Network Analysis of Collaboration and Information Sharing in the Management of the Lower Mekong River Basin

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Abstract

Collaboration in a natural resource management setting is vital to effective management. This paper evaluates collaboration and information and data exchange among organizations involved in the management of the Lower Mekong River Basin (LMB). As in other major river basins throughout the world, the LMB faces complex management challenges related to transboundary cooperation and competing demands from users in different countries. In response to stakeholder interest in understanding and strengthening collaboration and information sharing and identifying organizations well positioned to serve as research and information hubs to foster collaboration in LMB resource management, we conducted an organizational network survey of national, regional and international organizations that work in the LMB. An examination of network structure was conducted using key network measures and Jackson's (2017) social capital typology was used to examine which organizations in the network were well suited to serve as research and information hubs. The analysis showed that while the LMB network was relatively dense compared to other natural resource research and/or management networks, a lack of connections across national and organizational type boundaries could be a hindrance to transboundary collaboration and communication. The analysis also identified two organizations that were particularly well situated within the LMB network to act as brokers for knowledge and information exchange, with each organization occupying a complementary position in the network. This study illustrates the utility of social network analysis in identifying opportunities and hindrances for collaboration and information exchange and the potential roles of key actors in complex multi-scaled natural resource management contexts.

Keywords: Lower Mekong River Basin, social network analysis, natural resource management, social capital.

1. Introduction

Effective natural resource management requires managers to make timely decisions based on the most current data and scientific evidence available. For natural resource managers to employ the most up-to-date science and data in their decision-making processes they need access to pertinent research as well as information from relevant stakeholder groups. Similarly, researchers rely on social, biological, and physical data provided by resource managers and other resource stakeholders as inputs into research on ecosystems and their functions. In addition, government agencies that are integral to the creation and funding of resource management programs and interjurisdictional resource management agreements across government boundaries require input from natural resource managers, researchers, and other stakeholder groups including local communities and conservation groups. Successful communication and collaboration among the different actors in natural resource management can lead to more appropriate policy and management decisions based on accurate and timely data and increased acceptance of management policies by stakeholder groups.

Olsson et. al. (2007) emphasize that mobilizing the knowledge needed to deal with complex socio-ecological systems depends on social networks that can leverage a wide range of information sources and institutional arrangements. Past research has examined the importance of network structure on information sharing and collaboration in natural resource management settings and identified network measures that can provide insights into the effectiveness of natural resource management networks (Olsson et al 2004; Bodin et al 2006). Network density has been shown to be positively correlated with collaboration in resource management settings (Bodin and Crona 2009; Sandström 2008). In addition, while the development of subgroups within a collaboration network might be inevitable due to geographic boundaries (Ramirez-Sanchez 2007), local bonding links (Olsson et. al 2007) and specialization of roles within communities (Crona and Bodin 2006), the ability to communicate across these boundaries is critical for successful collaboration (Crona 2006; Newman and Dale 2005).

While most social network analyses of natural resource management issues have focused on whole networks and their structure, network analysis focused at the node, or actor, level can provide insights on network actors that are vital to collaboration and data and information sharing based on their network position (Bodin and Crona 2009). Several studies have identified the importance of bridging organizations for creating linkages across jurisdictions and organizational scales to manage complex ecosystems, foment learning and deal with change and uncertainty (Olsson et. al. 2007, Armitage et. al. 2015). Hahn et al. (2006) found that Ecomuseum Kristianstads Vettenrike, a bridging organization within a collection of Swedish ecosystem management stakeholders, was able to foster knowledge transfer, collaboration, and conflict resolution based on their bridging position. Angst et al. (2018) examined two types of bridging nodes in natural resource governance networks: periphery connectors and central coordinators. Their analysis indicated that central coordinator positions, which are nodes that facilitate coordinated action among central actors, are more likely to be held by government organizations. Periphery connectors that connect otherwise unconnected actors to larger groups and facilitate knowledge transfer are more likely to be organizations at a higher jurisdictional level. Within the broader social network literature, a number of studies have looked at the impact a node's position in the network has on accrual of social capital in settings ranging from college students use of social networking websites to organizational units within a business (Burt 1992, Tsai 2001, Ellison et al. 2007).

The analysis presented in this paper evaluates the collaboration and information sharing network of various types of entities (natural resource management organizations, academic organizations and think tanks, international development and conservation groups, national and international government entities, and private contracting firms) involved in natural resource management of the Lower Mekong River Basin (LMB). This study was conducted as a partnership between the Mekong Fish Network (MFN) and the United States Geographical Survey (USGS) Delta Research and Global Observation Network (DRAGON) initiative. The study was motivated in part by stakeholder interest in improving understanding of network connections in the LMB and to identify impediments and opportunities to strengthen connections.

Additionally, several network organizations wanted to identify LMB organizations well positioned to serve as research and information hubs that would increase collaboration and information sharing in the management of the LMB.

The LMB spans multiple countries and is ecologically, economically, and culturally diverse. The literature on Integrated Water Resource Management (IWRM) illustrates the management challenges faced by the LMB and other major transboundary river basins in the world. These challenges include balancing demands from users with competing interests at different territorial, jurisdictional and temporal scales and with asymmetries in knowledge, institutional capacity and political and economic power (Lebel et. al. 2005, Moder et. al 2012, Gupta 2005). In this context the need for and complexities of cooperation, mechanisms for trust-building, reliable monitoring, research and data exchange are even more significant than in smaller-scale more localized natural resource management scenarios (Eriksson et. al. 2015). Collaboration and information sharing represent important preconditions for negotiation between stakeholders and a means of building trust between countries necessary for basin-wide decision making, planning and monitoring (Hang and When 2016, Plengsaeng, Wehn, and van der Zaag 2014).

Numerous studies have emphasized the need for improved transboundary collaboration and information and data exchange and examined the challenges that have hindered the effectiveness of current information and data sharing arrangements within the LMB region (Plengsaen, Wehn, and van der Zaag 2014, Hang and When 2016, Gerlak et. al 2011, Moder 2012, Lebel 2005). These past studies focused primarily on the formal institutional arrangements between governments and the cultural, social, political and economic incentives and obstacles for effective cooperation. In contrast, this study explores the broader network of organizations involved in collaboration and information exchange in the LMB, to identify potential opportunities and hindrances within the network. In addition, we examine the positioning of actors in the network to identify organizations that may be well-suited to serve as a research and information hub for the LMB collaboration network based on their ability to function as a bridging agent to foster information sharing across regions and organization types.

1.1 Study Area

The Mekong River is the largest river in Southeast Asia and one of the longest in the world, extending some 2,700 mi (4,300 km) from China's Yunnan Province to southern Vietnam (USGS 2011). The Lower Mekong Basin (LMB) encompasses the lower three quarters of the river's extension, from the northern mountains of Lao PDR to the South China Sea.

