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MASTER OF ENVIRONMENT AND NATURAL RESOURCES MANAGEMENT

JOMARK T. ABLITER

SPATIO-TEMPORAL ANALYSIS OF THE MANGROVE FOREST WITHIN THE DUMANQUILAS BAY PROTECTED LANDSCAPE AND SEASCAPE (DBPLS): IMPLICATION TO MANGROVE MANAGEMENT AWARENESS IN MALANGAS, ZAMBOANGA SIBUGAY

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21 December 2023

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This Special Problem entitled "**SPATIO-TEMPORAL ANALYSIS OF THE MANGROVE FOREST WITHIN THE DUMANQUILAS BAY PROTECTED LANDSCAPE AND SEASCAPE (DBPLS): IMPLICATION TO MANGROVE MANAGEMENT AWARENESS IN MALANGAS, ZAMBOANGA SIBUGAY**" is hereby accepted by the Faculty of Management and Development Studies, U.P. Open University, in partial fulfillment of the requirements for the degree Master of Environment and Natural Resources Management.

DR. CONSUELO DL. HABITO
Faculty-in-Charge, Special Problem

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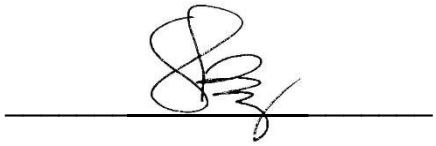
DECLARATION

This is to certify that:

I. The special problem comprises only my original work towards the MENRM except where indicated in the Preface.

II. Due acknowledgment has been made in the text to all other material used.

III. The special problem is fewer than 25,000 words in length, exclusive of tables, maps, bibliographies and appendices.



Jomark T. Abliter

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To God be the Glory.

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ABSTRACT

Mangroves are taxonomically diverse group of trees and woody shrubs that dominate the transitional margins and comprise one of the Earth's important ecosystems. This study aims to evaluate the site-specific management plan for the mangrove forests of the Dumanquilas Bay Protective Landscape and Seascape within the Municipality of Malangas, Zamboanga Sibugay by determining the spatio-temporal changes within the mangrove ecosystem using available remote sensing data and techniques and determining the level of awareness of its key stakeholders in terms of the ecosystem services and mangrove management.

The results revealed the mangrove forest within the study area lost about 43.81 ha, or about 12.30% of its land cover from 2003 to 2020. The largest decrease in land cover coincides with the alleged increase in the conversion of mangrove forest into fishponds and the proliferation of illegal cutting of mangroves. In addition, a more varied level of stakeholder awareness was identified across all key areas: mangrove species, mangrove ecosystem services, NIPAS Act, and issues with the current mangrove management.

Overall, despite the optimism demonstrated by the respondents, an improvement in the awareness of the key stakeholders is needed to ensure a more sustainable participatory mangrove management in DBPLS. Nevertheless, the current mangrove management is satisfactory considering the limited budget for the protected area, and the respondents were able to provide valuable insights on mangrove management. It is recommended to conduct another analysis of mangrove forest land cover using updated GIS datasets to further check the effectivity of the management plan and broaden the number of respondents to further evaluate the level of

awareness of the local community as well as the additional measures that can be implemented.

Keywords: mangrove, remote sensing, NIPAS Act, mangrove management

I. INTRODUCTION

Mangroves are taxonomically diverse group of trees and woody shrubs that dominate the transitional margins such as intertidal muddy shores, marshes, and swamps. These plants can tolerate fluctuating conditions of these transitional environments, including, but not limited to, salinity, dissolved oxygen concentrations, and even temperature (Hogarth, 2007).

Mangrove forests, being one of the most important ecosystems on Earth, has been the subject of a lot of studies worldwide. However, despite several studies done on various mangrove ecosystems, there are still a lot of knowledge gaps in terms of their ecological roles and the ecosystem services they provide (Lee et al., 2014). Mangrove ecosystems are severely threatened and undervalued; thus, identifying these knowledge gaps are important in determining all the use (direct and indirect) and non-use (option and existence) values of specific mangrove ecosystems in order to estimate its total economic values (Sondak et al., 2019). The total economic benefits from mangrove ecosystems are important in designing the appropriate and site-specific management approaches and strategies, especially for those values that are not easily convertible to monetary values, and to improve awareness of local stakeholders and ensure a more sustainable community-based mangrove forest management.

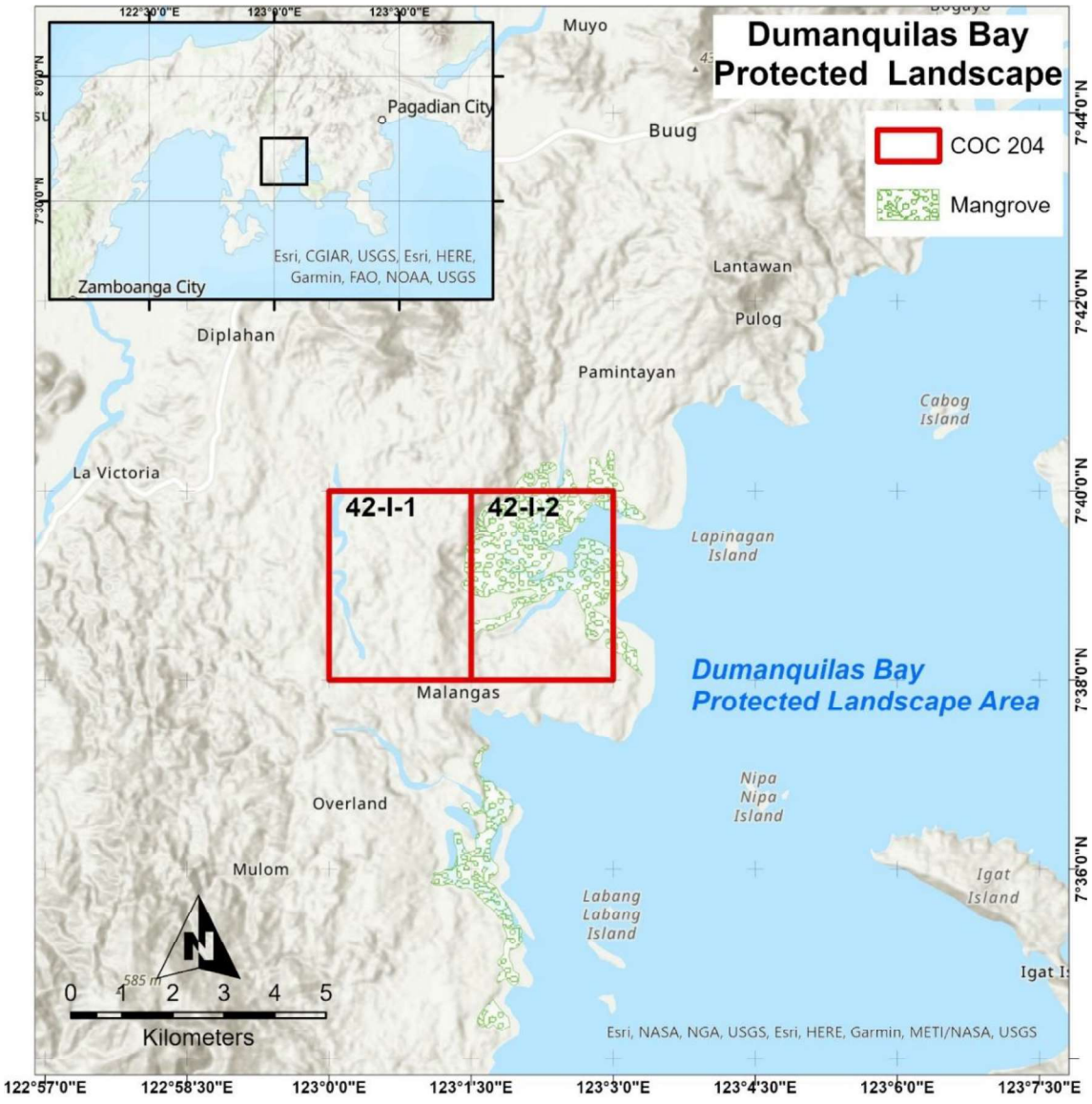
Location and Accessibility

The study area is a small portion of PNOC Exploration Corporation's (PNOC EC's) Coal Operating Contract (COC) No. 204 that overlaps with the Dumanquilas Bay Protected Landscape and Seascape (DBPLS), which is a marine protected area covering the subtidal, intertidal, and coastal areas of the Dumanquilas Bay by virtue of the Proclamation No. 158, series of 1999 in relation to Republic Act No. 7586, otherwise known as the National Integrated Protected Area System (NIPAS) Act of 1992 (**Figure 1**). PNOC EC's COC No. 204 is composed of two (2) coal blocks with a total area of about 2,000 hectares.

