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Social Network Analysis of Aquaculture Projects on Provisioning Services Enhancement of Peatland Forest Ecosystem in Central Kalimantan, Indonesia

Francisca Mutwa Kilonzi[1]*, Takahiro Ota[1], Kazuhiko Moji[2] and Aswin Usup[3]

[1]School of Fisheries and Environmental Sciences, Nagasaki University, Nagasaki, Japan
[2]School of Tropical Medicine and Global health, Nagasaki University, Nagasaki, Japan
[3]P2KLH-LPPM, University of Palangkaraya, Central Kalimantan, Indonesia

Abstract

Improper implementation of peatland forest activities has altered the forest ecosystem resulting to near extinct or degradation of the peatland forest and its biodiversity. This research focuses on stakeholder attribute analysis for successful management of the aquaculture projects to ensure enhancement of provisioning services (fish) in the streams, ponds and rivers in the peat forest by providing an alternative source of fish to the community in a case study of Hampangen village, central Kalimantan in Indonesia. The exclusive features in our analysis shows that the income of the stakeholders or their educational level do not necessarily influence their roles and position in the leadership network nor determine the ES usage from the forest. This research challenges the mainstream understanding on stakeholders' selection based on educational background or income levels. From our study, we propose stakeholder selection based on social network attributes for a successful group or communal project management.

Keywords: Aquaculture; Ecosystem services; Indonesia; Social network analysis

Introduction

Ecosystem services are benefits obtained from the ecosystem provided to the humans through the transformation of resources (or environmental assets, including land, water, vegetation and atmosphere) into a flow of essential goods and services e.g., clean air, water, and food [1]. According to the Millennium Ecosystem Assessment [2], ecosystem services can be categorised as regulating, cultural or provisioning services.

In this paper, we focus on the provisioning services which are purely the products obtained from the ecosystem such as food. According to Kilonzi et al. [3], fish obtained from the natural ponds and river streams in the tropical peatland forest in central Kalimantan recorded the highest obtained provisioning services in the recent years. This is mainly because of the rewetting of the tropical peat swamp in central Kalimantan, a recovery measure to reduce carbon emissions from the forest fires experienced in the region [4].

We base our research on Social Network Analysis (SNA) concept whereby we focus on the social capital of the stakeholders and analyse their potential in the management of the aquaculture projects as well as the overall characteristics of the network. Social capital is defined by the Organization for Economic Co-operation and Development (OECD), as "networks together with shared norms, values and understandings that facilitate co-operation within or among groups". It is the quality of relationship among and between people that promotes strong and resilient network of individuals [5].

Social network analysis therefore offers tools that enhance understanding of power structure within a community by identifying the links between social capital and management of the natural resources [6]. It shows the existing subgroups in a network structure and enhances the understanding of the specializations around livelihood activities [7]. The two key elements of social network that we focus on are the stakeholders of the aquaculture projects known as nodes and their relations known as social ties. The "nodes" of a network are the people and the "links" are the relationships between people [8].

In the SNA concept, diverse actors in the social network contribute to the shaping of the society on how to use and access the natural resources such as forest and water systems whereby various interactions among the community influence how people approach and, govern the natural resources [9,10].

For instance, governance through intra-community relationships includes activities such as local participations in the increase in wildfire risk prevention actions [11], and forest management information flow through various groups such as women and youth groups. On the other hand, inter – community relationships play the bridging role in social capital [12]. Their weak ties increase adaptability, social and ecological resilience [13], in the forest management. A good example of bridging role was in Sweden in a model forest establishment [14].

Researchers have pointed out the role of Social network in the management of forests by creating social norms. Brooks [15] proposed a model depicting the role of social networks in a community in the endogenous creation of informal rules. He explains that after a community becomes aware of the existing forest problems surrounding them, people start implementing good practices which eventually become formalized.

***Corresponding author:** Francisca Mutwa Kilonzi, Ph.D, School of Fisheries and Environmental Sciences, Nagasaki University, Nagasaki, Japan, Tel: +810891080729; E-mail: franciscakarem@gmail.com

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Ros-Tonen et al. [16] affirmed that social capital facilitates changes in the institutions for the management of forests in Ghana. Relationship between local institutions and social capital through the provisioning of anchoring role has been proved in a case study of villages in Paraguay [17]. Kim et al. [18] focused on the role of local institutions in the implementation of the Reducing Emissions from Deforestation and Forest Degradation and the Conservation and Enhancement of Forest Carbon Stocks (REDD+) in a case study of one of the Indonesian Forest Management units.