Sixty-five million people live in the LMB and with over 100 different ethnic groups it is one of the world's most culturally diverse areas (FAO Aquastat n.d.). Approximately 80% of the Lower Mekong Basin's population continue to live in rural areas, many in conditions of poverty (MRC 2016). The occupations of an estimated 60 percent of the economically active population are river dependent (FAO Aquastat n.d). The Lower Mekong River is important for irrigation of rice paddies and other crops; it also supports aquaculture, ecotourism, energy production, and the world's largest inland fisheries (International Rivers 2011). Capture and aquaculture fisheries provide the LMB population with its primary source of protein (Sverdrup-Jensen 2002). For centuries, the Lower Mekong River has also been a vital artery for trade and tourism (MRC n.d.).

Recent challenges threaten to significantly affect the Lower Mekong River's ecosystem and alter those ecosystem services upon which the region's population depends. In the past 10 years, the governments of Thailand, Lao PDR and Cambodia granted approval to investigate the construction of eleven hydropower dams in the Lower Mekong River's mainstream as part of a regional economic development strategy. In Lao PDR, construction has already begun on two of these dams and preparations are taking place to initiate the construction of a third (International Rivers 2018).[1] Local and international organizations, scientists, conservationists and journalists are raising the alarm about the potential adverse impacts of these dams on the Mekong River's ecosystem and dependent human communities. Conservationists have expressed concern that the building of the three dams in Lao PDR will damage the transboundary

[1] Construction has begun on the Xayaburi Dam in northern Laos and Don Sahong Dam in southern Laos. Preparations are reportedly well underway to initiate the construction of the Pak Beng Dam in northern Laos.

environment of the LMB, altering fish passages, disrupting downstream sediment transport and disturbing aquatic habitats (International Rivers 2018; Hecht et. al. 2019; Pokhrel et. al. 2018; Retka 2017). International Rivers, a conservation organization, claims that the construction of all eleven dams "will transform one of the world's most iconic rivers into a series of reservoirs… seriously jeopardize[ing] the future of the Mekong as a life-sustaining ecosystem (International Rivers 2018)."

Studies also frequently mention that managing the impacts of climate change is a growing challenge for the LMB. Climate change is anticipated to result in more intense and frequent floods and droughts, higher temperatures and a longer wet season (Hang and When 2016, Moder et. al. 2012). These changes will likely alter the flow of the river and its tributaries with cascading effects on the rest of the Lower Mekong's ecosystem. Studies also frequently mention the growth of other industrial activities along the river such as sand mining as a major threat (Bravard et al. 2013).

In the absence of proper management, these ecosystem stressors will ultimately affect agricultural productivity and the size of fish stocks that sustain the populations and interconnected economies of the LMB nations. Therefore, as noted in the Mekong River Commission's Basin Development Strategy for the Lower Mekong Basin 2016-2020, "a sense of urgency is growing among stakeholders for the need to move basin development towards more 'optimal' and sustainable outcomes" in the face of these challenges." Furthermore, solutions will require "increased levels of regional cooperation and integration" and efforts towards "joint management and development" (MRC 2016, p. 3).

1.2 Regional Management Initiative

Recognition of the need for collaboration in the management of the Mekong River extends back to the 1950s; however, it was in 1995 that the governments of Cambodia, Lao PDR, Thailand and Vietnam signed The Mekong Agreement, through which they agreed on the joint management of shared water resources and the development of the economic potential of the river. This agreement also created the Mekong River Commission (MRC) to provide advice and facilitate dialogue among the signatory governments, the private

sector and civil society related to the management of the resources of the Lower Mekong (MRC Annual Report 2014). In 2001, the Mekong River Commission (MRC) also established a formal set of procedures for data and information exchange and sharing (PDIES) among the four LMB countries as part of the region's integrated water resource management plan (IWRM) (MRC 2002, Hang and When. 2016, Plengsaeng, Wehn, and van der Zaag 2014).

Since the signing of the Mekong Agreement a wide range of other collaborations have emerged to support the sustainable management of the LMB, including regional and international government agencies, non-governmental organizations (NGOs), and academic institutions. Recent US-led initiatives include the Lower Mekong Initiative (LMI) and the USGS DRAGON network. The LMI was established in 2009 to promote cooperation between the United States and Thailand, Cambodia, Lao PDR, Myanmar and Vietnam to support regionally sustainable and environmentally responsible growth. DRAGON was established by the USGS in the mid-2000s to "create an international community of practice to share data on the great deltas and rivers of the world and to develop comparative models and visualization tools in order to facilitate ecological forecasting regarding climate change and development that ultimately helps in guiding decision making (USGS 2011)." The Mekong Fish Network is another recent initiative established by a US-based non-governmental group to "support partners in the lower Mekong River basin to advance the study and management of the region's unique and valuable aquatic life… build technical capacity and improve science communication in this ecologically diverse and productive region. (Mekong Fish Network 2018)." Other regional information networks include the ASEAN Fisheries Education Network and the Wetland University Network, the United States Agency for International Development (USAID) Partnerships for Enhanced Engagement in Research (PEER) scientist networks, and the Swedish International Development Agency (SIDA) Sustainable Mekong Research Network (SUMERNET), among many others. The transnational network for LMB collaboration and information exchange is, therefore, a complex web consisting of a wide range of formal and informal subnetworks, collaborations, and forums working across

multiple scales and levels on a wide range of different issues (Fisher and Leifield 2015, Maag and Fischer 2018, Armitage et. al. 2015).

Notwithstanding the efforts of the past 25 years, there is still much to learn about the Mekong River's complex and interconnected ecosystem including the integrity of the system and the value of the river's ecosystem services to the regional economy and culture. Although the MRC was set up to be an inter-governmental institution for regional cooperation, studies indicate that to date the MRC has been relatively ineffective in achieving its objectives to promote regional collaboration including data and information sharing through PDIES (Hang and When, 2016; Gerlak et al. 2011; Plengsaeng, Wehn, and van der Zaag 2014, Lebel 2005). Studies, workshops and discussions with key informants have also highlighted the vital need for improved collaboration and information and data sharing for more effective long-term management of the Mekong River system (e.g. Moder 2012). More information about the existing formal and informal networks in the region that collect and share data and information could strengthen collaboration at the national, regional and international levels to support cross-border policy development and resource management.

2. Methods

2.1 Network Survey

We used key informant interviews, organizational contacts, workshop proceedings and internet research to compile a list of organizations and key contacts that produce or use data and information for conservation and management of the LMB. The final network list contains a wide variety of organizations including: universities and research institutions; local, national and international government agencies; national, regional and international NGOs; and private consulting firms. It also includes organizations from different countries and regions, mainly Vietnam, Cambodia, Lao PDR, Thailand, the U.S., Asia and Europe (Appendix A).

An organizational network survey was developed in Survey Monkey, an online survey development software, to identify collaborations between network organizations. Individuals asked to take the survey had been identified as key leaders or points of contact for their organization's work in the LMB. The survey first asked participants to identify the primary focus and thematic areas of their LMB work. Using a closed-ended roster format of 182 organizations, the questionnaire then asked participants to identify organizations they collaborated with on LMB related projects in the past year.[2] Participants were also asked to weigh (on a scale from 1 to 5) the importance of their interaction with each organization in their LMB work.