The study area is situated in the municipality of Malangas, Zamboanga Sibugay Province (ZSP) in southwestern Mindanao. It is accessible via the nearest airports in Pagadian City (Zamboanga del Sur), Ozamiz City (Misamis Occidental), and Zamboanga City, which are about 80 km, 160 km, and 205 km, respectively, from Malangas Municipal Hall through the Pan-Philippine Highway.

The municipality of Malangas is a 3rd class municipality of Zamboanga Sibugay Province with a total population of 32,022 based on the 2020 census. The municipality has a land area of about 235 km^2 composed of twenty-five (25) barangays spread all over its generally rolling and mountainous terrains (PhilAtlas, n.d). **Figure 2 to Figure 4** show the municipality's location, administrative boundaries, and land use, respectively.

Figure 1. Map of COC 204 showing DBPLS overlapping with Coal Block System (CBS) 42-I-2 (Source: PNOC EC, 2022).



About 56.7% of the municipality's land area are agricultural lands (**Figure 4**), and merely 2.8% represents the mangrove forests along the coastlines of Malangas, where portion of DBPLS is part of. Although not indicated in the Land Use Map (**Figure 4**), Malangas is known for coal mining, its coal being one of the best in the Philippines in terms of coal quality or heating value.

Figure 2. Location map of Malangas, Zamboanga Sibugay in southwestern Mindanao (Source: Malangas Municipal Planning and Development).

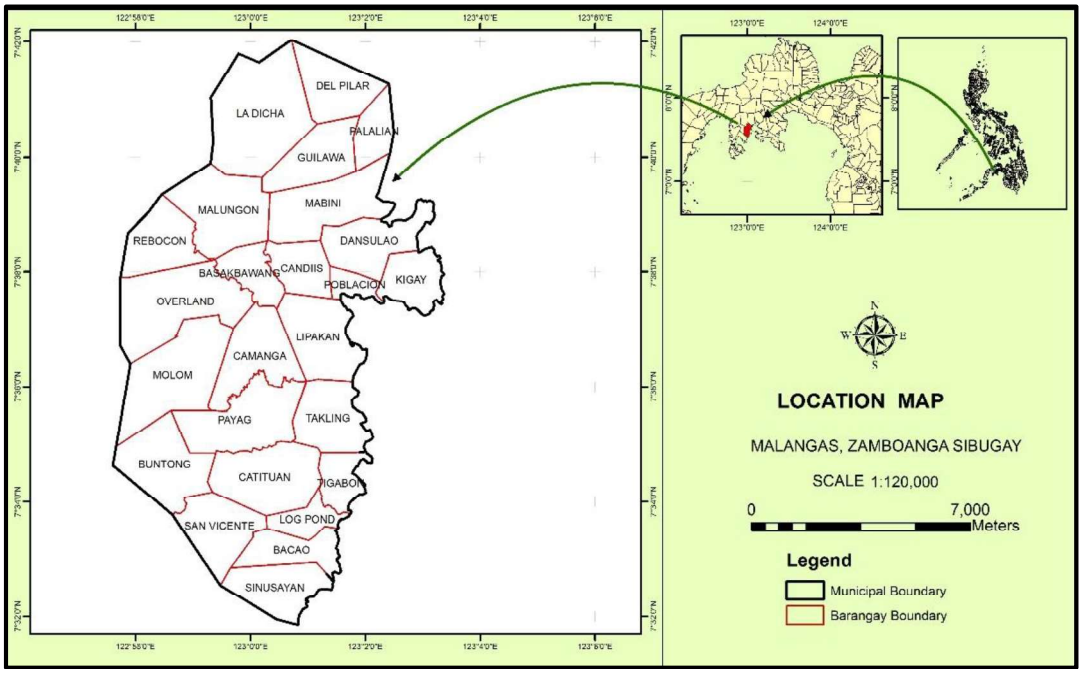


Figure 3. Administrative map of Malangas showing its 25 barangays and their boundaries (Source: Malangas Municipal Planning and Development).

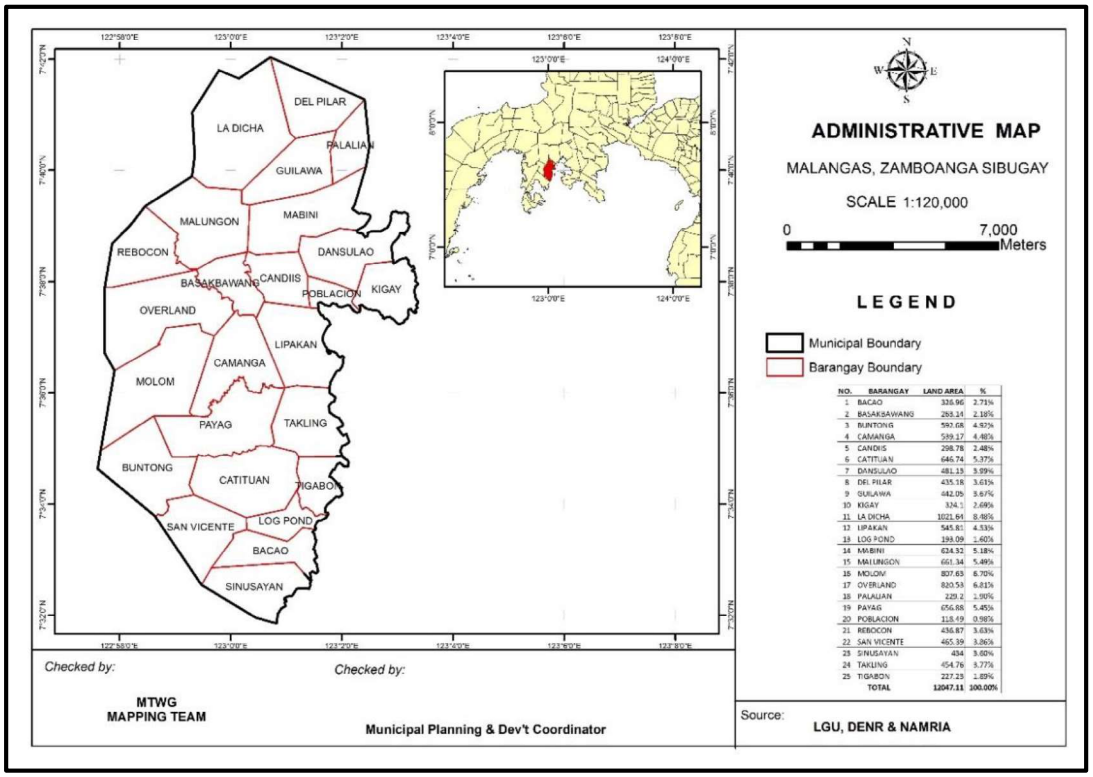
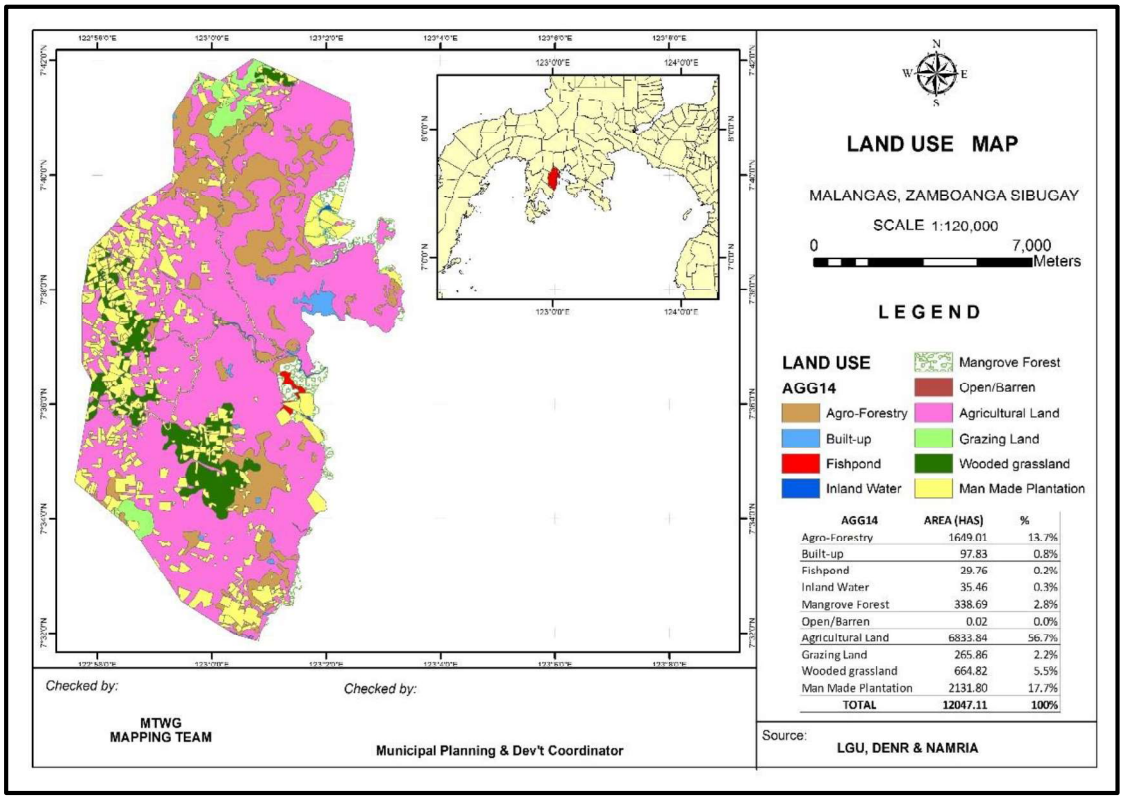


Figure 4. Land use map of Malangas showing ten (10) land use categories (Source: Malangas Municipal Planning and Development).



