

The Study of Socio-Economic Conditions of Local Communities towards Supporting Mangrove Restoration in Mahakam Delta, Indonesia

ヘル, スシロ

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Indonesia**

Heru Susilo
Kyushu University
2018



**The Study of Socio-Economic Conditions of
Local Communities towards Supporting
Mangrove Restoration in Mahakam Delta,
Indonesia**

By
Heru Susilo

A Dissertation Submitted to Kyushu University in Partial Fulfillment
of the Requirements for the Degree of

**DOCTOR OF PHILOSOPHY (Ph.D.)
IN AGRICULTURAL SCIENCE**
Department of Agricultural & Resource Economics

Supervised by:

Professor Dr. Mitsuyasu **YABE**
Associate Professor Dr. Yoshifumi **TAKAHASHI**
Assistant Professor Dr. Goshi **SATO**

Faculty of Agriculture
Graduate School of Bioresource and Bioenvironmental Sciences
KYUSHU UNIVERSITY
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Abstract

Worldwide, loss of mangrove forests is a cause for concern. Between 1980 and 2005, total global mangrove forests have decreased by approximately 20%. Over the last 25 years, mangrove forests have been reduced from 18.80 million hectares to under 15.20 million hectares and Indonesia is one of the countries with the fastest decline in the world. Some 1.30 million hectares or about 30.95% of mangrove forests have been lost from 1980 to 2005 or during the last 25 years. Indonesian mangrove forests account for 3,112,989 hectares or 22.6% of the global total. Indonesia has the enormous variety of species worldwide, accounting for 45 out of the 75 species.

Mangrove forests provide ecological and economic services for humans including protecting the area from tidal waves and erosion and offering carbon sequestration. They also provide nursery grounds for aquatic organisms that use them as food and are a source of community livelihoods. In many regions of Indonesia, the degradation of mangrove forests has primarily occurred due to population pressure and urbanization. Moreover, conversion of these areas into coastal aquaculture is the driving factor threatening mangroves. These problems are the result of mangroves having frequently been undervalued and considered as wastelands and unhealthy habitat. These characteristics provide the limitations of the potential for private incentives to manage sustainable mangrove services, and lack of markets for such services causes failure of the market for these services. As a result, mangrove forests are threatened and degraded. Mangroves are widely undervalued in both private and public decision-making relating to cost-benefit analyses of conservation and restoration versus other commercial land uses.

This study aims to provide an insight into how to determine the value of mangrove forest restoration by estimating communities' willingness to pay (WTP) and to labor and to compare the benefits and costs associated with a restoration investment project. This study also evaluates the impact of the silvofishery system on farmers' income. Using the contingent valuation method (CVM) through a double-bounded dichotomous choice format, the findings show that occupation, planting seedlings, responsibility, and nursery variables are statistically significant on WTP for mangrove restoration. The mean WTP of the respondents is estimated to be IDR 35,201 (model of all variables) and IDR 35,413 (model of only statistically significant variables). The opportunity cost of labor for mangrove restoration is applied to overcome the limitations of money as a payment vehicle in contingent valuation in developing countries. Results reveal that the opportunity cost of time is valued at IDR 398.76 thousand (US\$29.99) per month or IDR 4.79 million (US\$359.90) per year. A total annual benefit of mangrove restoration using the monetary contribution of labor (MCL) is IDR 143 billion (US\$10.77 million) per year. Using environmental cost-benefit analysis (ECBA), mangrove restoration projects reveals valuable benefits for sustainability of local livelihoods by Net Present Value (NPV), which is valued at IDR 250.15 million (US\$18.81 thousand) (WTP estimated) and IDR 4,372.63 million (US\$328.87 thousand) for willingness to contribute labor (WTCL) estimated, in a five-year project. Benefit-Cost Ratio (BCR) values are between 3.39 (WTP) and 42.79

(WTCL), respectively. Internal Rate of Return (IRR) values reach between 37.97% (WTP) and 135.78% (WTCL), respectively. Furthermore, propensity score matching (PSM) is applied to estimate the causal effect of the adoption of the silvofishery system on farmers' income. The findings reveal that in the first step of the model, logit estimation results show that socioeconomic characteristics, social capital, and the perception of the current condition and benefits of mangroves are significantly associated with the likelihood of silvofishery adoption. The average treatment effect (ATT) displays a positive impact of silvofishery on farmers' annual income per hectare, implying adoption of the system has increased the yearly earnings to between IDR 1.04 million (US\$78.22) per hectare and IDR 1.10 million (US\$82.73) per hectare.

The findings of this study can support decision-makers with relevant information for assessing a mangrove restoration project. Policy-makers should focus on considering knowledge and responsibility to protect and manage a sustainable mangrove forest. Furthermore, information on the benefits and economic values of mangrove services should be regularly disseminated through education and communication programs to enhance awareness of the sustainability of mangrove services. In addition, the importance of mangrove forests and the application of the silvofishery system should frequently be communicated by agencies involved to increase awareness, demonstrate the effectiveness of silvofishery, and gain farmers' trust in the program.

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Chapter 1
Introduction

1.1. Background on The Global Mangrove Ecosystems

Mangroves grow in the intertidal zones between land and sea in the tropical and the sub-tropics in the world. They are distributed on between about 30° north and 30° south latitude (Giri et al., 2011). The mangrove ecosystem is a mix of terrestrial and marine communities. This ecosystem is influenced by a daily input of water from the sea. Also, they receive freshwater and accept some sediments, nutrients and silt deposits that come from upland rivers. Mangroves are also found as trees or shrubs depending on topography, the climate and the water salinity of the area in which they originated (FAO, 2007). Regarding the classification, there are 16 families and about 40 to 50 species of mangroves. Tomlinson (1986) have made several criteria to classify for a species to be labeled a “true or strict mangrove”. The requirements include 1) complete allegiance to the mangrove environment; 2) As a primary role in the community structure and can design pure stands; 3) morphological and physiological specializations for their habitat adaptation; and 5) isolation of taxonomic from terrestrial relatives.

Mangroves produce ecological and economic services for humans. For instance, they protect the area from tidal waves and erosion (Everald et al.,2014), improve water quality and control sediment (Giri et al., 2011). Mangroves also act as habitats and nurseries for fish, shrimp, and crab (Kairo et al., 2009) and are sources of ecotourism (Vo et al., 2014). Furthermore, mangroves provide approximately US\$1.6 billion per year in ecosystem benefits worldwide, thus supporting the economy in coastal areas (Costanza et al., 1997; Polidoro et al., 2010).

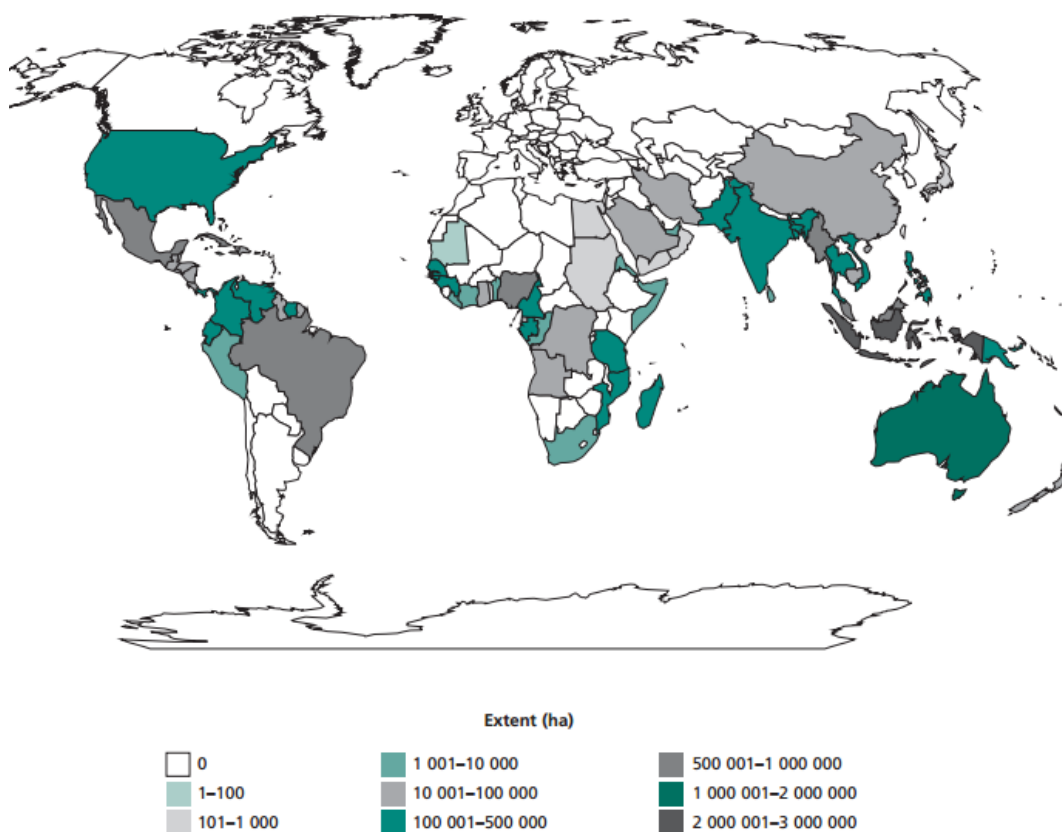


Figure 1.1. Mangroves distribution worldwide in 2005

Source: The Food and Agriculture Organization (FAO 2007)

Mangroves are found in 124 countries and territories, covering a global area of 15.2 million hectares as can be seen from Figure 1.1. For the region, Asia is the most extensive mangrove area in 2005, with 5.86 million hectares or 38.46% of the global total of mangroves. Africa is the second largest, with 3.16 million hectares (20.75%), followed by North and Central America (14.86%), South America (12.99%) and Oceania (12.95%). The extent of mangrove area by region in 2005 can be seen in Table 1.1.

Table 1.1 The extent of mangrove area by region in 2005

No	Region	Area (million hectares)	Percentage (%)
1	Asia	5.86	38.46
2	Africa	3.16	20.75
3	North and Central America	2.26	14.86
4	South America	1.98	12.99
5	Oceania	1.97	12.95
	World	15.23	100.00

Source: The Food and Agriculture Organization (FAO 2007)

1.2. Indonesia Mangrove Ecosystems

Global mangroves, which according to Giri et al., (2011), is dominated by 15 countries, where about 75.3% of global total derived from these countries (Table 2.1). Indonesia, Australia, Brazil, Mexico, Nigeria, and Malaysia are six countries that together account for 50.5 percent of the total global area, and 24,8 percent of the entire mangrove area is spread over nine countries, of which they have more than 250 thousand ha of mangroves each. Besides, Indonesian mangroves are the most significant mangrove area in the world with 3,112,989 hectares or 22.6% of the global total of mangroves. Indonesia has the enormous variety of species worldwide, accounting for 45 out of the 75 species.

Table 1.2 The 15 largest mangrove countries and their global contribution percentages

No	Country	Area (ha)	Percentage of global total (%)
1	Indonesia	3,112,989	22.6
2	Australia	977,975	7.1
3	Brazil	962,683	7.0
4	Mexico	741,917	5.4
5	Nigeria	653,669	4.7
6	Malaysia	505,386	3.7
7	Myanmar	494,584	3.6
8	Papua New Guinea	480,121	3.5
9	Bangladesh	436,570	3.2
10	Cuba	421,538	3.1
11	India	368,276	2.7
12	Guinea Bissau	338,652	2.5
13	Mozambique	318,851	2.3
14	Madagascar	278,078	2.0
15	Philippines	263,137	1.9

Source: Giri et al., (2011)

In contrast to mangrove data from Giri et al., (2011), Indonesia mangroves, which according to Bakosurtanal (2009) cover approximately 3,247,016 hectares and spread over seven regions. Papua mangroves are the most extensive area in Indonesia with 1,634,003 hectares or 50.32% of the Indonesia total of mangroves (Figure 1.2). The second largest is Kalimantan with 638,283 hectares (19.66%), followed by Sumatera with 576,956 hectares (17.77%), Maluku with 178,751 hectares (5.51%), and Sulawesi with 150,017 hectares (4.62%). The remaining 2.12 percent is spread over two regions covering Bali Nusra and Java with 34,524 hectares (1.06%) and 34,482 hectares (1.06%) respectively.

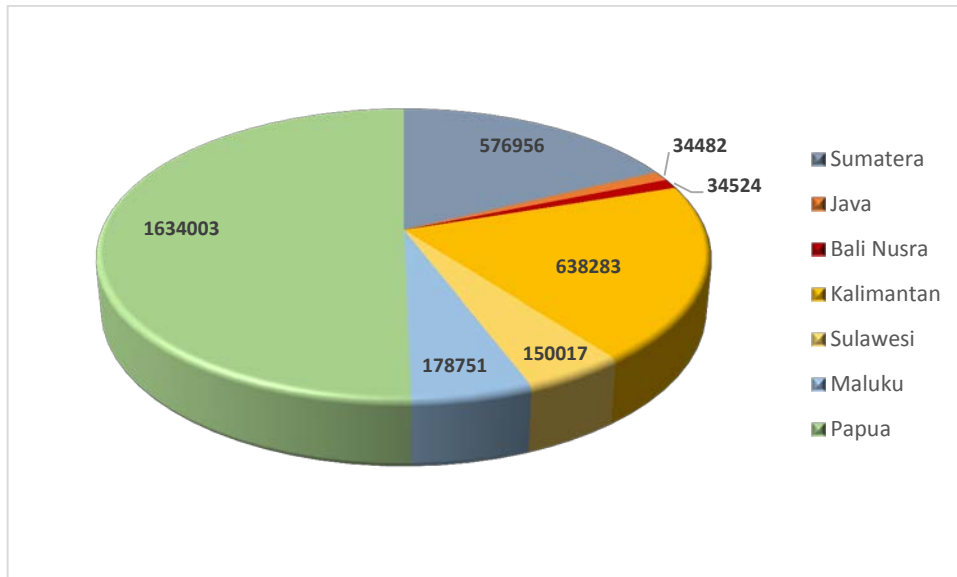


Figure 1.2 Indonesia mangroves in 2009 by regions

Source: National Coordinator for Survey and Mapping Agency, Indonesia (Bakosurtanal 2009)

Mangroves play a crucial role in the coastal communities' livelihoods of Indonesia, especially for farmers and fishers. They provide the nursery ground for aquatic organisms which use as food and a source of community livelihoods. Ecological functions of mangroves can be seen on a report of Ministry of Marine Affairs and Fisheries Republic of Indonesia in 2009 that showed shrimp exports of Indonesia reached US\$ 1 billion per annual. Moreover, Indonesia mangroves provide another indirect benefit from carbon sequestration and are the most significant mitigation potential in any country. Alongi and Mukhopadhyay (2015) reported that mangrove ecosystems and seagrass spread out Indonesia reserved about 3.4 billion metric tons of carbon (Figure 1.3). It is efficiently supplying the Blue Carbon of Indonesia potential a large global carbon sink. Furthermore, Mangroves supply direct benefits from their timber for constructions, medicines, and energy. Statistic Indonesia in 2009 reported that timber concession company

activities operating in mangrove forests produced approximately 50 thousand to 300 thousand cubic meters annually of mangrove logs. It does not include the community' operation living around the mangrove area who exploit timber from mangroves for charcoal and construction.

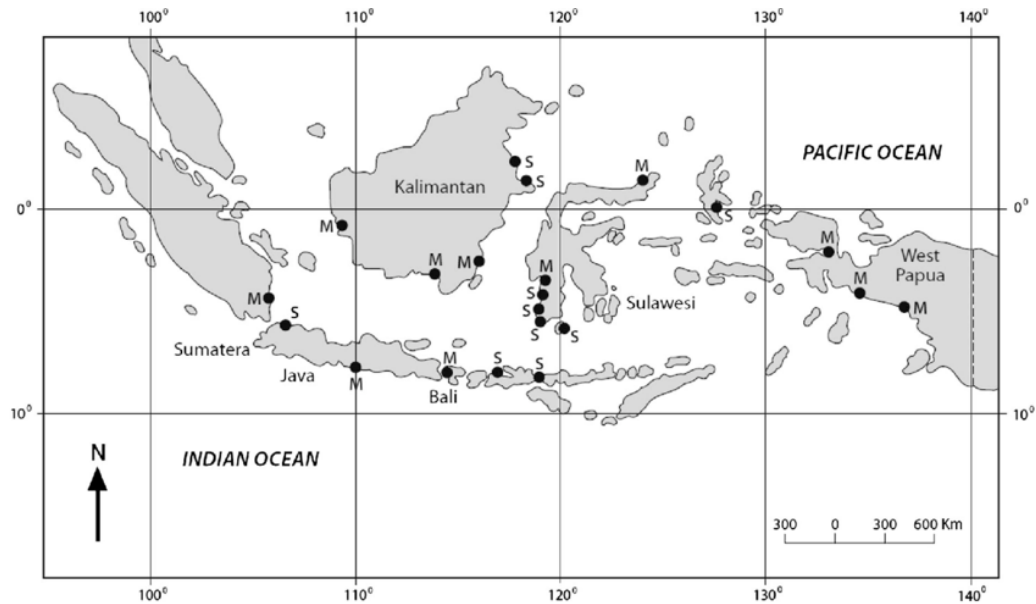


Figure 1.3 Indonesia's mangroves (M) and seagrass meadows (S) distribution

Source: Alongi and Mukhopadhyay (2015)

1.3. Problem Statement

Worldwide, Mangrove loss is alarming. According to FAO (2007), approximately 20% of global mangroves areas decreased between 1980 and 2005. Over the last 25 years, 18.80 million hectares of global mangroves fell to under 15.20 million hectares. Mangroves Indonesia has also suffered the same fate. Indonesia is one of the countries with the fastest decline of mangroves in the

world. In this country, some 1.30 million hectares of mangroves or about 30.95% have been lost from 1980 to 2005 or during the last 25 years (FAO, 2007).

In many regions of Indonesia, the degradation of mangrove areas occurred primarily because of population pressure and urbanization. Moreover, conversion of mangrove areas into coastal aquaculture is the driving factors threatening mangroves. These problems as a result of mangroves have frequently been undervalued and considered as wastelands and also unhealthy habitat. Many natural ecosystem benefits, including mangroves' benefits, have the characteristics of pure public goods, which mean that people can receive the benefit they provide without reducing the level of service received by another beneficiary (e.g., coastal protection, beautiful views, and carbon sequestration). Also, mangroves act as quasi-public goods when the benefit of services by the recipient at a particular level of use does reduce the degree of assistance obtained by others (e.g., feeding and nursery services for fisheries). These characteristics provide the limitations of potential for private incentives to manage sustainable mangroves services, and lack of markets for such services causes market failure on mangrove ecosystems services (Brander et al., 2012). As a result, mangroves are threatened and degraded. Mangroves, moreover, are widely undervalued in both private and public decision-making relating to benefit-cost analyses of conservation and restoration versus other commercial land uses (Salem and Mercer, 2012). Therefore, information on the economic value and accurate estimation for mangrove services as natural capital are necessary for making the best choices relating to conservation and restoration of mangroves.

Enhancing awareness and knowledge of coastal communities on the value of mangrove restoration as well as salvage coastal community's livelihoods is essential to increase the renewed attempts to preserve and restore the ecosystem of mangroves. Moreover, apparent efforts have been addressed toward the design and implementation of recovery management strategies for mangrove ecosystems in Indonesia. Integrated mangrove-shrimp farming, also called as silvofishery, is one of the concepts that have already been promoted by the government which attempts to combine the economic needs of coastal communities and conserving mangrove resources as a win-win situation. However, this system still has not accepted a favorable response from local communities especially farmers related lack of education, behavior that even comfortable with extensive aquaculture system, and unbelief that the new system will increase the income. There is a disparity in information and knowledge related to what extent the silvofishery can improve the welfare of small-scale fish farmers and why this system is still marginal. Therefore, appraisal of the feasibility of the new adoption regarding the income of farmers is required.

1.4. Objective of Study

Based on the problem statement, the primary objectives of this study are to analyze the economic value of mangrove functions and feasibility of mangrove restoration program and to evaluate the impact of the silvofishery system as one of Indonesian mangrove restoration program on farmers' income, which can be breakdown into four specific objectives.

- 1) To determine the local communities' willingness to pay (WTP) and its determinants in mangrove restoration.
- 2) To measure the local communities' willingness to contribute labor (WTCL) and its determinants in mangrove restoration.
- 3) Evaluate an economically viable mangrove restoration program, and investigate the uncertainty of the project against the change of the economic situation in the future for decision making.
- 4) To evaluate the impact of silvofishery adoption on farmer's income and its determinants in adoption.

1.5. Thesis Structure

The thesis contains seven chapters (Figure 1.4). **Chapter 1** consists of the background on global and Indonesia of mangrove ecosystems. This chapter also presents the problem statement, objective of study, and structure of the thesis. **Chapter 2** introduces the information of the Mahakam Delta as the study area. The information explains the population, people's livelihoods, land use change and current mangrove condition. Furthermore, Chapter 3, 4, 5 represent the first objective and chapter 6 for the second objective. The detail of each chapter can be listed as follows:

Chapter 3 discusses the value of mangrove restoration by estimating communities' willingness to pay using the contingent valuation method (CVM). Based on the most of the ecosystem services derived from mangroves provide indirect value and do not indicate marketed resources. Thus, identifying the value

of mangrove service functions is difficult. Therefore, this study used the CVM to deal with this problem.

The previous chapter used the money as a payment vehicle in contingent valuation (CV) to measure the willingness to pay (WTP) of mangrove restoration in the Mahakam Delta. In **chapter 4**, the study also determines communities' willingness to pay for mangrove restoration using the contingent valuation method (CVM) by another payment vehicle. In developing countries including Indonesia, the application of money as a payment vehicle in CV becomes limited, especially for low-income people who cannot contribute any part of their income for public activities. As an alternative measure in CV, therefore, non-monetary payment in the form of labor contribution is used in the study area. As a payment vehicle for CV studies, the theoretical framework of using time is utilized based on the concept of time compensating surplus comparable with a compensating surplus measure of monetary WTP. The findings are supposed to provide the estimation of the value of proper mangrove restoration and contribute to decision makers in the planning of mangroves restoration actions.

