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COLLABORATIVE BEHAVIOR NETWORK ON MANAGEMENT OF MOUNT GEULIS PROTECTED FOREST AT SUMEDANG REGENCY, WEST JAVA PROVINCE, INDONESIA

PUJO HUTOMO[1], TUBAGUS FURQON SOFHANI[2], BUDHI GUNAWAN[3] AND TATI SURYATI SYAMSUDIN[1*]

[1]*School of Life Sciences and Technology, Bandung Institute of Technology, Jalan Ganesa No 10, Bandung, 40132 Indonesia.*
[2]*School of Architecture, Planning and Policy Development, Bandung Institute of Technology, Jalan Ganesa No 10, Bandung, 40132 Indonesia.*
[3]*Faculty of Social and Polictical Sciences, Universiti Pajajaran Bandung, Jalan Raya Bandung Sumedang KM.21, Hegarmanah, Jatinangor, Kabupaten Sumedang, Jawa Barat 45363, Indonesia.*

**Corresponding author: tati@sith.itb.ac.id*

Abstract: Ecosystems are driven by inherent methodical processes and are often regulated by external forces. Ecologically, an ecosystem characteristic is influenced by their interaction processes as being generated by the activities of its community members. Humans are one of the ecosystem components which are both directly and indirectly influence the processes that occur in the ecosystem. In an ecosystem management, the sustainability of the ecosystem depends on the ability to maintain its functions by recognising and elevating the role of the local communities through structured cooperation. Cooperative behavior occurs through a process of development and is indicated by the network connectance. Collaborative behavior networks which are built by cooperative behavior are embedded in the network structure. This study aims to seek the connectance of local communities in a collaborative forest management system by analysing: 1) the structure of collaborative behavior networks, and 2) the structural characteristics of collaborative behavior networks. A survey was conducted with 60 respondents, selected purposively from the two villages in the Mount Geulis Protected Forest (MGPF) area - Sumedang Regency, West Java. To determine the structural characteristics of the collaborative behavior network, six variables were measured (degree centrality, betweenness centrality, closeness centrality, eigenvector centrality, beta centrality, and clustering coefficient). Data analysis was conducted by UCINET VI and the NetDraw Software Program. The results demonstrated that the relationship between the community members of the two villages has yet to formed collaborative behavior. This was indicated by low connectivity (degree centrality=14.93%; betweenness centrality=11.73%) between members of the two villages in MGPF management. However, the level of dependency was high (eigenvector centrality= 0.1588) and there was the existence of an actor which has strong influence (beta centrality= 0.8694), as shown by the strong dependency of the community members on the community leader. On the other hand, the community members have sufficient ability to reach other members in the network, as indicated by the moderate value of closeness centrality (0.5675) and tend to form clusters as indicated by the high clustering coefficient value (1.2674). This phenomenon could be explained by the kinship between members of the communities. The results indicate that the collaborative behavior is not suffice to mobilize community involvement in the management of the MGPF.

Keywords: Behavior pathways model, connectance, ecological network analysis, community-based forest management, West Java

Introduction

Ecosystems livelihood are directly or indirectly influenced by the interaction between individual species in the community. A new ecological paradigm had recognises that humans are a component of an ecosystem (Alberti *et al.,* 2003), and the community ecology theories stressed that the connectivity between ecological system and human community is distinguished by anticipating the perturbation of the latter (Gunderson, 2009). Therefore, human played an important role in the ecological alterations or as a legitimate users in the ecosystem (Hunziker, 2007).

In the forestry development, the ecological paradigm approach has been applied through community-based forest management (CBFM) (Fisher *et al.,* 2007). The implementation of CBFM has demonstrated the importance of community involvement in forest management (Lai, 2003; Hollenbach, 2005; Devkota, 2010; Maryudi, 2011; Maryudi & Krott, 2012; Schusser, 2012) and, specifically, in collaborative forest management system (Jones & Burgess, 2005; Muñoz-Erickson *et al.*, 2007; Scarlett, 2013). According to Pratt-Miles (2013), in the ecosystem management, collaboration is the best approach to manage the relationship between social and ecological systems. Therefore, collaborative forest management requires the balance of socioeconomic and ecological interests to mobilise community involvement (Keough & Blahna, 2006). Several studies have found that the failure to mobilise the community involvement was due to the inability in addressing issues of socio-economic importance, not accommodating the sovereignty and interests of local communities (Hollenbach 2005; Maryudi, 2011; Maryudi & Krott, 2012; Schusser, 2012). Meanwhile, the same impediment was observed in CBFM approach, where they are unable to mobilise community involvement to function (Murniati, 2005; Thomas, 2007; Ansori, 2012; Maryudi & Krott, 2012). However, people who live in close proximity to a forest are capable to be managed effectively over the long term (Li, 2007).

The existing theory (Lai, 2003; Hollenbach, 2005; Devkota, 2010; Maryudi, 2011; Maryudi & Krott, 2012; Schusser, 2012) has not been able to explain the transformation process of community involvement in integrating people into forest ecosystem management. Community Ecology theory had advocated that the existence of population connectivity patterns determines its landscape management (Franco, 2004). However, in Ecological Network Analysis theory, the connectivity patterns describe the cooperative behavior that occurs between organisms (people) in the ecosystem network (Johnson, 2008). Hence, the connectance of the ecosystem network structure determines the patterns among individuals as a reticulum interaction in the ecosystem network (Borrett & Patten, 2003).

