Location analysis of fish port complex planning in Surabaya City based on Integrated Coastal Zone Management (ICZM) approach

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Abstract. Fishery resources potential in Surabaya is high, about 8.146 tons per year, but until present Fish Port complex has not been exist yet. The City Regulation No 12/2014 about Spatial Planning stated that Fish Port Complex in Surabaya is important and has been part of the program that should be implemented, meanwhile the exact location has not been determined yet so it is important to follow up through. Location determination needs reflect to specific criterias in Peraturan Menteri Per.08/MEN/2012 and Integrated Coastal Zone Management Concept (ICZM) which are expected to run sustainly and considering aspects all the coastal. The purpose of this research to determining the location of the fish port complex planning in Surabaya coastal area based on ICZM approach through several stages: (1) Set the priorities the location determination of fish port criterias. (2) Decide the location of the fish port complex. The result of this research is to achieve the most suitable location based on ICZM criteria that is adjusted to real issues in the field and consensual process. Four locations that recommended for fish port complex are Romokalisari, Asemrowo, Kenjeran and Bulak.

1. Introduction

Fish port is a place that has a function as the central of fishermen activities and accommodates the activity of fishermen (Directorate General of Fisheries, 1995). Therefore, the existence of fish port became one of the factor that implies the performance of local fishermen. If there is no fish port, the fishermen activities would be difficult to be circulated transparently to markets. This makes the fisherman who work in fisheries household decreased. In East Java, the number of fisheries household is decreased from 2,293 in 2013 to 1,990 in 2015. If we see the existing fish potential, East Java had 416,529 tons, but only 6,944 tons that can be landed because there is only 32 units of fish port available. (Surabaya Government - Board of Fisheries, 2016).

As one of the biggest city in East Java, Surabaya that also a city which is in the coastal region did not slip from the fisheries and fisherman problems. The catches of Surabaya’s fisherman amounted to 8,146 tons (Department of Food and Agriculture Security, 2017), but the amount of catches did not have balance with the facilities of fish port, because in the document of Surabaya city fisheries profile 2012 did not said anything about fish port. However, in the spatial plans of Surabaya 2014-2034, in the part of port area plan said that there will be a development plan for the development of special terminal that has a function as fish port. The fish port will be in Romokalisari, Kalianak, Kedung Cowek, and Bulak.
It can be concluded that the government of Surabaya City is maintaining and enhancing the credibility of fisherman by build the fish port.

After the implementation of spatial plans of Surabaya 2014-2034 by the mayor of Surabaya in regional regulation of Surabaya City number 12 of 2014 concerning the spatial plans of Surabaya 2014-2034, to realize the planning of fish port in Surabaya need the research for considering the location of fish port. Determining the location of fish port need to be based on specific criteria such as the criteria for determining fishing ports that stated in ministerial regulation Per.08/MEN/2012 and supported by the Integrated Coastal Zone Management (ICZM).

According to Sorensen (1993), ICZM is an integrated management provides policy direction and a process for defining objectives and priorities and planning development beyond sectoral activities. It adopts a systems perspective and multi sectoral approach which takes into account all sectoral interests and stakeholder interests, and deals with economic and social issues as well as environmental and economic issues. Dahuri (2001) stated that ICZM is expected to be able to run sustainably by considering various aspects that exist in the coastal environment. It is intended so the function of fish port will be optimized, so the fisherman and community will have the better results of existing fisheries production in Surabaya.

This article is a dissemination of research-based decision making as an academic support for Surabaya city government in their effort to implement the spatial planning program in coastal area by providing fish port complex in the most suitable location.

2. Methods

2.1 Collecting Data Method

Data collecting is done by conducting primary and secondary survey. The data of marine and coastal of Surabaya is obtained with primary survey by interviewing the stakeholder of Department of Food and Agriculture Security fisheries field and field observation to conduct observations and extract information from fisherman of north coastal region and also the east Surabaya. Secondary survey is performed with analyzing the secondary data related to the oceanographic and physical aspects of the spatial planning document of East Java.