According to Michele Barnes-Mauthe et al. [19], there's a strong relationship between social network and ecosystem services in that strong social network enhance ecosystem services flow by enhancing collective action plan that leads to sustainable natural resource governance. Therefore, it is important to consider the quality of relationship among people working together to understand the common set expectations, the shared values and the trust amongst the individuals. This is mainly because for instance, weak social capital can result to conflicting values and lack of trust and strong social capital can lead to harmonious coexistence [20].

Social capital can be used to determine the stakeholders who emerge as influential in a natural resource management institution thereby empowering or disempowering the stakeholders [19]. Christina Prell et al. [21] and, Grimble and Wellard [22] pointed out that many initiatives and projects more so the conservation projects have often failed because little or no attention is paid to the stakeholders their interests and attributes, due to this, a lot of focus has now been given to the stakeholder analysis in natural resources management projects.

SNA measures have been suggested as important for the adaptive management of natural resources and for the ability of communities or groups to engage in a collective action for a successful project. Focus has been put on the bridging social capital which is the within group interaction and not the interaction between groups known as bridging social capital [23]. Thus, in our study, we address social networks as real observable phenomena that can be measured using quantitative techniques [24] and analysed using social network analysis [25,26].

We focus on stakeholder identification and attribute analysis of two major aquaculture projects in central Kalimantan. We attempt to find out the position of the stakeholders in the network, their attributes and the role that they play or ought to play to ensure the success of the aquaculture projects they help to manage in order to enhance fish quantity in the natural peatlands by offering alternative source of production from the aquaculture.

We emphasize on power and influence [27,28], since social networks are important in studying different kinds of influence phenomena. There is a well-established study on how social network influences behaviour among people to adopt new practices that affect their lives [29-31]. This influence has resulted to positive impacts in the social network such as behaviour change, social network change, improve organizational efficiency, enhance social change, bringing of new ideas and innovations in the network among others [13,29], [31-34].

Materials and Methods

Scope of the study

This research was based in central Kalimantan, in Indonesia, in Hampangen village which borders Hampangen peatland forest, an important source of livelihood to the surrounding communities. In the recent past, central Kalimantan has been experiencing forest fires caused by anthropogenic activities which have resulted to high carbon emissions. To salvage the situation, the government set strict rules on use of the peatland forest which resulted to permanent closure of timber related industries rendering the people jobless. To protect the peatland forest ecosystem and its services and offer income to the communities, the government initiated alternative livelihood projects such as aquaculture projects.

We focused on the SNA of Hampangen Indah Fish Group (HIFG) keeping catfish (lele) and Maneser Panatau Fish Group (MPFG) that keeps irrigation shark (patin) fish species, to examine their potential to ensure alternative source of fish to the community to avoid over utilization of the fish from the HEF. The fish species kept are highly adaptable to the local conditions and can live in waters with low levels of dissolved oxygen and low pH levels such as peatland [35]. The interviews and questionnaires were administered to the 11 members of each group.

We first sought out the formation criteria of the groups. Each group is composed of ten members whose income should not be more than 6 USD per day; they should come from the same village and commit to tropical peatland conservation. After the members meet the required conditions, they form a group and come up with a constitution which is handed to the government with the help of an influential member of the group or from the village.

The government goes through the constitution if accepted; the group is given financial support to start the project in form of fishing materials and fingerlings all worth 2000 USD. Three officials in each group are also given free training on how to manage fish farm that then comes to teach the other members. These ponds are built on the natural peatlands and generally depend on rainwater.

Methods

The SNA data were collected through interviews and name generator questionnaires to the members of each of the two aquaculture groups. We used recall method (respondents to generate a list of his/her relations) to get relational data since this kind of data is frequent in interaction, intense and recent hence possible to identity the most influential stakeholders [24].

Questions and Interviews required each member to nominate the most influential members up to 5 and indicate the frequency of communication. Least communication got a score of 1; most communication score of 5. This was to get the relations among actors, their position in the network and how relations are structured into overall network pattern.

