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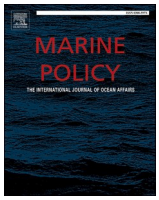

Network analysis of blue carbon governance process in Indonesia

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ABSTRACT

To align with international climate efforts to remain within 1.5 degrees of the earth temperature, Indonesia requires concerted measures from actors to preserve and restore carbon rich ecosystems, especially blue carbon ecosystem. Although studies have suggested the importance of blue carbon ecosystems in contributing to Indonesian climate action, translating science to policy remains a challenge. Mapping actors and the pattern of information exchange related to blue carbon can help identify potential barriers in the blue carbon governance process and policy development. This study uses Social Network Analysis and integrates it with results from in-depth qualitative evaluation of institutional respondents. Data is obtained through questionnaires and semi-structured interviews with representatives from a broad range of organizations. It was found that the actor who oversees the fulfilment of the climate commitment, which is the most common objective of the network, is not a central actor. Second, the actors with the highest degree of centrality received little trust from other actors. Third, overall, the network has low quality ties. Each of these hinders knowledge providers' ability to make an impact on policy development. By critically examining the interactions between actors, this research casts new light on the overlooked problem of the significance of the network in blue carbon governance process.

1. Introduction

In the last 10 years, blue carbon ecosystems, which consist of mangrove, seagrass, and tidal marsh, have gained increasing recognition [1]. Scholars, practitioners, and policymakers working on climate issues have begun to acknowledge the ecosystems' capacity to store 3–5 times more carbon than their terrestrial counterparts [2]–[4]. These ecosystems are especially important for Indonesia, a country that holds 17% of the world's blue carbon reservoir [4]. Indonesia is ranked first in terms of mangrove coverage, hosting 22.6% of the world's mangroves [5], and it is recorded to have at least 10% of the world's seagrasses [6]. Unfortunately, the number of mangroves coverage in Indonesia has been decreasing. While mangrove loss is only a small fraction (6%) of the total extent of deforestation in Indonesia, it is estimated that, if the deforestation were halted, total emission from land use sectors would reduce by 10–31% [3], [7]. Indonesia's blue carbon ecosystems are vital carbon sinks, and they are at the same time a global climate threat when released.

Aligning with international efforts to remain within 1.5 degrees Celsius of the earth's temperature, Indonesia has pledged to reduce 29% of its emissions by itself and 41% with international assistance by 2030. Achieving this target requires the incorporation of reliable scientific evidence into policy. Evidence that suggests the importance of Indonesia's blue carbon ecosystems is abundantly available, but moving from science to policy remains a challenge.

To this date, the Indonesia national greenhouse gas inventory has only measured mangrove's above-ground biomass. Soil ground carbon and seagrass are not included in the inventory framework. Meanwhile, several studies have reported that below-ground carbon pools account for 49–98% of the total mangrove ecosystem carbon stock [2], [8]. The above-ground carbon stock is no more than 20% of the total opportunity that is available from protecting and restoring blue carbon ecosystems. Therefore, the consequences of land use change or degradation create much more environmental impact in terms of carbon emissions. In addition, coastal areas, which are the habitat of blue ecosystems, are currently first in line for land use change due to settlement, commercial use such as port development as well as conversion to aquaculture ponds [9], [10].

A far more important issue is the social barriers that prevent disparate agencies and stakeholders from working together to achieve a

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common goal. The effective transmission of information and knowledge across networks is crucial to the decision-making process [11–13]. Coherence between science and policy is one of the elements that can allow transformative change [14], which involves a shift in attitudes, discourse, and power dynamics that govern the business-as-usual situation in the blue carbon policies formulation.

Governance processes are always interactive in a network because no actor has the ability to tackle a natural resource problem on one's own; consequently, network is essential in governance process [15,16]. Decisions are taken in a variety of settings, in range of policy domains in which actors from various policy networks engage [17]. If the network is an efficient one, these decisions can be made promptly and effectively [18]. If the network is inefficient, the decision-making process is affected negatively: decisions are not taken, or if they are taken, they do not respond adequately to the need they are meant to address [19]. Significant network centralization can lead to decision-making that is centered on a few actors, which can have a negative impact. For example, it can reduce important actors' access to diverse information sources [20].

This paper focuses on identifying network barriers that occur within the blue carbon network. This study asks questions about where and how the network may inhibit blue carbon policy development in Indonesia and how the network can be improved. In this study, social network analysis (SNA) was employed in the context of blue carbon ecosystems management. The study combines both quantitative SNA and actors' discourse on how they are participating in blue carbon policy process. This study uses the flow of information exchange to depict network exchange because of the importance of information flows among actors in influencing policy [21,22].

The purpose of this study is to better understand network interactions that affect blue carbon policy outcomes. It was hypothesized that these network interactions impede the transfer of scientific findings to the policy design process. By understanding the role of networks in the institutionalization of blue carbon policy development, this paper makes a contribution to blue carbon research on how a network can achieve a collective purpose on emerging issues on coastal and marine affairs.

2. Blue carbon policy progress

The significance of coastal ecosystems in mitigating climate change was first acknowledged in 2009 when two studies described the scientific evidence [23,24]. Blue carbon highlights the importance of coastal ecosystems management to enhance climate change mitigation efforts. In addition to United Nations Framework for Climate Change Convention (UNFCCC), the international community has discussed potential policy entries for blue carbon enhancement programs [25]. Those international linkages include Convention on Biological Diversity (CBD), Sustainable Development Goals (SDG), and Ramsar Convention. With other international frameworks in mind, coastal management can be more comprehensive and integrated, including whether adopting carbon-related policies and mechanisms makes sense for a country and how they might be better linked with current coastal regulations and policies.

