Blue carbon perceptions by locals deriving from coastal ecosystem services: A proposal for sustainable community-based managements in Indonesia

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Doctoral Dissertation

Blue carbon perceptions by locals deriving from coastal ecosystem services: A proposal for sustainable community-based managements in Indonesia

沿岸部生態系サービスに由来するブルーカーボンに関する 地域住民の認識： インドネシアにおけるコミュニティ・ベース管理への提案

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Abstract

Indonesia is an archipelagic country with the abundance and diversity of coastal and small island ecosystems which resides other ecosystems such as mangroves and seagrass. The salience of mangroves and seagrass, alongside the overall boundary of coastal and small island ecosystems, are being increasingly recognized in terms of "blue carbon", and within the context of preserving the environment and minimizing the carbon emission. In the wake of development and various socio-economic challenges faced by Indonesia, the country is now also needing to utilized the potential of coastal and marine resources. Such approach generates the threat to the dimension of environment, and various report and studies have shown the compromise between economic development and the sustainability aspect.

Thus, this dissertation aims to propose a sustainable management within the context of coastal ecosystem services in Indonesia, and using the framework of blue carbon perception and the focus on community-based for the "bottom-up" approach on the conservation of the coastal ecosystems. The setting for this study will be mainly within the boundary of Berau Regency, East Kalimantan Province, focusing on the Derawan Island, a small island to explore the threats faced by the local community, and Tanjung Batu, a coastal settlement, to understand the local perceptions on the potential of blue carbon ecosystems services' utilization, and to propose sustainable community-based managements as intervention tool to prevent and minimize the threat to the environment, while at the same time providing alternative livelihood with the involvement of local communities. To unravel such complexities and grasp a deep understanding on various issues in Derawan Island and Tanjung Batu, this thesis will consist of the following main contents: (1) Policy analysis on the Indonesia Provincial Spatial Plans, highlighting the various cluster which signifies the role of mangrove and acknowledgement of its role by the local government. This step will provide the understanding on the priorities and awareness of the mangrove ecosystem as part of the coastal ecosystems in Indonesia. The next content is (2) exploring the local awareness in regards to the seagrass ecosystem, to understand the utilization rate and the perceived threats by the local communities. After the threats were assessed, this dissertation will then branch the contents to tackle the three different issues in the Derawan Island and Tanjung Batu, and the surrounding of Berau Regency in the aspects of (3) Land-use change and how to triangulate a sustainable issue through the approach of policy, satellite image, and local perception to identify the gaps and way to move forward. (4) The issue of aquaculture which threaten the mangrove ecosystem, and

utilization of approach such as silvofishery and tourism to enhance and integrate the mangrove conservation into the aquaculture practices. (5) The issue of waste management in the small island of Derawan, in which the approach of Material Flow Analysis (MFA) was used to simulate several scenarios of minimizing the impact of domestic waste through the involvement of community-based management, such as waste bank and composting process, which complement the existing waste management.

The policy analysis to assess the acknowledgement of the role of mangrove, as part of the coastal ecosystem, in Indonesia will be explored through the document analysis on the Indonesia Provincial Spatial Plan (hereafter PSP). The formulation of PSP is based on the Indonesia Law No. 26 of 2007 on Spatial Management with PSP as a document for the provincial level. There are currently 34 provinces in Indonesia with authority to self-regulate their spatial plans, and in particular the difference of acknowledgement on the role and status of mangrove ecosystem at each province in Indonesia. In this thesis, 27 out of 34 PSPs document were analyzed using the systematic content analysis based on the coding keywords concerning mangrove management and their frequency of appearance in the document. The results of the content analysis of the PSP were categorized into nine clusters of: (1) *aquaculture*, (2) *carbon storage*, (3) *disaster prevention*, (4) *fish nursery*, (5) *prohibited activity*, (6) *reforestation*, (7) *regulating services*, (8) *research and education*, and (9) *tourism*. Out of the nine cluster, we have observed that the cluster *prohibited activity* was the most frequently mentioned in the context of management and utilization of mangroves across all provinces in Indonesia, with 21 out of 27 provinces provides the explanation on various lists activities that are prohibited to protect and conserve the mangrove ecosystem. The next dominant clusters were followed by the mangrove's potential to be utilized in *tourism* sector, and in the *research and education* activities, with 20 provinces give acknowledgment to allow the mangrove ecosystem as a tourism spot, and 17 provinces include the statement for mangrove ecosystem to be utilized for research and educational activities. However, there is also the concern of the aspect of "blue carbon" in the *carbon storage* was largely overlooked, with only 3 out of 27 PSPs document include the statement and acknowledgement of mangrove as ecosystem for carbon sequestration.

Next, this thesis investigates the local awareness for the seagrass ecosystem, a prominent ecosystem in particular for the Derawan Island. Seagrass, alongside with mangrove, is an

important part of coastal ecosystem, and also known to stored and sequestered carbon as part of "blue carbon" ecosystem. From the perspective of "bottom-up" measures on the community-based management on the conservation program, the people-centric approach is the focus for the management of resources, hence the awareness and perceptions of the local community is the crucial part to understand the current situation and status-quo on the seagrass ecosystem. A household survey was conducted in the Berau Regency on the areas of Derawan Island, Tanjung Batu, and Tanjung Redeb. The questionnaire consists of (A) socio-demographic, (B) resource utilization, (C) awareness, and (D) management. A total of 59 respondents' answers were collected, and statistical analysis of correlation analysis and regression analysis was performed to investigate the variable which influence the awareness of the seagrass ecosystem services. The results of the questionnaire shown that the awareness of the locals regarding the various benefit of seagrass ecosystems are relatively low, particularly the awareness of the carbon sequestration (72.88% of respondents were not aware or slightly aware). Nonetheless, there are other seagrass ecosystem services that were frequently highlighted by the locals, such as the role of seagrass as nursery and marine habitat, with 38.98% and 35.59% of respondents were fully aware of the services respectively. From the perspective of utilization rate of seagrass ecosystem, it is also relatively low on the aspect of provisioning services to collect food for consumption, with only 16.95% of respondents who utilize it in this way, but it is interesting that the study observed the utilization for tourism and education is higher with 27.59% of respondents used it in this manner. The insight on this study part from the correlation and regression analysis on the perceptions of the seagrass ecosystems services revealed that the role of fishermen and government employee can be critical to reach out the locals on the importance of utilization and the awareness of the seagrass, as well as the potential to involve the local communities on the local conservation effort. Aside of the utilization and awareness, the aspect of threats perceived by the local communities are also important to be assessed as the basis to propose the sustainable community-based management. Here, this study focused to assess the perceived threats to the seagrass ecosystem in Derawan Island, and the type of threats that were mostly perceived by the local are natural disasters and pollution from domestic wastes, followed with the threats from land-use change in the form of infrastructure development in the coastal areas. Based on these results, this study will propose the alternative sustainable community-based to intervene with the issues on the land-use change, aquaculture (mangrove conversion), and the domestic waste.

The issue on the land-use change in the coastal ecosystem was assessed in a holistic manner through the promotion of triangulating framework. This framework is defined through the utilization of three different sources of data consists of the land-use/land cover (LULC) change map, spatial plan policy map, and perception interviews with the local communities to triangulate the data and identify the land-use issues in the areas. The first data is from the land-use change perceptions, in which this study utilized a semi-structured questionnaire with focus on using satellite image to captured the locals' perception on the drivers of land-use changes. The second data from the LULC map was utilized using government dataset on the land cover maps to validate the perceived LULC changes. The third dataset in this framework is the spatial plan policy maps to understand the perspectives from government policy in the implementation of the different land uses. The triangulating framework compare each dataset and discuss the findings on the focus of complementing aspects and identified gaps in the context of coastal ecosystem land-use change. The results of this study illustrate the three intersections perspective of socio-ecological intersection, where perceptions provide another layer of information for the LULC to understand further the drivers and causes of the changes, for example in Derawan Island the abrasion case was reported by the locals. The second intersection is in regards of the environmental impact of policy, which for the Derawan Island and Tanjung Batu there were several identified gaps on the differences of how government perceived a certain land-use implementation with the actual land-use, for example in Tanjung Batu there is discrepancy on the assigned ecosystems of mangrove versus seagrass. The last intersection is the social impact of policy, where this study highlights another gap on the potential threat from existing spatial plan, nonetheless, there is also the potential of perception as an assessment tool for the policy implementation evaluation. Based on the triangulating framework approach, this study provided unique insights on land-use change, where the interviews facilitate the context of the perceived change by the locals, LULC maps based on remote sensing technology provides comprehensive information on the land-use change in the area, and policy map from the spatial plan provides the understanding on how the government perceived the development and the future of the land-use on the areas. Through the understanding on these three different dataset structures, a holistic result in regards of the land-use change issue can then be analyzed to provide robust policy implications in spatial plans for sustainable future on small island and coastal ecosystems such as in Derawan Island and Tanjung Batu. Results from this study can be integrated into a larger picture of ecosystem conservation.

The pressure from aquaculture industry was reported, in particular on Kalimantan island, where *tambak* (fish pond) as the main drivers of the conversion of mangrove ecosystems in the coastal environment, which gives the notions of mangrove as part of the blue carbon ecosystems is under threat of the decrease coverage and various other implications of the ecosystem services loss, such as carbon sequestration and disaster prevention. Nonetheless, the region identifies the economic improvement through the aquaculture industry, hence a balance between mangrove ecosystem conservation and economy sector improvement is needed. Despite various regulations and guidelines regarding sustainable aquaculture practices have been established on a *de jure* basis, there are challenges on the effective implementation due to the various environmental and social limitations. To address these *de facto* challenges, this study investigates the local communities' awareness regarding mangrove status and relevant aquaculture policies to identify the underlying challenges of sustainable aquaculture practices. An empirical survey was conducted to collect primary data on residents' awareness and perceptions regarding mangrove conservation related policies and activities necessary for sustainable aquaculture. Focusing on the area of Balikpapan and Berau, a total of 73 fishponds owner's respondents were collected in which statistical analysis methods of Chi-square test were utilized with focus on investigating (a) the relationship between residents' participation in mangrove programs and their awareness regarding mangrove benefits and (b) the relationship between residents' knowledge regarding *Cara Budidaya Ikan yang Baik* (CBIB; Good Fish Farming Practice) and perceptions regarding sustainable aquaculture activities. The first result is highlighting the participation in mangrove program such as mangrove transplantation and nursery gives a tendency toward higher awareness on fishpond owners for the mangrove ecosystem services, such as fish nursery (p-value = 0.0016 < 0.01), tourism/education (p-value = 0.0075 < 0.01), and aquaculture (p-value = 0.0002 < 0.01). This indicate the potential transfer of knowledge from the program participation. The second result on the relationship between CBIB knowledge and perception on sustainable aquaculture showed statistically significant results where fishpond owners who understand CBIB were more likely to perceived the utilization of feed as important sustainable practice, while fishpond owners with lack of CBIB knowledge belief that sustainable aquaculture can be achieved through the focus on the aspect of food safety. In addition, there are two distinct insights on Balikpapan with potential for integration of aquaculture and tourism, while in Berau, the focus is towards mangroves role for fish nurseries

and aquaculture improvement. These showcases the example of bundled ecosystems services implementation for particular site.

In the context of small island ecosystem, such as Derawan Island, another relevant issue highlighted from the previous perception study is from the domestic waste pollution. Small island is known with its limited capabilities to process and manage the generated waste, and in the case of Derawan Island, it is also a famous site for the tourism sector industry. This situation generates high pressure from the waste generation which can impact not only the tourism industry but also the blue carbon ecosystem which can be damaged from the leakage of the waste to the coastal and ocean environment. Understanding the future projection on how Derawan Island can manage the waste will be important, hence this study conducted a survey on local perceptions on impact of domestic waste on seagrass ecosystem and tourism industry, a topic cross-cutting the biodiversity and material cycles. A total of 22 respondents' responses were collected with highlights on the perceived threats of domestic waste as second-to-high (29.17%). threats to seagrass ecosystems, and the perception of tourism sector with negative impacts on the waste management (M = -0.71). Nonetheless, the chi-square test did not produce significant relationship between the perceived threats of domestic waste to the seagrass ecosystem and the perception of the tourisms' impact which suggests that the respondents did not associate the threat of domestic waste to the ecosystems with the tourism's impact to the waste management. This result was complemented with the second approach of material flow analysis (MFA) using Substance Flow Analysis (STAN) software and database from Ministry of Environment and Forestry to illustrate the existing and future sustainable scenarios of waste management in Derawan Island. A forecast analysis to the year of 2025, shown that the current waste management is impossible to manage 100% of the generated waste, with potential waste accumulation of 224.79 kg/day. Two alternative scenarios were provided with the extensive community initiative in the form of waste bank and composting which can provide alternative livelihood, and the scenario of tourism contribution where a certain fee is implemented to cover the operational cost of the waste management. The extensive community-based approach can be the most sustainable option; however, this approach requires careful planning on initiating and supporting the community-based program to ensure its sustainability. For the tourism contribution scenario, adequate monitoring and transparency will be needed to ensure the implementation of the system is also benefitting the local communities, as well as preserving the beauty of the Derawan Island with efficient waste management.

In conclusion, the dissertation proposes the holistic approach to tackle the issues in coastal ecosystem by using the framework of blue carbon perception and the focus on community-based for the three dimensions of land-use change, aquaculture and mangrove, and the domestic waste management. For the land-use change, this study proposed the holistic triangulating framework to understand the overall context of land-use change, as well as providing alternative way to complement the limitation of data with the use of perception interviews with the local community. For the aquaculture and mangrove, focusing on the strength and community awareness in regards of bundled ecosystem services can provide as a good start to initiate the transition of sustainable aquaculture practices. For the domestic waste management, this study showed two alternative future scenarios to intervene the issue of waste with the involvement of community or the implementation of the fee for the tourism sector. Community is an important factor in the context of coastal ecosystem and the anthropologic change in its surrounding environment with the various pressure from human activities. Through the involvement of community as main stakeholder, it can open a new way to the environment conservation, and in particular on the blue carbon ecosystem services in Indonesia.

Keywords: *community, conservation, blue carbon, content analysis, perceptions, land-use change, aquaculture, waste management, material flow analysis*

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List of Abbreviations

BPS	Statistics Indonesia (*Badan Pusat Statistik*)
CBIB	Good Fish Farming Practice (*Cara Budidaya Ikan yang Baik*)
CBM	Community-based management
GHG	Green House Gases
IUV	Indirect Use Value
LIPI	Indonesian Institute of Sciences (*Lembaga Ilmu Pengetahuan Indonesia*)
LULC	Land-use/land cover
MFA	Material flow analysis
NGO	Non-governmental organization
PSP	Provincial Spatial Plan
RZWP3K	Zonation Plan of Coastal Areas and Small Islands
SIPSN	National Waste Management Information System (*Sistem Informasi Pengelolaan Sampah Nasional*)
STAN	Substance Flow Analysis
TEV	Total Economic Value
TNC	The Nature Conservancy

List of Publications

Authorship	List of Authors	Journal	Title	Status	DOI	Link to the Dissertation
First Author	Kevin Muhamad Lukman, Jay Mar D. Quevedo, Kaoru Kakinuma, Yuta Uchiyama, Ryo Kohsaka	Journal of Forest Research, Vol. 24 (6)	Indonesia Provincial Spatial Plans on mangroves in era of decentralization: Application of content analysis to 27 provinces and "blue carbon" as overlooked components	Published (2019)	10.1080/13416979.2019.1679328	Chapter 2
First Author	Kevin Muhamad Lukman, Yuta Uchiyama, Jay Mar D. Quevedo, Ryo Kohsaka	Ocean and Coastal Management, Vol. 203, 105451	Local awareness as an instrument for management and conservation of seagrass ecosystem: Case of Berau Regency, Indonesia	Published (2021a)	10.1016/j.ocecoaman.2020.105451	Chapter 3
First Author	Kevin Muhamad Lukman, Yuta Uchiyama, Jay Mar D. Quevedo, Diana Harding, Ryo Kohsaka	Human Ecology	Land Use Changes Assessment using a triangulated framework: Perception Interviews, Land-Use/Land Cover Observation, and Spatial Planning Analysis in Tanjung Batu and Derawan Island, Indonesia	Published (2021c)	10.1007/s10745-021-00253-w	Chapter 5
First Author	Kevin Muhamad Lukman, Yuta Uchiyama, Ryo Kohsaka	Ocean and Coastal Management	Sustainable aquaculture to ensure coexistence: Perceptions of aquaculture farmers in East Kalimantan, Indonesia	Published (2021d)	10.1016/j.ocecoaman.2021.105839	Chapter 6

1. Introduction

1.1 Coastal ecosystem: Pressure and threats

Indonesia is an archipelagic state and maritime country with about 95,181 km of coastline, 17,504 islands, and 78% of the country territory is covered by waters, in addition of the coastal zone consisting of rich tropical marine ecosystems, such as mangroves and seagrass (Hutomo and Moosa, 2005; Sukardjo and Pratiwi, 2015). However, the coastal development which got influenced by the population growth have forced Indonesia to intensify and diversify the utilization of coastal and marine resources, with the development and anthropogenic factors play an important role in shoreline change, such as development of industry, residence, aquaculture, and the construction of jetties (Dewi et al., 2018; Sukardjo and Pratiwi, 2015). There is the concern that the coastal ecosystems are being increasingly degraded or destroyed (Lau, 2013), despite the coastal ecosystem services, such as mangroves and seagrasses, provide various benefits of protection from storms and erosion, tourism benefits, and climate adaptation (Wylie et al., 2016). Particular concern is linked to the mangrove and seagrass ecosystems as part of the coastal ecosystem boundary.

Despite the importance of mangroves to the environment and human such as protecting coastlines from storms, as well as habitat for fisheries and shrimp production, mangrove distribution is decreasing (Gedan et al., 2010; Giri et al., 2011; Ilman et al., 2016). For example, in between period 2000 and 2012, it was reported that the mangrove deforestation in Southeast Asia destroyed a total of 114,424 ha of which 60,906 ha of the total is accounted in Indonesia (Richards and Friess, 2016). The situation of mangroves in Indonesia is exacerbated with the report that over the last 6 centuries, the loss of mangroves was undetected by policy makers and activities such as aquaculture, timber production, palm oil plantation, and urban development was reported as the driving force of the land-use conversion (Ilman et al., 2016; Pagiola 2000). In another report, the mangrove's condition in Indonesia is worsening due to slack licensing regulations in municipalities and provinces (Sunyowati et al., 2016), or due to the convoluted regulations which might create mismanagements of mangrove (Irawan and Sari, 2008).

From the perspective of seagrass ecosystem, it is also under anthropogenic threat (Unsworth et al., 2018), with this ecosystem in Indonesia have declined due to various anthropogenic disturbances,

and in some areas the cause of the decline is unknown (Nadiarti et al., 2012). In addition, the extents and services of seagrass in existing coastal management plans is not as highlighted as compared to mangrove ecosystems despite seagrass ecosystem services and benefits to local livelihoods (Quevedo et al., 2020a). The seagrass coverage in Indonesia according to the report from Indonesian Institute of Sciences (LIPI) is 293,464 ha in 2017 (Sjafrie et al., 2018), and the ecosystem consists 13 out of 60 worldwide seagrass species (Nadiarti et al., 2012). The latest report on Indonesia's seagrass ecosystem showed that Indonesia's seagrass meadows are generally in moderate condition, however, with multiple threats are pressuring on this valuable habitat, seagrass conservation and restoration is essential to maintain the ecosystem services (Hernawan et al., 2021). The existing studies and status of the literature highlights the needs to focus the effort on the conservation, preservation, and protection on both mangrove and seagrass ecosystems. In the next section, this study will expand the understanding on various ecosystem services from mangrove and seagrass in the coastal environment, as well as the recent highlight on the focus of blue carbon ecosystem study.

1.2 Blue carbon ecosystem services

Coastal ecosystems of mangroves, seagrasses, salt marshes provide climate mitigation services with the particularly effective for sequestering and storing carbon dioxide, also known as coastal blue carbon (Wylie et al., 2016). The terminology of blue carbon itself is defined to describes the disproportionately large contribution of coastal vegetated ecosystems to global carbon sequestration (Macreadie et al., 2019), which refers to carbon stored and sequestered in mangrove forests, seagrass meadows and tidal salt marshes (Thomas 2014; Lovelock et al., 2017). The anthropogenic impacts were reported as a factor of the degradation on the blue carbon ecosystems which contributes to emission from land-use and preventing the ecosystems to continue their role as carbon storage (Wylie et al., 2016). Indonesia is estimated to emit 29,040 Gg CO_2 (eq.) annually into the atmosphere and ocean through the continued degradation and destruction, which led to an urgent need for blue carbon projects to mitigate the release of coastal carbon stores (Alongi et al., 2016). Aside of the blue carbon as part of coastal ecosystem services, there are other various ecosystem services, in particular from the mangrove and seagrass ecosystems.

The ecosystem services of protection from disaster, benefit from tourism, and climate adaptation have been increasingly recognized as important considerations for environmental policymaking

(Wylie et al., 2016). For mangrove ecosystem, the ecosystem services consist of disaster prevention (Osti et al., 2009), fish nurseries (Ilman et al., 2016), food production, water purification, and nature-based recreation (van Oudenhoven et al., 2015). For seagrass, this key ecosystem provides services such as protecting coastal shoreline, diminishing wave energy, trapping sediments, sustaining abundant marine life, and regulating the cycling of nutrients among others (Hejowicz et al., 2015; Ruiz-Frau et al., 2017). The ecosystem services on mangrove and seagrass are important to support the sustainability of coastal ecosystem, hence a conservation effort will be required to address the various threats and pressures in the coastal ecosystem. To date, the blue carbon ecosystems degradation is caused by direct and indirect anthropogenic factors while at the same time successful blue carbon projects highlights the involvement of local stakeholders with consideration on their livelihoods (Wylie et al., 2016). One of the stakeholder is the local communities of the coastal ecosystem.

1.3 The role of community-based management

In the woke of the coastal degradation, various conservation programs have been proposed to intervene the threats to the ecosystem. The approach of Community-based management (CBM) is characterized with the people-centric approach and special focus on the community to manage the resource and taking primary responsibility for major decision making (Siry 2011). The CBM approaches have been reported to be successfully implemented in various countries, with various degree of success, and high number of initiatives reported from South Asia and moderate number from South America (Datta et al., 2012). In Northern Kenya, the lack of community involvement lead to unsustainable resources extraction which implied the meaningful engagement of communities (Ouko et al., 2018).

The role of community is quite prominent in Indonesia, with various findings highlight the linkage with ecosystem management. For example, in the Ngurah Rai Forest Park management, community plays important role for the management and conservation on mangrove ecosystem (Utami et al., 2018). In the case of Pemuteran and Gili Trawangan, there is a strong shift for marine conservation with hybrid governance between state, private sector, and community (Bottema and Bush, 2012). In Central Java, the CBM for mangrove ecosystem highlights the key aspects of community participation, level of organization and economic assistance, magnitude of rehabilitation project, and time selected for rehabilitation and maintenance strategies (Damastuti

and de Groot, 2017). A study case from Buleleng Regency showed that the success of CBM for coral-reef ecosystem may depend upon the path of economic development, access to technology that facilitates coral recovery, and communication of conservation strategies to tourist visitors (Dunning 2015).

Despite the supportive finding on the CBM, there is also the critique on the approach. For example, the CBM initiative in small islands is seen as convoluted regulatory, with issue of lacking of authority and enforcing rules, in addition of coordination problem between the local community and higher-level state actors (Gorris 2016). Still from the same study, CBM was reported to be motivated by the short-term economic benefit which is a success factor for motivation, however there is also the concern on the sustainability (Gorris 2016). In Brebes Regency, a mangrove transplantation project involving local community showed the inefficient result with improper translation techniques, wrong choice of mangrove species, and inadequate monitoring and evaluation (Phong et al., 2017). Christie et al., (2005) stated that CBM regimes are frequently far from ideal, from ecological perspective, nonetheless, the approach remains important especially considering the socio-economic and institutional conditions in Southeast Asia. Indonesia frameworks on the coastal adaptation laws have limited consideration of community burden arising from the climate uncertainties (Nurhidayah and McIlgorm, 2019), and with the momentum for coastal ecosystem restoration with economic, social, and environmental payoffs for coastal communities (Steven et al., 2019), this study argues that involving the local communities can initiate the sustainable effort to protect and conserve the coastal ecosystem. Wylie et al. (2016) reported in their study that the success of blue carbon project is linked with the engagement of communities to understand the benefits.

1.4 Objectives and research framework

The overall aim of this study is to investigate coastal ecosystem in Indonesia, in particular focusing on the mangrove and seagrass ecosystem, to develop and propose community-based management system which will address the various challenges and pressures to the coastal ecosystem. The main objective is to formulate a holistic and sustainable community-based management system, deriving from the blue carbon perceptions of the coastal communities. The detail targets in this study is listed as follows:

(1) To investigate the spatial plan policy on each province in Indonesia through content analysis method to understand the status quo of the acknowledgement on the blue carbon ecosystem services as a baseline to breakdown the focus on the pressures and threats that needs to be managed by the community.

(2) To analyze the blue carbon ecosystem perceptions by the coastal communities, in particular the awareness of ecosystem services and ecosystem utilization, as well as working on correlation analysis to investigate the coastal communities' profile which influence their blue carbon ecosystem perceptions.

(3) To analyze the phenomenon of land-use change in the coastal ecosystem, using the proposed triangulating framework which utilized three different sources of dataset, consisting of land-use/land cover (LULC) map, spatial plan policy map, and perception interviews to triangulate the data and identify the issues, focusing on the understanding of the perceived drivers of land-use change by the community, as well as working on how each dataset can complement and identify the gaps on the issue of land-use change in the coastal setting.

(4) To analyze the perception of aquaculture farmers and to understand how community program can influence the awareness on the ecosystem services, as well as the understanding of *Cara Budidaya Ikan yang Baik* (CBIB; Good Fish Farming Practice) linked to the perception of sustainable practice by the fishpond owners. Chi-square test analysis was chosen to understand the relationship of the selected variables.

(5) To investigate the issue of domestic waste management in the context of small island and the communities' perceptions on the impacts of tourism sector to the waste management. Utilizing Material Flow Analysis (MFA), the existing situation is identified, as well as proposing two alternatives from perspectives of community-based and tourism contribution to improve the waste management by treating 100% of the domestic waste generated by the small island.

1.5 Scope of study

The setting of this study will be focused in Berau Regency, Indonesia, with particular focus on the coastal area of Tanjung Batu and the small island of Derawan Island. This study is part of the BlueCARES project social and policy science group, with the aim of a blue carbon strategy proposal for policy making bodies in national and local levels. The Berau Regency in East

Kalimantan Province has population of 220,601 in 2017 and total areas of 34,127 km^2 (BPS Kabupaten Berau 2018). The area is known for its high biodiversity, and in 2005 an area of 12,000 km^2 was declared a Marine Protected Area (TNC et al., 2008). Berau is among the most biologically rich areas in all of Indonesia, with the 500 different species of corals, the second highest diversity level of hard coral in the world (Coral Triangle Initiative 2019). The seagrass meadows in Berau Regency are located in inter and subtidal reef flats surrounding the islands (van Katwijk et al., 2011). Within the area of the Berau Regency, one can find Derawan and other small islands which are important feeding ground of green sea turtles *Chelonia mydas* (Christianen et al., 2012) and dugong *Dugong Dugon* (van Katwijk et al., 2011). Derawan Island is a potential destination for tourism in Indonesia (Mujiono 2018), as well as the area of Tanjung Batu with mangrove forests for potential ecotourism destination that is not yet well established (Mukhlisi 2017).

The increasing human population and activities in Berau have also had environmental impacts, for example overexploited fisheries and mangrove deforestation, which will eventually lead to declines in coral, seagrass, and fisheries (Vermaat et al., 2012). For the mangrove ecosystem, the concern lies on the spatial use sector in Berau Regency, with pressures from plantation concession and massive conversion into shrimp ponds (Yuliantri 2018). The land-use conversions have resulted to rapid loss of mangrove cover in the East Kalimantan Province (Richards and Friess, 2016; Malik et al., 2016). Berau district is rich in forestry, mining and fishery resources, and with the decentralization the district government gain more political power to govern these natural resources (Kusumawati and Visser, 2016). According to the policy from Ministry of Fisheries and Maritime Affairs in Ministry Decree No. 87/2016, the government state the efforts to protect and conserve the fishery potential of mangroves, coral reefs, and seagrass.

2. Indonesia provincial spatial plan content analysis

2.1 Introduction: Spatial plan as environmental regulation instrument

Spatial planning is a foundation for sustainable development policies with the role of protecting resources, preserving inhabitants' quality life and regional identity, as well as coordinating and integrating other policies such as environmental protection and economic development (Maksin-Mićić et al., 2009). Integration of spatial plan and environmental policy is likely to provide a better planning process, incorporating environmental improvements and physical developments (Simeonova 2006). From the perspective of mangrove, spatial planning also plays important role on the preservation of the ecosystem. The issue of land-use on the coastal development should consider the mitigation and prevention of mangrove loss at large scales (Mukherjee et al., 2014), especially considering mangroves as the most productive ecosystems which sustain millions of coastal livelihoods (López-Angarita et al., 2018).

Looking at the policy structure in Indonesia, the country has been developing its regulation hierarchy system, with the latest system being based on Law No. 12 of 2011 concerning the Guidance on the Hierarchy of Legislation (*Pembentukan Peraturan Perundang-undangan*). Based on these new systems, the layers and the hierarchy of regulations can be streamlined into seven different layers, with higher levels having stronger legal force (Aditya and Winata, 2018), as seen in **Figure 1**. In Indonesia case, the management of mangrove is also related with the decentralization phenomenon which influenced the management hierarchy from a central to lower level. Decentralization phenomenon in Indonesia has caused the number of provinces to be increased—from 27 in 1980 to 34 in 2013—with provincial governments being responsible for supervisory functions and ensuring that the decentralization is effective (Nasution 2016). The regional autonomy is a transfer of authority from central to regional government in order for more empowerment of area and people's prosperity, where in the implementation, there are coordination and cooperation between province level and the regency or town level (Wirasaputri 2014).