Results and Discussions

We examined the SNA measures in each group to determine the role of SNA in ES enhancement by examining the characteristics of each group and its members. Tables 1 and 2 show the calculated degree centrality for both indegree and outdegree, While Figures 1 and 2 show the visually directed ties for indegree and outdegree in the MPFG and HIFG networks, respectively. Figures 3 and 4 illustrate the tie strength, for MPFG and HIFG respectively by showing the connection lines and their thickness levels.

The thicker the lines of connection between stakeholders, the more the frequency of communication. The core stakeholders are located at the centre of the network while the periphery members are at the far edges of the network. Each group consists of 11 stakeholders, leaders being chairperson, secretary, treasurer and the organizing secretary

Actor/node	Indegree/popularity	Outdegree/influence	Degree centrality
Dina's social	9	1	10
Leader-1	7	1	8
Leader-2	5	4	9
Leader-3	4	0	4
Leader-4	5	2	7
Member-1	4	2	6
Member-2	5	3	8
Member-3	3	2	5
Member-4	3	2	5
Member-5	0	2	2
Member-6	4	4	8
Network centralization of 9.93%			

Table 1: Measures of degree centrality; indegree and outdegree for MPFG.

Actor/node	Indegree/popularity	Outdegree/influence	Degree centrality
Leader-1	7	1	8
Leader-2	5	4	9
Leader-3	9	1	10
Leader-4	4	4	8
Member-1	5	2	7
Member-2	3	3	5
Member-3	4	0	4
Member-4	5	1	6
Member-5	4	4	8
Member-6	2	3	5
Member-7	0	2	2
Group centralization network- 31.93%			

Table 2: Measures of degree centrality; indegree and outdegree for HIFG.

whom we referred to as leader 1, leader 2, leader 3, leader 4 and the other stakeholders without any leading role were referred to as member 1, member 2, etc. Dina's social is a stakeholder representing the government with no leadership role, in MPFG but in HIFG, we referred to him basically as leader1 because he plays a leadership role.

Maneser Panatau fish group

Degree centrality (indegree and outdegree): Indegree and outdegree of each actor was examined by counting the number of stakeholders who communicate to each actor as shown in Figure 1. For indegree we counted the incoming ties indicated by the arrows representing the number of stakeholders who communicate to the actor. For outdegree we counted the outgoing ties for the stakeholder whom an actor communicates to. Looking at Table 1, Dina's social a stakeholder representing the government had the most indegree which means 9 members communicate to him about the fish project, therefore he is the most popular stakeholder in the project. However, he has an outdegree of 1, which means despite his popularity, he communicates to only one stakeholder within the network hence less influential.

Leader 2 is popular as well as influential in the group, with an indegree of 5 and an outdegree of 4, thus, other stakeholders communicate to him and he also communicates to the fellow stakeholders, making him very significant in terms of leadership matters. On the other hand, member 5 is the least central, no actor that communicates to him and he only communicates to two members in the group, therefore plays a peripheral or passive role in the project, without him, the project management cannot be much affected in terms of performance. Member 6 has an indegree of 4 and an outdegree of 4, meaning that, he is both popular and influential in the network, very significant attributes for a potential leader.

Core and peripheral stakeholders MPFG: Leader 1, leader 2, Dina's social, and member 6 are the most central actors (located at the centre of the network) while leader 4, leader 3, member 2, member 4 and member 5 are at the periphery (located at the edges) of the network of MPFG as shown in Figure 1. The most central members tend to have the most responsibilities in a network organization; this is well proved in Figure 2 by the thickness of the communication lines. While the most peripheral members tend to be less active in the network as shown as shown by thin communication lines in Figure 2.

Tie strength of the stakeholders for MPFG: In MPFG the Network size (nodes) is 11 with a total number of 55 ties. The highest tie score is 5 and lowest tie score is 2. The thickness of lines indicates the strength of ties as shown in Figure 2. Thicker lines represent most frequency of communication between stakeholders that is a score of 5 which denotes strong ties while thin lines of indicate few frequency of communication or a low tie score which means weak ties.

The strongest ties are manifested among stakeholders namely; Dina's social, leader 2, leader 1, leader 4, member 6, member 4 and member 3, while weakest ties are between member 2 and member 4, and between member 2 and member 3. Generally, the network has very strong ties as depicted in Figure 2 above, hence very strong social bond and high levels of influence among the stakeholders.