In the protected area, the development of cooperative behavior among the local community based on mutual benefits (mutual beneficiaries) is crucial for the success of forest conservation (Fay, 2007; Merino & Carmenado, 2012). The definition of cooperative behavior is, an act of providing the benefits of a single individual (actor) to another individual (recipient) in a way that is altruistic and mutually beneficial (West *et al.,* 2011). Huxham (2003) suggests that collaboration is a resource exchange process which is done through joint action to gain mutual benefit. If the cooperative behavior between members of the local communities with their environment was built up, it would produce a strong cooperative relationship pattern (Rand *et al.,* 2011). According to Bizikova *et al.* (2012), the recognition of overall stakeholder legitimacy is the initial success of the collaborative approach. Thus, a collaborative approach is essential to developed cooperative behavior that can result in joint actions (Gomez, 2013).

Within the limitations of the theories, there rise a quest of how to optimise the roles of local communities in developing the collaborative forest management systems and its implementation, particularly in Indonesia. Therefore, to mobilise community involvement in forest management, a new concept is required in which have the capability to integrate the cooperative behavior concept and the collaborative approach, and hence this paper proposed collaborative behavior as its backdrop concept. The concept is essential for realising the sustainability of forest ecosystem management.

The purpose of this study was to investigate the connectance of local communities in collaborative forest management by analysing:
1) the structure of the collaborative behavior network, and 2) the structural characteristics of the collaborative behavior network. The study was conducted in the area and its vicinity at Sumedang Regency, West Java Province,

Indonesia. This paper is intended to contribute to the understanding of forest management practices, which in furtherance provide mutual benefits for the interests of ecology and the local communities' social economic importance.

Literature review

The concept of Sociobiology, Community Ecology and Ecological Network Analysis

The main concept expedited in this study relates to the concept of cooperative behavior, which is familiar in sociobiology, explains that human behavior is influenced by the biological and genetic characteristics (Johnson, 2008). The patterns of the human relationship with the environment in the context of sociobiology are explained through the concept of human behavior ecology (Halcom & Byron, 2013). Human behavior ecology is closely related to the concept of community ecology, which is a study of interactions between coexisting populations (Sahney & Benton, 2008). In the ecosystem, the biotic interactions between the species form an ecological network structure. The network structure is defined by the flow of materials, energy, and exchange of information between organisms and their environment that can be analyzed by an ecological network analysis. The connectivity patterns describe the behavior among community members in the network ecosystem and explain cooperative behavior within the structure of the network ecosystem (Johnson, 2008). The importance of cooperative behavior is indicated by the individual requirement to cooperate in dealing with other individuals. Cooperative behavior can be understood by holistically analyzing the characteristics of the relationships between components in a network (Borrett & Patten, 2003).

Collaborative behavior

Collaborative behavior involves two aspects: the concept of cooperative behavior and a collaborative approach. Cooperative behavior is a behavior that provides the benefit of one individual to another individual and is altruistic and mutually beneficial (West et al., 2011). Behavior is the internally coordinated response (actions or inactions) of the whole living organism (individual or group) to internal and or external stimuli (Levitis *et al.*, 2009). Hence, cooperative behavior is the actions of living organisms stimulated by providing mutual benefit. Cooperative behavior conducted through the process of social interaction could result from collective action (Muller & Mitani, 2005; Noe, 2006). Through the process of social interaction, cooperative behavior aims to achieve mutual benefits and common objectives between community members (Huxham, 2003). To achieve the mutual benefit of the cooperative behavior in a community, a collaborative approach is a must (Gomez, 2013). The collaborative approach can be conducted by implementing sharing strategies as a method to gain mutual benefit between the community members (Gilby, 2006). A sharing strategy is an important identifier of the collaborative approach which results from the cooperation mechanism (Boal, 2006). Therefore, to develop new forest management practices, collaborative forest management requires a collaborative behavior concept.

Social Networks Theory and Social Network Analysis (SNA) Methods

The social network is a set of individuals or groups with some patterns of contact and social interaction. Each individual in a social network builds social interactions, which connect between nodes (actors) and links (ties) (Borgatti *et al.*, 2009; Halgin, 2012). At individual level, the characteristics of networks are described as
(1) degree centrality, (2) closeness centrality and (3) betweenness centrality while at the group level, the measures of the network are the density and clustering coefficients (Scott et al., 2005). Eigenvector centrality is used to determine the connectivity level of individuals in a social network (Sueur *et al.*, 2011; Makagon *et al.*, 2012; Borgatti *et al.*, 2013). Beta centrality is used to explain the strength of

individual power in a social network (Bonacich, 1987; Borgatti *et al.,* 2013). The quality level of relationships between individuals within a social network structure can be measured by using the social network analysis (SNA). Social network analysis is a method of analyzing the relationship between the structural units that interact and determine the patterns of relationship between actors in the social structure (Wasserman & Faust, 1994; Breeiger, 2004).

Collaborative Behavior Network

Cooperative behavior occurs through a process of development (Levitis *et al.,* 2009) which can be seen from the interaction patterns in the network structure (Krause *et al.,* 2007; Madden *et al.,* 2009). Cooperative behavior is produced through species group interaction processes that are driven by the preferential reaction between individuals (Bode *et al.,* 2012). The process of cooperative behavior starts by building perception through several steps: "behavior of attention" (Bodenhausen & Hugenberg, 2009), then "visiting behavior" (Marin & Wellman, 2010), "empathy" or listening to the problem (Gerdes & Segal, 2009; Marin & Wellman, 2010; Boukricha *et al.,* 2011), "informing" (Crona & Bodin, 2006; Meleady *et al.,* 2013), "communicating" (Crona & Bodin, 2006; Meleady *et al.,* 2013), then "facilitating" (Forgie *et al.,* 2001; Marin & Wellman, 2010). If this behavior process is built with the collaborative approach, it will generate strong cooperative behavior (Bode *et al.,* 2012; Gomez, 2013). If cooperative behavior is embedded in social networks (Rand *et al.,* 2011), it will generate a collaborative behavior network (Figure 1).