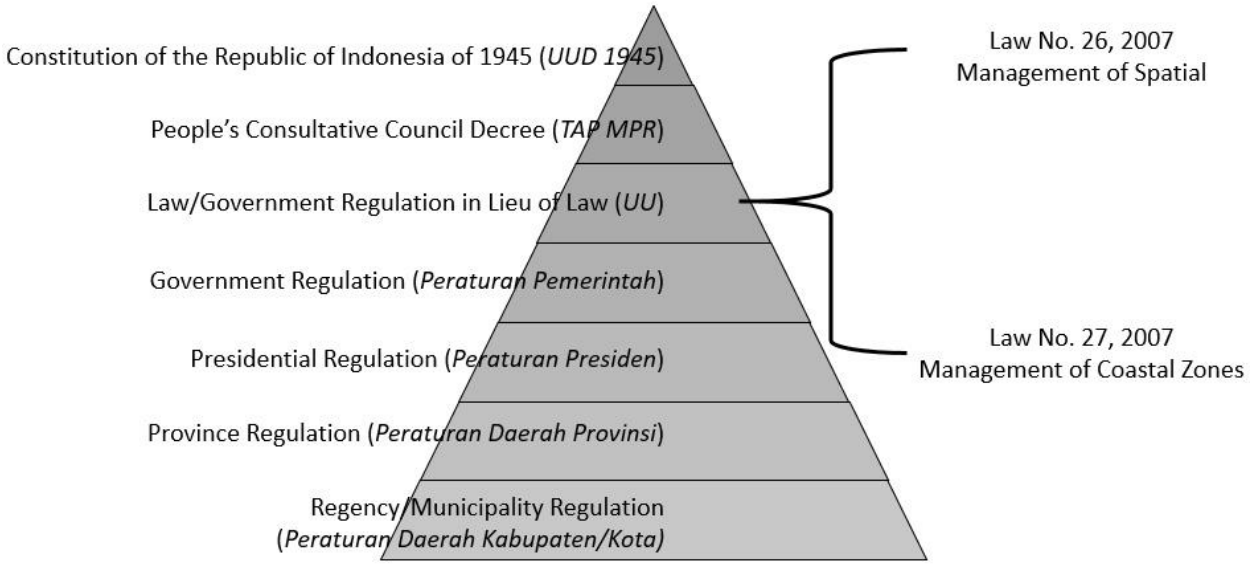

Figure 1 Mangrove's Implementation Regulation (Law No. 26 and No. 27) shown within Indonesia's Regulation Hierarchy [Retrieved from Lukman et al. 2019]

The enactment of Law No. 23 of 2014 on Local Governance (*Pemerintahan Daerah*) is another factor which focuses on transferring governance to provincial-level for transboundary resources, offering benefits involving various district areas, for example in the energy and mining sector (Budiyono and Firmansyah, 2015). The implementation-level policy concerning mangroves in Indonesia range across two regulations; Law No. 26 of 2007 on Spatial Management (*Penataan Ruang*) and Law No. 27 of 2007 on the Management of Coastal Areas and Small Islands (*Pengelolaan Wilayah Pesisir dan Pulau-Pulau Kecil*) (Sunyowati et al., 2016). The former (Law No. 26/2007) generates and regulates the Provincial Spatial Plans (PSP) documents, while the latter (Law No. 27/2007) generates document RZWP3K (Zonation Plan of Coastal Areas and Small Islands). The term mangrove is defined in Law No. 27/2007 that categorizes the ecosystem as a transition area between land and ocean ecosystems. The definition and the nature of mangrove—and therefore the authority under which it falls—are unclear. This is because land ecosystems and its management responsibilities falls under the Ministry of Environment and Forestry, while ocean ecosystem is the responsibility of the Ministry of Maritime Affairs and Fisheries. These issues have also been addressed in existing studies. These studies state that mangrove conservation needs to be managed through cooperation between the two ministries and local government and requires avoiding overlapping or contradictory policies (Heriyanto and

Subiandono, 2016). Furthermore, the variety of policies which govern the mangrove ecosystem directly and indirectly in Indonesia has led to confusion and potentially creating conflict between government departments (Sunyowati et al., 2016). Nonetheless, the formulation of the spatial plan policy was done at several stages, from gathering aspiration and communication with several stakeholders, such as central government, bordering province, town/regency, business-owner representative, academic institution, community and media (Wirasaputri 2014).

To understand how the overall view of each province in Indonesia perceived the role and status of mangrove ecosystem, this part of study for this dissertation will investigate the PSP to explore the status quo of the provincial-level acknowledgement on the blue carbon ecosystem services as a baseline to breakdown the focus on the pressures and threats that needs to be managed by the community in the later part of the dissertation. Here, this study will focus on examined statements in PSP document for each province in Indonesia related to mangrove ecosystem by applying a content analysis. The PSP is used as the chosen document due to the limitation of gathering the document dataset, and there were several provinces still in the process of formulating the RZWP3K document during the time of the study, hence increasing the unavailability of the document. In addition, focusing on the mangrove will also provide the understanding on the duality of mangrove ecosystem as part of inland and coastal ecosystem.

2.2 Method: Content analysis using provincial spatial plan

The methodology of content analysis is utilized in this study to observe the different provinces' PSP related to mangrove. Content analysis is a research method that provides a systematic and objective means to make valid inferences from written data in order to describe and quantify specific phenomena (Downe-Wambolt 1992). The groundwork for the credibility of content analysis study initiates when the planning of the study begins, with the purpose of content analysis is to organize and elicit meaning from the data collected and to draw realistic conclusions from it (Bengtsson 2016). The method of content analysis has been used for various field of researches, including anthropology, library and information studies, management, psychology, sociology and political science (White and Marsh, 2006). In this study, PSP documents were used to perform the content analysis on the understanding of mangrove's role in Indonesia. Content analysis can be used for document analysis to generates data that can be categorized into major themes and

categories (Labuschagne 2003), however, the content analysis method requires open mind to analyse text and identify meaningful subjects to answer the research question (Bengtsson 2016).

According to study from Bengtsson (2016), data analysis for content analysis method consists of (1) decontextualize to identify the meaning units, (2) recontextualize by re-read original text and removing unimportant information, (3) categorization by identifying themes and categories, and (4) compilation which is to find the essence of the studied phenomenon. Erlingsson and Brysiewicz (2017), describe the analysis steps with particular highlight on (1) read and re-read the materials to gain a general understanding, (2) dividing the text into smaller parts (meaning units), (3) condensation process of shortening text but preserving the core meaning, (4) code label name to describes the particular condensed meaning unit, and (5) category grouping the codes that related through content or context.

The process of the content analysis in this research is a qualitative content analysis. The aim is to systematically transform a large amount of text into highly organized and concise key results (Erlingsson and Brysiewicz, 2017). The first step is data gathering through the collection of PSP documents from government database. From the total 34 provinces in Indonesia, this study analyzed 27 PSP due to limited data availability from the publicly accessed documents from the government database of the Indonesian Ministry of National Development and Planning (Direktorat Tata Ruang dan Pertanahan – Bappenas 2013; JDIH Biro Hukum Kementerian Dalam Negeri 2013; Bappeda Provinsi Sumatera Selatan 2017; JDIH BPK RI Database Peraturan 2017). The second step is coding frame which consists of initial reading to familiarize with the PSP documents and observing the mangrove related statement within the document. In the third step the data was coded, dividing the mangrove statement (meaning units) and the condensed meaning units of keywords (codes), as well as developing clusters for each of the keywords. The code was then tested on other PSP documents, followed by an evaluation through consultation with other researchers and discussion meeting with researcher group from Ministry of Maritime Affairs and Fisheries Indonesia on whether there were any changes in applying the keywords before analysis. The summary of the research step can be seen in **Figure 2** below.

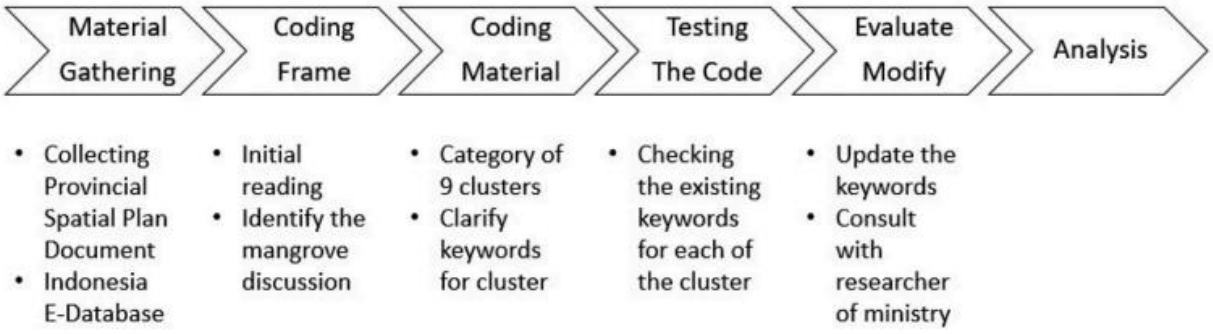

Figure 2 Research Steps to Implement Content Analysis on the PSP Documents [Retrieved from Lukman et al. 2019]

For the comprehensive list of keywords and a visualization of the selection process in this study, the **Figure 3** below outlined the keywords from the PSP (and the wording in *Bahasa*) and the cluster categorization. If a certain keyword from the clusters is included in the statements, it means that the PSP on that province contained those specific cluster elements. For example, the term tourist attraction (*obyek wisata*) was used as a keyword for the cluster "*tourism.*" Furthermore, an interview was also held with the Regional Development of the Planning Agency West Java the and Balikpapan Fishery Agency to explore the current situation of spatial planning. Based on these processes and criteria, the policy trends and status of the mangroves in the PSP were determined.

Cluster	Keywords (Bahasa)
Aquaculture	Allowed aquaculture (*diperbolehkan budidaya perikanan*); aquaculture improvement (*pengembangan pertambakan*); aquaculture integration (*memadukan budidaya ikan*)
Carbon storage	Carbon sequestration (*penyerapan karbon*); low carbon (*rendah karbon*)
Disaster prevention	Tsunami (*tsunami*); abrasion (*abrasi*); erosion (*erosi*); wave resistance (*penahan gelombang*); natural disaster (*bencana alam*)
Fish nursery	Germplasm (*plasma nutfah*); fisheries region (*kawasan ikan*); fisheries resource (*sumberdaya perikanan*); spawning (*pemijahan*); breed (*berkembangbiak*)
Prohibited activities	Forbid activities (*pelarangan kegiatan*); logging (*penebangan*); reclamation (*reklamasi*); development (*pembangunan*); damage threat (*mengancam kerusakan*); convert function (*mengubah fungsi*); decrease area (*mengurangi luas*); pollute (*mencemari*); conversion (*konversi*)
Reforestation	Rehabilitate (*merehabilitasi*); revitalize (*merevitalisasi*); improve (*meningkatkan*); strengthen (*penguatan*); reforestation (*reboisasi*); preserve (*melestarikan*)
Regulatory services	Environment services (*jasa lingkungan*); environment support (*daya dukung lingkungan*); pollution filtration (*filter pencemar*)
Research and education	Research (*penelitian*); education (*pendidikan*); research allowed (*diperbolehkan penelitian*)
Tourism	Nature tourism (*wisata alam*); tourist attraction (*obyek wisata*); tourism business (*usaha pariwisata*)

Figure 3 Outline of the Cluster and Keywords [Retrieved from Lukman et al. 2019]

2.3 Results

The content analysis of the PSP resulted into nine clusters of: (a) *prohibited activity*, (b) *tourism*, (c) *research and education*, (d) *reforestation*, (e) *fish nursery*, (f) *disaster prevention*, (g)

aquaculture, (h) *regulating services*, and (i) *carbon storage*. **Figures 4, 5**, and **6** show the frequency of the clusters in each province, the total frequency of the clusters in Indonesia, enforcement year and the geographical location of the cluster. The results showed *prohibited activity* as the most frequently stated cluster with 21 provinces explaining in various details on what activities considered to be prohibited. Activities such as logging, reclamation, development, convert function, decreasing area, polluting, and conversion are considered within the cluster of *prohibited activity*. The second and third most frequent clusters stated in the PSP are *tourism* and *research and education*, respectively. Activities such as tourism business and research are allowed with consideration in the PSP that these activities will follow and respect the conservation principle. The next focused cluster is *reforestation* with 12 provinces mentioning it, particularly on the aspect of mangrove conservation. Other ecosystem services such as *fish nursery*, *disaster prevention* and other *regulating services* are among the clusters that were mentioned in the PSP, with only 10, 8 and 5 provinces mentioned the cluster respectively. The cluster of *aquaculture* is discussed in the spatial plans of 7 provinces. For the least stated cluster, mangrove forests as a *carbon storage* are discussed in only 3 provinces of Central Kalimantan, Jakarta and Papua.

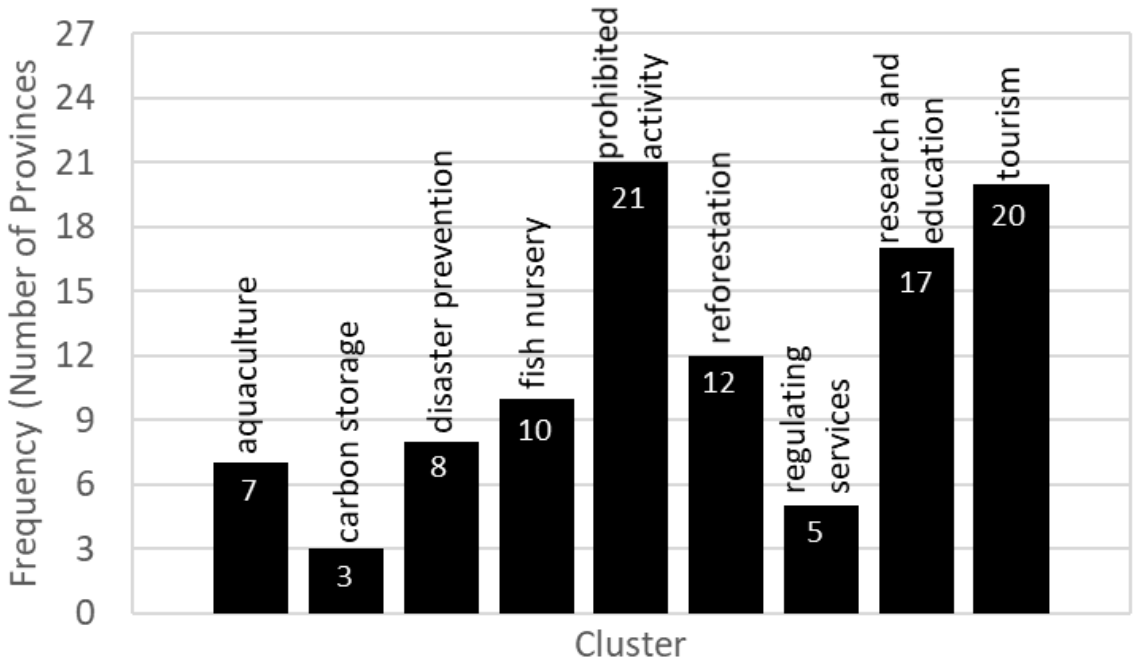

Figure 4 Frequency of the clusters across the provinces in Indonesia (27 PSP documents) [Retrieved from Lukman et al. 2019]

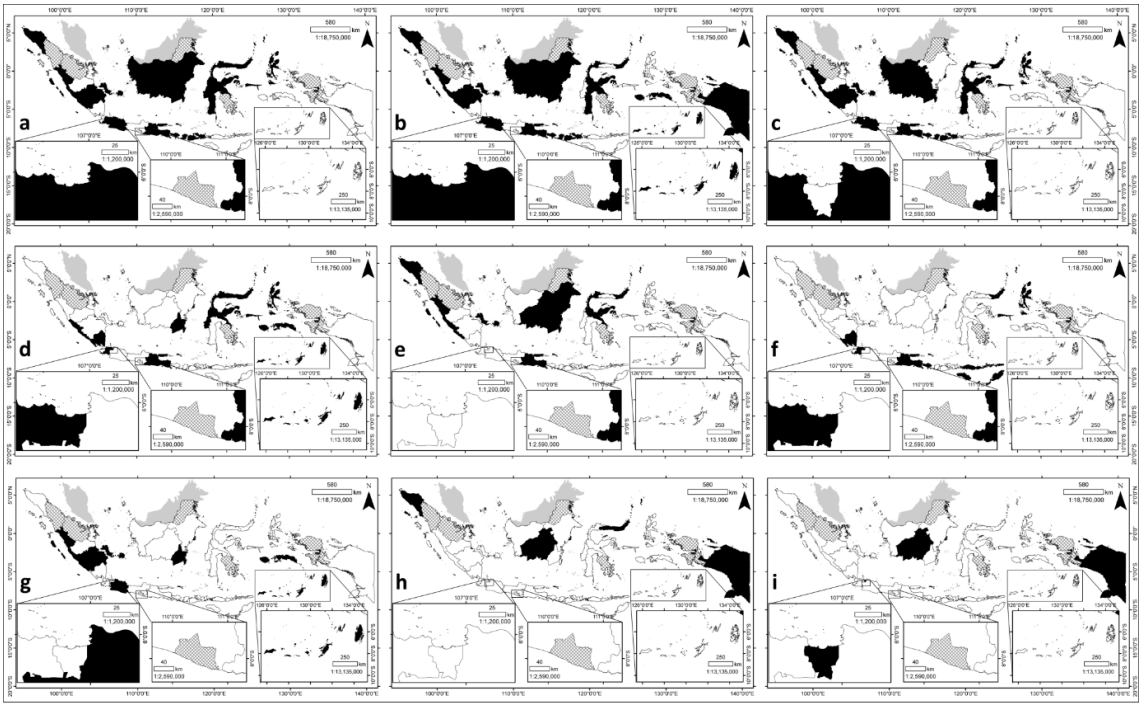

Figure 5 Location map of the provinces showing the nine clusters (Note: Provinces with black shade state the cluster, while unshaded provinces did not state the cluster. Areas that are filled with crisscross patterns are the provinces that were not analyzed [Retrieved from Lukman et al. 2019]

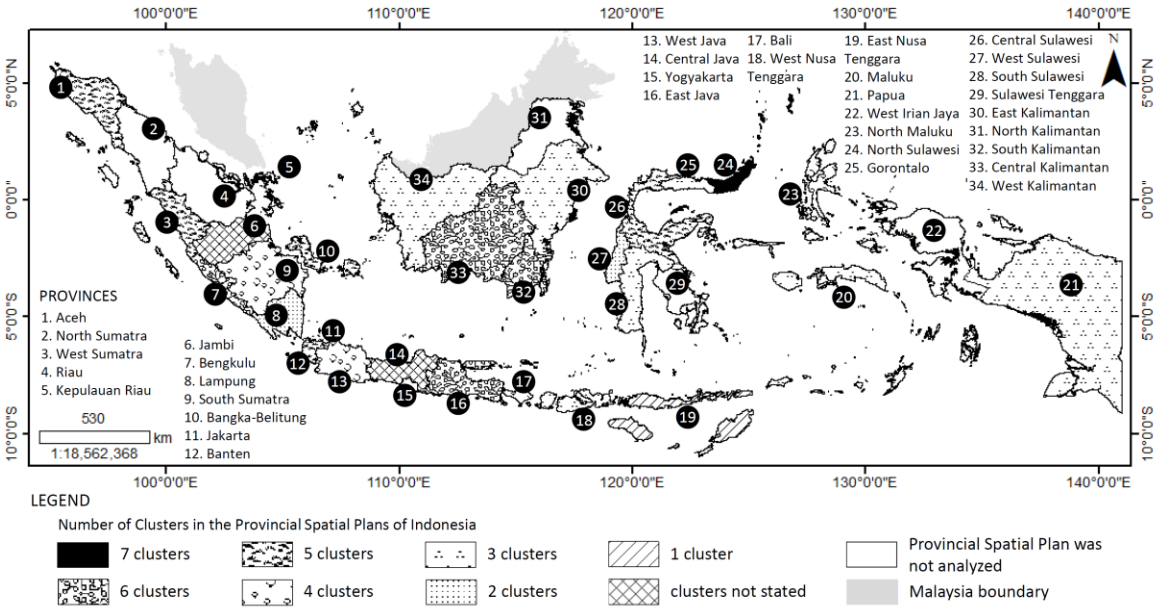

Figure 6 Location map of the nine clusters across the provinces in Indonesia [Retrieved from Lukman et al. 2019]

2.4 Discussion: Mangrove's acknowledgement in PSP

The contents of the PSP that were focused on mangrove ecosystems can be influenced by the provinces' characteristics, as according to PSP Formulation Guideline issued on Public Works Ministry Regulation, which stated that the formulation of PSP documents is based on province's spatial characteristics and resource capacity. Another factor that can affect the content of PSP is the existence of another laws. For example, the *Presidential Regulation* for Island Spatial Plan, which is a policy that states different objectives for each island. In the Kalimantan island, the first objective stated inside the Island Spatial Plan is to focus on conservation and preservation in forestry as according to Presidential Regulation No. 3/2012, while in Sulawesi island, their first objective is to establish a central marine economy as according to Presidential Regulation No. 88/2011. Another case of the provinces that differ in objectives is a combination of Papua and Sulawesi. The spatial plan of Papua states that 70% of the island's biodiversity including marine should be conserve as according to Presidential Regulation No. 57/2014, while Sulawesi only conserve 40% of their natural resources. These differences in socio-political aspects are reflected in the results of the content analysis, for example in *carbon storage* cluster with two provinces in Kalimantan and Papua, while none in Sulawesi island. This showed the connection between the statement inside the PSP and the Island Spatial Plan, with the latter have roles as coordination tool of development program, but unable to be used as a basis to give permission for spatial plan utilization.

The social condition on each province is another factor which influence the statement in PSP and the focus of the province's economy. Socio-economic development influences the nature-society interactions, for example the ecological-cultural value systems are attributed to mangrove ecosystems, and the rate of mangrove exploitations (Armitage, 2002). The difference of culture, developed from long historical values, also develop on how the province take a certain perspective regarding the utilization of specific ecosystem. The provinces in Kalimantan island, with extensive forest ecosystem, are more likely include the *prohibited activities* statement as a part of conservation effort on the terrestrial and mangrove forest ecosystems. In addition, there is also the characteristics of area in Indonesia development based on the local resources (Aritenang 2008), and the aspect of culture which plays the role in transformation of the main industries, such as the transformation from agriculture to tourism (Pudianti et al., 2016). In addition, ethnicity as part of identity can also shape the access and control over natural resources (Lau and Scales, 2016), while

at the same time, decentralization in Indonesia leads to the newly formed provinces as more ethnically homogenous (Alesina et al., 2019). Looking at the case of Central Sulawesi for example, economic and ethnic hierarchies in the mangrove forest conversion process are well established and place government and entrepreneurial elites at the top and immigrant caretakers at the center of a profitable economy. The local people and fishers of *Kaili* are typically marginalized from both the economic benefits of *tambak* production and the historically significant benefits of intact mangrove forest (Armitage 2002). The ethnic *Kaili* and *Bugis* which live closer to coastal areas in Central Sulawesi province and work as fishermen, are more likely can access the benefits from mangroves to fisheries. This could influence the governance in Central Sulawesi to incorporate *fish nursery* services on their PSP. In South Kalimantan province, reforestation of forest and mangroves is the focus of their PSP which could be influenced by their ethnicity. In this province, *Banjar*, the natives, lives within the forests so they focus on the protection of these resources. This highlights the aspect of community and bottom-up approach as integral part of PSP and specifically the mangrove management in the coastal area in Indonesia. Study from Maksin-Mićić et al., (2009) also highlight that the aspect of participation in the spatial plan formulation, with the example of informing and motivating citizens and other stakeholders in decision making.

In this section, the frequent topic within the PSP will be discussed. First, for the cluster of *prohibited activity* with 21 provinces acknowledged the variety of forbidden activities in the mangrove area. The results imply a somewhat "top-down" approach in provincial governments' conservation efforts concerning other sectors, including local communities. Prohibitions of activities that may damage the mangrove forests dated back to the Presidential Regulation No. 32/1990 on The Management of Protection Areas, where mangrove ecosystem are declared as a protected area (Sunyowati et al., 2016). The protected area status may have encouraged provinces to establish strict regulations regarding mangrove ecosystems and a good start on the conservation effort. Study from López-Angarita et al., (2018) highlighted the role of protected area as effective instrument to reduce mangrove deforestation and setting a positive example for regions where mangroves are in decline. However, there is also the concern on the conflicting interest between different level of government. The interview with the Regional Development of Planning Agency in West Java and the Balikpapan Fishery Agency indicate the potential conflict between central government and provincials governments regarding the national strategic development which can influence the areas of mangrove ecosystems, for example, the national strategic development

might assigned the development of infrastructure access such as highway or harbor, but the area of development is intersecting with mangrove protected areas within the provincial border. Hence it is possible that the province follows the guideline from the central government to convert the mangrove ecosystem into the new land function.

The next most frequent clusters were *tourism* followed by *research and education* which offer new insights concerning the approach to mangrove conservation. Mangroves were identified as suitable areas for teaching environmental education in senior high schools (Restu et al., 2017). Our results indicate that such elements are partially reflected in the PSP. The *tourism* cluster is included in the PSP since provinces of Indonesia have numerous potential ecotourism programs that highlight mangrove ecosystems. A few programs have been implemented already, this includes the mangrove sightseeing, visiting aquaculture, fishing, canoeing, bird watching and volunteering in mangrove conservation programs (Hakim et al., 2017). In addition to this cluster, certain elements of community and infrastructure also needs to be developed (Wijayanto et al., 2013; Luviana 2017; Pauziah 2017). The frequent inclusion of these two clusters in the statements of PSP might encourage the effort in lower-level government to promote their mangrove areas for tourism and research and education activities. Nonetheless, the utilization of mangrove ecosystem for tourism destination should also be considered in terms of the impact to the environment and socio-culture of the area.

The role of mangroves in the environment is not commonly reflected in the PSP across all of the provinces in Indonesia. Regulations and supporting functions (i.e., *disaster prevention*, *fish nursery*, *reforestation*, *regulatory services*, and *aquaculture*) and relevant ecosystem services were not frequently mentioned in the PSP. From a different perspective, focusing on one cluster—such as *aquaculture*—might come at certain cost for other clusters. The cluster *aquaculture* which was mentioned in the spatial plans of seven provinces is an indication that conversion of mangrove areas is still beneficial to these provinces from economic perspectives despite the footnote on following the conservation principle for the mangrove conversion. Study from Malik et al., (2015) reported that from the Total Economic Values (TEV) perspective, mangrove ecosystem contribution come from indirect use value such as benefit from nursery ground and carbon sequestration, with result of mangrove TEV to be higher compared with aquaculture TEV. In addition, there is also the concern of low productivity from shrimp aquaculture in Indonesia (Ilman

et al., 2016), and large proportion of aquaculture ponds are abandoned after 5-10 years with intensive aquaculture method which is rarely sustainable on the long-term (Oh et al., 2017). These finding highlights that there is still the tendency to utilize the mangrove for aquaculture and fishpond, which is a potential pressure to the coastal ecosystem from the land-use change.

Another finding from this study is the important role of mangroves which is not commonly stated in PSP—such as the *disaster prevention* and *carbon storage* clusters—may become the baseline for lower-level government initiatives. This research contributes to providing insight into Indonesia's efforts towards mangrove regulation within the limits of PSP by identifying the current status of the individual provincial plans. The different spatial plans showed similar trends for the cluster of *carbon storage*, with the exception of three provinces; Central Kalimantan, Jakarta, and Papua. Jakarta which is the capital of the country was chosen as area for training and education program on climate change issues, with the impact of climate change felt by people who lives in coastal area of Jakarta (Hidayati et al., 2012). Through Governor Regulation No. 131/2012, Jakarta aims to reduce 30% of greenhouse gas emission by 2030, with carbon sequestration of mangrove ecosystems has been introduced in this province in addition of functionality from tourism areas to control the damage of land-conversion process (Rahmawati 2018). This could contribute to the acknowledgement and inclusion of *carbon storage* cluster to the plan. For Papua and Kalimantan, these regions as well as Sumatra are the locations of the regionally important mangrove ecosystems (FAO 2007). In the case of Central Kalimantan, the province was chosen as model province for REDD+ implementation in 2000-2011, with inclusion of the *carbon storage* cluster can be attributed to forest fire incident and deforestation as major contributor to CO_2 emission (Krisnawati et al., 2015). The pristine forest condition in Papua can also influence the proposed statement of mangroves ecosystem as carbon sequestration feature in PSP, with the relatively pristine condition initiates the preservation of the natural mangrove reflected through the initial acknowledgement of carbon storage cluster service in the PSP. Meanwhile, in Central Kalimantan, the massive coverage of terrestrial forest ecosystems and the concerning deforestation might be another factors which influence the statement in their spatial plan. The statement of carbon storage as mangrove service may serve to spearhead the additional initiatives of mangrove conservation in other provinces in the country as well, which will be important for the future of the blue carbon ecosystems in Indonesia especially with the role of climate change mitigation recognized globally. In Indonesia, mangrove forests contain 3.14 billion metric tonnes of carbon (PgC) (Murdiyarso et

al., 2015) which is one third of global coastal carbon stocks (Pendleton et al., 2012), a potential for Indonesia's future carbon trade, expanding from the terrestrial forest ecosystem, as well as climate mitigation initiative.

2.5 Conclusions

This study has showed the findings on the acknowledgement of the Indonesia's provinces through PSP on the mangrove ecosystems in the context of decentralization. Overall, it can be stated that the decentralization phenomenon in Indonesia will likely lead to an improvement in accountability (Haryanto 2016). By increasing the number of provinces, decentralization shifts the focus of economic development to provincial level, which is supported by the enactment of Law No. 23/2014. Government at provincial level is also gaining more authority. Therefore, initiatives at provincial level may drive conservation efforts in the context of regulation statement for mangrove in PSP. From the perspective of the cluster acknowledgement on mangrove ecosystem, this study highlighted on the majority of the provinces targeting the threatening activities to the mangrove and listed as *prohibited activity*. The next acknowledgement came on the *tourism* and *research and education* with majority of the provinces recognized the potential utilization of mangrove on these two sectors. There were other mangrove ecosystem services that were least mentioned in the PSP, with the highlight on *carbon storage* which might still be early to be adopted, and the *aquaculture* with the concern on future expansion due to the demand of the sector. This finding will be the baseline for the conception on the next part of the study, investigating the local's perception on the blue carbon ecosystem services, particularly for the seagrass that was not mention in this part of the study, as well as selecting the main issues on the coastal ecosystem, which from this study the highlight is related with the land-use (*prohibited activity* from the conversion and infrastructure development), aquaculture, and tourism. This study has certain limitations. First, it is limited in terms of scope, as we only focus on the PSP. A comparison of the state of physical resources and the references in the Plans still need to be done. Second, we did not analyze the conflicts or trade-offs between the different clusters in the Plans, such as tourism and conservation. This remains as a critical task for future studies both at planning level as well as in practice.

3. Blue carbon ecosystem awareness, perception, and utilization

3.1 Introduction: Awareness and perceptions on ecosystem services

Climate change and sea level rise are the risks to the coastal communities (Nurhidayah and McIlgorm, 2019), with another layer of concern in Indonesia from unnoticed degradation due to low awareness from these communities and the government thus hindering the formulation of new policy or enforcement of existing policy (Sjafrie et al., 2018). The issues in the coastal ecosystem setting has forced governments to increase the awareness on the need of protection, adaptive management, and monitoring (Fortes 2018). Awareness, particularly linked for better participation, is highlighted as important approach by key stakeholders for blue carbon mechanism, along with other efforts of working together, implementation of financial incentives, and addressing cultural issues (Ahmed et al., 2018). In particular, for the involvement aspect, where the lack of involvement in ecosystem management can lead to unsustainable resource extraction by local community (Ouko et al., 2018).

According to study from Ogunbode and Arnold (2012), the concern over human exploitation of the natural environment can be addressed through an examination of human knowledge and attitudes toward the environment. In Indonesia, the challenge in regards to the knowledge and awareness is how to improve these aspects, particularly on the understanding on the importance of the ecosystem, such as seagrass, and engage the people in the ecosystem management (Nadiarti et al., 2012). Awareness is reported to play a crucial role in particular for the success of environmental policy (ECLAC 2000), with local residents' awareness enhances the positive response to the government's coastal management program (Gomez and Baldago, 2016). Hence there is the need to consider the awareness on the coastal communities as part of the sustainability and conservation effort.

Aside of the aspect of awareness, there is also the aspect of perception from the coastal communities. Human perceptions of the environment is defined as human interpretation of its space based on background, culture, reason and experience of individual, thus each individual can have different perception of the same object as it depends on their background (Utami et al., 2018), and the perceptions of environmental problems are appeared to be associated everyday experiences (Soto-Cruz et al., 2014). The critical aspect of understanding communities' perspective is linked with determining the ecosystem services management (Ouko et al., 2018). In the study of

perception for tourism, Vargas-Sánchez et al., (2011) reported that perception of an overall positive impact has a positive influence on the attitude towards tourism development, while perception of negative impact has negative influence. Still from the same study, perceptions of the impacts and its link to the personal benefit, in accordance with Social Exchange Theory, are not found sufficient to explain the attitude of residents, thus other consideration should be applied, such as economic level (Vargas-Sánchez et al., 2011). Perceptions and awareness of ecosystem services are known to be affected by variety of variables (Quevedo et al., 2020a), for example in coastal areas of Chile, the fishermen showed a strong economic and cultural dependency on provisioning while at the same time, their general perceptions were related to decreasing catches and a shift to less-valued resources (de Juan et al., 2017).