NIPAS Act of 1992

Republic Act 7586, otherwise known as the NIPAS Act of 1992, was promulgated to secure the perpetual existence of native plants and to protect biologically important public lands, biogeographic zones, and related ecosystems through the establishment of comprehensive system of integrated protected areas. It emphasizes that protected areas shall be governed by management strategies adopting applicable innovative techniques and using science-based studies for site-specific policy development. With this, a Protected Area Management Board (PAMB) for each protected area shall be established, composed of representatives from the regional and local government units as well as representatives from non-governmental organizations and the local communities. The PAMB will be responsible in managing the protected area which shall include their administration, budget allocations,

planning, approval, and implementation of various activities within the protected area. The funds for protected areas may come from donations, endowments, or grants, as well as from income taxes from permitted sale of resources within the protected area, proceeds from multiple-use areas, contributions, and other available fees and payment schemes.

II. REVIEW OF LITERATURE

Hogarth (2007) provided a comprehensive discussion of the biology of mangroves, including their common adaptations to their environment, unique structures, various communities, and biodiversity, as well as the ecosystem services they provide and how climate change has impacted them. Kathiresan (2012) made a thorough review of the importance of mangrove ecosystems in terms of the economic benefits they generate from wood and non-wood forest products, fishery products, and the invaluable ecological services they provide, such as the screening of the solar UV-B radiation, reduction of the greenhouse effect, coastal protection from floods, storms surges, tsunamis, and coastal erosions, trapping and recycling of nutrients and sediments, supporting fisheries and wildlife population, biomass and litter production and decomposition, and supporting food webs and energy fluxes in the entire coastal ecosystems and even to other marine ecosystems. However, for the mangrove forest of the DBPLS, there are still knowledge gaps and very minimal community awareness in terms of their ecological roles and the ecosystem services they provide to the local community. UNEP (2014) emphasized the need for mangroves to be understood for their valuable socio-economic and ecological resource to be able to conserve and manage them sustainably.

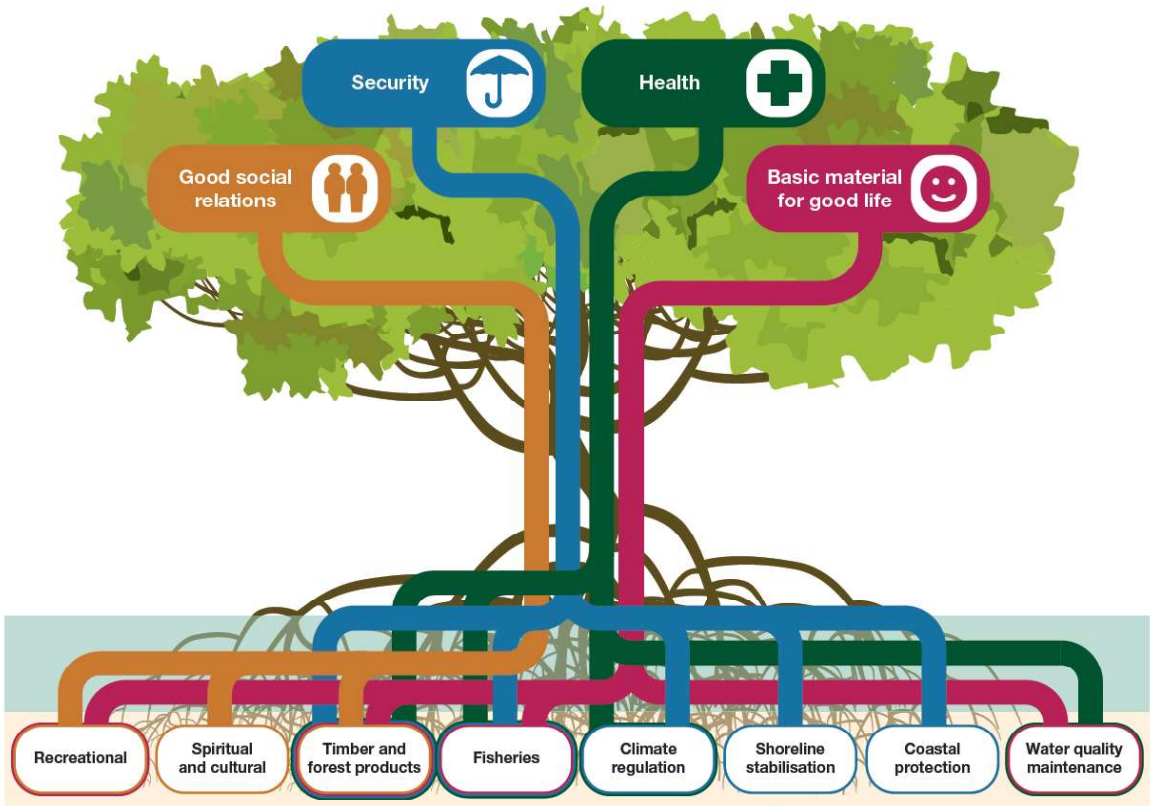
Table ***1*** summarizes the different ecosystem services provided by mangroves, while **Figure 5** shows a graphical representation of how mangrove ecosystem services support human well-being (UNEP, 2014).

Table 1

Summary of the Different Ecosystem Services Provided by Mangroves (Source: UNEP, 2014)

Provisioning	Regulating and supporting	Cultural
Timber and other construction materials	Climate regulation	Ecotourism
Fisheries	Coastal protection	Heritage and culture
Biodiversity	Water quality maintenance	Spiritual enrichment
Medicine	Nutrient cycling	Religious value and cultural ceremony
Food	Water cycling	Recreation
Fuelwood	Soil stabilization and erosion control	Aesthetics
Fiber	Provision of nursery habitats	Education
Tannins	Support to coral reefs, seagrass beds, mud flats, and sand flats	Scientific research
Fodder		

Figure 5. Graphical representation of how various mangrove ecosystem services support human well-being (Source: UNEP, 2014).



Hindersah et al. (2016) and Lee at al. (2014) argued the importance of filling in the knowledge gaps and characterizing the mangrove ecosystem and valuation of its ecosystem services prior to designing a sustainable management and development strategies in the coastal areas that considers the participation of local communities and all its stakeholders. Characterizing a mangrove forest can be done through large-scale mapping of the area using remote sensing data complemented with ground surveying. Kuenzer et al. (2011) provided a critical summary of literature and works undertaken on mangrove ecosystems using remote sensing techniques which is a good reference in determining the most suitable mangrove mapping data or technique to be used based on objectives of the study, the required accuracy, and the availability of resources. One example is a study of the transformation of the mangrove forest cover through time (Sainadh and Tripathi, 2018), among others (Barka et al., 2011; Kuenzer et al., 2011; Hammond, 2005; Dikau et al., 1991).

Various regional to local mangrove management resources (UNEP, 2014; DENR, 2013; Kustanti et al., 2012; Giesan et al., 2006; Melana et al., 2000) are already available which could be excellent basis for site-specific mangrove management for DBPLS that considers its specific biophysical characteristics and the socio-cultural perspectives of its stakeholders and the local community. The policy study of DENR (2013) was able to identify critical policy concerns involving abandoned, undeveloped, underutilized, illegally titled fishponds, special agreements for mangrove area developments, among others, and what policy reforms need to be adopted to improve the conservation of mangrove forest for a more sustainable mangrove management.

UNEP (2014) provided a science-based synthesis of the ecosystem services of mangroves while enumerating several management and protection measures that may be implemented at various scales to ensure a more sustainable mangrove

management. Some of these options may be applicable locally to the mangrove forest of the DBPLS and may be included in the interview questionnaire as follows:

- Provision of financial mechanisms and incentives, investment opportunities for private sectors, and payments for ecosystem services (PES)
- Developing protocols in the protection and sustainable use of mangroves
- Strict enforcement of all relevant laws and policies while providing income for the local communities
- Promoting other ecosystem services being provided by mangroves such as effective natural and adaptive defense structures in coastal development, reducing vulnerability to climate change, etc.
- Restoration or rehabilitation of lost or damaged mangroves and their biodiversity
- Educating the public to increase awareness of the economic and social importance of mangroves and the consequences of their loss.