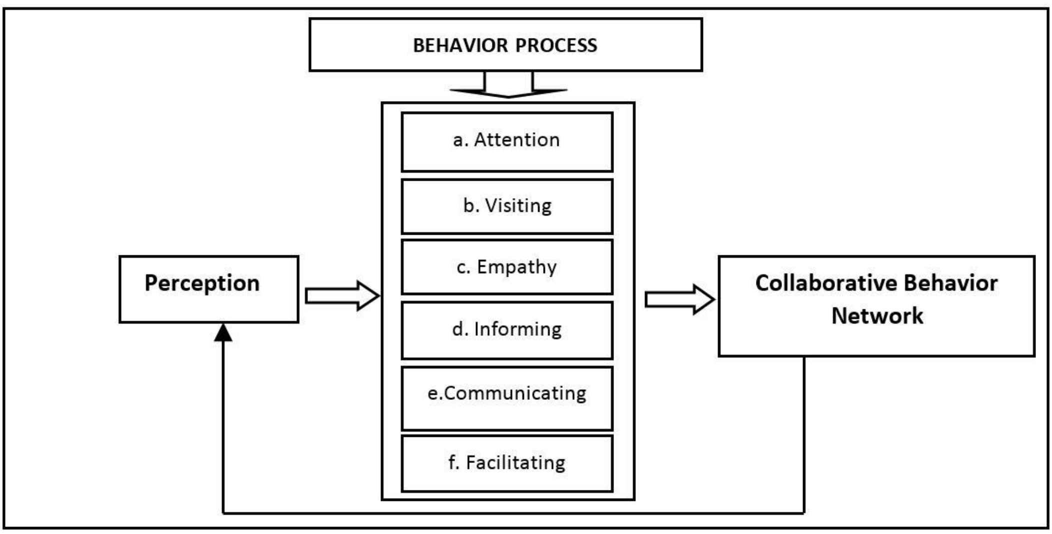


Figure 1: Behavior pathway model to generate collaborative behavior network (Modification from: Forgie *et al.,* 2001; Crona & Bodin, 2006; Bodenhausen & Hugenberg, 2009; Gerdes & Segal, 2009; Marin & Wellman, 2010; Boukricha *et al.,* 2011; Meleady *et al.,* 2013).

Methodology

Study Area

This study was conducted in the (MGPF) area and its vicinity at Sumedang Regency, West Java Province. Prior to 1991, the area of Mount Geulis was owned by the local communities and was used to plant annual crops. The Indonesian Government then had established the area of Mount Geulis as a state gazette forest in 1991. The attempt to use the area as state forest was conducted through the CBFM program, by involving the local communities and regional governments. Implementation of the program was developed by establishing the local community group, which was called the

Forest Village Community Institution (FVCI) or Lembaga Masyarakat Desa Hutan (LMDH) in Indonesian. In 2005, the status of the area was designated as a protected forest. However, until the year 2010, the FVCI was not active in establishing collaborative forest management, therefore, the area could not be considered as a protected forest. This was confirmed by the results of the study conducted by a team from the School of Life Sciences and Technology in 2012. The area of the MGPF was dominated by sparse vegetation and bare land in the form of shrubs and pioneer trees (54.8%), the shrub-dominated by *Calliandra sp* and almost covered about 45.2% of the area. Therefore, the study focus was conducted in two inactive FVCI villages, Cinanjung village in Tanjungsari Sub-district, and Cisempur village in Jatinangor Sub-district.

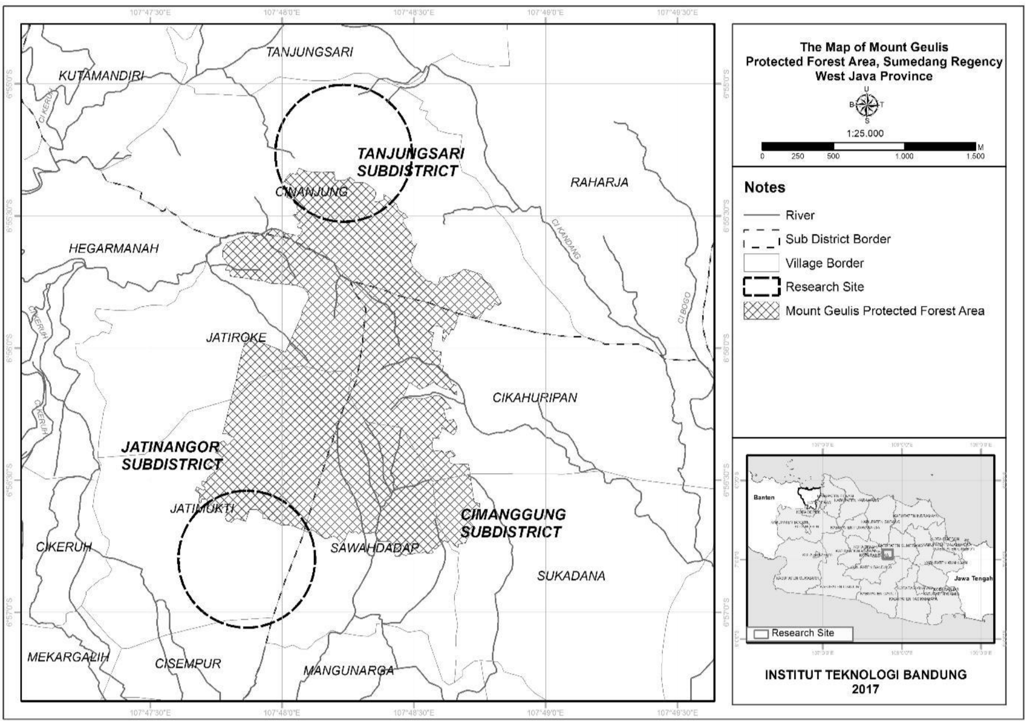


Figure 2: The geographical location of Mount Geulis Protected Forest Area structure of collaborative behavior network.