In 2014, Indonesia's former president declared in the United Nations forum that the country would explore the potential of such ecosystems for inclusion within the country's efforts to mitigate climate change. Through the ratification of the Paris Agreement, Indonesia identified five sectors as pathways for reducing greenhouse gas emissions. Those sectors are energy, waste, industrial process and product use, agriculture, and forestry. Indonesia national greenhouse gas inventory has included mangrove's above-ground biomass within the forestry sector. However, seagrass and below-ground carbon in mangroves are still excluded from the inventory.

Several efforts have been made despite the lack of adoption from science to policy. Indonesia Blue Carbon Strategy Framework was initiated in 2017 by the ICCTF, a trust fund entity under the Ministry of National Development Planning (*BAPPENAS*), to organize and assess in-country initiatives. Whereas in 2019 Indonesia has embarked on low carbon development path also by *BAPPENAS* which currently seeking to explore the potential for the inclusion of coastal ecosystems. In the last decade, numerous workshops to collect information from various stakeholders. Both government and non-government bodies initiated the workshop. Research institutions are also conducting studies to better understand ecosystems.

Sequential efforts have been made beyond the climate regime. In 2012, a Presidential Regulation (*Perpres)* 73/2012 on National Strategy for Mangrove Management was enacted. Followed by a Ministerial Regulation (*Permenko)* 4/2017 by the Coordinating Ministry of Economic Affairs in 2017, which targets the rehabilitation of 1.8 million hectares of mangroves. Indonesia has also launched one map policy that includes mangroves and seagrass as one of the thematic maps. The Directorate of Soil and Water Conservation at the Ministry of Environment of Forestry is the data custodian for mangroves. Whereas LIPI is the data custodian for seagrass.

It must also be noted that the enactment of Law 23/2014 on regional government provides an implication that complicates the existing condition. Mangroves under the spatial plan as forestry area falls under the jurisdiction of Ministry of Forestry and Environment. Mangrove outside of the forestry area, which categorized as coastal areas, falls under the jurisdiction of the regional government under the overall management of Ministry of Marine Affairs and Fisheries. Originally, the regency government has the authority to manage 4 mil marine areas which include mangroves and seagrass in the areas, but according to Law 23/2014, these now fall under the authority of the provincial government. Moreover, recent enactment of Presidential Regulation 120/2020 formalized the creation of Peat and Mangrove Restoration Agency. This research does not include the agency as the agency was formed in late 2020 when the data collection for this research has been done.

In addition to the progress at the national level, various independent conservation and restoration projects, particularly for mangrove, are being carried out at the grassroots level by civil society organizations. Discussion is ongoing as to whether market-based instrument is suitable for blue carbon projects and several CSOs have tried exploring this [26]. However, to date, there is no carbon credit payment that has been made to a blue carbon project in Indonesia. Although progress has been made, a better coordination among multi-level stakeholders is still required.

3. Conceptual Framework

Three theoretical suppositions underpin this research. First, the notion of network is an essential concept in formal policy and decision making. The significance of networks role is emphasized by the growing problem in environmental systems, in which multiple actors govern the systems on multiple scale [25,27]. Blue carbon is no exception; it has brought not only governmental actors but also CSOs, businesses, and academics to begin working on the challenges in their own way [28].

The interrelated systems highlight the need to investigate networks interactions in attempt to grasp institutionalization processes. Thus, our second supposition is that network performance affect the actual outcomes. This is based on the dialectical approach by [29] that policy networks influence policy outcomes and reciprocally the outcomes can also affects networks interaction (see Fig. 1). For example, actor's resources in network influence policy outcome; actor's learning influence actor skill and in network will also influence policy outcome. Ideas and lesson-learned sharing are considered requisite to find collaborative solutions [30].

The third supposition is that actors' characteristics and perceptions affect interactions within the network. In analysing network, concern is usually distressed on its structure rather than the actors' traits within a network. Whereas distinct knowledge and values, as well as diverse motivation and views of accomplishment, should also be considered

