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Conservation of green blue carbon ecosystem: Local perceptions and awareness on mangrove forest

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Abstract

Management of blue carbon ecosystems including mangrove and seagrass beds is necessary to reduce the global carbon emissions and mitigate the impacts of climate change, in addition to the managements of terrestrial forest ecosystem. The scheme of the REDD+, which is Reducing Emissions from Deforestation and forest Degradation, plus the sustainable management of forests, and the conservation and enhancement of forest carbon stocks, has been used for the managements of different types of forests and related ecosystems. The concepts of REDD+ can be applied for the blue carbon ecosystems. In recent academic literatures, the discussion of the application of REDD+ is increasing, considering the characteristics of the management of blue carbon ecosystems. The management of blue carbon ecosystems need the various stakeholders' collaboration, because they are in the border of different ecosystems including terrestrial and coastal ones, where different types of livelihoods and industries co-exist. To identify the status of discussions of REDD+ for blue carbon ecosystems, literature review on REDD+ and blue carbon ecosystem management was conducted by using quantitative text mining approaches.

Regarding the local perceptions and awareness on mangrove forest, a case study in the Philippines was conducted. In concrete terms, household surveys to the locals in Eastern Samar were implemented to identify their perceptions and awareness. The analysis result can contribute to science-policy interface by providing the following information; resource utilization, level of awareness on ecosystem services and existing management plans, and perceptions on natural and anthropogenic threats. It reveals that social demography and level of awareness of the locals are factors which influence status of utilization of mangrove ecosystem services. Those result can be used as an evidence of policy making and facilitate the application of conservation schemes considering the local context of the study site.

Keywords: blue carbon ecosystems; REDD+; perceptions; local stakeholders; conservation

Introduction, scope and main objectives

Mangroves along with seagrasses and salt marshes, collectively referred to as blue carbon ecosystems (BCEs), have now gained international prominence because of their key role in reducing the risks and impacts of climate change while achieving multiple benefits such as food provision and coastal protection (Crooks et al. 2017; Macreadie et al. 2019). BCEs sequester and store carbon dioxide as organic carbon in their biomass and soil material and carry out this process for over thousands of years, which make them an important player of global carbon sequestration, in addition to terrestrial forests (Nellemann et al. 2009). However, despite the diverse ecosystem services they offer, they are globally declining due to anthropogenic and natural threats (Crooks et al. 2017).

Among the BCEs, mangroves received more attention from coastal communities because of their tangible role, for instance, as a coastal defense against storm surges and strong waves (Dasgupta et al. 2019). In the Philippines, locals highly perceived mangroves for their coastal protection services along with other ecosystem

services (Quevedo et al. 2021b). However, the country observed a decline in mangrove cover which has been mainly attributed to overexploitation by coastal residents and conversion to other uses such as aquaculture ponds, industry, and residential areas (Primavera 2000). Depletion of these resources will result in the loss of valuable ecosystem services which in turn affects local communities who are dependent on them (Primavera 2000). Thus, mangroves are now targeted in global conservation initiatives such as the International Blue Carbon Initiative and the Global Mangrove Alliance (Friess et al. 2020).

Mangrove ecosystems are being discussed in international policy platforms, and are included in different schemes such as incorporation to the Nationally Determined Contributions of countries to meet their pledges to the Paris Agreement of the United Nations Framework Convention on Climate Change (Friess et al. 2020). The mechanism behind this and feasibility of applications of existing schemes for BCEs are still unclear and needs to be examined further, which this study aims to address.

MEA (2005) highlighted the importance of understanding the relationships between ecosystem services and the people since these studies can potentially increase the efficiency of ecosystem conservation and management. Recent studies have documented that understanding the perception of communities on ecosystem services can provide insights on their role and how they function in multi-scale governance, which may contribute to overall sustainable management (Quevedo et al. 2021a, b). Moreover, Arifanti (2020) highlighted that involving the local communities in the mangrove management-related activities would increase the success of the program. Thus, we also included in this paper a case study, which was conducted by Quevedo et al. (2020), about public's awareness and utilization of mangroves and their perceived threats and management strategies. We aim that by doing so, these results can be used as an evidence of policy making and facilitate the application of conservation schemes considering the local context of the study site.