Analysis of the collaborative behavior network among community members of FVCI in MGPF management was conducted through a structural characteristics analysis of the network. The method was a modification from Freeman (1979), Wasserman and Faust (1994), Otte & Rousseau (2002), Newman (2004), Ehrlich and Carboni (2005), Sueur et al. (2011), Baranyi *et al.* (2011), Rodan (2011), Baranyi *et al.* (2011), Makagon *et al.* (2012), Borgatti *et al.* (2013), Kurvers *et al.* (2014). The survey was conducted to determine the structure of relationships between FVCI members at MGPF. A total of 60 respondents were selected from the FVCI membership with a purposive sampling technique, with 30 respondents chosen from Cinanjung Village and 30 from Cisempur Village. The quality of interaction was judged by interviewing each respondent. Measurement of the behavior pathway model occurred through assigning a numerical value to a list of questions. Interviews covered some aspects related to collaborative management activities, namely, 1) intention of the individuals to engage in collaborative forest management activities; 2) visiting: improving social relations of the individuals by the action of visits; 3) empathy: the action of listening to or solving problems related to collaborative forest management activities; 4) informing: the action of giving information about collaborative forest management activities; 5) communicating: the action of communicating about collaborative forest management activities; 6) facilitating: the action of facilitating collaborative forest management activities (Table 1).

Table 1: Description of behavior pathway model.

No	Behavior	Relationship Type	Description
1	Attention (Bodenhausen & Hugenberg, 2009; Marin & Wellman, 2010)	Interaction	The behavior is shown by individuals in the form of action, for inviting, evoking awareness and interest to other people in order to engage in collaborative forest management activities
2	Visiting (Marin & Wellman, 2010).	Interaction	The behavior shown by individuals in the form of action, for visit other individuals to improve social relations related to collaborative forest management activities
3	Empathy (listening) (Gerdes & Segal, 2009; Marin & Wellman, 2010; Boukricha *et al.*, 2011)	Affective ties	The behavior shown by individuals in the form of action to listen to the problems faced by other individuals related to collaborative forest management
4	Informing (Crona & Bodin, 2006; Meleady *et al.*, 2013)	Flows	The behavior shown by individuals in the form of the act of giving information to other individuals on activities related to collaborative forest management
5	Communicating (Crona & Bodin, 2006; Meleady *et al.*, 2013)	Flows	The behavior shown by individuals in the form of actions for communicating activities related to collaborative forest management
6	Facilitating (Forgie *et al.*, 2001; Marin & Wellman, 2010).	Interaction	The behavior shown by individuals in the form of action, for facilitating activities to another individual related to collaborative forest management

Note:
Flows are the type of relationship based on an exchange or transfer between members of the network, including the resources, information, or influence through the network; Interaction refers to behavior-based bonding talk to, help, or inviting or visiting person; Affective ties: the patterns of relationships based on feelings members of the network to the other members.

The level of interaction of the six parameters was determined by the level of influences or frequency. These were: 0 (none); 1 (low); 2 (moderate) and 3 (high) and the data were constructed into a sociometry table. To determine the structure of the collaborative behavior network, the data obtained from the behavior pathways model were analysed using the NetDraw software program (Borgatti & Freeman, 2002). Data collection exercise was conducted in a period of three months, which commenced from 1 August 2015 to 31 October 2015.

Structural Characteristic of the Collaborative Behavior Network

The structural characteristics of the network describe the level of the relationship between actors in the network system, such as degree centrality, closeness centrality, eigenvector centrality, betweenness centrality, beta centrality and clustering coefficient, as presented in Table 2.

Table 2: Measurement the structural characteristic of collaborative behavior network.

No	Network Measure	Description	Measurement
1	Degree (Wasserman & Faust, 1994; Otte & Rousseau, 2002; Baranyi *et al.,* 2011; Makagon *et al.,* 2012; Borgatti *et al.,* 2013)	Shows how well the connection of certain individuals in the immediate environment.	Measuring the number of direct relationships possessed by an actor in a network
2	Closeness (Wasserman and Faust, 1994; Otte & Rousseau, 2002; Baranyi *et al.,* 2011; Makagon *et al.,* 2012; Borgatti *et al.,* 2013)	Shows a closeness degree of nodes with other nodes on based on the amount of the average distance between nodes.	Measuring the sum of shortest paths that connect a focal node to all other nodes in the network.
3	Eigenvector (Sueur *et al.,* 2011; Makagon *et al.,* 2012; Borgatti *et al.,* 2013)	Show the degree of equality between the nodes in a network	Measuring the level of connectedness of each node in social networks by giving value relative to all nodes in the network.
4	Betweenness (Freeman, 1979; Otte & Rousseau, 2002; Baranyi *et al.,* 2011; Borgatti *et al.,* 2013)	Shows the frequency of an individual intercourse with one click among other clicks	Measuring the number of shortest paths between all pairs of nodes in the network, divided by the total number of shortest paths between each pair of nodes.
5	Betacentrality (Bonacich, 1987; Rodan, 2011)	Shows the strength of the power of individuals in the network	Measuring the degree centrality of the actor who is the more powerful influence on other actors in the network.
6	Clustering Coefficient (Ehrlich & Carboni, 2005; Makagon *et al.,* 2012; Borgatti *et al.,* 2013; Kurvers *et al.,* 2014)	Shows a measure of how tightly the nodes are clustered in a network..	Measuring the degree of people know each other and form clusters

The connectivity between the members of FVCI at the MGPF area was determined by interviewing respondents that were selected from the two villages with a purposive sampling technique. The same respondents and the same questions as the previous study were used for the structure of collaborative behavior. Data collection was conducted at the same time as the previous study. Based on the behavior pathway model (Table 1) the data obtained were analysed using UCINET VI Version 6.614 for the structural characteristics of the collaborative behavior network.