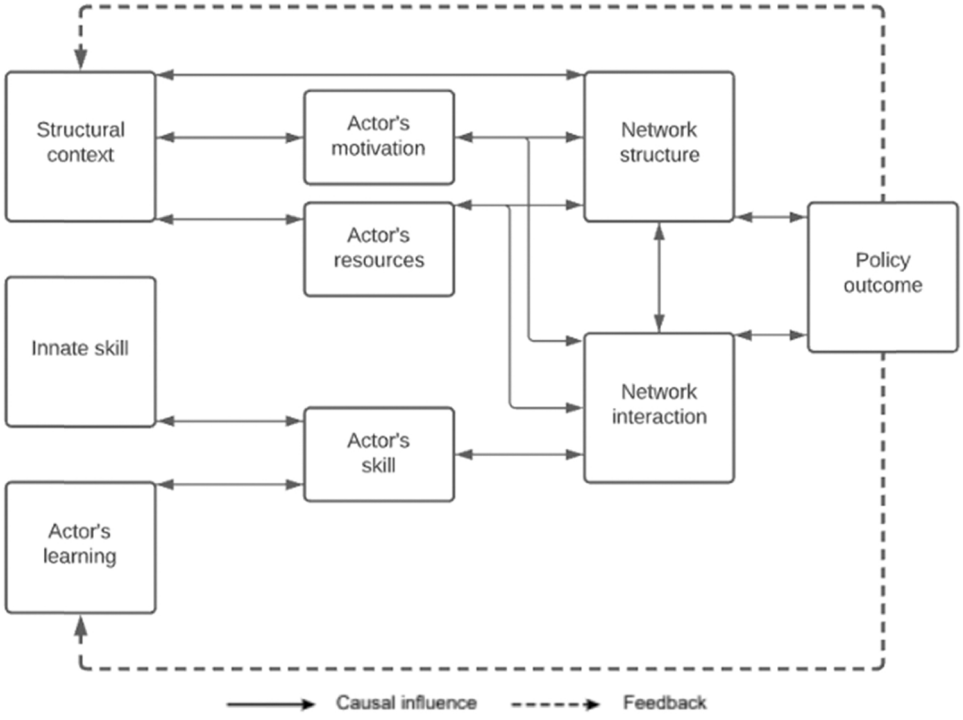

Fig. 1. The process of institutionalization occur affects actors and vice versa Adapted from (Marsh & Smith, 2000).

since they may impact collaborative actions within a network [31]. In addition to utilizing resources and information in the network, actors have been observed attempting to influence the network to align with their interests and motivation [27,32].

Policy network analysis is related to social network analysis because both include the concept that the network system is comprised of various actors, and that interactions between actors within the network can influence one's perceptions and ultimately change their actions [33]. Mathematical model is used to analyse relations and configuration in networks, in which computational analyses are used to translate matrix into graphs [34], these processes are now aided by the widely use network analysis software. Network characteristics can be measured by analysing its structure. We can discover sub-groups and players with important roles in the network by analyzing the structure. Thus, social network analysis can be used to identify institutional barriers as well as network flaws [35,36]. This study utilized social network analysis to better understand the networks that shape blue carbon policy with emphasis on national level actors. In addition to their involvement at the national level, some actors also work at the site level.

4. Materials and Method

4.1. Data collection

This research utilized a mixed method approach, combining both quantitative social network analysis (SNA) with qualitative analysis conducted through a semi-structured interview. SNA was used to identify and evaluate blue carbon network characteristics as well as important actor and connections. A qualitative analysis was used to assess actors' involvement and perceptions against the network result to evaluate interaction from both viewpoints.

This study particularly focuses on the national level actors and network as briefly discussed in the blue carbon policy progress section. An initial identification of actors was based on in-country team knowledge and cross-referencing with blue carbon related events invitation list. The complete list of actors was validated through expert consultations. Expert was selected through in-country team discussion considering their expertise and involvement, which represent government, NGOs, and academia.

Closed network analysis was used and only actors within the list were interviewed. A total of 43 actors were identified. However, due to scheduling conflicts and confidentiality issues, only 35 were interviewed. All interviews were tape recorded with permission from interviewees, except for one in which the permission was not granted. All 35 actors were included in network analysis and only 34 actors were included in the qualitative analysis. Table 1 represents a breakdown of study participants and the whole blue carbon network identified both by the type of organization they affiliated with and the main capacity (i.e. mode of work) of the organization.

The interview was conducted both face-to-face and when not

Table 1
Blue carbon network in Indonesia.

	Network identified (n = 43)		Network interviewed (n = 35)	
	Number	Percentage (%)	Number	Percentage (%)
Type of organization				
Central government	21	48.8	17	48.6
International NGO	6	14.0	6	17.1
Foreign government	5	11.6	4	11.4
University	4	9.3	2	5.7
International organization	2	4.7	1	2.9
National NGO	3	7.0	3	8.6
National organization	1	2.3	1	2.9
Private sector	1	2.3	1	2.9
Main capacity				
Regulatory body	16	37.2	12	34.3
Research	13	30.2	10	28.6
Funding	7	16.3	6	17.1
CSO – implementation focused	6	14.0	6	17.1
Business	1	2.3	1	2.9

possible, through a phone call. The length of the interviews varied depending on the respondent's interest and expertise, ranging from 40 min to 3 h. A questionnaire was used to obtain network data and details on interaction with other actors. This network survey was designed to capture linkage among actors regarding exchange information and the network captured represents information exchange. Information exchange measures were utilized to identify potential barriers to transformational change for blue carbon policy development [37]. For every linkage mentioned, respondents were asked the specific events, subject, and length of exchange information. Thus, a question with whom actors exchange information formed the basis of the network data.

The structure of the interview was formulated based on literature review, mainly derived from elements in the institutionalization process [29]. It was then synthesized through 3 trial interviews. The semi-structured interview evaluates respondents' motivations and objectives in conducting blue carbon activities, actions done based on their objective, perceived barriers, aspirations on how to overcome barriers in order to achieve their policy objective.

4.2. Data analysis

The network data sets were analyzed using UCINET 6 software [38] based on its network characteristics and node-based measure. Responses referring to the presence or absence of linkages for interaction were converted to binary network matrices that illustrated the presence of links between two actors as '1′ and absence as '0′. Netdraw software was used to visualize the relationship among actors within the network [39].

In analyzing network characteristics, this paper examined network density and network centralization that measures how well a network is linked [16]. Network density measure the proportion of tie exist relative to all possible link [40]. Whereas network centralization is an indicator to describe the extent of a network is concentrated around few actors [41] which shows the degree of how influence is spread across the network [42].