Methodology/approach

In the review research of REDD+ and BCEs, we conducted keywords analysis of existing papers. To focus on the blue carbon related research, relevant papers analyzing or reviewing blue carbon and mangrove were detected. The extracted keywords were analyzed based on the fields of studies and regions (Miwa et al. [under review]). The term, blue carbon, was mentioned in existing papers in different fields of research, however, studies focusing on BCE managements are rather limited especially in the early phase of the BCE research. For example, natural science approaches were applied in assessing the dynamics of BCEs' carbon stocks and fluxes, and limited social science investigations were conducted. Considering such circumstances, we focused on existing research on blue carbon and mangrove. In existing studies, analyses of coastal management plans and spatial plans were also conducted (Lukman et al. 2019; Quevedo et al. 2021c), in addition to the analysis on academic papers. The forthcoming paper will provide the detailed results of keyword analysis, thus, in this paper, we only provide the results of household survey, which is elaborated below.

The household surveys were conducted in the municipalities of Lawaan, Balangiga, Salcedo, and Balangkayan in the province of Eastern Samar, Philippines (Quevedo et al. 2020). The sites were selected based on the presence of mangrove ecosystems and the presence, proximity, and access of local communities to mangroves (Fig. 1). The sample size in each municipality was calculated at a 95% confidence level with a 10% sampling error based on the 2015 population census. A total of 372 individuals were surveyed in this study. The respondents were selected randomly and interviewed using a structured-questionnaire. The questionnaire which was translated to Waray, the local language of the province has four sections (A-D). Section A profiled the socio-demographic characteristics (e.g. age, education) of the respondents. Sections B and C collected the utilization frequency and awareness level of the respondents, respectively, using a five-point Likert Scale. The last section gathered the perceptions of management activities and natural and anthropogenic threats. Descriptive statistics were used to show the respondents' socio-demographic characteristics, awareness and utilization of mangrove's ecosystem services, and their perceptions of management activities. Spearman's rank

correlation (ρ) analysis was carried out to evaluate significant associations between locals' socio-demographic attributes and their utilization behavior and knowledge on ecosystem services.

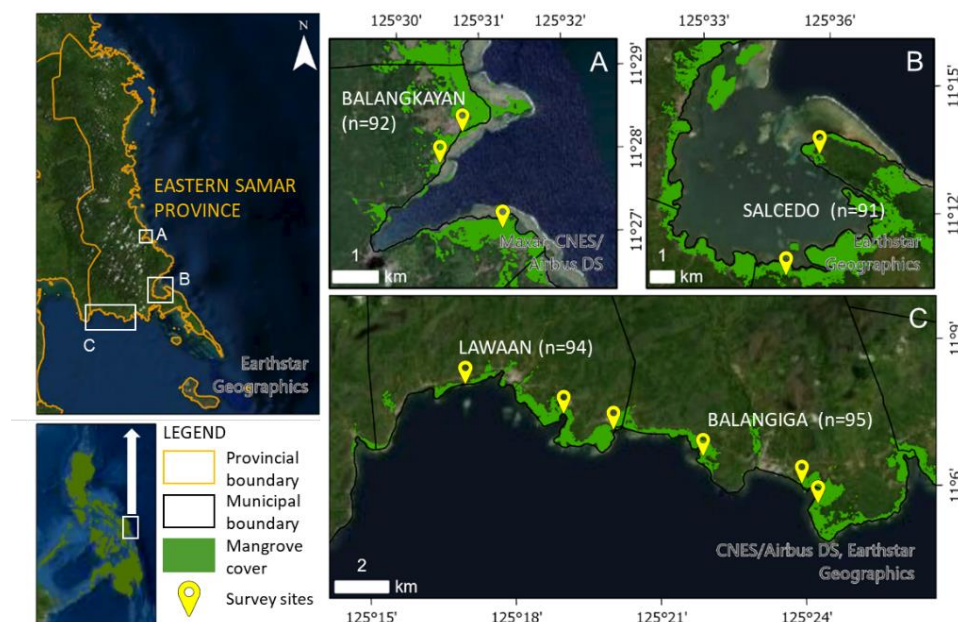


Fig. 1: Location map of the study sites (modified from Quevedo et al. 2020a).