Results and Discussion

Structure of the Collaborative Behavior Network

The social network structure at the Cinanjung and Cisempur villages tends to be centered in the form of a wheel network structure (Figure 3 & 4). According to Borgatti *et al.* (2009), the wheel network structure has a clear leader. These results show the existence of some individuals in the center of the community network who act as leaders and have a central role in developing collaborative behavior in the two locations. The wheel network structure shows the tendency for a small key actor who has plenty of ties or links in a network (Bodin *et al.,* 2006). This result also demonstrates the existence of key actors involved in conducting the activities of FVCI groups in the study area. Key actors have an important role in the development of collaborative behavior in the local community, especially in relation to the management and dissemination of information programs in the protected areas.

The development process of collaborative behavior can be seen from the position of the individual in the social network structure. In this study area, two types of network structure can be found, the core network structure and the periphery network structure (Figure 3 & 4). The core network structure means that the interaction between the members of the local community was relatively frequent. The periphery network structure indicates that interactions between community members were lesser than core network structure (Zhang *et al.*, 2013). In the study area, the periphery structure was dominant. This demonstrates that the members of the FVCI generally interacted less with other members. According to Madden et al. (2009), the process of social interaction within social networks is essential to generate collective movement (collective action). Therefore, to develop collaborative behavior in MGPF management, the strength of the social interaction in a community is crucial. This could be achieved by the involvement of local leaders as the key actors. The result has also confirmed Aregu and Darnhofer (2015) arguments which state that, in social networks, the local leaders have an important role to encourage cooperative behavior.

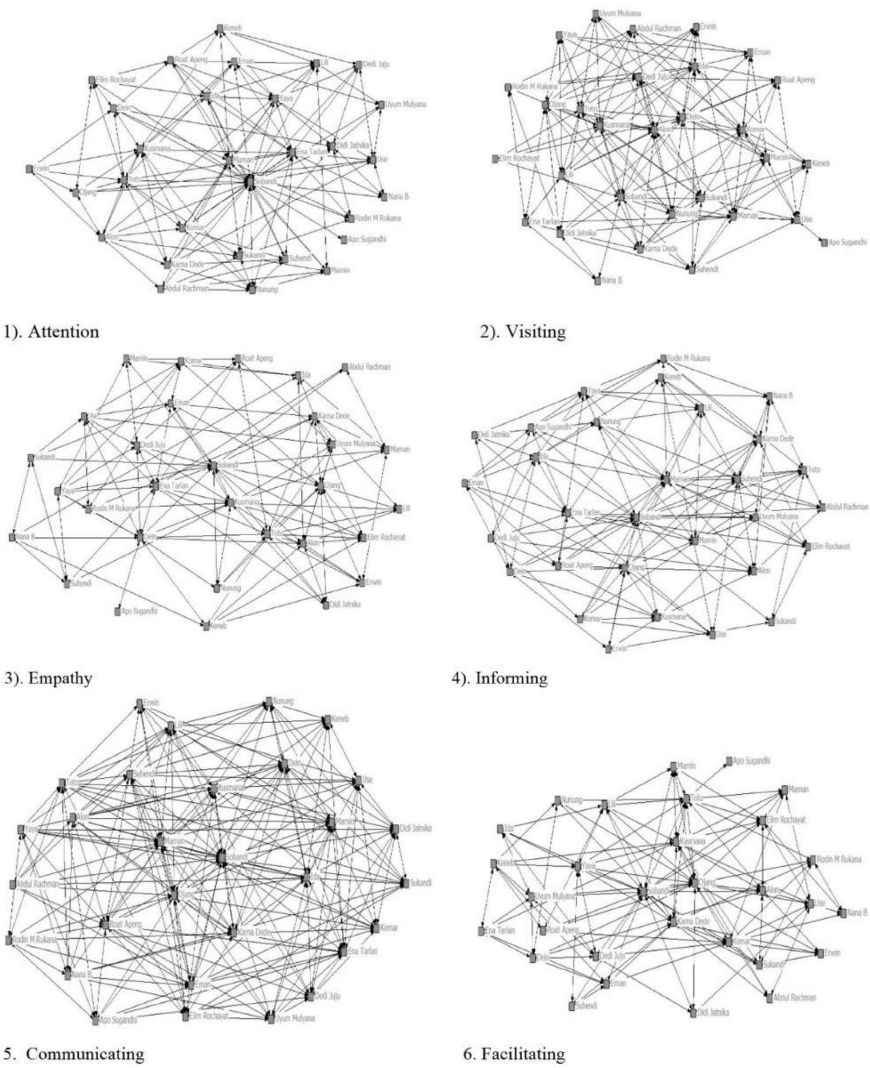


Figure 3: Structure of collaborative behavior network in cinanjung forest village community institution (FVCI) based on behavior pathway model.