Table 1. Organizations by Country and Type

Country/ Type	**Government Agency**	**University/ Research Institute**	**NGO[2]**	**International Agencies[2]**	**Private Sector**	**Total**
Cambodia	8	6	13	2	1	30
Vietnam	13	18	10	3	2	46
Lao PDR	6	3	6	5	3	23
Myanmar[1]	2	0	0	0	0	2
Thailand	4	7	6	6	0	23
Asia (regional)	0	1	3	5	0	9
Australia	2	2	0	0	1	5
Europe	3	4	1	5	0	13
USA	6	22	2	0	1	31
Total	44	63	41	26	8	182

[1]Myanmar was not explicitly included as part of this study which is why only 2 organizations were included.
[2]NGOs and International Organizations with country offices were treated as separate organizations affiliated with that country.

The survey also asked respondents to list any additional organizations not on the list that they collaborated with on LMB issues to determine if organizations important to the LMB collaboration network were not included in the roster. Respondents listed one-hundred and twenty additional

[2] We used the roster approach to minimize respondent recall bias and encourage high response rates by making it easier for participants to take the survey (Borgatti et. al 2013).

organizations but only six of those organizations were listed by two different respondents and none of the added organizations were listed by three or more respondents. Just two respondents provided forty-eight (40%) of the newly named organizations. It seems possible that these respondents misunderstood the question and provided all the organizations they work with, not just on LMB issues. If those outliers are removed, only three of the listed organizations were named by two different respondents. We feel the limited number of new organizations listed by two different respondents and the lack of any new organizations being listed by three or more respondents indicates that basing the LMB collaboration networks on the responses to the closed-ended roster section of the survey, as we have done, does not run the risk of ignoring key players in the network.

While the survey asked specifically about collaboration between LMB organizations, our analysis evaluates LMB network connections as pathways for both collaboration and the sharing of LMB information and data. Ideally, we would have asked respondents about both LMB collaborators and information and data sharing partners but asking two distinct network questions had the potential to confuse respondents. Generally, the nature of the work of LMB network organizations focuses on the production or use of data and information, making the delineation between collaborative and information sharing connections difficult. In addition, extra questions had the potential to increase survey fatigue and decrease the response rate.

The link between collaborative connections and information and data sharing pathways has been established in the literature. In a case study of the projects of a Palestine-based NGO, Hardy, Phillips, and Lawrence (2003) found that interorganizational collaborations led to bi-directional information sharing in all cases. Additional analyses of interorganizational collaboration in high technology industries, such as biotechnology and automobile manufacturing, have indicated that information gathering is a major objective of participants in collaborative networks and information sharing through these networks is key to the success of industry members (Dyer and Nobeoka 2000; Powell, Koput, and Smith-Doerr 1996).

The natural resource management literature has also noted the overlap between collaboration and information sharing relationships. Westley and Vredenburg (1997) examined interorganizational collaboration in natural resource management networks tied to the preservation of global biodiversity; their model identified collaboration as "involving linkages of technology, information and intent." A 2010 network analysis of watershed partnerships exploited the link between information sharing and collaboration by using frequency of contact between network participants as a measure of information sharing to analyze collaboration among network members (Muñoz-Erickson et al 2010). Based on the nature of collaboration in the LMB network and the connection between collaboration and information sharing pathways highlighted in previous literature we examine the LMB network from both a collaborative and information sharing perspective.

The survey was administered in English and sent by an email from the Mekong Fish Network to one or more key representatives from each of the organizations on the list.[3,4] The email contained a link to the survey. Survey administration took place over a period of two weeks; each week a follow-up request was sent to those participants that had not yet responded to the survey for a maximum number of three opportunities to take the survey. A total of 207 e-mails were sent out to organization representatives and 16 of the emails were returned as undeliverable, leaving 191 possible recipients. A total of 70 participants responded to the survey and, of these, 64 fully completed the survey for a 33.5% response rate. There were multiple respondents from some organizations (see below), so the response rate at the organizational level was 29.7%. Response rates at the organizational level by country and organization type are provided in Table 2.

[3] According to key informants from the Mekong Fish Network, USGS and others, English is the standard language used in international Mekong River meetings and science activities. We do not know whether administering the survey in English could have depressed response rates or biased the survey towards English speakers. However, as indicated in table 2, the response rates from some countries such as Laos PDR and Vietnam were relatively high in comparison to responses from international organizations, which tend to conduct much of their business in English.

[4] The survey was conducted on behalf of the MFN by FISHBIO, a fisheries and environmental consulting company that is a member of the MFN.

3. Results

LMB collaboration networks were constructed using responses to the online survey. UCINET (Borgatti, Everett, and Freeman 2002), a social network analysis software, was used to generate all network graphs and calculate network metrics. Nodes in the network represent the organizations. Edges, or ties in the network, show that a respondent to the online survey indicated that their organization interacted with the selected organization within the last year. The interaction scores provided the tie strength of the edges. In all, survey responses were gathered from individuals affiliated with 54 of the 182 organizations included in the LMB collaboration network.[5]

Table 2: Response rate by country and organization type

Country/ type	Government Agency	University/ Research Institute	NGO	International Agencies	Private Sector	TOTALS	Response Rate %
Cambodia	8 (3)	6 (0)	13 (4)	2 (0)	1 (0)	30 (7)	23.3
Vietnam	13 (4)	18 (5)	10 (4)	3 (0)	2 (0)	46 (13)	28.3
Lao PDR	6 (3)	3 (1)	6 (2)	5 (2)	3 (1)	23 (10)	41.3
Myanmar	2 (1)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)	50.0
Thailand	4 (0)	7 (1)	7 (0)	6 (0)	0 (0)	24 (1)	4.2
Asia - Other	0 (0)	1 (0)	2 (0)	5 (0)	0 (0)	8 (0)	0.0
Australia	2 (0)	2 (2)	0 (0)	0 (0)	1 (1)	5 (3)	60.0
Europe	3 (1)	4 (2)	1 (0)	5 (0)	0 (0)	13 (3)	23.1
USA	6 (3)	22 (13)	2 (0)	0 (0)	1 (1)	31 (17)	54.8
TOTALS	44(15)	63(24)	41(10)	26(2)	1(1)	182 (54)	29.7
Response Rate %	34.1	38.1	24.4	7.7	37.5	29.7	

[5] Seven organizations had more than one participant respond to the survey. .

Ideally, individuals from all 182 organizations in the network would have completed the survey, but the collection of a census of all organizations in the network was not possible given financial and temporal research constraints. Comparisons between respondents and non-respondents indicates that non-response bias was present in our estimation of the LMB network. On average, organizations that had a representative respond to the survey had 19 more network connections than organizations that did not respond to the survey, with the difference being statistically significant at the 0.01 level. However, the difference between average respondent and non-respondent in-degree (ties from being listed as a collaborator by another organization) was only two network connections.[6] Since a closed-ended roster format was used to name collaborators, we do not believe the difference between average respondent and non-respondent in-degree is due to non-response bias and is likely a result of more central actors to the LMB network being more willing to take a network survey regarding the region.[7]

An additional issue with the data set was that seven organizations had multiple individuals respond to the survey. We combined these responses and in instances where survey respondents from the same organization did not agree on tie-strength, we used the highest value provided in the network.[8] All responses were included in the network to give a more accurate picture of the entire network and its linkages. The inclusion of these multi-respondent organizations did not lead to a statistically significant change in either average total degree or out-degree (ties originating from the respondent naming a collaborator) of respondent organizations.