Results

Respondents' awareness and utilization of mangrove ecosystem services

The respondents' socio-demographic profile, awareness level, utilization frequency, perceived management strategies, and perceived threats presented in this study are all derived and modified from Quevedo et al. (2020). The age varies from 20 to 80 years old across the sites with a mean age of 48 years old. In terms of highest educational attainment, 30.8-47.9% of the respondents have finished primary education, 32.6-35.8% have attained secondary education, 3.2-14.7% are college graduates while 14.9-27.5% have reached elementary level. Majority (28.3-60.4%) of the respondents across the sites are fishers while 7.7-22.8% are farmers, 23.1-44.6% are salaried individuals (i.e. skilled workers), and 4.4-16.0% are housewives.

The respondents were asked about their knowledge of the ecosystem services (Fig. 2) and the frequency of using these benefits (Fig. 3). Twenty-three to sixty percent (23.0-63.0%) of the respondents are 'extremely aware' that mangroves can be a source of food (i.e. fishes, mollusks). Their high knowledge of mangroves' provisioning services complements well with their utilization behavior, 26.1-59.6% of the respondents collect fishes and other seafood in mangroves every day for their consumption while others (5.3-35.9%) do it at least once a week. If the daily fish yield is abundant, a few (12.1-29.8%) of the respondents sell their catch to their neighbors or at local markets. Majority (89.5-100.0%) of the respondents never extracted mangroves for firewood materials. In terms of respondents' knowledge of regulating services, 44.3-90.4% of the sample size are 'extremely aware' of the coastal protection benefits of mangroves against storm surges and strong waves. Mangrove's air and water purification functions are also well recognized with 9.9-52.2% and 7.6-52.2% of the respondents, respectively, are 'very' to 'extremely aware'. For the carbon sequestration functions, awareness was relatively low, 13.7-65.2% of the respondents are 'not aware'. Lastly, perceptions on cultural services vary across sites: 32.6% of the respondents in Balangiga are 'very aware', 23.1-30.9% of the sample size in Salcedo and Lawaan are 'not aware', and 42.4% of respondents are 'extremely aware' in Balangkayan. In terms of

utilization frequency, majority (70.5-97.8%) of the respondents have never accessed mangroves for recreational activities.

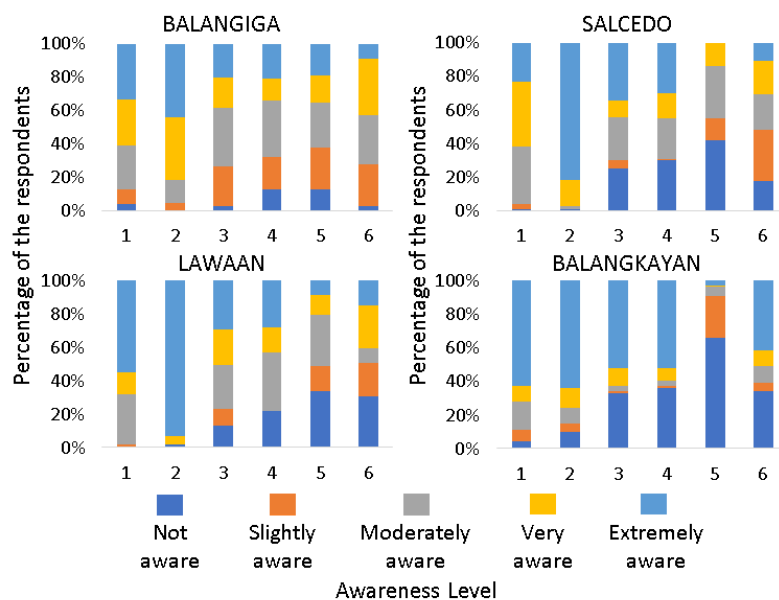


Fig. 2: Respondents' awareness level of ecosystem services – (1) Food source, (2) Coastal protection, (3) Air and (4) Water purification, (5) Carbon sequestration, and (6) Recreational site (modified from Quevedo et al. 2020a).