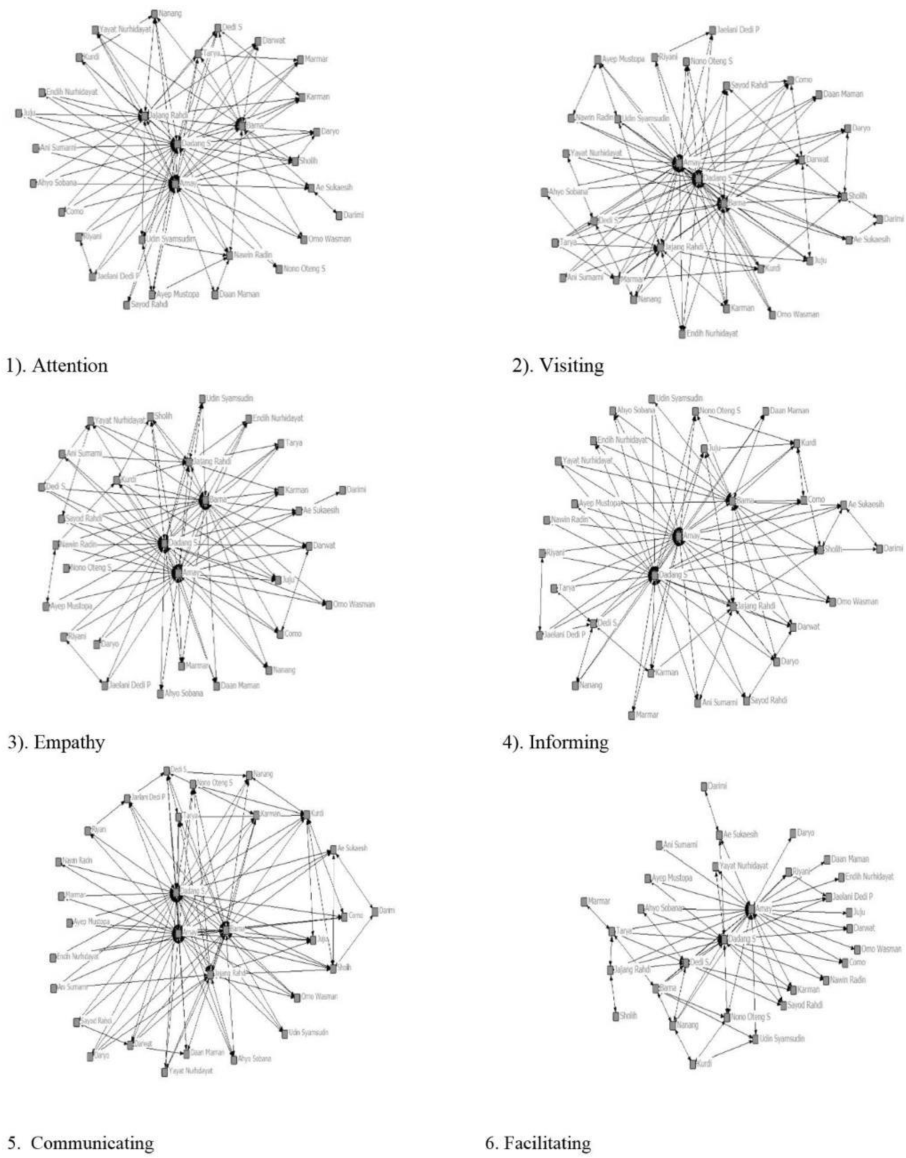


Figure 4: The structure of collaborative behavior network in cisempur forest village community institution (FVCI) based on behavior pathway model.

Based on the behavior pathways model, the structural characteristic of collaborative behavior networks in the MGPF is represented by degree centrality, closeness centrality, betweenness centrality, eigenvector centrality, beta centrality and clustering coefficient (Table 3).

Table 3: Structural characteristic of collaborative behavior network in management of MGPF.

Description	Degree Centrality	Eigenvector Centrality	Closeness Centrality	Betweenness Centrality	Beta Centrality	Clustering Coefficient
Mean	14.9333	0.1588	0.5675	11.7316	0.8694	1.2674
Median	11.4444	0.1373	0.5416	4.0295	0.7499	0.9830
Mode	6.0000	0.1070	0.5110	0.0110	0.0877	0.2910
Std. Deviation	12.4367	0.0816	0.0904	26.3747	0.4477	0.6651
Variance	154.6730	0.0070	0.0080	695.6260	0.2000	0.4420
Range	68.0000	0.4690	0.5860	156.0050	2.5710	2.3200
Minimum	4.0000	0.0160	0.3610	0.0000	0.0877	0.2910
Maximum	72.0000	0.4850	0.9470	156.0050	2.6587	2.6110
Sum	896.0000	9.5300	34.049	703.8950	52.1668	76.0420

Note:
Flows are the type of relationship based on an exchange or transfer between members of the network, including the resources, information, or influence through the network; Interaction refers to behavior-based bonding talk to, help, or inviting or visiting person; Affective ties: the patterns of relationships based on feelings members of the network to the other members.

Degree Centrality

The two villages in the MGPF showed a low value of connectance or connectivity between members of the local community. This result demonstrated that there was a low value of degree centrality (14.93%). The degree centrality value ranges from 0 to 100%, where the higher the degree of centrality value, the more connections between members of the community (Otte & Rousseau, 2002). It indicates that the actors in the MGPF were unable to collaborate. In general, the highest connectance for the members is the group administrators, especially the group leader. The network, which has been formed in this study area, has not been originated from collaborative behavior. The low value of connectance demonstrates that the collaborative process has not run well. Based on the behavior pathway model (Figure 5p), the relationships between community members of the FVCI in relation to degree centrality has yet lead to collaborative behavior. Therefore, the cooperative behavior has the potential to be improved by increasing the role of group leaders in developing collective action on MGPF.

Eigenvector Centrality

The two villages in the MGPF area show a low value of eigenvector centrality, at 0.1588. According to Seary and Richards (1995), eigenvector values range from 0 to 1. The higher value shows the node is well-connected with others, and it also measures popularity and influence of the actor in the group (Zhao, 2014). The eigenvector shows the connectivity, individuality and friendship in a community network and describes the equality of network members and the existence of key players in the community network as a flow function (Makagon, 2012).