Hampangen indah fish group

Degree centrality; indegree and outdegree: Looking at Table 2, leader 3 has the highest indegree of 9, this means 9, stakeholders communicate to him in regard to the fish project, he is therefore the most popular stakeholder in the network, however, he is not influential with an out degree of 1 means that he only communicates to one stakeholder. Leader 1 is also popular with an indegree of 7, but least influential with an outdegree of 1. Member 7 is the least popular stakeholder in the network, no stakeholder communicates to him while he communicates with only two stakeholders in the group. This means that his absence in the network has no significant impact in the management of the aquaculture project.

Stakeholders; leader 1, leader 4, member 5, and leader 4, member 2, member 6 have the same degree centrality of 8 and 5, respectively, this means that their influence level in the project is similar and thus they can competently play each other's role in the case of replacement or substitution. Member 5 comes has an indegree of 4 and an outdegree of 4 meaning that the rate of his influence and popularity is same in the group.

Generally, the degree centrality of the group is high, and strong

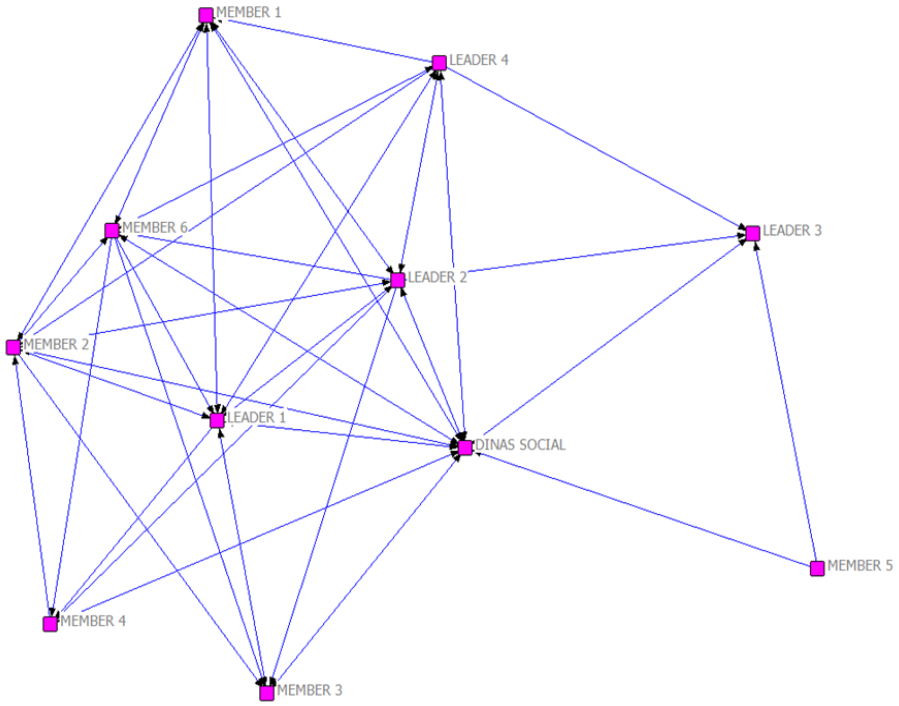

Figure 1: Directed communication lines for indegree and outdegree for MPFG network.