The analysis of node-based measures focused on determining actor centrality. We calculated and compared the results of degree centrality and in-degree centrality as well as betweenness centrality and reciprocal connection betweenness centrality. The degree centrality of an actor indicates the number of links it has to other actors, with the highest degree centrality indicating the most ties to other actors [39,40]. Betweenness centrality is a measure of how frequently one actor is in path between other actors, making them reliant on other actors who wish to reach actors outside their direct contact. To investigate further whether the connection has been perceived mutual, we assessed the indegree centrality and reciprocal betweenness centrality. A node's indegree centrality is a proxy for how important the actor is considered by the network [43].

Methods based on deductive insight were utilized to analyze the interview data sets [44]. The first reading and coding of the transcripts recorded the words used by the respondents and described the key topics that relate to the objectives of the study. Those topics are actors' objective in conducting or involving in blue carbon activities, actor's participation and actions that have been done, perceived barriers, and aspirations on how to overcome the existing barriers. The codes were organized systematically using NVivo 12 software [45] which identifies the data set's themes and subthemes. The data set was examined and topics were reorganized during the coding process. The number of respondents highlighting a specific point was registered as an indication of observable policy objective, involvement, observable barriers, and aspirational strategies.

5. Results

5.1. Network measurement

5.1.1. Whole network characteristics

The network includes a variety type of organizations, ranging from central government, international NGO, foreign government, university, international organization, national NGO, national organization, and private sector, indicating the importance of cross sector interactions. National organization category is for an organization created by government officials but are not part of the government. The network also represents organization with different capacity; the largest number of actors are working on regulatory (37,2%) and research (30,2%). The least is business with only one actor identified.

The network average density is 0.51, meaning slightly more than half (51%) of all potential ties within the network were observed. However, not all the connections are mutual, in fact, there is significant number of the connection is initiated by only one individual, indicated by the low reciprocity score (0.34).

Fig. 2 depicts the blue carbon network in Indonesia using degree centrality measure, with nodes representing actors and ties representing relations between them. The network represents the information exchange between actors. Nodes are coded by shape based on the affiliation and coded by colour based on the main capacity. Nodes sized reflect the actor's degree centrality measure, the bigger the nodes the bigger its degree centrality is. The network visualization shows the intricate of information linkage across policy communities that bridge actors with different capacities.

5.1.2. Actors centrality

The degree of centrality in blue carbon network is shown in Fig. 2. The average degree centrality for blue carbon network is 37,1. Regulatory agency has the highest degree centrality, shown by the two actors from the group that obtained the highest score (61 and 60). Table 2 shows that regulatory body subgroup and civil society organization (CSO) that focused on implementation has above average score of degree centrality. This suggests that these subgroups are the most active in the network, in the sense that they are well engaged with other actors, whether they received or they disseminate information.

However, these findings are not coherent with the indegree centrality measure result. It was found that both of the highest degree centrality actors do not happen to have the highest indegree centrality score (only 25 and 23). In fact, the two actors having the highest indegree centrality are both from the research subgroup (score 28 and 27), one is affiliated with university and the other one is affiliated with central government. Actors with a high degree centrality but a low indegree centrality have a disproportionately high outdegree centrality, which means that while they are actively engaging with other actors, the other actors do not feel the same way. Low indegree denotes a low capacity to be depended on and gain people' trust [46]. Administration and politics subgroup have above the average score for degree centrality. The other subgroup having higher than average indegree centrality is research subgroup. The funding and business subgroup consistently score below the average for both degree centrality and indegree centrality measures.

The average betweenness degree centrality for blue carbon network is 16,81. The two actors that have the highest score are CSO implementation focused and an actor from regulatory body (scoring 69,9 and 61,5 respectively). CSO subgroup is the only one that has higher above average betweenness centrality (score 26,83). However, these findings are not consistent when using only reciprocal relation in analysing betweenness centrality. The two actors with the highest reciprocal betweenness centrality are from research subgroup, affiliated with university and from implementation-focused CSO (scoring 49,8 and 49,2 respectively). The average score for betweenness centrality using reciprocal relation is 13,26. Three subgroups with different main