2.2 Analyzing Method

For determining the location of Surabaya fish port, the analysis used three stages, that is:

2.2.1 Determine the Location Priority of Fish Port in Surabaya

Analytical Hierarchy Process (AHP) can be used to achieve the second target that is determine the location priority of fish port in Surabaya using the variables adopted from the ICZM. This analysis aims to determine the weights for determine the location priority of fish port and it is necessary to conduct interviews with people who are experts in the studied field (Marimin, 2004). AHP analysis is using Expert Choice 2000 software.

In this research, the experts or stakeholders for the interviews consists of three field that can be seen in the table below.

| Number | Stakeholder                  | Institute                                          |
|--------|------------------------------|----------------------------------------------------|
| 1      | Government                   | Department of Food and Agriculture Security        |
| 2      |                              | Department of Bina Marga Public Works of Surabaya   |
| 3      |                              | Regional Development Planning Agency                |
| 4      |                              | Surabaya City Field Fisheries Companion            |
| 5      | Public                       | Fishermans                                         |
2.2.2 Determine the Instruction of Location for Fish Port in Surabaya based on ICZM.
Overlay analysis is used in this stage for searching the location based on fish port. In determining the location, the criteria that have been obtained from Qualitative Descriptive Analysis stage and the weights from the AHP analysis is used. Both criteria and weights will be used to determine the location in a way depicted on the map.

Weighted overlay tools inArcGis is used in overlay analysis to combine grid map with the weighting from AHP results. The results of weighted overlay is to show the influence of each input on a geographical area. The determination of the location for fish port in Surabaya will be known after conducting this analysis.

2.3 Research Variable
This research is using the variabel based on some scientific literature. The variable can be seen in the table below.

| Number | Aspects        | Variable          | Operational Definition                                                                 |
|--------|----------------|-------------------|----------------------------------------------------------------------------------------|
| 1      | Physical       | Shipping          | Condition of Shipping lines in the sea waters                                          |
|        | Environment    | Wave              | Condition of wave in the sea waters                                                    |
|        |                | Temperature       | Average condition of sea waters                                                       |
|        |                | Salinity          | Condition of clarity in the sea waters                                                |
|        |                | Bathymetry        | Depth level of sea waters                                                             |
|        |                | Mangroves         | Distance between studied location and mangroves area                                   |
|        |                | Coral Reefs       | Distance between studied location and coral reefs area                                  |
|        |                | Seagrass Beds     | Distance between studied location and seagrass beds area                               |
|        |                | Ecosystem         | Distance between studied location and the location of the fish                        |
|        |                | Fish Location     | Distance between studied location and the location of the fish                        |
|        |                | Land              | Availability of the land for fish port                                                |
| 2      | Infrastructures| Road System       | Distance with the road system                                                         |
|        |                | Clean Water System| Availability of clean water system                                                    |
|        |                | Processing Industry| Distance with the fish processing industry                                            |
| 3      | Social         | Fisherman Settlements | Distance with the settlements of fisherman as a workers in fish port                  |
|        |                | Boat              | Availability of the boats owned by fisherman                                         |
|        |                | Fishing Gear      | Availability of the fishing gears owned by fisherman                                   |
| 4      | Economy        | Market            | Distance with the market                                                              |
|        |                | Raw Material      | Distance with the market or seller of raw materials for fishing                        |
| 5      | Policy         | Regulations for Providing Integrated Coastal Facilities | Documents that correct the location of the fish port so it does not cross with the existing plan.
3. Result

3.1 Determine the Location Priority of Fish Port in Surabaya

In the process of analyzing the initial step taken are completing the AHP questionnaire to the related stakeholders that have been determined before. After completing the questionnaire, the results of each questionnaire will be processed using the Expert Choice 2000 software to combine the answers from respondents. The combination result will make the weight for every criteria and variable that used to determine the location of fish port in Surabaya. In the process, the inconsistency number for every analysis has to be below 0.1.