We took several steps to address data gaps due to survey non-responses. Firstly, network connections for those organizations were imputed from the lists of the respondents that did complete the survey using the procedure described by Borgatti et. al. (2013). Missing values were assigned based on the assumption that

[6] The in-degree difference was statistically significant at the 0.05 level.

[7] Two outliers that responded to the survey highly influenced the difference in average in-degree. Removing the two highest in-degree organizations, both of which were more than three times larger than the average in-degree value, made the difference between mean respondent and non-respondent in-degree values statistically insignificant at the 0.10 level.

[8] This included instances where one respondent indicated a tie and another did not.

an organization (A) that did not respond could logically be assumed to have a connection with an organization (B) that did respond and mentioned having a connection with (A).[9] For instances where there was disagreement between two responding organizations on the strength of a tie, the highest value given was used in the network. We assumed that individuals were not motivated to embellish when reporting tie strength and omissions or lower values from the other party to the connection simply indicated that the tie involved other individuals at that organization. Although survey non-response is likely to be affecting network structure and metric values, the large amount of data gathered from the survey (>1,000 connections identified) allows for insightful analysis of network structure and general collaboration tendencies within and across borders and organization types. In the results section, we discuss the possible implications of non-response bias on the analysis results.

3.1 Network Structure

Network level metrics are presented in Table 3.[10] Density is the number of edges in the network relative to the maximum possible if all nodes in the network were connected (Scott 2000). The LMB network was found to be quite dense relative to past research of similar networks. Previous studies of other natural resource research and/or management networks found network densities below 0.02 (Hoelting et al. 2014; Prell, Hubacek, and Reed 2009; Pietri, Stevenson, and Christie 2015). The effect of survey non-respondents on these network structure metrics is straightforward. Since a higher response rate could only increase the number of edges in the network, we can think of the values for network density and average degree as lower bounds for the network while the average distance value represents an upper bound. The higher network density relative to similar previous studies is somewhat surprising given the low response rate but may be

[9] Borgatti et. al. (2013, p. 75) argue that it is actually preferable to retain nodes with values missing because the respondent has chosen not to fill out the survey than to eliminate them. "The assumption … that, if the respondent had been able to answer, they would have listed all the actors that mentioned them… may not be exactly right, but it will be more accurate than treating the missing values as zeros."

[10] While scaling of tie-strength (1-5) allowed for the construction of multiple networks using the same survey data, the results presented are for the network based on all ties, of any strength, included in the network. Analysis was also completed on networks only evaluating relatively strong ties (4 or 5) and only strong ties (5) as well. The results of those analyses are available from the corresponding author upon request.

due to the closed-ended roster format of the network connections question that likely attenuated any recall issues associated with a free response format.

Table 3. Network level metrics.

# of Edges	1045
Network Density	0.063
Avg Degree	11.484
Avg Distance	2.249
# of Isolates	9
# of Components	10

3.2 Network Segmentation

The LMB network includes organizations spanning multiple countries and stakeholder group types. Myriad differences between the organizations can hinder effective data and information exchange between network members: language barriers; cross-border differences in resource management rules and regulations; cultural differences; variations in communication style across organization types; and disparate management and research goals (Armitage et. al. 2015, Gupta 2005, Plengsaen, Wehn, and van der Zaag 2014, Hang and When 2016, Gerlak et. al 2011, Moder 2012, Lebel 2005, Cash et. al. 2006). In informal conversations, stakeholders expressed the opinion that network ties are stronger within country borders but tended to emphasize the lack of strong ties between countries necessary for effective transboundary collaboration and information exchange.

A quadratic assignment procedure (QAP) was used to evaluate whether network connections were more common among organizations from the same country and from the same stakeholder group types. Affiliation networks were created for organization location and type. Edges in affiliation matrices indicate that two nodes are members of the same group (Easley and Kleinberg 2010). In this analysis, two nodes (i and j) are connected in the affiliation networks if they are located in the same country or region (country affiliation network) or were of the same organization type (type affiliation network). Once the affiliation

networks were created, they were compared to the LMB collaboration network using the Jaccard Coefficient.[11] Once the Jaccard Coefficient (observed correlation) was calculated, a quadratic assignment procedure (QAP) was run to test for statistical significance. To do this, the observed Jaccard Coefficient is compared to the Jaccard Coefficients of 5,000 pairs of matrices with the same number of nodes and edges but where the data is known to be independent. Independence is achieved by taking one of the two matrices and randomly rearranging the rows and columns, because the changes are random the new matrix is independent of the original (Borgatti, Everett, and Johnson 2013). The p-value is the number of randomly generated Jaccard Coefficients that are at least as large as the observed value.

QAP analysis results are presented in Table 4. The results indicate that connections were 2.2-2.7 times more likely between organizations located in the same country or region and 1.2-1.4 times more likely between similar types of organizations than would be expected if connections were random, both findings were highly significant. These results indicate that organizations in the LMB network tend to form collaborative connections with other organizations from their country and similar to themselves. Homophily, the tendency to associate with similar types, has frequently been found in collaboration, information, ally, and coordination networks (McPherson, Smith-Lovin, and Cook 2001; Ingold and Fischer 2014; Leifeld and Schneider 2012; Weible and Sabatier 2005) and is so common in social networks that some models of network formation include adjustments to account for homophily (de Almeida et al 2013; Malkov and Ponomarenko 2016). Given the prevalence of homophily in social networks, our finding of homophily based on shared nationality and organization type is not surprising.[12] However, this result also reinforces the findings of other non-network studies that emphasize the ongoing challenges related to transboundary information exchange and collaboration for management of the Mekong River and its resources. (Hang and Wehn 2016, Moder 2012, Lebel 2005). It should be noted that our QAP analysis did not include control

[11] The Jaccard Coefficient (J) calculates the similarities between sample sets as the size of the intersection divided by the size of the union (Hanneman and Riddle, 2005): $J(A,B) = |A \sqcap B|/|A \sqcup B|$. The intersection of the two networks is the node pairs that are connected in both networks and the union is all node pairs that are in both networks.

[12] We were unable to find previous studies employing QAP analysis in a similar setting to compare results.

variables such as geographic proximity. In addition, the intra-country homophily analysis did not control for organizational type homophily, and vice versa.

Table 4. QAP Analysis Results.

	Country	Organization Type
Observed Value	0.387	0.322
Avg. Random Value	0.157	0.247
SD of Random Value	0.016	0.020
P-value	0.0002	0.0004

Non-response bias could potentially affect these findings if non-respondents to the survey were fundamentally different in how they interacted in the LMB network. If non-respondents collaborated more frequently across borders and organization types, then network segmentation is overstated. On the other hand, if non-respondents collaborated less frequently across borders and organization types, these results are understating network segmentation in the LMB network.