Similarly, Melena et al. (2000) enumerated protection and management strategies categorized into assignment of users or property rights, regulatory techniques, and non-regulatory techniques (**Table 2**), while Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis of the integrated management of mangrove ecosystem in Indonesia also shows the similar strategies that will promote innovation and conservation of mangrove ecosystem while developing the welfare of the local community and its economy (Kustanti et al., 2012).

Table 2

List of Protection and Management Strategies for Mangrove Forests (Source: Melena et al., 2000)

A. Assignment of users or property rights	Protected areas (under the Protected Area Management Board) Contracts, permits, and leases (e.g., Mangrove Stewardship Agreement, Certificate of Stewardship Contract, Community-Based Forest Management Agreement, Nipa Lease Permit, etc.)
B. Regulatory techniques	Use of prohibitions (e.g., illegal cutting of mangroves, no illegal conversion of mangroves into fishponds, etc.) Use of regulation based on prescribed resource use plan Exploitation limitations Enforcement of forest laws
C. Non-regulatory techniques	Public education (e.g., seminar/workshops, meetings, dialogues, publications, etc.) Training on mangrove rehabilitation and management, alternative livelihood, enterprise development, cooperatives Mangrove rehabilitation/reforestation Research and monitoring (e.g., mangrove resource assessment, socioeconomic profiling, impact monitoring, etc.) Community participation in planting mangroves, fisherfolks organizations, women's organizations, NGOs, cooperatives Special projects (e.g., coastal cleanup, waste management, etc.) Alternative livelihood (i.e., fishery, cottage industry, seaweeds, mariculture, etc.)

Camacho et al. (2020), on the other hand, synthesized the best practices and challenges encountered in mangrove rehabilitation and provided a general framework or guidelines based on the community-based mangrove management practices from the Philippines. It listed the applicable steps in mangrove management and/or rehabilitation as follow:

(1) Local site coordination

(2) Comprehensive site assessment

(3) Participatory mangrove planning

(4) Participatory implementation of mangrove management

(5) Participatory monitoring and evaluation

Camacho et al. (2020) emphasized the need for the involvement of people during planning, implementation, and monitoring of management policies; thus, improving the knowledge of the local community about mangroves and mangrove management are essential.

Five-Year DBPLS Management Plan

Dumanquilas Bay Protected Landscape and Seascape is a Protected Area that covers a total of about 29,663 hectares and traverses four (4) municipalities of Zamboanga del Sur (Vicenzo A. Sagun, Margosatubig, Lapuyan, and Kumalarang) and two (2) municipalities of Zamboanga Sibugay (Buug and Malangas).

DBPLS was officially established August 10, 1999, by virtue of Presidential Proclamation No. 158, issued by then President Joseph Ejercito Estrada pursuant to the provisions of the NIPAS Act. It encompasses both terrestrial and aquatic ecosystems within the Zamboanga del Sur and Zamboanga Sibugay, affecting forest resources, fisheries, water resources, and mangroves.

Mangroves are important ecosystem that provides source of food and livelihood to coastal residents. Giesan et al., (2006) provided a simple guidebook for the management and conservation of mangroves in some parts of the Southeast Asia, including the Philippines, which highlights the importance of understanding the different mangrove species and their habitats. Based on the DBPLS Management Plan (2018-2022), there are about 18 species of mangroves recorded in the DBPLS, of which 15 species are found in the municipality of Malangas (Table 3).

Table 3

Mangrove Species Present in Malangas, Zamboanga Sibugay (Source: DBPLS PAMB, 2017; Primavera, 2009).

Mangrove Species	Local Name
Sonneratia alba	Pagatpat
Bruguiera parviflora	Langarai
Rhizophora apiculata	Bakhaw lalaki
Avicennia alba	Bungalon, apiapi, miapi
Rhizophora mucronata	Bakhaw babae
Avicennia rumphiana	Bungalon, apiapi, miapi
Aegiceras corniculatum	Saging-saging, tinduk-tindukan
Bruguiera gymnorrhiza	Pototan, busain
Avicennia marina	Bungalon, apiapi, miapi
Bruguiera sexangula	Pototan
Xylocarpus granatum	Tabigi
Aegiceras floridum	Saging-saging, tinduk-tindukan
Sonneratia caseolaris	Pedada
Lumnitzera littorea	Tabao, culasi
Ceriops tagal	Tungog, tangal

The Management Plan already identified poverty as the root cause of the problem in DBPLS, which forces families and the communities to resort to destructive activities such as illegal fishing (i.e., overfishing, using explosives), cutting of mangroves, among others. Other problems mentioned include the weak enforcement of the law, disregarded zone classifications, and volatile peace and order. The plan recommended strong shoreline management approach to be implemented by the six (6) covered municipalities.

It can be generally agreed upon that the adoption of a clear participatory approach and integrated coastal management approach is needed to ensure a more harmonized LGU ordinances and regulations for the DBPLS. In this case, an Integrated Baywide Resource Management programs is being implemented. The Dumanquilas Bay Protected Area Management Board (DBPAMB), composed of forty-

one (41) members representing the local government units (barangays and municipalities), the business sector, fishery sector, and the civil societies (i.e. NGOs), leads the monitoring and implementation of these bayside management programs.

In terms of the mangrove forest of the DBPLS, the DBPAMB also adopts an Ecosystem Approach as well as the Community-Based Forest Management (CBFM) Framework to ensure community ownership of these mangrove areas. Community-Based Forest Management Agreements (CBFMAs) are being issued and monitored, and thorough information and education campaigns are being conducted. Moreover, denuded mangrove areas and idle/undeveloped fishponds are being rehabilitated.

The DBPLS management plan provided a clear and comprehensive list of actions to protect the DBPLS which include capability-building and skills training activities, livelihood options, and funding requirements. Other specific plans include establishment of the DBPLS database system, underwater habitat monitoring, more economic valuation studies, good waste management, regular seaborne patrol/surveillance, ecotourism management, and appropriate zoning. It discussed the importance of the DBPLS zoning which aims to delineate specific use zones to regulate activities and avoid conflicts among LGUs and local communities. Identified zones have different rules for activities that may either be allowed, prohibited, or may be allowed with required permits and other government processes. There are two (2) general types of zones within DBPLS: (1) Strict Protection Zones (i.e., Marine Protected Areas, Sanctuaries, Restricted Areas, Buffer zones) and (2) Multiple Use Zones (i.e., Mariculture zones, Ecotourism zones). For Strict Protection Zones, the following specific management measures are prescribed:

- The number of humans and human activities are highly regulated.
- Setting up of fences and/or boundary buoys

- Regular patrolling of the areas
- Prohibition of destructive fishing methods
- Regulated extraction of marine resources
- Buffer zones provide social fence to prevent encroachment into the core zones, thus, some activities are allowed (i.e., traditional fishing, ecotourism activities).

On the other hand, Multiple Use Zones allow settlements, livelihood activities, resource extraction, and other non-destructive activities. Illegal fishing methods are still prohibited, while the establishment of permanent structures require permits from the PAMB. Mariculture must be a registered fisherfolk/organization and shall secure permit/clearance from their respective municipalities. All these activities within these zones shall still conform strictly to the guidelines under the NIPAS Act.

The DBPLS Management Plan enumerated its long-term goals into management strategies categorized into: (a) institutional development, (b) ecosystem approach to fishery management, (c) ecotourism development and management, (d) waste management, (e) enterprise and livelihood development, and (f) gender development and reproductive health management. All of these have specific action plans or activities with their corresponding expected outputs, timeframe, and budgetary requirements. Moreover, a separate monitoring and evaluation framework for the abovementioned strategies was established to ensure effectiveness and efficiency of the plan implementation, as well as to develop other measures or strategies that could also be effective and sustainable for the long-term.

III. OBJECTIVES OF THE STUDY

Evaluate the site-specific management plan for the mangrove forests of the DBPLS within the Municipality of Malangas, ZSP.

Specific Objectives

1. Determine the spatio-temporal changes within the mangrove ecosystem of the DBPLS using available remote sensing data and techniques.
2. Determine the level of awareness and local perceptions of key stakeholders in terms of the ecosystem services provided by mangrove forests as well as its environmental management.
3. Obtain valuable information on mangrove management throughout the years from key stakeholders which will be useful in evaluating the management plan and crafting more suitable management strategies, if necessary.