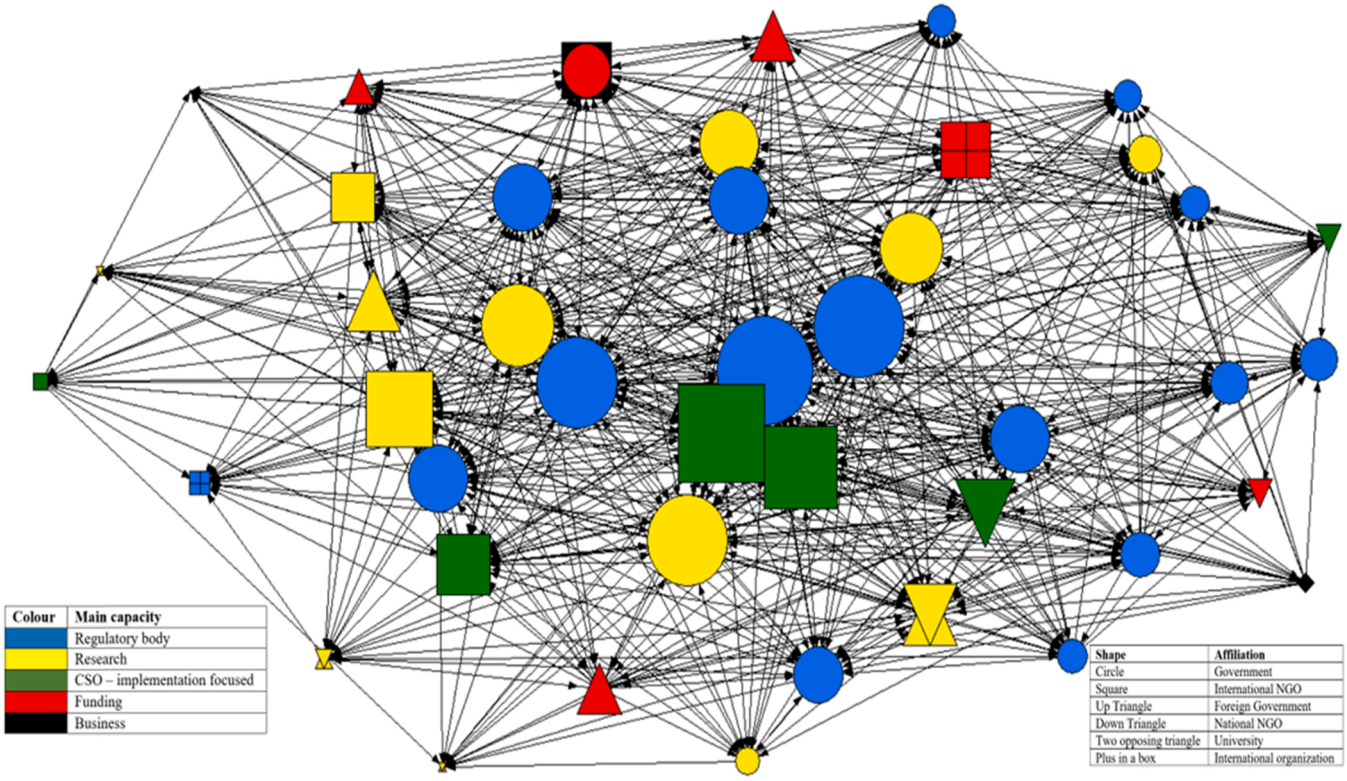

Fig. 2. Blue carbon network using degree centrality measure.

Table 2
Network centrality measure.

Overall Network	Degree Centrality	Indegree Centrality	Betweenness Centrality	Reciprocal Betweenness Centrality
Mean	34.84	17.42	17.05	13.26
Range	49.00	23.00	69.90	49.74
Standar Deviation	13.13	5.95	18.48	13.39
Subgroup	**Degree Centrality**	**Indegree Centrality**	**Betweenness Centrality**	**Reciprocal Betweenness Centrality**
Mean – Regulatory Body	37.13	19.50	16.81	14.65
Mean - Research	34.08	18.54	15.00	16.22
Mean - Funding	30.43	13.29	6.90	5.31
Mean - CSO	38.00	16.33	26.83	14.41
Mean - Business	20.00	5.00	1.14	1.06

capacities have above average scores those are research, administration and politics, and CSO subgroup. Research subgroup score significantly higher than the latter two, scoring 16,22. Analyzing mutual connections in the network data shows that research subgroup often being referred but not referring other actors. It shows that these actors from research is relied by others [47], despite their tendency to not initiate the communication.

5.2. Findings from interviews

5.2.1. Actors interest

Actors' interest can be divided into four distinct groups (Table 3). These groups are based on the policy objective stated in blue carbon policy framework [48]. During the interview, one actor may relate to more than one objective. The most common interest is to fulfill Indonesia's climate commitment which referred by 22 actors, with 75% of them belong to the administration and politics group that participated in the interview. Among the objective mentioned includes adaptation to climate change, greenhouse gas reduction, and the broader climate action. Interest in the coastal and marine ecosystems health, emphasizing the value of blue carbon ecosystem through its services, and ensuring communities well-being, were also mentioned.

Interviewed with foreign government reveal that 75% (3 out of 4) of them has interest in fulfilling Indonesia's climate commitment. Despite the fact that most actors are aware of the Indonesia's climate change commitment, some have expressly declared that it is not their primary concern. Many actors refer to particular ecosystem in their objective, such as are seagrass, and the majority of actors expressly mention mangroves when discussing their objectives in protecting coastal and marine ecosystems health and emphasizing the value of ecosystem services.

5.2.2. Actors involvement

The involvement of actors in blue carbon can be grouped into six large categories. The most common ones are on-the-ground work and field demonstration, potential and dynamic assessment, and policy intervention, each referred by 10 respondents. On-the-ground work includes coastal management and protection, creating a mechanism for coastal community livelihoods, coastal rehabilitation, and development of sustainable aquaculture. Potential and dynamic assessment mainly includes mapping and research activities. Some of the research topics described by respondents include carbon sequestration, carbon stock

Table 3
Representative quoted from respondents.

