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MODELLING JAKARTA BAY SMALL-SCALE FISHERIES SUSTAINABILITY USING SOCIAL ECOLOGICAL SYSTEM FRAMEWORK

(ROBIN)
C262140021

MINISTRY OF NATIONAL EDUCATION AND CULTURE
SECRETARIAT GENERAL
SEAMEO SEAMOLEC
SOUTHEAST ASIAN REGIONAL CENTRE FOR TROPICAL BIOLOGY
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APPROVAL SHEET

1. Research Title	:	Modeling Jakarta bay small-scale fisheries sustainability using social ecological system framework
2. Research Coordinator		
a. Name	:	Robin
b. Sex	:	Male
c. Occupation	:	Lecturer/ Ph.D Student
3. Institution		
a. Name of Institution	:	Muhammadiyah University of Sukabumi /IPB
b. Address	:	Jln RH Syamsuddin No 50 Kota Sukabumi
c. Telephone/Fax.	:	(0266) 218 345/ (0266) 218 342
d. Email Address	:	info@ummi.ac.id
4. Research Schedule	:	9 months
5. Research Budget	:	

Bogor, 16 March 2018

Endorsed by
Deputy Director for Programme
SEAMEO BIOTROP

Dr. Jesus C. Fernandez

Research Coordinator

Robin
NIM C262140021

Approved by
Director of SEAMEO BIOTROP

Dr. Ir. Irdika Mansur, M.For.Sc
NIP 19660523 199002 1 001

Mengetahui,
Head of Departement MSP FPIK IPB

Dr. Majariana Krisanti, S.Pi, M.Si
NIP 19691031 199512 2 001

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1. INTRODUCTION

1.1. Background

The coast is home to most of the world population that serves to support food production, industry, transportation and tourism needs (Salafsky & Wollenberg. 2000) but it also serves as a provider of environmental services. The coastal environment is currently largely under pressure and experiencing rapid changes due to the increasing need for coastal and marine resources (World Bank, 2006). Jakarta Bay is located between Tanjung Karawang in the east and Tanjung Pasir in the west. The bay is 285 km2, with 33 km of coastline and an average water depth of 8.4 m. The progress and development of Jakarta as the capital of Indonesia is closely related to socio-cultural, socio-economic, and political dynamics. The implications of these developments manifest in the development and economic growth seen from the city's physical growth that continues unlimited and continues from time to time (Azwar, *et al.*, 2013). Economic activity and population growth have caused problems in coastal areas and waters. In 1980 the population of Jakarta was recorded at 6.5 million people and 10 years later from 1990 to 2001 had reached 8.25 million with an average growth rate of 2.4% per year. Taking into account immigrant populations to Jakarta and commuters, the number has reached 9.7 million in 2010 (BPS 2011).

There are about 13 watersheds in this Jakarta Bay, making Jakarta very vulnerable to floods, where about 4 million people live in flood-prone areas and the value of economic losses that can be generated is about 104 trillion US dollar (NCICD, 2013). The Jakarta Bay is also experiencing mass waste transport pressure along the watershed as it has received both dissolved and unsolved pollutant loads from the various activities. Waste from land-based activities (land-based pollution) will accumulate at the mouth of the river, mainly due to the high population density and industrial activity. from the many threats that occurred in the coastal Jakarta, the development of coastal Jakarta through several activities aimed at protecting the Bay of Jakarta from damage. Among these activities are the first legal reclamation in the presidential decree no 52 of 1995 on the reclamation of the north coast of Jakarta with the consideration that in accordance with Presidential Decree No. 17 of 1994 on Repelita Six, the North Coast Region is a category of Mainstay Area, Which is a region that has strategic value in terms of economic and development of the city so that to realize the function of the North Coast Area of Jakarta as a Mainstay Area, it is necessary efforts to structuring and development of the North Coast Area through the reclamation of the north coast and simultaneously arranging the existing coastal space on a directional and integrated.

Then followed by Presidential Regulation 54 the year 2008 about the spatial arrangement of the area of Jakarta, Bogor, Depok, Tanggerang, Bekasi, Puncak, and Cianjur. Currently, the projection of coastal development in Jakarta has experienced an expansion of coverage, which is not only aimed at bay protection but has expanded on economic development and protection of the Gulf ecosystem of Jakarta itself and the threat of natural disasters such as flood, rob, and land subsidence.

With the support of the Dutch government, the Indonesian government and the Provincial Government of DKI Jakarta have worked together to reduce the threat of damage in the capital city, such as the decline of land, floods and other natural disasters such as major floods in 2007, 2009 and 2012, therefore a blueprint for the protection strategy The capital city known as the Jakarta Coastal Defense Strategy (JCDS) project. In 2013 the JCDS project was followed by the National Coastal Integrated Development (NCICD) program, taking offshore solutions as a starting point.

Reclamation is an activity that is considered to have an effect on the ecological social system in Jakarta Bay. The relationship or interaction of project implementation with the environment from the economic point of view can be seen from three points of view of sustainable development ie ecological, economic and social aspects. From an economic point of view, coastal reclamation projects can be regarded as a very lucrative prospect for generating benefits particularly in terms of regional economic revenues and turnover. Some experts argue that with the reclamation means that new land will be created in a region, the emergence of this new land will bring economic and business activities on it (Zulham et al, 2014). And if the reclaimed land is traded, it will generate enormous revenues, with reclamation areas now being sold in the range of Rp 13 million / m2-Rp30 million / m2 or be soaring from 2003 price of Rp4 million / m2. With a total land area of 2589 hectares for 17 islands, the total revenue is around Rp661.31 trillion-Rp1,526 trillion (PK2PM, 2016). From the ecological and social point of view Maritime Development and Maritime, Civilization Research Center noted the loss of capture fishery and cultivation of Rp 314.5 billion per year with the existence of this reclamation project. Meanwhile, other potential losses from coral reefs amounted to Rp 20.2 billion per year, mangrove forest 15.04 billion per year and seagrass beds amounted to Rp 92.57 trillion per year. This study uses calculations from Fortes (1990), where the total economic value of seagrass beds is associated with biota life in this ecosystem of 412,325 US dollars per hectare per year, equivalent to Rp 5.78 billion per hectare per year assuming 1 US dollar Equal to Rp 14,000 (Safitri et al, 2016).

In addition to threatening the sustainability of the Jakarta Bay ecosystem, reclamation activities have also directly threatened the livelihood of fishermen who inhabited several places in the bay of jakarta. In 2013 there are approximately 25,163 fisherman households inhabiting the coast of Jakarta with details of owner fishermen 4,347 households and workers fishermen 20.816 households (data.jakarta.go.id, 2015). The fishermen faced a very difficult problem, which in addition to the decline in the quality of the bay ecosystem Jakarta fishermen are also losing livelihoods due to the reclamation project. The existence of the reclamation of Jakarta bay will have an impact on the loss of economic benefits from fishing activities Rp314.5 billion, with the greatest impact experienced by traditional fishermen who eliminate employment that is able to absorb up to 30,000 people from various groups.

Jakarta bay as an ecosystem unit that is actually experiencing degradation but socially is still an important unit for some social entities such as fishermen and fish farmers. This research is aimed to build a comprehensive approach to the dynamics of social ecological system that takes place in Jakarta bay to provide an accurate description of environmental and social processes so that it can be a reference for decision making by stakeholders. The existence of fishermen as one of the social entities that interact with megapolitan complexity continues to be threatened. Therefore, with a proper and comprehensive approach is needed to analyze the problems that occur and provide an overview of the importance of the existence of fishermen as one of the important social units for the Jakarta bay ecosystem. We use Emergy based ecological footprint to measure the carrying capacity of Jakarta bay and also to determime the pattern of sustainability development for that ecosystem. We also use contructed livelihood vurnerability index to assess the condition of all the fisherman groups who occupying the coast of Jakarta, we targeting the mixing of that aprroach can produce better sustainaibility development models for Jakarta bay ecosystem and also for fisheries system.

1.2. Objectives

1. To analyze the fisheries ecological footprint at Jakarta bay ecosystem and its relation to fishermen livelihood vulnerability.
2. To analyze the sustainability of fisheries using embodied energy (emergy) approach.
3. To develop a management model for fisheries sustainability using social-ecological system approach.

1.3. Expected Output

The outcome of this research are :

1. Models and scenario development for small scale fisheries in Jakarta Bay.
2. The level of Vulnerability and resilience of the fishermen community according to their existing condition.
3. Energy flow for small scale fisheries in Jakarta Bay Ecosystem.
4. Carrying capacity and ecological Footprint level of the Jakarta Bay Ecosystem.

Output :

1. Two paper published by the international journal indexed by Scopus and at least one journal for ecological footprint will be published this year.
2. One paper published by national journal indexed by DIKTI or LIPI

2. IMPORTANCE OF RESEARCH IMPLEMENTATION

Research on the dynamics of fisheries in Jakarta has become one of the important agendas in the formulation of policies regarding the management of the Jakarta bay ecosystem so far. Moreover, with increasing capabilities that have expanded to take up marine space in the bay ecosystem that will have a positive and negative impact. One of the negative problems is the reduction in capture fisheries areas which traditionally still are the dominant livelihood of the Jakarta bay community. Environmental pollution and reclamation are of considerable importance to the environment

3. METHODS

Phase I

Emergy Analysis

The emergy evaluation method or so-called emergy synthesis, the whole system is considered through a diagram where the resource emergy flow and the information that drives for system analysis. Common stages used to perform the analysis of emergy synthesis starts from defining the system boundary by using energy system diagrams to describe system features, inputs and outputs. The next step creates a table that summarizes the emergy values of the system and flow stock. Stock and flow are converted from equivalent energy or mass units using emergy transformity coefficients. The sustainability of this system can then be evaluated using a number of emergy indicators (Voora and Thrift, 2010). Here are some methods of analysis of emergy synthesis:

1. Limitations of systems defined as areas used for the production as a whole and for individual sub-systems (management fields). The dimension of this limitation is in time.
2. All major energy sources and material resources flowing and stored in the system are identified and tabulated using the language of the energy and quantity systems recorded and converted into energy units (Joules), mass units (grams), or monetary units.
3. Various well-flowing resources that are measured directly or predicted from production records, financial records and available data. To obtain the emergy value of the resource stream, the amount is tabulated and multiplied by the corresponding transformations of the various literatures available.

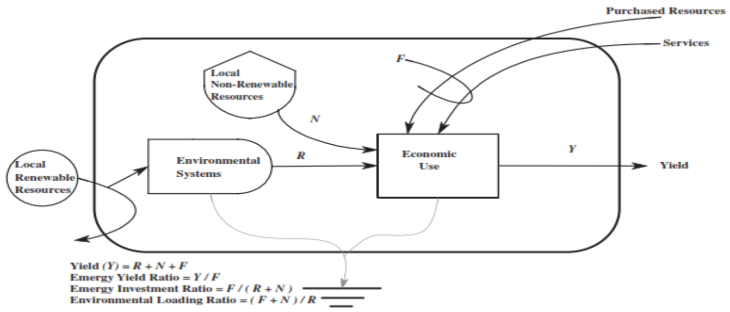

Figure 1 An emergy-based index for a region, which takes into account local renewable input emergy (R), local non-emitter input (N), and emergy inputs purchased from outside the system (F). Based on the diagram by Brown and Ulgiati (1997).

Counting Emergy

Analysis of the condition of coastal resources begins with the collection and preparation of data base based on socioeconomic data.

Table 1 Data needed for Emergy & Ecological Footprint survey

Main Component	**Colleting data method**	**Data Source**	**Type of data**
Social component of population	Survey, Interview	BPS	Primer (First Hand data) & Secondary
Livelihood	Interview	Bappeda dan BPS DKI Jakarta	Primer (First Hand data) & Secondary
Fish catching area/Fishing Ground	Survey, Interview	Fishermen dan Community	Primer (First Hand data)

Economic Component	Interview	Fishermen dan Community	Primer (First Hand data)
Operational Cost of Fishing	Survey, Interview	Fishermen	Primer (First Hand data)
Fish prices	Survey, Interview	Fishermen, TPI,	Primer (First Hand data) & Secondary data
Fish Production data	Survey, Interview	Nelayan, TPI, Sudin KPKP kantor walikota Jakut, Dinas Pertanian Kelautan dan ketahanan pangan DKI Jakarta	Primer (First Hand data) & Secondary data
Type of fish catched by fisherman	Survey, Interview	Nelayan, TPI, Sudin KPKP kantor walikota Jakut, Dinas Pertanian Kelautan dan ketahanan pangan DKI Jakarta	Primer (First Hand data)

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After the table that evaluates all inputs is obtained, then the product unit's emergy values can be calculated. Output or product is evaluated in units of energy, exergy, or mass; Then the emergy input is summed and the value of the emergy unit for the product is calculated by dividing emergy by the output unit. Thus, the evaluation of energy generates new unit energy values (Brown and Ulgiati 2004).

The energy flow data after being tabulated and adjusted is subsequently transformed. A number of emergy-based ratios and indices are calculated. The aggregate results of the indicators obtained will be helpful in interpretation in the analysis. The main indicators used in this analysis are defined as follows (Ulgiati and Brown 1998; Odum 1996):

a. Comparison of emergy yield (EYR) is ratio of emergy output (Y) divided by input emergency (F). Comparison of emergy results from each output generated is a measure of how many processes will contribute to the economy.

   EYR = Y/F ……………………………...…………………………….... (1)

b. The environmental load ratio (ELR) is the ratio of non-renewable emission (N) and imported emission (F) to emergy renewable (R). This is an indicator of the amount of pressure from the production process on the local environment.