IV. RATIONALE

There are very limited data and information available on the condition of the mangrove forest of the DBPLS, its economic value (direct and indirect), and how this mangrove forest is being managed by the local community. This study aims to fulfill this knowledge gap using available remote sensing data and targeted interviews with the local community. This study will assess the awareness of the stakeholders on their knowledge of the mangrove forest as well the current management plan of DBPLS. It will be valuable in designing a more suitable mangrove management strategies if the need arises. The evaluation of the current management plan of DBPLS and the possible development of new management strategies for its mangrove forest, being situated in between terrestrial and marine ecosystems, will address at least three (3) out of the seventeen (17) Sustainable Development Goals (SDG): SDG 6 (Ensure availability and sustainable management of water and sanitation for all), SDG 14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development), and SDG 15 (Protect, restore and promote sustainable use of terrestrial ecosystems) (U.N. 2015).

V. SIGNIFICANCE OF THE STUDY

The synthesis of all the data and information collected for this study will be the basis for evaluating the current management plan for DBPLS and the possible development of a more suitable site-specific mangrove management strategy for its mangrove forest. The management strategies may include the sustainable extraction of mangrove forest products, possible addition of corridors, creation of payment schemes to support the protection and conservation efforts and strengthening participation of local stakeholders in decision-making and environmental management. Aside from directly addressing three out of 17 SDGs, the study is expected to contribute to increasing the awareness of the local stakeholders and to improving the quality of life of the local community.

VI. MATERIALS AND METHODS

The methodology for the study involves two (2) main steps: (1) general characterization of the spatio-temporal changes of the mangrove forest of the DBPLS using available GIS datasets and remote sensing techniques, and (2) interview with various stakeholders to obtain valuable information on the management of the mangrove forest of the DBPLS. All these steps are complemented with extensive literature on mangrove ecosystems, remote sensing techniques, and various management approaches and strategies applicable for the study area.

The Study Area: The Mangroves of DBPLS

By virtue of the Proclamation No. 158, series of 1999, the then President Joseph Estrada declared the Dumanquilas Bay as protected area and its peripheral areas as buffer zone (**Figure 2**) pursuant to the NIPAS Act of 1992. Since then, there had been very limited studies done on the DBPLS in terms of its biophysical characteristics and its socio-economic impacts to the local community. The study area is the mangrove forest of DBPLS that overlap with PNOC EC's COC 204.

Based on the Land Use Map of Malangas (**Figure 4**), only about 2.8% of its land area comprise the mangrove forest located along its coastlines. The eleven (11) coastal barangays covering the mangrove forest in the municipality of Malangas, as identified by DENR, are: Palalian, Mabini, Dansulao, Kigay, Poblacion, Logpond, Tigabon, Sinusayan, Tackling, Bacau, and Lipacan (**Figure 2** and **Figure 3**). Actual photos of the mangrove forest within Barangay Dansulao, Malangas are shown in **Figure 6**.

Figure 6. Actual photos of the mangrove forest within the DBPLS.

Spatio-Temporal Analysis

Remote sensing, the process of acquiring information on a specific area from a distance using reflected and emitted light, is one of the latest technological trends that enables further advances in large-scale environmental research. It is a powerful tool to provide spatio-temporal information on various mangrove ecosystems (Kuenzer et al., 2011). The analysis of the transformation of the DBPLS through time since its proclamation as protected area in 1999 will be done (Sainadh and Tripathi, 2018). The following GIS datasets were obtained from the National Mapping and Resource Information Authority (NAMRIA) which will be used for the spatio-temporal analysis:

1. 2003 Land Cover with 14 categories generated from 2000-2003 Landsat 7 ETM, 30m resolution without ground validation
2. 2010 Land Cover with 12 categories generated from 2009-2012 ALOS-AVNIR2/SPOT 5 (10m resolution) and Landsat 7 (30m resolution) with ground validation

3. 2015 Land Cover with 12 categories generated from 2014-2016 Landsat 8 (30m resolution) with ground validation
4. 2020 Land Cover with 12 categories generated from 2016-2021 Sentinel 2 satellite imagery (10m resolution) with ground validation

Using the above GIS datasets, the transformation of the mangrove forest of the DBPLS within Malangas from 2003 to 2020 will be analyzed using ArcGIS software, ArcMap 10.5. The changes in land cover in the mangrove forest within COC 204 can easily be compared using the attributes of each shapefile. Note that all GIS datasets have ground validation except for the 2003 dataset.

Interview of Key Stakeholders

The result of the spatio-temporal analysis will be complemented with field data gathering through interview with key stakeholders. It is important to conduct field data to gather specific data that cannot be identified through remote sensing. Participation of various stakeholders is an integral part of an effective integrated community-based management of mangrove ecosystems; thus, vital information will be obtained through structured interview of key stakeholders within the local community. The level of awareness and perceptions of these key stakeholders and how these developed through time are important in mapping existing policies and management strategies, as well as the communities' willingness to participate in implementation and other improvement endeavors (Chassels and Bucol, 2022; Sumeldan et al, 2021). Data and information needed for this study include the stakeholder's awareness of the ecosystem services provided by the mangrove forest of DBPLS, the condition of the mangrove forests throughout the years, and their perspectives on the current management of the mangrove forest by the local community. Furthermore, their

recommendation/s on what can be an effective management strategy for the mangrove forest of DBPLS will also be elicited.

The study will use purposive sampling to ensure that respondents will have enough knowledge or awareness on mangrove ecosystem and its management. The identified key respondents are the following:

- Municipal Environment and Natural Resources Management Officer (MENRO) of Malangas
- Barangay Chairpersons
- Barangay Councilors
- Other Barangay Officials
- Other Members of the Protected Area Management Board (PAMB)
- Members of concerned Non-Government Organizations (NGOs)

The Survey Design

The interview made use of a three-part questionnaire consists of: (1) demographic profile of the key stakeholder, (2) knowledge on mangrove ecosystem, condition of the mangrove forest and management strategies currently being implemented within DBPLS, and (3) their own personal recommendation to improve current management of the mangrove forest based on their personal knowledge and experiences.

The first part of the questionnaire will elicit the demographic and socio-economic profile of the respondent. This will help examine the demographic profiles of the key stakeholders and whether being part of the management of the DBPLS requires or allows specific socio-economic class and provides justifiable compensation, its relationship with their awareness, among others.

The second part of the questionnaire will elicit the information on the condition of the mangrove forest of the DBPLS based on the respondents' awareness of the NIPAS Act, the ecosystem services being provided by the mangrove forest of the DBPLS, and the current management policies for this protected area, including their roles and responsibilities, curbing the proliferation of illegal activities, and the presence or absence of penalties and other payment schemes available for the maintenance of the mangrove forest. It will reveal whether the key stakeholders have good level of awareness and sufficient technical knowledge of the mangroves, as well as their overall assessment of the different activities within this protected area.

The final part of the questionnaire is simply the respondent's personal recommendation/s on how to improve or better manage the mangrove forest of the DBPLS based on their knowledge and personal experiences as key stakeholders of this protected area. It will further elicit capacity building and trainings needed to improve the management of the mangrove forest as well as the possible contribution of private entities, such as PNOC EC, in the overall management of protected areas such as the DBPLS. Finally, it will show the respondents' level of optimism in the management of the protected area, whether they will be preserved for the future generation and the illegal activities will be eradicated.

VII. RESULTS AND DISCUSSION

Change in Mangrove Forest Cover

Using the ArcMap 10.5 in the analysis of the GIS datasets obtained from NAMRIA, the following mangrove forest covers of the DBPLS within COC 204 of the Malangas municipality through time were obtained and summarized in Table 4:

Table 4

Mangrove Forest Cover of COC 204 from 2003 to 2020

Year	Total Mangrove Forest Cover (ha)	Change in Forest Cover (ha)	Change in Forest Cover (%)	Cumulative Change (ha)	Cumulative Change (%)
2003	356.16				
2010	369.82	13.66	3.84%	13.66	3.84%
2015	254.31	-115.51	-31.23%	-101.85	-28.60%
2020	312.35	58.04	22.82%	-43.81	-12.30%

Since the earliest GIS dataset available for the DBPLS is 2003, we assigned the mangrove forest cover in 2003 as the baseline for the cumulative change. Despite gaining land cover throughout the years from 2003 to 2020, the mangrove forest lost about 43.81 ha of its land cover in COC 204 since 2003 or about 12.30%.

Figure 7 to **Figure 10** show the Land Cover Map of COC 204 from 2003 to 2020 based on analysis of the GIS datasets obtained from NAMRIA.

Figure 7. Land cover map of COC 204 in 2003.