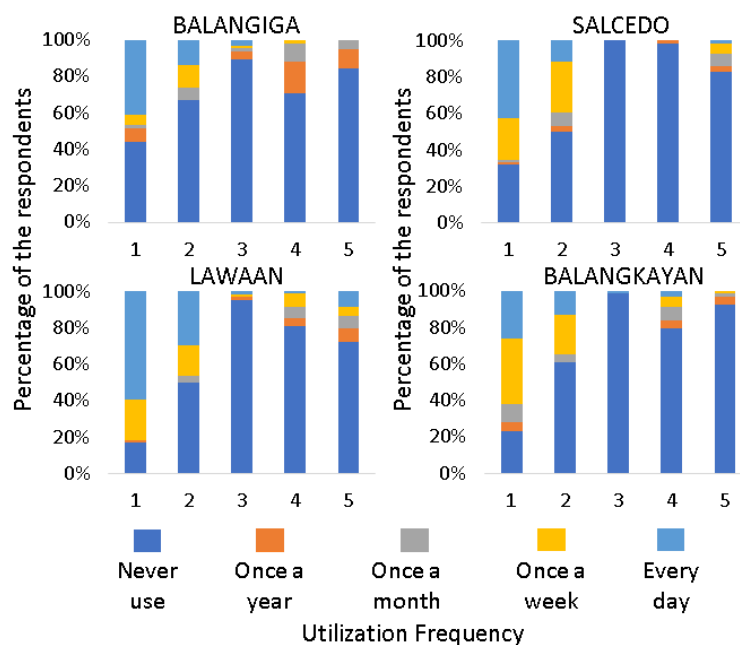


Fig. 3: Respondents' utilization frequency of ecosystem services – (1) Fishing/collecting seafoods for consumption, (2) Fishing/collecting seafoods for sale, (3) Extracting for firewood materials, (4) Recreational site bird or bat watching, and (5) Recreational site for mangrove boardwalks or eco-trails (modified from Quevedo et al. 2020a).

The relationships between the respondent's occupation, awareness level, and utilization frequency were explored in this study using correlation analysis. Results show significant associations among the variables

(Table 1). For instance, fishing for own consumption and sale significantly correlates with their livelihood (e.g. fishers) while respondents with high awareness that mangroves are a good source of food will collect seafood more frequently, and vice versa. The analysis also generated statistically significant negative correlations which suggest a reverse relationship between the variables. For example, occupations that are not directly related to fishing can also have high utilization. Housewives and farmers could use their time to fish or collect seafood.

Table 1: Correlation analysis between the respondents' socio-demographic characteristics, awareness level, and utilization frequency (modified from Quevedo et al. 2020).

	Fishing for consumption				Fishing for sale			
	Balangiga	Salcedo	Lawaan	Balangkayan	Balangiga	Salcedo	Lawaan	Balangkayan
<i>Socio-demographic characteristics</i>								
Age	-0.305				-0.238			
Education								
Fisher			0.354	0.428	0.366	0.368	0.689	0.441
Farmer	0.315						-0.324	
Salaried Individual	-0.305			-0.226	-0.265	-0.221	-0.256	-0.226
Housewife		-0.216	-0.264	-0.255			-0.305	
<i>Ecosystem services</i>								
Source of fish		0.544	0.366		0.355	0.414		
Coastal protection	0.336		0.231					
Carbon sequestration	0.325	0.507	0.317	-0.213		0.442		
Recreational site								

Note: Only statistically significant values (p -value < 0.05) are shown in this table.

Respondents' perceived threats and mangrove management strategies

Perceptions of management plans and threats were collected from the respondents. For the management, this was evaluated through the respondent's participation in coastal management activities. As shown in Fig. 4, 60.9-95.6% of the respondents have participated in coastal management activities such as coastal clean-up and mangrove planting while 4.4-39.1% have not joined yet. The willingness of the respondents to join the management activities complements well with their perception of who should manage the mangroves. Majority (71.7-100.0%) of the respondents perceived themselves to lead in mangrove management (Fig. 4). For the perceived threats, natural calamities such as typhoons and strong waves are the most concerning threats to mangroves across the study sites as perceived by 29.5-94.6% of the respondents. Conversely, the perceived least threats are conversion fishponds in Balangiga, Salcedo, and Balangkayan (35.2-75.0% of the respondents) and domestic pollution in Lawaan (35.1% of the respondents).