It means that the relationship patterns among community members of the FVCI are not equal and there is no key actor. The relationship between community members of the FVCI has yet to formed collaborative behavior, as shown by the behavior pathway model (Figure 5q). Therefore, to develop collaborative behavior in the MGPF, the equal relationship, friendship patterns, and the presence of key actors is a must to run the collaborative process. In this study area, key actors are the group leaders and members of the group that have influence on social control and as information disseminators between members of FVCI group. Key actors are equal to keystone species in community ecological theory. Individual keystone in this research has an important role, nexus among other members, as a leader, social control and as a super spread (Modlmeier *et al.,* 2014). The role of these key actors can be seen from the behavior pathway model in relation to the Eigenvector Centralization Percentages (Figure 5r). The roles of key actors in developing collaborative behavior are dependent upon these few individuals. Therefore, to develop collaborative behavior in the MGPF, the key actors are essential in the collaborative process programmes.

Closeness Centrality

The value of closeness centrality from the two villages in the MGPF is 0.5675. This result shows a moderate value of closeness centrality. According to Freeman (1979), Otte and Rousseau (2002), Ehrlich and Carboni (2005), closeness centrality measures how close the relationship of an actor is with other actors in the network (Freeman, 1979; Otte & Rousseau, 2002; Ehrlich & Carboni, 2005). The closeness value also illustrates the ability of community members to reach or to interact with other community members in the social network (Ehrlich & Carboni, 2005). The closeness centrality value ranges from 0 to 1 (Otte & Rousseau, 2002). The high closeness centrality value shows that an actor does not depend on other people to be connected to the network (Freeman, 1979). This indicates that FVCI members have sufficient ability to reach the other members of the network. This phenomenon could be explained by the kinship between members of the FVCI.

Based on a behavior pathway model (Figure 5s), the tendency of relationships between community members of the FVCI in relation to closeness centrality has yet to formed collaborative behavior. It showed that the closeness between members of the FVCI is not enough to mobilise community involvement in the management of the MGPF. To develop collaborative behavior in the management of MGPF, it is the role of community leaders to increase mobilisation of members in the group.

Betweenness Centrality

The two villages of the MGPF showed that the number of the community is on the shortest pathways between actors showed by the low value of betweenness centrality (11.73%) and network centralizations index (19.76%). According to Freeman (1979), Otte and Rousseau (2002), Ehrlich and Carboni (2005), betweenness centrality shows the extent to which the actor is positioned on the shortest path (geodesic) between other pairs of actors in the network. The betweenness centrality value ranges from 0 to 100% (Otte & Rousseau, 2002). Actors with the highest betweenness centrality are the people most likely to cause the others in the network must go through to reach each other (Ehrlich & Carboni, 2005) and have the potential to control the other actors (Freeman, 1979). Actors with high betweenness values play the role of intermediary to connect different groups (Otte & Rousseau, 2002). It indicates that the actors who serve as intermediaries (broker/ bridge) in the collaborative process are very few. It also denotes that the position of the FVCI members could not play a role in mobilizing the other members of the group and could not also serve as intermediaries to develop collaborative behavior in the management of MGPF.

Based on the behavior pathways model (Figure 5t; 5u), the relationships between community members of the FVCI in relation to betweenness centrality and the network centralizations index have formed collaborative behavior in moderate categories. The results indicates that community members have a high level of dependency on the community leader. Betweenness centrality could show the power position of an actor among the other actors to control the flow or exchange of information, resources and knowledge (Makagon, 2012) and determines individual roles in maintaining the cohesiveness of the network (Lusseau, 2007). However, to build collaboratively, the role of the informal leader is very important (Aregu & Darnhofer, 2015). To determine the presence of central actors who have an important role in information dissemination or distribution of resources a network centralizations index must be used (Freeman, 1979). Thus, the development of collaborative forest management in the MGPF was less developed. The development of collaborative behavior in the MGPF area requires the actor who has strong power to mobilise community members in the collaborative management.