There are several factors that influence the individual awareness and perceptions. Formal education has been reported to increase the chance of perceiving ecosystem services that are difficult to observe because some services require basic scientific understanding background (Lima and Bastos, 2019), and the level of awareness may also be associated with the effectiveness of formal education (Soto-Cruz et al., 2014). In addition, factors such as occupation were also reported to show marked effects on the environmental knowledge and attitudes (Ogunbode and Arnold, 2012). From the case study of Atacora Chain of Mountains, Benin, there is the insight of socio-demographic factors can predict local people's perception of ecosystem services (Moutouama et al., 2019), while in northeastern Brazil case, the socio-cultural dimension has implication on the perception of mangroves services as well as the decision-making process which should be considered by policymakers to overcome the challenges in coastal conservation (Queiroz et al., 2017). Providing opportunities for residents to voice their opinions has also been reported to generate a favorable perception of tourism's impacts and possibly resulting in support of tourism (Boley et al., 2014). The financial aspect is also said to influence the higher perception of tourism impacts for residents who derive economic benefits, as well as participating in the planning and in contact with tourists (Jani 2018). Looking from other perspective, a study from Wylie et al. (2016) stated that the blue carbon ecosystems degradation is caused by direct and indirect anthropogenic factors, such as coastal development, while at the same time, successful blue carbon projects focusing the involvement of local stakeholders, as well as considering the livelihoods aspect. These indirect drivers include the demographic, economic, cultural, sociopolitical, and technological

elements that exert different pressures such as land-use change and pollution which may affect the overall ecological integrity (Santos-Martin et al., 2013).

This study aims to investigate the blue carbon ecosystem perceptions by the coastal communities, focusing on the aspect of awareness and the resource utilization, as well as the local's participation in the coastal ecosystem program. This study explored the aspects of awareness and analyzed the perceptions of residents that underpin the indirect drivers of the blue carbon ecosystem to provide insight and suggestions for future policy implementation and improvements in coastal areas. As part of this dissertation, the study on the blue carbon ecosystem perception will focusing on the seagrass ecosystem in the coastal setting, where the result will complement the previous insight from the PSP on the mangrove ecosystem. The insight on this study will illustrate the blue carbon perceptions, from bottom-up approach of local communities, an opposite side of the PSP with the top-down approach from the provincial-level government statement. Through the understanding on the level of awareness for the blue carbon ecosystem services, this part of study will contribute to support the issues and threats that needs to be tackled for the next section of this dissertation, hence focusing the community-based management initiative, derived from the blue carbon perceptions.

3.2 Method: Survey on awareness and utilization

Perceptions, awareness and the utilization of seagrass habitats were investigated through the questionnaire surveys to the local residents. The survey was applied in the native language *Bahasa*, so that the locals could easily understand the content. Survey is a useful tool to gather insights regarding locals' perceptions as well as understanding their social contexts (Alshenqeeti 2014). The survey was conducted in the Berau Regency from August 22nd 2019 to September 1st 2019 in areas of Derawan Island, Tanjung Batu, and Tanjung Redeb.

The survey utilized a semi-structured questionnaire with the content of the questionnaire is derived from Quevedo et al.'s study (Quevedo et al., 2020a, 2020b) which consists of four sections: (A) socio-demographic, (B) resource utilization, (C) awareness and threats, and (D) management. In first section A, the questionnaire interviewed the profiles of the respondents, consisting of age, gender, occupation, and education. For section B, the questionnaire inquired the usage and utilization of seagrass ecosystems, focusing on the provisional services and catching fishes, shrimps, shells, and crabs as a means for self-consumption or for selling at the market. The

utilization for tourism and education sector is also explore in section B. In section C, twelve items of awareness to seagrass ecosystems benefits is prepared. The list of awareness consists of seagrass ecosystem services for (1) fish nursery, (2) marine habitat, (3) source of food, (4) source of herbal medicine, (5) coastal protection, (6) natural buffer, (7) air purification, (8) water quality, (9) domestic waste barrier, (10) climate mitigation, (11) groundwater protection, and (12) recreation and education site. In addition, for the awareness, the questionnaire also listed the perceived threats for both mangrove and seagrass ecosystems to support the selection of the issues tackled in this dissertation in the next chapter. The list of threats refers to Quevedo et al., (2021b) study which the questionnaire provides ten different sources of threats, and the respondents will be asked to ranked the threats from the most damaging threat (1) to the least damaging threat (10). For section D, the questionnaire asked the respondents on their experience of participating in coastal management activities. The questionnaire has prepared five different activities of (1) coastal clean-up, (2) mangrove planting, (3) monitoring and evaluation, (4) information and education campaign, and (5) ordinance formulation, in addition, the questionnaire also includes an open answer slot for additional activities which is not mentioned in the questionnaire, and the option of did not participate in the coastal management activities. The sections B and C utilized Likert scale responses ranging from 1 to 5 with different context for each section. Section B on resource utilization categorized the answers as 1 = never, 2 = once a year, 3 = once a month, 4 = once a week, and 5 = everyday, while section C on the awareness of ecosystem importance categorized the answers as 1 = not aware, 2 = slightly aware, 3 = somewhat aware, 4 = moderately aware, and 5 = fully aware.

The sample size for this study was calculated using Cochran's formula of: $n = n_0/(1+n_0/N)$, with $n_0 = (t^2*p*q)/d^2$, and t is equal with the critical value of selected alpha level; *p* is equal with the estimated proportion of the population which has the attribute in question; *q* is equal with 1-*p*; d is equal with the acceptable margin of error; and N is the population size (Bartlett et al., 2001; Quevedo et al., 2020b). In the case of this study, the N is using the Berau Regency population of 226,509 in 2018 (BPS Kabupaten Berau 2019), alpha level (α) of 0.05 with its critical value of 1.96, and confidence interval of 95%. For the sampling error, the initial planned is to aim for 10% margin of error, however, due to the limited time of the survey and data collection, the sampling error has increased to 13%. The selection of the respondents was supported by a local NGO (TNC

– The Nature Conservancy) which was involved in the initial discussion of research plan and also supported the interview and data collection during the field survey.

This study utilized descriptive statistics with the results of the questionnaires were identified and transformed into percentages to identify the current situation, the specific utilization, and the awareness of the ecosystem. Descriptive statistics are used for summarizing data in an organized manner; relationships between variables in a sample or population are described, where they process condensed data into a simpler summary (Kaur et al. 2018). In addition, a correlation analysis was performed to select variables from the socio-demographic details, utilization, and participation sections before further investigated with a regression analysis on the selected variables and awareness of the ecosystem services of seagrass. For the socio-demographic part on the variables of occupation and education, the respondents were given an assigned value for the correlation analysis (Quevedo et al., 2020a) the same approach was also used in assigning values to the respondents' participation in coastal activities.

3.3. Results

3.3.1. Socio-demographic profile

A total of 59 respondents from the Berau regency were interviewed for this study, with their profile can be seen in **Table 1**. The majority of the respondents were in the 31–40 (35.59%) and 41–50 (33.9%) age groups, followed with group of respondents in the 20–30 (15.25%), 51–60 (11.86%), and 61–70 (3.39%). From the survey, most of the respondents interviewed were male (67.8%, 32.2% female). The education level of the respondents was quite varied, with 22.03% attained college-degree level, while high school and junior high sharing the same value of 23.73%, and elementary school at 30.51%. For occupation, there were four categories: fisherman (37.29%), service-related business (32.20%), housewife (16.95%), and government employee (11.86%).

Table 1 Percentage Distribution of the Sociodemographic Profile of the Respondents [Retrieved from Lukman et al. 2021a]

Indicators	Percentage
Age Group	
61-70	3.39
51-60	11.86
41-50	33.90

31-40	35.59
20-30	15.25
Gender	
Male	67.80
Female	32.20
Education Level	
College	22.03
High School	23.73
Junior High	23.73
Elementary	30.51
Occupation	
Fisherman	37.29
Service Business	32.20
Housewife	16.95
Government Employee	11.86

3.3.2. Resource utilization

For the utilization of the seagrass ecosystem in Berau Regency, there are various activities as reported by the local communities as seen in **Figure 7** From the overall perspective of seagrass ecosystem utilization, most locals did not utilize it for consuming fish, with only 5.08% and 6.78% respondents collecting fish for consumption and to be sold everyday respectively, and from the opposite side, there are 69.49% and 71.19% respondents who never utilized the seagrass ecosystem for consumption or to be sold. From the perspective of weekly period, there are higher percentage of locals who utilized the seagrass ecosystem as a fishing site, particularly for personal consumption (11.86%), and for alternative livelihood (11.86%). The results were quite similar for the utilization of seagrass ecosystem on tourism (snorkeling) and education (research site), with the percentage of the locals who were not utilized it are 72.41% and 84.48% respectively. However, from different time scale of the annual span, there is the insight for higher utilization on both snorkeling (15.52%) and research activities (12.07%). Further interview showed that the locals who worked in tourism and as guides prefer to snorkel on a coral reef spot, which might be influenced by how the seagrass ecosystem is degrading and its unsightly appearance. As for the utilization of seagrass in the academic aspect, there is the insight that local universities quite often

do research that involves using the locals as their guides to sites such as the seagrass or mangrove ecosystems. However, this kind of activity is not frequent and usually only takes place once per year, which might answer the insight of higher utilization for the annual span time period of seagrass ecosystem on research activity.

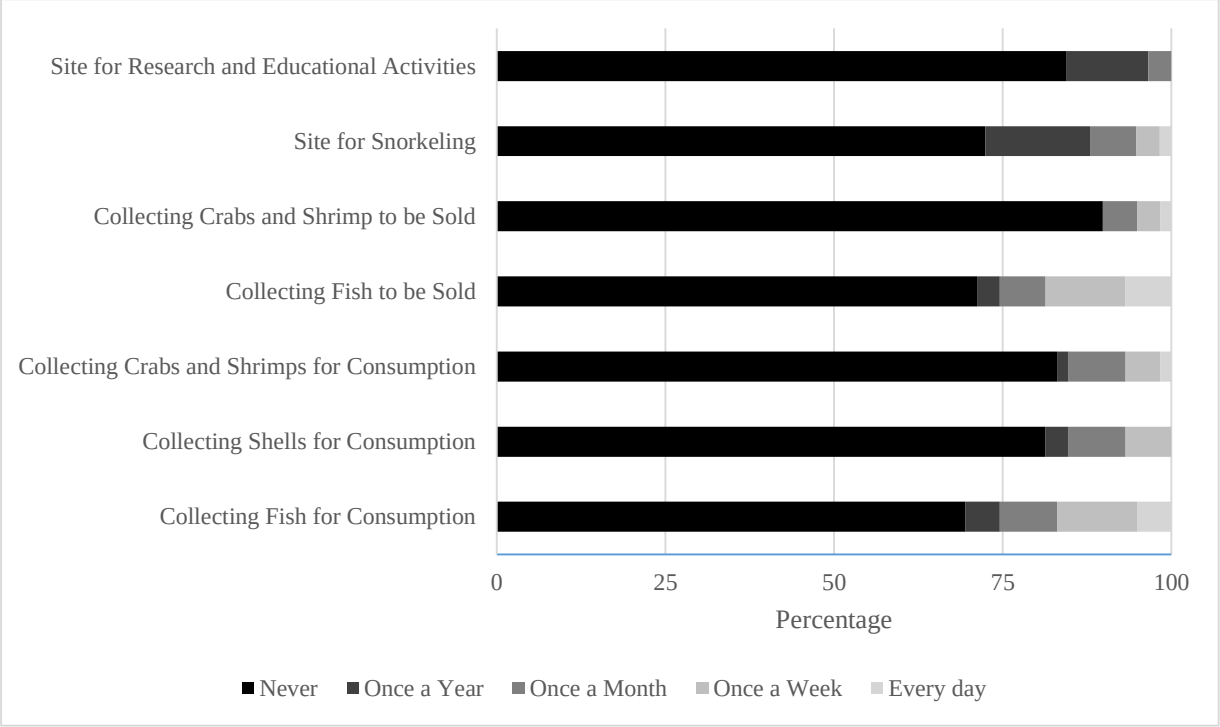

Figure 7 Seagrass ecosystem resource utilization profile [Retrieved from Lukman et al. 2021a]

3.3.3. Awareness of ecosystem services

For the awareness section, as seen in **Table 2**, the results are quite varied, but it is fair to say that the majority of the ecosystem services on seagrass were not known to the locals. For example, the service of seagrass as a nursery and marine habitat, with relatively high results of 38.98% and 35.59% of the respondents not being aware, and only about 3.56% and 15.25% of the respondents answered that they were being fully aware of these services, respectively. However, the survey showed another perspective of certain ecosystem services that were highlighted and perceived by the coastal communities. For example, the role of seagrass in protecting coastal areas and acting as a natural buffer, with quite high results of 23.73% and 20.34% of total respondents being fully aware of these benefits, respectively. The other services that also particularly highly perceived is the role of seagrass ecosystem as a recreational or education site with 27.12% of respondents being

fully aware of this and only 28.81% respondents who were not aware for this service, the lowest compared with other awareness. This result is quite interesting, especially as tourism sector is one of Berau Regency prominent feature, in particular the existence of Derawan Island and supporting tourism business, which can explain the influence to the awareness of the communities to utilized and perceived the benefit from tourism sector, despite there are other prominent ecosystems for tourism such as coral reefs and mangroves. Getting back to the ecosystem services that were not perceived by the locals, 66.69% and 70.69% of respondents were not aware of the carbon sequestration and clean ground water services, respectively. People with the awareness for both of these services were not that high as well, with 1.69% and 10.34% of the respondents that totally aware on the benefits of seagrass ecosystem for carbon sequestration and clean groundwater services respectively.

Table 2 Seagrass ecosystem services' awareness profile [Modified from Lukman et al. 2021a]

Ecosystem Services	Level of Awareness				
	Not Aware	Slightly Aware	Somewhat Aware	Moderately Aware	Fully Aware
1. Serves as nursery, feeding and breeding area for various life	38.98	13.56	25.42	8.47	13.56
2. Provides habitat for a large number of marine and terrestrial lifeforms	35.59	10.17	27.12	11.86	15.25
3. Source of food for consumption and selling	50.85	11.86	22.03	8.47	6.78
4. Source of herbal medicine for a variety of illnesses	59.32	10.17	16.95	6.78	6.78
5. Protects coastal areas from storm surges, strong waves, and typhoons	40.68	15.25	16.95	3.39	23.73
6. Act as natural buffer to coastal erosion from both land and sea	40.68	15.25	16.95	6.78	20.34
7. Helps clean the air	44.07	10.17	27.12	6.78	11.86
8. Helps establish good water quality of the sea	47.46	8.47	22.03	10.17	11.86
9. Prevents garbage scattering from seashore to sea	59.32	6.78	16.95	5.08	11.86
10. Helps mitigate climate change via carbon sequestration	66.10	6.78	18.64	6.78	1.69
11. Helps maintain a clean groundwater system	70.69	3.45	12.07	3.45	10.34
12. Can be used as a recreational (tourism) or educational site	28.81	11.86	20.34	11.86	27.12

3.3.4. Perception of threats

For the perceived threats to seagrass and mangrove ecosystems, the respondents in Berau Regency showed different perceptions, however, there is a trend on certain threats to be perceived as the most damaging threats, as seen in **Table 3** and **Table 4**. For mangrove ecosystems, the most perceived as the damaging threat to this ecosystem is from the activity of mangrove cutting (45.61%), with the second highest threat from the pollution of domestic wastes (21.05%). For seagrass ecosystem, the issue of the domestic waste pollution is the highest one (33.33%), followed with natural disasters (24.26%) and beach reclamation (17.54%). Within the questionnaire for this section, there is another free option for the respondents to fill the threats that were not listed in the ten items, however, there were no respondents who fill the free options, hence giving the argument that the listed threats in the questionnaire is relevant to the issue in the study sites.

Table 3 Perceived Threats to Mangrove Ecosystem

Type of threats	Mode[a]	Percentage[b]
Natural disasters	10	31.58
Pollution (domestic wastes)	2	21.05
Illegal settlement	3	17.54
Increasing population	10	21.05
Charcoal making	8	19.30
Palm oil conversion	5	15.79
Mangrove cutting	1	45.61
Building infrastructure	6	22.81
Residential conversion	4	19.30
Fishponds conversion	9	19.30

[a]The number indicates that (1) as the most damaging threats, and (10) as the least damaging threats; [b]The percentage showed the number of respondents who chose this threat in the that mode value

Table 4 Perceived Threats to Seagrass Ecosystem

Type of threats	Mode[a]	Percentage[b]
Natural disasters	1	24.56
Pollution (domestic wastes)	1	33.33
Increasing Population	9	21.05
Building infrastructures in coastal areas	4	22.81
Mangrove planting on seagrass beds	10	29.82
Sand mining	3	21.05
Unregulated gleaning	4	15.79

Siltation	4	17.54
Beach reclamation	2	17.54
Increasing sea surface temperatures	9	22.81

[a]The number indicates that (1) as the most damaging threats, and (10) as the least damaging threats; [b]The percentage showed the number of respondents who chose this threat in the that mode value

3.3.5. Management and participation in coastal programs

In regards to the coastal program in Berau Regency, the results showed that in overall the locals have participated in variety of programs. As seen in **Figure 8**, the type of coastal management which was most participated is coastal clean-up (43 respondents), followed by education campaigns (36 respondents), monitoring and mangrove planting (29 respondents), and the least participated is ordinance formulation (19 respondents). To get a better context on this result for coastal program in Berau Regency, during the survey, there was a discussion with the government employees and fishing communities which showed that coastal clean-up program is consisted of activities such as picking up waste and garbage, which is the common form of the coastal celan-up program and the active campaign by the local government. While other activities such as training and education programs in coastal conservation, mangrove planting and monitoring was sometimes promoted by third-party NGOs and foreign aid organizations. Meanwhile, for ordinance formulation with the lowest participation, one of the explanations for this phenomenon is this type of activity has low coverage and only invited certain group of people in the communities and only people with certain status (i.e. community leader, etc.) can be involved in the ordinance formulation.

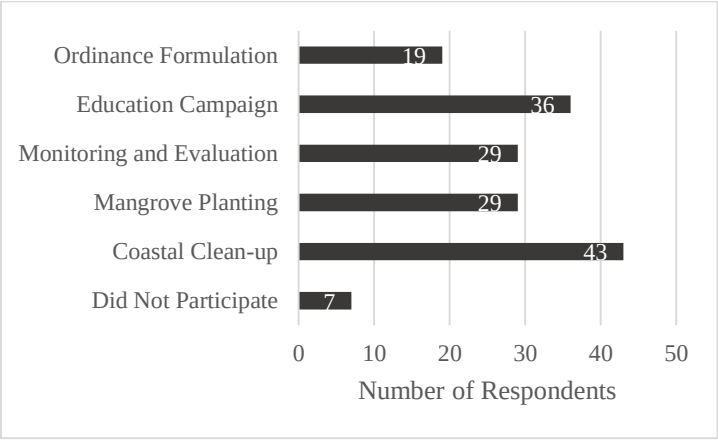

Figure 8 Coastal programs participation profile [Retrieved from Lukman et al. 2021a]

3.3.6. Correlation analysis

Correlation analysis was performed on the aspects of socio-demographic details, resource utilization, and awareness of ecosystem services by seagrass in the Berau Regency. For the correlation between socio-demographic details and resource utilization, as shown in **Table 5**, the results showed a significant correlation between fishermen and the activities of collecting fish, shells, shrimp, and crabs for personal consumption and trade in the seagrass ecosystem, particularly for the activity of collecting fish, as well as crabs and shrimp to be sold with the highest correlation of 0.554 (p-value < 0.001) and 0.436 (p-value < 0.001) respectively. The other occupations of service business, housewife, and government employee did not produce any significant results with the resource utilization for seagrass ecosystem. However, looking at the education level, the study found correlation between elementary school and junior high education and the collection of shells and fish, respectively, which might be related to the low educational backgrounds of the fishermen. At the senior high level, there was an interesting relationship where the respondents utilized the seagrass ecosystem as a site for snorkeling, with correlation value of 0.367 (p-value < 0.01). Despite seagrass in Berau Regency has least appeal compared with coral reefs for tourism, fishermen with this level of education can understand how seagrass can also contribute to other activities and alternative livelihoods for them, hence the tourism utilization.

Table 5 Correlation Analysis between Sociodemographic Profile and Resource Utilization [Modified from Lukman et al. 2021a]

Resource Utilization	Occupation				Education			
	Fisherman	Service Business	Housewife	Government Employee	Elementary School	Junior High	Senior High	College
Collecting Fish for Consumption	**0.384****	-0.332	-0.003	-0.057	0.061	0.201	-0.086	-0.186
Collecting Shellfish for Consumption	**0.268***	-0.328	0.137	-0.061	**0.287***	0.017	-0.265	-0.064
Collecting Crabs and Shrimp for Consumption	**0.407****	-0.310	0.024	-0.165	0.212	0.054	-0.150	-0.136
Collecting Fish to be Sold	**0.554*****	-0.372	-0.098	-0.145	-0.031	**0.325***	-0.122	-0.174
Collecting Crabs and Shrimp to be Sold	**0.436*****	-0.232	-0.152	-0.123	0.035	0.074	-0.062	-0.050

Site for Snorkeling	-0.244	0.127	-0.042	0.164	-0.149	-0.274	**0.367****	0.071
Site for Research and Educational Activities	-0.170	0.070	0.049	0.120	0.000	-0.251	0.050	0.206

*, **, *** indicate significant correlation at p-value of <0.05, <0.01, and <0.001 respectively

For the correlation analysis between the socio-demographic profile and participation profile in **Table 6**, several insights were gained on how occupation correlated with several coastal programs in the Berau Regency. Fishermen were drawn to mangrove planting activities with correlation value of 0.294 (p-value < 0.05), while housewives showed interesting result which is correlated with no participation with value of 0.393 (p-value < 0.01). Mangrove planting is a common program in the Tanjung Batu area, and some of the fishermen also utilized the mangrove area to collect fish and crabs, which can explain how these group of community is potentially influenced with the understanding on the benefit of certain ecosystem services, particularly the one that related the most with their livelihoods (fishermen). As for the housewives, the tendency of not participating for coastal program can be partially explained with the locals' culture and value which perceived the housewives to focus their activities on domestic chores, thus limiting their time to participate in coastal activities. Meanwhile, for government employees, this type of occupation correlates with mangrove planting activities, as well as ordinance formulation with correlation value of 0.373 (p-value < 0.01) and 0.308 (p-value < 0.05) respectively. The majority of the coastal-related programs can be traced back from a government initiative or facilitation by the government, thus the high participation from government employees can be linked as a requirement from their occupation. From the education level correlation with the participation profile, few significant results were seen, except for college-level respondents, with the highly correlated value of 0.421 (p-value < 0.001) with the participation in ordinance formulation activities. Policy-making is known to involve certain stakeholders from various sectors, although looking at the results there might be a tendency for this kind of activity to only draw people from certain sectors, such as NGOs and business owners, while possibly ignoring the lower-level education group. One interview with a respondent showed that some of the fishermen are fed up with participating in ordinance formulation, either because of the knowledge gap or because their aspirations are often ignored, which give insight on the formulation of policy needs to be followed up with the implementation which can give a good impact to the local communities, and not only focusing on the abstract rules.

Table 6 Correlation Analysis between Sociodemographic Profile and Participation Profile [Modified from Lukman et al. 2021a]

Participation Profile	Occupation				Education			
	Fisherman	Service Business	Housewife	Government Employee	Elementary School	Junior High	Senior High	College
Did Not Participate	-0.283	0.084	**0.393****	-0.135	0.098	0.042	-0.081	-0.069
Coastal Clean-up	0.155	0.012	-0.334	0.106	-0.093	-0.108	0.071	0.140
Mangrove Planting	**0.294***	-0.170	-0.444	**0.373****	-0.210	0.089	-0.070	0.214
Monitoring and Evaluation	0.153	-0.097	-0.083	0.059	-0.062	0.009	-0.070	0.132
Education Campaign	0.041	-0.044	-0.102	0.078	0.001	-0.044	-0.126	0.173
Ordinance Formulation	-0.081	-0.009	-0.118	**0.308***	-0.142	-0.214	-0.043	**0.421*****

*, **, *** indicate significant correlation at p-value of <0.05, <0.01, and <0.001 respectively

The last correlation analysis was done for the resource utilization and participation profile, as seen in **Table 7**. Looking at the seagrass ecosystem service for provisioning and collecting seafood aspect, the analysis showed that collecting crabs and shrimp for trade correlated with the activities of mangrove planting, with the correlation value of 0.342 (p-value < 0.01). The commonly expressed opinions during the survey by the communities was related to how the mangrove ecosystem can provide benefits for them such as seafood resources, which potentially influence their perceptions and daily behaviors on the resource utilization. The next correlation was found for the ecosystem utilization in the form of research and education activities which correlates with participation in the program of coastal clean-up, monitoring and evaluation, education campaigns, and ordinance formulation, with correlation value of 0.275 (p-value < 0.05), 0.287 (p-value < 0.05), 0.272 (p-value < 0.05), and 0.268 (p-value < 0.05) respectively. Based on the interviews with the respondents, there is the insight on how the fishermen benefit from this type of utilization, with the more common activities in the form of accompanying research teams or university students to a seagrass site. However, this type of activity is limited in term of frequency, which is only happens once or twice per year, thus reflecting the lower utilization frequency compared with

the activity which is linked to the occupation of fishermen for example. Nonetheless, the interactions between local communities who participate in seagrass research, cooperated with local universities showed the potential benefit not only from the utilization of seagrass ecosystem, but also the potential transfer of knowledge on the understanding of the various seagrass ecosystem services which can influence to the participation in coastal programs.

Table 7 Correlation Analysis Between Resource Utilization and Participation Profile

Participation Profile	Resource Utilization						
	Collecting Fish for Consumption	Collecting Shellfish for Consumption	Collecting Crabs and Shrimp for Consumption	Collecting Fish to be Sold	Collecting Crabs and Shrimp to be Sold	Site for Snorkeling	Site for Research and Educational Activities
Did Not Participate	-0.098	-0.045	-0.033	-0.112	-0.123	-0.230	-0.165
Coastal Clean-up	0.044	0.196	0.178	0.039	0.205	0.149	**0.275***
Mangrove Planting	0.154	0.063	0.210	0.111	**0.342****	0.006	-0.073
Monitoring and Evaluation	0.127	0.147	0.189	0.014	0.120	0.071	**0.287***
Education Campaign	0.053	0.048	0.097	0.018	0.051	-0.014	**0.272***
Ordinance Formulation	-0.018	-0.056	0.075	-0.143	0.126	0.118	**0.268***

*, ** indicate significant correlation at p-value of <0.05 and <0.01 respectively

3.3.7. Ecosystem service awareness, regression model

Next, a regression analysis was performed to investigate the model of socio-demographic profile, resource utilization, and participation profile when it comes to awareness of seagrass ecosystem services, as seen in **Tables 8** and **9**. For the awareness items 1–6 on **Table 8**, the results showed that government employees influenced awareness of nursery, coastal protection, and erosion services. Resource utilization of provisioning influenced awareness of the coastal protection and erosion aspects, while ordinance formulation influenced awareness of the nursery, source of food, and source of herbal medicine aspects. According to the interview with the respondents, there is

the expression on how certain seagrass utilizations were lost to time, such as its use for a coloring agent for fishing nets and herbal medicine as these benefits were replaced with more convenient technology. Most of this knowledge was abandoned due to the availability of other methods that are faster and easier. Looking at the awareness items 7–12 in **Table 9**, the regression analysis gave insight into how government employees influenced the awareness of most seagrass ecosystem services, even the carbon sequestration capacity of the seagrass, which is a service that is not really well known in the area. From the resource utilization aspect, it is interesting that the collection of crabs and shrimp for trade is a significant variable related to the better air and water quality services, and participation in ordinance formulation also contributes to the awareness of groundwater quality.

Table 8 Regression Analysis between Sociodemographic Profile, Resource Utilization, and Participation Profile for Awareness of Seagrass Ecosystem Services (1 – 6) [Modified from Lukman et al. 2021a]

Independent Variables	Awareness					
	1. Serves as a nursery, feeding, and breeding area for various lifeforms	2. Provides habitat for a large number of marine and terrestrial lifeforms	3. Source of food for consumption and selling	4. Source of herbal medicine for a variety of illnesses	5. Protects coastal areas from storm surges, strong waves, and typhoons	6. Acts as natural buffer to coastal erosion from both land and sea
Fisherman	0.299	0.746	0.119	0.127	0.498	0.625
Government Employee	**0.026***	0.086	0.635	0.378	**0.01***	**0.005****
Elementary School	0.983	0.803	0.787	0.854	0.347	0.337
Senior High	0.239	0.386	0.689	0.904	0.556	0.568
Collecting Shellfish for Consumption	0.877	0.154	0.433	0.061	0.036	**0.039***
Collecting Crabs and Shrimp to be Sold	0.105	0.603	0.641	0.384	**0.012****	**0.008****

Site for Research and Educational Activities	0.639	0.490	0.353	0.816	0.969	0.795
Mangrove Planting	0.469	0.420	0.247	0.730	0.746	0.781
Ordinance Formulation	**0.004****	0.050	**0.03***	**0.003****	0.432	0.510

*, ** indicate significant correlation at p-value of <0.05 and <0.01 respectively

Table 9 Regression Analysis between Sociodemographic Profile, Resource Utilization, and Participation Profile for Awareness of Seagrass Ecosystem Services (7 – 12) [Modified from Lukman et al. 2021a]

Independent Variables	Awareness					
	7. Helps clean the air	8. Helps establish good water quality of the sea	9. Prevents garbage scattering from seashore to sea	10. Helps mitigate climate change via carbon sequestration	11. Helps maintain clean groundwater system	12. Can be used as a recreational (tourism) or educational site
Fisherman	0.457	0.147	0.539	0.359	0.225	0.821
Government Employee	**0.026***	**0.026***	**0.013***	**0.007****	**0.033***	**0.032***
Elementary School	0.419	0.914	0.840	0.858	0.864	0.846
Senior High	0.459	0.990	0.753	0.414	0.980	0.423
Collecting Shellfish for Consumption	0.450	0.974	0.534	0.249	0.101	0.014
Collecting Crabs and Shrimp to be Sold	**0.031***	**0.005****	0.558	0.570	0.603	0.758
Site for Research and Educational Activities	0.924	0.708	0.661	0.567	0.979	0.584

Mangrove Planting	0.834	0.377	0.319	0.340	0.917	0.622
Ordinance Formulation	0.258	0.257	**0.01***	0.341	**0.013****	0.050

*, ** indicate significant correlation at p-value of <0.05 and <0.01 respectively

3.4. Discussion

3.4.1. Socio-demographic details, resource utilization, and participation profile

The findings of this study showed that in terms of socio-demographic, resource utilization, and participation profile of the local communities in Berau Regency, there is the indication that the seagrass ecosystems are not well utilized, with highlight on few respondents (21.17% in average for all type of utilization) but most respondents did not. Similar trends apply to the perspective of the tourism business, which is lacking in seagrass utilization. The interviewees on Derawan Island perceived that the environmental aspect is one of the factor linked to the tourism sector, however, seagrass was not considered as the important one, compared with ecosystem such as coral reefs. There is the potential to expand the seagrass utilization, with seagrass link to the habitat of sea turtle (Mukhlisi 2017) and dugong (Marsh 1992) which can be another potential spot for tourism sector attraction. Broadening the ecosystem services, beyond tourism and recreation remain challenges. The service beyond tourism include services such as provisional service for drinking water, water purification, medicinal products, water flow regulation, biodiversity, and cultural values, has been reported to be related to valuing the ecosystem services (Himes-Cornell et al., 2018). Fishing is a common occupation along the coastal shoreline of the area. Some of the fishermen's houses face the ocean and are adjacent to the seagrass, and they had noticed it change over time due to degradation. Several respondents expressed how they had felt changes in this seagrass; for example, in the past there were abundant fish and they could go fishing right in front of their homes, but the situation has changed and it is now more difficult to get fish near the seagrass. The decline of seagrass is also reported in existing studies with highlight on the threats reported in Derawan Island in regards to the loss of seagrass ecosystem due to the overfishing, and there is association of the fishery catch declined from this phenomenon (Unsworth et al., 2018). In another study from Nadiarti et al., (2012) it was reported that the decline of seagrass in Indo-Pacific region is linked with the coastal development, poor land management, and fisheries over-exploitation, which is potentially become a serious threat to seagrass.