The lack of information on the economic value of mangrove services has led to neglect in decision making, and the ecological benefits of mangrove as natural capital tend to be rejected when compared directly with the economic value of other public investments. As a result, mangroves converted into the instantly profitable venture such as aquaculture, and coastal industries. Relating to the problem of information in understanding the adequately economic value of mangrove services, **chapter 5** discusses the application of Environmental Cost-Benefit Analysis (ECBA) to compare the benefits and costs associated with a

mangrove restoration investment project. In this chapter, the study estimates the benefits of ECBA by estimating communities' willingness to pay by money (chapter 3) and labor contribution (chapter 4) as a payment vehicle. Results of the CBA provide crucial information for policymakers implementing the estimation of mangrove ecosystems values and to achieve the sustainable use of mangroves in the study area.

Furthermore, **Chapter 6** focuses on silvofishery system adoption as one of Indonesian mangrove restoration program and its impact toward the income of small-scale farmers. This chapter also discusses the primary driving factors that affect farmers' approval of the silvofishery scheme. Results provide useful insights for countries, especially developing countries to overcome the conflict between the livelihoods of local communities and ecology conservation. Also, the study contributes to the literature on the impact of adoption of the silvofishery farming system on small-scale farmer welfare in the Mahakam Delta.

Lastly, **Chapter 7** summarizes the conclusions drawn from this research and presents the policy recommendations for sustainability mangroves management.

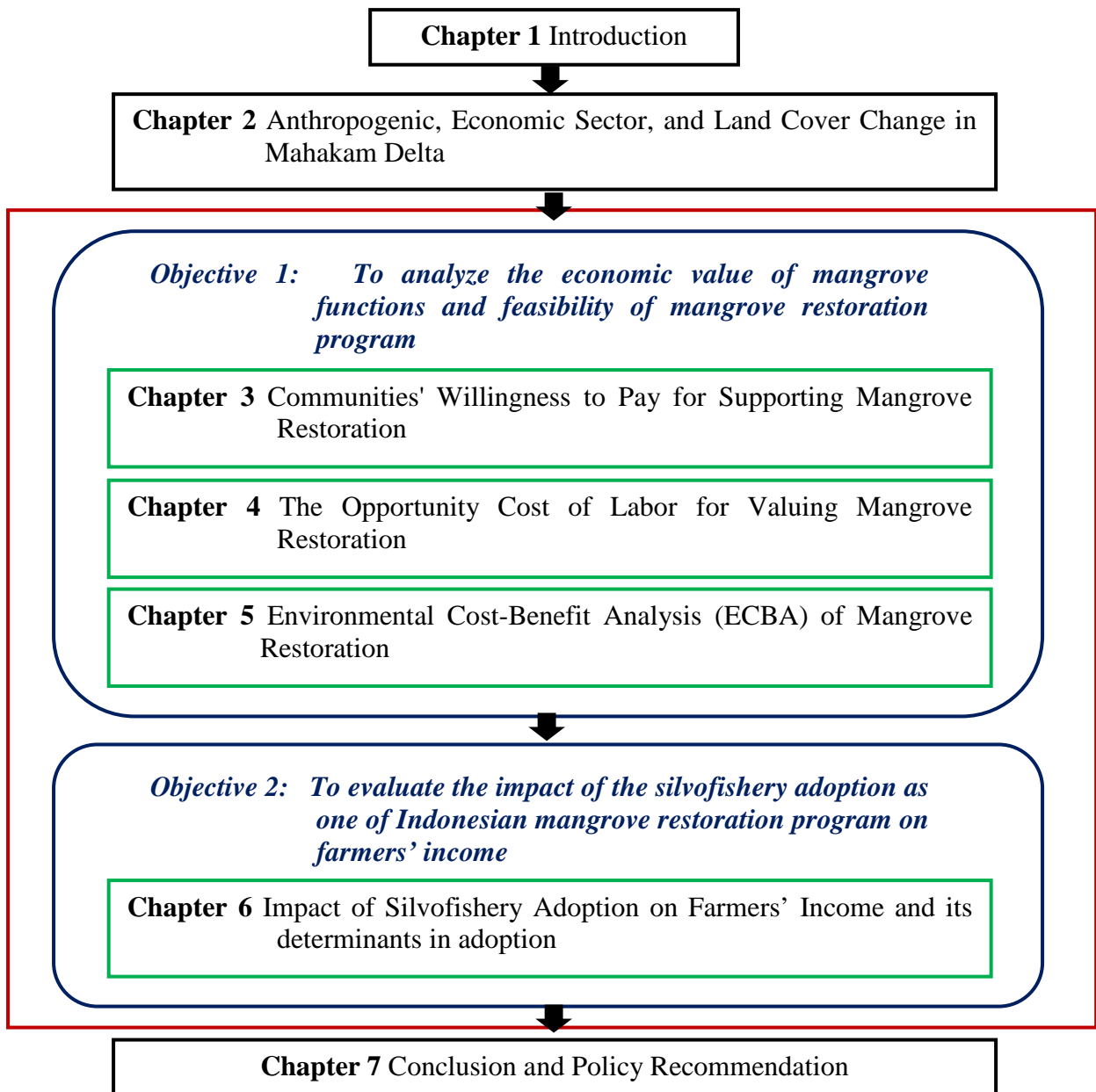


Figure 1.4 Structure of thesis

Chapter 2

Anthropogenic, Economic Sector, and Land Cover Change in Mahakam Delta

2.1 Introduction

The Mahakam Delta is situated on the eastern coast of Kalimantan Island between $0^{\circ}19'-0^{\circ}55'$ S and $117^{\circ}15'-117^{\circ}40'$ E. This delta is situated at the mouth of the Mahakam River. This river is the second longest river in Indonesia with a length of 980 km and has an estimated catchment area of around 77.8 thousand km^2 . The watershed area (DAS) Mahakam is 98,194 km^2 . The Mahakam Delta has river channels with canal depths between 5 to 17 meters, which were formed radially with a width of between 300 to 600 meters. In the oil industry, these canals are known as "distributary channels" with a length of 42 km. The tributaries formed in the Mahakam Delta are a result of from the flow of seawater during tidal that cutting parts of the edge delta and edge of canals.

The Mahakam Delta covers 5200 km^2 consisting of 1500 km^2 of delta plain, 1000 km^2 of the delta front, and 2700 km^2 of pro-delta. This delta is geologically divided into three parts, namely delta plain, delta fronts, and pro-delta. Delta plain is a delta that is almost entirely muddy and swampy. The area that located at the mouth of the river is called the upper delta plain, while another area that towards to sea represents the lower delta plain. Furthermore, delta front is the deltaic fringe influenced tidal and sandy. It is also a dominant region for sediment deposition. Lastly, pro-delta is the more in-depth area and is inundated by seawater adjacent to the Makasar Strait.

The deposition of suspended solids has formed the delta, including 46 small islands that have been shaped over time as the result of sediment (Sidik, 2009; Persoon and Simarmata, 2014; Allen and Chambers, 1998). The Mahakam delta has one of the highest levels of biodiversity in Indonesia, including more than 260

bird species, 86 freshwater fish, and 86 plants. The delta contains 20 true mangrove species from at least seven families. Creole (1999) reported that nipa palm (*Nypa fruticans*), covering 60,000 hectares, grows throughout the Mahakam Delta, which is one of the most widely distributed mangrove species worldwide. The proboscis monkey (*Nasalis larvatus*), which is endemic to East Kalimantan, also occurs in this area.

Mangrove vegetation types in the Mahakam Delta can be identified based on several zones (Sidik, 2009; Prihatini, 2003). Firstly, the pedada zone located adjacent to the delta front is an area dominated by vegetation of pedada (*Sonneratia alba*) and api-api (*Avicennia sp.*). The bakau zone is an area of *Rhizophora* vegetation that is found mainly in the lower delta area and tunu and selete small islands. Thirdly, the transition zone is a varied area that has various mangrove species, such as pedada (*Sonneratia caseolaris*), bakau (*Rhizophora sp.*), api-api (*Avicennia sp.*), nyirih (*Xylocarpus granatum*), tancang (*Bruguiera sp.*), and nipa (*Nypa fruticans*). Fourth, nipa zone is an area located at central of delta and entirely affected by freshwater from the Mahakam River. Lastly, the nibung zone is a zone located the upper area of the delta and has mangrove species such as dungun (*Heritiera littoralis*), nibung (*Oncosperma sp.*), buta-butua (*Excoecaria agallocha*), and mata buaya (*Bruguiera sexangula*).

Besides having high biodiversity, the Mahakam Delta also has diverse natural resource base for oil and gas. Oil and gas exploration and exploitation have been conducting since the mid-seventies and mostly held in the delta and off-shore. Three multinational companies that operated in this delta, namely Total E&P Indonesia (occupying at the most significant part of the delta), Vico

Indonesia Co., and Chevron Indonesia Co. According reported from DKP (2007), Total E&P Indonesia exploited the oil and gas daily with 70,000 barrels of oil and 200 thousand barrel, respectively.

Administratively; Mahakam Delta includes on Kutai Kartanegara District, East Kalimantan Province, Indonesia. There are five sub-districts involved in the Mahakam Delta, namely Muara Badak, Anggana, Muara Jawa, Sanga-Sanga, and Samboja (Figure 2.1)

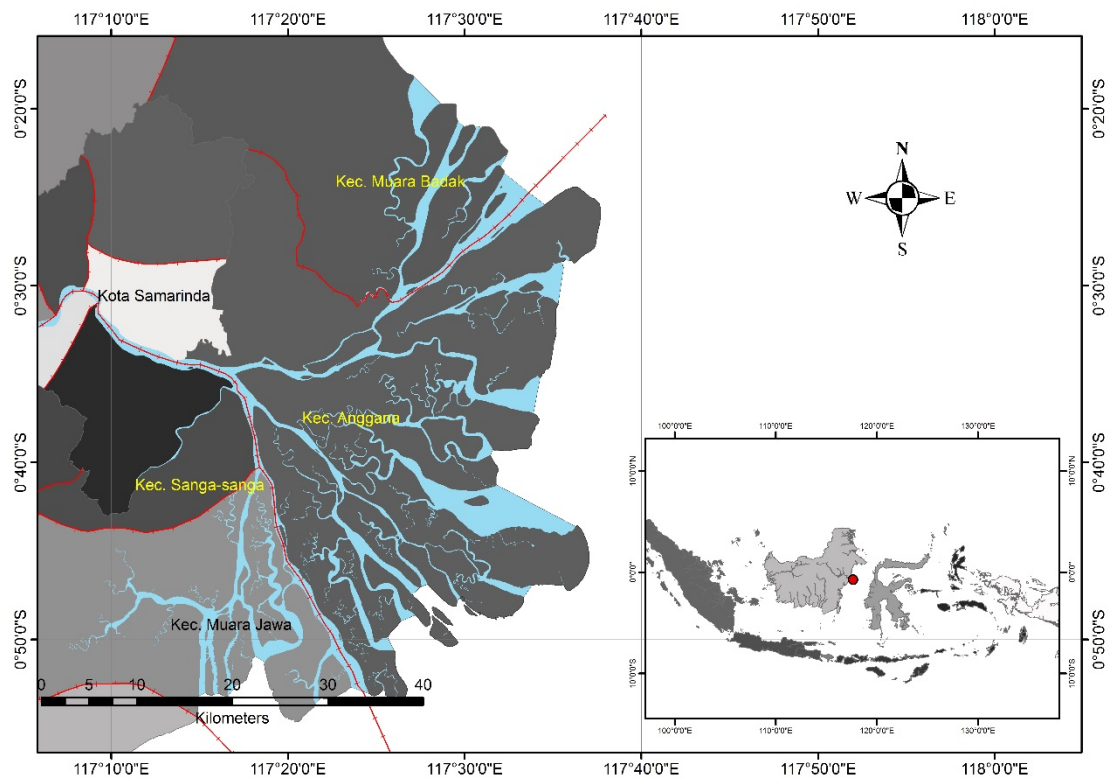


Figure 2.1 Study areas in Mahakam Delta

2.2 Population Growth

Population in the Mahakam Delta is proliferating. Various ethnic groups are evolved in this delta as a result of movement from different other regions,

especially from the island of Sulawesi. They presented and lived in the mainland part of the delta. Commonly, they are involved in activities that depended on the coastal resource, such as fishing, aquaculture, fish/shrimp trading, and gas and oil extraction. Mahakam Delta consists of five sub-districts, including 20 villages that whose areas part of the Delta. The five sub-districts include Samboja, Muara Jawa, Sanga-Sanga, Anggana, and Muara Badak.

Total population and households in this area are 97,448 individuals and 30,254 head households, respectively. Anggana sub-district has seven villages which are included in the Mahakam Delta area. This sub-district is the most massive population and families, with 43,998 people (45.13%) and 13,366 (44.18%) households, respectively. The second largest is Muara Jawa consisting of six villages, with 27,572 people (28.28%) and 9,259 families (30.60%), followed Muara Badak having four communities for 17,394 people (17.84%) and 5,286 households (17.47%). Also, Sanga-Sanga having two villages with 6,400 people (6.56%) and 1,859 homes (6.14%). Samboja is a sub-district that has the least population and household, with 2,124 people (2.18%) and 484 people (1.60%), respectively (Table 2.1).

Table 2.1 Sociodemographic of households in Mahakam Delta, 2016

No	Sub-districts	Villages	Population	Households
1	Samboja	Muara Sembilang	2124	484
2	Muara Jawa	Muara Kembang	4039	1356
		Tamapole	516	174
		Dondang	2907	976
		Muara Jawa Ilir	3448	1158
		Muara Jawa Tengah	5382	1807
		Muara Jawa Hulu	11280	3788
3	Sanga-Sanga	Sanga-Sanga Muara	3713	967
		Pendingin	2687	892
4	Anggana	Tani Baru	4457	1335
		Kutai Lama	4183	1332
		Muara Pantuan	5478	1687
		Anggana	3621	1175
		Sepatin	4718	1326
		Sungai Meriam	14998	4587
		Handil Terusan	6543	1924
5	Muara Badak	Saliki	5288	1698
		Muara Badak Hulu	5037	1486
		Muara Badak Ilir	5058	1472
		Salok Palai	2011	630
		Total	97488	30254

Source: Analyzed from Central Bureau of Statistics (BPS 2017)

The increasing of the number of the population began when foreign and national oil and gas companies operated and established their companies in the Mahakam Delta due to the exploration of those resources was victorious in the mid-1970s. Moreover, a pulp industry was also produced in 1976 but was bankrupt in 1980 related to lack of raw materials. Afterward, people from Sulawesi island also came and lived in this area (Powell and Osbeck, 2010). Secondly, the highest migration wave of other islands, especially Buginese from Sulawesi Island, appeared in the last 1990s. In this period, the monetary crisis of Indonesia occurred, and Indonesia currency rate dropped extremely toward the US

Dollar. However, at the same time, Indonesia experienced a boom in export due to international shrimp price heightened. Immigrant came and settled in the Mahakam Delta to obtain income from opening shrimp ponds.

By now around 70% of the land surface, including mangroves, of the Mahakam Delta has been changed into shrimp ponds and settlements. Currently, the population of the Mahakam Delta covering twenty villages has grown to about 97,488 people. Approximately 34.29% of the total population in the delta have been increased from 2009 to 2016 or during the last eight years. During this period, the highest increase in population is Anggana sub-district with 47.90%, followed by Muara Jawa (30.41%), Muara Badak (21.15%), and Sanga-Sanga (20.19%). Whereas, Samboja that has only one village in the delta area is the lowest population growth with 5.15% during 2009-2016 (Figure 2.2).

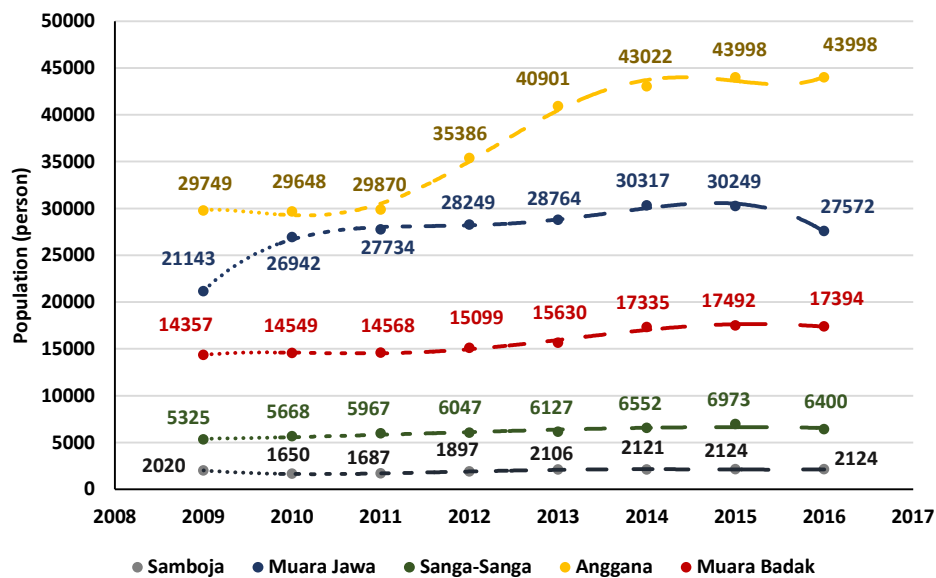


Figure 2.2 The trend of the population in the Mahakam Delta in 2016

Source: Analyzed from Central Bureau of Statistics (BPS 2017)

2.3 Economic Sector of the Mahakam Delta

Mahakam Delta located in Kutai Kartanegara District has the diverse potential natural resource. This delta has a vital role in Indonesia development and has turned Kutai Kartanegara District into one of the wealthiest areas in Indonesia. Two sectors of the mainstay of this delta are oil and gas and fisheries sector. As a district in East Kalimantan Province, oil and gas of Kutai Kartanegara district significantly contribute to the province by supporting the regional economy. Statistic of East Kalimantan Province stated that oil and gas provided around 50% of East Kalimantan's Gross Domestic Product (GDP) in 2013. At the same time, East Kalimantan Province was the most significant oil and gas exporter in Indonesia. In 2008, 2013, and 2015, East Kalimantan province contributed to the Indonesian oil and gas production in 37.56%, 45.08%, and 16.53%, respectively (Priambodo, 2016; Sylviani and Suryandari. E.Y, 2017).

Another potential sector of natural resources in the Mahakam Delta is the fisheries sector. Mahakam Delta significantly contributes to Indonesia's fisheries. Referred to as the most significant maritime country in the world, Indonesia, then, has the high potential of capture fisheries. Moreover, as the third largest shrimp exporter in the world, Indonesia has a lot of shrimp aquaculture which spread throughout Indonesia's region including the Mahakam Delta area.

2.3.1 Oil and Gas Sector

Mahakam Delta has a high economic potential from the oil and gas sector, where there are five companies operated in this area. They are PT. Pertamina EP, Total E&P Indonesia that collaborates with Indonesia Petroleum Ltd. (INPEX),

Virginia Indonesia Company (VICO), and PT. Chevron Indonesia. Oil and gas working area in the Mahakam Delta covers Samboja, Muara Jawa, Anggana, Sanga-Sanga, and Muara Badak sub-districts.

Total oil lifting compiled by five companies in the Mahakam Delta in 2015 is 17.03 million barrels. The collaboration between Total E&P Indonesia and INPEX significantly contributes to Kutai Kartangera's oil lifting of 10.94 million barrels or 64.25% of the total output. The remaining is VICO with 5.31 million barrels (31.21%) and PT. Pertamina EP to 0.74 million barrels (4.34%). Whereas, PT. Chevron Indonesia is the least oil lifting with 0.03 million barrels or 0.20% of total output.

Table 2.2 Oil lifting in Mahakam Delta area in period 2010-2015 (million barrels)

No	Companies	Year					
		2010	2011	2012	2013	2014	2015
1	PT. Pertamina EP	1.70	2.43	2.63	2.54	2.81	0.74
2	Total E&P Indonesia - INPEX	20.57	18.73	13.79	12.97	11.41	10.94
3	VICO	6.54	5.45	5.40	4.50	4.56	5.31
5	PT. Chevron Indonesia	0.04	0.06	0.07	0.34	0.21	0.03
	Total	28.86	26.68	21.89	20.35	18.99	17.03

Sources: Sylviani and Suryandari. E.Y (2017); Ministry of Energy and Mineral Resources of the Republic of Indonesia (2016)

Figure 2.3 shows that the total of oil lifting from five companies tends to decline every year. In the last six years, an average of decline annually is 9.91%. From 2010 to 2015, a decrease in the total of oil lifting reached 11.83 million barrels or decline about 40.99% during the last six years. The decline in oil production is due to oil reserves in the declining Mahakam Delta because these resources are non-renewable and scarce.

In company level, PT. Pertamina EP is the most significant declines in 2010-2015 periods. Though an increase of 54.53% in 2010-2012 and 10.83% in 2013-2014, however, overall oil production of PT. Pertamina EP decreased approximately 56.58% in the last six years. In second place is the collaboration of Total E&P Indonesia - INPEX, which continually declines annually. The decline of oil lifting that having this collaboration company reaches approximately 46.80% during the last six years or decreases an average 11.48% annually.

Furthermore, VICO that has oil lifting of 5.31 million barrels in 2015 overall declines about 18.81% of from 2010. Though experienced a constant annual decrease of about 11.44% in the last four years or 2010-2013 periods, however after that, oil production of VICO continually increases annually. From 2013 to 2015 observed that the increase of oil lifting was 0.81 million barrels or up to 18.04%. Contrast with VICO, interestingly, oil lifting of PT. Chevron Indonesia continually rises in the beginning period or 2010-2013. In 2013, oil production of this company was 0.34 million barrels or increased about 684.04% from 2010 that only 0.04 million barrels. However, oil production of this company continually declines annually in 2013-2015 periods. The decline of oil lifting reached about 0.30 million barrels or down to 90.11% in the latest period. An average annual decrease is 61.33%.