Motivations and underlying policy objectives	Number of respondents	Example quotes from respondents
To fulfil Indonesia's climate change commitment	24	"…one of the target is emission reduction through coastal and marine ecosystems."(NG13)
To ensure coastal and marine ecosystems health	15	"… maintaining land cover and its habitat in a good condition…" (NG12)
To emphasize the value of coastal ecosystems services	12	"… through blue carbon activities, the other valuable mangrove ecosystem services can be recognized." (INGO5)
To ensure coastal communities' well being	10	"… beyond the ecosystems, it is about the communities including their economy." (NNGO2)
Involvement	**Number of respondents**	**Example quotes from respondents**
On–the–ground work and field demonstration	12	"… we work with them to manage marine protected areas where abundant of mangroves can be found…" (INGO5)
Blue carbon ecosystem potential and dynamic assessment	11	"We started conducted mapping in 2009… after one map mangrove it was no longer ourselves but together with national mangrove working group." (NG17)
Policy intervention	10	"… we develop national policy regarding conservation and the rehabilitation of the ecosystem according to data from technical implementation unit." (NG12)
Consolidation	8	"…together prepare the data and information. That we have started.we arrange a massive rehabilitation movement…" (NG2)
Capacity development	5	"We still assist and supervise… we support that team as a supervisor…" (NG17)
Funding	5	"… we did not involve directly but we give grant to local community groups." (NNGO1)
Perceived barriers	**Number of respondents**	**Example quotes from respondents**
Lack of inter-institutional coordination and systemic defect	19	"… there is one assumption that one handled within forestry area and the other one handle outside those areas… lack of communication ultimately leaves the matter unmanaged all together…" (NG14)
Insufficient data and information that are reliable	14	"… data that are produced needs to have the same methodology… inconsistent that is why it was late to be included… who has accurate data on seagrass coverage? Even…does not have them…" (NG15)
Resources constraint	11	"… lack of funding that fully comprehend our research obsessions… we have standard equipment and tools. However, to do advance analysis requires more…" (NG10)
Research does not translate into policy	10	"… how many of the research produced can feed into policy? Very few." (NO1)
Lack of awareness and buy-ins from local actors	10	"The challenge is how we raise this issue to local stakeholders towards their regional policy and plan." (NG16)
Absence of political will	9	"We invite leaders to attend workshop, raising their awareness… there is no awareness nor affecting their decision making." (NG3)
Competing priorities with other land users and unclear land status	7	"… when we start rehabilitating… there is a land status problem, where government land has become settlement, aquaculture…" (NG1)
Lack of clear understanding among stakeholders of the blue carbon concept and science	5	"Mangroves needs to be seen as a whole ecosystems… so far, methodologies and concept on mangroves revolve around forestry concept… whereas there is hydrodynamics, geomorphology…" (NG7)
Lack of clarity who leads	4	"Lack of clarity who leads and who's doing what… we get the impression that one ministry leads. However, when we look at the situation in the field… many institutions want to take part." (FG1)
Inconsistent programs that focused only on a project basis	4	"Many activities that has been done focused too much on ceremonial aspect… however if we look at the situation that the degradation rate is still high…" (NG2)
Suggested strategies	**Number of respondents**	**Example quotes from respondents**
Market-based measure	15	". it is not only about conserving mangrove, but what is the additional value for coastal communities… one of the solutions is through market, how to finance the conservation…" (U1)
Policy change	15	"… that is the reason why at the end of every presentation, I suggest the urgency for mangrove moratorium." (NG6)
Institutional reform	9	" … this is about blue carbon potential distribution, not mangrove coverage nor seagrass coverage. So who is the data custodian for this?" (NG17)
Dissemination of agreed knowledge	9	"… we need agreed methodologies to count blue carbon. The baseline to account emission…" (NG14)
Development of research	4	"… data obtained from research or other field work should be delineated…"(NG1)

assessment, economic valuation, ecosystem services, ecosystem degradation, and rehabilitation. Policy intervention activities include developing guidelines, involve in international communication, and planning. Activities such as consolidation, capacity development, and funding projects, were also mentioned.

Some research respondents mentioned that the topics conducted depend on the resources or funding they get and that this is often depending on the government current priorities. All of the actors that involve in on-the-ground work and field implementation describe their involvement specifically in mangroves ecosystem if not referring to the coastal ecosystem in general. Whereas among the actors involve in potential and dynamic assessment activities, only 3 out of 10 actors refer seagrass ecosystems specifically, and 1 of them also work on mangroves. Some government actors' that involve in policy intervention describe that they are actively looking for adequate evidence in order to do their

policy intervention activities.

5.2.3. Perceived barriers

The main barriers in pursuing the blue carbon objectives are summarised in Table 3. Lack of inter-institutional coordination and systemic defects, which includes discord as well as gaps and overlaps of institutional mandates, were the most common barriers referred. Many respondents mentioned discord among institutions that have authority for mangrove management as a major barrier. For example *'.so when there is mandates overlaps what will happen is the weight will be thrown around and no one really understand who's really responsible' (NNGO1)*. Individual interest that does not represent the institutions mandates were also mentioned as one of the systemic defects that posed significant barrier.

Insufficient data and information that are reliable were the second most referred barrier. In addition, respondents also mentioned the need of consensus and agreement on standardized data and information. These information is needed by actors that involve in policy intervention activities, as mentioned: *'we can't develop a plan if the data is not good, it will result in a poor action plan due to invalidity, inconsistency, and the incompleteness of the data.' (NG1)*. In terms of data coverage, most respondents are aware of the one data policy and that each ecosystem has their own data custodian. However, many respondents mentioned the need to improve and update mechanism for mangrove ecosystem and established an accurate baseline coverage for seagrass.

Researches that does not translate into policy were one barrier that were mentioned by 10 respondents. Other barriers mentioned were lack of awareness and buy-ins from local stakeholders, absence of political will, competing priorities with other land users and unclear land status, lack of clear understanding among stakeholders, lack of clarity of who leads, and inconsistent programs that were projects based instead of a long-term initiative.

5.2.4. Suggestions or aspirations

The suggested opportunities to enable blue carbon activities are shown in Table 3. The suggested strategies can be divided into 5 broad groups. Market-based measure were the most referred strategies, those measure are develop ecotourism activities, involve private sector to finance conservation and restoration, enable alternative livelihoods for coastal communities, incorporate the ecosystems in natural capital accounting and possibly use village fund to develop such program. For example, *'… improving the areas for conservation through ecotourism, or develop a mangrove-crab nursery… after being rehabilitated the socio-economic concept must follow…'(NG1)*.