3.4.2. Concern over illegal fisheries practices

The environmental degradation of the coastal ecosystem in Berau Regency is also related to the practice of fish bombing. The practice of bomb fishing is one of the common environmental problem perceived in Berau (Widodo et al., 2010). It is the rising concern from the local fisherman over and is considered as quite common practice. Based from the statement of the local people and government in the interview, there is the indication that the number of illegal practices has been significantly reduced. One factor which reduce the illegal practice is the introduction of the tourism industry which generates awareness on the understanding of the environmental services benefits, and becoming a driver to convert from illegal practice to tourism services livelihood. The introduction to the tourism sector is an initiative by the local government that involves identifying illegal fishermen and educate them through the series of workshop training in the tourism business so that they can become a tourist guide for example. Nonetheless, several fishermen still raised concerns about the existence of illegal fishing. The most common type of practice is using bombs and potassium. Although the bombing practice is not linked directly to the seagrass because it is often done on the open ocean, this phenomenon is another layer of concern in Berau Regency in terms of sustainable coastal management and future fisheries industry, particularly so with the fishermen experienced the change in their fish catch and they require a longer fishing distance to get to an abundant fishing site. The fishermen household is also concerned for their future generation, whom they predicted will suffer more heavily to benefit from fisheries sector, resulting in them facing more difficulty in entering the profession. The long recovery for coral reefs and other ecosystems damaged by illegal practices is a concern and key challenge to initiate the behavior change. However, the intervention of this challenge may generate potential conflict, as most of the illegal fishermen are also from their neighborhoods, and members would rather avoid any conflict. The existence of the market and bomb supplies within the local area is driving the demand of the illegal practices, and the government should also consider to concentrate their effort in monitoring the legal and safe market.

3.4.3. The government's role and community initiative

The regression analysis in this study has examined the relationships between the variables of socio-demographic profile, resource utilization, and participation profiles, in regards to the level of awareness of seagrass ecosystem services. A significant highlight is that the respondents working as government employees showed high awareness of the various seagrass ecosystems services.

This finding can be explained with the environment and exposure of the Berau Regency local government's various coastal programs and initiative which carry the potential to influence awareness of the many ecosystem services provided by seagrass. The concern lies in how the government can effectively spread this awareness to the local community and push forward to better coastal management and sustainable utilization of the seagrass ecosystem, especially when the frequency of ecosystem utilization is intertwined with the level of awareness. In study from Parker (2018), the lack of capacity and environmental understanding among government officials in Indonesia can resulted in the rarely enforced law to protect the environment. Hence the characteristic of Berau Regency local government with the capacity to initiate the change in the awareness level should be treated as the potential of the region. The public image of Berau as a national tourism site, particularly the existence of Derawan Island, can be another factor which promote the awareness of environmental protection of the coastal ecosystem and increasing the priority of the joint tourism and environment program. Nonetheless, even with the various programs and initiatives for coastal management in the Berau Regency, particularly one that initiated by the government, it is also important to look at the effectiveness and continuity of the programs themselves. Based on the interviews with the locals, several foreign-aid programs were established with the cooperation of the local government, but few participants mentioned receiving any benefit to this day. Community involvement in coastal programs can also be seen in Berau Regency, with a specific focus on Tanjung Batu. The fishermen in that area established a fishermen community that is in harmony with the mangrove tourism community, which can be an incentive on the aspect of voluntary monitoring of the mangrove ecosystem, especially when it comes to illegal mangrove cutting in the area. The mangrove trees in Tanjung Batu are regarded as high quality, and outsiders are known to cut them late at night. The initiative started through simple communication between fishermen who, while fishing at night, happened to witness illegal mangrove cutting. They reported it to the community leader and the information was forwarded to the appropriate authorities. In study from Vermaat et al., (2012), a projection scenario until 2030 foreseen that under business-as-usual conditions, mangrove deforestation will continue to exists and become a part of pressures in Berau Regency, with cases of conversion and overexploitation. Hence, the community initiatives such as voluntary monitoring might help the community to conserve the mangrove ecosystem and foster a sense of belonging to the environment so that ecosystem services are not perceived in a separate manner but rather as a "bundle of services,"

including cultural and supply services (provision, education, etc.). This will lead to the more comprehensive perception of the ecosystem by the locals. This is especially true considering the current perception of the locals, where the carbon-sequestration service is not necessarily well understood. Nonetheless, blue carbon services remain a conundrum in the current approach and the sole focus on this aspect will not solve the low awareness, thus initiative such as blue carbon projects can be considered to be integrated in the local regulation by the government. Blue carbon projects might engage the communities and provide the understandings on the benefits, as well as incorporate funding mechanisms (Wylie et al., 2016).

The discussion at the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) proposed the concept of transformative changes at various levels. Transformative change was the message of the IPBES, which focused on immediate and massive changes to the global economic and political systems to slow the deterioration of nature (Bonebrake et al., 2019). The finding from this study gives the argument that capturing the perceptions of and changes in related values (including those related to blue carbon) is an integral part of the "transformative change" that will make the blue carbon ecosystem sustainable (Díaz et al., 2019). The formulation of such initiatives by the Berau Regency local government and the concurrent coordination with the community might contribute to new ideas being incorporated into the bottom-up approach program, such as the community-based management, while at the same time synergizing the conservation movement with provincial and central governments, thus transforming conservation from a local movement into a national effort.

3.5. Conclusions

This study investigated the locals' awareness and resource utilization of the seagrass ecosystem, with the findings of the awareness are relatively low, particularly in the aspect of blue carbon sequestration services. However, the ecosystem services such as coastal protection and recreational site were rather well-perceived. Nonetheless, this study also showed the condition of utilization rate that is low for provisioning services and tourism sector. Highlighted points for the role of fishermen and government employee which is critical to reach out the locals and transfer the awareness and involve the local communities on the local conservation effort. The finding on this study, as part of the thesis, contribute to the overall understanding on how the coastal communities perceived the seagrass ecosystems, utilization of resource, and the coastal program participation,

particularly on the understanding of bundled services to integrate various ecosystem services for the community-based management initiatives. In addition, from the perception of the threats, this chapter contributes to the insights on the issue of mangrove cutting and pollution from domestic wastes as the perceived threats to the blue carbon ecosystems. Hence, in the next part of the thesis, three coastal ecosystem challenges were selected to be intervened with the community-based management initiative, with the selected challenges are based from the PSP findings and the perceptions study. The three challenges are waste management in the context of community and tourism, land-use change, and sustainable aquaculture.

4. Waste management in small-island with community and tourism sector

4.1. Introduction: Small island limitation and threats from domestic waste

Indonesia as archipelago nation face the issues of sustainable development for the ocean and coastal areas (Farhan and Lim, 2011), with most of the Indonesia's islands are relatively small islands with the dense population and economic growth born within the island (Hidayah et al., 2016; Hutomo and Moosa, 2005; Maulana and Benita, 2017). The definition of small islands in Indonesia is explained in the Indonesian Cooperation Law, Act 27 of 2007, as an area less than 2,000 km^2 (Farhan and Lim, 2011). Within these small islands, there are various potential marine resources and environmental services (Hidayah et al., 2016), with tourism in small islands can be considered an ecosystem service as its existence is beneficial to human life (Kurniawan et al., 2019). As with the results from Chapter 2 on the PSP, tourism in blue carbon ecosystems, such as mangrove, is one that is particularly acknowledged by various provincial-level in Indonesia, which creates another concern on the pressures to the coastal and small island ecosystems.

Another consideration for the small island's ecosystem is also related to its vulnerability, with the characteristics of limited land and clean water, limited resources, remote location, high dependency on imported goods, high costs for transportation, and prone to natural disasters, which highlights the importance of sustainable and integrated management (Kurniawan et al., 2016; Zulriskan et al., 2018). In addition to the vulnerability of the small islands ecosystems, there are other pressures which can exacerbated the situation. For example, the threat from human activities with the overexploitation of resources, alteration to coastal and marine habitats, coastal and marine pollution, introduction of alien species, global climatic change (Hutomo and Moosa, 2005) as well as the global environmental problem in the form of marine debris and marine litter which is particularly apparent and impacting the small islands (Owens et al., 2011; Sur et al., 2018). The situation revealed the reality of the small islands development as double-edged blades, with positive side of economic benefits, job creation, and business opportunities, however there are also observed negative impacts to the environment and socio-cultural dimension (Kinseng 2018).

From Indonesia government's perspective, the development of small islands is directed to the focus of conjunction with tourism industry to boost the country's economy, however, simultaneously the development generates the threat which can cause environmental depletion due to the buildings construction and tourism activities, contributing to the increase of water pollution

and solid waste (Kurniawan et al., 2016). It is also worth to be noted that the large influx of tourists to tropical coastal areas can affect coastal ecosystems through land conversion and waste generation activities (Nelson et al., 2019). Particularly on the issue of waste, which is the indicators for sustainable tourism (Kurniawan et al., 2019). In Indonesia, the limited infrastructure for waste management is another layer of concern which resulted in much of Indonesia's waste makes its way onto the islands and ocean areas (Sur et al. 2018).

4.1.1. Waste management on small islands

There are various challenges in regards to the waste management within the setting of small islands, for example the limited space availability, high energy costs, large seasonal fluctuations in waste volumes, restricted recycling, impacts on the local environment, complex social and political dynamics, densely populated, and tourist dependent, which in results discourage typical waste management practices and no straightforward solutions (Camilleri-Fenech et al., 2018; Eckelman et al., 2014). Looking at the case of Bali Province in Indonesia, the waste management consists of activities such as transport to landfills, recycling, and processed in the *waste bank* (Widyarsana et al., 2020), and waste collection was reported to be the critical part of the waste management logistical chain (MacRae and Rodic, 2015). In the case of Kayangel Island, Palau, there is the insight that the treatment of waste is done through removal from island via boat (Owens et al., 2011). In regards to the waste generation, in the case of Gili Trawangan, a small island in Indonesia, the largest waste generation rate came from the large hotels, followed with small hotels, households, and restaurants, with dominant recyclable materials in the form of beer bottles, cardboards, plastics, and metals (Sekito et al., 2019). The waste generated in small islands in general have another difficulty to be processed for recycling due to the high-operational costs, high tipping fees for treatment disposal, as well as the issue of low material quantities (Eckelman et al., 2014). In addition, recycling is also not viable for small island case such as Kayangel Island due to the energy expended in transporting recyclable materials to urban centers, despite that recycling can potentially reduce the accumulated household waste (Owens et al., 2011).

4.1.2. Environmental perception on waste issue

With waste as a major concern in the environment dimension, there is the aspect of environmental perception which can determines how the coastal communities understand and perceived the threats of waste. The concept of environmental perception is known to illustrate the relationship

of human beings with the environment which determines the attitudes of the people to the environment hence it is important in the context of implementing waste management programs to consider the environmental perception (Buenrostro et al., 2014). The public perception and knowledge of islanders can provide the guidance for optimizing the waste management system of the island, in which the success of the strategies depend on the end user sensitivity and awareness on environmental and sustainable development (Gisi et al., 2017). Looking at a study case of small island in Indonesia of Karimunjawa, it was reported that the pollution from domestic wastes came second as the most perceived threats to mangrove ecosystems, following the illegal cutting of mangrove, and it was ranked first as the damaging threats to seagrass ecosystems (Quevedo et al., 2021b). The situation, such as visible rubbish on the beach, can change the people's perception on the environment, related to the human behavior, both intentional and unintentional (Hayati et al., 2020). Study from Kiessling et al., (2017) also highlighted the factors such as cultural history, landscape interaction with nature, and economy based on sustainable tourism which facilitates the engagement on environmental issues.

Given the issue of waste management in small island, in regards to the tourism as prominent sector for locals' livelihood, this study argue that the issue is important to be tackled on, especially with all of small islands' limitation characteristics. Failure on sustainably managing the waste management can potentially harm not only on the livelihoods with degrading tourism sector, but also to the leakage of waste on the other ecosystems, such as ocean and blue carbon ecosystems. As with the supporting insights from Chapter 2 on the PSP, tourism is acknowledged as a sector which can utilized the mangrove ecosystems. Despite the benefits to the locals' livelihood, the concern is how to preserve the ecosystems, hence the aspect of waste management and how the coastal communities can contribute will be discussed in this part of dissertation. The objectives of this chapter is to capture the perceived impacts of tourism activities from the perspectives of the small island communities of Derawan Island and investigate the waste management capacity to propose a sustainable alternative waste management with material flow analysis approach to ensure an effective and efficient system, while minimizing the impact of waste to the small island ecosystem.

4.2. Materials and methodology

In this chapter, the issue of waste management will only be focused to Derawan Island as small island ecosystem. An environmental health studies conducted in Derawan Island has highlighted the locals' concern on the household waste management, with many of the respondents mentioned the waste management through burning the waste in household garden as one indicator of the environmental health concern (Anwar and Sultan, 2016). The issue of waste in Derawan Island was also highlighted in regards to the potential of harming the green turtle, by blocking the space to spawn their eggs, and in period between 2004 to 2005, the number of green turtle landing in Derawan Island was decreasing due to the environmental degradation associated with anthropogenic activities and settlement expansion (Dharmadi and Wiadnyana, 2008). In addition, the threats of waste also can harm the blue carbon ecosystems, with government report in 2007 mentioned that the pressure of waste can influence the ecosystems in Berau Regency, such as the case of tree branch and other large size waste can cover the seagrass areas which will kill the seagrass as the waste can block the incoming sunlight (Pemerintah Kabupaten Berau 2007).

4.2.1. Survey questionnaire

In order to investigate the perception and, this study conducted a survey questionnaire to the locals' communities in Derawan Island in the context of the threats and impact of waste to the environment and its association with the tourism. The format of the questionnaire is based on Quevedo et al., (2021c) study to cover residents' opinion on either the positive or negative impact of tourism industry. There are eight items on the impact of tourism where this study will be focusing on the environmental dimension affected by tourism sector, consisting of: (1) *availability and stocks of fish, shellfish, and other seafoods*; (2) *the condition of domestic waste management*; (3) *conditions of sewage systems*; (4) *conditions of beaches*; (5) *conditions of coral reefs*; (6) *conditions of seagrass ecosystems*; (7) *conditions of mangrove ecosystems*; and (8) *availability of fresh water* which is recorded with the responses utilizing Likert scale (range: −2 to 2; −2 = *very negative impact*, −1 = *negative impact*, 0 = *no impact*, 1 = *positive impact*, and 2 = *very positive impact*). The compiled results of the questionnaire were organized and presented with descriptive statistics approach. Descriptive statistics are used for summarizing data and describe the relationship between variables in a sample with a simpler summary (Kaur et al., 2018).

4.2.2. MFA scenarios

In the second part of this study, the waste management system in Derawan Island will be investigated with the approach of Material Flow Analysis (MFA). MFA is a constructive tool for designing waste management systems, environmental pollution control, and to provide a system-oriented view for the waste management strategies (Allesch and Brunner, 2017; Laner et al., 2014; Phu et al., 2019). The challenges of using MFA in developing countries is related with the data scarcity (Montangero, 2007), and the information of the flows is usually taken from databases or using proxy data from other location that can be used in the study (Brunner and Rechberger, 2004). Several reports were used to provide the data for the MFA from BPS (Statistics Indonesia), SIPSN (*Sistem Informasi Pengelolaan Sampah Nasional*/National Waste Management Information System) database from Ministry of Environment and Forestry, existing studies, and news article as seen in **Table 17**. The source of domestic waste can be traced back into two type of household waste and non-household waste. For the non-household waste, the source of the waste can be categorized further into (i) *commercial sector* (traditional market, commerce, office), (ii) *public facility and area*, and (iii) *other*. According to the Law No. 18/2008 on the Waste Management, the source of waste from *other* include the waste from tourism sector. The units to calculate the waste in MFA is converted into kilogram/day (kg/day) for consistency and represents better on the number of waste generated in Derawan Island.

To estimate the waste generation in Derawan Island, this study utilized the approach from Chen et al., (2019) by estimating waste generation from the secondary data based on the island population and tourism sector for simplicity. Using this approach, the secondary data is utilized to estimates the waste generation, waste composition, and finally design the MFA model for the waste management in Derawan Island. First, the formula to determine the waste generation in Derawan Island, this study use the expression of: Derawan Island waste generation (kg/person/day) = [Berau Regency waste generation / Berau Regency population] x Derawan Island population. The formula resulted in the value of waste generation 0.71 kg/person/day, where this estimated value of waste generation will be used to calculate the three scenarios in this section. In addition, other complementing secondary data will also be used, particularly on the waste composition, waste source and the waste management data to better understand and propose the sustainable scenarios approach, highlighting the different focus for the alternative waste management in Derawan Island.

The (a) *current situation* scenario illustrates the existing situation in the Derawan Island, the (b) *community initiative* scenario propose a sustainable approach to reduce the waste generation through recycling initiated by local community, and (c) *tourism contribution* scenario propose the improvement of waste management with contribution of tourism in terms of supporting the operational cost. For the scenario (b), this study refers to the report from Sekito et al., (2019) in Gili Trawangan case, Indonesia, where the waste management strategy utilized the approach of all recyclables were fully recovered and sold, organic waste was composted, and the residue waste was transported to the main island to be deposited in a landfill. For scenario (c), the idea is to improve the existing waste removal via boat, in which the additional cost will be supported by tourism sector, and the goal is to have zero accumulated waste in the island. Using the compiled and processed secondary data, the authors then processed it with Substance Flow Analysis (STAN) software to design the MFA model for all of the scenarios. STAN is a software tool to design material flow systems consisting of all relevant inputs to be established, quantified, and visualized the complexity of MFA systems, in which it has been used in many studies on the waste management system (Allesch and Brunner, 2017; Turner et al., 2016). The MFA process with STAN consists of three steps with (a) building graphical model, (b) input the waste-related data, and (c) performing the calculation of waste flow and the mass balance in the model (Phu et al., 2019).

Table 10 Secondary Data Collected for the MFA Model

Variable	Unit	Value	Source
Derawan Island Population (2019)	person	1,515	BPS Kabupaten Berau 2020
Derawan Island Population Growth Rate (2010-2019)	%/year	1.1	BPS Kabupaten Berau 2020
Berau Population (2018)	person	226,509	BPS Kabupaten Berau 2019
Total Waste Generation (2019)	kg/day	161,760	SIPSN
Waste Composition, Berau Regency (2019)	%		SIPSN
a.) Food Waste		55.39	
b.) Plastic		26.47	
c.) Metal		9.63	

d.) Paper/Cardboard		4.02	
e.) Wood/Branch		1.28	
f.) Glass		0.99	
g.) Rubber/Leather		0.07	
h.) Fabric		0.05	
i.) Other		2.1	
Source of Waste, Berau Regency 2019	%		SIPSN
a.) Household		67.4	
b.) Non-Household (*Commerce, Public Facilities and Area, Other*)		32.6	
Commerce		18.82	
Public Facilities and Area		11.04	
Other		2.74	
Dump Truck Capacity	kg/removal	2,000	Berau Post 2020
Frequency of Waste Removal from Island	removal/week	3	JPNN 2018

The definition of household waste (which in this study will be shortened as domestic waste) is stated in Berau Regency Regulation No. 1/2017 as waste generated from household activities, and domestic-household-like waste as a type of waste with similar characteristics of domestic waste although not necessarily generated from household sector. According to Berau Regent Regulation No. 46/2018, there is the goal to reduce household waste by 30%, and 70% of it treated by 2025. Within all of the three scenarios, this study will consider to forecast the island's situation into 2025 with the assumption of growing island population influences the waste generation.

4.2.3. Comparison of scenario's cost

In addition to the MFA scenarios, this study will also include the operational cost for each of the scenarios as another discussion point for comparison of the three scenarios with the supporting data as seen in **Table 18**. The units to calculate the cost analysis is converted into USD/month, with the currency rate of 1 USD equal to 14,433.85 IDR as per currency data from Google and Morningstar database on 2021 April 23 during the time of the writing and analysis for this study.

This study refers to the news article from Kompasiana (2020) which states that Derawan Island provide a budget of 24 million IDR per month (1,662 USD/month) for the waste management. This value is applied to calculate the average operational cost for removing the waste from the island via boat, based on the (a) *current situation* which stated of three removals per week, which gives the reference of removal coast via boat is around 1.99 million IDR/removal (138.5 USD/removal). Using this calculation, the removal cost can be calculated for each of the scenario, where the (a) *current situation* and (b) *community initiative* scenario utilized three waste removal frequency per week, and for scenario (c) *tourism contribution* with the waste removal frequency of four times per week. For scenario (b) and (c), the assumption is that the recovered waste can be fully sold in the main island, and for scenario (b), the compost is also assumed to be fully sold to support the waste management budgeting. In addition, all of the scenarios use the assumption that that the locals will contribute 100% to support the waste management operation with the cost as described in the PERDA Berau No. 7/2010.

Table 11 Secondary Data Collected for the Cost Analysis Scenarios

Variable	Unit	Value	Source
Waste Removal Cost*	USD/month	1,662	Kompasiana 2020
Waste Management Fee	USD/month/unit		PERDA Berau No.7/2010
a.) Small Household		0.12	
b.) Small Hotel		1.73	
Total unit	Unit		
a.) Small Household		447	BPS Kabupaten Berau 2020
b.) Small Hotel		20	BPS Kabupaten Berau 2016
Recovered Waste Price	USD/kg		Waste Bank Resik 2019
a.) Plastic		0.06	
b.) Metal		0.12	
c.) Paper/Cardboard		0.02	
d.) Glass		0.02	
Compost Price	USD/kg	0.07	Sekito et al., 2019

Compost Production**	%	50	Sekito et al., 2019

**The waste removal cost refers to the operation with three removals per week; **Compost production refers to the 50% of organic waste can be converted into compost*

4.3. Results

4.3.1. Perception of tourism's impact

Total of 22 respondents were interviewed for this part of study with the support from local NGO of The Nature Conservancy (TNC) during the survey. In overall, for the perception impact on the tourism sector to the environment, this study showed that for several aspects, the tourism sector is perceived to give positive impacts, but in other aspects, the locals perceived that tourism will give negative impact, as seen in **Table 19**. The positively perceived aspects were identified in the items of *availability and stocks of fish, shellsfish, and other seafoods* (*M* = 0.5) along with other items related to the condition of the environment such as *condition of beaches* (*M* = 0.23), *conditions of coral reefs* (*M* = 0.17), *conditions of seagrass ecosystems* (*M* = 0.08), and *availability of fresh water* (*M* = 0.38). In overall, the average scores for these perception items are closer to the understanding of the tourism sector does not give any negative impact. However, this study observed the perceived negative impacts on the aspects of *conditions of domestic waste management* (*M* = -0.71) and on *conditions of sewage systems* (*M* = -0.42) which highlights the concern of the locals in the perspective of waste management in the island.

Table 12 The perception profile on the impact of tourism to the environment

Perception Items	**Perception of Impact of Tourism (%)**					**Mean (*M*)**
	Very Negative Impact	**Negative Impact**	**No Impact**	**Positive Impact**	**Very Positive Impact**	
(1) Availability and stocks of fish, shellsfish, and other seafoods	0.00	29.17	20.83	20.83	29.17	0.5
(2) The condition of domestic waste management	16.67	54.17	12.50	16.67	0.00	-0.71
(3) Condition of sewage systems	8.33	50.00	16.67	25.00	0.00	-0.42
(4) Conditions of beaches	8.70	17.39	21.74	47.83	4.35	0.23
(5) Conditions of coral reefs	8.33	16.67	29.17	41.67	4.17	0.17
(6) Conditions of seagrass ecosystems	4.17	25.00	33.33	33.33	4.17	0.08
(7) Availability of fresh water	0.00	16.67	37.50	37.50	8.33	0.38

4.3.2. MFA scenarios for Derawan Island waste management

Moving on to the MFA for Derawan Island waste management, this study has compiled the secondary data and with the process from STAN software, three different scenarios will be explained. First, for the (a) *current situation* scenario, the total of the waste is accumulated in the stock of Island Waste Generation, and with the consideration of waste removal via dump truck and boat of about 857.14 kg/day, this study showed that the removal won't take all of the generated waste in the island with potential waste accumulation of 224.79 kg/day. Using the same approach, this study forecasted to the year of 2025 as seen in **Figure 22**, and the result showed how the waste accumulation grows to 292.03 kg/day, with the number of populations increase and the assumption of no improvement to the waste management. This illustrates the (a) *current situation* is not capable to remove every waste from the island and in addition of potential waste accumulated.

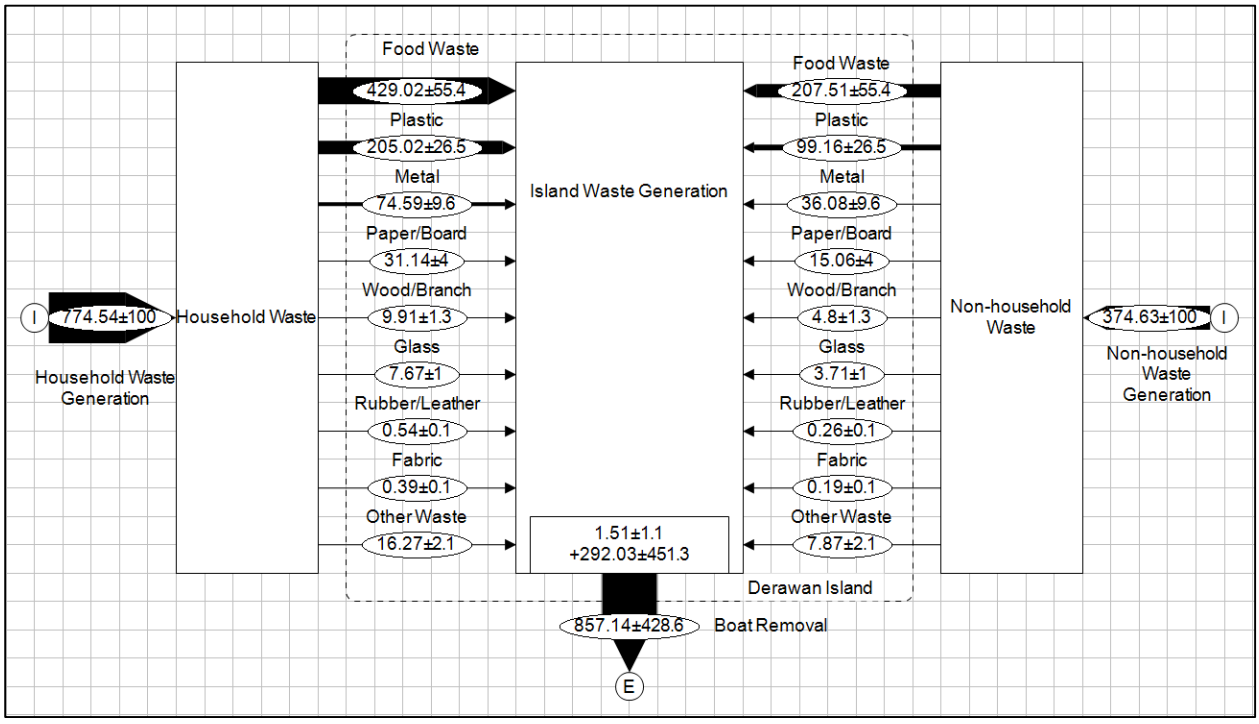

Figure 9 Material flow analysis of waste generation and waste treatment in Derawan Island in 2025 for the (a) current situation scenario (unit in kg/day)

In the alternative scenario of (b) *community initiative*, the food waste is assumed to be collected and recycled into compost and plastic, metal, paper/board, and glass are recovered in the waste bank. The (b) *community initiative* scenario shows that in 2019 with the same amount of boat removal frequency with scenario (a), there will be no accumulated waste in the island. In addition,

forecasting the scenario into 2025, as seen in **Figure 23**, still eliminates all of the generated waste to be 100% removed from the island, as well as giving enough space in the boat removal to transport the produced compost and recovered materials to be sold off in the main island with total of 790.69 kg/day.

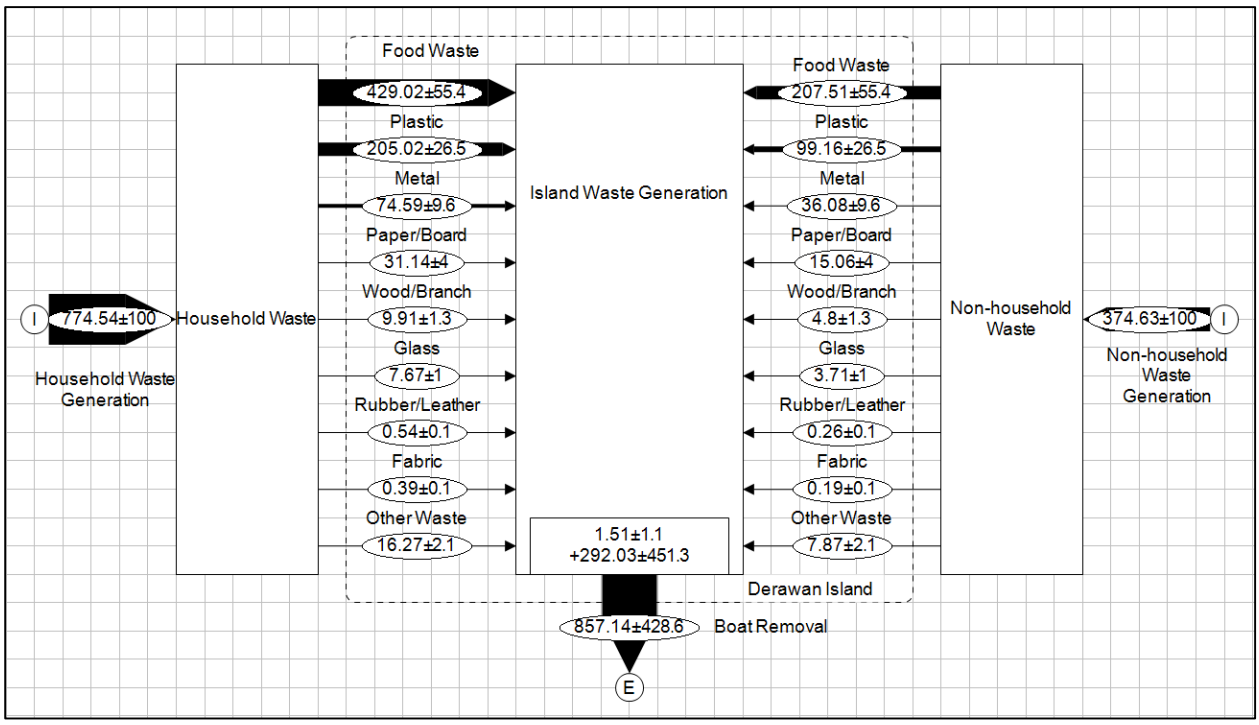

Figure 10 Material flow analysis of waste generation and waste treatment in Derawan Island in 2025 for the (b) community initiative scenario (unit in kg/day)

For the scenario (c) *tourism contribution*, the similar approach with (a) *current situation* is used in which there is no composting process for the food waste, but in addition, this scenario assumed for the existence of community intervention to separate and recover the recyclables materials. To prevent the waste accumulation in the island, this scenario assumes the local government to increase the frequency of waste removal from three times per week (857.14 kg/day) into four times per week (1,142.86 kg/day). Increasing the waste removal frequency is effectively preventing the waste accumulation while also serve the role to transport the recovered materials for period of 2019 to 2024, however in 2025, as seen in **Figure 24**, the accumulation starts with 6.31 kg/day as some of the waste and/or materials are unable to be fully removed from the island in this period. In another note, the increase of waste removal frequency from three times removal per week into four removals only managed to treat 100% of the waste until 2024, but in 2025, additional

frequency will be required with the assumption of population growth which will increase the waste generation. The increase of frequency of removal via boat will requires additional cost for the operation, in which tourism sector can support the waste management as will be discussed in the next section for the comparison of operational cost for the three different scenarios.