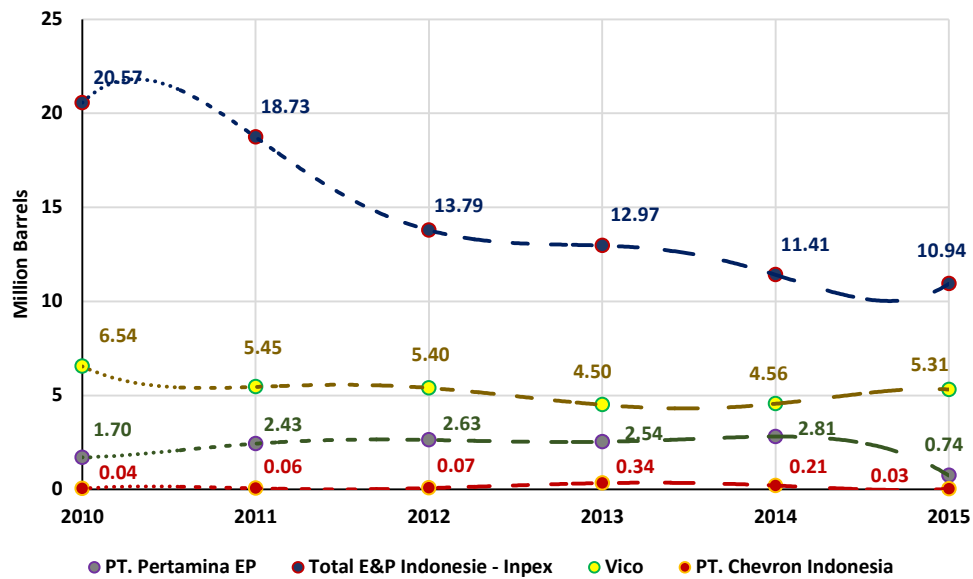


Figure 2.3 The trend of the total of oil lifting from five companies in Mahakam Delta

Sources: Sylviani and Suryandari. E.Y (2017); Ministry of Energy and Mineral Resources of the Republic of Indonesia (2016)

Besides oil resource, Mahakam Delta also has a high potential for the gas resource. In 2014 Kutai Kartanegara District significantly contributed to East Kalimantan Province's gas lifting of 62.12% (Ministry of Energy and Mineral Resources of the Republic of Indonesia, 2016). Five companies that operated in the Mahakam Delta produced a total of gas lifting to 334,850.24 Million British Thermal Unit (MMBTU) in 2015. The Total E&P Indonesia and INPEX collaboration dramatically contribute to Kutai Kartanegara's gas lifting of 246,480.46 MMBTU or 73.61% of the total output. The remaining is VICO with 82,816.63 MMBTU or 24.73% of the maximum gas lifting and PT. Chevron Indonesia with 1.66% of the total production or 5,553.15 MMBTU. PT. Pertamina EP in 2015 did not provide the gas. Gas production data are only Recorded in

2010 at which time PT. Pertamina EP produced around 211.40 MMBTU (Table 2.3).

**Table 2.3 Gas lifting in Mahakam Delta area in period 2010-2015
(thousand MBTU)**

No	Companies	Year					
		2010	2011	2012	2013	2014	2015
1	PT. Pertamina EP	0.21	-	-	-	-	-
2	Total E&P Indonesie - INPEX	561.42	408.16	327.11	301.20	282.81	246.48
3	VICO	104.63	89.50	90.67	108.85	81.06	82.82
5	PT. Chevron Indonesia	1.74	4.77	12.31	17.51	7.12	5.55
	Total	668.01	502.43	430.09	427.57	370.99	334.85

Sources: Sylviani and Suryandari. E.Y (2017); Ministry of Energy and Mineral Resources of the Republic of Indonesia (2016)

The total of gas lifting from five companies tends to decline annually. In the 2010-2015 period, an average of decline annually is 12.55%. In the last six years, a decrease in the total of gas lifting reached 333,162.63 MMBTU or decline about 49.87%. Similar to oil production, the decline in gas production is due to gas reserves in the declining Mahakam Delta because these resources are non-renewable and scarce.

In company level, the collaboration of Total E&P Indonesie - INPEX is the most significant declines in 2010-2015 periods. This collaboration company continually declines annually with an average annual decline of 14.81%. In the 2010-2015 period, a decrease in the total of gas lifting reached 314,942.63 MMBTU or drop about 56.10%. In second place is VICO with an average decline of 3.29% annually in the 2010-2015 period. However, this company experienced an increase in 2011-2013 with up to 19,351.51 MMBTU (21.62%) and 2014-2015

with up to 1,754.16 MMBTU (21.16%). Additionally, a contradiction with other companies, gas lifting of PT. Chevron Indonesia continually increases in the beginning period or 2010-2013. However, this company regularly experienced a decrease in after that period, with down to 11,956.39 MMBTU or 68.29% in the 2013-2015 period (Figure 2.4).

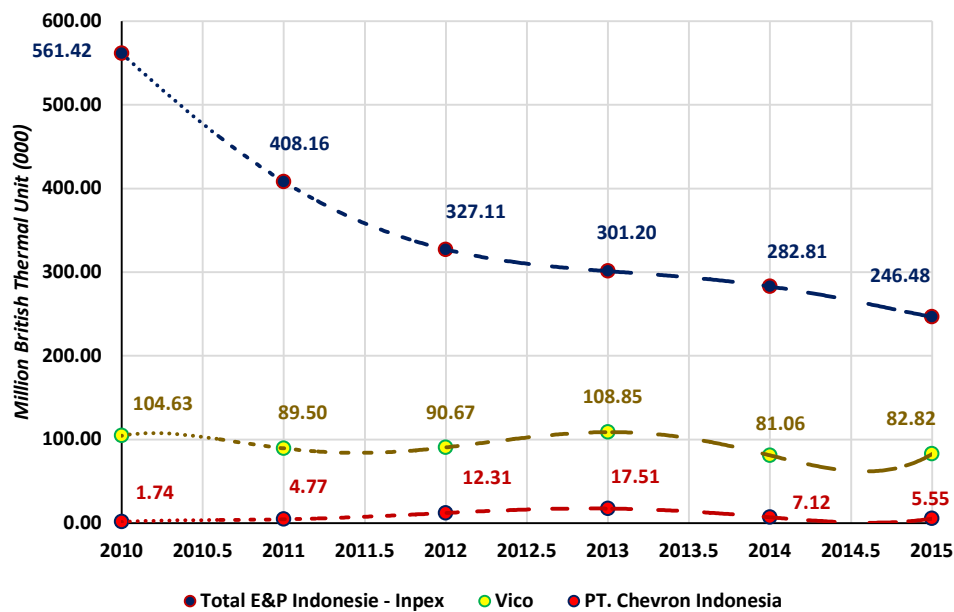


Figure 2.4 The trend of the total of gas lifting from five companies in Mahakam Delta

Sources: Sylviani and Suryandari. E.Y (2017); Ministry of Energy and Mineral Resources of the Republic of Indonesia (2016)

2.3.2 Fisheries Sector

One of the mangrove benefits is providing a nursery ground for all aquatic organisms. The excellent development of mangrove ecosystems can ensure the prosperity of coastal communities' livelihoods. The total number of households in the Mahakam Delta is 8,936 household head consisting of 3,394 households of

marine capture (37.98%) and 5,542 households of brackish water pond (62.02%). In 2015, Muara Badak sub-district was the most substantial fisheries households with 5,240 households (58.84%), followed by Anggana sub-district with 2,665 homes (29.92%), and Muara Jawa sub-district with 871 families (9.78%). Sanga-Sanga and Samboja were sub-districts that have the least households, with 130 houses (1.46%) and 30 homes (0.34%), respectively (Table 2.4).

For households of marine capture, Anggana is a sub-district that has the most substantial marine capture household with 1,685 families or 49.90% of total marine capture household in the Mahakam Delta. In second place is Muara Badak sub-district with 1,237 homes (36.63%), followed by Muara Jawa sub-district with 325 families or 9.62% of total marine capture households. Sanga-Sanga and Samboja were sub-districts that have the least marine capture households, with 130 houses (3.85%) and 17 homes (0.50%), respectively.

Additionally, households of brackish water pond, Muara Badak sub-district is the most extensive brackish water pond households with 4,003 homes or 72.40% of total brackish water pond households in the Mahakam Delta. In the second rank is Anggana sub-district with 980 families (17.72%), followed by Muara Jawa and Samboja sub-districts with 546 homes (9.88%) and 13 households (0.24%), respectively. There is no household of brackish water pond in Sanga-Sanga sub-district.

Table 2.4 Fisheries households in the Mahakam Delta in 2015

No	Sub Districts	Villages	Households	
			Marine Capture	Brackish Water Pond
1	Samboja	Muara Sembilang	17	13
2	Muara Jawa	Muara Kembang	105	428
		Tamapole	25	8
		Dondang	35	5
		Muara Jawa Ilir	75	64
		Muara Jawa Tengah	50	25
		Muara Jawa Ulu	35	16
3	Sanga-Sanga	Sanga-Sanga Muara	109	0
		Pendingin	21	0
4	Anggana	Tani Baru	262	230
		Kutai Lama	65	0
		Muara Pantuan	518	315
		Anggana	30	0
		Sepatin	645	411
		Sungai Meriam	90	0
		Handil Terusan	75	24
5	Muara Badak	Saliki	35	1475
		Muara Badak Ulu	235	1375
		Muara Badak Ilir	948	3
		Salok Palai	19	1150
		Total	3394	5542

Source: Analyzed from Central Bureau of Statistics (BPS 2016)

The total of fisheries production in the Mahakam Delta is 50,716.88 tons consisting of 28,329.31 tons of marine capture (55.86%) and 22,387.57 tons of brackish water pond or 44.14% of total output. Anggana sub-district in 2013 was the most significant fisheries production with 15,483.34 tons or 30.53% of the total production, followed by Muara Badak, Muara Jawa and Samboja sub-districts with 13,285.22 tons (26.19%), 11,315.28 tons (22.31%), and 9,828.23 tons (19.38%), respectively.

Anggana that has seven villages in the Mahakam Delta and Muara Badak are sub-districts having the most massive marine capture production of 7,243.29 tons (25.57%) and 6,921.37 tons (24.43%), respectively (Figure 2.5). Furthermore, Samboja and Muara Jawa sub-districts with marine capture production are 6,760.40 tons (23.86%) and 6,599.44 tons or 23.30% of total output, respectively. Sanga-Sanga is a sub-district that the least productive of 804.81 tons of marine capture production (2.84%).

Further, brackish water pond production, Anggana sub-district is also significant production of 8,240.05 tons or 36.81% of total output, followed by Muara Badak sub-district with 6,363.85 tons (28.43%). Also, Muara Jawa and Samboja are sub-districts having production of 4,715.84 tons (21.06%) and 3,067.83 tons (13.70%) in each. There is not any brackish water pond production in Sanga-Sanga sub-district.

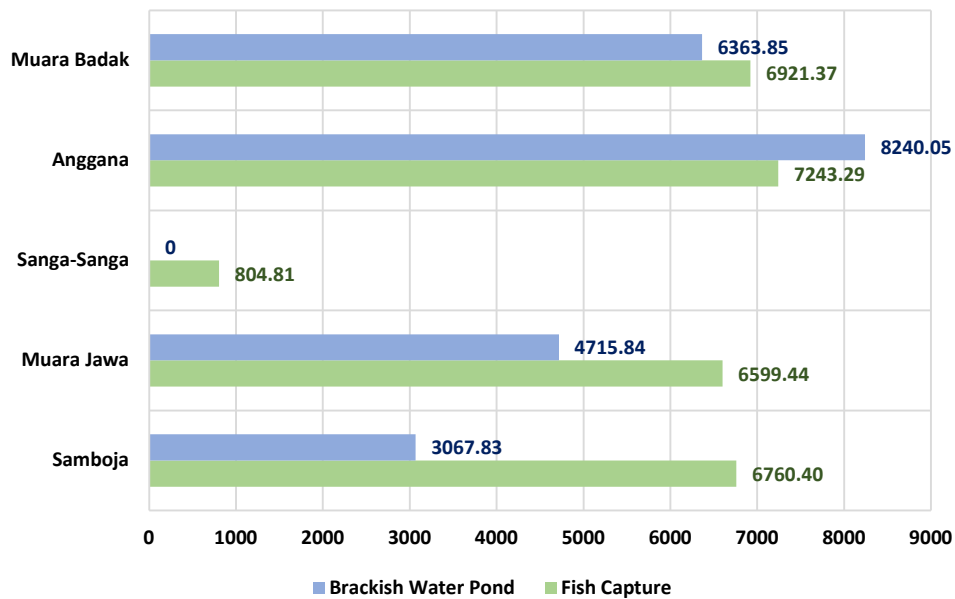


Figure 2.5 Fisheries production in the Mahakam Delta in 2013

Source: Analyzed from Central Bureau of Statistics (BPS 2014)

An economy of the fisheries sector in the Mahakam Delta significantly contributes to the potential prosperity of Kutai Kartanegara District. Figure 2.6 shows that the total of the value of fisheries of the Mahakam Delta adds IDR 1,403.08 billion (US\$105.53 million) for Kutai Kartanegara's fisheries economy. Approximately 88.20% of fisheries values of Kutai Kartanegara originated from this delta that consists of five sub-districts, namely Samboja, Muara Jawa, Sanga-Sanga, Anggana, and Muara Badak sub-districts. Fisheries value of the Mahakam Delta covers marine capture of IDR 450.51 billion (US\$33.88 million) and brackish water pond with IDR 952.57 billion (US\$71.64 million).

Anggana, for the economic value of marine capture, is a sub-district that has the significant contribution in the Mahakam Delta. This sub-district contributes IDR 115.19 billion (US\$8.66 million) or about 25.57% of total output.

Furthermore, Muara Badak sub-district is IDR 110.07 billion (US\$8.28 million) and contributes approximately 24.43% of total marine capture values. The remaining is Samboja and Muara Jawa sub-districts with IDR 107.51 billion (US\$8.09 million) and IDR 104.95 billion (US\$7.89 million), respectively. These two sub-districts contribute approximately 23.86% and 23.30% of the total value in each. Sanga-Sanga is sub-district that has the least marine capture values with IDR 12.80 billion (US\$0.96 million) or only 2.84% of the total output.

Additionally, Anggana sub-district is likewise the highest of production values for brackish water pond with IDR 350.61 billion (US\$26.37 million) or contributes about 36.81% of the total of production values in the Mahakam Delta. In second place is Muara Badak sub-district with IDR 270.78 billion (US\$20.37 million) or contributes to 28.43%. Also, Muara Jawa and Samboja sub-districts add approximately IDR 200.65 billion (US\$15.09 million) and IDR 130.53 billion (US\$9.82 million) in each. The contribution of these two sub-districts is about 21.06% and 13.70%, respectively. There are no production values of brackish water pond in Sanga-Sanga sub-district.

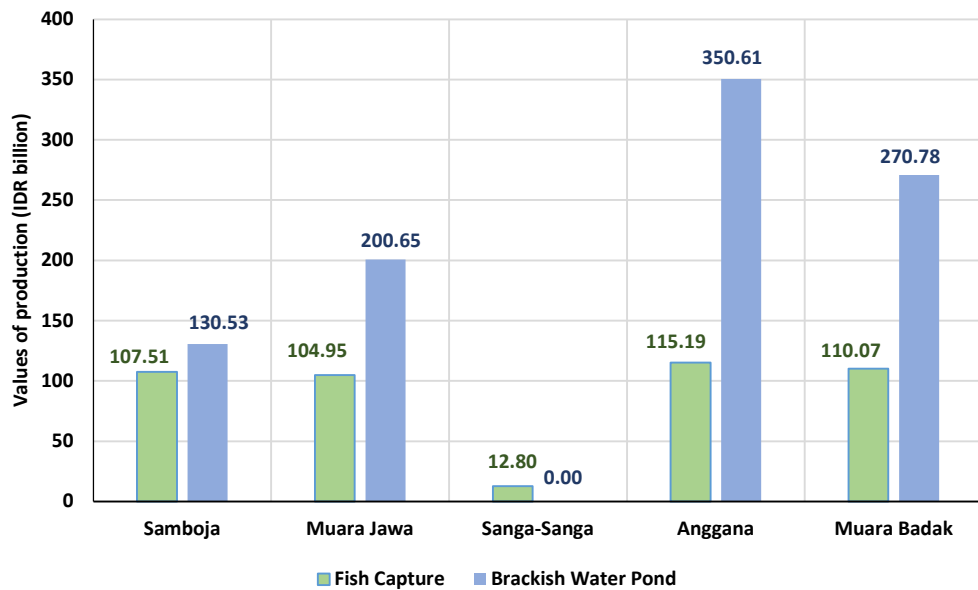


Figure 2.6 The economic value of fisheries of the Mahakam Delta in 2013

Source: Analyzed from Central Bureau of Statistics (BPS 2014)

2.4 Land Cover Change

Bourgeois et al. (2002) have identified the land cover change in the Mahakam Delta in several phases. The phases are: prior to settlement, Shivers: 1992, Take off: 1996, Blast: 1999, and Peak: 2001.

a. Prior to settlement

Before the change in around 1950, the Mahakam Delta consisted of the original vegetation of mangrove forest. Figure 2.7 depicts from upstream to the seashore a sequence of the blended fresh-water forest, fresh-water mangrove, naturally *Nypa* stands, mixed *Nypa* and *Avicennia* and several dense *Rhizophora*, with here and there degraded forest. In this phase, the total area of this area was around 106,000 hectares, and *Nypa* was the prominent species covering 55% of the entire area, followed by fresh-water mangrove or 17% of the total area and

dense *Avicennia*. At the same time, the Delta Mahakam was the most significant pure *Nypa* mangrove in the world.

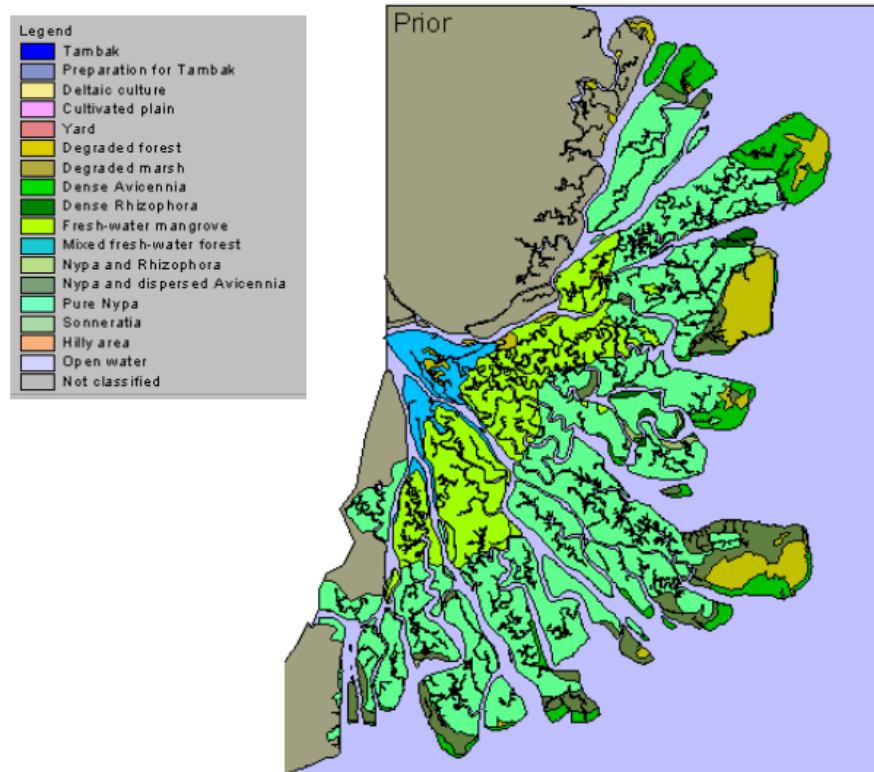


Figure 2.7 Prior to Settlement

Source: Bourgeois et al., (2002)

b. Shivers: 1992

In 1992, ponds, primarily in Muara Pantuan, began to appear in the former coconut plantation area along the seashore side of the Delta. This situation coincided with the development of villages inhabited by migrant fishers. The entire area of ponds in the Mahakam delta by 1992 was only around 3% of the total area. Figure 2.8 shows an increase of up to 120,000 due to the rise of cultivated plains along the coastal regions of the mainland. In this phase, the impact of pond opening on the mangrove ecosystem is still very finite. Fresh-

water mangrove, *Nypa*, and dense *Avicennia* are the dominant vegetation of mangrove forest in this area, with the similar proportion as before.

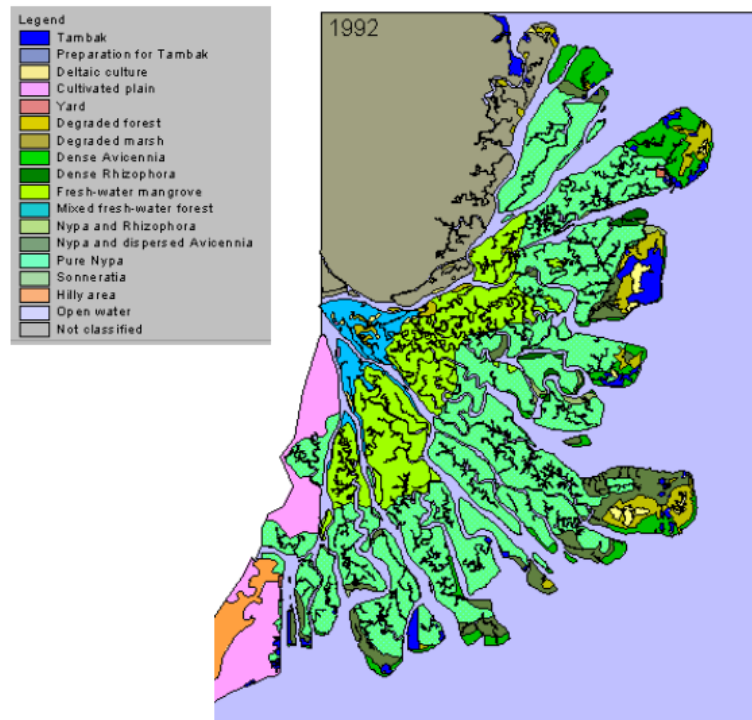


Figure 2.8 Land cover in 1992

Source: Bourgeois et al., (2002)

c. Take off: 1996

The apparent change in 1996 has occurred. Even though *Nypa* was still the prominent species covering 48% of the entire area, this vegetation, however, has begun to disappear. In this phase, fresh-water mangrove was also still the second largest and nearly untouched. Interestingly, ponds start to develop and occupy 14% of the total area or become the third largest land cover. Ponds development by replacing *Nypa* of 5,000 hectares, and *Nypa* and disperse *Avicennia* of 2,000 hectares. Also covering dense *Avicennia*, and degraded forest with 1,600 and

1,500 hectares, respectively. The opening of ponds is opened in several places with still clearly patterned of a pioneer front strategy where forest clearings appear from the central point of the settlement to the periphery. The particular thing here is that settlement points are situated at the edge of the resource.