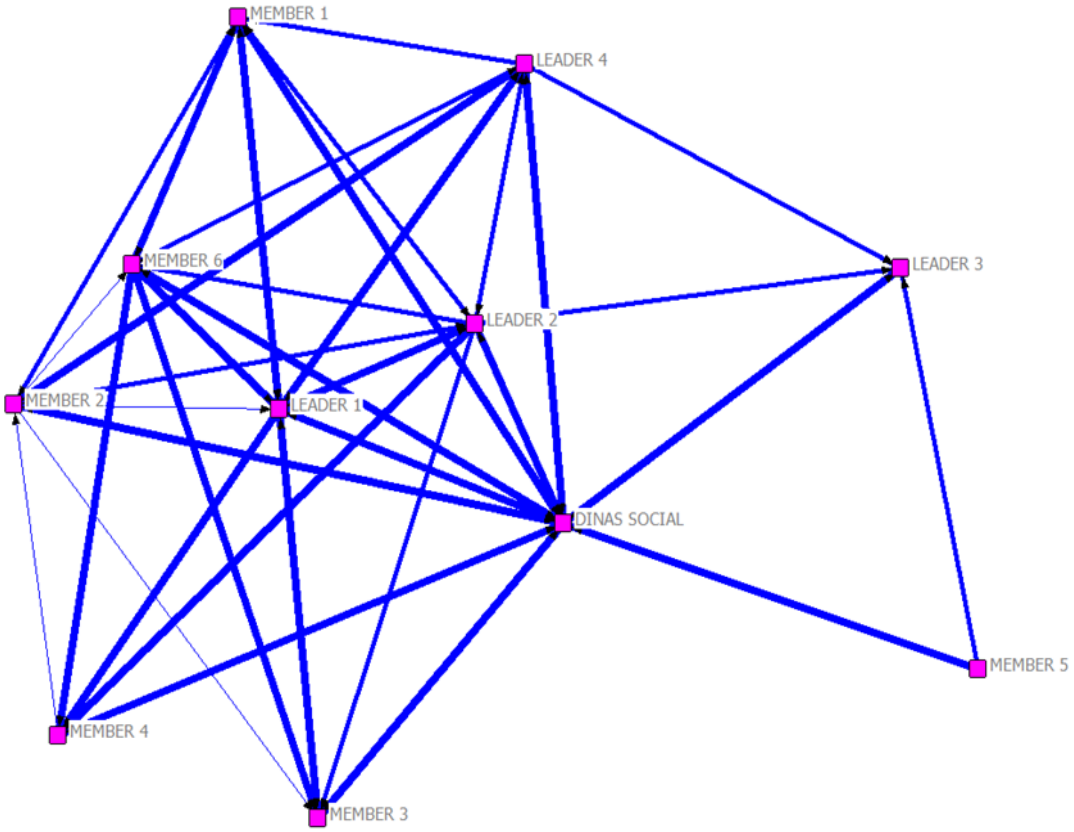

Figure 2: Various line thickness indicating stakeholders tie strength for MPFG.

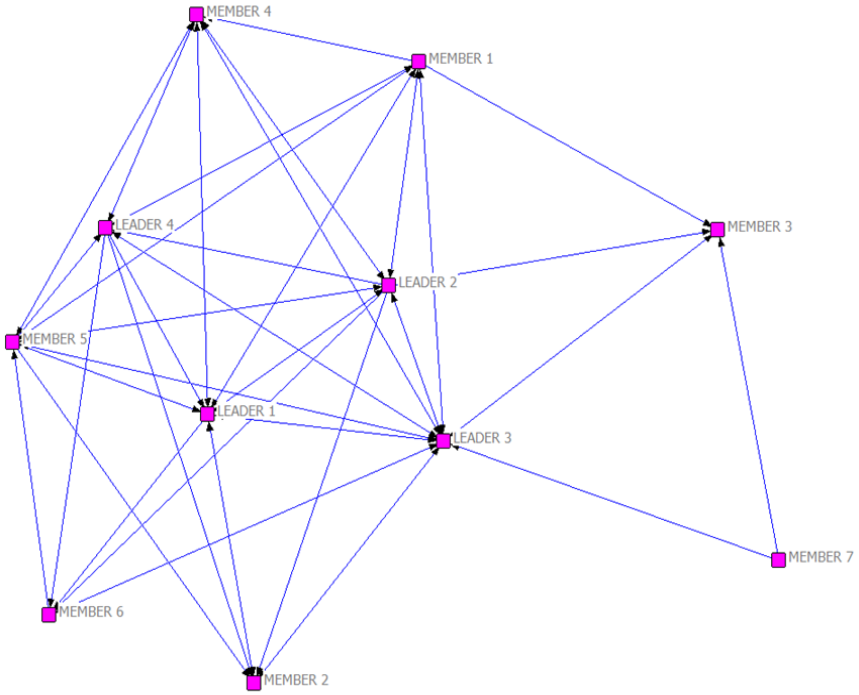

Figure 3: Directed communication lines for indegree and outdegree for HIFG Network.