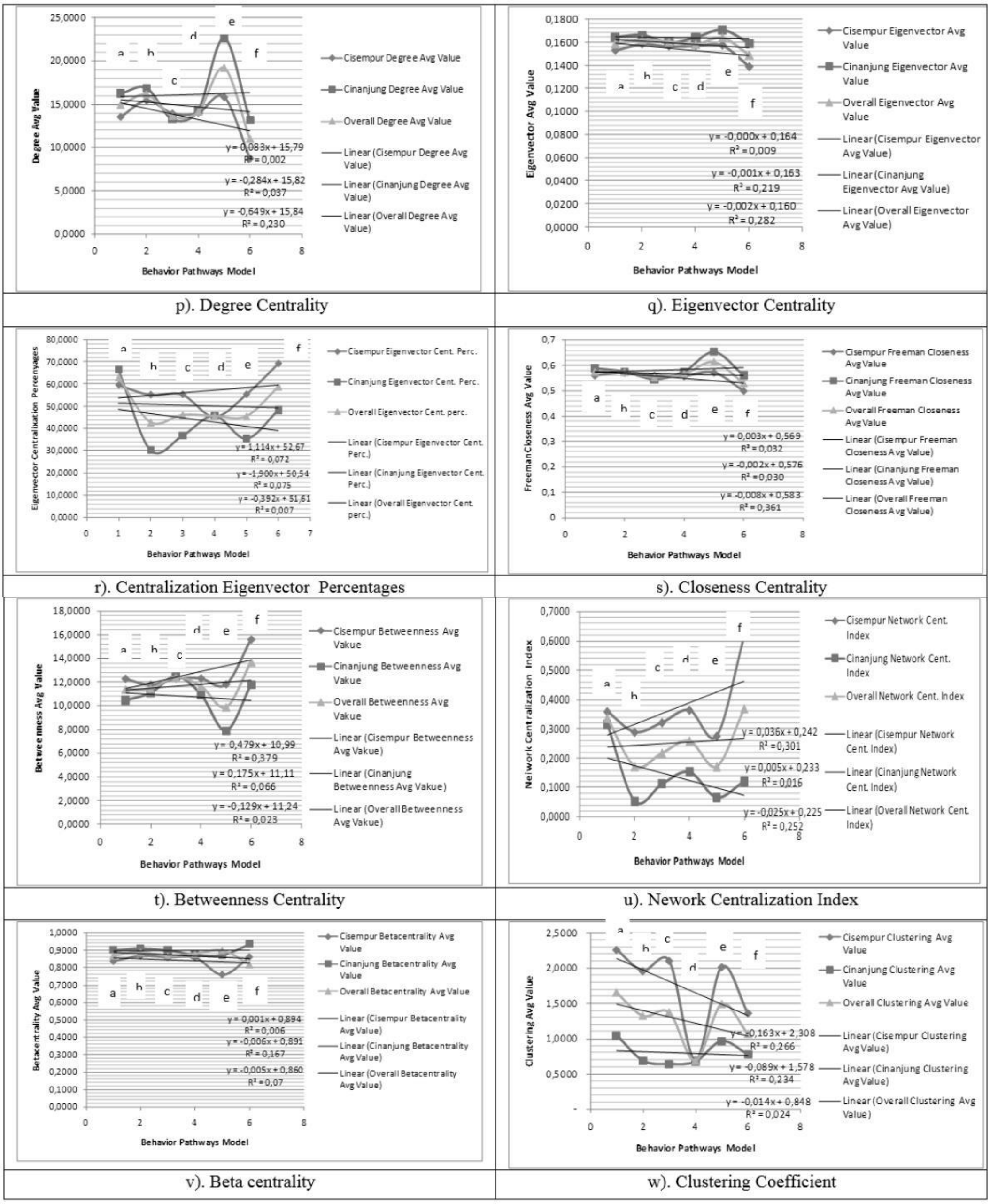
Beta Centrality

The two villages in the MGPF showed a beta centrality value of 0.8694. This denotes that the two villages in the MGPF found a strong actor. In social networks, the power of actors is very important (Devkota, 2010; Maryudi, 2011). The actor who has a central role in the network is a powerful actor (Hanneman & Riddle, 2005) and have the ability to change the behavior of other actors (Krott *et al.*, 2013). Beta centrality is used to describe the power of actors in the network represented by a beta centrality coefficient (β). If $\beta > 0$, the focal network has higher centrality when the people tied to other people who are in the central network. If $\beta < 0$, the focal network is tied to people who are not central to the network. If $\beta = 0$, the focal network becomes the center of the network (Bonacich, 1987; Rodan, 2011). In this study area, the position of the actor who has strong power is not enough to mobilize community participation (beta centrality = 0.8694). This result showed that the relationships between community members of the FVCI tend to decline and collaborative behavior has not yet formed (Figure 5v). To develop collaborative behavior in forest management, does requires the power of the actor who has a strong driving force, such as a coercive approach, a system of incentives or disincentives and dominance information (Krott *et al.*, 2013).

Clustering Coefficient

The two villages of the MGPF have a high clustering coefficient (1.2674). The results shows that the FVCI members in this study area tend to form clusters, which demonstrates the stability of the group. The clustering coefficient measures the degree of individual recognition to other individuals and the potential to form clusters (Ehrlich & Carboni, 2005). Clustering coefficient values greater than one indicate that nodes in the network are more likely to be clumped, while values smaller than one indicate that the node in the network tends to avoid clustering (Just *et al.*, 2015).

The clustering strength of the FVCI is affected by the kinship relations among members of the community. Theoretically the strong kinship relations will produce group stability (Alvard, 2003), however, in this study area, the stability of the group is not enough to encourage the formation of collaborative behavior. This result is also confirmed by the behavior pathway model (Fig. 5w), which demonstrates that collaborative behavior tends to decline. In the evolution of cooperative behavior, kinship is less important for certain circumstances (Alvard, 2003). Theoretically, to maintain cooperative behavior the size of the group is also important. By increasing group size, the capacity to maintain cooperative behavior decreases (Henrich & Henrich, 2006). This was supported by Scott (1995) who identified that group size determines the strength of collaboration within the community. Therefore, to improve the cooperative behavior in the MGPF, there should be an adjustment of group size.



Note : a. Attention b. Visiting c. Empathy d. Informing e. Communicatng f. Facilitating

Figure 5: The structural characteristic of collaborative behavior network in cinanjung and cisempur FVCI based on behavior pathway model.

Conclusion

Based on the structural characteristics of a collaborative behavior network examinations, the two villages in the MGPF area showed low value of connectivity between members of the local community. This demonstrates that the collaborative process has not run well. Based on the behavior pathway model, the relationships between members of the FVCI, in relation to the structural characteristics of a collaborative behavior network (degree centrality, eigenvector centrality, closeness centrality, betweenness centrality, beta centrality) have not led to collaborative behavior. Even for the clustering coefficient, the result showed that collaborative behavior tends to decline. Therefore, to develop collaborative behavior in the MGPF area, key actors are needed in the collaborative process of the programs. It requires an actor who has strong power to mobilise community members in the collaborative management. Key actors are equal to keystone species in community ecological theory. Actors are integral to run the collaborative process, and the roles of key actors in developing collaborative behavior dependent upon a few individuals in this study area. To enhance the successful implementation of collaborative forest management in the MGPF area, collaborative behavior needs to be increased through the development of a collaborative behavior network approach.

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