The aspirations of policy change were referred by 13 respondents. Those policy change includes for blue carbon ecosystems, in particular its soil carbon, to be included in greenhouse gas accounting, for blue carbon conservation and restoration to be included in national and regional development plans, assess the possibility to do mangrove moratorium, and integrate the conservation and restoration framework throughout national policies. Many respondents mentioned that being incorporated to national greenhouse gas accounting scheme can particularly boost stakeholders attention to ensure conservation and restoration of the ecosystems. Although it would need some amount of political will, after being included it would increase political will from the same or lower hierarchy to put attention to the ecosystems.

6. Discussion

This study examined inter-institutional interactions to understand barriers and opportunities to develop enabling mechanism. The integration of SNA with result from in-depth qualitative evaluation of institutional respondents allowed us to match key institutions and their participation from both viewpoints. This study can be an important lesson for countries with significant blue carbon ecosystems, for example, countries in the tropics such as Brazil and Malaysia, but find it difficult to incorporate scientific findings into policy. It must be noted that this study is just a snapshot in time during the relatively early stage of blue carbon policy development in Indonesia and that the network dynamics may change overtime. Some changes that may affect the network includes change in government structure, people change position or jobs, and change of authority. This section discusses the current condition of blue carbon network and how to overcome some of the phenomenon through network approach.

6.1. The one with authority is not the central actor

There is a range of engagement (see Table 3) extent in blue carbon governance process that reflects each institutions mandates, interest, and objective. While the most common objective of the network is to achieve Indonesia's climate commitment through blue carbon, the institution with such mandate is not the central actor. Furthermore, that institution is not among the actors that has highest degree centrality and betweenness centrality. In fact, the institution has below average in-degree centrality and reciprocal betweenness centrality score. It shows not only small number of actors that considered to have relation or seek information from them but also that their engagement in the issues are limited. This phenomenon indicates a gap, between the institutions that has formal regulatory mandate over the most common objectives and the one that are central and has informal power over the network.

One actor that has mandate related to Indonesia climate commitment mentioned: *'…within the IPCC 2013 supplement there is a detailed explanation that mangrove is categorized under land sector… however, most of the research is still within scientific phase, if we want to move it to implementation we need agreed methodology both within the satellite imagery and the development of permanent sampling through ground truth.'* The statement shows that some of the required information by the policy makers is clear. However, this required information has not been thoroughly communicated to the network and received by the research community, due to the actor's position being in the peripheral and not in the central. The lack of access to diversity and certain kind of information result in the lack of evidence from the policymaker side to develop a robust policy.Fig. 3

6.2. The government agencies that are central receive low trust from actors

Being active in the network means that an actor has many ties, hence has access to many sources of information [42], [47]. Nevertheless, many of these connections was not been perceived as mutual. There is a disparity between nominating others and being nominated. It was also found that research subgroup, even though did not have high degree centrality, has high indegree centrality. Actors having a high degree centrality but a low indegree centrality have a disproportionately high outdegree centrality, which suggests that even if they are actively connecting with other actors, the other actors are not. Thus, research community as knowledge provider is relied and trusted by other actors [49], given their long term participation in blue carbon issues.

Two of the most central actors according to degree centrality measure were from government. Nevertheless, these actors were observed to have low indegree centrality. While having high degree centrality show the capacity of an actor to develop communication within a network [50], having a low indegree indicates the low ability to be relied on and obtained trust from others [46]. As policymakers, government agencies require not only scientific evidence but also the right information. The most appropriate policies based on the most recent scientific data cannot be developed if actors who provide the right information do not share their knowledge with government agencies. Moreover, this leads to stagnation, since buy-ins from stakeholders are weak even if they initiate communications or act as a broker.