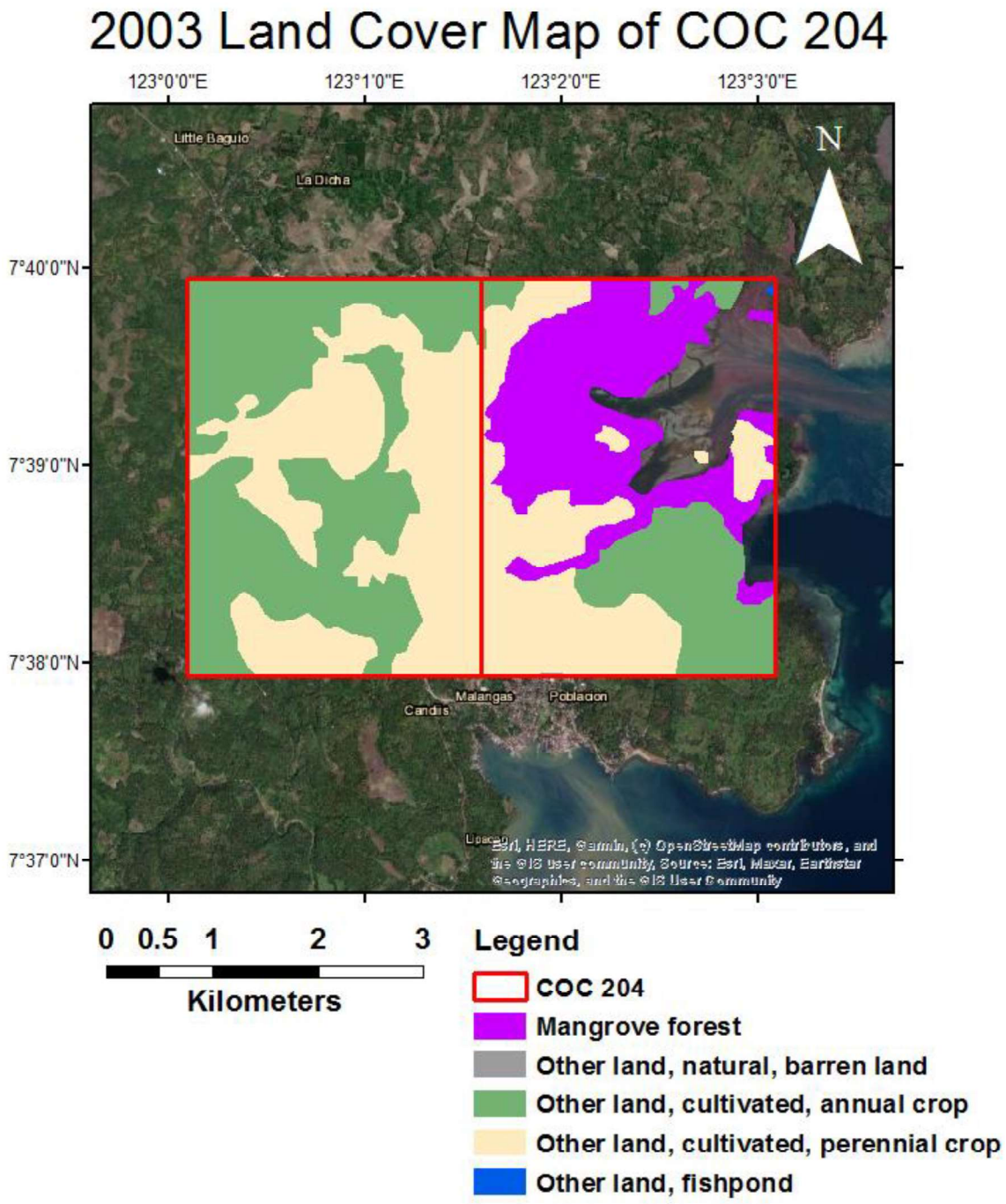


Figure 8. Land cover map of COC 204 in 2010.

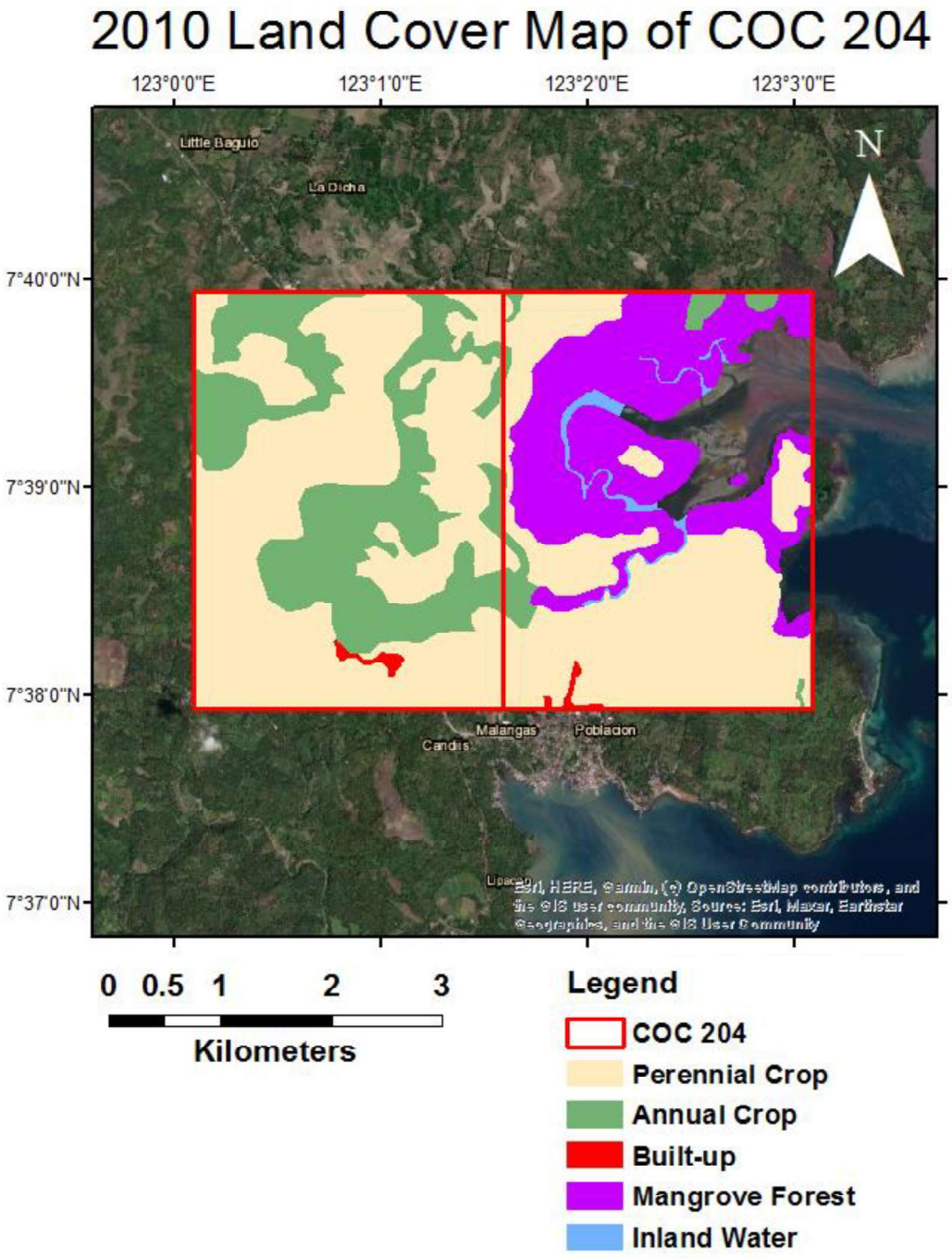


Figure 9. Land cover map of COC 204 in 2015.