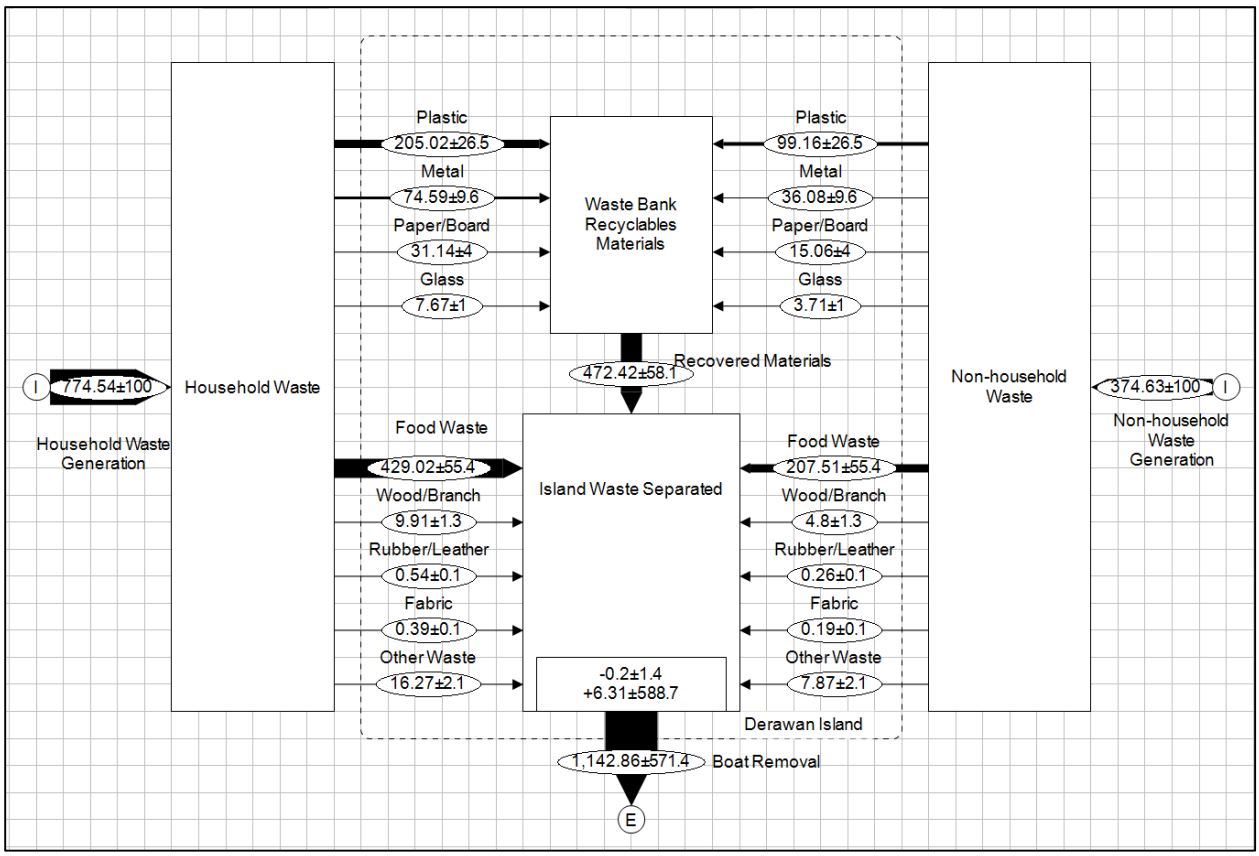

Figure 11 Material flow analysis of waste generation and waste treatment in Derawan Island in 2025 for the (c) tourism contribution scenario (unit in kg/day)

4.3.3. Operation cost comparison

Moving on to the operational cost for each of the scenario. This study calculated the cost as seen in **Table 20**. For the scenario (a) *current situation*, the waste management fee from the community and hotel sector only provides 88.24 USD/month, while the remaining of the operation cost (1,573.76 USD/month) needs to be covered by village budget. For the scenario (b) *community initiative*, the compost sale and waste bank activities can generate additional cost of 665.1 USD/month and 980 USD/month respectively, which in result there will be no village budget required to cover the operation cost, instead there is still remaining benefit of 72 USD/month. For

scenario (c) *tourism contribution*, the calculation found that to support the operation cost from the waste management fee and waste bank, the tourism contribution needs to provide 1,147 USD/month to achieve 0 USD/month used from the village budget. Based on the data from BPS Kabupaten Berau (2016), the number of tourists visited Derawan Island in 2015 is total of 45,865 tourists. Thus, to cover the 1,147 USD/month, in average one tourists should be imposed of additional fee of 4,400 IDR (0.3 USD) to balance the cost.

Table 13 Estimation on Operation Cost Comparison for Three MFA Scenarios in 2025

Scenario	Operation Cost (USD/month)	Removal Frequency (removal/week)	Untreated Waste (kg/day)	Cost Analysis (USD/month)				
				Village Budget	Waste Management Fee	Compost Sale	Waste Bank	Tourism Contribution
Current Situation (Scenario A)	1,662	3	292.03	1,573.76	88.24	-	-	-
Community Initiative (Scenario B)	1,662	3	-26.23*	-	88.24	665.1	980	-
Tourism Contribution (Scenario C)	2,216	4	6.31	-	88.24	-	980	1,147

**Indicate the state of no untreated waste, and the number refers to the remaining capacity for the treated waste*

4.4. Discussion

4.4.1. Perceived tourism impact to domestic waste management

In this study, one of the finding is related with the perception of the local community in Derawan Island in regards to the threat of domestic waste. This study gives the indication that the perceived negative impact to the tourism is more particular on the infrastructure-related aspects compared to the environment. The domestic waste management and sewage system is perceived to be negatively impacted by tourism, but the aspects of the ecosystem are relatively perceived to be positively impacted by the tourism sector. One of the explanations on this phenomenon is that the tourism sector was not the dominant source of the waste in the island as per the results with MFA scenarios, which demonstrate that household is the dominant sector of the waste generation. This situation can influence the perception which concerns the locals, in particular to the future of

domestic waste management, as per the (a) *current situation* scenario there is the indication of accumulated, hence the question of how the impact of tourism is negative. There is also the possibility of diverse perception of the solid waste problem, in Mexico case study, some group of respondents perceived that solid waste is not a problem, while other group of respondents perceived it as a serious problem, in which the visual aspect of the waste represents as the main complaints (Buenrostro et al., 2014). For the positive perception to the environment impact, one of the explanations is the experience or perception of the locals when they witnessed the pro-environment behavior from the tourists or outside especially as they show a respect to not pollute the environment while visiting Derawan Island. A study from Stefanica and Butnaru (2015) reported that tourists can contribute through the adoption of pro-environment attitudes and proper behaviors. In the case of Derawan Island, not only relying on the proper behavior from tourists, the awareness of relationship between tourism and environment should also be considered. Residents who perceive tourism as having positive effects on the environment will generate stronger support for tourism development (Demirovic et al., 2018). Thus, to support the sustainable tourism in the future, Berau Regency government should consider the locals' involvement in the decision-making which can alters the condition of tourism and environment in Derawan Island. Initiatives such as social marketing in the tourism industry to promote pro-environmental behaviors could also be considered to help the visiting tourists to Derawan Island to develop more positive environment-related behaviors and attitudes (Tkaczynski et al., 2020).

4.4.2. Improving waste management, the case of three scenarios

Three different MFA scenarios are proposed in this study, and this section will discuss on the strength, weakness, and feasibility of each scenario. First, for the (a) *current situation* scenario the insight is related with the current system of three waste removal per week won't be enough to handle the current and future generated waste in Derawan Island. The accumulated waste can be a potential threat to the island, where the mismanagement by the locals can occurred to keep their surrounding environment to be "clean". Example of mismanagements are burning the waste and leakage to the water body. A study case from Kayangel Island shows that the leftover waste which were not been able to be removed from the island ends up burned, where typical of waste such as plastic, paper, and cardboard treated this way (Owens et al., 2011). Treatment of burning waste can potentially be the source of air pollution, particularly if the waste consists of plastic (Damanhuri and Padmi, 2010). Thus improving waste management in Derawan Island will be

crucial to avoid such mismanagement and leakage of waste to the environment which in turn can generates negative impact to public health and the tourism industry.

The scenario of (b) *community initiative* try to intervene the threat of domestic waste through the intensive community-based approaches. The main challenge lies on reducing the food waste. In the Gili Trawangan case, the compost produced from the organic waste can fulfills a portion of the compost demand from the nearby farmland of coconuts and crop fields, with 93.3 ha of farmland estimated for the compost demand of 5.11 tons/day (Sekito et al., 2019). Although this study did not estimate the compost demands, according to BPS Kabupaten Berau (2020), there are total of 82 ha of rice and crops field in Derawan Island Districts. The number showed the potential for the compost produced from Derawan Island to satisfy the needs for the compost demands if the local government decide to pursue the scenario (b), further challenge should be highlighted on the transportation aspect to avoid mixing of waste, as well as the cooperation between stakeholders to ensure the collaboration can give benefit to everyone. In overall, the scenario (b) is most promising from environmental perspective with less waste removal which can reduce the operational cost, in addition of the activities can potentially generate additional income for the locals. However, careful consideration is needed that the scenario requires an effort to support the community to start such initiative. Future study should consider the cost analysis of recovery and recycling activities between small island and main island, as well as the recycle market feasibility and the possibility of competition with other producers.

The scenario of (c) *tourism contribution* give another perspective to improve the waste management by involving the tourism sector. Although from the perspective of the number of generated waste, the number from non-household sector is smaller compared with the household sector, which gives opposite results compared with the findings from Sekito et al., (2019). This phenomenon can be influenced due to the intermingled phenomenon as explained in the Chapter 4 on the triangulating framework with the mixed function of residential and tourism in Derawan Island, in particular for the tourism with homestay mixed with the locals' residential. Nonetheless, the local government of the island can still opt to share the burden of operational cost by charging a fee for tourists entering the Derawan Island as a part of conversation program. In Gili Trawangan case, the high operation cost of waste management strategy requires the approach of charging additional fee for the tourists (Sekito et al., 2019). According to the Berau Regency Regulation

No. 7/2010 on the fee for waste management, the household and tourism sector is charged with fee based on the household and hotel size. Thus the argument for scenario (c) is particularly focused on the potential to charge the tourism sector with relatively small fee of 4,400 IDR per tourist (0.3 USD/tourist) entering Derawan Island based on the cost analysis. Although the fee is not necessarily high, its implementation will require an appropriate management and monitoring to ensure the fee is collected and used properly, with the results can be felt by both tourists and the local community. The initiatives for the implementation fee, as well as the aforementioned pro-environment behavior from tourists can support the sustainability of the tourism sector in Derawan Island, especially with the support from government and the local communities in the decision-making and implementation.

4.5. Conclusions

The perceived impacts of tourism sector by the local community and the scenario of waste management in Derawan Island were analyzed in this study. The local community of the small island perceived that tourism will negatively impact the domestic waste management, and with MFA approach, this study has provided three different scenarios to give better understanding on how Derawan Island can progress forward to tackle the domestic waste from household and tourism through the utilization of community-based approach and involvement of tourism. Community-based approach seems the most sustainable option, especially considering most of the domestic waste came from this sector. Nonetheless, this approach requires careful planning on initiating and supporting community-based program to ensure its sustainability, in addition of collaborating with the market to ensure the demand for the recycled products, thus encouraging the community that the domestic waste separation and recovery is contributing not only to preserve the environment but also the incentive as alternative livelihood. The community initiative scenario also supports the finding for this dissertation in regards to the contribution for sustainable management in coastal setting. Nonetheless, the limitation on this study revolves on the finding is only in the conceptual form, while the implementation of such scenario is outside the boundary of this study. Looking at the tourism scenario option, this study showed the alternatives for feasible implementation by charging fee to visiting tourists to support the operation cost for waste management. However, monitoring and transparency will be needed to ensure the effectivity of the fee system. Future study should consider more specific data for the waste composition and generation to elaborate the diversity of the option for the small island waste management.

5. Triangulating framework for land-use change analysis

5.1 Introduction: Integration of perception for land-use change study

In Indonesia, the population growth and food demands have forced the government to intensify and diversify the utilization of coastal and marine resources, resulting to overexploitation in the highly vulnerable coastal and marine ecosystems (Hutomo and Moosa, 2005; Pomeroy et al., 2007). Despite Indonesia coastal ecosystems that offer diverse ecosystem services, that are important at the local (e.g., fishing ground) and global scales (e.g., carbon sequestration) (Sukardjo and Pratiwi 2015), the coastal environment in Indonesia is currently under pressures with coastal ecosystems degradation in the form of coral reef damage (bombing, poisons), mangrove conversions, sedimentation, and erosion (Hutomo and Moosa, 2005; Suroso and Firman, 2018). The exploitation has been observed not only in Indonesia but in other countries as well (Quevedo et al., 2021a). Based on the previous chapter in the PSP which showed the concern of mangrove ecosystem with the regulation on prohibited activities as well as the overall low awareness and utilization in seagrass ecosystem, this study argue that land-use conversion is a coastal ecosystem challenge that needs to be considered and intervened.

The definition of land-use is the use of land by humans, and the terminology is also used in the sense of the social and economic purposes (IPCC 2000; Kim 2016). In Indonesia, despite the beneficial need with the land-use change, for example in the form of forest conversion, the process of land-use change in the country is considered to be socially sub-optimal (Pagiola 2000). The conflict of land uses is typically associated with the opposing interests over the type of land use, limited access, unclear ownership, and delineation of boundaries (Adam et al., 2015). The land-use change in coastal areas has affected the rate of erosion and sedimentation (Sanjoto et al., 2019) which influence the essential services of coastal ecosystem such as coastal protection, tourism, and climate adaptation (Wylie et al., 2016). As per the finding of the previous chapter, the degradation of the seagrass, as part of coastal ecosystem, has been perceived by the locales with the interview results on the complaints of the decline in fisheries catch as well as the concern on the resources for future generation. The perception of the community to analyze land-use change is a considered approach with the local community is a key actor for sustainable land-use, and this approach can explore the interrelated social, economic, and ecological transformations in the area (Schubert et al., 2019). This study argue that perception of the local community can also contribute to the

overall understanding of the land-use change in Berau Regency with the environmental cognition theory to understand the environmental changes from the perception. The environmental cognition theory states that the land and environmental change can influence the cognitions, including perceptions, which in turn affect human behavior towards environmental changes (Meyfroidt 2013).

The study of land-use change with the application of remote sensing has been prominent in the recent years, however, some studies have reported the limitation of remote sensing, hence awareness and perceptions can be used to consider the sensitive aspect not recorded in remote sensing, for example in the phases of crops cycle (Fonta et al., 2015). The utilization of perception as part of land-use change study has been recorded in various existing studies. For example, in the case of Northeast Brazil forests, people's perception is used to assess the landscape changes and identify the causal factors (de Almeida et al., 2016). Study from Lee et al., (2008) showed that perceptions are essential to understand the interlocking relationship between humans and landscapes, which hypothetically links ecosystem with human activities, including land use decisions and landscape planning. The aspect of perception can also be used to support remotely sensed data and identify the land-use changes. In Ethiopia, a study was conducted to explored the perception and adaptation strategies by comparing the perceived land-use change and the observed changes from remote sensing data, resulting in valuable insights on the accuracy of public's perception to identify land-use change (Ariti et al., 2015). Similarly, Munthali et al., (2019) have combined GIS-based analysis with focus-group discussions and interviews to assess the land-use change dynamics and its associated drivers in Central Malawi region, with insights of perceptions tended to validate the observed patterns of remote sensing data-analysis. In Indonesia, there were also several land-use change studies which were integrated with public's perceptions. A study from Kikuyama et al., (2018) highlighted that people's perceptions and adaptation strategies is vital part to better understand the status and causes of the coastal problems through their identification of countermeasures (e.g., for land erosion) and promotion of sustainable land-use. In Borneo, communities' perceptions were essential in the opposition of palm-oil land-use conversion, as the locals' acknowledged the conversion impacts to the environment and their livelihoods (Abram et al., 2017).

In this study, the framework of integrating public's perceptions to identify land-use changes in the coastal ecosystems is proposed. Based on the existing literatures on the use of locals' perceptions in land-use change analysis as the basis, this study presented the research gaps and methods as presented in **Table 10**. Within the table, this study illustrated the indication of how land-use change studies with remote sensing data can be combined with perception interview to supplement the analysis and provide further understanding on the causal drivers of land-use change. In addition, according to the Indonesia's Ministry of Environment and Forestry, the satellite image on the mapping system was first implemented in 2000 and updated every three years with the limitation of data availability and cloud coverage. Thus, in this study, the triangulating framework approach is proposed to better encapsulate the land-use changes and its causal drivers in the coastal ecosystems of Indonesia. The framework is considering the gaps (**Table 10**) from existing studies, mainly on the focus of in-person interviews to get better response, using supplement data to support the interviews results, and focus on smaller region scale. The triangulating framework, as the name suggests, uses three datasets of: land-use/land-cover (LULC) maps based on remotely sensed data, spatial plan policy maps, and locals' perceptions. The first two datasets are the secondary data of this study while the third dataset is the primary data.

Table 14 Summary List on the Integration of Perceptions for Land-Use Change Studies [Modified from Lukman et al. 2021c]

Authors	**Title**	**Methodologies**	**Gaps**
Hur et al., 2010	Neighborhood satisfaction, physical and perceived naturalness and openness	GIS data and resident surveys to assess the environment and resident responses	(1) Uncertainty due to the response rate; (2) In-person interviews may get better response rate
de Almeida et al., 2016	Human perceptions of landscape change: The case of a monodominant forest of *Attalea speciosa* Mart ex. Spreng (Northeast Brazil)	Synthesizing and comparing historical documents and local perceptions on landscape change	(1) Participatory methodologies for collecting perceptions is challenging; (2) Supplement data from

			satellite images and individual interviews
Lee et al., 2008	Relationship between landscape structure and neighborhood satisfaction in urbanized areas	Mail-out survey and landscape measurement with NDVI method	(1) Neighborhood scale and (2) consideration to apply the approach in greater scale
Munthali et al., 2019	Local Perceptions of Drivers of Land-Use and Land-Cover Change Dynamics across Dedza District Central Malawi Region	Mixed method of remote sensing and GIS-based analysis, focus group discussions, key informant and semi-structured interviews	To include the investigation on the impact and consequences of LULC changes on rural livelihoods

Within the triangulating framework (**Figure 9**), there are three sub-sections which illustrated the relationship between the three datasets. The first one is the *social impact of policy* which is the intersection between the perception dataset and the policy map, the second sub-section is the *socio-ecological intersection* to describe the interaction between perception dataset and LULC maps, and the third sub-section of *environmental impact of policy* which cover the intersection of policy map and LULC maps. The triangulating framework is proposed to provide a holistic approach of understanding the land-use change, its drivers and existing policy strategies, in addition of promote the understanding of land-use change from different perspectives, circumvent the data limitation, and involving the local coastal community in the initiative for monitoring of the environment.

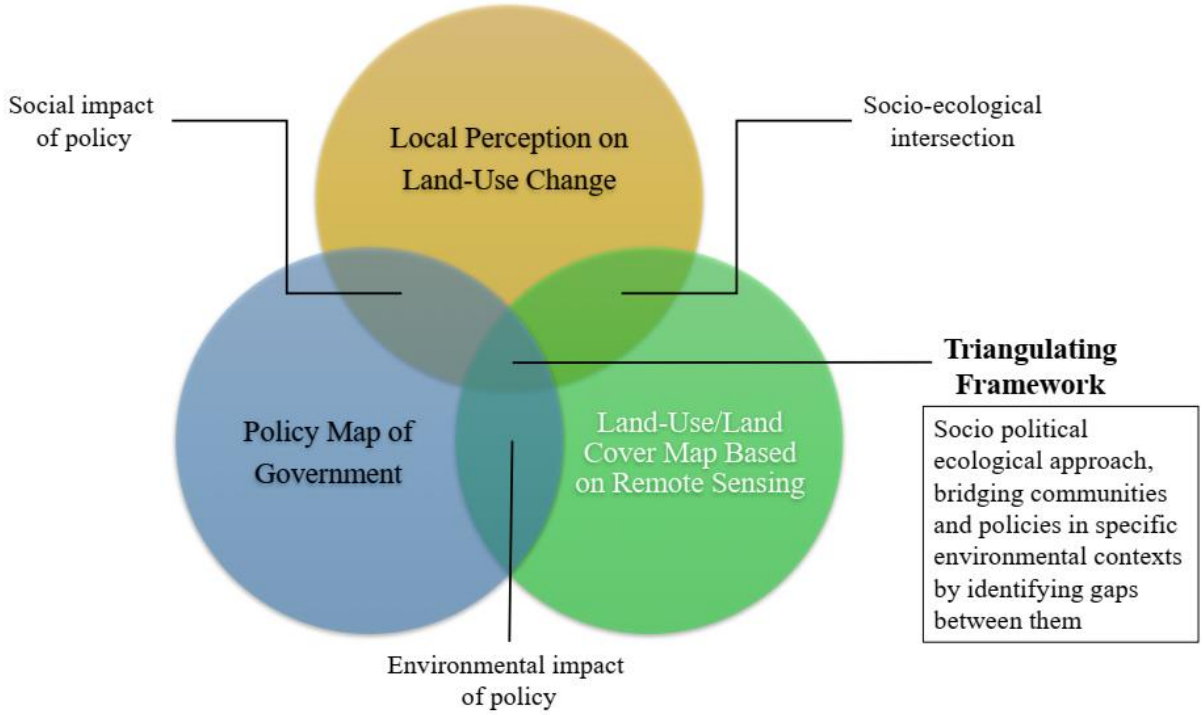

Figure 12 The Overview of the Triangulating Framework [Retrieved from Lukman et al. 2021c]

4.2. Method: Triangulating framework with three datasets

The setting for this study will be focused on both Tanjung Batu and Derawan Island in Berau Regency, East Kalimantan province, Indonesia (**Figure 10**). According to study from Richards and Friess (2016) and Malik et al., (2016), East Kalimantan province have experienced land-use conversions which resulted in the rapid loss of mangrove cover. In the previous chapter on PSP, East Kalimantan Province was observed with the acknowledgement on the regulations regarding the *prohibited activities* to protect the mangrove ecosystems, as well as the services of *fish nursery* and *tourism*.

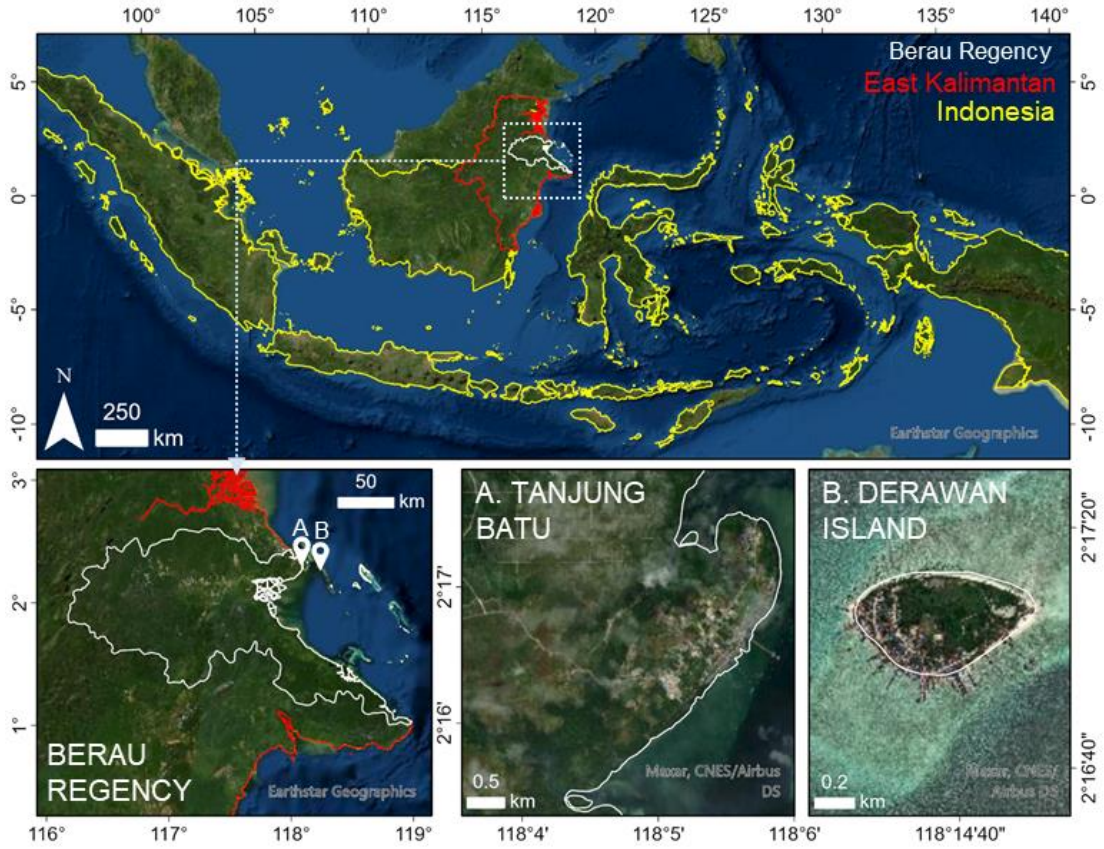

Figure 13 Study Site Location for Tanjung Batu and Derawan Island, Berau Regency [Retrieved from Lukman et al. 2021c]

The triangulating framework will be used in this study to explore the land-use change in Tanjung Batu and Derawan Island, using three datasets on perception interviews, LULC maps, and policy maps. In detail, the three sets of data for the input in this study are: (i) face-to-face interviews, (ii) secondary data of LULC, and (iii) secondary data of local government spatial plan policy map. The three datasets were compared to be discussed in qualitative manner on the findings and gaps between each of the dataset. The **Figure 11** illustrated the steps-by-steps of conducting the research, complemented with **Table 11** on the criteria for the categorization of the gaps which were identified with the triangulating framework.

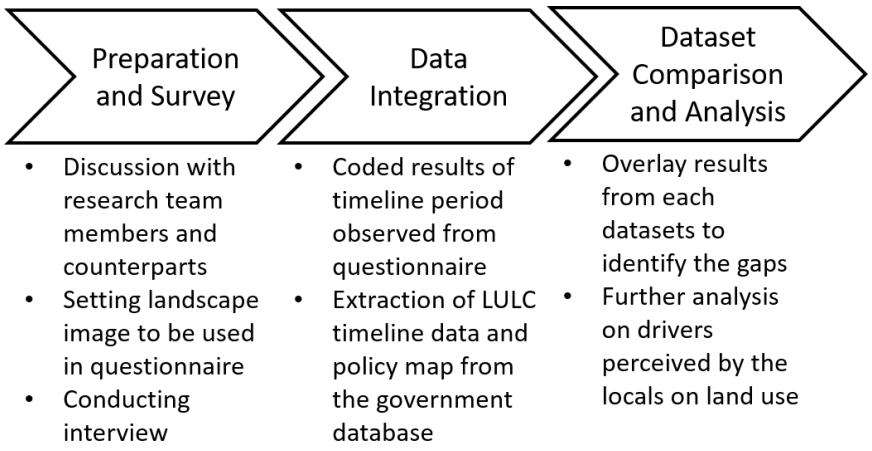

Figure 14 Research Activities [Retrieved from Lukman et al. 2021c]

Table 15 Categorization to Identify the Gaps Between Three Datasets [Modified from Lukman et al. 2021c]

Sub-section	Categorization of Gaps
Socio-ecological intersection (Local perceptions and LULC maps)	a.) Identify the perceived changes by the locals compared with the actual changes captured in the LULC maps b.) Identify the perceived impacts of the changes by the locals compared with the actual changes captured in the LULC maps
Environmental impact of policy (Policy map and LULC maps)	a.) Identify the gaps of the difference between assigned land-use and land-cover in the spatial plan policy map and the LULC map.
Social impact of policy (Policy map and local perceptions)	a.) Identify the gaps of potential threat from spatial plan not captured by perception.

5.2. Materials and methodology

5.2.1. Land-use change perceptions

The first dataset came in the form of face-to-face interviews to captured the land-use change perceptions. Survey can be used to captured the historical landscape change perceived by

populations (de Almeida et al., 2016). The interview was done with semi-structured questionnaire consisting of two parts. The first part profiled the socio-demographics to classify the respondents based on their living area in Tanjung Batu or Derawan Island. The second part of the interview gathered the perception of land-use changes.

In the second part of the interview, satellite image (derived from Google Earth) of each site (Tanjung Batu and Derawan Island) was used to document the location of observed changes. Gridlines were embedded in the maps to help the respondents locate the observed land-use/land cover (LULC) changes. The extent of the maps for both areas were considered to include the benchmark site for Tanjung Batu, this include the mangrove center tourism, port, guest house for athlete, school, and main road. In the case of Derawan Island, the map is provided on the entirety of the island. Possible explanations of the perceived changes by the respondents were also gathered in this part. The sample size for this study was calculated using Cochran's formula (similar in the chapter 3) with Tanjung Batu population of 4,388 in 2019 and Derawan Island population of 1,515 in 2019. Initially, this study refers to the insight from Quevedo et al. (2021b) on the margin of error which in this study was initially set on 14-15%. However, due to the limited time for the survey, the interview results only collected the total of 27 respondents from Tanjung Batu and 24 respondents from Derawan Island, increasing the margin of error into 19 and 20% respectively. The selection of key respondents (e.g. head of community organization) was supported by a local NGO (TNC – The Nature Conservancy) which was involved in the initial discussion of research plan and also supported during the course of interview in the field survey.

5.2.2. LULC maps

The second dataset used in the triangulating framework is the government data retrieved from the Ministry of Environment and Forestry public database to validate the perceived LULC changes. According to the website on the Ministry of Environment and Forestry, the LULC maps for period 2009 onwards were based on Landsat as the primary data, and can be used for various aspects, one of them is the planning and development in the context of spatial plan. Full extent of the retrieved land cover maps covers the entire East Kalimantan province. No further actions (e.g., georeferencing, interpolation) were undertaken since the format of the readily available maps are in shapefiles and, therefore, compatible with the software (ArcGIS pro v.2.6.2) used in this study. In this study the maps were only zoomed to focus on Tanjung Batu and Derawan Island. Two point

of times were used in this study – 2011 and 2019 (**Figure 12**). These points of times were selected because on the visible changes in the study areas and its close proximity to perceived time periods of the respondents.