   ELR = F/R……………………………………………………………...…(2)

c. EIR (Emergy Investmen Ratio), EIR represents the ratio of resources purchased to local and renewable non-renewable inputs. This will tend to be economical if the ratio is less or equal to the one that applies in the region (Odum, 1996). The fewer the ratio, the less economic cost, so the lower-ratio process tends to compete, prosper in the market.

EIR = F / (R + N)...

d. The emissions sustainability index (ESI) is a measure of yield and sustainability that assumes that the objective function for sustainability is to obtain the highest yield ratio at the lowest environmental load.

   ESI = EYR/ELR ……………………………………………………..….. (3)

e. The renewability ratio (% R) is the relationship between inputs from renewable resources to the total amount of total emergy.

   %R = R/(R+NR+F)× 100%..(4)

   % R is used for environmental sustainability assessment,% R shows the percentage of renewable emergy used by the system. High percentage systems have high sustainability capabilities from systems that use most of the non-renewable emergy. The flow of emergy can be modeled using sofware emSIM version 1.3.1

Ecological Footprint

Ecological footprint data collection using data analysis of land conversion using spatial approach.

Data Analysis

Ecological footprint (ecological Footprint) is an approach used to analyze total resources produced and related to the use of space / land. The equation of ecological footprint calculation can be seen based on Lin *et al* (2016) equation

EF for consumption:

$$\boldsymbol{EFc = EFp + EFi - EFe} \text{...}\mathbf{(1)}$$

Where:

EFC = Footprint of consumption associated with a product or waste (gha)

EFP = Footprint of production associated with product or waste (gha)

EFI = Footprint of imports associated with product or waste (gha)

EFE = Footprint of exports associated with product or waste (gha)

EF for product extraction and waste generation per year:

$$\boldsymbol{EFp = \frac{P}{Yn} * YF * EQF * IYF} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (\mathbf{2})$$

EFP = Ecological Footprint associated with a product or waste, gha

P = Amount of product extracted or waste generated, t yr^{-1}

YN = National average yield for product extraction or waste absorption, t $nha^{-1}\ yr^{-1}$

YF = Yield factor of a given land use type within a country, wha nha^{-1}

EQF = Equivalence factor for given land use type, gha wha^{-1}

IYF = Intertemporal Yield factor of a given land use type, no units

To measure a single system unit of ecological footprint, We use a more aplicable equation based on Pauly & Christensen (1995); de Leo et al, (2014), its called Marine Ecological Footprints (MEF):

$$\boldsymbol{MEFa = \frac{PPRia}{PPa}} \text{...} \textbf{\textit{(3)}}$$

MEF_a = Ecological footprint for aquatic systems a (km^2/y), PPR_{ia} = *Primary Production Required* for spesies ***a*** on aqatic system ***a*** ($tC.y^{-1}$). PP_a = Primary Productivity for aquatic systems a ($tC.km^{-2}.year^{-1}$).

$$PPRi = CC * DR * \left(\frac{1}{TE}\right)^{(TL-1)} \text{..} \textit{(2)}$$

PPRi is primary productivity needed for species i ($tC.y^{-1}$), CC adalah *carbon content* per unit weight of species i (1/9 Pauly and Christensen 1995), DR adalah *discard rate of bycatch* (1,27 Pauly dan Christensen 1995) TL is a trophic level for species taken from fishbase.org or other sources.

Biocapacity for single landuse type:

Biocapacity using the equation de Leo et al. (2014):

Regional Fisheries Biocapacity (RFBC) = A x YF x EQF...............(3)

The above equation is modified to be:

$RFBCj = Aj - A_{rek} \times YFj \times EQF$..*(4)*

*YFj = (1/9*Catch)/A*...*(5)*

Aj = fisheries zone in Jakarta (km^2); A_{rek} = Area of waters – area of reclamation; YFj = regional performance factors are calculated from $(Tcatch/A)/9)$, or the number of catches divided by the total area of a particular year waters divided by the transformation value of carbon per Ton weight of fish (1/9 menurut Pauly & Chiristensen, 1995); Faktor ekuivalen (EQF) Indonesia = 0,35 (Lin *et al*, 2016).

If RFEF < RFBC ; *Undershot*/sustainable: If RFEF > RFBC; *overshot*/unsustainable.

Phase II

Fishermen Livelihood

This research will be conducted in the area that has been surveyed previously, that is the area that there are many fishermen community that is Penjaringan sub district (kamal muara and pluit/muara angke), and cilincing subdistrict (kalibaru, cilincing and marunda), North Jakarta and also in Tidung island and Pramuka island administrative area of kepulauan seribu as a comparison. The study will be conducted for 9 months starting from the preparation of the proposal to the final stages of completion of the analysis.

Data collection in this research will be done quantitatively by using questionnaire instrument. But this research is also supported by qualitative data through in-depth interviews, secondary data and field observation to see the daily life of fishermen families. Population taken per "*kelurahan*" is all fisherman household. Beaman and Dillon (2012) describe a household as a social group in the same place, share the same food and make joint and coordinated decisions about resource and income pooling. Household samples were selected by snowball sampling (Goodman, 1961), a non-probability sampling technique in which participants present an incident in future interviews (Baum et al, 2016). The number of respondents is about 30 respondents from each "*kelurahan*". These respondents were subjected to surveys to obtain data, facts, and necessary information.

Table 2 Collecting data method

Data collection technique	Data collected	Type of data
Questionnaire	1. Characteristics of respondents 2. Livelihood assets ownership 3. Fishermen's livelihood strategy 4. Structure of the livelihood of fishermen 5. The resilience level of fishermen households	Primer (First Hand data
Deep interview	1. How Fishermen take advantage of the livelihood assets they have in their lives 2. Fishermen's livelihood strategy 3. Form of resilience of fishermen	Primer (First Hand data
Field observation	Activities undertaken by fishermen	Primer (First Hand data)
Document analysis	Overview of locations through monographic data	Primer (First Hand data) & Secondary data

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Livelihood Analysis

The Ellis (2000) approach was used to analyze the resilience of shifting from fishermen groups based on research locations, starting with scoring all parameters of resilience in the form of capital to support fishermen's livelihood, where data for each capital was obtained from quisioners and in-depth interviews to gather information to fishermen . Data retrieval is done by observation, interviews, and documentation to collect information related to fishermen households including: 1) use of marine resources, 2) perception and 3) livelihoods (Baum et al. 2015). Beaman and Dillon (2012) define a household as a social group in the same place, share the same food and make joint or coordinated decisions regarding the allocation of resources and pooling income. Household samples were selected by snowball sampling (Goodman 1961), which is a non-probability sampling technique in which the participants suggested interview participants in the future (Baum et al. 2015), in which about 150 households were interviewed in the sample.

Promethee Analysis

PROMETHEE (Preference Ranking Organization MeTHod for Enrichment Evaluations) analysis is an outranking multi criteria analysis (MCA) method (Macharis et al. 2004), including PROMETHEE I for partial ranking of alternatives and PROMETHEE II for complete ranking of alternatives, developed by Brans , 1982; Behzadian et al. 2010. This analysis is used to further examine the results of the questionnaire that describes the status (resilient, non-resilient or vulnerable) of the location of the sampling.

Weighting

Weight can be determined according to various methods. PROMETHEE does not provide specific guidelines for determining this weight but assumes that decision makers are able to weigh criteria correctly, at least when the number of criteria is not too large.

Preference function

The preference function (Pj) translates the difference between evaluations (i.e., scores) obtained by two alternatives (a and b) in terms of specific criteria, to preference levels ranging from 0 to 1.

$$Pj(a,b) = Gj[fj(a) - fj(b)] \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ (1)$$

$$0 \leq Pj(a,b) \leq 1 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . . \ldots \ (2)$$

becomes a preference function related to the criterion, f (.) where Gj is an uncertain function of the observed deviation d between fj (a) and fj (b) (Macharis *et al*. 2004).

Ranking

After the data quisioner is processed in the exceel file to assign an average of each weight of capital, then the results are presented in the Promethee table to see the ranking of each research station capital.

The ranking results are obtained based on the current Phi preference value. Preference flows are calculated to consolidate the results of paired comparisons of actions and to rank all actions from the best to the worst. Three different preference flows are calculated:

Phi+ (ϕ+): positive (leaving) flow:

$$(\phi^{+})\ (a) = \frac{1}{n-1} \sum_{b \neq a} \pi(a, b)$$

Positive preference flow ϕ + (a) measures how much action a is preferred over the other n-1. This is a global measurement of the power of action a. The greater ϕ + (a) the better the action

Phi- (ϕ^{-}): negative (entering) flow

$$(\phi^{-})\ (a) = \frac{1}{n-1} \sum_{b \neq a} \pi(b, a)$$

Negative preference flow ϕ- (a) measures how much other n-1 actions are preferred over actions a. This is a global measurement of action weaknesses a. The smaller the ϕ- (a) the better the action.

Phi (ϕ): net flow

Net preference flow ϕ (a) is a balance between positive and negative preference flows:

$$(\phi)(a) = \phi^{+}\ (a) - \phi^{-}\ (a)$$

Calculations and combining strengths and weaknesses of actions to be one value ϕ (a) can be positive or negative. The greater a (a) the better the action.

4. RESULTS AND DISCUSSION

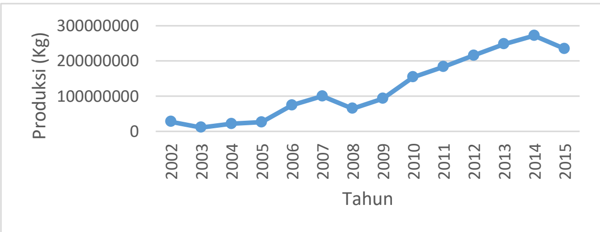
4.1 Fisheries in the Jakarta Bay

Teluk Jakarta is one of the most strategic areas in terms of landing fishery products. This can be seen from the large number of fleets both from the bay region of Jakarta and from outside Jakarta anchoring their catches at several fish landing sites in Jakarta. This is because DKI Jakarta and its surroundings are very dense areas so that they can form a potential market for fishery products, besides the existence of several fish landing sites (TPI), the pelabuhan perikanan nusantara (PPN) at Muara Angke and ocean fishing ports in the Kalibaru have become the main attraction for economic activists in the fisheries sector is to market their catches abroad. The following are some descriptions of these places.

Muara Baru PPS

Muara Baru PPS was built by the Indonesian government in 1980 and was inaugurated on July 17, 1984. Referring to the official PPS Muara Baru data page, initially the port was named PPS Jakarta and in 2004 it was changed through Decree of the Minister of Marine Affairs and Fisheries 04/2004 to PPS Nizam Zachman, Jakarta. As one of the PPS in Indonesia, Muara Baru PPS has five main services in shipping and fisheries, namely: subsidized fuel services for fishermen, fish loading and unloading inspection services, written log book services or written daily reports from skipper about fishing activities, certificate services fish catch (SHTI) and service for sailing approval letters (SPB) for ships sailing from Muara Baru PPS.

The Muara Baru PPS is the largest fishing port in Indonesia that has provided sustainable loading and unloading of fishery products because it is supported by good fisheries logistics patterns.



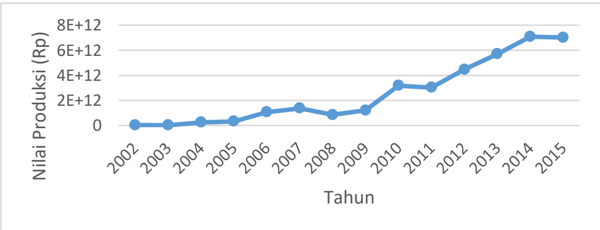


Figure 2 Results of Fisheries Production landed in Muara Baru PPS (a) along with the value of fisheries production (b)

From the picture above, it can be seen that fisheries production landed in the estuary PPS has only experienced a significant increase over the past 15 years. This can not be separated from the pattern of improvement in fishing activities from fishermen and the development of fishing fleets in Indonesia. However, it was seen in 2015 that landed catches decreased, this was due to the time span the government through the Ministry of Maritime Affairs and Fisheries (KKP) issued a ministerial regulation concerning the ban on the operation of ships over 30 GTs ex-foreign. This indirectly suppresses national fisheries production. This picture can be seen from the decline in landed catches at PPS Nizam Rachman (Muara Baru) which decreased by 24,000 tons in 2015 if compared to the previous year's production. Research by Hikmayani et al. (2015) also gave a similar indication where there had been a decline in fish production by 11% since the enactment of KP No. 56 2014. However, there were interesting data where although the number of fisheries production had been delayed in the 2014-2015 period, the catch value tended to be stable (see figure b). This is due to the price of fish which tends to be maintained even though it increases slightly. Hikmayani et al. (2015) stated that there was a percentage increase in fish prices by 100% at the fishermen level.