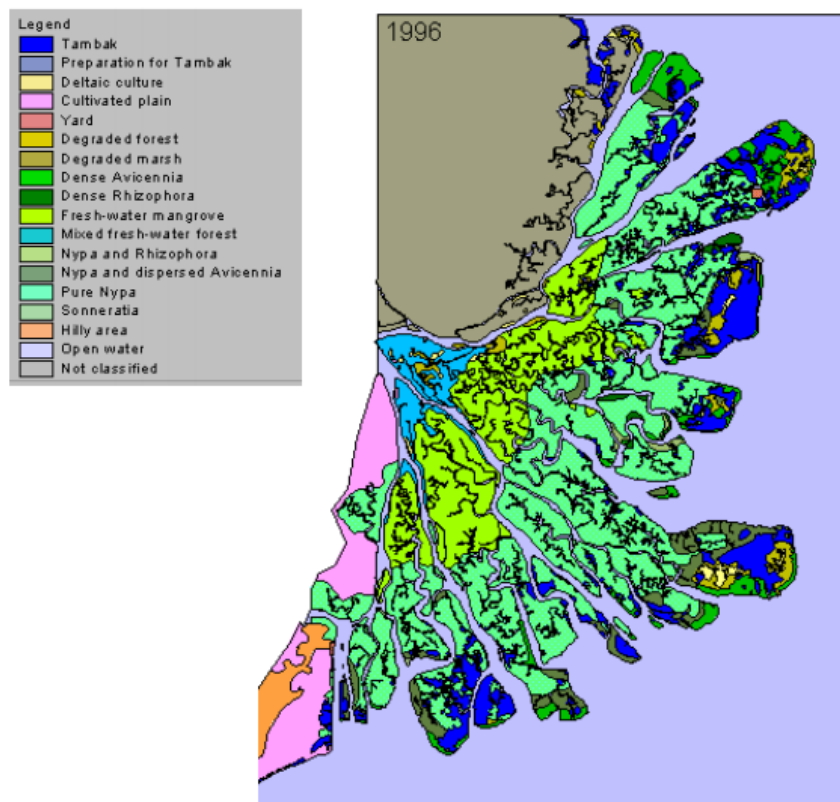


Figure 2.9 Land cover in 1996

Source: Bourgeois et al., (2002)

d. Take off: 1996

The most dramatic changes of *Nypa* mangrove taken place in 1999. Ponds or prepared for pond opening have converted around 36,000 hectares of *Nypa* within three years. Land cover from 3,700 hectares of dense *Avicennia* has disappeared, and the replacing of a further 4,000 ha of mixed *Nypa* and disperse

Avicennia as well as approximately 5,500 hectares of fresh-water mangroves are cleared for the preparation of ponds.

Fresh-water mangrove, however, should not be assumed to be a suitable environment for shrimp pond because of insufficient salinity. The conversion of this ecosystem into ponds causes the change of the physical-chemical environment in the apex area of the Delta, where salt-water intrusion significantly enters the river mouth. In this phase, ponds are the most significant land use with approximately 63% of the total area comprising of about 34% of productive ponds and around 29% of ponds in preparation. In the same phase, furthermore, pure *Nypa*, fresh-water mangrove, and mixed fresh-water forest represent only 15%, 11% and 3% of the aggregate area, respectively.

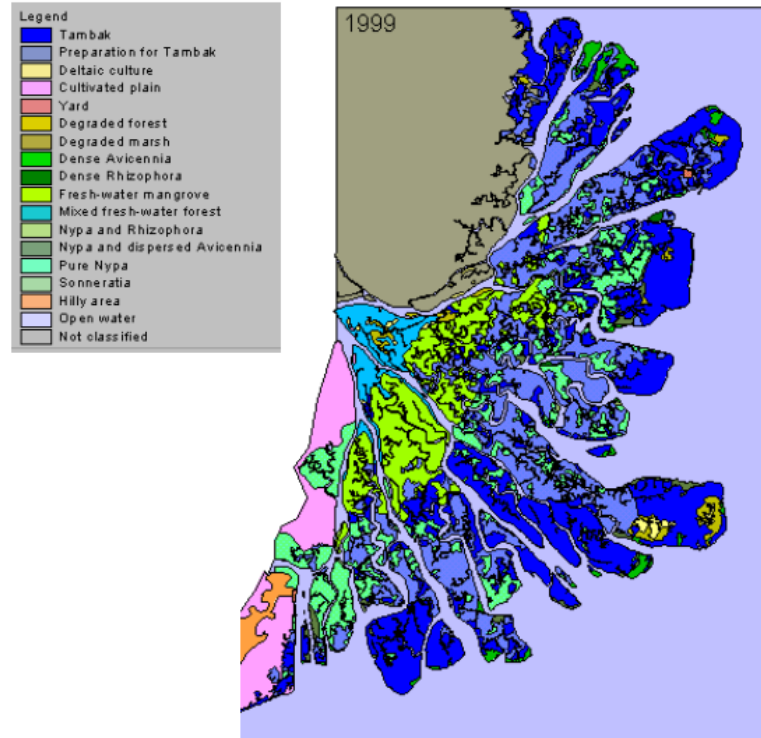


Figure 2.10 Land cover in 1999

Source: Bourgeois et al., (2002)

e. Peak: 2001

In phase 2011 is the peak of land cover change in the Mahakam Delta. Though data in Figure 2.10 does not cover with the entire delta due to only partial photo satellite, however, 90 000 hectares covered are matched with other maps data (110,000 hectares). It was designed to consider that fresh-water mangrove and fresh-water forest were almost nonexistent in this non-covered area. Therefore, the ratio pond/*nypa* of the covered area was applied as a proxy for the unknown region. In this phase, the result is a continuous increase of the pond area which up to 75% of the entire area that comprised of 50,000 hectares of productive ponds and 31,000 hectares of ponds in preparation. Besides 7,000 hectares of *Nypa* have significant been converted, the little poaches of dense *Avicennia*, degraded forest, *Nypa* and disperse *Avicennia* were only more than 2,500 hectares, whereas they still represented altogether about 6,000 hectares in 2009. Also, *Nypa* stands, and the fresh-water mangrove only cover a less area or just 8% and 11% of the total area in each.

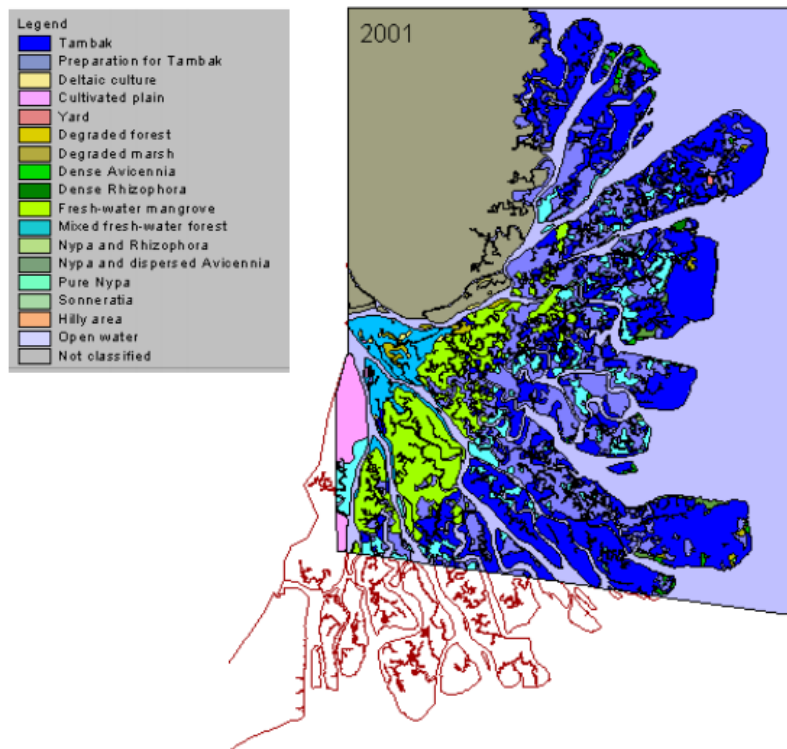


Figure 2.11 Land cover in 2001

Source: Bourgeois et al., (2002)

Another data of land use change from Local Planning and Development Board of Kutai Kartanegara District (2010) reports that mangroves in the Mahakam Delta declined in 1992-2009 periods of 29,600 hectares or decreased by 72.08% from in 1992 which was 105,998.68 hectares (Figure 2.12). Interestingly, land conversion for settlements and ponds has grown in the period. In the same period, settlements increased 8,000 hectares in 2009 from only 73.74 hectares in 1992. Alike of settlements, brackish water ponds also increased 69,354.37 hectares or raise to reach 65,725.77 hectares from 1992 which was just 3,628.6 hectares. However, brackish water ponds declined in the last period (2009) of 13,252.37 hectares or only 56,102 hectares in 2001. From 2001 to 2009, brackish

water ponds decreased by 19.11%. The decline in 2009 is due to brackish water ponds begin to be unproductive, then fish farmers sell their ponds to private sectors, primarily to oil and gas companies for reforestation as part of the corporate social responsibility (CSR). Moreover, the government and NGOs also start to intensify the mangrove restoration program in the Mahakam Delta.

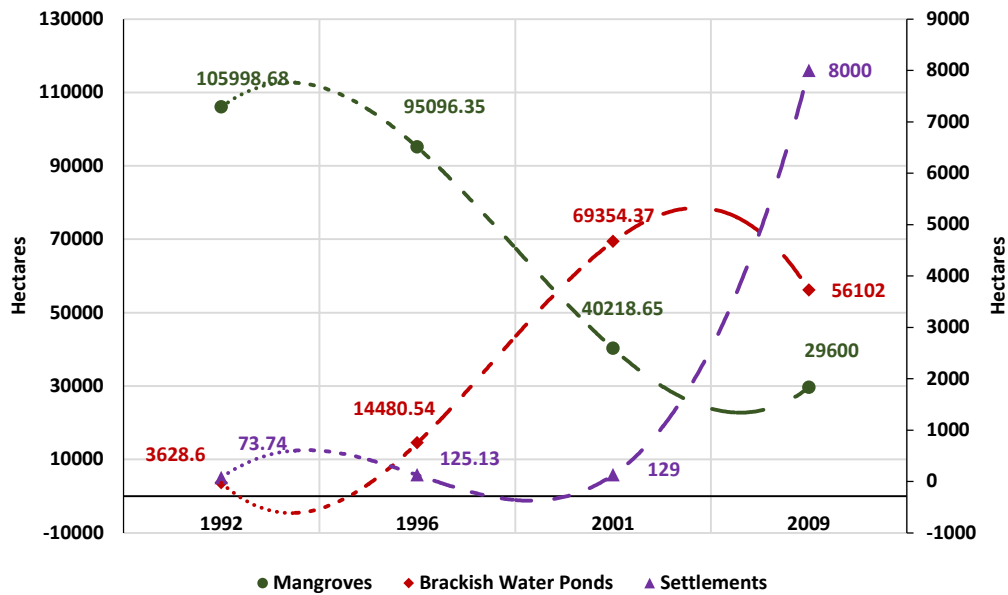


Figure 2.12 Land use change in Mahakam Delta

Source: Local Planning and Development Board of Kutai Kartanegara District (2010)

Chapter 3

Communities' Willingness to Pay for Supporting Mangrove Restoration¹

¹ Reprinted from: Susilo, H., Takahashi, Y., and Yabe, M. 2017. Evidence for Mangrove Restoration in The Mahakam delta, Indonesia, Based on Households' Willingness to Pay. *J. Agric. Sci*, 9, 30-41. doi: <http://dx.doi.org/10.5539/jas.v9n3p30>

3.1 Introduction

Mangroves grow in the intertidal zones between land and sea in the sub-tropics. Mangroves are highly productive and promote ecological diversity in coastal environments as well as supporting socioeconomic activities (Nagelkerken et al., 2008; Barbier et al., 2011). Mangroves provide valuable ecological services including acting as nurseries for fish and crustacean (Kairo et al., 2009) and offering carbon sequestration (Lee. S.Y et al., 2014; Alongi and Mukhopadhyay, 2015). Mangroves also protect coastal areas from tidal waves (Everard et al., 2014) and filter suspended solids (Gautier, 2002). Mangroves are found in 123 countries, covering a global area of 152.360 km² (ITTO,2012). Asia is the center of origin of mangroves. Indonesia has the largest area of mangrove growth in the world and is home to some of the world's most abundant species of mangroves. Over 22.6% of the world's mangroves originated in Indonesia (Giri et al., 2011). Spalding et al., (2010) noted that mangroves in Indonesia cover approximately 30,000 square kilometers and comprise 45 out of the 75 species of true mangroves found globally.

East Kalimantan is the province with a second-largest area of mangroves in Indonesia. Mangroves in this province cover 364,254.98 hectares, equaling over 11% of Indonesia's total mangrove area (Hartini et al., 2010). Most of East Kalimantan's mangroves originated from the Mahakam Delta. Located at the mouth of the Mahakam River, the delta forms a unique fan-shape that includes 46 small islands in the coastal area of the Makassar Strait (Sidik, 2009). It is one of the most suitable environments for natural mangrove development in Indonesia. Currently, mangroves in the Mahakam Delta cover approximately 29,600 hectares.

The area of mangroves has declined significantly worldwide as a result of economic development, population pressure and industrial and urban development (Polidoro et al., 2010). The Mahakam Delta has also suffered the same fate. The degradation of mangrove areas in the Mahakam Delta occurred primarily because of shrimp pond expansion and, to a lesser degree, urban and industrial development. From 1992 to 1996, there was a 3.67% decrease in a mangrove area, and from 1996 to 2009, there was a further 20.52% decrease (Local Planning and Development Board of Kutai Kartanegara District, 2010). Mangroves carry out multiple functions that are important to humans. Declines in mangrove area could lead to less income for local people (e.g., lower fishery yields and unproductive brackish ponds). From 2011 to 2014, fishery yields in the Mahakam Delta area declined continuously from 28,222 tons to 18,492 tons, while brackish pond production has continually decreased from 18,615 tons to 17,445 tons (Central Bureau of Statistics-BPS, 2015).

Previous studies have been carried out in the Mahakam Delta (e.g., Storms et al., 2005; Persoon and Simarmata, 2014; Effendi et al., 2016). However, studies that focus on assigning value to non-market resources in this area are scarce. The economic value of mangrove ecosystem services should be evaluated to assist with the future management and conservation of mangrove ecosystems. Economic valuation can support the formulation of policies by attaching and the economic value of the preservation of biological resources (Christie et al., 2006). The economic valuation of mangroves involves constructing a hypothetical market because the majority of the ecosystem service functions performed by mangroves provide indirect value and do not imply marketed resources. Thus, identifying the

economic value of mangrove ecosystem services is difficult. Therefore, this study used the contingent valuation method (CVM) to solve this problem.

The CVM, which uses a questionnaire-based approach, has been widely applied to determine willingness to pay (WTP) for non-marketed assets or services (Hanemann et al., 1991). There are various means of framing the WTP question commonly used in CVM studies, such as payment cards and dichotomous choice (DC). The DC comprises two formulas: the single-bound model, in which individuals can “accept” or “reject” a bid, and the double-bound model, in which an individual accepts the first bid and a second, higher bid is offered. Previous studies have also examined the value of WTP for mangrove restoration. Utilizing the single-bound model, Tuan et al., (2014), estimated the WTP for mangrove restoration in Thi Nai Lagoon, Vietnam within the context of climate change. Stone et al., (2008) also investigated factors that influenced households’ WTP for mangrove restoration among three subsistence groups on the west coast of India. The application of the single-bound model for non-market valuation has been commonly used to assess programs for natural resource assessment (Gelo and Koch, 2015).

This study applies the double-bound model to estimate WTP for mangrove restoration in the Mahakam Delta. Calia and Strazzera (2000) explain that the single-bound model has lower survey costs according to respondent group size when the interview is conducted face-to-face or over the telephone, especially when the targets of the interview are part of a specific respondent. Unlike the double-bound model, the single-bound model only offers one question to determine whether a bid is “accepted” or “rejected”, so little time is required to

complete interviews. However, CVM analysts prefer the double-bound model to the single-bound model. They argue that the double-bound model provides more information to better estimate an individual's true WTP and produces less biased WTP estimates than the single-bound model (Hanemann et al., 1991; Calia and Strazzera, 2000; Gelo and Koch, 2015). Using Monte Carlo analysis, Calia and Strazzera (2000) found that the double-bound model was more effective than the single-bound model because it resulted in more accurate point estimates of parameters and central tendency measures of WTP, with smaller confidence intervals for mean and median WTP. Hanemann et al., (1991) also demonstrated that the double-bound model provides more information than the single-bound model. The double-bound model produces less biased estimates of WTP and asymptotically more efficient than the single-bound model for CVM.

Considering these points, this study decided to use the double-bound model to determine households' WTP for mangrove ecosystem restoration in the Mahakam Delta. This study also investigated the factors influencing WTP, including sociodemographic characteristics and the perception of the local community. This study hypothesized that higher bids would have a negative effect on respondents' WTP. Further, restoration program preferences and those with a perceived responsibility toward mangrove restoration were expected to have a bigger probability of answering "yes" to WTP bids. Occupation and residential status were expected to have a positive effect on answering "yes" to WTP bids.

3.2 Methodology

3.2.1 Data Collection

Data collection was conducted from April to June in 2016 through face-to-face interviews with respondents. This study selects three villages in the study area based on the highest number of households in a village. Surveys were carried out in three villages: Tani Baru, Muara Pantuan, and Muara Badak. Of the 380 questionnaires that were distributed, 364 were completed. The sample from three villages was purposively selected based on the socio-demographic characteristics of respondents. This study designed the questionnaires by conducting a pre-test with 30 respondents to ensure that respondents had sufficient information and understanding to answer all questions in the questionnaire. The questionnaire was composed of three parts. In the first part, respondents were provided with a summary regarding mangroves in the Mahakam Delta and the problems associated with inappropriate resource utilization and lack of mangrove management. Information about the impact of mangrove degradation was also included in this section. In the second part, respondents were asked if they would be willing to pay for mangrove restoration according to five bid levels (Table 3.1). In the second section, respondents were also asked to indicate how important they felt that different mangrove functions were to their livelihoods. In the third (final) section, respondents were asked to provide demographic information including sex, age, number of household members, residence status, occupation, education level and income.

Table 3.1 Double-bounded CVM offer prices

First bid	Second higher bid	Second lower bid
10000	20000	5000
20000	30000	10000
30000	40000	20000
40000	50000	30000
50000	60000	40000

Note. 1 USD was equivalent to 13,296 IDR at the time of the study

3.2.2 Analytical Techniques

Bishop and Heberlein (1979) first introduced the double-bounded questionnaire to determine WTP. This approach requires respondents to answer either "yes" or "no" to the offer price in a hypothetical market (Venkatachalam, 2004). This approach was then modified by Hanemann (1985), who introduced the double-bounded dichotomous choice method (DBDC). In this approach, each respondent is presented with two bids. The amount of the second bid depends on the reply to the first bid. The second bid (B_i^u) is a certain amount higher than the first bid ($B_i < B_i^u$) if the individual responded "yes" to the first bid. However, the amount of the second bid (B_i^d) is smaller than the first bid ($B_i^d < B_i$) if the individual responded "no" to the first bid. Four possible outcomes are obtained when each respondent is presented with two bids: (a) both answers are "yes" (π^{yy}); (b) both answers are "no" (π^{nn}); (c) a "yes" followed by a "no" (π^{yn}); and (d) a "no" followed by a "yes" (π^{ny}).

The likelihood of these responses occurring can be described by the following formulas, assuming a utility-maximizing respondent (Hanemann et al., 1991): In the first case, we have $B_i^u > B_i$ and

$$\begin{aligned}
\pi^{yy}(B_i, B_i^u) &= \Pr\{B_i \leq \max \text{ WTP and } B_i^u \leq \max \text{ WTP}\} \\
&= \Pr\{B_i \leq \max \text{ WTP} | B_i^u \leq \max \text{ WTP}\} \Pr\{B_i^u \leq \max \text{ WTP}\} \\
&= \Pr\{B_i^u \leq \max \text{ WTP}\} = 1 - G(B_i^u; \theta)
\end{aligned} \tag{1}$$

Since, with $B_i^u > B_i$, $\Pr\{B_i \leq \max \text{ WTP} | B_i^u \leq \max \text{ WTP}\} \equiv 1$.

Similarly, with $B_i^d < B_i$, $\Pr\{B_i^d \geq \max \text{ WTP} | B_i \geq \max \text{ WTP}\} \equiv 1$. Hence,

$$\pi^{nn}(B_i, B_i^d) = \Pr\{B_i > \max \text{ WTP and } B_i^d > \max \text{ WTP}\} = G(B_i^d, \theta) \tag{2}$$

When a ‘‘yes’’ is followed by a ‘‘no’’, we have $B_i^u > B_i$ and

$$\pi^{yn}(B_i, B_i^u) = \Pr\{B_i^u \leq \max \text{ WTP} \leq B_i^u\} = G(B_i^u, \theta) - G(B_i, \theta); \tag{3}$$

And when a ‘‘no’’ is followed by a ‘‘yes’’, we have $B_i^d < B_i$ and

$$\pi^{ny}(B_i, B_i^d) = \Pr\{B_i > \max \text{ WTP and } \geq B_i^d\} = G(B_i, \theta) - G(B_i^d, \theta) \tag{4}$$

Given a sample of N respondents, where B_i, B_i^u and B_i^d are bids used for the i th respondent, the log-likelihood function takes form

$$\begin{aligned}
\ln L^D(\theta) &= \\
&\sum_{i=1}^N \{d_i^{yy} \ln \pi^{yy}(B_i, B_i^u) + d_i^{nn} \ln \pi^{nn}(B_i, B_i^d) + \\
&d_i^{yn} \ln \pi^{yn}(B_i, B_i^u) + d_i^{ny} \ln \pi^{ny}(B_i, B_i^d)\}
\end{aligned} \tag{5}$$

Where d_i^{yy} , d_i^{nn} , d_i^{yn} , d_i^{ny} are binary-valued indicator variables; the double-bounded dichotomous choice model is estimated using log-normal and log-logistic model.

$$\text{Mean (WTP)} = \int_L^U (1 + e^{-(\beta_0 + \beta_1 \log T + \beta_2 X)})^{-1} dT \tag{6}$$

Where $(1 + e^{-(\beta_0 + \beta_1 \log T + \beta_2 X)})^{-1}$ the probability of saying ‘‘yes’’, $T = \text{bid}$, L and U are the upper and lower limits of the integration.