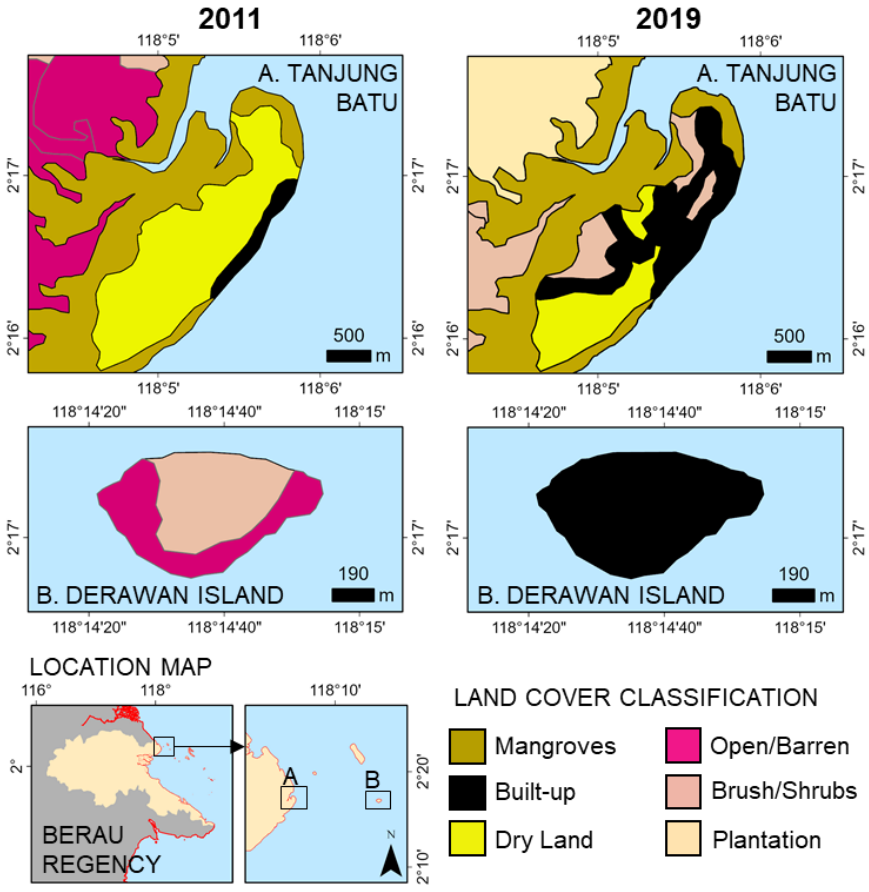

Figure 15 LULC maps of the study sites for point of times 2011 and 2019 [Retrieved from Lukman et al. 2021c]

5.2.3. Spatial plan policy maps

The third dataset is using the policy maps to show how local government perceived and managed land territories. The retrieved policy maps are currently being implemented in Berau Regency from 2016 to 2036 (*Rencana Tata Ruang Wilayah Kabupaten Berau Tahun 2016-2036*) as part of Berau Regency Policy No. 9/2017 and is readily available for download (shapefile format) from government database. No further actions (e.g., georeferencing, interpolation) were undertaken except for zooming in to show the study sites of Tanjung Batu and Derawan Island. The spatial plan policy map containing the details and explanation of the different land uses in accordance

with other government agencies' land-use categories. This document is a public domain, and it was accessed on the Berau Regency government database on December 2019. Unfortunately, there was no access to the Berau Regency Policy No. 9/2017 which describes in more details the reasoning on the land-use assignment for the study sites, thus this study will be limited to refer on the spatial plan policy maps from the land uses visualization. Based on the policy map from Local Policy of Berau Regency No. 9/2017 this study explored the various land-uses in Tanjung Batu and Derawan Island as per assignment from the government. The policy map illustrated 8 different land-use categories, 1 area of jurisdiction, and 1 landscape feature as depicted on **Figure 13**. For Tanjung Batu, the policy map has more categories for spatial plan. The center of Tanjung Batu is assigned as urban settlements, the surrounding land area falls under plantation, mangrove is categorized separately (*mangrove/bakau*), beach shoreline category, and landscape feature of river. Meanwhile for the coastal and ocean spatial plan, categories such as seagrass and fisheries, in addition of the area jurisdiction of the territorial sea. For Derawan Island, there are 2 major categories within the spatial plan map, that is the village settlement and the marine park tourism which covers the ocean side, as well as within the island which supports the tourism sector. Outside the boundaries of marine park tourism area, there is the category of fisheries, and area jurisdiction of territorial sea.

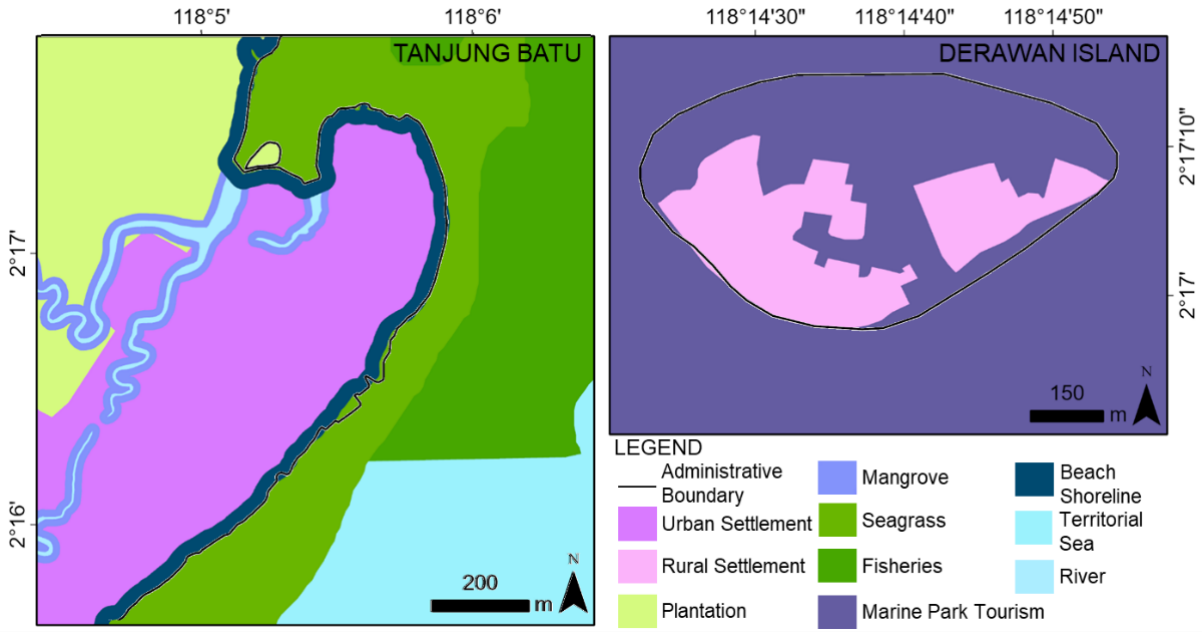

Figure 16 Spatial plan policy maps of the study sites [Retrieved from Lukman et al. 2021c]

5.3. Results

5.3.1. Perceptions of land-use change

The results from the survey interview were captured the perceptions of the locales about the drivers of the land-use change around their areas. The cause of the land-use change in Tanjung Batu can be categorized into three different drivers of infrastructure development, settlement development, and tourism development in the form of mangrove center building. From the total of 27 respondents in Tanjung Batu, the drivers of the change across the entire map of the area can be categorized into infrastructure development which was mentioned 246 times (59.56%), while settlement development was mentioned 133 times (32.2%), and the mangrove center for tourism development was mentioned in least frequency with only 34 times (8.23%). Meanwhile for the Derawan Island case, based on the results from interview with 24 respondents, the drivers of change across the entire map of the area can be categorized into four types of infrastructure development and abrasion, in which both types were mentioned in quite high rate of 53 times (31.55%), and the settlement development was mentioned in relatively smaller frequency (28.57%, 48 times), and tourism development was mentioned the least, with only 14 times (8.33%). The percentage of the drivers mentioned in both areas can be seen in **Figure 14**. For both respondents group on Tanjung Batu and Derawan Island, this study found similarities of the tourism as the drivers of land-use change is relatively low in both areas, while for the difference, Derawan Island respondents managed to perceived abrasion as one of the land-use change drivers, while Tanjung Batu highlights particularly on the drivers from infrastructure development.

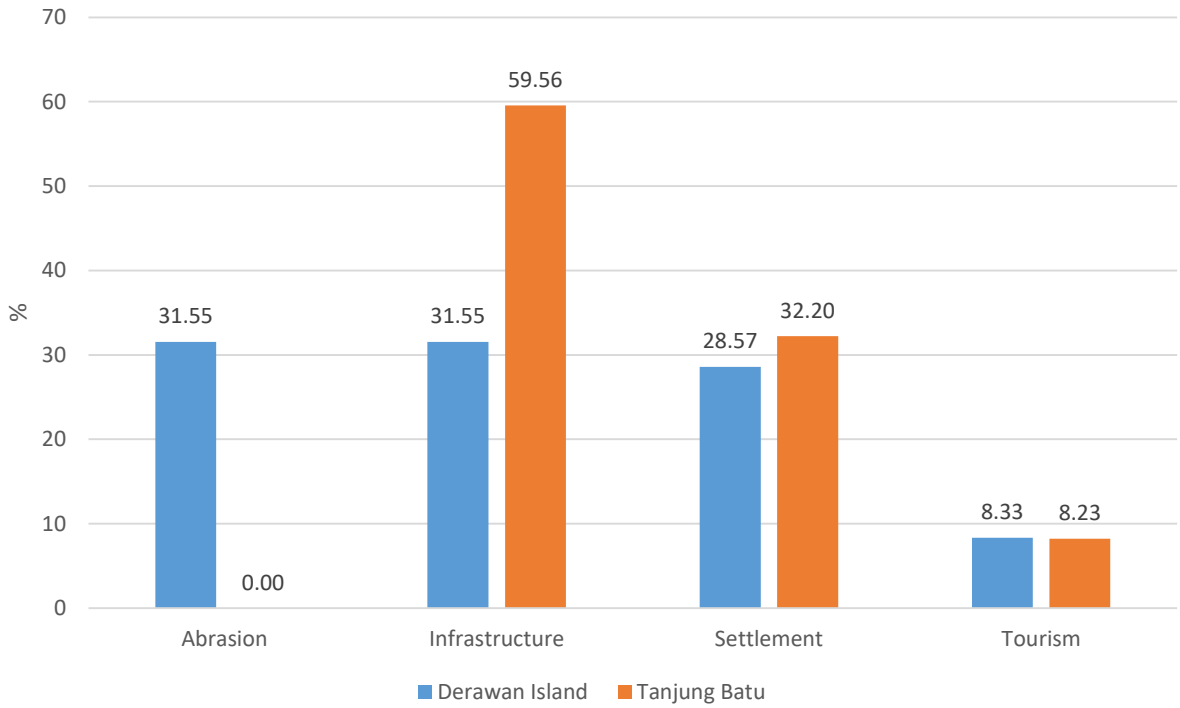

Figure 17 Perception of the Drivers of Land-Use Change [Retrieved from Lukman et al. 2021c]

In this section of the result, this study focused on describing the results of the perception map which observed certain parts of the study sites as well as the perceived drivers by the locals. For each study sites, this study observed several parts of the area that were mentioned the most by the respondents, thus enhancing the visibility of the perception map. First, on the perception map for Tanjung Batu case in **Figure 15**, the respondents mentioned the drivers of the land-use change in the northern part of the area was influenced with the establishment of mangrove center which serves as tourism infrastructure on mangrove ecosystem in Tanjung Batu. Furthermore, the drivers of infrastructure development in the land-use change also mentioned, with the highlights on the road and port construction which increase the accessibility of Tanjung Batu as the tourism hub to Derawan Island. There is also report of the land-use change from additional infrastructures such as school and athletes' dorm which was used in National Sports Week (PON) in 2008. Regarding the settlement development, there are two areas that were particularly highlighted by the respondents. The first one is near the coastal shoreline, with the expanding settlement from the increasing number of population inhabitants, as well as in the northern part of Tanjung Batu which is relatively close to the mangrove center tourism area.

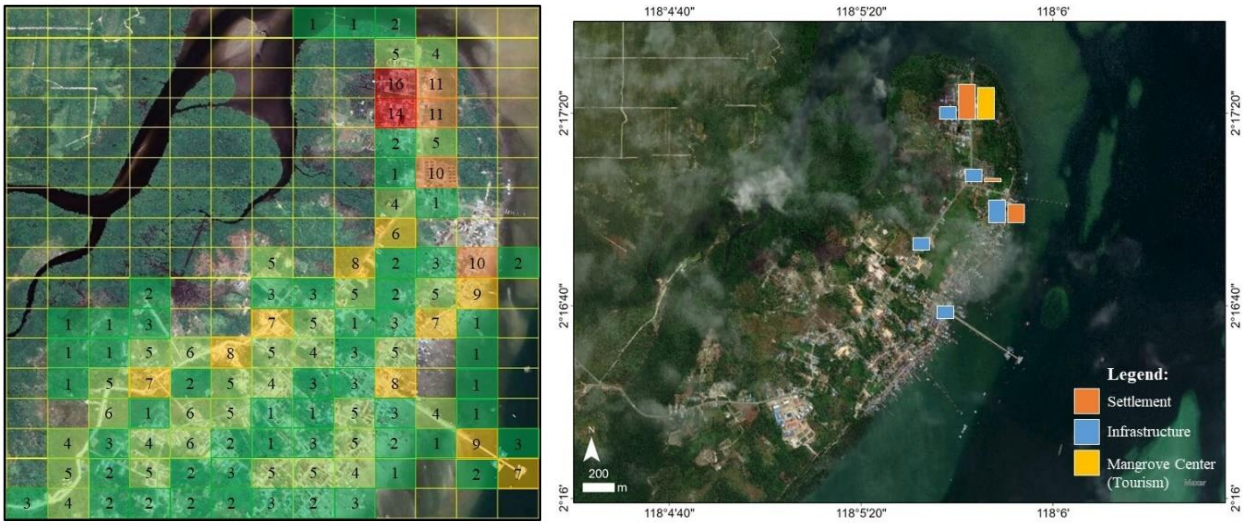

Figure 18 Perception Map of Land-Use Change Drivers – Tanjung Batu (top: distribution of the frequency perceived by respondents; bottom: type of drivers perceived with the height of the bar illustrate the frequency) [Satellite image last year 2018, Source: USGS] [Retrieved from Lukman et al. 2021c]

In Derawan Island case, the drivers of land-use change perceived by the locales is slightly differs compared with the Tanjung Batu area. Aside from the similar drivers of settlement development, infrastructure development, and tourism development, the locales also perceived the change based from the abrasion on the eastern part of the island, as seen in **Figure 16** below. In the coastal shoreline area on the western and southern part of the island, the majority of the perceived drivers by the locals were linked with the settlement development. Interestingly, the tourism sector is perceived relatively less as the drivers of land-use change, considering the status of Derawan Island with the status as tourism destination. Looking at the eastern side of the island, this study highlighted the finding on the concern of the locals in regards to the perceived drivers in the form of abrasion which shape the change of the island. Six respondents in Derawan Island mentioned that the abrasion in this side was occurred due to the mismanagement from resort construction in that area and the impact of the development which influence the abrasion to occur. Furthermore, there is also the concern that the abrasion decreases the island size. Another thing to be noted is the abrasion areas is the only one where all of the locales simultaneously agree on the drivers of the change, while the same thing can't be said in other part of the island, although there are also other respondents who did not perceived the change on the eastern part of the island.

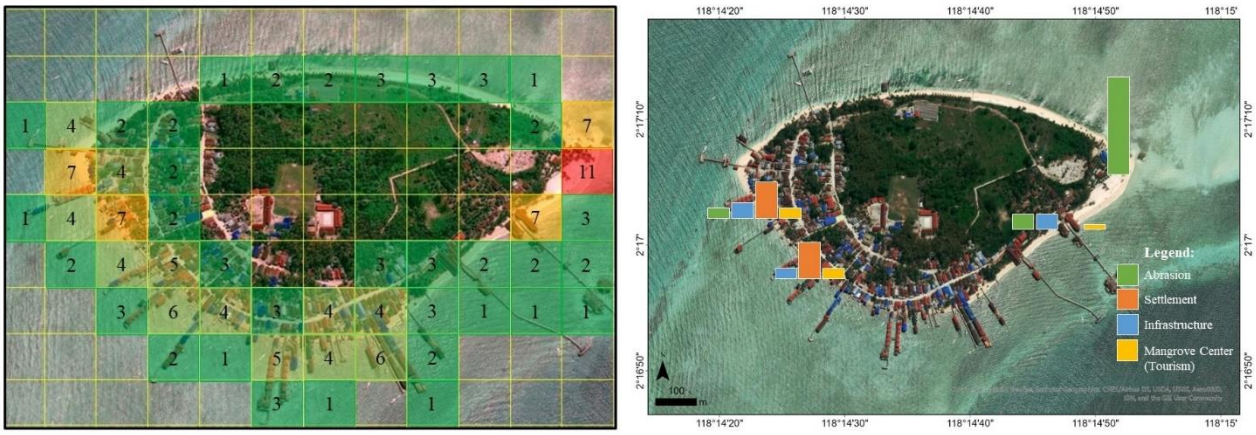

Figure 19 Perception Map of Land-Use Change Drivers – Derawan Island (top: distribution of the frequency perceived by respondents; bottom: type of drivers perceived with the height of the bar illustrate the frequency) [Satellite image last year 2018, Source: USGS] [Retrieved from Lukman et al. 2021c]

5.3.2. LULC change: 2011 and 2019

Moving on to the comparison result for the LULC maps in 2011 and 2019, first, looking at the Tanjung Batu area, one of the noticeable observed change is the settlement land-use coverage which expand throughout the area, replacing some of the dry fields coverage. Outside the settlement coverage, on northwest of Tanjung Batu, there is also the change of open fields conversion into plantation. One interesting note on the expansion of the settlement and plantation in Tanjung Batu is the relatively large intact areas of mangroves ecosystems. For the area of Derawan Island, the database of LULC map from ministry showed two different results, where in 2011 the Derawan Island LULC can be categorized into two types of open fields and bushes, however in 2019, the whole island has somehow turned into settlements coverage. Based from the observation in the field, while it is true that the nearby coastal areas are mostly filled with settlements, there are parts of the island with coverage of bushes still remains as well. The reason for the drastic LULC changes in Derawan Island in 2019 is this study limitation in terms of the limited map resolution retrieved from the government database which hinders the understanding on the drastically changes in the LULC. Nonetheless, this situation also highlights the argument of the triangulating framework which provide the opportunity for the framework to shine by using other available dataset from the spatial plan and perceived changes by the community. Referring to the document of East Kalimantan Province No. 1/2016 on the Spatial Plans (which is also where

the Berau Regency refers to), that the area of Derawan Islands (*Kepulauan Derawan*) is acknowledged as strategic zone for environment conservation and tourism. There is the insight on the changes of the LULC in Derawan Island is related with the tourism which will be discussed in the next paragraph, in addition of the gaps between the three different datasets as well as the complementing aspect.

5.3.3. Gaps between the three approaches

Next, this study will shift the focus to observed the gaps regarding land-use amongst the three approaches (perception interview, LULC maps, spatial plan government) used in this study, which are summarized in **Table 12**. First, the gaps between perception of land-use and the actual land-use from LULC maps was identified in our triangulating framework within the sub-section of *socio-ecological intersection* in which the maps based from remote sensing technology can objectively detect the results of the land-use change. However, in reality, the locals have their own perceptions in regards to their understanding on the cause of the change, which illustrated in the perception map with varying results of drivers perceived by the locals, which is especially true for artificial development such as infrastructure (i.e. settlement, tourism, road), but in some cases there is unifying results for driver such as environment change like abrasion process. The remote sensed map can identify the change of land-use shown as land-cover change, and the perception can complement it by providing the information of land-use change drivers and for further clarification study. In concrete terms, comparing the perception interview and the LULC map was able to detect the changes in the expansion of the settlement in the area while the interview results substantiated the causes of these changes, as the respondents explained the socio-ecological phenomenon of the population growth in Tanjung Batu, and the inhabitants develop settlement with highlights on the coastal and the northern part which borders with the mangrove ecosystem. In Tanjung Batu, the land-use changes from infrastructure development were prominent in the perception of the locals with detailed explanations of the locals pointing in which part of the island were changed due to the development of various infrastructures such as port and the main road which connects back to the capital of the regency in Tanjung Redeb, meanwhile the land-cover use only categorize the change within one category of settlement. This result gives a unique understanding on the detail of the land-use change which gives another insight on how the community perceived the change which potentially be influenced with the benefits from the infrastructure development as well. In Derawan Island, the perception interview gives a more substantial results as the respondents share

their perception on the cause of the change in the land cover, with the detection of the abrasion as well as the notion on the understanding of the locals on how the settlement in the island grows. One thing to be noted is the terrestrial vegetation and bushes land cover that were observed in the survey were not mentioned in the perception interviews with the locals. In overall, the result for *socio-ecological intersection* also notify the importance of further clarification and verification, despite the initial understanding from perception results on the cause of the land-use change. For example, the aforementioned abrasion in Derawan Island can be further investigated.

Table 16 Identified Gaps within Three Sub-Sections of Triangulating Framework [Modified from Lukman et al. 2021c]

Sub-section	Identified Gaps	Complementing Aspects
Socio-ecological intersection (Local perceptions and LULC maps)	a.) The perceptions of drivers and causes of the changes from the respondents should be further investigated for clarification and verification to identify the factor of the changes of the LULC. For example, the perceived abrasion phenomenon in Derawan Island.	a.) Perceptions provide another layer of information with the drivers and causes of the changes in the LULC maps. b.) The settlement growth (Tanjung Batu) was reported in the LULC maps and also perceived by the locals' perception. c.) Certain impactful environmental change was perceived such as the abrasion (Derawan Island) with socio-ecological phenomenon details, such as historical land-use.

Environmental impact of policy (Policy map and LULC maps)	a.) Duality of function between residential and tourism (Derawan Island). b.) Identified gaps on the assigned ecosystem in the LULC maps and the assigned ecosystem in the spatial plan policy map, for example the seagrass-mangrove ecosystem (Tanjung Batu), and settlement-tourism (Derawan Island).	a.) LULC maps can serve the role as a basis for the policy formulation, for example the assigned mangrove and seagrass ecosystem (Tanjung Batu).
Social impact of policy (Policy map and local perceptions)	a.) Identified the gaps of potential threat from spatial plan not captured by perception from neighboring area such as plantation expansion (Tanjung Batu), and the terrestrial tourism expansion (Derawan Island).	a.) Perception as an input and assessment tool for the policy implementation, for example in the tourism sector (Derawan Island).

Moving on to the second sub-section of triangulating framework, which is the *environmental impact policy* from the two datasets of LULC maps and policy map, the overall result show that these two datasets is relatively complement with each other. However, there is still the gaps and different results especially from the policy map with various areas in different land-use categories from the LULC maps. In context of Tanjung Batu, the gaps between LULC maps and policy map were related to the assigned ecosystem conservation area. The policy treated mangroves and seagrass in a similar manner; for example, in Article 50 point 7 for the regulation of the coastal shoreline zone, mangrove and seagrass were stated as indicators for protected areas and forbade any activities that could threaten such ecosystems. However, the observed policy map in this study did not highlight the mangrove ecosystems as observed in the LULC maps with the remote sensing data. This can be a concerning matter on the government ignoring or misinterpreting the ecosystems, as the policy map highlight seagrass more intensively in the area of mangrove ecosystem. In Derawan Island, the settlement indicated by the LULC maps supports the policy map's categorization of Derawan Island as a village settlement area. However, considering the

author's experience on the survey as well as the interview results, some of the settlements were actually used to support the terrestrial tourism business, serving as cottages and restaurants among other services, thus there is the concern on the duality of function between the settlement and tourism which can generates the overcapacity situation for the tourisms sector of the island. This duality phenomenon of intermingled between the residential and tourism sector can also influence the drivers of the development expansion in Derawan Island, which in the East Kalimantan Province policy on Spatial Plans No. 1/2016, where the policy stated the permit for the Derawan Island to be utilized as tourism zoning, but at the same time, there is the reality of the duality functions between the residential buildings and tourisms services, with the example of the residential building also provide the services of homestay for tourists.

For the third sub-section of *social impact of policy* with the datasets from perception and the policy, there is also the highlight where both datasets can complement with one another in the case of the social policy. However, there is also the concern on the gaps of potential threat from spatial plan, such as the plantation in the northwest side of Tanjung Batu, not captured by the local's perception, as well as the expansion of terrestrial tourism in Derawan Island. The notion of trade-off between the conversion of land-use with the benefits received by the locals can potentially influence the perceptions. Nonetheless, the concern on the blue carbon ecosystems conversion, such as mangrove into aquaculture, should be considered, with the example of mangrove ecosystem in Suaran in the southern part of Berau is now threatened by the plantation area, which is adjacent to the ecosystem. In Derawan Island case, the *social impact of policy* sub-section can be seen which illustrated the synergy on how the government assign the island as marine tourism with the perception of the people who also benefitted from the tourism sector. However, there is the indication that the small island is becoming a system supporting terrestrial tourism business, with cottage and various other business activities, which should be considered by the local government, especially as the assignment of tourism zone can also generate other phenomenon aside of the aforementioned duality function. Understanding the capacity of island to support the locals and the tourism industry may prove essential for understanding sustainability of the area, concerning issues such as water scarcity and abrasion. In regards to the triangulating framework, the sub-section of *environmental impact policy*, particularly on the utilization of the perception data can assess such concern to provide the government the necessary inputs and consideration before enacting any policy.

5.4. Discussion

5.4.1. Implication of local perceptions for land-use policy

Moving on to the discussion, first this study will highlight the implication of local perceptions for land-use policy. One of the highlight results from this study is related with the local's perceptions were focused on artificial land-use changes in Tanjung Batu and Derawan Island. Based on the interviews, most of the respondents' perception of land-use change was based on the visible infrastructural development, whether in the form of road access, port construction, settlement expansion, or tourism facilities. Two interesting highlights are regarding Mangrove Center in Tanjung Batu, and the abrasion site in Derawan Island. The phenomenon of the locals' attention drawn to the artificial development and land-use change can be an interesting input for the government to implement the spatial plan. Certain development can either give positive or negative image in the perception of the local community, due to the lack of understanding or the impact caused by such development. Acknowledging such potential threats on the coastal ecosystem from the land-use change should be considered by the government as a part of the conservation effort in the area as well as the *social-impact of policy*. The result of this study also showed the point on how perception can complement the land-use studies. Nonetheless, future study which integrate the perception with land-use change should also be careful on the classification and categorization used to captured the perception. Study from Ethiopia reported that farmers' perception of woodland changes and forest changes were differed from remote sensing results, with indication of the classification of land, limited access for farmers, and the relatively small losses (Ariti et al., 2015). In addition, future study should also consider other variables that can potentially influence the perceived drivers of land-use change. Study from Munthali et al., (2019) reported that education has emerged as a significant factor that influence respondents' perceptions of the drivers for the LULC changes.

5.4.2. Implication of LULC maps for land-use policy

The second discussion point will be shifted to the implication of the LULC maps with the land-use policy. From the perspective of policy map and actual condition of Berau Regency, the study found concerning gaps, which is within the context between the LULC maps results and policy map plan (*environmental impact of policy*). In Derawan Island, the assigned land-use in the policy map potentially differed from the actual use of the island in terms of its supporting capacity to facilitate the tourism industry, especially as seen in the LULC maps results with the increase of

settlement from 2011 to 2019. Another highlighted concern from this study is the difference between the observed assigned ecosystems in the spatial plan and the current conditions in Tanjung Batu during the field survey for this research, where the current mangrove tourism was assigned as a seagrass ecosystem in the spatial plan. The spatial plan regulation perceived and treated both the ecosystems in a similar way, which could have possibly influenced the confusion between mangrove and seagrass ecosystems. The difference in the conditions perceived during our survey and official policy land-use could indicate exploitation and mismanagement, thus efforts are required to eliminate such discrepancies. A clear statement in the spatial plan could eliminate the illegal conversion of coastal ecosystems. In addition, the difference between the assigned land-use in the policy and the actual condition can also be the initiative for the implementation of monitoring system with community-based management that can attract and involves the locals' participation to support the protection of the coastal ecosystems. This kind of initiative is especially true in regards of formulating the holistic approach of the triangulating framework.

5.4.3. Attention to land-use change

From the perspective of the perception, this study also tried to discuss on the findings which related on how the locals' perceived particular land-use changes. The "undetected" land-use change identified by the locals could be related to the concept of attention. The environment as an object for an individual plays the role of a stimulus, although every individual has certain inclinations as to what kind of object draws their attention. According to Solso, attention was the concentration of mind to several stimulant objects, which implied how certain objects were ignored to be able to perceive other objects effectively (Solso 2001). In this study, one of the finding is that the respondents were able to perceive land-use change in form of infrastructure development. Infrastructure such as roads, transform the accessibility of the locals, in which this type of change demands people's attention away from static types of land-uses such as vegetation. Attention, a cognitive function, is shaped by both internal and external factors. The external factors could be the dynamic factors which allows movement. The insight for this study based on the attention theory from Solso can explain why the drivers of land-use change from infrastructure development was largely perceived by the communities. Aside of the dynamic nature from infrastructure development (construction of road, port, etc.) in Tanjung Batu, there is the impact of service that felt and satisfied the needs of the local community, hence draws their attention and later remember and perceived the changes from this causes. However, for the environmental-related drivers of

changes such as in Derawan Island with the abrasion case, there might be lies a certain "threshold impact" from either social, economy, or environment dimension that will later draws the communities' attention. The decrease of coastal areas in Derawan Island can be a very high stimulant which draws the perception of the community to perceived the phenomenon as a very high impact in addition of the small island vulnerability, hence the locals can link it with the landscape change. Internal factors also play an important role in shaping attention. There is significant difference from the point of view of gender, for example, females are better at focusing their attention to the environment (Liu et al., 2013). In this study most of the respondents were male, thus the transformation of land-use of inland areas might escape their attention, except certain land-uses that have major implication for them or have a significant impact, as in the case of Derawan Island abrasion and growing importance of Mangrove Center in Tanjung Batu drawing the attention of locals. Another internal factor that can be considered on the improvement of attention to the environment is the education. For example, through the green ethos education program which aims to increase students' awareness and the concern on the environment aspect (Kadiyono et al., 2019). Environmental care behavior of making choices how to behave and respond can be influenced with educational activities and environmental awareness on long-term scale (Hafiar et al. 2019). With the increase of awareness and the attention of the locals, it is expected for the locals to be more proactive as they witness any environmental degradation on their area by collaborating with government in policy or decision-making, or participating in various means of conservation effort.

5.4.4. Holistic approach of the triangulating framework

The main insight on this study is to illustrated how the triangulating framework with three different datasets can offer the holistic and integrated approach to protect and conserve the coastal environment. The data from LULC maps, and law enforcement of the policy should consider the cooperation with the local community, for example in the form of community-based management program on monitoring blue carbon ecosystems, to prevent the mismanagement and degradation of the environment. For Tanjung Batu case, the holistic approach of the triangulating framework can be utilized in the aspect of the settlement growth in the area. Based on the LULC maps to understand the current condition of the area, the government can use such knowledge to formulate the spatial plan which considers various aspects of socio-ecology-economic for the future development. In the formulation of such policy, the locals can be involved in the decision-making,

as well as using valuable knowledge of the perception of the locals and how they perceived future development based on their understanding, whether a development is considered to give positive or negative impact. Simultaneously, government and related stakeholders should use this chance of involving the locals' community with discussion and sharing so both sides can understand the best interest of the land-use change in the area while avoiding any future potentials of conflict. Land-use conflicts were reported due to the increasing numbers of stakeholders having incompatible interests (Sinthumule et al., 2020). In Berau Regency, the marine conservation movement was reported with the issue of the local elites were excluded from the policy-making, and it is important to positively engaged and capture the elites from both government and local entrepreneurial side to be involved, as their historical knowledge and interests in the conservation implementation will influence the effective approach (Kusumawati and Visser, 2016). For Derawan Island case, with highlight on tourism sector, the island faces an issue due to limited natural resources, such as ground water, and this scarcity phenomenon was expressed by several respondents. Although the policy map has stated that the spatial plan in Derawan Island can be categorized for two distinct uses of Village Settlement and Marine Park Tourism, in reality, there is the threat of the duality function of residence and supporting tourism. The holistic approach of triangulating framework can utilize the data from LULC maps, and law enforcement of the policy to consider the cooperation with the local community to maintain the island capacity on benefitting from tourism sector while at the same time preserve the island's limited natural resources.

The integration of the triangulating framework which combines the three different approaches can serve as a best example on the holistic approach which considers the social aspect and the utilization of technology in regards to the spatial plan policy. This study illustrated the highlights of the triangulating framework implementation which can contribute to the existing policy as seen in **Figure 17** for the study case in Tanjung Batu and Derawan Island where the intersection of perception, policy map, and land-use dimension can provide unique insights on the aspect of supporting and identifying the drivers and causes of land-use change (perception-land-use), an assessment tool for policy implementation (perception-policy), and supporting tool on the basis of government's policy in regards to LULC (policy-land-use). Particular focus from this result is highlighted on the local's perception as assessment tool, which in the context of this dissertation is a potential resource for the government to initiate and involve the communities' participation. Community-based management, in particular for the monitoring of blue carbon ecosystems, is now

highlighted with additional contribution for the land-use change studies. Study from Phong et al., (2017) mentioned that in the case of Brebes Regency with mangrove project, there was the lack of on-going monitoring and evaluation. In addition, with the mangrove conservation project in Karawang District, West Java Province, where the activities of monitoring, reporting, and verification for the project is important to assess and improve future activity (Randy et al., 2015). Author give the argument that initiating the community-based management in Berau Regency, in particular Tanjung Batu and Derawan Island, can be suggested to the local government in the form of monitoring to the mangrove and seagrass ecosystems. In particular, fishermen group is the potential community to be involved, as well as other coastal communities. This type of initiative can initiate the increase of awareness and involvement of the locals to synergize the conservation effort with other stakeholders.