PPN Muara Angke

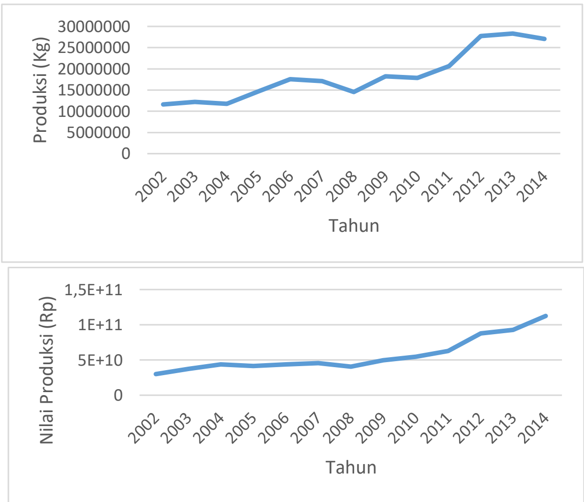


Figure 3 Results of Fisheries Production landed at Muara Baru PPS (a) along with the value of fisheries production (b)

The muara angke fishing port (6 ° 6′21 ″ LS, 106 ° 46′29.8 ″ BT) is located in Penjaringan sub-district, North Pluit sub-district, which is one of the largest fishing ports in the DKI Jakarta area. Formerly this port was a small port that was joined close to several other important ports such as the Sunda Kelapa port which was the main port area in the past. Like the port of the archipelago in general, the Muara angke PPN area is an integrated area equipped with fisheries product processing centers and fish auctions. According to data obtained from the DKI Jakarta Provincial KPKP service (2017), fisheries production landed at Muara Angke PPN has experienced a significant increase over a period of 15 years.

TPI Kamal Muara

TPI Kamalmuara is a fish landing site located in Penjaringan sub-district, North Jakarta. In general, the condition of this TPI is quite vulnerable because it is located near the Jakarta bay reclamation project, namely on islands C and D. At the time of research data collection, the location of TPI was an area affected by the eviction of the Jakarta coastal management project in the NCICD project.

Figure 4 Several fishing fishing boats moored around TPI kamal Muara

But lately the NCICD project has experienced a delay so that activities at TPI still continue as usual. The sale activity in this fish market can apply the auction system or sell directly to consumers. Aside from being a location for selling fish, the TPI location is also a tourist crossing pier to a thousand islands, especially those going to the island of P. Kelor, P. Cipir and P. Onrust. The following are data obtained from the KPKP service in 2017 related to fisheries production at TPI Kamal Muara.

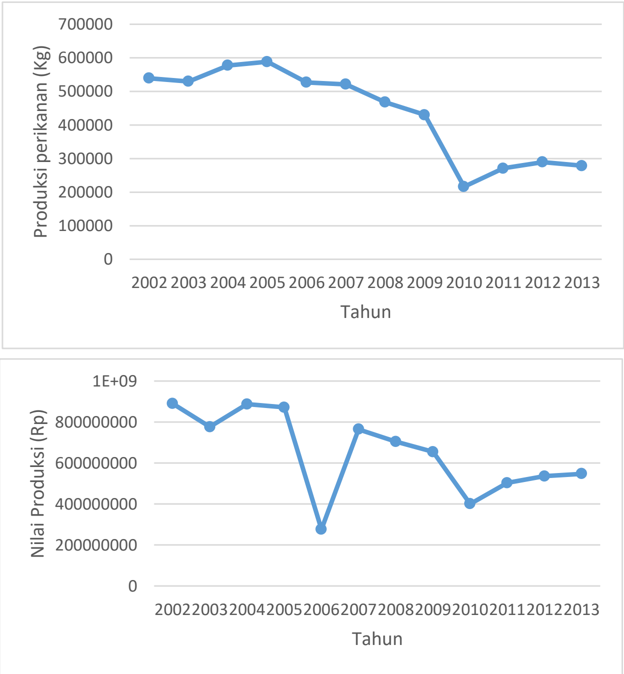


Figure 5 Produksi Perikanan di TPI Kamal Muara dan Nilai Produksi

It can be seen from the picture above that fishery production on land in TPI Kamal estuary has decreased by 40% over the past 15 years, this is due to the coastal area reclamation project which makes it difficult to access ships that will dock at TPI. In addition, several fishing gear such as sero and green mussel rafts have been evicted due to the reclamation island project in North Jakarta. From the results of interviews, most of the residents of Kamal Muara came from the Bugis tribe who in the 70s migrated to Kamal Muara area.

TPI Kalibaru

One of the most vulnerable TPI areas is the new times, this is due to the location of the TPI located very close to the expanded Tanjung Priok port area. In addition, NCID's activities in the form of a response to the Jakarta coastal area also had a major effect on Kalibaru's TPI activities. This has also triggered a decline in fish landed at the new TPI as seen in the graph below.

Figure 6 The path ways to Kalibaru TPI

From the Figure 7, it can be seen that there has been a decline in very large catches over the last 15 years landed at TPI Kalibaru. The decline reached its peak in 2003, where in the previous year fishery production reached more than 1200 tons of lau had dropped dramatically to 400 tons in 2003 and then stagnated and tended to decline until 2014.

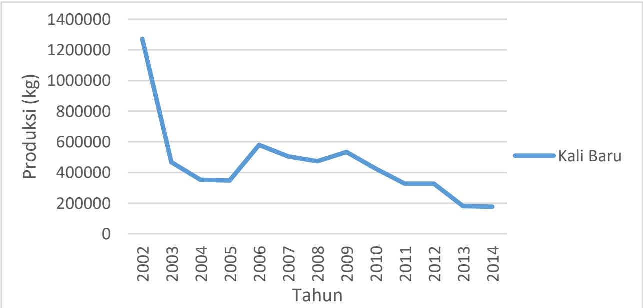


Figure 7 Fisheries production at Kalibaru TPI

Even though the number of fish landed at TPI continues to decline, the value of fisheries production shows a stable trend, even when the number of fisheries production is very high, but its production is low, but when production decreases the value of the rupiah produced by fishermen increases. So as to maintain the sustainability of the fisheries business in the region.

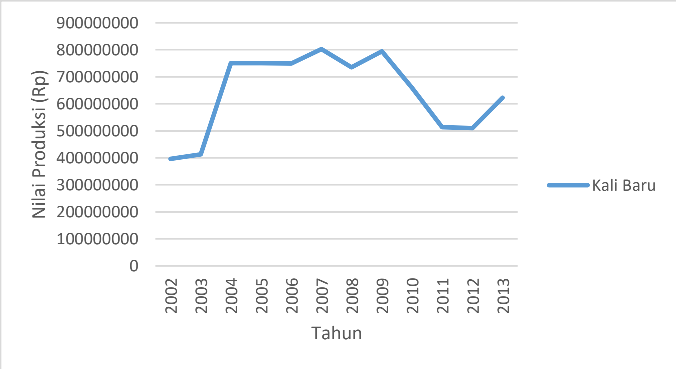


Figure 8 Fisheries Production Value at Kalibaru TPI

TPI Cilincing

Figure 9 Fisherman Vessels that are being moored around the Kalibaru TPI

The TPI cilincing region is generally better known as KCM, namely kalibaru, cilincing and Marunda. Where every activity held by government agencies such as the KPKP and KKP Service is always centered on cilincing TPI. Likewise the activities of many fishing organizations are concentrated in the TPI cilincing region.

The trend of fish landed in TPI has continued to decline and even reached 80% of the total landed in 2004. However, there are things that are quite interesting where the value of these fisheries has increased which is a buffer for fisheries activities in this region. In general, fishermen who occupy the Cilincing area are small fishermen who inhabit the coast and river estuary in Cilincing. From the results of interviews with several leaders of fishermen's organization groups, the majority of fishermen in Cilincing were immigrant fishermen from Indramayu and its surroundings.

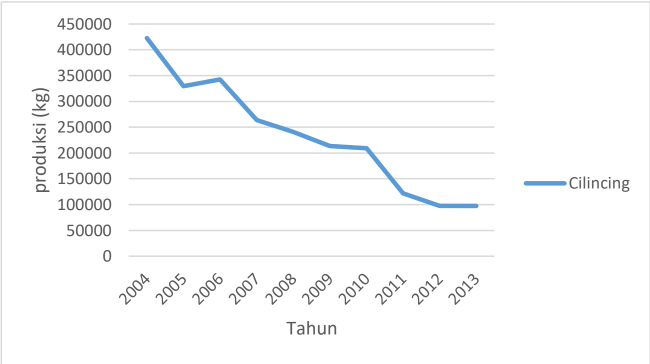


Figure 10 Fisheries production in TPI Cilincing

In addition, most of them are Andon fishermen who do not have a Jakarta ID card. Most fishermen in cilicning are small fishermen (0-10 GT vessels) with the main target being small pelagic fish. The fishing range is still around the bay of Jakarta and in the thousand islands. Besides the small pelagic fish, fishermen in cilincing also catch shrimp, rebon and rajungan (Marunda).

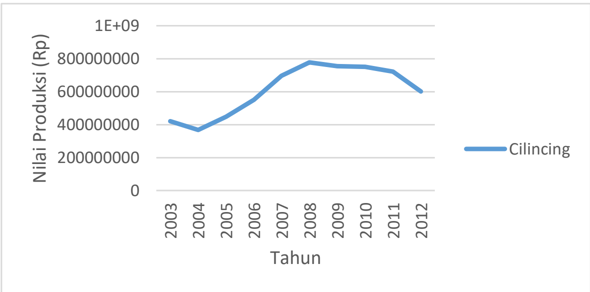


Figure 11 The value of fisheries production in TPI Cilincing

4.2 Capture Fisheries and Aquaculture

Capture fisheries and aquaculture activities are the main sources of fulfillment of animal protein for people throughout the world with more than 249 million tons of exploited fisheries. With details of 91 million tons of capture fisheries and 158 aquaculture fisheries. although since the 1970s capture fisheries have begun to show stagnation but fishing efforts have entered a new phase with the use of fishing equipment that is not environmentally friendly and the high capture effort due to the development of fishing fleets currently dominated by fisheries from China (FAO 2017)**.** Although overall aquaculture continues to increase, including aquaculture in Indonesia, the fisheries trend in DKI Jakarta actually shows the opposite, where it can be seen from the trend of fishing in the last 15 years that capture fisheries continue to increase while aquaculture stagnates. Stagnation of the aquaculture sector is more due to changes in the use of coastal land, especially along the bay of Jakarta, into residential areas. In addition, the decline in environmental functions in the Jakarta coast is a major cause of low productivity of aquaculture which is dominated by brackish ponds.

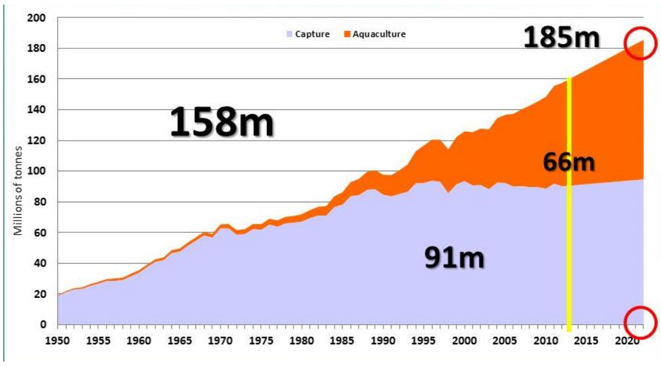


Figure 12 Trend of yields from capture fisheries and aquaculture (FAO, 2017)

On the other hand, the growing population in the Jakarta and surrounding areas has opened up huge market access, especially to meet domestic needs and seafood restaurants that are mushrooming in the Metrropolitan area. The development of new estuary fishing ports and muara angke has encouraged fisheries exports to foreign countries. The need for export fish raw materials is increasing very rapidly and potentially.

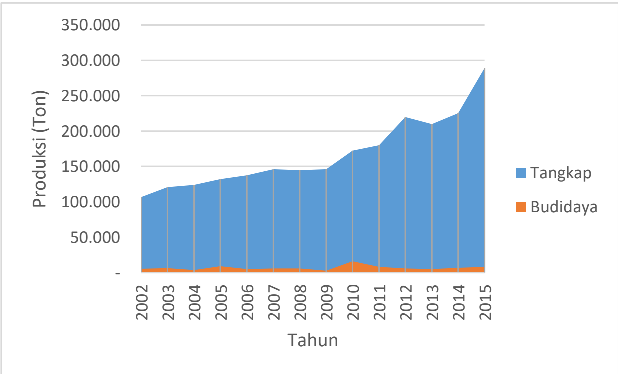


Figure 13 The trend of capture and aquaculture products landed in Jakarta

4.3 Composition of Local and Non-Local Catches of Fish

As an area that has PPS and PPN as well as many fish landing sites, the DKI Jakarta area gets a lot of fish supply both from local fish production (Fish caught by ships registered in Jakarta) and non-local fish caught and distributed from ships who are not registered in Jakarta

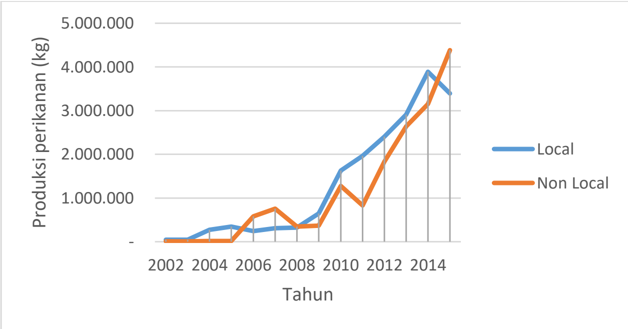


Figure 14 Comparison of Local and Non-Local Fish in Jakarta

It can be seen in the picture above that even though in total fish local production still dominates, in 2015 there were quite large fluctuations, while fish originating from outside the trend region continued to increase.