3.3 Identification of Key Actors in the Network

One practical objective of this study was to evaluate the position of different organizations within the network to determine if there were organizations that were well suited, based on their position in the network, to serve as a research and information hub for the collection and exchange of LMB data and information. . An organization's suitability for such a role is in part a function of its position within the network: Is the organization well connected within the LMB network? Does the organization serve as a bridge between different stakeholder group types and countries? How strong are the organization's ties within the network?

The literature on information sharing and collaboration in a natural resource management setting has illustrated the importance of network entities that serve as brokers between entities and bridges between disparate network groups. Bodin, Crona, and Ernstson (2006) highlighted the fact that solely based on network position, a broker or bridging organization has access to information from multiple disparate groups that allows the organization to gather and share a large amount of information. Additionally, Hahn

et al. (2006) showed how a bridging organization in a Swedish ecosystem management network was able to foster knowledge generation and collaborative learning within the network.

This analysis evaluated the social capital of the different organizations within the network as one indicator of their suitability to serve as an LMB research and information hub. While many definitions of social capital have been put forth (Baker 1990; Bourdieu 1986; Brehm and Rahn 1997; Burt 1992; Coleman 1990; Knoke 1999; Loury 1977, 1992; Nahapiet and Ghoshal 1998; Portes 1998; Putnam 1995; and Woolcock 1998), there is no single agreed upon definition for the term due in part to the many different academic disciplines and research frameworks to which the term is applied. Generally, most definitions of social capital include some focus on the ability of social interactions to produce benefits for the parties involved. In the LMB collaboration network the benefits provided by social capital could include access to LMB stakeholders for data and information exchange as well as collaboration for a variety of other purposes such as research, training and implementation of resource management and governance projects.

For this analysis, we measure the LMB network organizations' suitability as a research and information hub by evaluating each organization based on several forms of social capital outlined by Jackson (2017). Jackson identified seven different types of social capital along with metrics intended to measure each; this analysis focuses on those social capital types that are relevant to the LMB collaboration network and were calculable with the data available. The capital types analyzed are displayed in Table 5. While both reputation capital and community capital, as outlined by Jackson (2017), could be relevant to the analysis, lack of data on trust and institutional reputations within the LMB collaboration and information sharing network made estimation impossible. Favor capital (Jackson 2017) also was not included because the ability to exchange favors and transact with others did not seem relevant in determining whether an institution could adequately serve as a research and information hub within the LMB network.

The node level metrics used to measure social capital are all, in some way, a function of the number of edges connected to LMB network nodes. Because of this and the effect of non-response bias noted previously, all the social capital measures presented were calculated based on in-degree measures. By

employing a closed-ended roster format to the network connection question and focusing only on edges directed at a node (where they were named as a collaborator by another LMB organization), non-response bias was removed from the social capital metrics.

Table 5. Social capital types.

Social Capital Type	Definition
Information Capital	Ability to acquire and spread information to other people/organizations through network connections.
Brokerage Capital	Ability to serve as an intermediary, based on network position, between people/organizations that want/need to interact.
Coordination Capital	Ability, through network position, to organize and coordinate actions between network actors that are not directly connected.
Bridging Capital	Ability to serve as a prominent information sharing connection between different network sub-groups that are generally not connected within the network.

Information Capital

Information capital is the ability to both acquire and spread information through a network to those entities that need and can use it. Information capital can be measured broadly by determining how many different network actors a node can reach and how easily those actors can be reached. Generally, the ease with which nodes can communicate is inversely related to the distance between them. This analysis relies on the decay centrality (Jackson 2008) metric to measure a node's information capital. Decay centrality counts the shortest paths of a node *i* to other nodes in the network and weighs the connections based on the path length (Jackson 2017), with shorter paths receiving a larger weight. The weighting of connection value by path length measures the ease with which a node can transmit and receive information from other nodes in the network.[13]

[13] The decay centrality of node i (DC_i) is given by the following equation: $DC_i(g,p,T) = \sum_{l=1}^{T} \rho^l\left(N_i^l(g)\right)$. g is the network being examined, p is the decay parameter and varies from 0 to 1 ($0 < \leq 1$), T is the maximum geodesic length to be considered in the calculation, and $N_i^l(g)$is the number of nodes that are distance l from node i -only

We calculated decay centrality for each node in the network focusing only on in-degree edges. Decay centrality was calculated with varying values of the decay parameter, p, and maximum geodesic length included in the analysis (T). Results presented (Table 6) focus on the five highest scoring organizations with the decay parameter (p) set equal to 0.25 level and the maximum geodesic length (T) set equal to 3. Results for the same five organizations are also shown for the 0.50, 0.75, and 1.0 level to show how the decay centrality scores vary with the decay parameter.[14]

Table 6. Highest Decay Centrality Scores

	Decay Centrality Score			
Organization	p = 0.25	p = 0.50	p = 0.75	p = 1.0
Can Tho University - Vietnam	7.25	17.50 (1)	30.75 (1)	47.00 (1)
Mekong River Commission - Lao PDR	7.20	17.38 (2)	30.61 (2)	47.00 (1)
USGS (US Geological Survey) - USA	6.78	16.75 (3)	30.09 (3)	47.00 (1)
National University of Laos – Lao PDR	6.64	16.63 (4)	30.05 (4)	47.00 (1)
Mekong River Commission - Cambodia	6.22	16.00 (5)	29.53 (8)	47.00 (1)

Brokerage and Coordination Capital

Similar to Jackson (2017) we examine brokerage and coordination capital as intertwined forms of social capital that can be evaluated using the same metric. Brokerage capital is the ability to serve as a connection between pairs of network actors that need to interact; is a node in a position to act as a broker? Coordination capital is the ability to directly organize and coordinate the actions of a disconnected network.

In this analysis we evaluate both brokerage and coordination capital using the Godfather Index as outlined by Jackson (2017).[15] Well-connected nodes with relatively few connections between their network

in-degree edges were employed in the calculation. Decay centrality is highly reliant on the decay parameter (p); as the value decreases the benefit associated with more distant network connections diminishes and, at the opposite end of the spectrum when it is set equal to one all connections are considered equal regardless of path length. Similar to a low value, a low geodesic maximum (T) completely ignores longer connections in evaluating information capital.

[14] The ranking of the organizations varies with the decay parameter value – the number in parenthesis in the three additional degree centrality scores indicates the institutions ranking associated with that decay parameter.

[15] The Godfather Index value of node *i* (GF_i) is given by the following equation: $GF_i(g) = (1 - clust_i(g))d_i(g)(d_i(g) - 1)/2$. $clust_i(g)$ is the clustering coefficient of node *i* and measures the fraction of *i*'s in-

neighbors score highly on the Godfather Index because these nodes have the potential to connect network actors (brokerage capital) and/or coordinate their activities towards a common goal (coordination capital).

The Godfather Index was calculated using only in-degree neighbors to measure clustering coefficient and in-degree to measure overall connectedness. The five highest scoring organizations in the LMB network and their scores are displayed in Table 7.