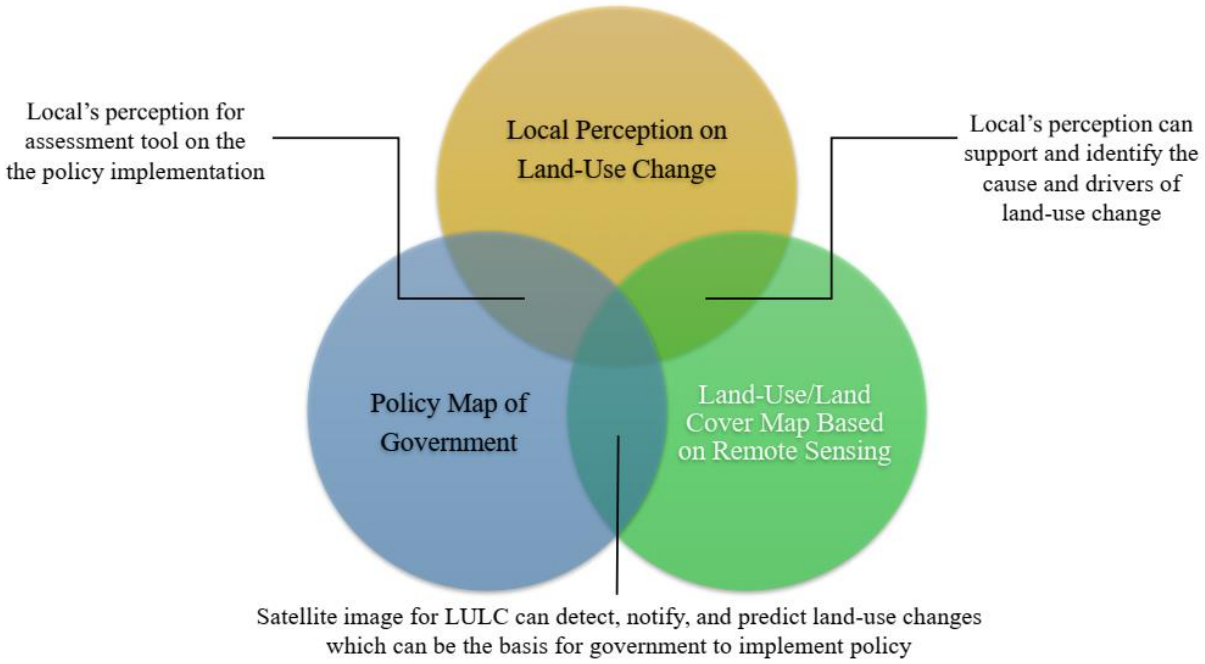

Figure 20 Highlights of Triangulating Framework in the Case of Tanjung Batu and Derawan Island [Retrieved from Lukman et al. 2021c]

5.5. Conclusion

This study has illustrated the unique insights on land-use change from the triangulating framework with three approaches of perception interviews, LULC maps and policy map. Each of these approaches have their own strengths. The interviews facilitate the context of the perceived changes

by the locals, LULC maps based on remote sensing technology provides comprehensive information on the overall land-use change, and policy map gives the understanding on how the government perceived the development and the future of the land-use on the areas. Through the understanding on the entirety of the structure between the social phenomenon of the locals' perception complemented with the reality of the existing LULC from remote sensing, a holistic result can then be analyzed for policy implications in spatial plans.

In concrete terms, this study identified that local communities tend to be aware of the changes related to the development of infrastructure, but their awareness and perceptions of the changes in natural resources is relatively low. In this regard, the remote sensing data could complement the perceptions of locals and help them in understanding the accurate trends of ecosystem changes. Based from the environmental cognition's theory of Meyfroidt (2013), this study complements the importance of the perception in regards to the land-use change study, where certain events can affect the locals' perception such as in the case of abrasion in Derawan Island. Future study should consider the importance of rich information from the perception, as such approach can give a better understanding on the environmental management. Results from this study can be integrated into a larger picture of ecosystem conservation, targeting vulnerable areas that undergo changes, while at the same time providing insights to the government on the appropriateness of spatial plan policy in addition to the possible threats to the ecosystem. Combining the initiatives from community, such as community-based management on the monitoring of blue carbon ecosystems, and strong law enforcement may drive the improvement of land-use sector and prevent the negative impacts in the future.

6. Sustainable aquaculture with bundled ecosystem services

6.1 Introduction: Aquaculture as the main pressure to mangrove ecosystem

In global perspective, Indonesia has the richest mangrove system, with the country accounts for about 22.6% (3,112,989 hectares) of total global mangrove habitat (Giri et al., 2011), however, there is a simultaneous concern on deforestation, with 60,906 hectares of mangroves being reportedly destroyed in Indonesia during the 2000-2012 period because of activities such as urban development and exploitation from pam-oil and aquaculture sector (Richards and Friess, 2016). Particularly on aquaculture sector, there is a strong concern with the widespread use of shrimp ponds and fishponds, which can pose a threat to mangrove ecosystems. Shrimp ponds are a major cause of mangrove loss with the damage caused in the form land-use conversion, and exacerbated due to the relatively short productive life (Steven et al., 2019). In Indonesia, the aquaculture sector is valued highly, and the country has announced in 2015 the mission to become the highest producer of aquaculture products in the world (Rimmer et al., 2013). The concern for the brackish water shrimp aquaculture (or *"tambak"* in Bahasa) in Indonesia is also linked with the sector as the main driver of mangrove conversion activities thanks to *tambak* abandonment practices, which are undertaken due to the general low productivity and its vulnerability to diseases (Ilman et al., 2016).The Indonesian government has issued policy guidelines to ensure the good aquaculture practices, also known as *Cara Budidaya Ikan yang Baik* (CBIB; Good Fish Farming Practice). CBIB has been promoted through various legislations, education initiatives, and certification schemes (Rimmer et al., 2013), however CBIB still requires further governmental action to disseminate the guidelines, for example in Yogyakarta, only 62.24% of farmers have implemented CBIB (Nugroho et al., 2016).

Looking at the historical timeline of mangrove loss in Indonesia, industries sector has been systematically exploiting mangroves ecosystem since 1800s, and in 1960s to the 1990s the exploitation result in a mangrove loss of nearly 800,000 hectares (Ilman et al., 2016). Various report of mangrove loss across Indonesia have been reported. In North Sumatra, the mangrove forests are facing rapid endangerment from anthropogenic activities including aquaculture conversion activities (Basyuni et al., 2018). In Lombok, the heavy degradation of the mangrove ecosystem leaves the aquaculture pond system unstable and seasonally fluctuating (Senff et al., 2018). In Perancak estuary, Bali, during the 80's most of the mangrove forest was converted to

shrimp ponds, however, many of shrimp ponds have been abandoned since the 90's and covered by mangroves through plantation programs, however, the revegetation of abandoned aquaculture with mangrove showed a very low regeneration capabilities compared with natural mangroves (Proisy et al., 2018; Rahmania et al., 2015). In Mahakam Delta, silvofishery system was proposed to solve the severe issue on mangrove loss while at the same time maintain farmer livelihood, with silvofishery as part of recovery management strategies for mangrove ecosystems (Susilo et al., 2018). In South Sulawesi, the area has suffered from degradation and declining spatial extent on the last decades, with mangrove forest areas were reduced by 66.05%, mainly because mangrove clearing and aquaculture conversion, over the last 33-years period and the biggest negative change occurred during 2006-2011 (Malik et al., 2016). These conversion of mangrove to aquaculture generates a major concern in regards to the release of blue carbon, with indication that the greenhouse gases (GHG) emissions from mangrove conversion into aquaculture is comparable with peat forest conversions in Indonesia, and possible to be higher emission if the ponds are constructed in the newly cleared mangrove forests (Sidik and Lovelock, 2013). The annual mangrove loss in Indonesia was reported only 6% of the total forest loss, however, if this loss were halted, total emissions would be reduced by about 10-31% of annual emissions from land-use sectors which highlighted the importance of conservation for carbon-rich mangroves in Indonesia as strategy to mitigate the climate change (Murdiyarso et al., 2015). In addition, from Chapter 2 on the PSP, there is the insight that the spatial plan does not clearly define the environmental role of mangroves in Indonesia in regard to their supporting functions, which include aquaculture, disaster prevention, and production of fish nurseries habitat, hence creating another concern on the mangrove losses phenomenon.

Various strategies have been proposed to incorporate aquaculture into mangrove conservation efforts, for example the silvofishery approach. In principle, the silvofishery method integrates mangrove conservation into aquaculture practices by providing improved livelihoods for local communities (Basyuni et al., 2018). Silvofishery systems can provide an alternative solution for reducing mangrove losses while maintaining local farmers' livelihoods (Susilo et al., 2018). This strategy is particularly beneficial for low-productivity aquaculture activities and abandoned ponds. The characteristic low productivity of shrimp aquaculture in Indonesia could force shrimp producers to clear an estimated 600,000 hectares of mangrove area for shrimp farm conversion activities over the next two decades (Ilman et al., 2016). A large proportion of the aquaculture

ponds are abandoned after 5-10 years, as intensive aquaculture practices are rarely sustainable; however, abandoned ponds have reportedly been found suitable for mangrove rehabilitation (Oh et al., 2017). A study by van Oudenhoven et al., (2015) on suitable management regimes for various mangrove ecosystems suggested that future research should focus on quantifying linkages between management, ecosystems, mangrove capacities, and the overall socio-economic and cultural value of services involving mangrove ecosystems. In addition, study from Malik et al., (2015) also reported the indirect use value (IUV) of mangrove ecosystem in the form of coastal protection, nursery ground, and for carbon sequestration has overall highest total economic value (TEV) contribution. Thus, there is the incentive to take the approach of integrating the aspect of aquaculture and mangrove conservation with other management regimes which involves the richness of mangroves ecosystem services and not only focusing on the aquaculture industry.

Often, aquaculture sector activities are related to the behavior and attitudes of fishpond owners and farmers. In Karimunjawa, fishpond conversion activities are perceived as being a damaging threat to the local mangrove ecosystems (Quevedo et al., 2021). Concerns regarding human exploitation activities in the environment could be asserted by examining people's understanding of appropriate knowledge and attitudes regarding the environment (Ogunbode and Arnold, 2012), with local perceptions are critical for supporting any collective responses made toward the sustainable management of natural resources (Quevedo et al., 2021). In the setting of Berau Regency, as illustrated in Chapter 3 in this dissertation, the awareness to the ecosystem services, particularly for seagrass, is concerning with the example of carbon-sequestration functions are not necessarily well understood by local residents, however, the awareness for the mangrove ecosystem services were not yet explored. Thus in the Chapter 5, the study will be focused on the understanding of the awareness for the mangrove ecosystem services, particularly for the aquaculture farmers, and the relationship with the participation on mangrove-related program, as well as the status of CBIB implementation and the perception of sustainable aquaculture to identify the status quo for tailoring future policy implementation related with the community-based management of the aquaculture sector.

6.2. Materials and methodology

To understand the awareness of the aquaculture farmers, this part of the study will expand the setting, which covered Berau Regency (Tanjung Redeb, Sukan, Suaran) and Balikpapan. The

reasoning on expanding the respondent is related with the aquaculture sector in Berau Regency exists in certain areas, excluding Derawan Island, and the aquaculture in Balikpapan can also provide comparison on the difference of the utilization integration between mangrove and fishpond. The province of East Kalimantan has extensive mangrove areas and is home to a growing aquaculture industry. According to the Statistical Yearbook of Indonesia 2018 (BPS-Statistics Indonesia 2018), East Kalimantan province generated 38,792 tons of aquaculture products from brackish water ponds in 2015 which increased to 66,579 tons in 2016. Simultaneously, the Kalimantan area has witnessed a reduction in mangroves and a high rate of expansion of mangrove-related land conversion activities into aquaculture (Malik et al., 2016; Richards and Friess, 2016). Common products cultivated in brackish water ponds include milkfish (*bandeng*) and tiger prawn shrimp (*udang windu*).

Questionnare survey was utilized in this study to collect the data about aquaculture farmers' awareness on the mangrove ecosystem services, as well as the perceptions regarding sustainable aquaculture linked to the CBIB policy. In the Balikpapan municipality, the questionnaire respondents were fishpond owners involved in the local community fisheries group, while respondents in Berau Regency were not involved in a community fisheries group but were selected based on their residential area. The fisheries group itself is directly related to the Government Agency in the Fisheries Sector (DP3 Balikpapan), and it receives extensive training and support. A questionnaire survey was completed by 73 respondents in February 2019. This survey was conducted with the help of government agency staff in Balikpapan (DP3 Balikpapan) and with NGO involvement in Berau Regency (TNC).

The content of the survey questionnaire is divided into two sections to investigate the (a) the relationship between residents' participation in mangrove programs and their awareness regarding mangrove benefits and (b) the relationship between residents' knowledge regarding CBIB and their perceptions regarding sustainable aquaculture activities. For the first section, several awareness included in the survey questionnaire which consists of (1) *wildlife habitat*, (2) *fish nursery*, (3) *food*, (4) *medicine*, (5) *disaster prevention*, (6) *erosion*, (7) *clean air*, (8) *water quality*, (9) *prevention of garbage disposal in the sea*, (10) *climate change*, (11) *groundwater*, (12) *tourism/education*, and benefits related to (13) *aquaculture*, and (14) *alternative livelihoods*. This awareness is based and expanded from the list of awareness used in the Chapter 3. To investigate

the relationship between residents' CBIB knowledge and their perceptions regarding sustainable aquaculture activities, participants were required to rank several listed activities in the questionnaire (rank order: most important to least important). The list of sustainable activities was based on materials produced by the Ministry of Maritime Affairs and Fisheries No. 2/2007 with regard to the CBIB guidelines; these defined sustainable practices and classified them into four categories: (1) *food safety*, (2) *utilization of feed*, (3) *safety in harvest*, and (4) *verification*. *The food safety* aspect highlighted facilities and activities related to fish cultivation, which are designed to maintain hygiene and safety standards, while *utilization of feed* focused on certain criteria for fish feed, which ensure that it contains the necessary nutrition in terms of calories and protein, and does not contain any poisonous ingredients that could pollute the environment and/or endanger humans and fish. Other criteria ensure that the feed will not contain any antibiotics and hormones; furthermore, the feed has to be certified and registered. For *safety in harvest*, the government guideline highlights handling activities, which include aspects of tools and procedure-related criteria to ensure that they are not dangerous or poisonous. This section also includes systematic supplies that play a role in the delivery of the harvest. The last part, *verification*, includes ideas for sustainable aquaculture as well as documentation for every activity in the sector; the idea is to use the documentation as a tool for tracing back and guaranteeing the legitimacy of the aquaculture activities, including the processes of correction and verification. In the interview, the respondents received explanation on the core ideas of each category, and then asked to rank them (most important to least important) based on their own perceptions. Aside of the two sections, the survey also notes the off-discussions with the aquaculture farmers' respondents on the further utilization linked with the aquaculture fishpond and other situations or concerns in aquaculture sector.

Chi-square test analysis of the relationship between (a) the mangrove program and awareness regarding mangrove benefits as well as (b) the relationship between knowledge about CBIB and perceptions regarding sustainable aquaculture activities were performed in order to identify the statistical significance of these relationships. First, the respondents were classified into two groups using medians of the awareness value for (a) relationship between the mangrove program and awareness regarding mangrove benefits and using medians of perception values for (b) the relationship between CBIB and sustainable aquaculture. One example of such median utilization is that a group of respondents had a higher value than the average perception value regarding mangrove benefits as a part of *wildlife habitat*, while the other group had a lower value than the

average perception value regarding the same benefit. This principle was also used for analyzing perceptions regarding sustainable aquaculture by using the median value for each perception.

6.3. Results

6.3.1. Aquaculture farmers' profile

The respondents' profile can be seen in **Table 13**. Among the aquaculture farmers, most respondents were male (89.04%) and were married (90.41%); the age groups varied considerably, but most respondents were 31-40 years old (30.14%), 41-50 years old (35.62%), and 51-60 years old (23.29%). With regard to the educational level of the respondents, most had attained senior high school (36.99%), elementary school (27.40%), and junior high school (20.55%) educational qualifications, while a few also managed to attain college level qualifications (4.11%). The questionnaire also asked respondents to indicate how long they had lived at their current residential sites and results indicated that most of the farmers had been staying at their current residential sites for quite a long time, and many for more than 20 years (46.58%) or for 10-20 years (38.36%).

Table 17 The sociodemographic profiles of the aquaculture farmer respondents at the study sites [Retrieved from Lukman et al. 2021d]

Sociodemographic Profiles of the Respondents	
Gender	**%**
Male	89.04
Female	8.22
Others	2.74
Marital Status	
Single	2.74
Married	90.41
Others	6.85
Education Level	
Elementary School	27.40
Junior High	20.55
Senior High	36.99
College	4.11
Others	10.96

Age Group	
51-60	23.29
41-50	35.62
31-40	30.14
20-30	6.85
Others	4.11
Duration of Stay	
1-5 years	1.37
5-10 years	9.59
10-20 years	38.36
20>years	46.58
Others	4.11

6.3.2. Mangrove program participation and mangrove benefit awareness

The respondents were further asked about their perceptions regarding changes in the mangroves in their surrounding living areas (whether changes were increasing or decreasing and whether there were no changes at all). For changes in mangroves, 67% of the respondents believed that the mangrove areas had decreased over time, while 30% of the respondents believed that mangrove areas were increasing; the other 3% stated that there had been no changes in mangrove coverage. Common mangrove programs conducted in this area included transplantation and mangrove nursery programs. The respondents' experiences regarding such mangrove programs could be classified as (1) *never participated*, (2) participated in *one activity* from the program, or (3) participated in *both activities* from the program. Using the analysis approaches outlined in the Method section, two groups were classified based on the mangrove benefits, with one group having a higher awareness value than the average, and one group having a lower awareness value than the average. The former group was categorized as *superior*, while the latter was categorized as *inferior* (**Figures 18** and **19**). The results show that the *superior* group for each of the awareness regarding the mangrove benefits had a higher percentage of respondents who participated in *one activity* from mangrove program; the opposite was true as well—respondents who *never* participated had a lower percentage of inclusion in the *superior* group but a higher percentage of inclusion in the *inferior* group. The only exceptions to this trend were observed for awareness regarding mangrove benefits relating to *food*, *medicine*, and *alternative livelihoods*.

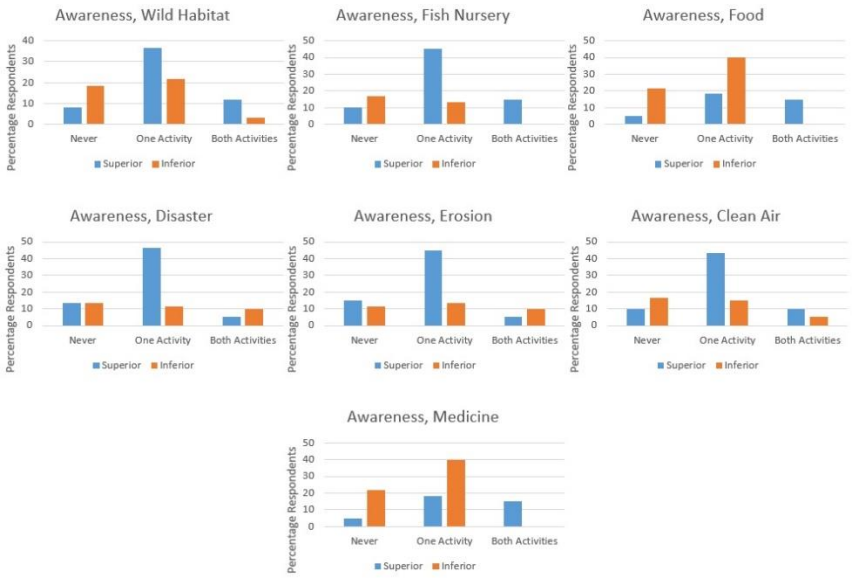

Figure 21 The percentage of respondents with different experiences related to mangrove program in the superior and inferior groups based on awareness of mangrove benefits (Awareness: wild habitat, fish nursery, food, disaster, erosion, clean air, medicine) [Retrieved from Lukman et al. 2021d]

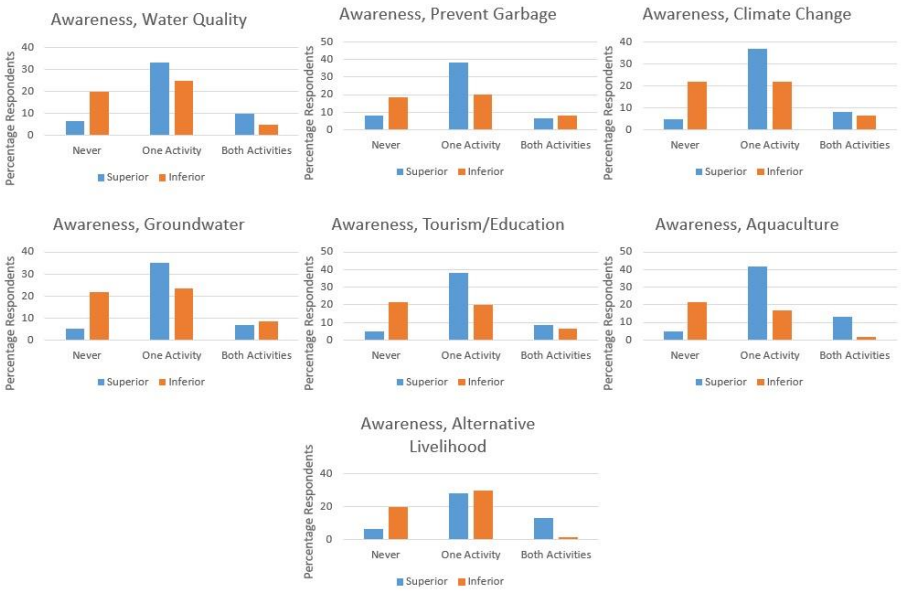

Figure 22 The percentage of respondents with different experiences related to mangrove program in the superior and inferior groups based on awareness of mangrove benefits (Awareness: water quality, prevent garbage, climate change, groundwater, tourism/education, aquaculture, alternative livelihood) [Retrieved from Lukman et al. 2021d]

Chi-square tests were performed for each awareness with a 5% level of significance. The sample size (73) was large enough to validate the chi-square test, with the minimum sample size varying from 20 and no expected cut-off (Rana and Singhal, 2015). Of the 14 awareness types, 12 were statistically significant, and two were not statistically significant—that is, *water quality* and *prevention of garbage disposal in the sea*. **Tables 14** and **15** show the chi-square test (*p-value*) results for each awareness type. The results in particular can be seen in the awareness of *fish nursery*, *food*, *medicine*, *tourism/education*, *aquaculture*, and *alternative livelihood* with the *p*-value of 0.0016, 0.0001, 0.0001, 0.0075, 0.0002, and 0.009 respectively with all of this awareness were statistically significant (p-value < 0.01). The other awareness with statistically significant value is *wild habitat*, *disaster prevention*, *erosion*, *clean air*, *climate change*, and *groundwater*, with the *p*-value of 0.0409, 0.0338, 0.0397, 0.013, and 0.0231 respectively (p-value < 0.05). The results from Chi-square tests showed that through the participation on the mangrove-related program, there is the indication for the aquaculture famers to have higher awareness on the various mangrove ecosystem services compared with the aquaculture farmers who never participated in any type of mangrove-related program.

Table 18 The perception profiles of the respondents: awareness of the mangrove ecosystem-related services (Awareness: wild habitat, fish nursery, food, disaster, erosion, clean air, medicine) [Retrieved from Lukman et al. 2021d]

Wild Habitat	Fish Nursery	Food	Medicine	Disaster Prevention	Erosion	Clean Air
0.0409*	0.0016**	0.0001**	0.0001**	0.011*	0.0338*	0.0397*

* and ** indicate significant correlations at p-value < 0.05 and p-value < 0.01, respectively

Table 19 The perception profiles of the respondents: awareness of the mangrove ecosystem services (Awareness: water quality, prevent garbage, climate change, groundwater, tourism/education, aquaculture, alternative livelihood) [Retrieved from Lukman et al. 2021d]

Water Quality	Prevent Garbage	Climate Change	Groundwater	Tourism/Education	Aquaculture	Alternative Livelihood
0.0574	0.0615	0.013*	0.0231*	0.0075**	0.0002**	0.009**

* and ** indicate significant correlations at p-value < 0.05 and p-value < 0.01, respectively

The analysis results regarding the relationship between participation in the mangrove program and awareness of the benefits of the mangrove ecosystem, indicated a tendency toward higher

awareness shaped through participation in the programs. The participation in the mangrove-related program can trigger and invoke the potential transfer of knowledge to the aquaculture farmers' way of thinking. From the results of the survey, this study observed that the majority of the aquaculture farmers only joined one type of program, either the nursery or mangrove transplantation, with 39 farmers at least participated in one type of program, 9 farmers who participated in both type of programs, and 25 farmers who have never participated. The analysis results for the awareness on ecosystem services of *food*, *medicine*, and *alternative livelihood* among farmers who participated in *one activity* showed that the differences in awareness could be influenced by the lack of utilization of particular aspects of the ecosystem services. The study interviews showed that most of the farmers did not even know about the potential or processing methods related to creating certain snacks from fruits in the mangroves; in most cases, the knowledge had already been lost with the passage of time. Regarding medicine, few farmers understood how the mangrove leaves could be used for treating certain illnesses or wounds (for example, treating fishermen who dived into the ocean and got accidentally stabbed by certain coral reefs or fish). Other benefits indicated a that there were higher awareness levels among farmers who participated in mangrove programs. This suggests the importance of effectively implementing mangrove programs within the communities that frequently interact with mangrove ecosystems and also great potential for utilization of these resources.

6.3.3. CBIB knowledge and sustainable aquaculture perceptions

In this section, this chapter analyzed the relationship between CBIB knowledge and sustainable aquaculture perceptions. Here, the respondents were classified as farmers with knowledge regarding CBIB (*yes*) and farmers without knowledge regarding CBIB (*no*). The respondents were asked to rank the four activity types necessary for achieving sustainable aquaculture (score range: 1 to 4, where 4 indicates the most important, and 1 indicates the least important). The four types of activities were based on the following general categories within the CBIB guidelines: (1) *food safety*, (2) *utilization of feed*, (3) *safety in harvest*, and (4) *verification*. Using the analysis explained in the Method section, two groups were classified based on each perception, with one group having a higher value than the average, and one group having a lower value than the average. The former group was categorized as *superior*, while the latter was categorized as *inferior* (**Figure 20**). The initial results showed that farmers without CBIB knowledge in particular perceiving the aspect of *food safety* as part of sustainable aquaculture. Meanwhile for farmers who classified themselves

with knowledge on CBIB have tendency to perceived the aspect of *utilization of feed* as the part of sustainable aquaculture practices.

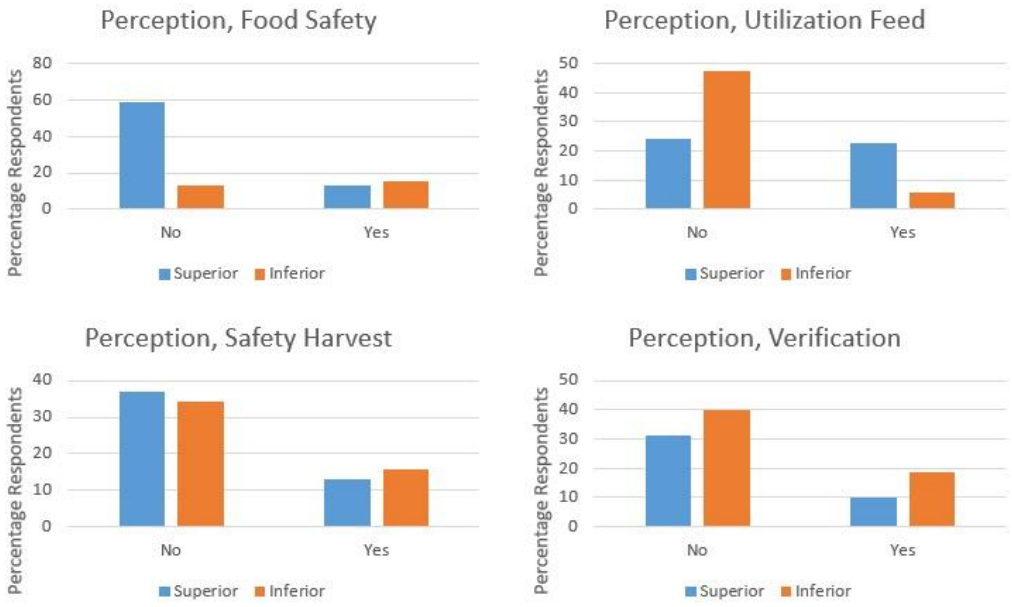

Figure 23 The percentage of respondents with based on CBIB knowledge (No and Yes) in the superior and inferior groups with regard to perception of sustainable aquaculture activities [Retrieved from Lukman et al. 2021d]

Chi-square tests were also performed for each perception, with a 5% level of significance. The results from the Chi-square tests also supported the initial observation, with the statistically significant on the aspect of *food safety* and *utilization of feed*, and the other two were not statistically significant (*safety in harvest* and *verification*), as seen in **Table 16**. The perception analysis results indicated a relationship between aquaculture farmers' lack of knowledge regarding the CBIB policy guidelines and the belief that sustainable aquaculture can be achieved by focusing on important aspects of *food safety* activity; farmers with an understanding of CBIB were more likely to focus on the *utilization of feed* activity. Overall, CBIB itself was relatively unknown to the aquaculture farmers, with only 20 farmers stating that they knew about the CBIB guidelines, with the detail percentage of farmers with CBIB knowledge from both sites can be seen in **Figure 21**. Confirming this situation with the local government authority of Balikpapan and Berau Regency, the government had confirmed that they had already disseminated the policy and practices information to the aquaculture farmers; however, most of those farmers still could not

understand the CBIB, and still relied on traditional practices that were based on passed down knowledge and experiences.

Table 20 The correlation between knowledge about CBIB and the perception of sustainable aquaculture activities [Retrieved from Lukman et al. 2021d]

Food Safety	Utilization Feed	Safety Harvest	Verification
0.0019*	0.0004*	0.5967	0.4898

* indicates a significant correlation at *p-value* < 0.01.