4.4 Fishing gear (Fishing Gear)

Table 3 Some fishing gear commonly used by fishermen in Jakarta Bay

Type of gear		DKI Jakarta	Kep. 1000	Jakarta Utara
TOTAL		19.893	6.448	13.445
Purse seine	Jaring lingkar bertali kerut (Pukat cincin)	353	-	353
Pull net	Dogol	65	-	65
	Payang	156	86	70
Pukat Hela	Pukat hela pertengahan berpapan (Pukat ikan)	2	-	2
Lift net	Bagan perahu	88	-	88
	Bouke ami	1.050	-	1.050

	Bagan tancap	87	31	56
Gill net	Jaring insang tetap/Jaring lion bun	332	-	332
	Jaring insang hanyut/Jala insang osenik	667	137	530
	Jaring klitik	397	-	397
Trap	Bubu ikan	14.593	5.043	9.550
	Sero	168	-	168
Pole and line	Pancing ulur	1.361	1.151	210
	Huhate	15	-	15
	Pancing cumi	461	-	461
	Rawai tuna	98	-	98

Sumber: (Dinas KPKP, 2017)

The actual use of fishing gear cannot be released from the activities of fishermen in conducting exploration and exploitation of fisheries resources which are the classification or media classification of the types of fishermen who inhabit an area. Technically the use of fishing gear is very closely related to the composition of fishermen, the number and length of trips and capital used, for example Bouke ami as one of the dominant fishing tools whose purpose is only to catch squid, where the size of the ship is 10-30 GT, 100 trip length days and operational costs of 300 million in one trip. This is certainly not comparable with traditional fishermen who use boats that are only <5GT, 1-day trips and 200,000-300,000 operational costs in one trip. Interestingly, from the data above, it can be seen that even though the regulation of Minister of Agriculture KP No. 2 of 2015 is still valid, the existence of cantrang fishing gear and the like is still found there even though the value has decreased dramatically. On the other hand the number of bubu usage continues to increase.

4.5 Catches Per fishing gear

Table 4 Catches based on the type of fishing gear

Jenis Alat Tangkap	Jumlah Hasil Tangkapan (Ton)		
	2013	2014	2015
Payang	118	192	622
Dogol	146	168	446
Pukat Cincin/Purse Seine	71.444	77.907	69.693

Jaring Insang/Encircling Gill Net	1.221	1.199	1.400
Jaring Rampus	61	63	13
Bouke Ami	29.173	21.834	41.223
Rawai Tuna/Long Line	13.695	11.686	6.196
Pancing Cumi/Squid Jigger	230	240	210
Pancing/Hooks and Lines	79	74	755
Bubu	236	216	278
Muro Ami	-	-	-
Lainnya/Others	161.057	186.917	207.536
Jumlah/Total	277.460	300.495	328.373

Sumber (KPKP, 2017 diolah)

From the table above, it can be seen that the trawl rings and Bouke Amami are the two dominant catches with a much larger catch compared to other fishing gears. According to KPKP official data (2017) the number of Bouke ami fishing gear is 1,050 units, most of which are in the Muara angke PPN area. Purse sein amounts to 353 units with an average catch of 73,000 tons each year with an average sales value of Rp 1,907,147,989 while tuna long lines are 98 units with an average production of 10,526 tons per year with an average value sales of Rp. 411,587,274. Of some dominant fishing gear such as Bouke Ami and Sein Purse, tuna longline longline production continues to decline and even reaches more than 50% of the total production two years earlier.

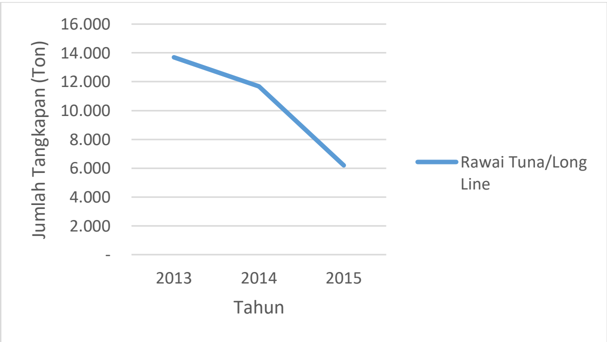


Figure 15 Trends in the Catch of Rawai Tuna

In theory, the high number of fishing efforts will greatly affect the number of catches in an aquatic area to a certain extent or commonly known as Maximum Sustainable Yield (MSY). The trend of landed catches in Jakarta DKI has a tendency to increase every year with an average of 166,520 tons as well as the number of fishermen recorded reaching 33,500 fishermen. Although the trend of production and fishermen are equally increasing, however, if it is linked in regression the effect of increasing the number of fishermen does not have a strong correlation with the amount of production. This can be a symptom or signs regarding the stagnation of fisheries resources, especially in the fishing area.

4.6 Number of Fishermen and Fisheries Production

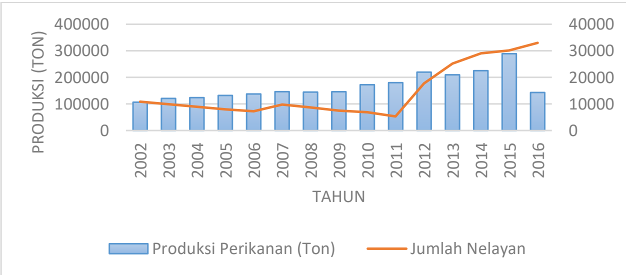


Figure 16 Comparison between total fisheries production and the number of fishermen in Jakarta

4.7 Fisheries Product Distribution Scheme

As an interconnected system, fisheries activities must be carried out with appropriate and directed mechanisms to ensure the sustainability of the fisheries system itself. In metropolitan areas such as Jakarta, fulfilling the need for animal protein is very important. In addition, large cities that use services as their main source of income increasingly encourage the growth and development of culinary tourism places, traditional markets (especially in satellite cities), which require a wide supply of fisheries resources every day. In Figure 18 the distribution patterns of fisheries commodity catches reach consumers.

In Figure 18, it can be seen that the catches of fishermen who enter PPN or PPS are more oriented to the industry and export destinations where, 90% of fishermen's catch enters cool storage, then 70% is for export and special orders and only 10% of the catch who entered the auction which then arrived at household consumers. From this picture it can be concluded that the fulfillment of household consumption of fish catches will be supplied from TPI in several areas in Jakarta. This information was obtained at the time of the survey in several TPIs, indicating that buyers for household scale were more likely to enter TPI compared to industry.

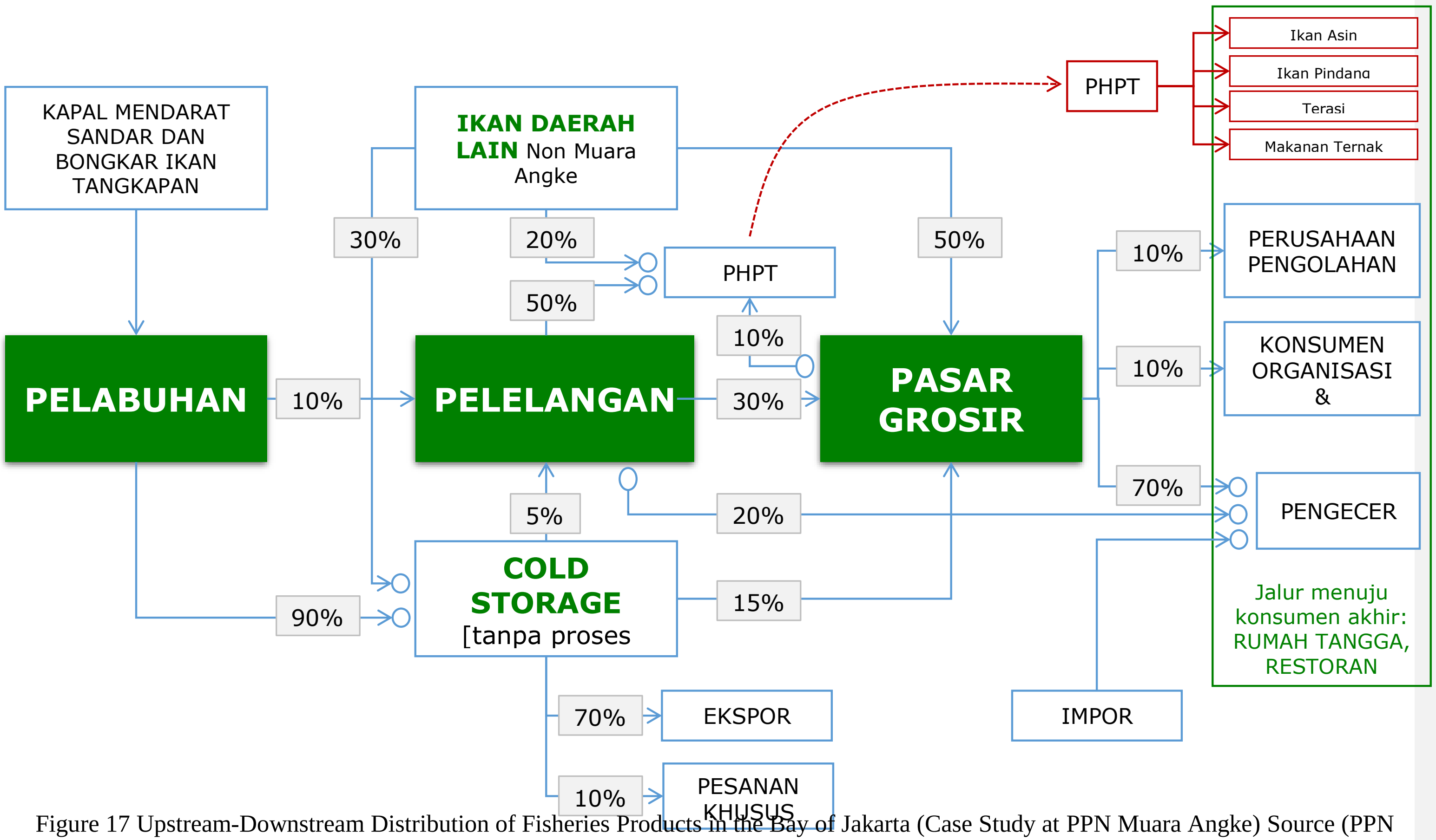


Figure 17 Upstream-Downstream Distribution of Fisheries Products in the Bay of Jakarta (Case Study at PPN Muara Angke) Source (PPN Muara Angke 2017)

4.8 Analysis of PRR & Regional Fisheries Ecological Footprint

In this study we conducted an analysis related to primary production required (PPR) based fisheries ecological footprint. To facilitate the analysis process we limit the scope of the analysis only to the Jakarta bay area, where the determination of the number of catches and types of fish captured is determined based on the results of interviews with small fishermen, it is assumed that the small fishermen only catch the Jakarta bay area. From the results of interviews with fishermen, there were several types of fish which were the main catches for fishermen who made arrests around the bay of Jakarta. Knowledge of carrying capacity through the analysis of the ecological footprint of the Jakarta bay has not been specifically carried out so that in this study an ecological footprint analysis was carried out to see how much the water system's ability in Jakarta Bay to support fisheries activities. Regional ecological footprint (RFEF) is an approach to calculating the ability of an area to support the sustainability of aquatic biota. In other words this approach also shows the carrying capacity of an aquatic ecosystem.

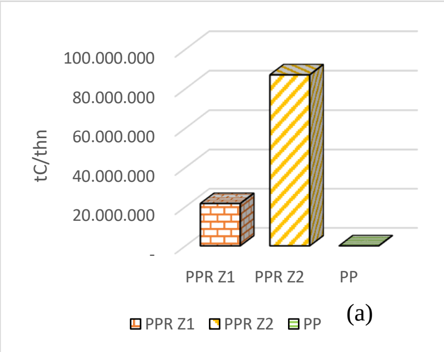
Table 5 The main catches of Jakarta bay fishermen

Coastal & Coral System						
NO	**Jenis Ikan**	**Nama Latin**	**SP**	**TL**	**SD**	**Nama Global**
1	Rajungan	*Portunus sp.*	2	3,43	-	Swimming Crabs
2	Baronang	*Siganus sp.*	2	2,4	0,08	Streaked spinefoot
3	Teri	*Stolephorus tri*	2	3,3	0,4	Spined anchovy
4	Kakap Merah	*Lutjanus sp.*	2	3,8	0,6	Indonesian snapper
5	Kerapu	*Epinephelus sp.*	2	4,2	0,61	Malabar Grouper
7	Kwee	*Charanx sp.*	2	4,2	0,4	Giant trevally
8	Udang+Rebon	*Acetes sp*	2	3,11	-	Shirimp
9	Cumi	*Loligo*	2	3,3	-	Squid

10	Mayung	*Arius sp.*	2	3,5	0,37	Threadfin sea catfish
11	Belanak	*Mugil sp.*	1	2,5	0,7	Flathead grey mullet
			Tropical Shelves			
NO	**Jenis Ikan**	**Nama Latin**	**SP**	**TL**	**SD**	
1	Tembang	*Sardinella sp.*	1	2,7	0,3	Fringescale sardinella
2	Kuro	*Eleutheronema sp*	1	4,1	0,5	Fourfinger threadfin
3	Bentrong	*Selar sp.*	1	3,8	0,2	Big eye Scad
4	Kembung	*Rastrelliger sp.*	1	3,2	0,38	Indian mackerel
5	Alu-alu	*Sphyraena barracuda*	1	4,5	0,6	Great Barracuda
6	Tenggiri	*Scomberomorus sp.*	1	4,5	0,4	Narrow-barred Spanish mackerel
7	Layur	*Trichiurus sp.*		4,3	0,76	Savalai hairtail

(Sumber: Data penelitian)

RFEF was developed from the study of pauly & Christensen (1995) about Primary Production required which had little modification in its primary productivity value. Pauly & Christensen (1995) determine the divider from the PPR value (gC / km2 / year) is the value of primary productivity (PP) (gC.m-2.y-1) according to the water system. In this case they divide the water system into several aquatic systems such as oceanic systems, upwelling systems, tropical shelves, non-tropical shelves, coastal & coral systems, and fresh water systems. The six water systems have a predetermined primary productivity level of 103, 973, 310,310, 890, 290 respectively. The survey results on the main catches of fishermen, obtained about 17 species of fish which are the main catches for fishermen who make arrests around Jakarta waters which are then used as the main basis for calculating the PPR value. Pauly & Christensen (1995) determine dividers from the value of PPR (tC year-1) is the value of primary productivity (PP) (tC.km-2.tahun-1) according to the water system.