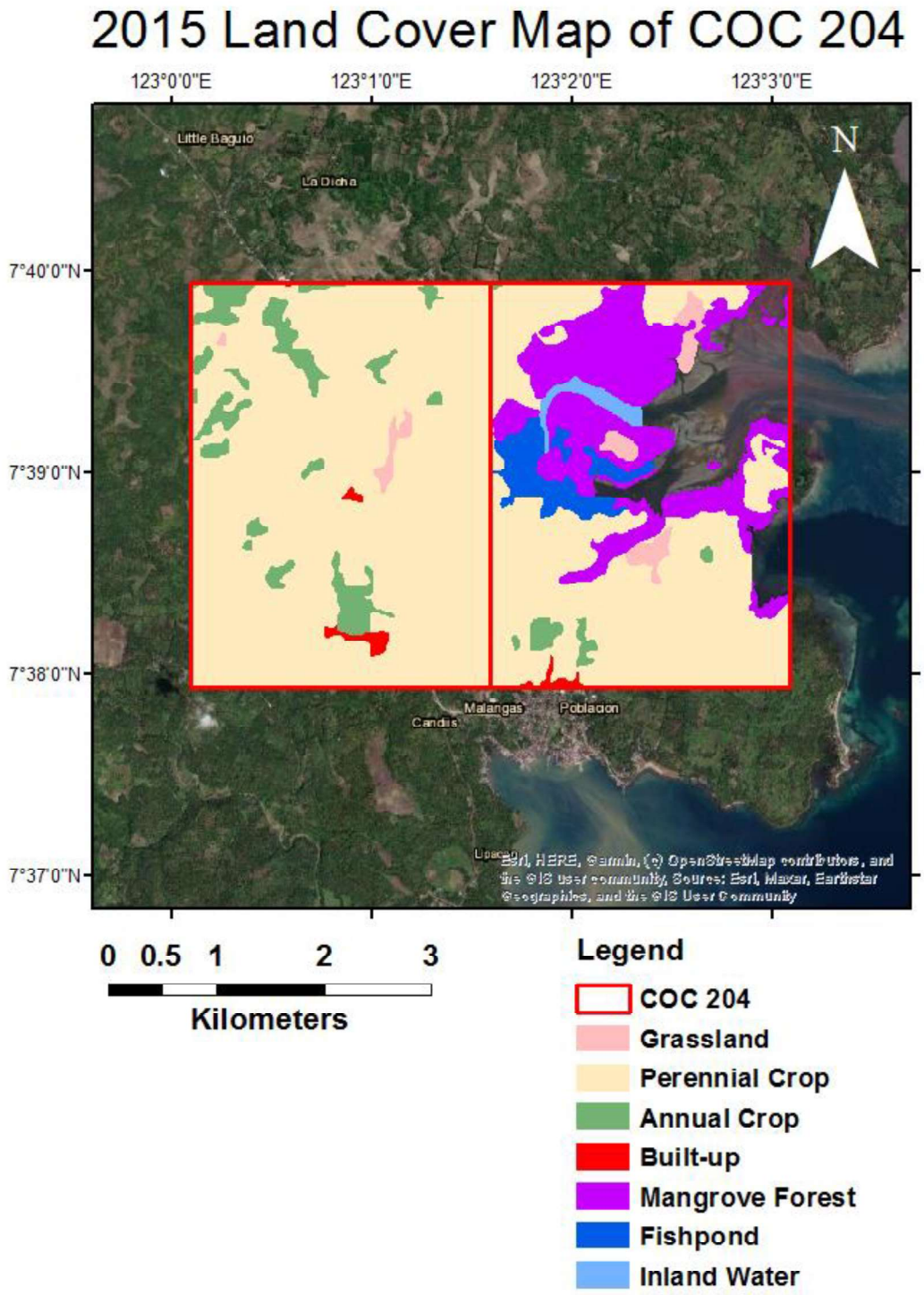
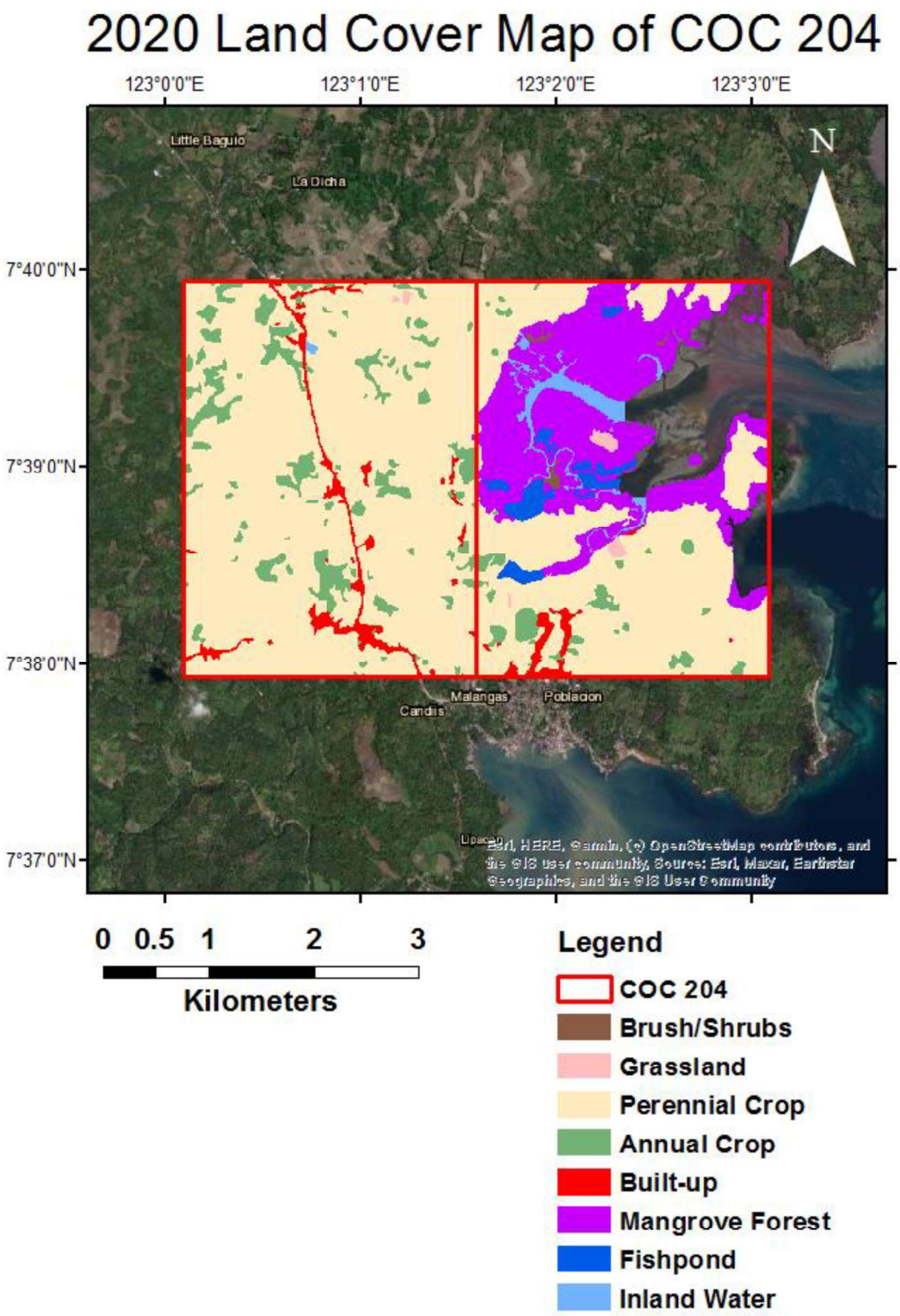


Figure 10. Land cover map of COC 204 in 2020.



One of the apparent observations in the generated land cover maps is the increasing quality of GIS data available from 2003 to 2020. In 2003 datasets, most of the land cover in the study area are cultivated lands made up of either annual or perennial crops, with some mangrove areas (about 356.16 ha) and very minor fishponds. Built-up areas were not identified, probably due to the quality of satellite imaging and/or processing, or the absence of ground validation, as stated earlier.

In 2010 land cover map, about 369.82 ha of mangrove forest within COC 204 was delineated, an increase of about 13.66 ha or 3.84% from the 2003 mangrove forest cover. This slight increase may be attributed to the increase in the GIS data quality and the presence of ground validation which was not done in 2003. Moreover, the land cover map was able to delineate inland waters (i.e. rivers), as well as patches of built-up areas. The effectiveness of the NIPAS Act on this change in mangrove forest cover may be inconclusive at this point.

In 2015 land cover map, majority of the land cover is composed of perennial crops, possibly due to the timing of the satellite imaging when the annual crops already completed their life cycle. A significant decrease in the mangrove forest cover, about 115.52 ha or 31.23%, can be observed due largely to the conversion of these mangrove areas into fishponds, which was also mentioned by the various stakeholders interviewed in this study. Grasslands were also differentiated in this dataset.

Lastly, in 2020 land cover map, one apparent observation is the significant increase in the quality of GIS data which resulted in higher resolution of the delineation of the land covers. Perennial crops still make up majority of the study area but there are increased patches of annual crops and built-up areas compared to the 2015 land cover map. About 58.04 ha of mangrove forest cover representing 22.82% increase is also observed, which can be attributed to the decrease in the fishpond areas. The

decrease in the fishpond areas can be subsequently attributed in the management of the mangrove forest within DBPLS, implying possible effective management strategy, like rehabilitation of abandoned, underdeveloped, and underutilized fishponds as well as prohibiting the conversion of mangrove forests into fishponds. However, despite this significant increase in the mangrove forest cover, it still lost about -12.30% of its cover since 2003.

Stakeholder Awareness and Perspectives

A total of fifteen (15) respondents from five (5) different barangays participated in the survey which was conducted on December 9 and 16, 2022 and March 4, 6, 7, and 11, 2023. **Table 5** categorizes the composition of the key stakeholders, while **Table 6** shows the summary of the demographic and socio-economic profiles of the respondents.