Table 7. Highest Godfather Index Scores

Organization	GF Index Value
Mekong River Commission - Lao PDR	156
Can Tho University - Vietnam	148
USGS (US Geological Survey) - USA	129
National University of Laos – Lao PDR	99
NSF (National Science Foundation) - USA	76

Bridging Capital

Bridging capital is the ability to receive and transmit information between different subgroups within a network that have limited connectivity (Jackson 2017). Bridging capital is similar in some ways to both information and brokerage/coordination capital. Like information capital, it involves the ability to acquire and disseminate information within a network but with a narrower focus on the transfer of information between disparate groups in the network. Bridging capital is similar to brokerage/coordination capital as it relies on the ability to connect unconnected actors in a network but without the focus on direct neighbors and driving collective action. Within the LMB collaboration and communication network, bridges allow information to flow across borders, participant types (NGOs, government agencies, researchers, etc.,), and research/management disciplines. Bridging capital, within a collaboration network, is conceptually similar to Granovetter's (1973) strength of weak ties.

degree neighbors who are connected to each other and $d_i(g)$ is the in-degree of node *i*. The Godfather Index of a node is inversely related to the nodes clustering coefficient and then weighed by the connectedness of the node.

Everett and Valente (2016) employed a two-step process to measure bridging capital using edge centrality[16] Previous research (Valente and Fujimoto 2010; and Everett and Valente 2016) has calculated a node's total bridging capital and then divided by the node's total number of edges to account for the costs, as measured by time and effort, associated with developing and maintaining relationships. This is a technique which penalized high degree nodes. We felt this penalty was inappropriate for the LMB network since we had no way to calculate the cost of developing and maintaining relations among organizations or even to determine if any costs were incurred. Given that all of the organizations in the network are stakeholders in the LMB, either through resource management or research, it seemed likely that many of the connected organizations might have required interaction through their work in activities such as joint service on management task forces or shared grants.

We developed a metric to measure a node's bridging capital that evaluated only in-degree edges to avoid non-response bias and did not artificially lower the bridging capital of high degree nodes to account for costs associated with developing and maintaining relationships. We used the network segmentation results indicating collaboration across borders and organizational types are less common in the LMB network and looked for nodes that bridged these gaps. We calculated the proportion of bridging in-degree edges present for each node across both geographic and organizational boundaries. A node *i*'s bridging capital was a value between 0 and 1 and represented the fraction of respondent organizations not from *i*'s country or of *i*'s organization type that named *i* as a collaborator. In addition, the two values were averaged to measure bridging across both boundary types. The five highest scoring organizations for each network are shown in Table 8.

Table 8. Highest Bridging Capital Scores

Organization	Country	Organization Type	Average
Can Tho University – Vietnam	0.37	0.50	0.44

[16] The centrality of edge *I* is the proportion of all geodesics, shortest paths, linking independent nodes that pass through edge *I* (Hanneman and Riddle 2005). Everett and Valente's process involves: 1) calculating an edge centrality measure and 2) assigning a brokerage score to each node that is the average of the edge centralities that are incident to it.

Mekong River Commission – Lao PDR	0.42	0.38	0.40
National University of Laos – Lao PDR	0.31	0.47	0.39
USGS (US Geological Survey) – USA	0.46	0.31	0.38
Mekong River Commission – Cambodia	0.30	0.23	0.27

4. Conclusions

Collaborative governance is extremely complex and requires overcoming the fact that each actor also has particular incentives, goals and priorities for collaboration (Huxam 2000, Maag and Fisher 2018). Our analysis focuses on network structure and begins to paint a picture of the LMB collaboration network as a collection of dense subnetworks delineated by national boundaries and organization type. These dense subnetworks are linked through weaker network connections across boundaries through a complex system of informal and formal cross-organizational interactions, working relationships and regional networks. This picture of the LMB network is supported by findings of high network density (in spite of a low survey response rate) and network segmentation that provides evidence of a tendency towards homophily within geographic boundaries and organization type.

Increasing LMB network connectivity across countries and organization types could provide an opportunity to improve collaboration and information exchange within the network. Valente (2012) outlined four distinct strategies of network interventions (individual, segmentation, induction, and alteration) designed to hasten behavior change or improve organizational performance. Based on the characteristics of the LMB network, the strategy best suited to increasing cross-border collaboration and information sharing is induction; facilitation of node interactions to stimulate information diffusion. For the LMB network, interventions would likely involve encouraging both international and interdisciplinary engagement among organizations. In this case, information diffusion would involve the strengthening of network connections across boundaries as participants shared their network resources (organizational ties) while discussing common issues and concerns regarding resource management. Ideally participants would also work together to implement projects to promote more effective data collection and exchange for improved management and conservation outcomes. Along these lines, a number of international and regional actors

have made a concerted effort to improve transboundary networks in recent years and the resulting transboundary connections can be seen in the LMB network. From a network standpoint, these existing transnational connections can possibly serve as building blocks for increased collaboration at a regional and international level in the future.

The node-level network analysis focused on identifying organizations well-suited to serve as a research and information hub for the LMB collaboration network. Network-derived measures of information, brokerage and coordination, and bridging capital were used to quantify each organization's ability to function as a bridging agent across regions and organization types by fostering information sharing, brokerage and coordination among network actors. The analysis revealed two organizations that displayed high scores across all metrics: Can Tho University and the Mekong River Commission (MRC), Lao PDR. Can Tho University and MRC-Laos had the highest or second highest scores for information capital, brokerage and coordination capital, and bridging capital for the full LMB network. In addition, both of these organizations scored highly when the same scores were calculated for the networks that only included high tie strength connections, indicating that these organizations were also key components of the LMB network backbone.

The high position of the MRC-Laos makes sense in light of the fact that it is one of the two main offices of the MRC Secretariat, which as the regional coordinating body and operational arm for the MRC, essentially had its network position mandated by the 1995 Mekong River Agreement (MRC Annual Report 2014).[17] The MRC has played an important role by promoting regional cooperation and dialogue between countries for the management of the LMB. Nevertheless, as previously mentioned, studies indicate that the MRC has not been very effective overall in promoting collaboration and information exchange due primarily to political and socio-cultural impediments (Hang and Wehn 2016).

[17] At the time of the study, the MRC Secretariat had two offices, with one located in Vientiane, Laos and the other located in Phnom Penh, Cambodia. Since this study was conducted, the MRC Secretariat has consolidated all of its operations in Vientiane, Laos, with the only the MRC Regional Flood Management and Mitigation Centre (RFMMC) remaining in Phnom Penh.

Can Tho University is one of the most important universities in the Vietnamese Mekong River Delta. In comparison to MRC-Laos, the network analysis indicates that Can Tho has a greater reach within the LMB research sub-network, highlighted in particular by stronger connections with non-governmental actors. For example, Can Tho has 3.0 times as many connections as MRC-Laos to universities and research institutes in the network.