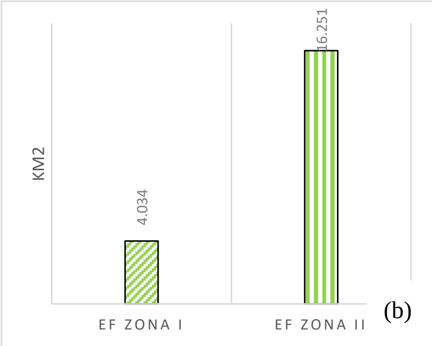


Figure 18 PPR values (a) each zone (tC / yr) and fisheries ecological footprint (km2) (b)

In this study, observations regarding the ecological footprint are slightly different from the above division, which only divides the calculation base into two main parts, namely zone I and Zone II where the base is the type of fishermen including fish species which are usually caught by each fisherman. PPR analysis (Figure 2a) is done to see how much primary productivity concentration is needed in this case carbon harvested from the waters and how much carbon is available in these waters to support the sustainability of fish resources. While Figure 2b is an ecological trace value which is a division between PPR and regional primary productivity obtained from the equation de Leo et al. (2014) namely Gross Primary value Production x 365 days x The area of DKI Jakarta's sea waters then divided by 1000 or equivalent to 6708 tC.km-2.tahun-1. PPR is a product of the mass of the carbon catch being converted and the conversion ratio for the trophic level of each taxa involved. For example that PPR is needed to produce one metric ton of tuna significantly greater than the metric ton of sardines because tuna is much higher in the food chain. According to pauly & Christensen (1995) that global fishing is highly mediated by aquatic productivity. Morato et al. (2009) tried to connect between orange roughy biomass (Hoplostethus atlanticus) and changes in the level of primary productivity in the seamount ecosystem area as well as to look at its relationship with PPR (Primary Production Recquired). Structurally Morato et al. (2009) also calculated the biomass relationship of several types of fish that are on the border of marine mountain ecosystems such as sharks, rays, billfishes, balen whales, toothed whales, seabirds, tuna, skates and turtles. The results in the second part of the modeling study have attempted to measure more accurately by modeling PPR values to maintain large aggregations of fish around the underwater ecosystem. In the Study, it has supported the idea that increasing local primary productivity cannot sustain large aggregations of marine fish. This is because it does not allow the circulation of water to be maintained around the submarine for several months which is needed for productivity which works through food networks to a higher level than trophic level which is on the underwater mountain itself. Further analysis related to the ability of an ecosystem to ensure the sustainability of fish biomass is to analyze the biocapacity of ecosystems, namely linking the ecological footprint obtained from the PPR value divided by the value of the primary productivity of a particular waters. Through this research, biocapacity calculation (BC) was modified to suit the research area, because in general biocapacity calculations are global calculations so that it needs to get a little adjustment especially in the calculation of yield factors on this occasion obtained by dividing the total catch of fish species divided by the area of last waters divided by carbon transformation value. In addition, the distribution of the value of biocapacity to the rate of carbon exploitation was also applied to see the differences in the actual conditions of comparison between ecological footprint and biocapacity without and or with the rate of exploitation of carbon.

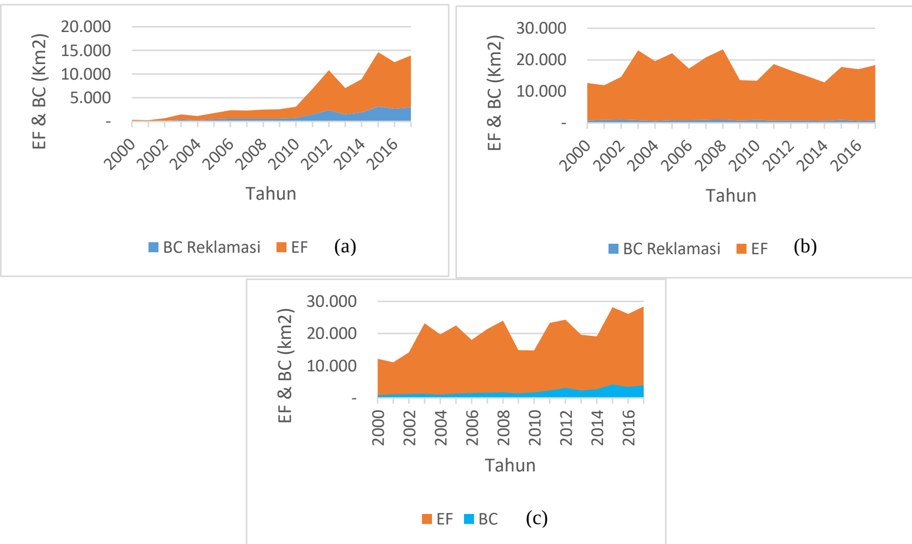


Figure 19 Comparison of EF values for zone I (a), zone II (b) and total (c) for the past 17 years

In Figure 20c, it can be seen that the ecological trace value far exceeds the water biocapacity with a ratio of 10: 1, in other words, this condition shows symptoms of overshot or potentially unsustainable due to the enormous burden on the environment. Specifically the biocapacity value averages only 2023 km2 or 30% of the total area of DKI Jakarta's waters, while the ecological footprint reaches 20,284 km2The status of aquatic ecosystems that overshot means that the carrying capacity of the waters for the life of organisms is very worrying, this can be seen from the total fisheries production landed at several fish landing bases which continue to decline, for example in the Kalibaru area, fisheries production decreases from 1300 tons for 2000 to only around 190 tons in 2017 or reduced by 72% as well as fish landed in Kamal estuary decreases from 500 tons in 2000 to only 250 tons in 2017 or reduced by half.

In particular, the high ecological footprint has become a special problem in tropical coastal ecosystems of large cities, including DKI Jakarta, which are comprehensively marked and quantified by the occurrence of pressure that threatens the function and health of the environment in the long run, especially in the Jakarta Bay region (TJ). Breckwoldt et al. (2016) explain the environmental stresses that occur in Jakarta Bay with a number of possible feedback loops between various environmental stressors, marine resources and human populations in the Jakarta Bay and Thousand Islands can be seen. The magnitude of anthropogenic pressure on the larger TJ ecosystem can be clearly seen. Cleary et al. (2016) found that the distribution and abundance of several organisms associated with coral reefs could reflect very eutrophic and chronically exposed water conditions caused by the large number of disturbances originating from land use over.

Compared to the middle and offshore sampling locations, the area near the coast is dominated by sand algae, debris and grass, little fish, sponges, echinoderms, ascidia, molluscs, benthic, foraminifera and macroalgae which are characterized by disturbed physical chemical conditions where surface temperature high seas, dissolved oxygen and chlorophyll concentrations, and very low live coral cover. Environmental gradients along the Thousand Islands also affect the ratio of Sr / Ca in coral cores, which is used as a proxy for estimates of sea surface temperatures in the past. Cahyarini et al. (2016) can show that coral cores obtained at TJ are more influenced by air temperature and thus urbanization while nuclei obtained from offshore are further affected by sea surface temperaturesIn addition, during the El Niño onset phase in previous years (exemplified in 2015), the coastal core showed warming while the offshore core showed cooling. This impact on coral reefs will affect more various fish resources that live in the ecosystem. From the basis of this research, we confirmed the pattern of decreasing fish catches, especially those associated with coastal areas and coral reefs, and on the other hand the ecological footprint exceeds

Jakarta bay biocapacity, thus requiring a sustainable management pattern to map the sustainability of the fisheries sector in Jakarta bay, especially now is being faced with massive intensity of coastal development. Based on the magnitude of the pressure that occurs, it can also be described in the number of catches of fishermen. Seen some economically important fish species the number of arrests continues to decline from year to year.

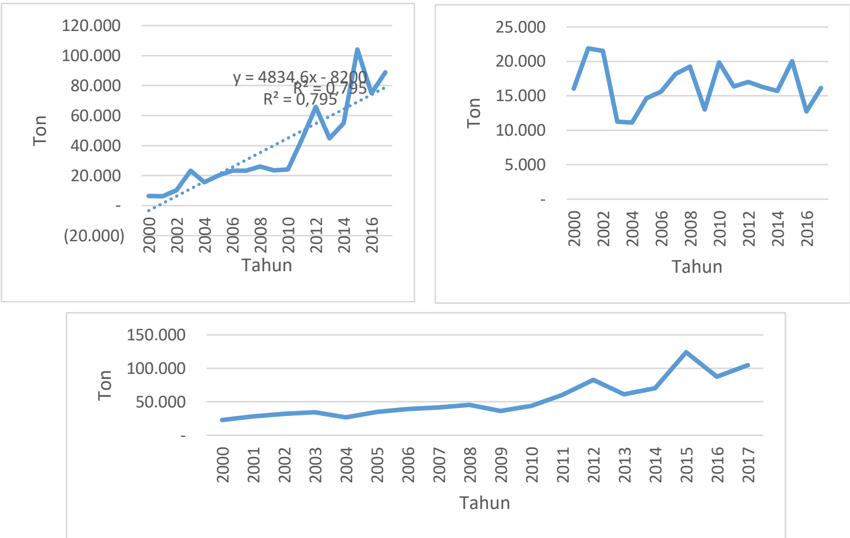
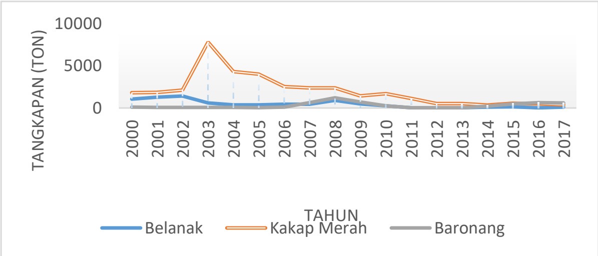


Figure 20 Jumlah hasil tangkapan (Ton) pada sistem perairan a) coastal & coral reef; b) Tropical shelves; c) Total a&b

Seen in Figure 21, fisheries production continues to increase every year, but if the production is based on the aquatic system, it can be seen in Figure 21a that the number of fish production in tropical shelves has decreased while total production in the coastal and coral system continues to increase. But it needs to be underlined that the increase occurs in total but if sorted by type of fish, it will be seen that the majority of fish catches continue to decline.

It can be seen in Figure 22. There was a drastic decline in red snapper associated with coral reefs, as well as mullet (Mugil sp) which was analized with mangroves, while baronang fish (Siganus sp) was stagnant. Decreasing the catch of some economically important fish species in the waters of the bay of Jakarta is caused by a decrease in environmental quality due to the damage to important ecosystems that support the life of living things in the bay of Jakarta. Burke et al. (2011) explain that damage to coral reefs is strongly influenced by human activities. Furthermore Baum et al. (2015) explained that the condition of the coral reefs in the bay of Jakarta had suffered damage due to high sedimentation and anthropogenic pollution which caused a decrease in fish species.



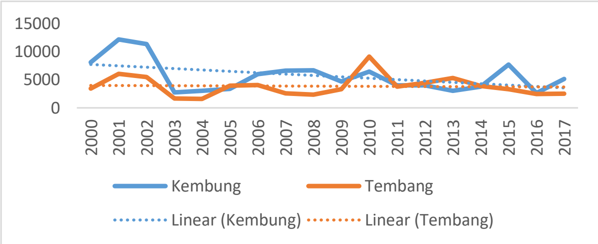


Figure 21 Trend of fish catches associated with coral reefs, seagrass beds and mangroves

Maduppa et al. (2012) have also predicted a decline in fish stocks in TJ and a thousand islands. Overall, the biodiversity of reef fish in the Thousand Islands seems to be related to environmental conditions such as turbidity and pollution levels from the Jakarta Bay to the north of the island. Research on the relationship between diversity of coral reefs and the diversity and density of fish has been widely carried out (Jayaprabha et al. 2018). But there are interesting things where baronang fish production (Siganus sp.), Tends to be stagnant and even increase (although not so large). According to Clearly (2017) fish species in disturbed coastal waters relatively have faster growth speeds but are short-lived when compared to fish species that inhabit areas that are still good. These include species found on the coast such as Canthigaster compresus, Cephalopholis fish, Cheilodipterus quinquelineatus and Siganus canaliculatus. Species found on the coast tend to occur throughout the Jakarta Bay which shows a general lifestyle and tolerance for various environmental conditions. For middle fish communities and far from the coast, the opposite consists of species that have relatively longer growth and slower growing species such as Abudefduf sexfasciatus and Hemiglyphidodon plagiometopon which are not really found on the coast. This is also evident from observations during the study of the crab (Protunus sp), where the crab catches experienced considerable fluctuations but with an increasing trend over the past 17 years. From several studies on crabs, it was seen that the crabs in the bay of Jakarta had carapace size and size when they first matured gonads which were relatively smaller when compared to other regions. According to Hamid et al. (2017) the size of the crab carapace when first gonad mature found in Lasongko Bay in Southeast Sulawesi was 109.83 mm for males and 115.71 for females. Ernawati et al. (2014) the size of the crab in the Central Java starch regency first gonad matured an average of 107 mm.