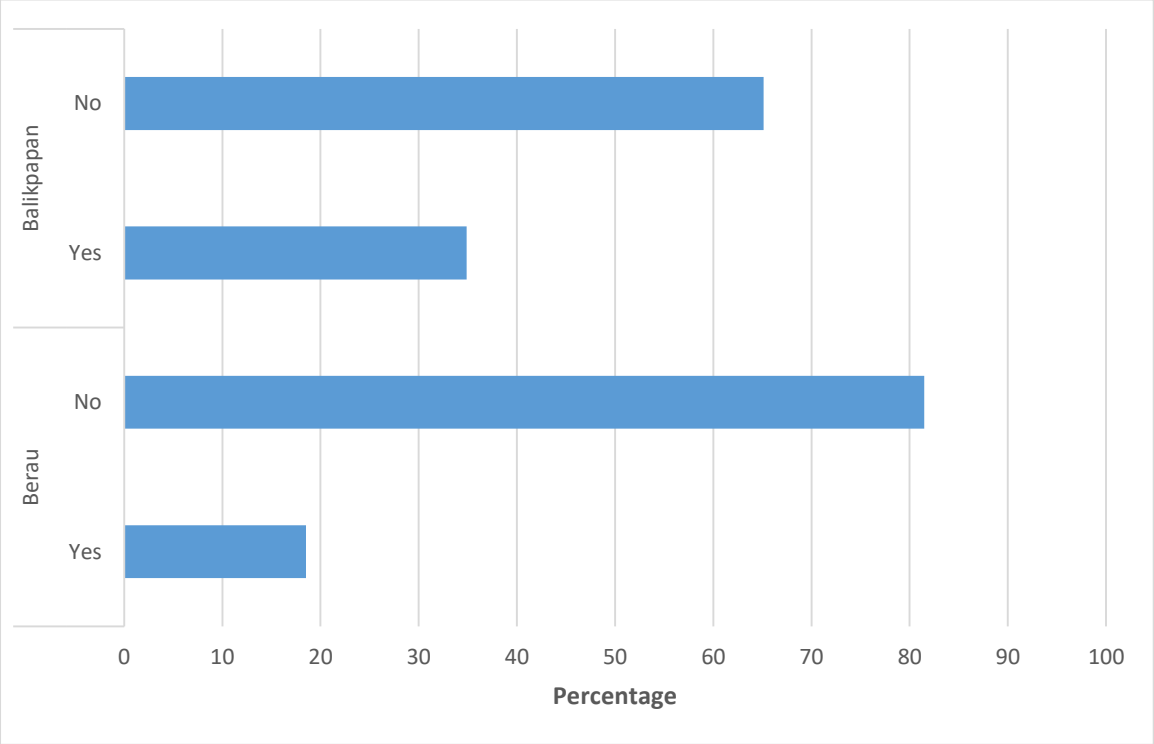

Figure 24 The Percentage Levels of CBIB Knowledge in Balikpapan and Berau Regency [Retrieved from Lukman et al. 2021d]

6.4. Discussion

6.4.1. Approaches toward mangrove-aquaculture integration: bundled ecosystem services

Aquaculture practice in mangrove areas is widely seen in Indonesia, with intensive shrimp farming being practiced in the region of Java, Sumatra, South Sulawesi, and Kalimantan (Malik et al., 2016). Further observation between the two study sites of Balikpapan and Berau Regency give the indication of the differences between the aquaculture farmers' communities. The first difference is related to the CBIB knowledge, as seen in **Figure 21**, with aquaculture farmers in Balikpapan

having a higher percentage who understand CBIB. Other differences between the two study sites were also observed in the off-discussion. The first difference is related to the fish pond scale, with the Balikpapan farmers operating on a relatively smaller scale and the farmers in Berau Regency operating in larger scale. The difference in scale size can be linked with the difference situation in Balikpapan and Berau Regency, with Balikpapan becoming a center of business in East Kalimantan province, the farmers were potentially having difficulties in expanding and operating fishpond in larger size, unlike in Berau Regency where the empty space in particular is relatively more available and can be utilized for large scale fishpond. The second differences between the two study sites were linked with the plans and potential integration into other potential types of activities. In Balikpapan, the common activities by the aquaculture farmers' group in this area is integrating the fishpond utilization with the tourism-related activities. These activities came in the form of utilizing the fishpond as a fishing site, where tourists and visitors could use the fishpond as a fishing site as well as requesting to the owner of the fishpond for the caught fish to be cooked and consumed. Thus, mangroves play a major role not only in enhancing the fishpond but also in beautifying the site as part of the vegetation canopy; this allowed visitors to feel more comfortable when they spent their time fishing in the aquaculture fishpond. This type of integration of aquaculture activities into tourism also helped to increase mangrove conservation effort; several mangrove programs were also related to conservation and tourism. Based on the insight from Chapter 2 on the Indonesia PSP, this study has shown that mangroves' ecosystem utilization for tourism and educational site is relatively more acknowledged. This part of study argues that the Balikpapan case shows the potential of the area to promote mangrove conservation within the boundaries of the tourism and education sectors; this is also reflected in how the locals who participated in the mangrove programs understood the benefits of mangroves as tourism sites. Balikpapan with high accessibility, supported with large airport and well-maintained road also attracts various tourists to the city, which can give another reason for the aquaculture farmers to benefit from this type of integration. Nonetheless, the initiatives to combine aquaculture with tourism should consider the main challenge in terms infrastructure development; with most aquaculture sites have poor access, and this may discourage people from visiting the site. Based on a case study of aquaculture communities in Sekotong, Lombok, the key points to improve aquaculture production rely on official support and focus should be placed on infrastructure development, such as for ponds and canals (Senff et al., 2018).

Meanwhile, in Berau Regency, the particular focus from the off-discussion resulted in the insight of difference integration between aquaculture and mangrove ecosystem. The benefits of mangroves as a fish nursery was reported by the aquaculture farmers in Berau Regency. Although these farmers were not reported the utilization of their fishpond for tourism activities, there is still the potential value to linked the aquaculture with the benefit from mangrove ecosystem. The farmers in Berau Regency particularly highlighted the mangroves to support the aquaculture, with report such as planting mangroves surrounding the fishpond can give benefit such as maintaining the soil structure integrity and feeding the fishes in the pond. The phenomenon of different aspect highlighted for the mangrove ecosystem benefit in the aquaculture sector boundary can be partially explained with the difference of the scale of activities. The larger scale in Berau Regency, one fishpond in Berau can be five times larger compared in Balikpapan, might influences the focus to the fishpond production, hence the perceived awareness from mangrove ecosystem is rather linked heavily with the support to aquaculture, unlike in Balikpapan. The off-discussion also noted that the farmers in Berau Regency recognized the importance of mangroves; the frequently mentioned features were preventing disasters and erosion. Thus, some farmers initiate planting or keeping the remaining mangrove ecosystem within the surrounding fishpond. The threat from coastal erosion, which can destroy ponds, can also be related to the phenomenon of aquaculture abandonment (Malik et al., 2016). Local governments can intervene in such issues by integrating disaster prevention into the aquaculture sector. In Jakarta, governor's regulations have introduced the concept of controlling the damage from land conversion with tourism functionality and have also included the target for reducing greenhouse gas emissions (Rahmawati 2018). In addition to the mangroves' services for disaster prevention, the integration of mangroves into aquaculture can also provide environmental benefits. Integrated mangrove shrimp cultivation, also known as organic aquaculture, is an option for mangrove restoration that can compensate for the loss of mangrove areas through conventional aquaculture (Ahmed et al., 2018). Other approaches, such as the silvofishery system, had the reported ability to solve the issue of mangroves in the Mahakam Delta, East Kalimantan with particular highlight to consider the aspect of community involvement within the scope of information, education, and communication (Susilo et al., 2018). In both cases of Balikpapan and Berau Regency, this study provides the insight on the idea for bundled ecosystem services, with Balikpapan bundling the idea of aquaculture-tourism-alternative livelihood, and Berau Regency bundling the idea of aquaculture-fish nursery-erosion. The

approach of bundled ecosystem services can further be enhanced with the conception of community-based management, particularly in Balikpapan with the aquaculture farmers were already grouped based on their area, while in Berau Regency, the farmers were more scattered. Promoting the idea of bundled ecosystem services can be initiated with the involvement of the aquaculture farmers' community, supported by local government and NGO for the knowledge transfer and spreading the awareness and utilization of mangrove ecosystems while at the same time forwarding the effort for conservation. Nonetheless, there is also other challenges from the practices of the aquaculture sector, where the next section will explain the aspect of CBIB guidelines, especially with the status quo of farmers not understanding or knowing the guidelines.

6.4.2. Challenges and support for the aquaculture farmers

First, to understand the significance of sustainable practice guidelines such as CBIB is through the understanding on the various challenges faced by the aquaculture farmers. From the off-discussion in both Balikpapan and Berau Regency, aquaculture practitioners reported the concern about the problem of diseases that struck fishponds. This concern was more targeted at the cultivation of tiger prawn shrimp (*udang windu*), which have a higher selling price but are more prone to disease. Thus, aquaculture farmers also cultivated milkfish (*bandeng*); while it fetches lower prices, it is easier to cultivate and more resistant to disease. The main cause of the shrimp disease was reported to be the use of non-environmentally friendly feed for aquaculture. The disease phenomenon can also influence mangrove clearing (Malik et al., 2016), thus exacerbating the degradation of the mangrove ecosystems. Although CBIB has a section that explains the technicalities of safe feeding, there is the issue of CBIB itself being not widely understood. Further studies should examine the factors that influence the disease, in addition to the linkage with the driving force of the phenomenon of abandoned fishponds which can further expand the land-use conversion to aquaculture sector.

The results of the analysis show a correlation between participation in conservation activities and awareness of mangrove benefits. To enhance the awareness of the farmers, a support to attracts more participation from the farmers in the mangrove-related program can be considered. However, simultaneously, it is also instrumental to consider the effectiveness of the mangrove conservation program. In discussions between the researchers and local government staff members and NGOs, several cases in Balikpapan were mentioned as examples of the ineffectiveness of the

transplantation program, as most of the mangrove seedlings were swept away. This situation could influence farmers' perceptions and prevent them from engaging in conservation practices. Mangrove rehabilitation projects often fail to meet their objectives, with factors such as poor site and species selection (not always compatible) as well as factors such as high and low elevations (Wodehouse and Rayment, 2019).

Regarding the knowledge of CBIB, the result show that the farmers with an understanding of CBIB tended to focus on the *utilization of feed* activity, and the farmers without CBIB knowledge tended to focus on the *food safety* activity. According to the CBIB guidelines issued by Ministry of Maritime and Fisheries No. 02/MEN/2007, the goal of CBIB formulation is to guarantee the quality and safety of the fisheries products according to national and international standards. However, full dissemination and training on the CBIB guidelines is still lacking. For example, in the Yogyakarta case, from the three regions of Sidorejo, Kuwaru, and Ngentak, only 12.5% of farmers, were aware of the importance of feed for aquaculture from other sources of feed producer (Nugroho et al., 2016). It is possible that in the East Kalimantan case of Balikpapan and Berau that most of the aquaculture farmers were also in a similar situation of lacking knowledge of CBIB. They receive influence and knowledge from other sources which shapes their understanding on the "good" practices of aquaculture oriented to the aspects of *food safety*, while the focus on the *utilization of feed* for the farmers who already received CBIB training can be linked to the concerning aquaculture situation which is prone to disease, and perception of quality feed is important.

Based on the observations during the survey, there were moments when the farmers associated their "good" practices with the traditional knowledge that was passed down to them, and with the communication happening among the farmers. Indeed, the level of dissemination of the CBIB policy to the practitioners is concerning in Indonesia. In another study in East Bolaang Mongondow Regency case, it was also reported that the CBIB situation in the area demonstrates a lack of guidance and supervision, with minimal human resources and a limited program budget, even though strengthening the local government can assist the CBIB implementation and hence achieve the safety and quality targets of production (Ayuningtyas et al., 2018). This study argues that aside from strengthening the government sector to support the CBIB implementation, it is also important to support and strengthen the existing aquaculture farmers' community groups. For

example, in Balikpapan, there are several community groups in different neighborhoods complete with organizational functions. Therefore, to widely share the CBIB knowledge with aquaculture farmers, sharing the different perspectives of the farmers can facilitate updating their knowledge of, and interests in, CBIB. Paying attention to such community groups and enabling their support and cooperation with local government can be a platform to increase the awareness and implementation of the mangroves ecosystem in aquaculture sector. Based on the insight from Chapter 3 of the dissertation, the role from government employees with high capacity in the knowledge of seagrass ecosystem services observed in Berau Regency can be a good asset to promote the spread of awareness and at the same time involving the communities in the conservation effort.

Focusing on the local government role to communicate and help the aquaculture farmers, this study identified that in Balikpapan case the local government accommodated the establishment of aquaculture communities in several areas. The established communities can request any assistance from the government regarding aquaculture practices, and also serves as a hub for spreading knowledge regarding the model and good practices of aquaculture. Interesting point is that some of the communities' members also manages different community that focuses on tourism and mangrove conservation. In Berau Regency, the local government has initiated the creation of their own guidelines for aquaculture practices, using the CBIB as the basis and adjusting it to be appropriate for the region's geographical and social conditions. Both municipalities' agencies also assisted with the training aspect for the farmers; they monitored the disease and took samples for laboratory inspection. The training was really well appreciated by the aquaculture farmers, although the problem is its lack of frequency; it only happens once in a month—sometimes even less frequently. Providing training and education to new farmers can enhance product quality from mangroves and aquaculture (Ismail et al., 2018). The main limitations in the study sites were caused by the number of agency staff, as well as access, which has also been mentioned before. Nonetheless, farmers were enthusiastic about working with local government and expanding their knowledge regarding aquaculture practices.

In addition, there are official legal instruments with market mechanisms to promote value-added products from local livelihoods. Milkfish (*bandeng*) is registered as a locally specific product under the protection of geographical indications in other areas (Palar et al., 2021). Milkfish is also

a prominent product in aquaculture practice in both Balikpapan and Berau, as farmers shared in the off-discussion. Because aquaculture with tiger prawns (*udang windu*) has the dilemma of high market prices with high risks of disease, milkfish are increasingly perceived as stable and resistant cultivation, despite their lower market prices. Another point in the off-discussion in Balikpapan indicated that fishermen were proud of the uniqueness of the taste of the milkfish in the area—especially when it was cooked with old mangrove branches that fell off the mangrove tree. Future studies can explore the feasibility of geographical indications of milkfish as a local alternative livelihood from aquacultures in East Kalimantan. Such systems can be used to add value to the products produced, leading to more intensive production schemes with less pressure to expand in other areas (Durand and Fournier, 2017).

6.5. Conclusions

The aquacultures in Balikpapan and Berau Regency of East Kalimantan Province and their impacts on mangroves and blue carbon ecosystems were analyzed in this study. Aquaculture farmers are already aware of the various benefits of mangroves, such as fish nursery grounds, prevention of disasters, wildlife habitat, contributing to clean air, and tourism utilization. This provide another insight from the results on Chapter 3, where the coastal communities are particularly unaware on the seagrass ecosystems. In other words, this finding suggest that aquaculture farmers are aware of benefits provided by mangrove ecosystem, which also include the carbon sequestration as part of the blue carbon ecosystems services. As the opportunity costs of conserving coastal ecosystems tend to be high due to increasing population and growing aquaculture, developing bundled ecosystem payments can provide incentives to protect coastal areas (Lau 2013). Balikpapan has the potential for integration of aquaculture and tourism, and Berau Regency, with a focus on fish nurseries, can be an example of focusing on bundled ecosystem services. In addition, we observed in this study that the aquaculture farmers' participation in the mangrove program on transplanting and nursery is also related to their awareness of the importance of the mangrove ecosystem. Both aspect of bundled ecosystem and mangrove-related program give the insight on initiating the community-based management to promote the awareness and utilization of aquaculture sector with the mangrove ecosystems, in particular to forwarding the conservation effort.

CBIB as a guideline is still not commonly understood by farmers, with the tendency of farmers to rely on traditional practices, and the limitations from the local government in terms of manpower

to disseminate and implement the CBIB and support the aquaculture communities in a consistent and continuous manner. Further study is required to explore the lack of knowledge in each area and to determine how central and local governments can collaborate and mainstream their local CBIBs. For the sustainability of a region, a holistic view is necessary to understand its dynamics, and the conditions with collaboration among different sectors, such as monitoring and management practices, are common challenges in municipal biodiversity management (Uchiyama and Kohsaka, 2019). The insight from Chapter 5 on the triangulating framework can be utilized to understand the situation in the region from holistic view, shifting the focus from land-use to the observation on the aquaculture sector. It is also important to introduce legal instruments with certain market mechanisms (such as geographical indications systems) to protect and enhance the value of the products to support sustainable livelihoods, for example in the form of geographical indications. In combination with official training, such market-based instruments can be important for building sustainable communities and for preventing the generation of abandoned ponds and mangrove deforestation.

7. Conclusion and recommendation

The aim of this dissertation was to proposed a holistic approach to tackle the issues in coastal ecosystem by using the framework of blue carbon perception and the focus on community-based management. The case study was conducted in Berau Regency, East Kalimantan Province, Indonesia, focusing on the coastal areas of Tanjung Batu and Derawan Island. To unravel such complexities of the various pressures and threats to the coastal and blue carbon ecosystems, this study utilized the approach of policy analysis on the Indonesia PSP to understand the priorities and awareness of the local government in regards to the acknowledgement of mangrove ecosystems, and exploring the local awareness to understand the utilization rate and perceived threats on the blue carbon ecosystems by local communities. Three dimensions were selected, consisting of issues on land-use change, aquaculture, and the domestic waste management. In each dimension, this dissertation proposed a community-based management to intervene the pressures, with triangulating framework involving locals' perception on land-use change issue, bundled ecosystems service approach for the aquaculture, and MFA scenario of community and tourism contribution to handle the domestic waste management.

7.1. Summary of key findings

In the first part of this study, the overview on the issues and threats looming to the coastal ecosystems, and in particular to the blue carbon ecosystems was discussed. The issues becoming more significant with the trend from previous studies highlighting the concern on Indonesia with prominent number of blue carbon ecosystems, but at the same time there is the indication of decline and degradation for mangrove and seagrass ecosystems due to the various anthropogenic pressures, such as infrastructure development and aquaculture. The idea of community-based management to tackle such threats is presented with findings of the role and importance of the communities' involvement in decision-making, implementation, and the continuity of program to ensure the sustainability of the initiatives as well as forwarding the environment conservation effort. An aspect which can influence the initiative of community-based management is related to the perceptions of the locals to the blue carbon ecosystems.

There are various issues related to the blue carbon and strongly coastal ecosystems in Indonesia, and to narrow down and unravel the complexities, this dissertation proposed the approach of investigating PSP policy on each province in Indonesia and analyze the perceptions of the coastal

communities. Through these two approaches, the pressures and issues will be narrowed down and this study can propose a holistic initiative for every issue with the focus on the involvement of community-based management. The insights from the PSP and perceptions study is presented as follows:

1. Content analysis study using 27 PSP in Indonesia was performed with the findings of 9 clusters identified which discussed and acknowledged the mangrove ecosystems benefit and protection. These clusters consist of *aquaculture, carbon storage, disaster prevention, fish nursery, prohibited activity, reforestation, regulating service, research and education,* and *tourism*. The clusters of *prohibited activity*, *tourism,* and *research and education* were particularly highlighted with 21, 20, and 17 provinces mentioned each of these clusters respectively, while the least discussed clusters consist of *aquaculture, regulating services*, and *carbon storage* with only 7, 5, and 3 provinces mentioned each of these clusters respectively.
2. The findings on PSP study with most of the provinces acknowledged the protection of mangrove ecosystems through the regulation on the *prohibiting activities*, listing the forbidden activities which can harm and degrade mangrove ecosystems, such as logging, development, damaging, decreasing, polluting, and converting mangrove ecosystems. This result gives the insight on the issue of land-use in particular to the conversion of mangrove is a prominent one in Indonesia, hence the dimension of land-use will be included to be discussed in this dissertation.
3. The next prominent highlight is related with the *tourism* sector which is acknowledged as potential utilization, and the other concerning dimension from *aquaculture* which can be conflicting with the existence of mangrove ecosystems. Both of these dimensions (*tourism* and *aquaculture*) is also be selected to be discussed in this presentation, with the argument of *tourism* and *aquaculture* can generates pressure to the coastal and blue carbon ecosystems, in particular with how the government acknowledged the potential which can be conflicting or degrading the environments if not managed in proper and sustainable manner.
4. Looking at the blue carbon perceptions of the communities in Berau Regency, the resource utilization for seagrass ecosystems is still relatively low, with 69.49% respondents never utilized seagrass for provisioning services, and only 11.86% utilized it in weekly period

manner. The utilization rate for tourism and education is also not much different, with no utilization by 72.41% and 84.48% of total respondents respectively, with indication of preference to utilize coral reefs for tourism sector. Nonetheless, from the annual time span, the utilization rate is higher with 15.52% for tourism, and 12.07% for research and education, showing the rare case of utilization, for example the visit from local university to conduct research in seagrass ecosystems while involving the local communities.

5. For the awareness on the seagrass ecosystem services, the results were quite varied, but in general the majority of the ecosystem services were not known to the locals. For example, the role of seagrass as a nursery and marine habitat with total of 38.98% and 35.59% of respondents were not aware, and the role of supporting the environment such as carbon sequestration and clean ground water services were even lower, with 66.69% and 70.69% of respondents were not aware of such services from seagrass ecosystems. Despite the lower overall awareness, there were several services that being perceived, for example the role of seagrass to protect coastal areas (23.73% respondents fully aware) and the role as a recreational or educational site (27.12% respondents fully aware).
6. The regression analysis was performed in the perception study to understand the relationship between sociodemographic profile, resource utilization, and participation profiles with the awareness of ecosystem services. The results showed that government employees have high awareness of the various seagrass ecosystem services, for example in the understanding o seagrass as natural buffer to coastal erosion (0.005, p-value < 0.01), as well as the blue carbon role of seagrass via carbon sequestration (0.007, p-value < 0.01). Aside government employees, the perception study showed the association of fisherman group for higher utilization rate of seagrass ecosystems, in particular with the provisioning services, such as catching fish for consumption (0.384, p-value < 0.01), and catching crabs and shrimp to be sold (0.436, p-value 0.001) in the seagrass areas.
7. Results from the perception of threats to mangrove and seagrass ecosystems support the idea to narrow down the threats that will be tackle in this dissertation, with the threat of mangrove cutting as the highest (45.61% respondents chose as the highest threat), and for seagrass ecosystem the number one threat chosen by respondents is the pollution from domestic wastes (33.33% respondents chose as the highest threat). Thus, supporting the

findings from the PSP studies, three challenges were selected in this study will be focused on the land-use change, aquaculture, and waste management.

Moving on to tackle the issue of land-use change, this dissertation proposed the concept of triangulating framework which utilized the three approaches of perception interviews, LULC maps, and policy map. Through the utilization of these three different datasets, the idea is to understand the holistic structure between the social phenomenon of the locals' perception, focusing on how the communities perceived and understand the change in the land-use and the identified cause, complemented with the reality of the LULC from remote sensing as well as the future implementation from the government sector in the form of spatial plans policy. The major findings on this study is presented as follows:

1. In the setting of Tanjung Batu and Derawan Island, the locals perceived the change of the land-use associated with the drivers from infrastructure, settlement, tourism, and abrasion (Derawan Island only). In Tanjung Batu case, infrastructure was the most mentioned as the drivers of land-use change (59.56%, 246 times mentioned), followed by the settlement (32.2%, 133 times mentioned), and tourism in least frequency (8.23%, 34 times mentioned). Meanwhile for Derawan Island case, the similar trend can also be seen with infrastructure and abrasion as the highest percentage of 31.55% (53 times mentioned) for both infrastructure and abrasion, followed by the settlement development (28.57%, 48 times mentioned), and tourism development (8.33%, 14 times).
2. Looking at the comparison between perception interviews, LULC maps, and policy map, the triangulating framework illustrate each intersection of the datasets, with the three intersection consists of *socio-ecological intersection* (local perceptions and LULC maps), *environmental impact of policy* (policy map and LULC maps), and *social impact of policy* (policy map and local perceptions). Through these intersections, the complementing results and identified gaps were illustrated to better understand the situation in both study sites.
3. For the *socio-ecological intersection*, the complementing aspects between the local perceptions and LULC maps were found on how the perceptions provide another layer of information in the form of the drivers and causes of the land-use change explained by the respondents. For example, the settlement growth in Tanjung Batu case explain the changes in the LULC maps, as well as the case in Derawan Island where the impact of

environmental change was also perceived by the local communities with the highlight on the abrasion phenomenon pointed by the respondents. However, the perceived drivers and the changes in LULC maps is also the potential for the identified gaps, hence the perceived drivers should be treated as initial understanding which needs to be further clarified and verified to fully understand the factor of the changes of the LULC. For the *environmental impact of policy* between the policy map and LULC maps, there is the complementing aspect on how the LULC maps can serve the role as a basis for policy formulation with the LULC maps illustrate the blue carbon ecosystems distribution which can be used as the basis for the policy. However, there were gaps in understanding phenomenon such as the duality of function between residential building and tourism service (Derawan Island case), as well as the discrepancy on the assigned ecosystem in the spatial plan, where the observed mangrove ecosystem in LULC was categorized as seagrass in policy map, which might trigger a mismanagement in the future. In the last intersection of the *social impact of policy* (policy map and local perceptions), there is the insight on how the perception can be another input and assessment tool for the policy implementation, for example in the tourism sector (Derawan Island), nonetheless, solely relying on perceptions won't be able to understand the threat that were not captured by the perceptions, for example the plantation expansion (Tanjung Batu), thus becoming the gaps for this intersection.

4. Through the approach of triangulating framework, the initiatives which involved the local communities can be started. One example is the local perceptions to assess the and perceived the land-use change can be a form of community-based managements on the monitoring of blue carbon ecosystems.

The challenges intervene in this study is the issue of aquaculture and the coexistence with mangrove ecosystems. Aquaculture sector expansion has bee reported as major driver of mangrove deforestations, and in Indonesia this issue can lead into the potential carbon emission from the mangrove conversion as a suitable place for fishpond. Local awareness regarding mangrove ecosystem services were investigated in this study to identify how the locals perceived the potential utilization benefits, and the association with the participation in the existing mangrove conservation program in the region. In addition, one of the issues in Indonesia's aquaculture sector is related with the low productivity and abandoned aquaculture phenomenon, associated with the

unsustainable practices by the farmers. The CBIB guidelines enacted by the government is another aspect investigated in this study, the major findings are presented as follows:

1. The results from chi-square tests showed that out of the 14 mangroves ecosystem services, there is the correlation between the aquaculture farmers who participated in the mangrove-related program (mangrove transplantation and/or mangrove nursery). The results in particular can be seen in the awareness of *fish nursery*, *food*, *medicine*, *tourism*/*education*, *aquaculture*, and *alternative livelihood* with the *p*-value of 0.0016, 0.0001, 0.0001, 0.0075, 0.0002, and 0.009 respectively with all of these awareness were statistically significant (p-value < 0.01), showing that the participation of the farmers in the mangrove programs can be associated with the higher awareness compared with the farmers who were not participating. From total of 73 respondents in Balikpapan and Berau Regency, 39 farmers have at least participated in one type of program, 9 farmers participated in both type of program (mangrove transplantation and/or mangrove nursery), and 25 farmers never participated. This gives the insights on the importance of conducting such programs, in particular with community-based management approach, with the communities, supported by the government, facilitates the widespread of mangrove conservation initiatives which can serves to provide the transfer of knowledge and awareness in regards to the understanding of the various mangrove's ecosystem services.
2. Looking at the aspect of CBIB guidelines, the chi-square tests showed interesting results with the farmers who did not understand the CBIB tends to perceived that *food safety* is the important aspect of sustainable aquaculture practices, while aquaculture farmers who claimed to have the knowledge of CBIB guidelines tend to associate the sustainable aquaculture practices with the aspect of *utilization of feed*. Nonetheless, the CBIB guidelines in general is not widely understood by famers.
3. Through the observation during the survey, particular note was taken with the differences of utilization in Balikpapan, which focusing on the integration with tourism to support the aquaculture activities, while in Berau Regency, the focus is more towards the integration with mangrove ecosystems. Aquaculture farmers have the awareness on variety of mangrove's ecosystems services, and developing community-based management with focus on bundled ecosystem services (i.e. aquaculture-tourism, aquaculture-fish nursery) give the insight on initiating community-based management to promote the awareness and

utilization of aquaculture sector with the mangrove ecosystems and forwarding the conservation effort.

The last challenges discussed in this dissertation is related with the issue of domestic waste in the context of small island and pressure from tourism sector. The perceptions of the locals were collected to investigate how they perceive the impact of tourism to the environment, as well as formulating the scenarios of waste management in Derawan Island using MFA. The key findings are shown as follows:

1. The locals perceived that tourism will give positive impact in overall to the Derawan Island environment, with items o *availability and stocks of fish, shellfish, and other seafoods* (*M* = 0.5), *condition of beaches* (*M* = 0.23), *conditions of coral reefs* (*M* = 0.17), *conditions of seagrass ecosystems* (*M* = 0.08), and *availability of fresh water* (*M* = 0.38). However, two particular items were highlighted which were perceived by the respondents to be negatively impacted due to the tourism industry, these two items are *conditions of domestic waste management* (*M* = -0.71), and *conditions of sewage system* (*M* = -0.42) which highlights the concern of the locals especially for the future waste management of Derawan Island.
2. Three MFA scenarios were formulated using the secondary database and processed with STAN software. For the (a) *current situation* scenario, the forecast result in 2025 showed that the current waste treatment system won't be able to treat 100% of the waste, and estimated of 292.03 kg/day of waste will be accumulated. The second scenario of (b) *community initiative* showed the potential of waste treatment in Derawan Island through waste recovery and composting in addition of the potential benefits received from the community management of the waste (i.e. composting, waste bank). This scenario also showed that the current waste removal frequency (3 times per week) can support the 100% waste removal, complemented by the communities' initiative. For the third scenario of (c) *tourism contribution*, the general idea is limiting the community initiative only for the waste recovery, and the remaining of waste will be removed from the island. To achieve the 100% waste treated, the number of frequency removal via boat in this scenario should be increased from three times per week (857.14 kg/day) into four times per week (1,142.86 kg/day), and the additional operation cost will be supported by the tourism sector.

3. Looking at the perspective of the cost comparison between the three scenarios revealed that for the scenario (a) the total operation cost of 1,662 USD/month for the three removal a week will be mostly allocated from the village budget (1,573.76 USD/month) and the waste management fee from households and small hotels (88.24 USD/month). For the scenario (b), the benefits from community-based managements can potentially cover 100% of the village budget with details of retribution contributes 88.24 USD/month, compost sale contributes of 665.1 USD/month, and waste bank contributes of 980 USD/month. The village budget that was not used can be allocated for public benefits (i.e. infrastructure maintenance). The scenario (c) dismissed the benefits from compost, and instead this study calculated the costs that should be covered by tourism sector to support the waste management operational cost. The results showed that tourism contribution should contributes of 1,147 USD/month to achieve no fee used from village budget. In smaller scale, this means that each tourist visiting Derawan Island can be charged the entry fee of 0.3 USD/tourist.

7.2. Limitations of the study and recommendations for future studies

The dissertation aimed to promote the utilization of locals' perception as integral part of the holistic community-based managements for blue carbon ecosystems, tackling the various challenges existed in the coastal ecosystems. However, there are limitations and lessons learned from this study.

1. The content analysis study was done using the only the PSP, thus limiting the scope. Investigation on other policy such as RZWP3K and comparison with the state of physical resources need to be done in future studies to fully understand not only in the policy-level, but in the implementation and current situation as well.
2. The blue carbon perceptions study in the Chapter 3 is limited in terms of the respondents interviewed. Future study should consider to upscale the studies, and incorporate wider area to capture the overall interactions of not only the blue carbon ecosystems, but other ecosystems such as river basins and small islands. The widened scope can better reflect the perceptions of wider coastal communities and provide a more holistic examination on the proposal of community-based management for conservation effort.

3. The triangulating framework in this study was done with heavy focus on the qualitative study with the comparison of the three datasets. Future studies should consider the integration of the quantitative approach to calculate the areal change in the LULC and policy maps. In addition, the identified drivers of the land-use change from locals' perception should not only be the sole reliance on the input data for the triangulating framework, rather future study may consider to expand the perceived input to clarify and verify, giving a better and interesting take on how accurate the perception of the locals to support the land-use studies.
4. Study on the integration of mangrove and aquaculture is only limited in terms of perception, and actual practice and operation of the fishpond farmers were not included in the understanding of the bundled ecosystems services implementation. Understanding the technicalities issues such as fishpond disease and silvofishery is recommended.
5. The MFA study has illustrated the results on improving the waste management in Derawan Island, however, the scenario is heavily relied on secondary and proxy data, thus future studies should consider to collect primary data on the waste generation in the island. In addition of investigating the market and possibilities of the community-initiatives to provide feasibility results on the composting and waste recycling.
6. The study has proposed the overall initiatives to tackle the various coastal ecosystems issues, based on the perception of blue carbon ecosystems. However, the findings were more leaned on the conceptual for future implementation. Understanding the implementation of community-based management initiatives to tackle the blue carbon ecosystem issues is recommended in particular on the sustainability and feasibility of such initiatives made from the community, and supporting factors needed.

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