Can Tho University and the MRC-Laos are both important brokers in the LMB that have different and potentially complementary positions in the network. The two organizations are directly connected to 121 of the other 180 organizations in the network (67%), but only share mutual connections with 36 of the other LMB network organizations (30% overlap). This indicates that Can Tho University is able to reach LMB network participants that the MRC-Laos cannot, and vice versa. Furthermore, the Pearson's correlation measure of structural equivalence between the two entities is -0.0780, reinforcing the observation that both organizations are important but perform different roles within the network.[18]

While the findings of this analysis provide important insights into the LMB collaboration network they only provide a snapshot of the network's structure and characteristics at a point in time. Follow up analyses of the LMB collaboration network would allow for examination of how the network changes through time and could be used to measure the impacts of network interventions designed to increase cross boundary communication among stakeholders and/or the development of a research and information hub at one of the organizations. Additional research on the LMB network could also benefit from analyzing respondent attitudes toward network collaboration, trust among organizations, and barriers to network connectivity; such data would allow for more direct analysis of network issues and node level social capital measures that impact data and information exchange across the region.

5. Acknowledgements

[18] Person's correlation measures the similarity of valued ties between nodes in a network. The value ranges from -1.0 to 1.0. A value of -1.0 indicates that the nodes have exactly opposite ties in the network, 0.0 indicates that knowing one of the node's network ties provides no information on the ties of the other node, and a value of 1.0 means the two nodes have the exact same network ties (Hanneman and Riddle 2005).

The corresponding author conceived of this project and conducted data collection and preliminary analysis as part of a rotational assignment with the USGS. The authors would like to thank, in particular, the support of assignment sponsor Matthew Andersen from USGS and Erin Loury from FISHBIO for ongoing encouragement, sharing of information regarding the region and key contacts, and support provided for survey development and implementation. We would also like to acknowledge the contributions and support provided by Shaara Ainsley and Doug Demko from FISHBIO and Melissa Monsalve, Rudy Schuster, Nina Burkardt and Kristin Hoelting from USGS.

This research did not receive any specific grant from funding agencies in the public, commercial or non-profit sectors.

Declarations of Interest: none

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Appendix A: List of Organizations Contacted for Network Survey

Organization	Country/ Region	Organization Type	Responded to Survey (Y/N)
Asian Development Bank	Asia	International Agency	N
Association of Southeast Asian Nations (ASEAN)	Asia	International Agency	N
Food and Agriculture Organization (FAO)	Asia	International agency	N
Japan International Cooperation Agency (JICA)	Asia	International Agency	N
The World Bank, Asia	Asia	International Agency	N

BirdLife International	Asia	NGO	N
Nagao Natural Environment Foundation - Japan	Asia	NGO	N
Center for Environmental Biology and Ecosystem Studies -- Japan	Asia	University/Research	N
Australian Centre for International Agricultural Research	Australia	Government Agency	N
New South Wales Department of Primary Industries	Australia	Government Agency	N
Australasian Fish Passage Services	Australia	Private Sector	Y
Charles Sturt University	Australia	University/Research	Y
La Trobe University	Australia	University/Research	Y
Inland Fisheries Research and Development Institute	Cambodia	Government Agency	Y
Mekong River Commission, Cambodia	Cambodia	Government Agency	Y
US Embassy, Phnom Penh	Cambodia	Government Agency	Y
Fisheries Administration - Dept. of Aquaculture	Cambodia	Government Agency	N
Forestry and Fisheries, Ministry of Agriculture	Cambodia	Government Agency	N
Mekong River Commission Secretariat	Cambodia	Government Agency	N
Ministry of Environment and Water	Cambodia	Government Agency	N
Tonle Sap Authority, Natural Resources Department	Cambodia	Government Agency	N
GIZ Cambodia	Cambodia	International Agency	N
USAID Cambodia	Cambodia	International Agency	N
IUCN Mekong Water Dialogues, Cambodia	Cambodia	NGO	Y
National Heritage Institute	Cambodia	NGO	Y
Wildlife Conservation Society, Cambodia	Cambodia	NGO	Y
WorldFish Center	Cambodia	NGO	Y
Conservation International, Cambodia	Cambodia	NGO	N
Fauna and Flora International, Cambodia	Cambodia	NGO	N
Fisheries Action Coalition Team	Cambodia	NGO	N
IUCN Cambodia Country Program	Cambodia	NGO	N
Open Development	Cambodia	NGO	N
Scientific Capacity Development Initiative	Cambodia	NGO	N
The Asia Foundation, Cambodia	Cambodia	NGO	N
Wildlife Alliance	Cambodia	NGO	N
World Wildlife Fund Greater Mekong	Cambodia	NGO	N
International Centre for Environmental Management, Cambodia	Cambodia	Private Sector	N
Build Bright University	Cambodia	University/Research	N
Cambodia Development Research Institute	Cambodia	University/Research	N
Cambodian Molecular Genetics Group and Scientific Capacity Development Initiative	Cambodia	University/Research	N
Paññāsāstra University of Cambodia	Cambodia	University/Research	N
Royal University of Agriculture	Cambodia	University/Research	N
Royal University of Phnom Penh	Cambodia	University/Research	N
German Aerospace Center (DLR) - Germany	Europe	Government Agency	Y
Netherlands Institute of Applied Geoscience TNO, National Geological Survey - Netherlands	Europe	Government Agency	N
Russian Academy of Sciences, Institute for Biology of Inland Waters - Russia	Europe	Government Agency	N
Belgian Development Agency - Belgium	Europe	International Agency	N
Danish International Development Agency, Denmark	Europe	International Agency	N
Department For International Development - United Kingdom	Europe	International Agency	N
Swiss Agency for Development and Coooperation	Europe	International Agency	N
VLIR – UOS (Flanders) - Belgium	Europe	International Agency	N

Environmental Impact Assessment Centre of Finland - Finland	Europe	NGO	N
Hull University - Hull International Fisheries Institute - UK	Europe	University/Research	Y
Nottingham University - UK	Europe	University/Research	Y
Finland Futures Research Center - Finland	Europe	University/Research	N
University of Oxford, Wildlife Conservation Research Unit	Europe	University/Research	N
Living Aquatic Resources Research Center (LARReC)	Lao PDR	Government Agency	Y
Mekong River Commission, Lao PDR	Lao PDR	Government Agency	Y
The Agro-Biodiversity Initiative (TABI)	Lao PDR	Government Agency	Y
Australian Embassy	Lao PDR	Government Agency	N
Department of Livestock and Fisheries, Ministry of Agriculture and Forestry	Lao PDR	Government Agency	N
Ministry of the Environment	Lao PDR	Government Agency	N
CGIAR Research Program on Water, Land and Ecosystems	Lao PDR	International agency	Y
International Water Management Institute , Lao PDR	Lao PDR	International agency	Y
Australian Government Overseas Aid Program (AusAID)	Lao PDR	International Agency	N
GIZ Lao PDR	Lao PDR	International Agency	N
USAID Lao	Lao PDR	International Agency	N
Natural Heritage Institute	Lao PDR	NGO	N
Wildlife Conservation Society (WCS), Lao PDR	Lao PDR	NGO	Y
World Wildlife Fund Greater Mekong, Lao PDR	Lao PDR	NGO	Y
IUCN Lao PDR Country Program	Lao PDR	NGO	N
IUCN Mekong Water Dialogues, Lao PDR	Lao PDR	NGO	N
The Asia Foundation, Lao PDR	Lao PDR	NGO	N
FISHBIO	Lao PDR	Private Sector	Y
Hatfield Consultants	Lao PDR	Private Sector	N
International Centre for Environmental Management, Lao PDR	Lao PDR	Private Sector	N
National University of Laos	Lao PDR	University/Research	Y
Champasak University	Lao PDR	University/Research	N
Savannakhet University	Lao PDR	University/Research	N
Ministry of Agriculture	Myanmar	Government Agency	Y
Department of Meteorology and Hydrology	Myanmar	Government Agency	N
Department of Groundwater Resources, Ministry of Natural Resources and the Environment	Thailand	Government Agency	N
Embassy of Finland, Bangkok	Thailand	Government Agency	N
Mekong River Commission, Thailand	Thailand	Government Agency	N
US Embassy, Bangkok	Thailand	Government Agency	N
GIZ Thailand	Thailand	International Agency	N
Mekong Institute	Thailand	International Agency	N
Southeast Asian Fisheries Development Center	Thailand	International Agency	N
UNDP Asia - Pacific Regional Center	Thailand	International Agency	N
USAID Thailand	Thailand	International Agency	N
World Bank, Thailand	Thailand	International Agency	N
Stockholm Environment Institute(SEIA), Thailand	Thailand	NGO	N
IUCN Mekong Water Dialogues, Thailand	Thailand	NGO	N
IUCN Thailand Country Program	Thailand	NGO	N
Mekong Region Futures Institute	Thailand	NGO	N
PACT - Mekong Partnership for the Environment	Thailand	NGO	N
The Asia Foundation, Thailand	Thailand	NGO	N
World Wildlife Fund Greater Mekong, Thailand	Thailand	NGO	N