4.9 Emergy Analysis

In calculating the emergy value, we observed and collected data around the fishing village in North Jakarta as a database and for the addition we also observed thousand islands (Tidung and Pramuka Islands). We determine 12 items for the emergy calculation approach (see table of results).

Table 6 Emergy calculation results of capture fisheries in Jakarta Bay

Item	Unit	Data (Unit/Year)	Transformity (Sej/Unit	Emergy	Refference
			Renewble emergy		
Solar	J	1,46E+08	1	1,46E+08	Odum 1996; Ulgiati & Eliana Bardi
Wind		1,41E+09	2450	3,45E+12	Patria
Tide		2,31E+14	44	1,02E+16	Ulgiati & Eliana Bardi
Total R				1,02E+16	
			Paid Input		
Labor		1,35E+12	1670	2,25E+15	Ulgiati & Eliana Bardi
Fuel		1,06E+13	53000	5,64E+17	Hadem, 2002;Patria 2012
Operationa Cost	Rp/Yr	4,64E+10	1,77E+08	8,21E+18	Patria, 2012
			Capital Cost :		
Fishing vessel	Rp		1,77E+08	656,0419	
Fishing gears	Rp		1,77E+08	1009,295	
Machine	Rp		1,77E+08	126,1619	
Total F				8,78E+18	
			Output		
Fish production	g/yr		1,77E+08	6,79E+13	
Fishing value	Rp		1,77E+08	2,73E+19	
		Total J		2,73E+19	
			Y = I + F	8,79E+18	

R	1,02E+16	
F	8,78E+18	
Emergy Yield Ratio (EYR)	1,001158	Does not affect the economy
Environmental Load ratio (ELR)	863,4472	
Emergy Sustainability Index (EYR/ELR	0,001159	unsustainable

Renewable Resources

Renewable resources are substances of economic value that can be replaced or refilled at the same time or less time needed to pull supplies down. Some renewable resources basically have endless supplies, such as solar energy, wind energy and geothermal pressure, while other resources are considered renewable, although some time or effort must go into their renewal, such as wood, oxygen, skin and fish.

Most precious metals are considered renewable too; even though they are not naturally replaced, they can be recycled because they are not destroyed during extraction and use. In this study, we calculated the emergy value of renewable resources in the Jakarta bay such as sunlight, sea tides and wind. Sunlight is calculated by means of area x insolation x albedo x transformation from the calculation generated emergy value of 1.4×10^{8} while for wind is calculated by taking into account the area of the sea, drag coefficient and wind speed that is 2.37×10^{14}. Sea tide as the main source of mass transport movement and aquatic biota has an emergy value of 1.02×10^{16}. From these results it can be seen that the tides have a much greater emergy value, this shows the magnitude of the tidal effect on the Jakarta bay ecosystem. While the sun's energy functions as the main energy source that grows food sources for all organisms that live in the sea waters.

Paid input

The fisheries system as a unit has a causal relationship that coheres with each other, including the cost of carrying out fishing activities. High fishing activities have been suspected as a result of a decline in a number of fishery commodities. BRKP (2018) explains that the condition of a resource contained in a natural ecosystem such as the sea, will experience variation from year to year due to the influence of biotic and abiotic factors contained in the ecosystem, so that if an ecosystem has experienced the symptoms of over-population and exploitation, it will be difficult for the ecosystem to recover. Measurement of the sustainability of fisheries resources can be approached with many methods such as Catch per Unit effort and in this study will be illustrated by the value of energy transformation that is produced in each fishing effort.

Paid inputs in small-scale capture fisheries in the Jakarta Bay consist of operational costs including fuel and capital costs (machinery, fishing gear, ice, ships). From the results of emergy calculations produced for fuel worth 5.64 x 10^{17}, labor 2.25 x 10^{15}, operating costs 8.2 x 10^{18}, vessels 6.5 x 10^{5}, fishing gear 1.01 x 10^{3}, engine 1.26 x 10^{2}.

Emergy Yield Ratio

According to emergy algebra, the emergy output of a system equals the sum of all independent emergy inputs (IE non-product) to the system. Emergy analysts are often called the sum of the types of resources that can be renewed with the types of resources that cannot be renewed (Non Renewable) and the inputs spent (F) (Yield = R + N + F) of a system. Although what is actually the theory represents the total "memory" of the total exergy (available energy) needed to produce a system. So, consistent with the command of emergy theory, the so-called "Yield" is actually a donor-side measure of the resources needed to make something, rather than a user-side measure of what can be obtained from energy (Raugei et al, 2005). Furthermore, the value of EYR is also defined to calculate how much influence a resource has on the economy in an area. From the results of Emergy Yield Ratio calculation of capture fisheries in the Jakarta Bay produced a value of 1.001158 or in other words capture fisheries activities have not provided a significant influence on the economy in the Jakarta area. This can be seen from the low contribution of the fisheries sector to the DKI Jakarta GRDP which only reached 0.001% (JDA, 2017). Brown & Ulgiati (1997) describes that Emergy Yield Ratio is an Index that can be interpreted as the ability of the local system to exploit local resources to deliver 'real' wealth to a larger economic sector. When applied to an activity, EYR reflects 'efficiency' in processing local resources: the smaller the input emergy (M + S), the higher the EYR value, which indicates the more efficient an activity (Arbault et al, 2014).

Furthermore, from the calculated value, it can be seen that emergy values >1 and <2 have no effect on the economy because the results obtained are more supported by local resources. But Brown et al (2012) argues that this definition is misleading for the evaluation of technological systems (i.e. the chain of processes), because usually they do not have specific locations in the global economy. Therefore, the perspective on EYR explores developments in its application. (Arbault et al, 2014) proposes switching from vs. local vs. import 'to' foreground vs. background 'by adopting a life cycle perspective when calculating EYR for industrial processes. For example, in the case of diesel oil input into the modeled process, crude oil emergy is considered as foreground input, while background investment includes additional emergy inputs throughout the production chain used to extract crude oil and convert it into diesel oil. The EYR value may be compared with several economic investment theories. For example, it is related to the value of the incremental capital output ratio (ICOR) and Incremental Labor Output Ratio (ILOR) which, according to the Bappenas RI (2014) analysis the value of both items can show the investment pattern of a resource by looking at the efficiency of a project. However, calculations related to EYR will be greatly influenced by the accuracy of determining the transformity value of each calculation item to avoid bias from the approach.

Environmental Load Ratio (ELR)

ELR is defined as the total energy value of a resource that cannot be renewed and invested divided by the value of energy from renewable (ELR = (N + M + S) / R). A high ELR indicates the high intensity of non-renewable (N) and / or high technology (M + S) resource use of the process. In addition, it is often claimed that high ELR highlights high levels of environmental stress in the local environment (Brown and Ulgiati, 1997; Ridolf and Bastianoni, 2008; Ulgiati and Brown, 1998). The value of capture fisheries ELR is 863,4472 a year. The greater the value of ELR shows the greater pressure of human activities on resources. Although the idea of environmental stress can be adapted for emergy accounting, where it focuses on resource use, but usually does not include pollution-related impacts (for further discussion about accounting for the impact of pollution on emergy evaluation). The considerable environmental burden (Figure 3b) has suppressed the existence of several important economical fish species that were captured by fishermen in the Bay of Jakarta. This is reflected in Figure 3a that the number of reef fish catches has continued to decline due to the high catching effort and the decreasing environmental conditions due to pollution and land conversion (Robin, 2018).

In Figure 22 b, it can be seen that the ecological footprint in the Jakarta Bay has experienced a very large increase that has exceeded environmental biocapacity to support the sustainability of fisheries resources in the Jakarta Bay (Robin, 2018). This phenomenon can theoretically be correlated with the increasing burden of the Jakarta Bay ELR which, if left unchecked will cause the bay fisheries system to become obstructed and possibly even permanently damaged.

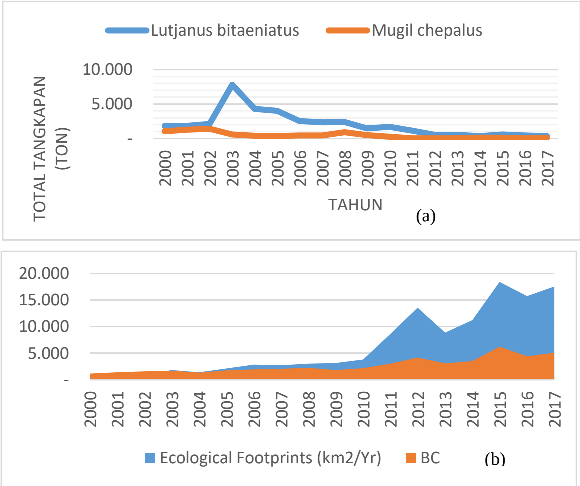


Figure 22 Trend of catching several economically important fish (a) and comparison of the value of ecological footprint and biocapacity in Jakarta Bay (b)

Emergy Sustainability Index

The Emergy Sustainability Index (ESI) is the emergy yield ratio (EYR) to the environmental loading ratio (ELR), which is a measure of the sustainability of a product, process or service. Thus, a larger ESI shows better sustainability than those that are suitable for goods, processes, or services. Calculation of the sustainability index of capture fisheries energy in Jakarta Bay is 0.001159. Ren et al (2015) A process is not sustainable in the long run when ESI <1; a process can have an ongoing contribution to the economy for the medium period when 1 <ESI <5; a process can be recognized as sustainable in the long run when ESI> 5; a process does not develop when ESI> 10.

4.10 Livelihood Analysis

Ranking

After the data quisioner is processed in the exceel file to set the average of each weight of capital, then the results are presented in the Promethee table to see the ranking of each research station capital, the results are presented in Table 2.

Table 7 The value of Phi inhalation in Promethee's analysis

Rank	action	Phi	Phi+	Phi+
1	Kamal Muara	0,7000	0,8000	0,1000
2	Marunda	0,3000	0,6500	0,3500

3	Kalibaru	0,2500	0,6000	0,3500
4	Cilincing	-0,3500	0,3000	0,6500
5	Muara Angke	-0,9000	0,0500	0,9500

The ranking results are obtained based on the current Phi preference value. Preference flows are calculated to consolidate the results of paired comparisons of actions and to rank all actions from the best to the worst. Three different preference flows are calculated:

Phi+ (ϕ+): positive (leaving) flow:

$$(\phi^{+})\text{ (a)} = \frac{1}{n-1}\sum_{b\neq a}\pi(a,b)$$

Positive preference flow ϕ + (a) measures how much action a is preferred over the other n-1. This is a global measurement of the power of action a. The greater ϕ + (a) the better the action

Phi- (ϕ^{-}): negative (entering) flow

$$(\phi^{-})\text{ (a)} = \frac{1}{n-1}\sum_{b\neq a}\pi(b,a)$$

Negative preference flow ϕ- (a) measures how much other n-1 actions are preferred over actions a. This is a global measurement of action weaknesses a. The smaller the ϕ- (a) the better the action.

Phi (ϕ): net flow

Net preference flow ϕ (a) is a balance between positive and negative preference flows:

$$(\phi)(a) = \phi^{+}\ (a) - \phi^{-}\ (a)$$

Thus calculating and combining strengths and weaknesses of action into one value. ϕ (a) can be positive or negative. The greater a (a) the better the action.

Figure 23 shows that Kamal Muara is ranked highest or in other words has a smaller value of vulnerability, whereas muara angke has the lowest value or has a high or very high vulnerability. This ranking is a combination of all research items described from the condition of the five capitals owned by each fisherman family per research station. To see the influential capital factors of each research station, the promethe analysis provides tools to solve this problem.

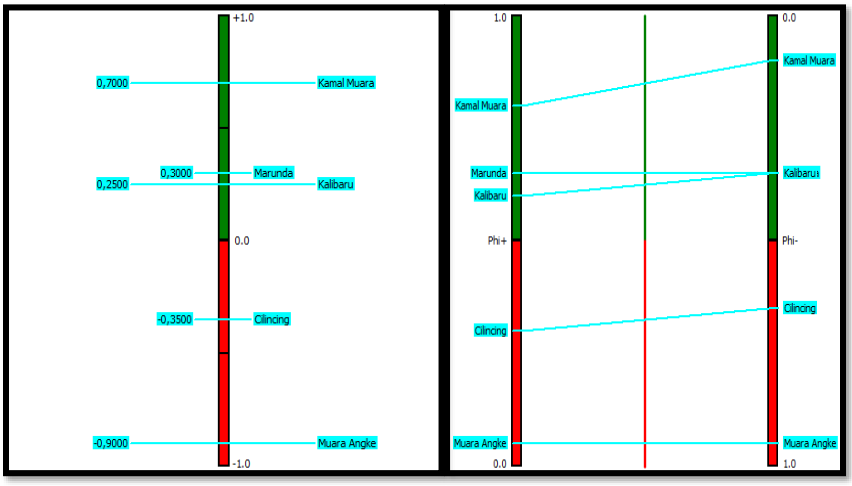


Figure 23 Ranking of vulnerability of fisherman livelihoods in 5 research locations in Jakarta Bay Promethee I partial ranking (Right) and Promethee II complete ranking (left)

PROMETHEE Rainbow

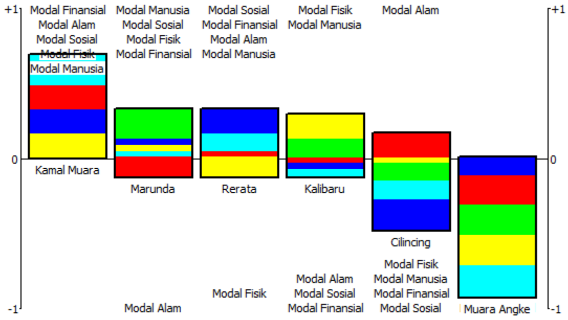


Figure 24 Contribution of each capital to the level of vulnerability of each station

PROMETHEE Rainbow is a disaggregated view of the complete ranking of PROMETHEE II. This shows the detailed calculation of Phi net flow, emphasizing the good and weak features of each action or action. To see what capital factors most influence the resilience of each research station, Promethee's analysis can also map the combination of each capital to maintain the stability of fisherman household conditions. For each action described by the bar (bar). Different slices of each bar are colored according to the criteria. Each slice is proportional to the contribution of one criterion (flow value multiplied by the criteria weight) to the net value of the Phi network from the action. Positive slices (upwards) are in accordance with good features while negative pieces (down) are in accordance with weaknesses. In this way, the balance between positive and negative slices is equal to Phi's score. Actions are ranked from left to right according to Complete Ranking PROMETHEE II (Figure 23).