The results of AHP is divided into two, namely aspect weighting and variable weighting for each criteria. For the result of weighting can be seen in the table below.

| Number | Aspect            | Aspect Weight | Variable           | Variable Weight |
|--------|-------------------|---------------|--------------------|-----------------|
| 1      | Physical Environment | 0.266         | Shipping           | 0.126           |
|        |                    |               | Wave               | 0.121           |
|        |                    |               | Temperature        | 0.08            |
|        |                    |               | Salinity           | 0.076           |
|        |                    |               | Bathymetry         | 0.096           |
|        |                    |               | Mangroves          | 0.078           |
|        |                    |               | Coral Reefs        | 0.068           |
|        |                    |               | Seagrass Beds      | 0.073           |
|        |                    |               | Ecosystem          | 0.073           |
|        |                    |               | Fish Location      | 0.128           |
|        |                    |               | Land               | 0.153           |

The aspect weight of physical environment found that the land variable has the highest weight and coral reefs variable has the lowest weight. It means that land variable has the bigger influence in determining the location of fish port in Surabaya on physical environment aspect.

| Number | Aspect            | Aspect Weight | Variable           | Variable Weight |
|--------|-------------------|---------------|--------------------|-----------------|
| 1      | Infrastructures   | 0.168         | Road System        | 0.126           |
|        |                    |               | Clean Water System | 0.121           |
|        |                    |               | Processing Industry | 0.08            |

The aspect weight of infrastructures found that the road system variable has the highest weight and processing industry variable has the lowest weight. It means that road system variable has the bigger influence in determining the location of fish port in Surabaya on infrastructures aspect.

| Number | Aspect        | Aspect Weight | Variable               | Variable Weight |
|--------|--------------|---------------|------------------------|-----------------|
| 1      | Social       | 0.205         | Fisherman Settlements  | 0.381           |
|        |              |               | Boat Location          | 0.301           |
|        |              |               | Fishing Gear           | 0.317           |
The aspect weight of social found that the fisherman settlements variable has the highest weight and boat location variable has the lowest weight. It means that fisherman settlements variable has the bigger influence in determining the location of fish port in Surabaya on social aspect.

| Number | Aspect       | Aspect Weight | Variable            | Variable Weight |
|--------|--------------|---------------|---------------------|-----------------|
| 1      | Economy      | 0.207         | Market Location     | 0.53            |
|        |              |               | Raw Material        | 0.47            |

The aspect weight of economy found that the market location variable has the highest weight and raw material variable has the lowest weight. It means that market location variable has the bigger influence in determining the location of fish port in Surabaya on economy aspect.

After weighting each variable on each aspect, the weighting between the aspect that used to determine the location of fish port in Surabaya. For the table can be seen below.

Table 6. Weight of Economy Aspect

| Number | Aspect       | Aspect Weight | Variable            | Variable Weight |
|--------|--------------|---------------|---------------------|-----------------|
| 1      | Economy      | 0.207         | Market Location     | 0.53            |
|        |              |               | Raw Material        | 0.47            |

In weighting every aspect, the results is physical environment aspect has the highest weight and policy aspect has the lowest weight. It means that physical environment has the biggest influence in determining the location of fish port in Surabaya.

3.2 Determine the Instruction of Location for Fish Port in Surabaya based on ICZM

After weighting every variable using the AHP analysis, the variable can be used for overlay analysis using the ArcGIS 10.3. Scoring the variable is needed for this analysis based on the predetermined parameter using Reclassify tools in order to obtain uniformity in format in weighting each variable.

For the scoring process, it consists five class as seen in table below.

Table 8. Variable Scoring

| Number | Score Parameter                                      | Score |
|--------|------------------------------------------------------|-------|
| 1      | Very suitable with the location criteria of fish port| 5     |
| 2      | Suitable with the location criteria of fish port     | 4     |
| 3      | Quite suitable with the location criteria of fish port| 3    |
| 4      | Least suitable with the location criteria of fish port| 2    |
| 5      | Unsuitable with the location criteria of fish port   | 1     |

The scoring process is carried out for each variable with each parameter. Very suitable with the location criteria of fish port parameter will got the highest score and unsuitable with the location criteria of fish port will got the lowest score. The scoring results for each variable can be seen on the table below.