Table 5

Composition of the Interview Respondents

Key Stakeholders	No. of Respondents
MENRO of Malangas	1
Barangay Chairpersons	4
Barangay Councilors	4
Other Barangay Officials	3
Other Members PAMB	1
Members of concerned NGOs	2
Total	**15**

Table 6

Summary of the Demographic and Socio-economic Profiles of the Interview Respondents

Individual-level variables	**N**	**%**
Barangay		
Dansulao	4	26.67%
Kigay	3	20.00%
Mabini	2	13.33%
Palalian	3	20.00%
Poblacion	3	20.00%
Age		
Group A (18-39)	2	13.33%
Group B (40-65)	12	80.00%
Group C (above 65)	1	6.67%
Sex		
Male	12	80.00%
Female	3	20.00%
Civil Status		
Single	0	0.00%
Married	14	93.33%
Separated	1	6.67%
Tribe		
None	6	40.00%
Subanen	4	26.67%
Samal	2	13.33%
Others	3	20.00%
Educational Attainment		
Elementary graduate	3	20.00%
High school undergraduate	2	13.33%
High school graduate	3	20.00%
College undergraduate	4	26.67%
College graduate	3	20.00%
Source of Income		
Employed	2	13.33%
Farming	5	33.33%
Business	5	33.33%
Others (Retired)	3	20.00%
Estimated Gross Monthly Income		
PhP 1,000-5,000	1	6.67%
PhP 5,001-10,000	8	53.33%
PhP 10,001-50,000	5	33.33%
PhP 50,001 and 100,000	1	6.67%

Most of the respondents live in Brgy. Dansulao (26.67%), followed by those who live in Brgys. Kigay (20%), Palalian (20%), and Poblacion (20%), all in the

municipality of Malangas. Brgy. Mabini has the least number of respondents (13.33%). The respondents are mostly male (80%), are mostly within the age group 45-60 years old (80%) and are mostly married (93.33%). Moreover, 60% of the respondents are members of tribal groups (i.e., Subanen, Samal, others).

In terms of educational background, only 20% of the respondents completed college. This can be an important determining factor in the level of awareness of these key stakeholders. Finally, most of the respondents get their income from either from farming/fishery (33.33%) or having their own business (33.33%) with most of them earning about PhP 5,001-10,000 monthly.

In general, the respondents have moderate understanding of the mangrove ecosystem and the concept of environment and natural resources management of this protected area. The level of awareness of the local community is an interplay of various factors including the educational attainment of the respondents, their roles in the management of the mangrove forest and/or the DBPLS, and the length of their service. For the educational background, most college graduates and undergraduates are expected to have moderate to high awareness of the mangrove species, the ecosystem services provided by mangrove forests, the NIPAS Act, and the status and management of the mangrove forest within the DBPLS.

Finally, when asked about what would improve the management of the mangrove forests, the respondents were able to provide useful information which is categorized in **Table 7**. Please note that respondents provided more than one (1) recommendation, thus, the total number of recommendations will not match the total number of respondents for this study.

Table 7

Summary of Recommendations from the Respondents

Recommendations	N
Increase in Budget and Financial Support	12
Livelihood Programs	11
Improvement in Monitoring (i.e., increase in provision of Bantay-Dagat/forest rangers, materials, and services, etc.)	10
IEC, Trainings, and Capacity-building	8
Reforestation Programs	5
Strict Enforcement of the Law	4
Ecotourism Projects	4
Improvement of Buffer Zones	1

Majority of the respondents have identified the need to increase the budget for the management of the mangrove forests as well as some financial support to those who are actively participating in its protection and various monitoring activities. Secondly, since poverty is the root-cause of the illegal activities within this protected area, many respondents also identified the need to provide livelihood programs to the host communities to divert their source of income/livelihood, thereby reducing the illegal activities (i.e., dynamite fishing, illegal logging) and overextraction of wood and non-wood products within the mangrove forest.

Another recommendation from the respondents is the improvement of monitoring of the mangrove forest in the form of additional Bantay-Dagat and/or forest rangers, and provision of various monitoring materials and services. This can loosely be tied to the first recommendation where appropriation of additional budget is needed

to support the management of the mangroves. Furthermore, the succeeding recommendation – the provision of IECs, trainings and capacity-building, aims to improve the awareness of the community about the mangrove forest and strengthen the skills and capacity of the key stakeholders in managing the protected area. Similarly, these IECs and trainings can also be tied to the first recommendation where increase in budgetary requirement of the protected area is needed. Other recommendations include additional appropriate reforestation programs, strict enforcement of the law, ecotourism projects, and improvement of buffer zones.

During the elicitation of the recommendations from the respondents, all of them are highly optimistic about the future of the mangrove forest within the DBPLS considering status quo. Despite the identified challenges in the management of the mangrove forest, and their recommendations to improve them, all of respondents expect a continuous increase in the number and sizes of mangroves, as well as the increase in the fish population and other aquatic resources, which then will improve resources for the local community and their livelihood.

Mangrove Management within DBPLS

Despite the significant decrease in the mangrove forest cover within COC 204 from 2003 to 2020, the key stakeholders are satisfied with the implementation of the current mangrove management plan which improves the monitoring of the protected area and the enforcement of the law such as the prohibition of dynamite fishing, illegal cutting of mangroves, and illegal conversion of mangrove forest into fishponds. Several mangrove reforestation/rehabilitation projects were also noted in the past which increased the mangrove forest cover between 2015 and 2020. With all these improvements in the management, all the respondents are optimistic about the future

of the mangrove forest. However, it is still recommended to conduct another spatio-temporal analysis when an updated GIS datasets become available to check whether there will be an increase in the mangrove forest cover which could directly be correlated with the current management plan.

VIII. SUMMARY AND RECOMMENDATIONS

The mangrove forest within PNOC EC's COC 204 is an integral part of the ecologically important DBPLS – a protected area covering the subtidal, intertidal, and coastal areas of the Dumanquilas Bay by virtue of the Proclamation No. 158, series of 1999 in relation to the NIPAS Act of 1992 (**Figure 1**). This mangrove forest provides valuable ecosystem services that directly and indirectly improve the well-being of the local community of Malangas, Zamboanga Sibugay (**Table 1**). For this reason, it is important to evaluate the current management plan of the DBPLS by (1) determining the spatio-temporal changes within the mangrove ecosystem using available remote sensing data and techniques, (2) determining the level of awareness and local perceptions of key stakeholders in terms of the ecosystem services as well as its current environmental management, and (3) integrating valuable information on mangrove management from key stakeholders which will be useful in evaluating the management plan and crafting more suitable management strategies, if necessary.

The spatio-temporal analysis of the GIS datasets obtained from NAMRIA revealed that despite gaining land cover throughout the years from 2003 to 2020, the mangrove forest within COC 204 lost about 43.81 ha, or about 12.30% of its land cover in COC 204, when comparing 2020 and 2003 datasets. The largest decrease in land cover coincides with the alleged increase in the conversion of mangrove forest into fishponds and the proliferation of illegal cutting of mangroves. On the other hand, the significant increase in the mangrove cover resulted from the improved enforcement of the NIPAS Act and the DBPLS Management Plan, which include mangrove reforestation and rehabilitation coupled with monitoring of concerned LGUs and local volunteers.

Stakeholder awareness is an important aspect of participatory approach to mangrove management. The interview of key stakeholders within COC 204 mangrove forest revealed a more varied level of awareness across all key areas: mangrove species, mangrove ecosystem services, NIPAS Act, and issues with the current mangrove management. Overall, an improvement in the awareness of the key stakeholders, as well as the local community, is needed to ensure a more sustainable participatory mangrove management in DBPLS.

All the interviewed key stakeholders are optimistic that, considering the current mangrove management, the mangrove forest will continue to improve in terms of its cover, the number of mangroves and their sizes. However, they recommended some actions and strategies to further improve or better manage the mangrove forest which include increasing the budget and financial support for better mangrove management, providing livelihood programs for the local community, further improving the monitoring of the protected area, providing IECs, capacity building and trainings to improve awareness, knowledge, and skills of the key stakeholders, and implementing reforestation and rehabilitation programs.

Based on the spatio-temporal analysis and the interview of the key stakeholders, the current mangrove management is satisfactory considering the limited budget for the protected area. It is recommended to conduct another analysis of mangrove forest land cover using updated GIS datasets to further check the effectivity of the management plan. Likewise, interview of additional stakeholders may also be done to further evaluate the level of awareness of the local community as well as the additional measures that can be implemented. Aside from the additional financial support and livelihood programs from the government, NGOs, and private

and business sectors, it is important to improve the awareness of the local community about to encourage a more participatory mangrove management within the DBPLS.

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