In Figure 24 it can be seen that each capital that characterizes the level of vulnerability of fishermen's livelihood is different for each station, where in the kamal muara region, all capital has a positive value or in other words shows resilience while in Marunda the value of human capital, social and financially contribute positively but for natural capital or access to be a major weakness. Kalibaru area is highly supported by physical capital and human resources while the other three capital have not had a positive effect but also have no negative effects. In other words, these three capitals are still very possible to be improved to maintain the level of resilience of fishermen in the area. The Cilincing and Muara angke areas are very vulnerable areas based on the bar position in promethee analysis in the overall negative quadrant and only natural capital in the positive quadrant (Cilincing area only). The factor that has the biggest contribution is financial factors for muara angke while for Cilincing is a social factor

Contribution of each Station Capital

The contribution of each capital to the resilience of fishermen in the bay of Jakarta will be easily understood if it is displayed in the form of a spider web diagram. Promethee analysis provides tools called GAIA Web. The GAIA Web window describes the appearance of spiderweb which is enhanced for one action. there are five separate GAIA web windows that can be opened to compare various actions. In ordinary spiderweb, displaying variables (criteria) are equally placed around the center of the screen. The shape of the spider web depends very much on the order of changing criteria. In Web GAIA, the criteria axis is oriented as in the GAIA field. So, criteria that state similar preferences are located close to each other and the spiderweb form is more meaningful. For each dimension (individual or group criteria or group criteria criteria), the radial distance corresponds to the net flow score (-1 in the center and +1 in the outer circle). If the value of phi is on the decision axis (dashed circle image), the contribution of capital shows good value at each station, meaning that the station is resilient, while the capital value that passes through the DM axis is said to be very good otherwise if the capital value is below the DM axis then said capital is vulnerable. This study shows that each fisherman at the observation station has its own characteristics in maintaining a resilient condition except in the Kalibaru and Marunda regions which have almost the same capital characteristics.

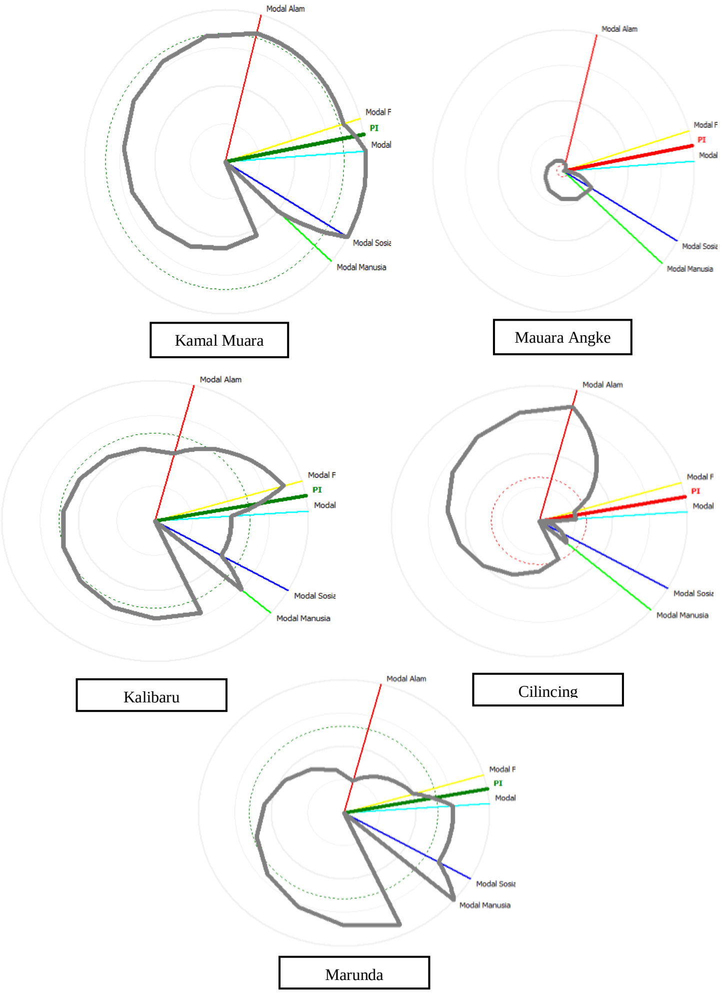


Figure 25 GAIA Web pada setiap stasiun penelitian

Resilience Shifting

Resilience shifting in this study was translated by analyzing walking weight on capital values at each research station, meaning that the value of the contribution of each capital will be adjusted manually to see the movement of the situation at each research station based on the value of capital. in this experiment the value of each capital weight will be increased per 20%, 40%, 60% and 80%. For the record, each capital is considered to have the same contribution in the model.

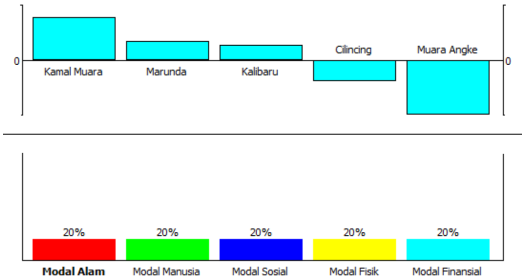
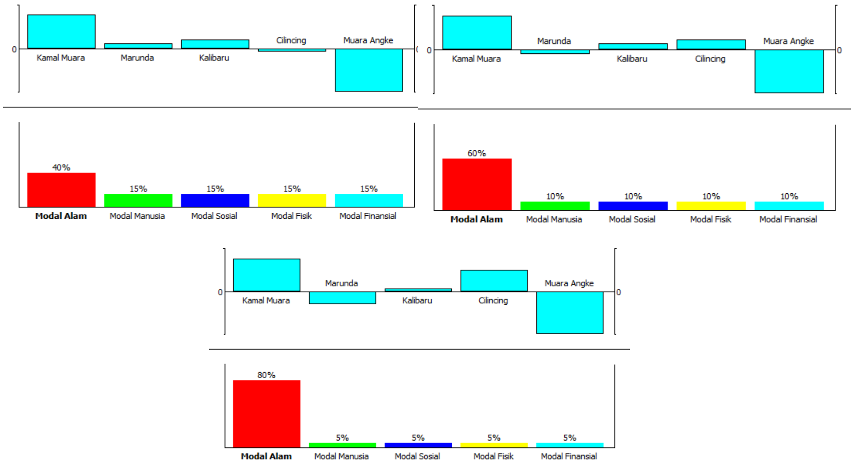
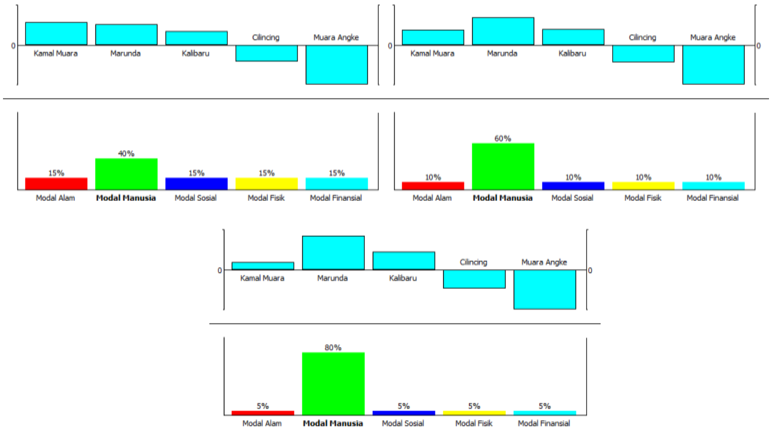


Figure 26 Condition of study location based on Phi netflow value

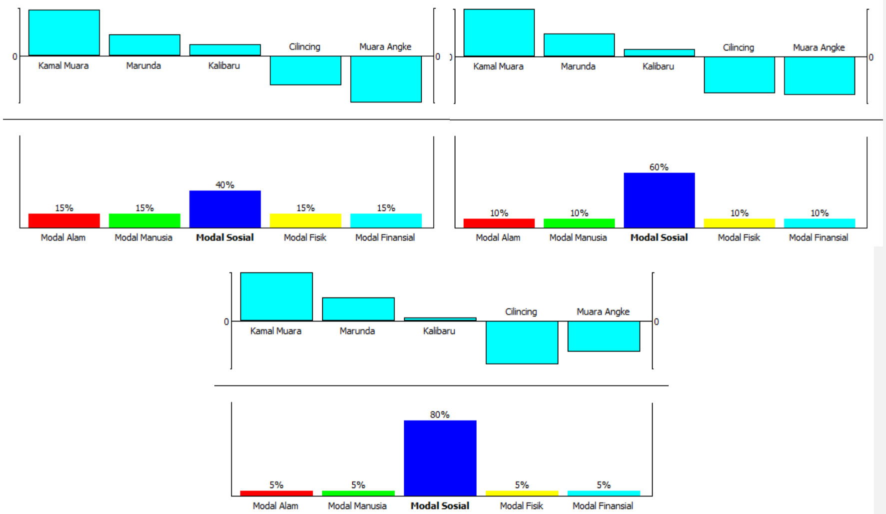
In the picture above, all capital is considered to have the same contribution to the condition of the research station. It can be seen that the Kamal Muara station has better conditions than the other four stations, so as an inseparable part of efforts to manage coastal and marine areas it is necessary to analyze the interventions that must be done to maintain the condition of each research station so that it is in a stable condition (resilient). In this study, 15 times the combination of intervention quantities for each capital was carried out to produce resilient conditions for each study location.



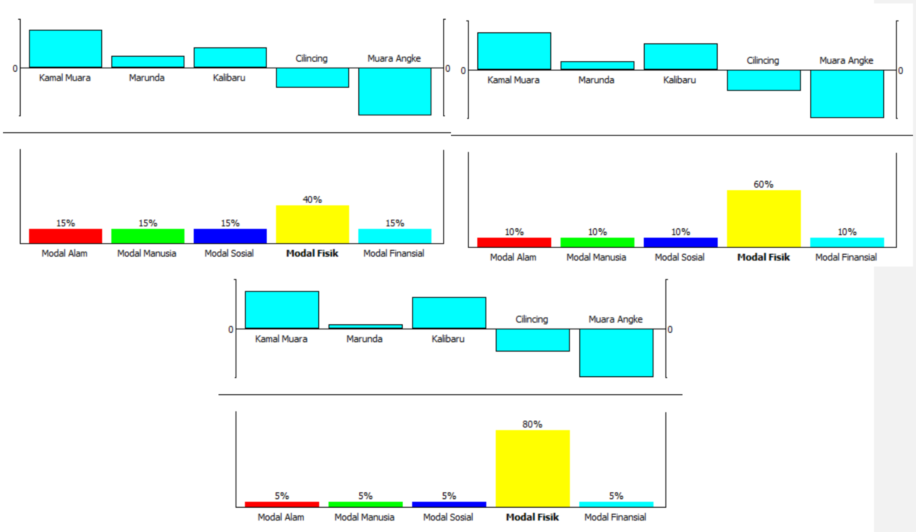
a. Modal Alam



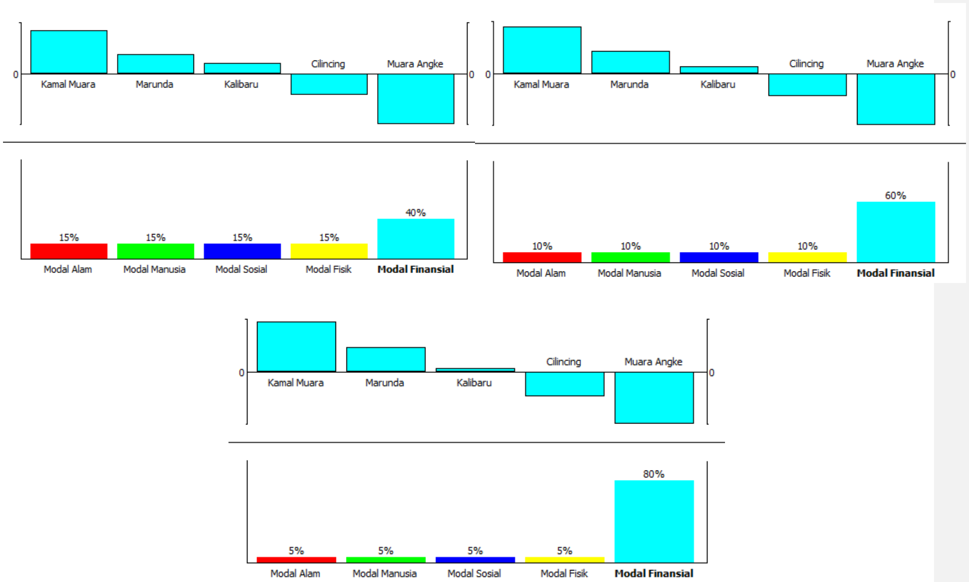
b. Human Capital



c. Social Capital



d. Physical Capital



e. Financial Capital

Figure 27 *Walking weight* setiap modal terhadap kondisi stasiun penelitian

Best combination

Promethee analysis makes it possible to elaborate on the role of each capital in forming a model through walking weigths. Seen in the picture above there are 15 models formed through this system. From the 15 models above, conclusions can be drawn that natural capital with determination of capital weight between 40% to 60% is the most influential factor in 3 stations in the positive quadrant (kamal muara, kalibaru and marunda) and 1 at stations with negative quadrants namely Cilincing. Precisely on the interception of natural capital contributions of 47% there are 4 stations which are in a positive atmosphere (Cilincing changes the position of the quadrant). This further reinforces that access factors and conditions of coastal resources are the main capital in maintaining the sustainability of fisheries business carried out by small fishermen in the bay of Jakarta. Access which has been limited by reclamation, water pollution and ecosystem damage has become a major factor affecting the resilience of fishermen in Jakarta. In addition, there are several combinations of other models that are tried to see patterns of resilience between stations.