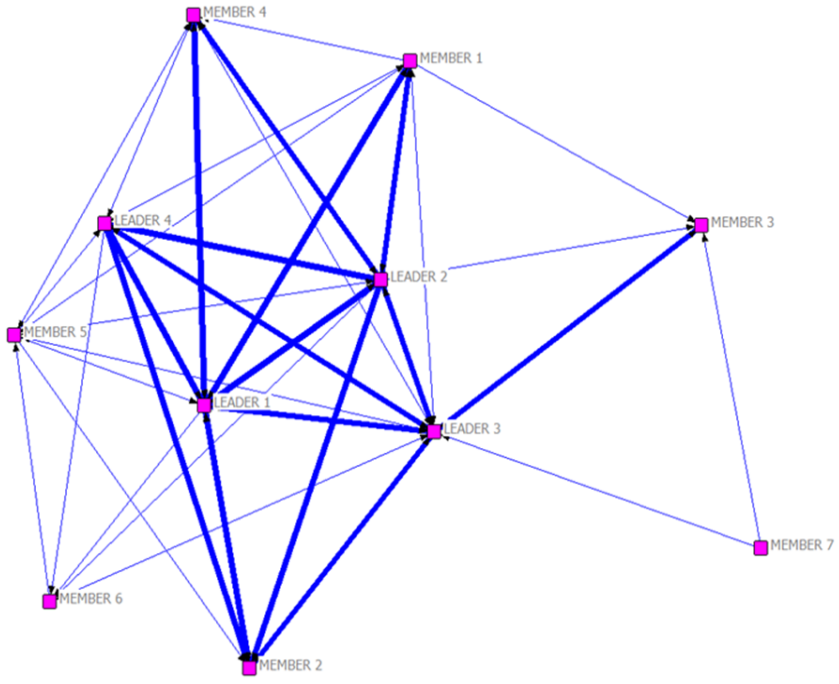

Figure 4: Various lines thickness indicating stakeholders tie strength for HIFG.

ties among the central members meaning there's are close knit social bond amongst the members. This is very important in social network for communal or group responsibility, hence, high success rates for the group.

Core and peripheral stakeholders HIFG: The core or most central stakeholders are; leader 1, leader 2, leader 3 and leader 4 normally located at the centre of the network. The peripheral stakeholders are member 1, member 2, member 3, member 4, member 5, member 6 and member 7 located at the edges of the network as shown in Figure 3. Member 3 and member 7 are the most peripheral stakeholders in HIFG. The peripheral stakeholders hold minor responsibilities in the network

Name	Gender	Age	Education	Occupation	Monthly income (USD)	Ecosystem services	Frequency	Amount
MPFG								
L1	M	33	12	Government official	300	Seedlings	Monthly	1000 per type
L2	F	40	9	Worker	150	Fish	Monthly	1 kg
L3	F	88	6	Worker	180		None	
L4	F	36	6	Worker	100	Fish	Weekly	5 kg
M1	F	48	6	Worker			None	
M2	F	32	12	Government official	300	Seedlings	Monthly	10000
M3	F	38	6	Worker	140	Fish	Monthly	1 kg
M4	F	60	6	Worker	150	Wood, Seedlings	Monthly	Home use 1000/type
M5	F	34	6	Worker	300	Birds, Fish	Daily, Monthly	3-5 Birds 1 kg
M6	F	36	6	Worker	150	Wood, Fish, Herbs	Monthly, Daily	5 kg
HIFG								
L1	M	36	6	Worker	100	Wood, Birds, Seedlings	Daily, Monthly	1 Bird 1000
L2	M	29	6	Worker	3000	Fish, Seedlings, Bird	Weekly, Yearly, Daily	1 kg 1000 1 Bird
L3	M	31	9	Contractor	210	Fish, Wood	Daily, Monthly	1 kg -
M1	M	70	6	Worker	150	Fish	Daily	0.5 kg
M2	M	40	6	Worker	132	Herbs, Birds, Fish	Yearly, Weekly	Home use 3 kg
M3	M	45	6	Worker	150	Birds	Daily	3 kg
M4	M	40	9	Worker	150	Wood	Yearly	-
M5	F	50	6	Worker	180		None	
M6	M	31	6	Worker	300	Wood, Birds	5 kg 1	Yearly Yearly
M7	M	55	6	Worker	250	Herbs	3 kg	Yearly

Table 3: Stakeholders' demography and fish ES use from the HEF.

compared to the core stakeholders, a fact that can be depicted by the communication ties as shown in Figure 4 where the peripheral members have thin lines of communication whereas the core stakeholders have thick communication lines.