Median is as expressed follows:

$$\text{Median (WTP)} = \exp\left(\frac{-\hat{\beta}_0 - \hat{\beta}_2 \bar{X}}{\hat{\beta}_1}\right) \tag{7}$$

In which $\widehat{\beta}_0$, $\widehat{\beta}_1$ and $\widehat{\beta}_2$ are estimated parameters, \bar{X} = mean of socioeconomics variables. Finally, estimation of parameters was carried out using the LIMDEP software (NLOGIT version 5).

3.3 Results

3.3.1 Sociodemographic Characteristics

Table 3.2 presents the sociodemographic characteristic of the respondents. On average, respondents in the study area are the male, with an average of 78%. The mean actual age is 31–40 years, implying that the average households in the study area are in the productive life phase. Regarding family size, the study found that respondents who three members were the domination in the study area. The data shows that 33% of occupation type is fish farmers and residence status in the study area is dominated by the immigrant (68%). Respondents have only a primary school, implying that they work to earn a living without any education background. The respondents with incomes of IDR 2–2.9 million are most prevalent in the study area. The study also asked respondents how they would like to participate in mangrove restoration; the options were: planting mangrove seedlings, monitoring plant progress and protecting the mangrove area. Thirty-six percent of respondents chose planting seedlings, and 64% chose the other options. Furthermore, 90% of respondents agreed that the protection of mangroves was their responsibility. 43% of respondents assess that mangroves provide the benefit as a nursery ground for aquatic organisms. Of the 364 respondents who were interviewed, 313 respondents (86%) were willing to pay for mangrove restoration.

Table 3.2 Sociodemographic characteristic of respondents

Variables	Description	Mean	Std. Dev
<i>Gender</i>	1 if the respondent is male; 0 if female	0.78	0.41
<i>Age</i>	1 = below 20; 2 = 20-30; 3 = 31-40; 4 = 41-50; 5 = 51-60; 6 = over 60)	3.32	1.01
<i>Family size</i>	Family size of respondents	2.94	1.54
<i>Occupation</i>	1 if the respondent is fish farmer; 0 if otherwise	0.33	0.47
<i>Residence status</i>	1 if the respondent is indigenous; 0 if immigrant	0.32	0.47
<i>Education</i>	1 = never; 2 = primary school; 3 = secondary school; 4 = high school; 5 = university degree	2.27	1.06
<i>Income</i>	1= less than 1; 2 = 1-1.99; 3 = 2-2.99; 4 = 3-3.99; 5 = 4-4.99; 6 = more than 5) (million IDR)	3.24	1.49
<i>Planting of mangrove seedlings</i>	1 if respondent wants to participate in planting of mangrove seedlings, 0 if otherwise	0.36	0.48
<i>Responsibility</i>	The responsibility of the local community to mangrove restoration. 1 if the respondent agrees, 0 is disagree	0.90	0.29
<i>Nursery</i>	1 if mangrove benefit as nursery ground; 0 if otherwise	0.43	0.49

3.3.2 Perceptions Regarding Mangrove Benefits

Table 3.3 depicts the responses of respondents to the questions regarding the relative importance of mangrove ecosystem functions associated with their livelihoods. The respondents were asked to respond to six questions about mangrove ecosystem functions on a five-point scale ranging from 1 = not very important to 5 = very important. The results revealed that over 80% of respondents assessed the benefits of some mangrove-related ecosystem functions associated with their livelihoods as "important" or "very important". However,

0.27%–28% of respondents responded that mangrove functions were neither important nor unimportant depending on the question.

Table 3.3 The importance of mangrove ecosystem functions

Mangrove Function	Not very important	Not important	Neither	Important	Very important
Timber and plant product	0.82	3.02	17.58	69.23	9.34
Coastal protection and erosion control	0.27	0.82	0.27	34.34	64.29
Water purification	0.27	1.92	7.69	51.10	39.01
Carbon sequestration	0.27	0.55	9.07	66.48	23.63
Fisheries	0.27	0.27	3.02	34.89	61.54
Tourism	0.27	3.85	28.57	46.70	20.60

Note. values are % of total individual responses

3.3.3 Individual WTP

Table 3.4 summarizes the bids and responses to the WTP questions. The proportion of 'yes' responses to base bid (BD) and upper bound (UB) ranged from 57.97% for IDR 10000 to 14.04% for IDR 50000. An identical pattern was recognized for the proportion of 'yes' responses to BD, and the proportion of 'no' responses to UB ranged from 30.43% for IDR 10000 to 17.54% for IDR 50000. In contrast to the previous pattern, the BD and lower bound (LB) provide a different pattern. The proportion of 'no' responses to BD and the proportion of 'yes' responses to LB ranged from 7.25% for IDR 10,000 to 28.07% for IDR 50,000. Also, the proportion of 'no' responses to BD and LB ranged from 4.35% for IDR 10,000 to 40.35% for IDR 50,000.

Table 3.4 Summary of respondent answer for WTP

First Bid (IDR)	Base bid (BD) and upper bid (UB)				Base bid (BD) and lower bid (LB)				Total	
	yes-yes		yes-no		no-yes		no-no		N	%
	N	%	N	%	N	%	N	%		
10,000	40	57.97	21	30.43	5	7.25	3	4.35	69	100
20,000	31	46.97	14	21.21	12	18.18	9	13.64	66	100
30,000	15	24.19	21	33.87	18	29.03	8	12.90	62	100
40,000	21	35.59	12	20.34	17	28.81	9	15.25	59	100
50,000	8	14.04	10	17.54	16	28.07	23	40.35	57	100

Note. 1 USD was equivalent to 13,296 IDR at the time of the study

3.3.4 WTP estimates

Maximum likelihood estimation using the log-logistic model was used to determine the coefficients. The log-logistic model is estimated using two models. Model 1 includes all variables, whereas model 2 includes only statistically significant variables. The dependent variable is the probability of answering "yes" to the WTP bid for mangrove restoration. In contrast, the explanatory variables consist of bid levels, sociodemographic characteristics and the respondents' perceptions of mangrove functions.

Table 3.5 shows five variables that impact a respondent's WTP for mangrove restoration. The "bids" variable was statistically significant at 1% and had a negative coefficient. This implies that as the bid amount increased, the likelihood of saying "yes" decreased. Of the sociodemographic characteristics recorded, the only occupation was statistically significant at 1% and had a negative coefficient. The estimated coefficient for planting seedlings was also negative and significant at the 5% level. Furthermore, the variable of responsibility was positive and significant at 5%. Finally, the "nursery" variable

that depicts the mangrove's function as a breeding ground for aquatic organisms was significant at 5% and had a positive coefficient. The mean WTP of the respondents was estimated to be IDR 35,201 (model 1) and IDR 35,413 (model 2). The median value of the WTP was about IDR 32,899 (model 1) and IDR 33,172 (model 2).

Table 3.5 Maximum likelihood estimation results for WTP

Variables	Model 1 (all variables)			Model 2 (statistically significant only)		
	Coeff		Standard Error	Coeff		Standard Error
<i>Constant</i>	28.09	***	1.76	27.27	***	1.64
<i>Bids</i>	-2.66	***	0.16	-2.63	***	0.16
<i>Gender</i>	0.18		0.27	-		-
<i>Age</i>	-0.18		0.15	-		-
<i>Household Resident</i>	-0.01		0.09	-		-
<i>Occupation</i>	0.37		0.27	-		-
<i>Education</i>	-0.77	***	0.29	-0.68	**	0.28
<i>Income</i>	-0.11		0.11	-		-
<i>Planting of mangrove seedlings</i>	0.24		0.25	-		-
<i>Responsibility Nursery</i>	-0.61	**	0.24	-0.68	***	0.23
	0.52	**	0.24	0.47	**	0.23
	0.49	**	0.23	0.47	**	0.22
The number of samples	313			313		
Log Likelihood	-412.46			-416.46		
Mean	35201			35413		
Median	32899			33172		
[95% Confident Interval of Median]	30098-35961			30310-36305		

Note. ***, **, * = Significant at 1%, 5%, and 10%

3.4 Discussion and Conclusions

Up till now, few studies have focused on valuing non-marketed resources and applying CVM to the appraisal of ecosystem services for mangrove restoration in the Mahakam delta. Therefore, we sought to apply CVM to investigate whether sociodemographic characteristics and perceived importance of mangrove ecosystem function the value of local communities' WTP for mangrove restoration. The maximum likelihood estimation results confirmed the hypotheses. As explained previously, mangroves in the Mahakam delta are now facing degradation as a result of urban and industrial development as well as shrimp pond expansion.

The study used the double-bound model rather than an open-ended WTP question format to reduce strategic bias and the elicitation effect (Burton et al., 2003). Several previous studies have also used this method (Zografakis et al., 2010; Lee, C.Y and Heo, 2016). CVM is a stated preference method through which respondents' maximum WTP or minimum willingness to accept a bid in exchange for a corresponding increase or decrease in environmental quality is assessed. Diamond and Hausman (1994) expressed that even though CVM has been applied to calculate the value of a broad range of environmental resources, several criticisms have been raised regarding its ability to produce reliable estimates of WTP. However, by following all of the precautions mentioned above, it is expected that the major limitations of CVM were avoided.

In line with studies conducted by Stone, Bhat, Bhatta, and Mathews (2008) and Tuan et al., (2014), the current findings also indicated a relationship between a respondent's WTP and the bid levels offered, where a higher bid bid amount

decreased WTP for mangrove restoration. Aside from occupation, most of the socioeconomic characteristics of respondents in this study did not significantly influence the WTP of respondents. The results of Tuan et al., (2014) showed a similar trend, but only household size influenced the WTP of respondents in their study.

The study asked respondents to select their preferred mode of participation if were to participate in a future mangrove restoration program. The possible types of participation for mangrove restoration were planting mangrove seedlings, monitoring plant progress and protecting the mangrove area. Table 3.5 shows that respondents who selected planting mangrove seedlings tended to be WTP less than respondents who selected other types of participation. This study also tried to examine the relationship between respondents' feeling of responsibility and their acknowledgement that mangroves can function as aquatic nurseries with their willingness to pay for mangrove restoration. The study confirmed that respondents who said that they have a responsibility toward the sustainable management of mangrove ecosystems were willing to pay more. Similarly, respondents who recognized that mangroves provide a breeding ground for aquatic organisms were prepared to pay more. These results are important because they indicate that if community responsibility and information regarding mangrove functions are increased, community members will be willing to pay more for restoring mangroves.

Chapter 4

The Opportunity Cost of Labor for Valuing Mangrove Restoration²

² Reprinted from: Susilo, H., Takahashi, Y., and Yabe, M. 2017. The Opportunity Cost of Labor for Valuing Mangrove Restoration in Mahakam delta, Indonesia. *Sustainability*, 9(12), 2169. doi: <https://doi.org/10.3390/su9122169>

4.1 Introduction

Many natural ecosystem benefits, including mangroves' benefits, have the characteristics of pure public goods, which means that people can receive the benefit they provide without reducing the level of service received by another beneficiary (e.g., coastal protection, beautiful views, and carbon sequestration). Also, mangroves act as quasi-public goods when the benefit of services by the recipient at a particular level of use does reduce the degree of assistance obtained by others (e.g., feeding and nursery services for fisheries). These characteristics provide the limitations of potential for private incentives to manage sustainable mangroves services, and lack of markets for such services causes market failure on mangrove ecosystems services (Brander et al., 2012). As a result, mangroves are threatened and degraded. Mangroves, moreover, are widely undervalued in both private and public decision-making relating to benefit-cost analyses of conservation and restoration versus other commercial land uses (Salem and Mercer, 2012). Therefore, information on the economic value and accurate estimation for mangrove services as natural capital are necessary for making the best choices relating to conservation and restoration of mangroves. Mostly, mangrove services are undervalued in both private and public-policy relating their non-market services. The lack of information on the economic value of mangrove services has led to neglect in decision making, and the ecological benefits of mangrove as natural capital tends to be rejected when compared directly with the economic value of other public investments services (Brander et al., 2012). As a result, mangroves converted into the instantly profitable venture such as aquaculture, and coastal industries. Relating to the problem of information in

understanding the adequately economic value of mangrove services, it is crucial for policymakers implementing the estimation of mangrove ecosystems values.

Furthermore, mangrove loss could lead to a diminishing of mangrove function as a nursery ground for aquatic organisms, which in turn reducing the marine yield. As a result, the income of communities whose mangroves-based livelihoods decline. Mangrove function, moreover, provides the protected coastal area from natural disasters. Participation of local communities, therefore, is significant to contribute to mangrove conservation and restoration.

The primary objective of this study is valuing the economic value of mangrove restoration using the opportunity cost of labor. This method is applied to measure the willingness to pay (WTP) of mangrove restoration in Mahakam Delta. The adoption of money as a payment vehicle in contingent valuation (CV) is well known for measuring the value of WTP of public goods and environmental quality. It, however, poses certain limitations when applied in developing countries relating low disposable income and imperfect labor markets (Swallow and Woudyalew, 1994; O'Garra, 2009). Using a monetary payment vehicle can confine the households' ability to allocate any part of their income to the restoration program, related to having tight budgets and a low income. This study hopes the results provide the estimation of the value of proper mangrove restoration and contribute to decision makers in the planning of mangroves restoration actions that can embrace and stimulate the willingness of local communities to be involved in mangrove conservation and restoration.

4.2 Methodology

4.2.1 Data Collection and Survey Structure

The study designed a structured questionnaire by conducting a pre-test survey on a sample of 30 randomly chosen households to ensure that respondents had accurate and sufficient information to make them fully understand the hypothetical market situation. This study arranged the questionnaire with three parts. The first section describes the general information about current mangroves' condition in the study area. It also explains the impact of mangrove degradation on local communities' livelihoods, including the advantages of mangrove restoration programs. The second part was comprised of questions for respondents regarding the WTCL for mangrove restoration program. The respondents' duration of labor time was also requested in this part. The last part started by asking the respondents about socioeconomic characteristics including age, gender, education level, income, occupation, number of household members, and residence status. A sample of respondents is selected based on the highest number of households in a village. Two villages (Tani Baru and Muara Pantuan) are currently under the jurisdiction of the Anggana sub-district, and two settlements (Salok Palai and Saliki) are under Muara Badak sub-district. The survey was conducted from April to June 2016 with face-to-face interviews. It required between 30 and 45 min for completing interviews. Of the 380 distributed questionnaires, 364 were completed.

4.2.2 Method

4.2.2.1 Determinants and Intensity of WTCL for Mangrove Restoration

Contingent Valuation Method (CVM) is a widely used economic valuation method for the ecosystem and ecological services. In environmental economics, CVM is applied to estimate the monetary value of changes in non-use values, non-market values or both of environmental resources Venkatachalam, 2004; Huang and Wang, 2015). CVM is based on interviews with people regarding a contingent valuation survey that presents them with a hypothetical scenario to elicit individuals' maximum willingness to pay (WTP) or willingness to accept (WTA). Money is a payment vehicle widely used in contingent valuation (CV) questions (Lankia et al., 2014). In developing countries, however, the application of money as a payment vehicle in CV becomes limited, especially for low-income people who cannot contribute any part of their income for public activities. As an alternative measure in CV, therefore, non-monetary payment in the form of labor contribution is widely used in developing countries (e.g., Asrat et al., 2004; Tilahun et al., 2013; Hung et al., 2007; Arbiol et al., 2013). As a payment vehicle for CV studies, the theoretical framework of using time is used based on the concept of time compensating surplus comparable with a compensating surplus measure of monetary WTP (Arbiol et al., 2013; Eom and Larson, 2006). Based on this framework, we can express the welfare estimates of restoring mangroves in the following:

$$V(M - WTCL, \mathbf{Z}, q^1) = V(M, \mathbf{Z}, q^0) \quad (1)$$

where V denotes the indirect utility function representing the amount of time a respondent is willing to contribute labor ($WTCL$) for mangroves restoration and

also helps to provide a change in environmental quality from unimproved (q^0) to improved (q^1). The labor time contribution to mangrove restoration denotes a payment that reduces availability in respondents' time budget (M) for other activities. Z is the variable indicating the vectors of the socioeconomic status of the respondents.

CV studies take various forms, including open-ended, dichotomous choice, multiple-bounded dichotomous choice, iterative bidding, and payment cards. In this study, we adopt an open-ended CV format to elicit each respondent's willingness to contribute labor ($WTCL$) for mangrove restoration. Respondents who were not interested to contribute labor for mangrove restoration or did not accept the hypothetical scenario defined in the survey were dealing with as having zero values (Ready et al., 1996). Strazzera et al., (2003) stated true zero values could be covered in CV analysis using Tobit model. This model accepted zero values, but it is not observed because of censoring at zero. Application of Least Squares Estimation in open-ended bid formats often produces biased and inconsistent parameter estimates when a dependent variable in the model is censored (Maddala, 1983). Also, useful information will be missing, and there is sample selection bias into the model if we reduce zero values from the sample set. Therefore, the maximum likelihood estimation technique of the Tobit model is used to provide unbiased and suitable parameter estimates (Tobin, 1958).

$$y_i^* = x_i' \beta + e_i, \quad e_i \sim N(0, \sigma^2) \quad (2)$$

where, y_i^* is latent or unobserved willingness to labor for mangrove restoration; β is unknown parameter vector to be estimated; x_i' is a vector of explanatory

variables, e_i is an independently distributed error term assumed to be normally distributed with a zero mean and constant variance σ^2 ; and $i = 1, 2, \dots, n$ represents individual in the sample. The observed dependent variable (y) as follow:

$$y_i = \begin{cases} y^* & \text{if } y^* > 0, \\ 0 & \text{if } y^* \leq 0. \end{cases} \quad (3)$$

The likelihood function for Tobit model as follows:

$$L = \prod_{y_i=0} \left[1 - \Phi\left(\frac{x'_i \beta}{\sigma}\right) \right] \cdot \prod_{y_i>0} \frac{1}{\sigma} \phi\left(\frac{y_i - x'_i \beta}{\sigma}\right) \quad (4)$$

where Φ and ϕ are the distribution and density function, respectively, of the standard normal variable. β represents a vector of Tobit maximum vector likelihood estimates; and σ is the standard error of the error term.

4.2.2.2 Marginal Effects

Marginal effects are the change of predicted probability related to changes in explanatory variables of Tobit model (Andersen et al., 2011). Marginal effects explain the effects of a given explanatory variable on the probability of dependent variable, which coefficients of Tobit model are not able to interpret directly. The formula can be shown as follows:

$$\frac{\partial E[y^*]}{\partial x_k} = \beta_k \quad (5)$$

4.2.2.3 Conversion of Labor Contribution into Monetary Value

In this study, respondents who have positive responses to WTCL provide labor contribution. Meanwhile, those who do not respond to the hypothetical scenario of CV survey are treated as having zero values. Labor contribution will be converted into monetary values to determine the economic value of mangrove restoration based on the assumption that voluntary time of respondents will require an opportunity cost. Respondents who are willing to contribute as labor will be asked about their expected wage rate (IDR per hour) if they are to get paid. Thus, WTCL can be converted into monetary value. The expected wage rate of respondents is used to identify the opportunity cost of time contribution for mangrove restoration.

The opportunity cost of time could be valued using the average monetary contribution of labor (MCL), where $MCL_i = WTCL_i * w_i$ if respondents undertook trade-off between working time and time spent contributing. Therefore, the opportunity cost of time can be estimated in a comparatively straightforward approach using the average MCL as described in Equation (6):

$$Average\ MCL = \frac{\sum[WTCL_i * w_i]}{n} \quad (6)$$

4.3 Results

4.3.1 Descriptive Statistics

Table 4.1 presents descriptive statistics of those surveyed. On average, labor time contribution of interviewees is 9.18 h/month with the distribution ranging from 0 to 80 h/month. Of the 360 samples, 261 respondents (71.70%) were

willing to contribute to mangrove restoration programs, while 103 respondents (28.30%) were not willing and gave a zero value. About 79% of respondents in the study area are male and dominated by households who have three members. The average age of respondents is in the productive life phase indicated by the mean actual age that ranged from 31 to 40 years. We found that 34% of occupation types in the study area were fish farmers and immigrants (66%). On average, education level of respondents is primary school, implying that their work does not require any education background. The average monthly income of respondents ranged between IDR 2 million and IDR 2.9 million (US\$150.42 to US\$218.11).

Table 4.1 Descriptive statistic of the sampled respondents

Variables	Description	Mean	Std. Dev	Min	Max
1. Dependent					
<i>Labor time</i>	Number of hours that households are willing to contribute labor time per month on mangrove restoration program	9.18	10.99	0	80
<i>Monetary contribution of labor</i>	Monetary compensation per labor time received by the household for mangrove restoration program (in IDR thousand/month)	398.76	625.76	0	6400
2. Independent					
<i>Gender</i>	1 if the respondent is male; 0 if female	0.79	0.41	0	1
<i>Age</i>	1 = below 20; 2 = 20–30; 3 = 31–40; 4 = 41–50; 5 = 51–60; 6 = over 60	3.38	1.03	1	6
<i>Family size</i>	Family size of respondents	2.94	1.52	0	7
<i>Occupation</i>	1 if the respondent is fish farmer; 0 if otherwise	0.34	0.47	0	1
<i>Residence status</i>	1 if the respondent is indigenous; 0 if immigrant	0.34	0.48	0	1
<i>Education</i>	1 = never; 2 = primary school;	2.18	0.98	1	5

Variables	Description	Mean	Std. Dev	Min	Max
<i>Income (Million IDR)</i>	3 = secondary school; 4 = high school; 5 = university degree 1 = less than 1; 2 = 1–1.99; 3 = 2–2.99; 4 = 3–3.99; 5 = 4–5; 6 = more than 5	3.18	1.45	1	6
<i>Planting of mangrove seedlings</i>	1 if respondent wants to participate in planting of mangrove seedlings; 0 if otherwise	0.37	0.48	0	1
<i>Responsibility</i>	The responsibility of the local community to mangrove restoration. 1 if respondent agrees; 0 is disagree	0.90	0.30	0	1
<i>Nursery</i>	1 if mangrove benefit as nursery ground; 0 if otherwise	0.40	0.49	0	1

Note. 1 USD was equivalent to 13,296 IDR at the time of the study

Regarding the participation of respondents in mangrove restoration, we asked respondents to select the options of planting mangrove seedlings, monitoring plants' progress and protecting the mangrove area. Only 37% of respondents chose the planting seedlings, and 63% wanted the other options, including respondents were not willing to participate. On average, 90% of them agreed that the restoration of mangroves was their responsibility. The data also shows about 40% of respondents recognize that mangroves ecosystems are a nursery ground for aquatic organisms.