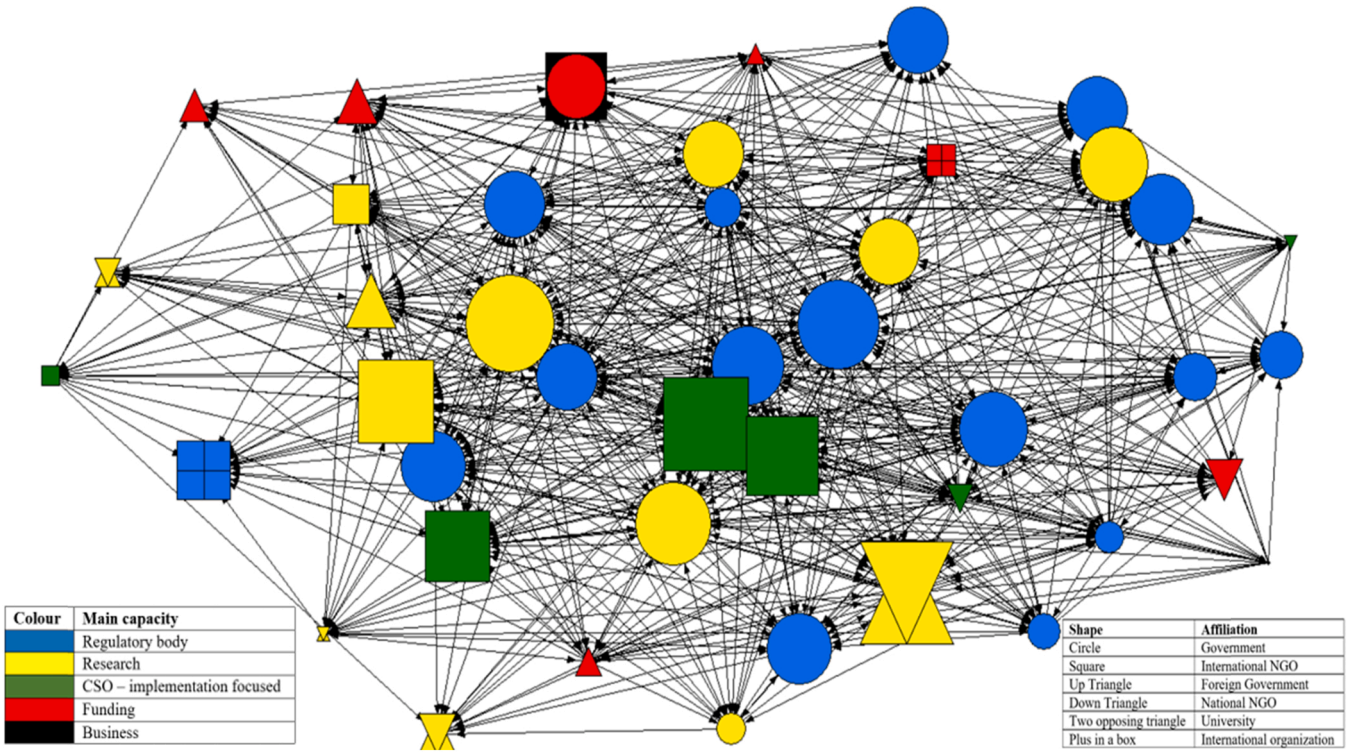

Fig. 3. Blue carbon network in Indonesia using indegree measure.

6.3. The overall low quality of ties

While high density suggests a relatively good quantity of existing ties, blue carbon network generally has low quality ties which indicates mistrust among the network. It was demonstrated through the high density of blue carbon network in which many of these linkages are not reciprocal. According to the findings of the interview, there are several obstacles that blue carbon actors encounter as a result of poor communication, such as lack of inter-institutional coordination and lack of understanding of blue carbon concept. All of which should not exist in the first place or, at the very least, can be reduced when ties between actors are of high quality.

Research community is well placed to support and bridge information across network and could plays an important role in the institutionalization process because they have the highest indegree centrality, therefore, trusted and relied by other actors. However, they perceived their information and research not being adopt by the mandated policy makers. Many policy makers mentioned the lack of data and research; nevertheless, what they actually need are some specific data that the existing research landscape is still lacking, both due to invalidity of the data and they need a more advanced one. Given the relatively low indegree among some of the most central actors within the government, there is a great chance that this information, about what specific data required for policy making, has not been received and internalize by the research community. Moreover, even when research community understand the kind of demand that the policy landscape has, many of them mentioned the lack of resources due to the absence of political will. As a result, potential donors do not consider it as national priorities.

Furthermore, there are four main different motivations or underlying policy objectives of blue carbon actors. As mentioned by one government researchers *'the difficulties are that different institutions holds different view, including the individual researchers view and their own institutions, that sometimes caused overlaps, miscommunications, and competing priorities among stakeholders…'*. Given that different interest also contribute to rivalry and mistrust [36], establishing reliable networks for information exchange must be a deliberate part of the institutionalization process of blue carbon policy. Stakeholders across sector obviously aware the importance of policy makers, especially the one that has specific mandates on blue carbon, for providing guidance and directions.

7. Conclusions

Transition from science to a policy design for blue carbon ecosystems is challenging for Indonesia. The blue carbon network contributes to both the advancement and the stifling of overall progress. We discovered that the network may hinder the institutionalization process of blue carbon policy in a variety of ways. First, the one who has a mandate on the network's most shared goal is not a central actor. This actor also lacks robust access to a diverse set of information needed for integrative decision making, which would allow for a comprehensive policy design process to take place.

Second, both of the two most central actors with the most connections received little trust from other actors. The disparity between having high degree centrality and indegree within the most central actors highlights the lack of trust received. Whereas trust is essential for stakeholders to share resources and establish shared goals, especially within a network setting. Third, there is a general lack of quality in the network's ties. All of these factors contributed to the fact that knowledge providers often do not have a clear direct impact upon policies. They are peripheral actors who, in fact, have been largely trusted by the network, as evidenced by their high degree of centrality and a track record of long-standing interactions with other actors.

The key to a resilient blue carbon governance network is thus to improve communication pathways between knowledge providers and policy decision makers by fostering network trust. As noted in the discussion section, several steps can be taken to improve the network's function in the institutionalization process. It is critical to provide policymakers more access to a diversity of information. Existing policymakers who are well-known and respected by the networks should also give direction and advice.

According to the findings of this study, networks play a significant

role in how information and science can help in the development of policy and regulation. Members of the network may better organize their actions to meet the collective goals by recognizing a few issues that may impede the institutionalization process. Furthermore, the outcome can be used to investigate the development of a wide range of topics other than blue carbon, particularly in connection to the emerging issues of coastal and marine affairs. Specifically, how current knowledge and science are conveyed amongst actors in the institutionalization process.

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CRediT authorship contribution statement

Ines Ayostina: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data curation Writing – original draft, Visualization, Project administration. **Lucentezza Napitupulu**: Conceptualization, Methodology, Validation, Writing – review & editing, Supervision. **Barakalla Robyn**: Funding acquisition, Supervision, Writing – review & editing. **Cynthia Maharani**: Validation, Data curation, Writing – review & editing. **Daniel Murdiyarso**: Writing – review & editing.

Declaration of Competing Interest

There is no conflict of interest to declare.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.marpol.2022.104955.

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