Tie strength of the stakeholders in HIFG: In HIFG the Network size (nodes)=11 with a total number of ties=55. With the highest tie score=5 and lowest tie score=2. In Figure 4, below, leader 1, leader 2, leader 4, leader 3, member 1, member 4 and member 2 depict a very strong communication lines indicating strong ties amongst them. Peripheral members depict thin communication lines hence weak ties amongst themselves.

Relationship between ES Use and the Stakeholder's Socio-Ecological Demographics

We analysed the relationship between ES use and the stakeholders, of the 21 out of 22 interviewed stakeholders of the two groups, 10 members obtain fish from the HEF, and nine of them are casual workers in the village earning less than 300 USD in a month (Table 3). This can be interpreted that, the success of these fish projects, shall lead to decline in frequency and amount of fish catch from the natural river streams and ponds in HEF, resulting to fish ES enhancement in the HEF because averagely 50% of the members will be able to get alternative source of fish through the aquaculture project.

In terms of economic income and employment, only three out of the 22 stakeholders are not casual laborers, one is a contractor while the other two are government officers with salaried income. However, there is no correlation between stakeholders' income and ES use that is to say; high income levels do not translate to no ES use or Low income levels does not mean more ES use from the forest. In relation to age, all the age brackets obtain various ecosystem services from the forest.

Gender based analysis indicated that men visit the forest more frequently than their female counterparts. The female interviewees mostly cited the hot scorching sun as the main barrier to visit the forest coupled with the gender roles such as nursing the young family members since majority are house helps hence making it more obvious for the men to visit the forests for harvesting the ES.

We investigated the actors position in the network, betweenness, income and the ES usage. From the results, the position or rather the leadership role in the network has no influence in the ES use. Half (50%) of the stakeholders' who catch fish ES are at the core while the other 50% of the stakeholders are at the periphery of the network with a betweenness of 0.500 to 3.433 (Table 4). In terms of income, stakeholders with highest income (300 USD) per month and those with the lowest income (100 USD) per month were found to obtain the Fish ES from the forest. These exclusive features in our analysis (Table 4) indicate that the income of the stakeholders or their education level do not necessarily influence their roles and position in the network nor do they determine the ES usage from the forest.

Conclusion

In conclusion, this study has widely covered the ecosystem services use from the peatland forest in central Kalimantan, by the surrounding communities. Fish obtained from the natural ponds in the forest for

Stakeholder/ actor	Education (in years)	Fish ES use	Monthly income (USD)	Betweenness	Core/ periphery
MPFG					
L2	9	Monthly	150	3.900	Core
L4	6	Weekly	100	3.433	Periphery
M3	6	Monthly	140	0.450	Periphery
M5	6	Monthly	300	1.650	Periphery
M6	6	Daily	150	0.950	Core
HIFG					
L2	6	Weekly	300	3.815	Core
L3	9	Daily	210	1.833	Core
L4	6	Monthly	140	3.259	Core
M1	6	Daily	150	3.222	Periphery
M2	6	Weekly	132	0.500	Periphery

Table 4: Analysis of stakeholder's betweenness, core and periphery and the ES use.

home consumption was identified as the most consumed ecosystem service. Therefore, we carried out the social network analysis of the aquaculture projects in Hampangen village as an alternative potential source of fish to the community.

The stakeholder attribute analysis of the two groups reveals good leadership skills and harmonious coexistence amongst the project members from the tie strength and the frequency of communication. This eventually shall lead to high success of the projects resulting to more fish production hence alternative source of fish to the people. Having an alternative source of fish implies reduction in fish catch from the natural pond hence enhancement of fish in the natural ponds in the forest.

The exclusive features in our analysis from the stakeholder attributes indicate that income or educational levels do not influence the roles and position of stakeholders in the leadership network nor do they determine the ES usage from the forest. High income stakeholders as well as low income stakeholders were found to obtain various provisioning services from the forest. Again, both high and low education level members were found to occupy leadership positions in the project and portrayed good management skills.

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