4.3.2 Interest of Household in Salaried Work

Respondents were asked to express their interest in working if money was available as compensation with some questions regarding their passion. If willing to work, they were offered the participation types consisted of planting of mangrove seedlings, monitoring of plants progress, and mangrove areas

protection. As mentioned earlier, only 261 households or 71.70% were willing to contribute to mangrove restoration. We offered them some alternatives of participation including the planting of mangrove seedlings, monitoring of plants' progress, and mangrove areas protection. Table 2 reveals that among 261 households, 134 (51.34%) select planting of mangrove seedlings as their preferences, 86 homes (32.95%) choose the monitoring of plants' progress and the remaining 41 households (15.71%) select mangrove areas protection.

Table 4.2 Restoration work preferences of households

Participation	Frequency	Percent	Cumulative
Planting of mangrove seedlings	134	51.34	51.34
Monitoring of plants progress	86	32.95	84.29
Mangrove areas protection	41	15.71	100.00

4.3.3 Willingness to Contribute Labor (WTCL) and Monetary Contribution of Labor (MCL)

As explained in Section 2, households were asked whether they would be willing to contribute labor for the mangrove restoration program. Those who were ready to participate were then asked how many hours per day, how many days per week and how many weeks per month they would be prepared to contribute. Results in Table 4.3 show that households that select WTCL below 10 h per month or 2.5 h per week are dominant, with 143 respondents (54.79% of the sample), followed by 10–30 h per month of 101 households, or 38.70%. WTCL with a duration of 51–70 h per month and length of above 70 h per month are the

fewest working hours that participants choose, namely three households (1.15%) and one family (0.38%), respectively.

Out of the 261 households, about 66.28% (n = 173) have a MCL amount below IDR 500 thousand (US\$37.61) per month with a contribution time between 4 and 16 h per month. Besides, about 59 households or 22.61% have MCL value range between IDR 500 thousand (US\$37.61) and IDR 1 million (US\$75.21) monthly with contribution time between 8 and 36 h per month. Only 2.68% of respondents or seven households have MCL value above IDR 2 million (US\$150.42) per month with contribution time between 36 and 80 h per month.

Table 4.3 Distribution of willingness to contribute labor (WTCL) and monetary contribution of labor (MCL)

WTCL			MCL		
Hours/ Month	Freq	%	IDR 000/Month	Freq	%
> 10	143	54.79	> 500	173	66.28
10–30	101	38.70	500–1000	59	22.61
31–50	13	4.98	1001–1500	16	6.13
51–70	3	1.15	1501–2000	6	2.30
70 <	1	0.38	2000 <	7	2.68

Note. 1 USD was equivalent to 13,296 IDR at the time of the study

4.3.4 Monetary Value of Mangrove Restoration

The opportunity cost of time using the average monetary contribution of labor where households are WTCL to mangroves restoration is valued at IDR 398.76 thousand (US\$29.99) a month or IDR 4.79 million (US\$359.90) per year. The estimated benefits of mangrove restoration were determined as the estimated annual opportunity cost of time, the number of households, and the questionnaire response rate. Table 4.4 shows that the number of homes living in the Mahakam

Delta was 31,241. Of 380 questionnaires distributed, 364 respondents responded (thus, the survey response rate was computed as $364/380 = 0.96$). Therefore, a total annual benefit of mangrove restoration using the MCL is IDR 143 billion (US\$10.77 million) per year. These values reflect 0.12% of GDP of Kutai Kartanegara Regency, valued at IDR 117,461 billion or equivalent to US\$8.83 billion (Central Bureau of Statistics, 2017).

Table 4.4 The economic value of mangrove restoration

Description	
Number of samples (respondent)	364
Number of distributed questionnaires (respondent)	380
Questionnaire response	0.96
Number of households (person)	31,241
Opportunity cost of time (IDR million/year)	4.79
Annual benefit (IDR billion/year)	143

Note. 1 USD was equivalent to 13,296 IDR at the time of the study

4.3.5 Parameter Estimates of Willingness to Contribute

Table 4.5 shows the results of the estimated parameters and marginal effects of the independent variables that were hypothesized to influence households' labor time and MCL for mangrove restoration. The estimated Tobit model is determined to be the good fit of the model as the value of the Likelihood Ratio-Chi-Square test (124.88) is significant at 1% level of significance. Of 10 independent variables considered in the Tobit model, five variables affect willingness to provide labor time and MCL significantly for mangrove restoration. Based on the obtained results, for labor time, planting of mangrove seedling and responsibility variables are statistically significant at 1% and have a positive coefficient. The estimated coefficient for nursery depicting mangrove's biological

function as a breeding ground for fish, shrimp, and crab is also positive and significant at the 5% level. Meanwhile, family size and income variables are considerable at 1% and have a negative coefficient. The results in Tables 5 also indicate gender, planting of mangrove seedling, and responsibility variables have a positive coefficient with statistically significant influence on MCL at 10%, 1%, and 5%, respectively. Family size and income variables, meanwhile, are statistically significant at 1% and have a negative coefficient.

Table 4.5 Comparison between tobit model estimates of willing to contribute labor (WTCL) and MCL for mangrove restoration

Variables	WTCL			MCL		
	Coeff	<i>t</i> -Value	ME	Coeff	<i>t</i> -Value	ME
<i>Constant</i>	7.45 *	1.73		114.08	0.46	
<i>Gender</i>	1.19	0.74	0.03	165.27 *	1.79	0.09
<i>Age</i>	0.71	1.09	0.02	51.69	1.40	0.03
<i>Family size</i>	-1.87 ***	-4.06	-0.05	-81.7 ***	-3.10	-0.05
<i>Resident</i>	-1.64	-1.15	-0.05	-62.78	-0.77	-0.04
<i>Occupation</i>	0.53	0.33	0.02	-21.99	-0.24	-0.01
<i>Education</i>	0.43	0.61	0.01	18.14	0.45	0.01
<i>Income</i>	-3.51 ***	-6.55	-0.10	-170.42 ***	-5.56	-0.10
<i>Planting of mangrove seedlings</i>	7.98 ***	5.52	0.23	592.2 ***	7.17	0.33
<i>Responsibility</i>	8.37 ***	3.45	0.24	361.74 **	2.59	0.20
<i>Nursery</i>	3.32 **	2.45	0.10	99.96	1.28	0.06
Log Likelihood	-1090.46			-2135.96		
LR χ^2 (10)	124.88 ***			122.48 ***		
Pseudo R ²	0.0542			0.0279		

Note: ME is marginal effects; ***, **, and * indicate significance level at 1%, 5%, and 10% respectively.

Gender has a significantly positive relationship with MCL ($p < 0.10$) that indicates male respondents expect to obtain considerably higher MCL in mangrove restoration programs than female respondents do. The marginal effect

of gender presents that when households that contribute labor time for restoring mangroves are male, the probability of MCL increases by 9%. Furthermore, the parameter estimate of the family size variable is negative and significant toward both labor time contribution and MCL with the p -value less than 0.01. It expresses that households with larger family size contribute less labor time and expected MCL than households that have relatively smaller family size. The result of the marginal effects in Table 4.5 also displays that when the family size of the household increases by one member, then the probability of a household's labor time and expected MCL declined to 5%.

Similarity, the other variable that had a negative and significant effect on both labor time contribution and MCL was income with the p -value less than 0.01. This indicates that households with lower income contribute more labor time and expected MCL than those with higher incomes. The marginal effect shows that a one-rupiah increase in a household's income will decrease the probability of labor time and expected MCL to 10%.

Additionally, planting of mangrove seedlings as participation type selected by the household has a positive and significant influence on both labor time contribution and MCL ($p < 0.01$). It demonstrates that a family that chooses this participation type has more labor time and expected MCL than other participation models. The marginal effect also shows that when a household that decides to plant of mangrove seedlings increases by one family member, the probability of a household's labor time and expected MCL increases by 23% and 33%, respectively. Interestingly, WTP results reported by Susilo et al., (2017) shows that a household who selects planting of mangrove seedlings tends to be less

willing to pay for mangrove restoration, or in other words, respondents who selected other participation types such as the monitoring of plant progress and the protection of the mangrove area are more willing to pay. Thus, this WTCL result confirms that a household prefers to donate time to contribute labor than to pay.

As expected, households that agreed about the protection of mangroves have a positive sign and significant effect on both labor time contribution and MCL with the p -value less than 0.01 and 0.05, respectively. It proves that households are willing to contribute more time for labor and expected MCL toward mangroves protection. Correctly, the marginal effect shows that every home that agrees to be responsible for mangrove protection increases the probability of labor time by nearly 24% and the chance of MCL by 20%.

As explained earlier, mangroves have multiple benefits such as providing a nursery ground for aquatic organisms, protecting coastal areas from tidal waves and erosion, improving water quality, controlling sediment and encouraging ecotourism. Households that selected mangroves as nursery ground are more willing to make a contribution of labor time than other chosen benefits. Results from the marginal effects also show that when a household that picked it increases, it also increases the probability of a family being willing to contribute labor to 10% and expected MCL increases by 6%.

4.4 Discussion and Conclusions

Some attractive finding emerged from the study. Firstly, compared to reference Susilo et al., (2017), results revealed that MCL based on a labor payment vehicle provided a higher mean than the mean WTP value under a

monetary payment vehicle. In line with studies conducted by Hung et al., households in this study are more likely to state a real WTCL than to donate money for mangrove restoration. Contrary to the situation in developed countries, where payment vehicles are appreciated only in money terms, in a context of developing countries, payment vehicles as a donation or a pay money are impractical for poor households with tight budgets. Thus, households cannot convey their appreciation of environmental programs.

Secondly, family size and income have a significant effect with a negative sign on the willingness to contribute. It is possible that households with larger family size dedicate more attention to their families and have a high cost of living. Therefore, they are too busy with their primary occupations to meet the needs of their family and cannot spare the time or less willing to contribute labor to mangrove restoration. Furthermore, the tendency of the household with higher income is to be less willing to give work than households with lower incomes are. This finding might be explained because mangroves ecosystems are public goods, and the presence of free-riding behavior in the valuation of common-property resources causes small WTCL values. However, in comparison with WTP results from Susilo et al., (2017), although not statistically significant, a household's income has a positive sign, showing that those with higher incomes are more willing to pay for mangrove restoration. It revealed that those who have lower earnings in the study area were more willing to donate time than to give money for mangrove restoration. According to Arbiol et al., (2013), within the context of developing countries, the use of labor time as a payment vehicle in CV is more

precise than the use of money, related to the fact that disposable income is low (O'garra, 2009).

Another finding is that planting of mangrove seedlings as one of participation type has a significant influence with a positive sign on the willingness to contribute. The local community is familiar with mangrove planting programs. Since mangroves have been massively degraded in the study area, the local community is aware of mangrove planting activity. Governments, NGOs, the private sector and universities have raised funds and involved local communities in planting mangrove seedlings as part of mangrove restoration actions.

Lastly, this study also examines households' responses towards their responsibility and their knowledge about mangroves' functions with the willingness to contribute to mangrove restoration. This study revealed that households believed that they were also responsible for the sustainability of mangrove forests were willing to provide more. This finding is essential in this study because it shows that if households' responsibility is enhanced, they will provide more value for restoring mangrove ecosystems. Similar to the results by Tuan et al., (2014), local community's awareness and responsibility for the impact of climate change provided significant implications toward their willingness to participate in mangrove restoration. Furthermore, knowledge about mangrove functions may increase local community interest in participating in mangrove restoration. Fish farmers and fishermen are the occupation type that dominate in the study area. Those who recognized that mangroves function as a nursery

ground for aquatic organisms and provided benefits for their communities had higher levels of willingness to contribute.

These findings of the study must be explained to deal with several limitations. First, use of an expected wage of households to identify the opportunity cost of time contribution might result in overestimation. For instance, in comparison, we use a minimum wage stipulated by the Governor of East Kalimantan Province Regulation No 561/K.573 of 2016 to replace the using of expected wage from of households. This regulation stipulated minimum wage for 2017 is IDR 2.33 million (US\$175.96) a month. According to Indonesian labor law no 13 of 2003 that the working hours are 40 h a week or 160 h a month, thus, the minimum wage used is IDR 14.62 thousand (US\$1.10) an hour. The opportunity cost of time under a minimum wage brings the value of mangrove restoration down to 3.24 times from an expected wage. Future studies could be considered by offering to respondents regarding an expected wage by households and a minimum wage stipulated by the local government simultaneously, and then compare them to identify the true preference of respondents in determining willingness to contribute labor.

Another limitation of is that some variations of WTCL values are found regarding the large range between some zero responses and a few high WTCL values (maximum 80 h/month) when using an open-ended question format. The way this form was applied made it less sensitive to components in the questionnaire, and the lack of incentive compatibility gives rise to a free-ride from respondents (Arbiol et al., 2013). It is an exciting finding that merits further studies to explore the use of dichotomous question formats. Loomis et al., (1997)

noted that the dichotomous question format is a suitable incentive device for respondents to express true preferences about a provision of the goods.

Chapter 5

**Environmental Cost-Benefit
Analysis (ECBA) of Mangrove
Restoration**

5.1 Introduction

Cost-benefit analysis (CBA) is an instrument that can be used by policymakers to quantify the perceived value of all the benefits and costs of a project. Initially, CBA applies to the assessed feasibility of investment instead of for policy assessment. However, CBA has also drawn up to measure the viability of alternative public policies (Pearce, 1998). In the practice of carrying out appraisals, CBA has transformed over the last two decades. CBA also applies for environmental applications determining the cost-benefit evaluations of policies and projects to improve the provision of ecological services (Atkinson and Mourato, 2008). Eventually, this approach has been reconstructed into the environmental cost-benefit analysis (ECBA) that reflected a design of conceptual and empirical developments, especially in environmental economics.

Perman et al., (2011) divides two main ways to understand CBA associated with the environment. Firstly, projects expected to obtain benefits in the format of the provision of goods and services have environmental impacts. This impact is externalities as results of market failure and does not appear in private or commercial assessments. Commonly, the costs of externalities are not included or understated in an ordinary financial assessment. Secondly, projects that have the primary goal to receive beneficial environmental impacts (e.g., the construction of a waste treatment plant). The consequences also include external effects and so would not show in an ordinary financial assessment. In addition, Atkinson and Mourato (2008) state that in the implementation, ECBA is different from CBA for the private sector. ECBA considered the provision of environmental services or

human reactions influencing the environment as an economic assessment of policies and projects.

Mostly, the basic strategy of CBA for all cases is similar. ECBA, however, involves monetary values to the environmental impacts both desired and undesired. The environmental effects are calculated as inputs or outputs in the same way as an ordinary appraisal in the project. To determine the value of environmental impacts, economists have developed methods to effects of environment that can be calculated in CBA. Atkinson and Mourato (2008) mentioned that two principal ways determining an economic value of non-market goods and services, namely revealed preference (RP) and stated preference (SP) approaches.

5.2 Methodology

5.2.1 Determination of Costs and Benefits Variables

Costs variable derived from the project of mangrove restoration in 2014 conducted by the collaboration between Planete Urgence, the project financier, and Yayasan Mangrove Lestari, a local non-governmental organization through the Mahakam Delta Integrated Management Program (MADIMAP) in around Muara Badak village. In this project, a total of 39,575 mangrove seedlings were planted along the river. Benefits variable is obtained the mean of WTP and WTCL from Chapter 3 and Chapter 4. This chapter used the unit value transfers method of the benefits transfer approach to estimate the WTP value in Muara Badak sub-district (the policy site) based on the WTP value from the Mahakam Delta region (the study site). This method enables the applications of quantitative estimates of

non-market ecosystem service values to another site where direct evaluation cannot be carried out. The “policy site” refers to the area to which the estimated values are applied (Johnston et al., 2015). Muara Badak village is located in Muara Badak sub-district in the Mahakam Delta region. This village has a demographic makeup that is similar to other villages in the Mahakam Delta. Johnston et al., (2015) stated that one of the requirements to conduct transfer benefits analysis was that the policy site should not be geographically different from the study site. The formula of benefit transfers is as follows:

$$WTP_p/WTCL_p = WTP_s/WTCL_s \left(Y_p/Y_s \right)^\beta \quad (1)$$

Where, $WTP_p/WTCL_p$ is the mean WTP estimate from the policy site, $WTP_s/WTCL_s$ is the mean WTP estimated at the study site. Y_p and Y_s are mean the income levels (regional GDP per capita) at the policy and the study sites, respectively, and β is the income elasticity of WTP for environmental good. Of the various environmental goods, Income elasticity of WTP is smaller than 1, and generally in the 0.4-0.7 range.

5.2.2 Investment Evaluation Criteria

Investment evaluation criteria are applied to evaluate an economically viable mangrove restoration program or not. In this study, the evaluation criteria of mangrove restoration in Mahakam Delta involve NPV, BCR, and IRR.

5.2.2.1 Net Present Value (NPV)

NPV is one of the most investment evaluation criteria used in capital budgeting to analyze the feasibility of a projected investment or policy assessment. NPV analysis distinguishes between the present value of cash inflows and the present value of cash outflows in an investment project over a period. The result of NPV analysis provides three interpretations. Firstly, positive NPV that depicts present value of cash inflows (the benefits) is higher than the present value of cash outflows (the costs) and the investment is considered to be acceptable. Secondly, zero NPV that represents the present value of cash inflow (the benefits) and the present value of cash outflow (the costs) is equal, and the investment is considered to be tolerable. Lastly, negative NPV that shows the present value of cash inflow (the benefits) is less than the present value of cash outflow (the costs) and the investment is rejected. The formula of NPV as follows:

$$NPV = \sum_{t=0}^n \frac{B_t - C_t}{(1+r)^t} \quad (2)$$

where B_t and C_t denote the present value of benefits and costs at the time, respectively. t represents the year, and r is the interest rate.

5.2.2.2 Benefit-Cost Ratio (BCR)

BCR applies to determine the relationship between the discounted benefits and the discounted costs in a projected investment or policy assessment over a period. Two interpretations of BCR results are a planned investment or policy assessment will be accepted or can be considered economically justified if the

BCR above 1 or higher than 1. Whereas, if the BCR below 1 or less than one then the project should be denied. The formula of BCR as follows:

$$BCR = \frac{\sum_{t=0}^n \frac{B_t}{(1+r)^t}}{\sum_{t=0}^n \frac{C_t}{(1+r)^t}} \quad (3)$$

where B_t and C_t denote the present value of benefits and costs at the time, respectively. t represents the year, and r is the interest rate.

5.2.2.3 Internal Rate of Return (IRR)

IRR is applied to evaluate and compare the profitability of potential investments. Mostly, IRR analysis assesses the desirability of a project, which a plan is acceptable or desirable if the IRR exceeds a project's required rate of return. The higher a project's IRR, then a project is more desirable or feasible to undertake. The formula of IRR as follows:

$$IRR = i_1 + \frac{NPV_1}{(NPV_1 - NPV_2)} (i_2 - i_1) \quad (4)$$

where, i_1 and i_2 denote discount rate which produces positive NPV and negative NPV, respectively. NPV_1 and NPV_2 represent positive net present value and negative in each.

5.3 Results

5.3.1 Benefits of Mangrove Restoration

To determine the benefits of this mangrove restoration project, the unit value transfers method of the benefits transfer approach was applied to estimate the WTP value in Muara Badak sub-district (the policy site) based on the WTP value from the Mahakam delta region (the study site). The mean WTP/WTCL values for the Mahakam Delta (study site) from Chapter 3 and Chapter 4 were IDR 422,412 per year or US\$31.77 (WTP) and IDR 4.79 million or US\$359.90 (WTCL), respectively. The report of Statistics Indonesia (BPS) (2015) noted that the regional GDPs per capita of Anggana and Muara Badak sub-districts were IDR 100.5 million and 118.1 million (policy site), respectively. Assumed, the average income level of the study site based on the average GDP per capita from two sub-districts (study site) was IDR 109.3 million. Also, the income elasticity of WTP for environmental good was 0.4, Therefore, using the formula in Section 5.2.1, the mean WTP/WTCL values at the policy site were determined to be IDR 408,465 per year or US\$30.72 (WTP) and IDR 4.63 million or US\$348.01 (WTCL), respectively.

The estimated benefit of mangrove restoration in Muara Badak village was determined as the product of the mean WTP and mean WTCL per year, the number of households who lived around the project area, and the questionnaire response rate. Table 5.1 shows the annual mean WTP and mean WTCL per household was valued at IDR 408,465 and IDR 4.63 million in each; the number of families was 1,229 households; and the questionnaire response rate was computed as 0.86 (WTP) and 0.96 (WTCL). Therefore, the yearly benefit of

mangrove restoration can be calculated as IDR 0.43 billion or US\$32.47 thousand for WTP and IDR 5.45 billion or US\$409.69 thousand for WTCL.

Table 5.1 Benefits of mangrove restoration

Description	WTP	WTCL
Mean (IDR/year)	408,465	4,627,125
No. Households	1,229	1,229
No. respondents	364	380
WTP respondents	313	364
Return Rate	0.86	0.96
Income (IDR Billion/year)	0.43	5.45

Note. 1 USD was equivalent to 13,296 IDR at the time of the study

5.3.2 Costs of Mangrove Restoration

As mentioned in section 5.2.1, The estimated initial costs of the restoration project for a total of 39,575 mangrove seedlings were IDR 68.28 million (US\$5.14 thousand) which included the cost of the seedlings, bamboo poles, labor, and transportation (Table 5.2). Maintenance costs (started in first year) were estimated at IDR 9 million in annual (US\$0.68 thousand annually).