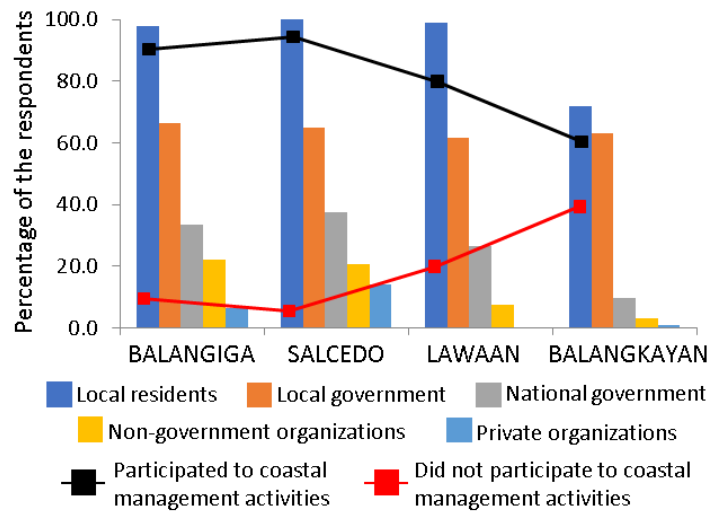


Fig. 4. Respondents' perceived stakeholders that should manage the mangroves overlaid with participation to coastal management activities (modified from Quevedo et al. 2020a).

Discussion

Locals' perceptions of mangrove ecosystems and management

This study presents the potential factors that affect locals' perceptions of mangrove ecosystems and how these perceptions translate to management practices. The socio-demographic attributes of the respondents affect the utilization frequency of mangrove services. For instance, respondents who are fishermen have higher (as expected) utilization yields compared with other occupations. Although respondents' occupation can explain the patterns reflected in the utilization frequency, the level of awareness of mangrove services has been observed to be an important driver as well. Based on the correlation analysis done, respondents with high awareness of the provisioning services of the mangroves have higher utilization rates whereas those with low awareness tend to utilize less. Another example is the low rate of extraction of mangroves for firewood materials which can be attributed to respondents' high awareness of mangrove benefits coupled with strict implementation of the "no illegal cutting of mangrove" policy of local government. For perceptions on coastal protection services of mangroves, respondents highly perceived this benefit based on their personal experiences and observations particularly when super typhoon Haiyan hit their towns. Similar observations were documented by Delfino et al. (2015) in their perception survey in Leyte and Eastern Samar. For the carbon sequestration, the low awareness of the respondents statistically correlates well with their educational attainment; college level and college graduates have high awareness whereas locals who finished elementary and highschool have low awareness. In general, respondents' awareness level and socio-demographic characteristics can affect their utilization behavior of mangrove services. In recent studies, awareness, socio-demographics, and utilization correlate with each other in certain degrees (e.g., Lukman et al. 2021; Quevedo et al. 2021a). Although this study presented significant correlations among the observed parameters, it is important to explore multiple factors to better understand the variations reflected on the perceptions of mangrove ecosystems and their services across the study sites.

The zero to low utilization frequency of cutting mangrove trees documented in this study can indicate that existing management interventions such as "no illegal cutting of mangrove policy" are effective. Respondents' high recognition of themselves to lead the management corresponds well with their willingness to participate in coastal management activities like mangrove planting and coastal clean-up (see Fig. 4). Community-led management has been known to influence the success of managing coastal resources (Camacho et al. 2020). In

Banacon Island, Bohol in central Visayas, organizing and strengthening of people's organization (Banacon fisherfolks and mangrove planters' association or BAFMAPA) has resulted in a successful mangrove forest management through mangrove planting and strong commitment of the locals (Gevaña et al. 2018). According to Muhamad et al. (2014), local stakeholders should be integrated into ecosystem management since they are the ones who manage, utilize, and change these ecosystems. Moreover, engaging local communities in mangrove forest management is ideal since it decentralizes the management functions, particularly to resource-dependent locals since they have better stakes in the conservation and protection of mangroves (Gevaña et al. 2018).

Conclusions/ wider implications of findings

The perceptions of local communities can provide insights into future management strategies. For example, the low awareness of carbon sequestration services of mangroves can be a baseline for local government units to invest more in IEC (Information and Educational Campaigns) materials about these benefits. Local government units can educate coastal communities on mangrove ecosystem services while communities can support them through active participation and cooperation in coastal management activities. Respondents' high recognition of mangroves' vulnerability to natural threats can initiate proper mitigations (e.g., science-based mangrove planting) to be in-placed in the study sites. Moreover, local government units can invest more in implementing community-based mangrove management since the respondents are willing to lead and participate in management activities.

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