Mahidol University	Thailand	University/Research	Y
Asian Institute of Technology, Thailand	Thailand	University/Research	N
Chulalongkorn University	Thailand	University/Research	N
Kasetsart University	Thailand	University/Research	N
Khon Kaen University	Thailand	University/Research	N
Mahasarakham University	Thailand	University/Research	N
Ubon Ratchathani University	Thailand	University/Research	N
International Technical Assistance Program(ITAP)	USA	Government Agency	Y
U.S. Army Corps of Engineers	USA	Government Agency	Y
US Geological Survey (USGS)	USA	Government Agency	Y
National Science Foundation (NSF)	USA	Government Agency	N
Pacific Northwest National Laboratory, Department of Energy	USA	Government Agency	N
Royal Thai Embassy, Office of Science and Technology	USA	Government Agency	N
Global Wildlife Conservation	USA	NGO	N
The Nature Conservancy (TNC), Asia and the Pacific	USA	NGO	N
I.M. Systems Group, Inc.	USA	Private Sector	Y
University of Colorado Boulder	USA	University/Research	Y
Auburn University	USA	University/Research	Y
City College of New York	USA	University/Research	Y
Louisiana State University	USA	University/Research	Y
Mississippi State University	USA	University/Research	Y
Portland State University	USA	University/Research	Y
University of California Irvine	USA	University/Research	Y
University of Kentucky	USA	University/Research	Y
University of Minnesota	USA	University/Research	Y
University of Missouri	USA	University/Research	Y
University of Texas San Antonio	USA	University/Research	Y
University of Washington	USA	University/Research	Y
University of Wisconsin Madison	USA	University/Research	Y
Columbia University	USA	University/Research	N
Old Dominion University	USA	University/Research	N
Purdue University	USA	University/Research	N
Smithsonian Conservation Biology Institute	USA	University/Research	N
University of California Berkeley	USA	University/Research	N
University of California Davis	USA	University/Research	N
University of Maryland	USA	University/Research	N
University of Michigan	USA	University/Research	N
University of Nevada, Reno	USA	University/Research	N
Directorate of Fisheries, Ministry of Agriculture and Rural Development	Vietnam	Government Agency	Y
Ministry of Natural Resources and Environment	Vietnam	Government Agency	Y
National Center for Water Resource Research and Planning	Vietnam	Government Agency	Y
US Consulate, Ho Chi Minh City	Vietnam	Government Agency	Y
Can Gio Biosphere Reserve, HCMC	Vietnam	Government Agency	N
Center for River Basin Water Resources and Environmental Management	Vietnam	Government Agency	N
Center for Water Resource Technology	Vietnam	Government Agency	N
Department of Water Resources Management, Ministry of Natural Resources and Environment	Vietnam	Government Agency	N

Mekong River Commission, Vietnam	Vietnam	Government Agency	N
Southern Institute of Water Resource Research, Ministry of Agriculture and Rural Development	Vietnam	Government Agency	N
US Embassy, Hanoi	Vietnam	Government Agency	N
Vietnam Institute of Meteorology, Hydrology and Climate Change	Vietnam	Government Agency	N
Vietnam National Mekong Committee	Vietnam	Government Agency	N
GIZ Vietnam	Vietnam	International Agency	N
USAID Vietnam	Vietnam	International Agency	N
World Bank, Vietnam	Vietnam	International Agency	N
International Crane Foundation (ICF)	Vietnam	NGO	Y
IUCN Mekong Water Dialogues, Vietnam	Vietnam	NGO	Y
IUCN Vietnam Country Program	Vietnam	NGO	Y
World Wildlife Fund Greater Mekong, Vietnam	Vietnam	NGO	Y
Children of Nature - Mekong Riverbank Network	Vietnam	NGO	N
Fauna and Flora International (FFI), Vietnam	Vietnam	NGO	N
International Water Management Institute (IWMI), Vietnam	Vietnam	NGO	N
The Asia Foundation, Vietnam	Vietnam	NGO	N
Wildlife Conservation Society (WCS), Vietnam	Vietnam	NGO	N
Winrock International, Vietnam	Vietnam	NGO	N
DHI Vietnam	Vietnam	Private Sector	N
International Centre for Environmental Management, Vietnam	Vietnam	Private Sector	N
Can Tho University	Vietnam	University/Research	Y
Southern Institute of Forest Survey and Inventory	Vietnam	University/Research	Y
University of Natural Resources and the Environment, HCMC	Vietnam	University/Research	Y
University of Science, HCMC	Vietnam	University/Research	Y
University of Social Sciences and Humanities	Vietnam	University/Research	Y
An Giang University	Vietnam	University/Research	N
Asian Institute of Technology, Vietnam	Vietnam	University/Research	N
Hoc University of Agriculture and Forestry	Vietnam	University/Research	N
Nong Lam University	Vietnam	University/Research	N
Research Institute for Aquaculture 1	Vietnam	University/Research	N
Research Institute for Aquaculture 2	Vietnam	University/Research	N
Research Institute for Aquaculture 3	Vietnam	University/Research	N
Research Institute for Aquaculture 4	Vietnam	University/Research	N
Tay Nguyen University	Vietnam	University/Research	N
University of Fisheries, Nha Trang University	Vietnam	University/Research	N
Vietnam Academy of Science and Technology	Vietnam	University/Research	N
Vietnam Institute of Fisheries Economics and Planning	Vietnam	University/Research	N
Vietnam Water Resources University	Vietnam	University/Research	N