Table 5.2 Costs of mangrove restoration

Description	IDR
(I) Initial costs	
<i>Seedlings</i>	39,575,000
<i>Bamboo pole</i>	3,957,500
<i>Labor for planting</i>	23,745,000
<i>Transportation</i>	1,000,000
<i>Total initial cost</i>	68,277,500
(II) Maintenance costs	
<i>Seedlings for replanting (year)</i>	5,000,000
<i>Labor for monitoring</i>	3,000,000

Description	IDR
<i>Transportation</i>	1,000,000
<i>Total maintenance cost (year)</i>	9,000,000

Note. 1 USD was equivalent to 13,296 IDR at the time of the study

5.3.3 Economic Feasibility of Mangrove Restoration

To appraise the economic feasibility of mangrove restoration based on the time value of money, NPV, BCR, and IRR are applied as accepted evaluation criteria for evaluating the economic viability of the program. There are three assumptions used in this cost-benefit analysis. First, according to a local biologist, the mangrove ecosystem benefits will start accruing in the fifth year of the project. Second, the maintenance and protection costs start in the first year, and after four years, the costs are assumed to be 50% of the initial maintenance costs. Third, the discount rate used is 4% according to Sala et al., (2016) that stated standard discount rates for environmental projects are between 4 and 8%.

Two options for life of the project are used to evaluate the feasibility of the project. Taking into account the mangrove ecosystem benefits will start accruing in the fifth year of the project, then the life of project five years is considered to evaluate the feasibility of the project in the short term. Another option is the life of the project ten years to assess the viability of the project in the long run.

Table 5.3 provides the estimated present value of benefit and cost, NPV, BCR, and IRR in a discount rate of 4% and a lifetime evaluation period of five and ten years, respectively. As mentioned previously, there are two estimations used in this CBA: WTP estimated, and WTCL estimated. The present value of benefit to WTP estimated for life of the project in five and ten years is IDR 354.80 million (US\$26.68 thousand) and IDR 1,934.30 million (US\$145.48

thousand), respectively. While, with WTCL estimated, the present value of benefit is IDR 4,477.28 million or US\$336.74 thousand (5 years) and IDR 24409.33 million or US\$1,835.84 thousand (10 years). Furthermore, the present value of cost in all projects reaches about IDR 104.65 million or US\$7.87 thousand for life of project five years and IDR 121.11 million or US\$9.11 thousand for life of project ten years.

The quantified values of various investment evaluation criteria are also given in Table 5.3. The amount of NPV was calculated as IDR 250.15 million or US\$18.81 thousand for WTP estimated. While IDR 4,372.63 million or US\$328.87 thousand for WTCL estimated in a life of project five years, respectively for the WTP estimated of IDR 1,813.19 million (US\$136.37 thousand) and WTCL estimated of IDR 24,288.22 million (US\$1,826.73 thousand) in a life of project ten years. All estimations and the life of the projects presented NPV greater than zero, indicating that the present value of benefit for mangrove restoration project is higher than the present value of all investment and maintenance costs of mangrove restoration. Hence, NPV values indicate that the mangrove restoration project is economically feasible.

The BCR is rated as the expected net benefits of the mangrove restoration project over both five years and ten years projected lives and evaluated at a 4% discount rate. Using WTP and WTCL estimated, BCR values for life project of five years are between 3.39 and 42.79, respectively. For life project of ten years, BCR values range between 15.97 and 201.55. The BCR values are greater than one implying that for each IDR 1 invested at a discount rate of 4%, a return of IDR 3.39 to IDR 42.79 (life project of five years) and ranging from IDR 15.97 to

IDR 201.55 (life project of ten years) are obtained. This result indicates that the mangrove restoration project is economically feasible.

The IRR is determined as the expected rate of return that will be obtained on the mangrove restoration project. For life project of five years using WTP and WTCL estimated, IRR values reach between 37.97% and 135.78%, respectively. Furthermore, IRR values range from 66.36% to 160.27% in the life project of ten years. IRR values are higher than the discounted rate approved by standard discount rates for environmental projects (4%) and explaining that the project is profitable.

Table 5.3 Cost-benefit analysis of mangrove restoration

Description	Life of project 5 years		Life of project 10 years	
	WTP	WTCL	WTP	WTCL
Present Value of Benefit (IDR million)	354.80	4477.28	1934.30	24409.33
Present Value of Cost (IDR million)	104.65	104.65	121.11	121.11
Discount Rate (%)	4.00	4.00	4.00	4.00
NPV (IDR million)	250.15	4372.63	1813.19	24288.22
BCR (times)	3.39	42.79	15.97	201.55
IRR (%)	37.97	135.78	66.36	160.27

Note. 1 USD was equivalent to 13,296 IDR at the time of the study

5.3.4 Sensitivity Analysis

Sensitivity analyses were conducted to investigate the uncertainty of the project against the change of the economic situation in the future. This analysis considers the different discount rate used in mangrove restoration project. In various environmental literatures, the interest rate in the discount rate way is deemed to affect ecological resources. Higher discount rates cause heightened exploitation of environmental resources. The changes of the discount rate for

long-term mangrove restoration can produce a difference in the present value of new benefits. Hence, the discount rate scenario is considered in sensitivity analysis.

The scenario applies the discount rate of 4 (initial base) and 8 percent referring standard discount rate for environmental projects, While the discount rate of 10% and 15% see to the interest rate of commercial banks in the study area. Results of sensitivity analysis in Table 5.4 show that although the increase of the discount rate leads NPV and BCR values to reduce. However, all simulated discount rate scenarios present that NPV and BCR values are still positive. At a discount rate of 15%, NPV varies between IDR 118.41 million (US\$8.91 thousand) and IDR 2,612.06 million (US\$196.45 thousand) in the life project of five years. All of them are higher than zero indicating a mangrove restoration project could still be profitable. Furthermore, BCR values even reach between 2.23 and 28.15 at a discount rate of 15% in the life project of five years. All of the BCR values are greater than 1 implying the project could still be viable.

Table 5.4 Sensitivity analysis of mangrove restoration in life of project five years

Discount Rate (%)	NPV (IDR million)		BCR (times)	
	WTP	WTCL	WTP	WTCL
4	250.15	4372.63	3.39	42.79
8	192.64	3606.19	2.90	36.65
10	168.43	3282.74	2.69	33.96
15	118.41	2612.06	2.23	28.15

Note. 1 USD was equivalent to 13,296 IDR at the time of the study

5.4 Discussion and Conclusions

The findings of this study conclude that mangrove restoration project provided valuable benefits for the sustainability of local livelihoods and crucial information to improve the sustainable use of mangroves in the future. Assuming a discount rate of 4% based on the environment of interest rates and a project life of 5 years, investing in mangrove restoration produced the present value of cost about IDR 104.65 million (US\$7.87 thousand). It was less than the estimated benefits attained from mangrove restoration according to WTP and WTCL, which ranged from IDR 354.80 million (US\$26.68 thousand) to IDR 4477.28 million (US\$336.74 thousand). All evaluation criteria also indicated that the mangrove restoration project was economically feasible and all simulated discount rate scenarios presented that NPV and BCR values were still positive changed in different discount rate of from 4% to 15%.

Mangrove restoration will provide benefits for a much longer period. A project life of 10 years, for example, results in the BCR of approximately 15.97-201.55. In other words, for each IDR 1 invested at a discount rate of 4%, a return of IDR 15.97 to IDR 201.55 in the life project of ten years are obtained. Thus, mangrove restoration project in the study area is a viable plan that should be implemented.

Chapter 6

Impact of Silvofishery Adoption on Farmers' Income and Its Determinants in Adoption³

³ Reprinted from: Susilo, H., Takahashi, Y., Sato, G., Nomura, H., and Yabe, M. (2018). The Adoption of Silvofishery System to restore Mangrove Ecosystems and Its Impact on Farmers' Income in Mahakam Delta, Indonesia. *Journal of Faculty of Agriculture Kyushu University* (In press).

6.1 Introduction

East Kalimantan Province is the second-largest area of mangrove forests in Indonesia, covering more than 364 thousand hectares or over 11% of the country's total mangrove area. The mangrove ecosystem in this province has played a crucial role in contributing to the ecological benefits for local communities, primarily direct-use values such as fishing, aquaculture, and fuelwood use (Susilo *et al.*, 2017). One of East Kalimantan's mangrove areas is the Mahakam Delta. The Mahakam Delta has a unique fan-shape and consists of 46 small islands that have been formed by the deposition of suspended solids over time (Sidik, 2009). In the 1950s, the expanse of mangrove as the original vegetation dominated this area with a total area of 106 thousand hectares (Bourgeois *et al.*, 2002). At the time, *Nypa* was the most prominent mangrove species covering 55% of the entire region and the most significant pure *Nypa* vegetation site in the world (Creocean, 2000). However, the continuous degradation of mangrove forests in this delta has reduced mangrove coverage to around 29 thousand hectares. From 1992 to 2009, there was a 72% decrease in the mangrove area (Susilo *et al.* 2017a).

As a result, the Indonesian government has taken steps to design and implement programs directed towards the recovery and management of its mangrove ecosystems. Integrated mangrove-shrimp farming, also called silvofishery, is one of the strategies promoted by the government to combine the economic needs of coastal communities and conserve mangrove resources. Silvofishery, which is locally known as *wanamina*, is a form of integrated coastal farming system that combines brackish water aquaculture with mangrove

conservation. It was first implemented in Indonesia in 1978 through a national cooperation program in research and has since been actively promoted by the Ministry of Environment and Forestry (MEF) the Ministry of Marine Affairs and Fisheries (MMF) and academic institutions (Fitzgerald, 1999). After 20 years, the silvofishery model has been implemented across several regions by local government units (Takashima, 1999).

Silvofishery is a sustainable alternative to shrimp pond development without compromising for the economic welfare of farmers and at the same time support conservation efforts of mangrove ecosystems. This issue is firmly related to sustainable development and to diminish inherent conflicts between shrimp pond development and mangrove conservation. The benefits from silvofishery in Indonesia is well-documented (e.g., Sukardjo, 1999; Takashima, 1999). Moreover, previous studies on aquaculture development in Mahakam Delta also give encouraging evidence for development (e.g., Bosma *et al.* 2012; Bunting *et al.* 2013; Rahman *et al.* 2013; Fauzi *et al.* 2013). However, the silvofishery system still hasn't gained a favorable reception from local communities, mainly fish farmers in the Mahakam Delta. Silvofishery lack of popularity is related to lack of education, behavior that even comfortable with old system or extensive aquaculture system, and disbelief that the new system will increase their income. There is a disparity in information and knowledge to the extent of silvofishery' power to improve the welfare of small-scale farmers and how this system affects farmers' income in the study area. Therefore, appraisal of the feasibility of the silvofishery adoption regarding the income of farmers is required.

As explained above, this study will focus on silvofishery system adoption and its impact toward the income of small-scale farmers. We also determined the primary driving factors that affect farmers' approval of the silvofishery scheme. The results provide useful insights for countries, especially developing countries to overcome the conflict between the livelihoods of local communities and ecology conservation. Also, the study contributes to the literature on the impact of adoption of the silvofishery farming system on small-scale farmer welfare in the Mahakam Delta.

6.2 Methods and Data Collection

6.2.1 Adoption Decision

We employ a logit model to analyze the factors influencing the farmer's decision to adopt the silvofishery system. We assume that farmer will select to adopt the silvofishery only if the expected net benefits from adoption are positive and vice versa. The adoption benefits include improving farmers' income. The logit model can be written as follows:

$$U_i^* = \beta_i X_i + \mu_1 \quad (1)$$

where, U_i^* is a latent variable reflecting the net benefit of adopting the silvofishery, β_i is the vector of logistic regression coefficients, X_i is the vector of I explanatory variables, and μ_1 is the error term. As U_i^* is not observable, then:

$$U_i = \begin{cases} 1 & \text{if } U_i^* > 0 \\ 0 & \text{if } U_i^* \leq 0 \end{cases} \quad (2)$$

where, U_i represents that farmer will adopt the silvofishery system ($U_i=1$) only if the net benefits from adoption are positive ($U_i^* > 0$). Otherwise, farmer will not adopt ($U_i=0$) if the net benefits are non-positive.

6.2.2 Propensity Score Matching

Since cross-sectional data was used, the effect of adoption could be estimated by differentiating the outcome of adoption and non-adoption directly. These estimates, however, may be ambiguous and biased when counterfactual information is not available (Abid *et al.* 2016). The issue of self-selection bias becomes essential when calculating the net impact of adoption on farmer' income. For a non-randomized design, the PSM is one of several econometric approaches to solve the problem of selection bias. The PSM is a form of causal inference to design a balanced sample between the treatment (silvofishery adoption) and control (non-adaption) groups based on propensity scores. The propensity score is characterized as the conditional probability of receiving adoption or treatment (Rosenbaum and Rubin, 1983). The inference of silvofishery adoption impact is reasonable when comparing two farmer groups with identical observable characteristics. Following Rosenbaum and Rubin (1983), the PSM has implied the conditional probability that a farmer adopts the silvofishery, given pre-adaptation characteristics.

The PSM applies the conditional independence assumption (CIA) to create a statistical comparison group by matching both groups of adopters and non-adopters according to on the similarity of predicted probabilities of adopting the silvofishery (p-score). The CIA can be represented as:

$$(Y_0, Y_1) \perp U | X \quad (3)$$

The CIA states that for the set of observed covariates X is independent of possible outcomes. In other words, the participation in the adopting program is considered that does not depend on results, when the variation in findings created by differences in X has been controlled. This assumption states that the counterfactual income indicator in the adopted group is the same as the observed income for the non-adopted group. Then, the PSM as the first step can be denoted as:

$$P(X_i) = \Pr(U_i = 1 | X_i) < 1 \quad (4)$$

where P indicates the propensity scores of pre-adoption characteristics (X_i), $U_i = \{0,1\}$ shows an indicator for adoption, and P_r is the probability. The conditional distribution of X_i , given $P(X_i)$ is similar in both groups. In this study, logit regression is used as the first step to determine the propensity score for estimating the likelihood of adopting the silvofishery system.

The second step of PSM is to determine the average treatment effect on the treated (ATT) to estimate the impact of adoption on income variable. To identify the ATT, let we start to define the treatment effect (TE) following Rosenbaum and Rubin (1983) as the difference between the outcomes of farmers who adopted the silvofishery system and that the results of farmers who did not adopt the silvofishery system. It can be estimated as follows:

$$\tau_{TE} = Y_1 - Y_0 \quad (5)$$

in which Y_1 and Y_0 are, respectively, the outcome variables of farmers for adopters and non-adopters. Furthermore, the Average Treatment Effect (ATE) is computed

to determine the effect of silvofishery adoption on farmer income. The ATE can be expressed as follows:

$$\tau_{ATE} = E(Y_1 - Y_0) \quad (6)$$

ATE shows the average difference between the outcome of adopters and non-adopters. It also represents the overall impact of adoption on the outcome variables referring all farmers as respondents. As noted by Cameron and Trivedi (2005), the ATE proportion will be applicable if the adoption has universal application. Therefore, considering the hypothetical gain of adopting a randomly selected member of the population is feasible. In this study, because the respondent of silvofishery adoption is not chosen randomly, we employ the Average Treatment on Treated (ATT) to estimate the effect of silvofishery adoption on those who have adopted silvofishery. It can be written as follows:

$$\tau_{ATT} = E(Y_1 - Y_0|D = 1) = E(Y_1|D = 1) - E(Y_0|D = 1) \quad (7)$$

where $D = 1$ denotes a farmer as adopter and $D = 0$ indicates a farmer as non-adopter. Although we can determine $E(Y_1|D = 1)$, we cannot observe $E(Y_0|D = 1)$ because it is the outcome farmer would have experienced if they had not been involved. Therefore, the CIA as explained in Equation (3) is an essential assumption underlying the PSM method. If the CIA is fulfilled, ATT can then be redefined as:

$$\tau_{ATT} = E(Y_1 - Y_0|D = 1) = E(Y_1|D = 1, \mathbf{X}) - E(Y_0|D = 0, \mathbf{X}) \quad (8)$$

In the PSM, we use propensity score as explained in Equation (4) to match identical individuals. Rosenbaum and Rubin (1983) defined the propensity score $P(\mathbf{X})$ as the conditional probability of accepting treatment given the observed covariates \mathbf{X} . In this study, the logit model is used to determine the propensity

score for estimating the likelihood of adopting the silvofishery system. The mean difference in outcomes between the adopting group and the control group under the CIA can then be estimated as follows:

$$\tau_{ATT}^{PSM} = E(Y_1|D = 1, \mathbf{P}(\mathbf{X})) - E(Y_0|D = 0, P(\mathbf{X})) \quad (9)$$

The results of the ATT (τ_{ATT}^{PSM}) are presented based on the matching technique which is Nearest Neighbor Matching (NNM) as the third step. The NNM is the easiest matching estimator that selects individuals from the comparison group as matching partner for adopted individuals that are closest regarding the propensity score (Caliendo and Kopeinig, 2008). Various literature explained several variants of the NNM, including NNM 'with replacement' and 'without replacement'. Caliendo and Kopeinig (2008) described that NNM 'with replacement' referred an untreated individual as a match can be used more than once, while NNM 'without replacement' is only once. In NNM 'with replacement', matching covers a trade-off between bias and variance, where there is an increase in the average quality of matching and the bias decreases. By replacement, use of the distinct number of nonparticipants to arrange the counterfactual outcome will reduce and thereby the variance of the estimator will increase (Smith and Todd, 2005). In this study, we apply the single and five NNM with replacement and common support to matching. Finally, estimation of the whole empirical analysis was carried out using the STATA software package.

6.2.3 Data Collection and Survey Structure

Data collection was taken out from February to April in 2017 using face-to-face interviews. Respondents were selected from three villages with the highest

number of farmers, namely: Tani Baru and Muara Pantuan under Anggana sub-district, and Salok Palai and Saliki which are currently under the jurisdiction of the Muara Badak sub-district. Of the 300 distributed questionnaires, 284 were completed. For this study, adopters are farmers who applied silvofishery system, while non-adopters are farmers who did not implement the silvofishery system. Table 6.1 summarizes the definition and type of variables used for analysis including socio-economic, social capital, and perception attributes.

Table 6.1 Definition and type of the variables used

Variable	Unit	Description
Socio-economic attributes		
<i>Age</i>	Year	The actual age of respondents
<i>Family size</i>	Person	Number of family members
<i>Residence status</i>	Dummy	1 if the respondent is indigenous; 0 if immigrant
<i>Education</i>	Ordered	1 = never; 2 = primary school; 3 = secondary school; 4 = high school; 5 = university degree
<i>Experience</i>	Year	Farmers experience in aquaculture
<i>Income</i>	Million IDR	farmer income per hectare per year
Social capital attributes		
<i>Group member</i>	Dummy	1 if the farmer is a member of a farmers' group, 0 otherwise
<i>Training</i>	Dummy	1 if farmers have attended the aquaculture training, 0 otherwise
<i>Extension</i>	Times	Number of visits of extension agent each year
Perception attributes		
<i>Severe</i>	Ordered	Farmer' attitude on the impact of mangrove degradation: 1 = completely not severe; 2 = not severe; 3 = neither; 4 = severe; 5 = very severe.
<i>Nursery ground</i>	Ordered	Farmer' perception of mangrove benefits as nursery ground for human being: 1 = strongly disagree; 2 = disagree; 3 = neither; 4 = agree; 5 = strongly agree.

6.3 Data Characteristics

6.3.1 Descriptive Statistics

Table 6.2 presents a descriptive analysis of the respondents. Of the 284 samples, 94 respondents (33.10%) are adopters, while 190 respondents (66.90%) are non-adopters. The average age of respondents is 40.18 years old, and insignificant differences between adopters and non-adopters were observed. Table 6.2 also displays that the average family size is 2.67 members and about 56% of farmers in the study area are the immigrants. The majority of respondents have primary school education, which reflects their current occupation as fishermen. This type of work does not require a high educational background, and many in the Mahakam Delta become skillful fishermen through years of experience. Both respondents from the adopter and non-adopter group have a similar number of years of farming experience at 12.15 years and 2.59 years, respectively. As such, group differences between adopters and non-adopters for the average of farming experience are not statistically significant.

Information about the social capital of respondents is also shown in Table 6.2. It shows the differences in mean along several observed covariates between adopters and non-adopters. For instance, we found that more adopters have farmers' group membership than non-adopters do. Likewise, farmers who have attended aquaculture training and had a higher number of visits from an extension agent annually tend to belong to the adopter's group. This suggests that farmers who have more significant interaction with social groups through farmer group membership, training attendance, and regular contact with extension agents have greater insight and are likely to become adopters. Despite the low level of

education of respondents, these activities became an informal venue to enhance farmer knowledge and improve their livelihood.

Respondents were asked to rate the current mangrove condition and their responses regarding the importance of mangroves as a nursery ground and its relationship to their farming activities (Table 6.2). A five-point Likert scale measuring the degree of their agreement was applied ranging from 1 = entirely not severe/strongly disagree to 5 = very severe/strongly agree. On average, respondents rated that the current condition of mangrove forests condition was severe. Most respondents also agreed that the benefits of mangroves as nursery ground provided a positive impact on their farming.

Table 6.2 Descriptive statistic of respondents

Variables	All (n=284)		Adopters (n=94)		Non-adopters (n=190)		Differences	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev		
<i>Age</i>	40.18	10.28	40.21	10.33	40.16	10.28	0.05	
<i>Family size</i>	2.67	1.37	2.93	1.35	2.55	1.37	0.38	**
<i>Residence status</i>	0.44	0.50	0.37	0.49	0.48	0.50	-0.11	*
<i>Education</i>	2.44	0.74	2.60	0.81	2.36	0.69	0.24	**
<i>Experience</i>	12.45	6.80	12.15	6.37	12.59	7.01	-0.44	
<i>Group member</i>	0.08	0.27	0.17	0.38	0.04	0.19	0.13	***
<i>Training</i>	0.50	0.50	0.74	0.44	0.38	0.49	0.36	***
<i>Extension</i>	0.52	0.96	0.66	1.18	0.45	0.82	0.21	*
<i>Severe</i>	3.85	0.50	3.90	0.47	3.83	0.51	0.07	
<i>Nursery ground</i>	3.78	0.64	3.96	0.53	3.69	0.67	0.27	***

Notes: ***, **, and * indicate significance level at 1%, 5%, and 10% respectively

6.3.2 Awareness and Perceptions Regarding Mangrove Benefits

Respondents were asked to rate the current condition of mangrove forests and the benefits derived from mangroves as a nursery ground for their farms. Table 6.3 shows their responses using a five-level Likert scale. Results reveal that the majority (85.92%) of respondents indicated that the current mangrove condition as "severe", and 1.76% provided the rating "very severe". Meanwhile, 4.23% of respondents indicate that the mangrove condition is "not severe, and the remaining 23 of respondents indicate that the condition of mangroves is neither severe nor not severe. In addition, 227 (79.93%) agreed that mangroves provided the benefits for their ponds as a nursery ground. The same number of respondents (8.45%) disagreed and did not respond to this question.