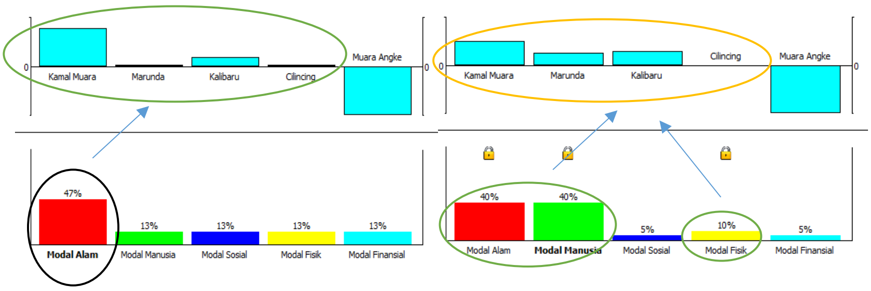


Figure 28 Walking weight combillation which has a positive impact on the resilience of research stations

4.11 Management Strategy

Conceptual Model

A tried conceptual model was developed to see patterns of adaptation of fishermen to environmental conditions. The exisiting conditions of Jakarta Bay fishermen are explained through the ecological footprint conditions and their relation to livelihood vulnerability (Livelihood Vulnerability).

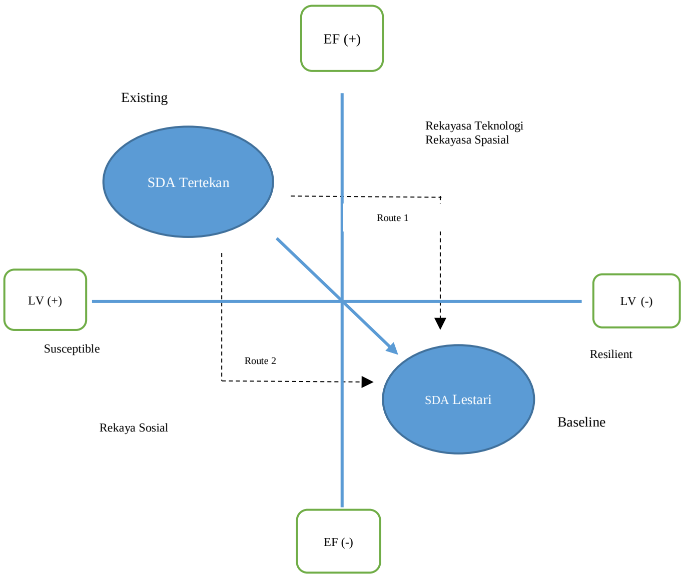


Figure 29 Conceptual model of adaptation of fishermen in Jakarta Bay

Route 1

The adaptation model is developed through 2 main routes, this is related to the current conditions of the Jakarta ecological footprint and the conditions of livelihood of vulnerable fishermen. Route 1 with a deficit of ecological footprint, which is fishing ground 2,047,015 gha and Biocapacity is only 133 gha (KemenPUPR, 2010). and the ecological footprint of fisheries in the Bay of Jakarta has a deficit, with a ratio of 10: 1. The analysis of fisherman resilience is illustrated by the level of vulnerability of fishermen's livelihood in the Bay of Jakarta. The description of the vulnerability of fishermen's livelihood can be seen in the five main capitals of fisherman resilience capabilities, namely: natural capital (0.60), human capital (0.51), physical capital (0.61), social capital (0.74) and capital financial (0.54). Using Promethee's analysis it can be seen that the movement of each capital if the weight is of importance is changed. It is seen that Kamal Muara station has better conditions than the other four stations, while the overall capital value is combined (Average value), the conditions of fishermen's livelihood are in a very vulnerable status. So that fishermen must be directed to maximize adaptive capacity, especially adaptation to fishing technology so that the vulnerability of their livelihood becomes a minimum in this case the fisherman is resilient. In the route 1 approach, naturally fishermen have adapted to the reduction in catches due to natural factors by combining fishing gear as seen from Fishermen in Kamal

Muara. 43% of respondents combined fishing gear and fishing techniques such as daytime catching with sero and night catching by shoot (spear fishing), 54% of fishermen use a chart and sondong 3% of fishermen sondong and nets. In addition to combining commonly used fishing gear, fishermen also try to use new fishing gear as done in Kamal Muara and Kalibaru using sondong fishing gear.

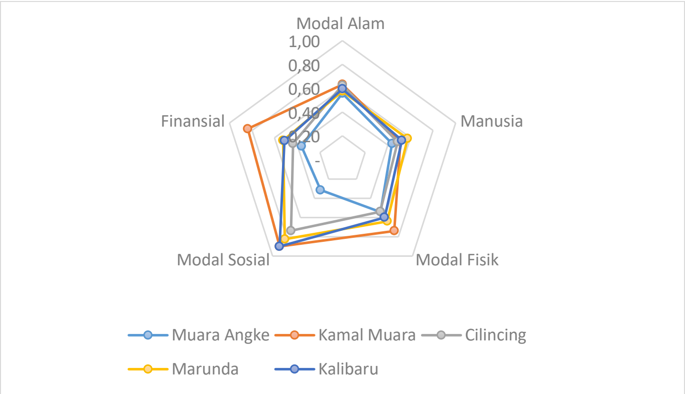


Figure 30 *Kite diagram* resilience of fishermen in 5 sampling regions

Sondong fishermen are typical fishermen in Kamal Muara that have not been found in Muara Angke. In addition, from a brief interview with Kalibaru, Cilincing and Marunda fishermen the method of catching fish with sondong fishing gear was not widely known and was only recently operated by few fishermen in Kalibaru. This is because the method of catching with sondong fishing gear has only begun to be operated by Kamal Muara fishermen in the past 2-3 years. Sondong fishing equipment is one form of technology adaptation of Kamal Muara fishermen from the reduction of sero catches due to the presence of reclamation and water pollution activities with the main target being catching rebon.

Rahmani, U (2016) Explains that Sondong fishing gear is a substitute for Sero equipment which is exposed to excess from reclamation and is a CSR implication of reclamation in accordance with a mutual agreement between the owner and the reclamation manager. As with the Kalibaru fishermen, they started using sondong by catching rebon which took refuge in the reclamation area. This activity based on the results of the interview is very beneficial especially if done during the winter season (high waves). The quiet port is the right place for rebon shrimp to seek protection so that it can become a new fishing ground location for fishermen. This fact strengthens the management scheme by using route 1 where the techno-adaptation mechanism can help fishermen to adapt to reclamation activities, where replacing fishing rods, rampage and bubu with fishing equipment has minimized the vulnerability of fishermen's livelihood in Jakarta Bay . In addition to technological adaptation in this route fishermen also indirectly develop spatial adaptations, especially fishermen in Kalibaru, where making the New Priuk Port as a fishing ground can reduce operational costs because of the closer distance compared to where they have been fishing. In a short interview with the head of the Rajungan fishermen group who temporarily switched to using sondong to catch rebon, in December 2017 rebon catches can reach 3 quintals / trip at a price of Rp. 10,000-12,000 / kg, this value is much higher than the crab catches in normal months. In the short term, sondong fishing gear can be a solution for fishermen to fulfill their daily needs, but the concern is the operational method of this tool that is active and uses waring with a very small mess size so it is feared that the catch is not selective. However, this fishing gear is different from the mini trawll operational method where the sondong is used in front of the boat not by means of pulling and the cruising depth is not up to 5 meters.

Route 2

In this pathway the approach model taken in management is by reducing the ecological footprint with an engineering model of the social aspects of Jakarta Bay. Spatial engineering can take the form of adjusting the place of residence of fishermen through infrastructure engineering or by shifting the profession of fishermen to the non-fisheries sector through mentoring and training but this option will be constrained by many things because fishermen are one of the entities that are very difficult to accept change. This can be seen from the calculation of livelihood vulnerability in the aspect of human capital (0.51) which means that fishermen in the study area mostly work alone only and do not have other skills besides the fisheries sector. This can be caused by low education levels and history. From an anthropological perspective, fishing communities are different from other communities, such as farmers, laborers in cities or communities on high land. This anthropological perspective is based on social reality, that fishing communities have cultural patterns that are different from other communities as a result of their interaction with the environment and the resources within it. These cultural patterns become a framework for thinking or referencing the behavior of fishing communities in their daily lives (Satria, A, 2014).

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

After discussing the ecological footprint analysis and relationship with the level of resilience of fishermen in DKI Jakarta, the following conclusions can be drawn:

1. The ecological footprint of fisheries in Jakarta waters has a value that is far greater than the water biocapacity value so that the fishery carrying capacity continues to decline.
2. Value of Sustainability Emergy (LSI) shows that transportation in Jakarta Bay tends to be unsustainable.
3. The performance of Jakarta fishermen's resilience is in a positive quadrant but is very vulnerable to changes that occur so it requires strong policies to maintain the sustainability of fisheries in DKI Jakarta.
4. The link between the ecological footprint and the fishery resilience produces two management directions called route 1 (spatial engineering and technology engineering) and route 2 (social engineering).

5.2 Recommendations

The development of this research is highly expected to support integrated fisheries governance so that through this research several things can be suggested as follows:

1. Spatial analysis and dynamic systems are needed to look at several small-scale fisheries management scenarios in Jakarta Bay.
2. Spatial analysis and dynamic systems are needed to look at several small-scale fisheries management scenarios in Jakarta Bay.

6. PERSONAL INVESTIGATOR AND OTHER RESEARCHER

This research is a single study in the framework of completion of doctoral studies. But in the process will be assisted by several enumerators and field attendants. Monitoring and evaluation of the carrying capacity of Jakarta Bay can be evaluated approximately 3 months after the implementation of the research, starting from the collection and analysis of data along with the calculation of carrying capacity and emergy analysis can be displayed. As for the livelihood analysis, it can be evaluated after 5 months of the implementation of the research where the description of resilience and the livelihoods of fishermen in Jakarta Bay has been successfully analyzed and simulated. Finally, the overall picture of the social-ecological system which is a combination of all components has been simulated using dynamic systems and analytical frameworks at the end of the research period. The people involved were the heads of fishermen's groups, fishermen, and some field enumerators in the Jakarta Bay.

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ANNEX

Sampling Station Map

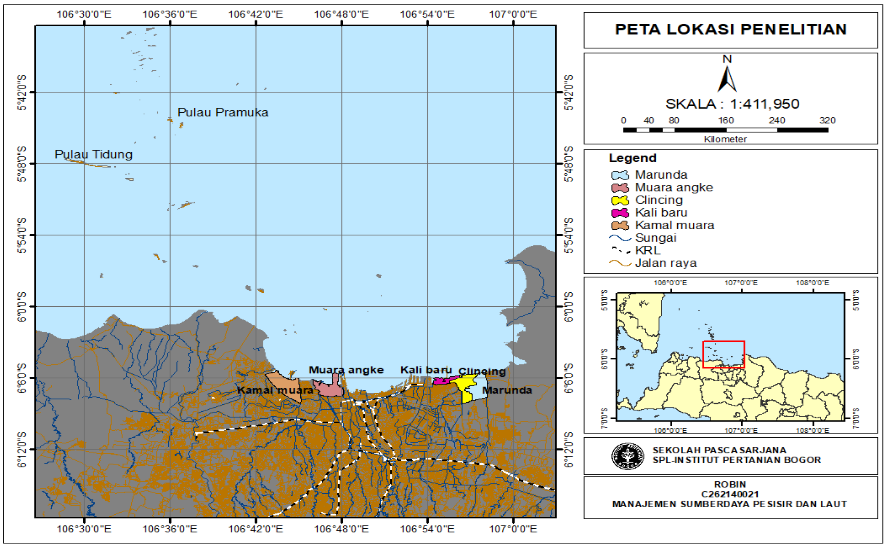

Foto Penelitian

Figure 31 Photo of Kalibaru fishermen between “Bagan” fishing gear and container port

Figure 32 fishermen and the principle of life

Figure 33 Together with crab fishermen in Muara Angke

Figure 34 Together with crab fishermen in Marunda