Table 6.3 Farmers rate the current mangrove condition and the benefits of mangroves as a nursery ground

Description	ENS/SD	NS/D	N	S/A	VS/SA
<i>Severe</i>	0	12	23	244	5
<i>Mangrove benefits</i>	0	24	24	227	9

Notes: ENS = entirely not severe; SD = Strongly disagree; NS = Not severe; D = Disagree; N = Neither; S = Severe; A = Agree; VS = Very severe; SA = Strongly Agree

6.3.3 Pond Characteristic and Income by Land Size

Farmers in the study area generally operate their ponds by traditional or extensive systems due to the availability of mangrove forestland for conversation. Silvofishery system was developed and promoted by the government and NGOs to reduce mangrove degradation because of extensive farming in the area. There are two types of silvofishery design found in the study area: (1) mangroves are maintained within ponds and around the dikes, and (2) mangroves are outside the

ponds. The income generated by respondents based on their pond area is shown in Table 6.4. Results show that the majority of (47.18%) farmers have ponds ranging from 5 to 10 hectares. The remaining 24.65% (n=70), 8.45% (n=24), and 8.45% (n=24) have ponds less than 5 hectares, 11 to 15 hectares, and 16 to 20 hectares, respectively. Thirty-two farmers (11.27%) have ponds with dimensions greater than 20 hectares. Farmers cultivate different types of seafood. Farmers cultivate tiger shrimp (*Penaeus monodon*) in 3 cycles per year, each period lasting 3 to 4 months. For milkfish (*Chanos chanos*), one cycle requires 6 to 8 months before harvest. In addition to tiger shrimp and milkfish, farmers also raise wild shrimp varieties such as the white shrimp (*P. indicus*) and pink-T shrimp (*Metapenaeus affinis*), and native crabs (*Scylla spp*). Farmers collect their spawn for wild shrimp during the tidal exchange which allows shrimp to enter the pond. These are collected every 20 days or at each new moon. Respondent revenues from their harvest are shown in Table 6.4. Results show that the average revenue of farmers whose pond size is greater than 20 hectares are the largest, with IDR 140.78 million (US\$10.59 thousand) per hectare per year, followed by 16 - 20 hectares with IDR 104.18 million (US\$7.84 thousand) per hectare annually.

The operational cost of farmers comes from the purchase of tiger shrimp and milkfish seeds (also locally known as *benur* and *nener*), saponin, lime, and labor wages. Saponin is used to treat ponds before seed stocking to wipe out the threat from predators and competitors. Lime, is used to reduce sediment and water acidity. Labor wage system is based on profit-sharing after total revenue less the operational cost with a ratio around 50:50 or 60:40 for labor. Farmers do not use the feed to grow tiger shrimp and milkfish. Farmers whose pond size is less than 5

hectares have the lowest annual operational cost, with IDR 26.91 million (US\$2.02 thousand) per hectare, while those with the highest operational expenditure are farmers with ponds more 20 hectares at IDR 94.05 million (US\$7.07 thousand) per hectare. Farmer income per hectare per year is thus IDR 19.38 million (US\$1.46 thousand) for ponds less than 5 hectares (lowest) and IDR 46.73 million (US\$3.51 thousand) for ponds measuring more than 20 hectares (highest).

Table 6.4 Income of farmer by land size

Variables	Pond Area (ha)				
	<5	5-10	11-15	16-20	>20
<i>Revenue (IDR Million/year)</i>	46.29	76.49	86.47	104.18	140.78
<i>Operational cost (IDR Million/year)</i>	26.91	45.84	54.07	68.07	94.05
<i>Income (IDR Million/year)</i>	19.38	30.65	32.40	36.11	46.73
<i>Farmers (persons)</i>	70	134	24	24	32

Note. 1 USD was equivalent to 13,296 IDR at the time of the study

6.4 Results

6.4.1 Adoption Model Estimation Results

Table 6.5 presents results of the prediction the silvofishery adoption using logit model. In this model, the dependent variable is coded as 1 for silvofishery adopters and 0 for non-adopters. The estimated logit model is rated to be the proper fit of the model as the percentage correctly predicted is 76.76%, and the value of the Likelihood Ratio-Chi-Square test (76.13) is significant at 1% level of significance. The estimated parameters indicate that the adoption among farmers is influenced by the socioeconomic characteristics, social capital and the perception of the current mangrove condition and mangrove benefits. Of 5

socioeconomic variables considered in the logit model, two variables affect the silvofishery adoption. Based on the collected results, family size and residence status variables are statistically significant at 10% and have positive and negative coefficients, respectively. Based on the obtained results, for family size, it indicates that farmers with larger family size want to adopt the silvofishery than farmers that have relatively smaller family size. Because pond farming is a labor-intensive action that requires labors, then, the larger sized household is the source of family labor that could contribute the cheap labor for adopting and implementing the silvofishery system. By selecting this system, moreover, farmers desire to have a sense of security in retirement by passing on the pond to their members of the household as the successor. Contrary, the result of residence status expresses that indigenous expects to accept considerably higher silvofishery than immigrant does.

All variables of social capital are positively related to the likelihood of a farmer adopting silvofishery. The estimated coefficients for group and extension are considerable at 1%. Meanwhile, the training variable is significant at 5%. Results indicate that farmers who have involvement with a farmers' group and have attended the aquaculture training actively want to adopt the silvofishery as compared to respondents who are not members of a farmer group and who has not attended an aquaculture training. Because farmers in the study area have only lower formal education background, farmers who involved in a farmers' group and the aquaculture training obtained the informal knowledge and sharing insight that helped them to increase the skill and the ability to understand and appraised the silvofishery system adoption. Attained information provides the benefits for

farmers to increase the productivity and income as well as contributing to the conservation of mangroves. Also, the number of visits of an extension agent annually has significant effects on respondents' decision to adopt silvofishery. On respondents' responses about the current mangrove forest condition (severe variable) and mangrove functions (benefit variable), results indicate that silvofishery adoption among farmers is statistically significant at 10% and have a positive coefficient with their opinion on the severity of mangrove condition in the study area. Moreover, nursery ground variable also significantly effects the silvofishery adoption at 1% and has a positive coefficient. This finding implies that if farmers' attitude and knowledge of mangrove benefits on the severeness of mangrove degradation are enhanced, they are likely willing to adopt the silvofishery system. In particular, if farmers' awareness on the impact of mangrove loss is raised and agree that the damage would also affect their livelihood, they will appreciate more value for the existence of mangrove and adopt a more environmentally friendly farming system.

The results of marginal effect also appear in Table 6.5. The marginal effect of family size shows that increase by one member also increases the probability of a farmer to adopt the silvofishery system by 5%. However, the result of residence status is contradictory: when a farmer who adopts the silvofishery is an immigrant, then the probability of adoption decreases by 11%. Similarly, the marginal effect for group and training variables show a farmer who is involved in a farmers' group and attended the aquaculture training will increase the probability of adoption to 27% and 36%, respectively. Also, the marginal effect of the extension variable shows that when extension agents have visited a farmer, the

probability of adoption increases by 8%. These findings indicate that the farmer organization, practice, and extension services in the study area contribute to increasing the likelihood of farmers to adopt silvofishery.

Table 6.5 Logit estimation results of factors determining silvofishery adoption

Variables	Coef.	Std, Err.	z-value	Marginal Effects
<i>Age</i>	-0.01	0.02	-0.70	-0.01
<i>Family size</i>	0.26 *	0.14	1.86	0.05
<i>Residence status</i>	-0.54 *	0.30	-1.79	-0.11
<i>Education</i>	0.30	0.20	1.51	0.06
<i>Experience</i>	-0.03	0.03	-1.13	-0.01
<i>Group</i>	1.35 **	0.55	2.44	0.27
<i>Training</i>	1.75 ***	0.32	5.56	0.36
<i>Extension</i>	0.38 **	0.17	2.24	0.08
<i>Severe</i>	0.59 *	0.33	1.78	0.12
<i>Nursery ground</i>	0.82 ***	0.31	2.68	0.17
<i>Constant</i>	-7.72 ***	1.97	-3.93	
Log-likelihood	-142.24			
LR Chi ²	76.13 ***			
Pseudo R ²	0.21			
% predicted correctly	76.76			
Observations	284			

Notes: ***, **, and * indicate significance level at 1%, 5%, and 10% respectively

6.4.2 Silvofishery Adoption Impact

Before estimating the ATT, we test the indicators of the matching quality before and after matching from the nearest neighbor matching (NNM) using single and five NNM with replacement and common support. Table 6.6 shows that after randomization the standardized mean difference of the overall covariance lies between 9.3% and 11.9%. Rosenbaum and Rubin (1985) suggested that below the critical level of 20% for the standardized mean

difference was still proper. Results of the model goodness of fit are also presented in Table 6.6. The value of pseudo R^2 shows a decline from 21% before to 3%-6% after matching. Further, the corresponding p-values for likelihood ratios present that a change from a statistically significant model to an insignificant model after matching. It displays that after matching the covariates are no more related to adaptation decisions. Also, the joint significance of covariates on adopter status could always be rejected after matching, where it was never denied before matching. Results after matching for the mean standardized bias, the pseudo R^2 values, and insignificant p-values in the likelihood ratio test depict that significant reduction in bias after matching was attained and the model is no more difference in the distribution of covariates between the two groups after matching. Thus, the specification of a model is acceptable, and that the primary assumption of 'selection on observables' is reliable.

Table 6.6 Test of matching quality indicator

Matching Method	Pseudo R^2		LR χ^2 (p-value)		Mean standardized bias after matching
	Before	After	Before	After	
NNM ^a	0.21	0.06	76.13	***	15.23
NNM ^b	0.21	0.03	76.13	***	7.64

Notes: NNM^a = single NNM with replacement and common support, NNM^b = five NNM with replacement and common support

***, **, and * indicate significance level at 1%, 5%, and 10% respectively

As illustrated in equation (9), the ATT measures the outcome (income) between the silvofishery system adoption and non-adoption. The ATT after matching using single and five NNM with replacement and common support was presented in Table 7. Results display a positive impact of silvofishery on annual

income per hectare of farmers, implying adopter system has increased the yearly earnings to between IDR 1.04 million (US\$78.22) per hectare and IDR 1.10 million (US\$82.73) per hectare. Results suggest that farmers of silvofishery made the right decision to adopt their shrimp pond system. These results are also in agreement with those obtained by Sukardjo (1999); Fitzgerald (2000); and Takashima (1999) who found that silvofishery has positive impacts on farmers' income in Indonesia. For non-adopters, their annual earnings would raise from IDR 3.93 million per hectare to in the range of IDR 0.75 million per hectare - IDR 1.45 million per hectare were they to adopt their shrimp pond to the silvofishery system. It indicates that silvofishery adoption was an appropriate decision for both groups.

Table 6.7 The average treatment effect of silvofishery adoption

Outcome	Matching Method	ATT			ATU		
		Adopter	Non-adopter	Dif.	Adopter	Non-adopter	Dif.
Income	NNM ^a	5.23	4.13	1.10 ***	4.68	3.93	0.75 ***
	NNM ^b	5.23	4.19	1.04 **	5.38	3.93	1.45 **

Notes: Average treatment effects on the treated (ATT) and the untreated (ATU)

1 USD was equivalent to IDR 13,296 at the time of data collection.

***, **, and * indicate significance level at 1%, 5%, and 10% respectively

6.5 Discussion and Conclusions

This study shows that silvofishery system positively affects mangrove conservation and maintain a coastal livelihood in Indonesia. By assessing the impact of the silvofishery system on farmer income, we provide the basis for decision-makers to associate the driving factors of adaptation in the Mahakam

Delta. The PSM method is implemented to determine the output of the adaptation process, with a model for selection bias according to observable differences for both adopter and non-adopter groups. Statistical results show that the primary assumptions used is acceptable and a causal interpretation of the conclusion is reliable.

The causal impact estimation of the PSM model reveals that the impact of silvofishery system adoption did have a significant influence on the income of farmers in the Mahakam Delta. Farmers who adopt silvofishery system can obtain higher earnings than those who did not choose to select it. A prominent characteristic of farmers' socio-demographic profile shows that family size and residence status are significant factors that influence the adoption decision. Moreover, social capital which includes membership to a farmers' group, attendance at aquaculture training and extension services significantly affected farmer adoption and continued the practice of the silvofishery system. Farmer knowledge and awareness of mangrove forests' current condition and the benefits derived from their conservation have a positive influence on the adoption of an eco-friendly fish farming system.

These result findings must be elucidated to handle certain limitations and also provide insights for further studies. Firstly, although silvofishery system adoption can offer higher income than the non-silvofishery system, however, this adoption requires tight requirements. Silvofishery farmers who obtained higher income than non-adopters might already be well established and have more experience with this system. New farmers who want to switch to this system may have barriers associated with biophysics of land and water, mangrove vegetation

suitability, carrying capacity, socio-economic condition, and land ownership. It is a crucial finding that merits further studies by adding indicators to evaluate the effects of new system adoption to new farmers who want to switch to the silvofishery system such as biophysics land suitability and the engineering suitability of silvofishery. Further, integrated coastal zone planning and development is recommended to create harmony between conservation and economic interests and also mangrove damage can be controlled. The government also should contribute to monitoring, evaluation, and assistance related to aquaculture feasibility including technical, social, economic, and ecological aspects. Secondly, since cross-sectional data were used in this study, then it was not possible to assess the dynamic of farmer assets and evaluated the impact of silvofishery continuously and over time. Therefore, longitudinal researchers using time series data and integrated studies are recommended to estimate the long-term effects of silvofishery and its influence on all aspects. Also, due to this study has the limitations where only uses income variable in the scope of impact estimation to estimate farmer welfare, then, future studies could be considered by offering additional indicators of farmer welfare to evaluate the effects of silvofishery adoption. Despite this limitation, however, the findings provide some insight to help the decision makers on the practical policy options available to promote eco-friendly adoption. The impact of silvofishery adoption showed a significant influence on the income of farmers and the determinants of adoption has recognized that socio-economic condition, social capital, and the awareness are driving forces for adopting.

From results, we interpret that the silvofishery system adoption is a complementary solution to preserve mangrove ecosystems and improve farmer income in the Mahakam Delta. However, silvofishery is only a tool, and for it to continue work as a sustainable solution in the Mahakam Delta, the concerted effort of stakeholders and the government is critical. The role of the government, NGOs, private sectors, and universities are central in leading programs that empower farmer groups. These institutions can provide training on eco-friendly aquaculture and expand extension services to include environmental check, adequate pond construction, mangrove vegetation selection, commodity type, and marketing. Farmers are conscious of the current mangrove condition and recognized mangrove benefits as a nursery ground for fish and shrimp. Therefore, policy should focus on community involvement to conserve the environment. Also, the importance of mangroves and silvofishery system application should frequently be communicated thoroughly by agencies involved to increase awareness, demonstrate the effectiveness of silvofishery, gain farmers' trust on the program.

We recommend looking carefully at problems faced by farmers who have adopted the silvofishery system to retain their participation. For instance, fish or shrimp yields have been reported to decline when mangrove trees within the ponds reach 7-10 years of age due to lack of sunlight or shading effect of the forest canopy. In addition, mangrove leaves have a high tannin level that contaminates the water in ponds where substantial mangrove leaves fall and decompose. Due to the effect of these incidents in pond productivity, farmers commonly cut back mature mangrove trees within or around their ponds. Forcing

farmers to retain mangroves where clearly affects, their livelihood is a disincentive to the program. However, a policy on cutting and replanting felled mangrove trees may be integrated with the current system to encourage farmers that mangrove forests and their ponds can co-exist. Wood from mature mangroves may be sold and could be an incentive for farmers who maintain mangrove trees and replant the ones they cut down. The government and the private sector can collaborate in designing an environmental incentives programs that focus on preserving mangrove trees within ponds and reducing operational cost for farmers.

Chapter 7

Conclusion and Policy Recommendation

This study was carried out to analyze the economic value of mangrove functions and feasibility of mangrove restoration program, and to evaluate the impact of the silvofishery system as one of Indonesian mangrove restoration program on farmers' income. The conclusions and policy recommendations are summarized based on the primary purposes of the study. To deal with the objective 1, namely to analyze the economic value of mangrove functions and feasibility of mangrove restoration program restoration, this study focused the crucial point from Chapter 3, Chapter 4 and Chapter 5, which were presented below:

Chapter 3 attempts to determine the economic value of mangrove restoration and its determinants based on the coastal communities' willingness to pay (WTP) using contingent valuation method (CVM) through a double-bound dichotomous choice format. The results revealed that over 80% of respondents assessed the benefits of some mangrove-related ecosystem functions associated with their livelihoods as "important" or "very important". Moreover, occupation, planting seedlings, responsibility, and the nursery variables were statistically significant on WTP for mangrove restoration. Government and NGOs should respond to these findings by regularly disseminating the information of mangrove benefits and the impacts of mangrove loss on local livelihoods to enhance awareness, responsibility, and knowledge of local communities on the values given by mangrove services. Thereby, this way can affect the attitude, involvement, and behavior of local people on mangrove restoration towards the better. Furthermore, the mean WTP of the respondents was estimated to be IDR 35,201. The finding provides persuasive evidence to solve the problem of

asymmetric information of decision makers to understand the economic value of mangrove benefits based on communities' preferences. Thus, in mangrove restoration and conservation programs, communities should be engaged from the beginning of the program.

Chapter 4 assessed the opportunity cost of labor for valuing mangrove restoration to overcome the limitations of money as a payment vehicle in contingent valuation in developing countries. In this chapter, CVM payment in a labor contribution design is applied by converting labor-time donation of households to the monetary value of the benefits that local communities receive from the restoration of mangroves. Also, this chapter identifies how socio-economic characteristics of families and their awareness affect whether they are willing to contribute labor to mangrove restoration. This findings of the study show that the average homes in the study area ready to provide work to the restoration program. Furthermore, the study findings indicate using labor-time contribution as a CVM payment vehicle is acceptable to households in the study area. A total annual benefit of mangrove restoration using the monetary contribution of labor (MCL) is IDR 143 billion (US\$10.77 million) per year. These values reflect 0.12% of GDP of Kutai Kartanegara Regency, valued at IDR 117,461 billion or equivalent to US\$8.83 billion. The findings present estimates of the economic value of mangrove restoration to provide the relevant information for assessing a mangrove restoration project. Furthermore, evidence from the study demonstrates that socioeconomic characteristics of households such as family size and income are significant factors that influence the household's willingness to contribute labor for mangrove restoration. Also, policy should

focus on considering responsibility, participation type and knowledge of local communities to participate. Furthermore, information on benefits and economic values of mangrove services should be regularly disseminated through education and communication programs to enhance awareness of the sustainability of mangrove services.

Chapter 5 examined the benefits and costs of mangrove restoration using environmental cost-benefit analysis (ECBA). In this chapter, the benefits were obtained by estimating communities' willingness to pay money in Chapter 3 and labor contribution in Chapter 4 as a payment vehicle. While, the costs were obtained from the project of mangrove restoration in 2014 conducted by the collaboration between Planete Urgence, the project financier, and Yayasan Mangrove Lestari, a local non-governmental organization through the Mahakam Delta Integrated Management Program (MADIMAP) in around Muara Badak village. The findings revealed that mangrove restoration project provided valuable benefits for sustainability of local livelihoods by NPV was valued at IDR 250.15 million or US\$18.81 thousand (WTP estimated) and IDR 4,372.63 million or US\$328.87 thousand (WTCL estimated) in a life of project five years. BCR values were between 3.39 (WTP) and 42.79 (WTCL), respectively. IRR values reached between 37.97% (WTP) and 135.78% (WTCL), respectively. With compare the benefits of mangroves and the costs of the project, it revealed that at different interest rate levels, the values of NPV and BCR were still positive until the next 10-years for the three scenarios of increasing discount rate, implying the benefits of mangrove outweigh the costs of mangrove restoration project. Thus, mangrove restoration project was a feasible plan and policymakers should

implement and expand the project. The results also provide the valuable information for policymakers in estimating the economic value of mangroves and deal with market failure on mangrove ecosystems services. Therefore, policymakers should apply economic valuation as a means to compare mangrove restoration and conservation projects with other commercial land uses.

Furthermore, Chapter 6 discussed the objective 2, namely to evaluate the impact of the silvofishery adoption as one of Indonesian mangrove restoration program on farmers' income. This chapter evaluated influencing factors on silvofishery system adoption and its impact toward the income of small-scale farmers using propensity score matching (PSM). The findings revealed that in the first step of the model, logit estimation results showed that the socioeconomic characteristics, social capital and the perception of the current mangrove condition and mangrove benefits were significantly associated with the likelihood for the silvofishery adoption. Decision makers should consider the driving factors of silvofishery adoption when introducing silvofishery system program. Understand well the socioeconomic characteristics of adopters can help the success of the adoption program. Regarding social capital, it is critical to provide training on eco-friendly aquaculture and expand extension services to include environmental check, adequate pond construction, mangrove vegetation selection, commodity type, and marketing. To increase awareness and knowledge of farmers, policy should focus on community involvement to preserve the environment. Also, the importance of mangroves and silvofishery system application should frequently be communicated thoroughly by agencies involved to increase awareness, demonstrate the effectiveness of silvofishery, gain farmers' trust on the program.

Moreover, Results in this chapter also proven that silvofishery system adoption has a great impact on farmers' income. However, decision-makers should consider barriers experienced by farmers to adopt this system. Thus, the government and the private sector can collaborate in designing an environmental incentives programs that focus on preserving mangrove trees within ponds and reducing operational cost for farmers.

Lastly, this study concludes that the existence of mangroves is crucial for humans, and the involvement of communities is essential to reduce mangrove loss and to support the success of mangrove restoration programs. The information and application of economic valuation for the value of mangrove functions be fundamental required in private and public decision-making to avoid the undervalued and market failure from mangrove benefits when compared with other commercial land uses in benefit-cost analyses.

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