Table 9. Variable Scoring Parameter

| Number | Variable | Parameter                      | Score |
|--------|----------|--------------------------------|-------|
| 1      | Shipping | More than 12 Km away           | 5     |
## Table

| Number | Variable         | Parameter                                                                 | Score |
|--------|------------------|---------------------------------------------------------------------------|-------|
| 1      |                  | 9.1 - 12 Km away from the shipping lane                                    | 4     |
|        |                  | 6.1 - 9 Km away from the shipping lane                                     | 3     |
|        |                  | 3.1 - 6 Km away from the shipping lane                                     | 2     |
|        |                  | 0 – 3 Km away from the shipping lane                                       | 1     |
| 2      | Wave             | Wave height from 0 – 0.20 meter                                            | 5     |
|        |                  | Wave height from 0.21 – 0.50 meter                                         | 4     |
|        |                  | Wave height from 0.51 – 0.80 meter                                         | 3     |
|        |                  | Wave height from 0.81 – 1 meter                                            | 2     |
|        |                  | Wave height more than 1 meter                                              | 1     |
| 3      | Temperature      | Sea water temperature 30 – 31°C                                            | 5     |
|        |                  | Sea water temperature 28 – 29°C                                            | 4     |
|        |                  | Sea water temperature 26 – 27°C                                            | 3     |
|        |                  | Sea water temperature 24 – 25°C                                            | 2     |
|        |                  | Sea water temperature less than 25°C                                       | 1     |
| 4      | Salinity         | Sea water salinity less than 3%                                           | 5     |
|        |                  | Sea water salinity 3 - 5%                                                 | 4     |
|        |                  | Sea water salinity 5.1 - 7%                                               | 3     |
|        |                  | Sea water salinity 7.1 - 9%                                               | 2     |
|        |                  | Sea water salinity more than 9%                                           | 1     |
| 5      | Bathymetry       | Depth less than 3 meter                                                   | 5     |
|        |                  | Depth of 3 – 5 meter                                                       | 4     |
|        |                  | Depth of 5.1 – 6 meter                                                     | 3     |
|        |                  | Depth of 6.1 – 7 meter                                                     | 2     |
|        |                  | Depth more than 7 meter                                                   | 1     |
| 6      | Mangrove         | More than 10 km away from the mangrove area                               | 5     |
|        |                  | 7.6 – 10 km away from the mangrove area                                   | 4     |
|        |                  | 5.1 – 7,5 km away from the mangrove area                                  | 3     |
|        |                  | 3 – 5 km away from the mangrove area                                       | 2     |
|        |                  | Less than 3 km away from the mangrove area                               | 1     |
| 7      | Coral Reefs      | More than 10 km away from the coral reefs area                            | 5     |
|        |                  | 7.6 – 10 km away from the coral reefs area                                | 4     |
|        |                  | 5.1 – 7,5 km away from the coral reefs area                               | 3     |
|        |                  | 3 – 5 km away from the coral reefs area                                    | 2     |
|        |                  | Less than 3 km away from the coral reefs area                             | 1     |
| 8      | Seagrass Beds    | More than 10 km away from the seagrass beds area                          | 5     |
|        |                  | 7.6 – 10 km away from the seagrass beds area                              | 4     |
|        |                  | 5.1 – 7,5 km away from the seagrass beds area                             | 3     |
|        |                  | 3 – 5 km away from the seagrass beds area                                 | 2     |
|        |                  | Less than 3 km away from the seagrass beds area                          | 1     |
| 9      | Fish Location    | More than 10 km away from the fish location                              | 5     |
|        |                  | 7.6 – 10 km away from the fish location                                   | 4     |
|        |                  | 5.1 – 7,5 km away from the fish location                                  | 3     |
|        |                  | 3 – 5 km away from the fish location                                       | 2     |
|        |                  | Less than 3 km away from the fish location                               | 1     |
| Number | Variable     | Parameter                                                                 | Score |
|--------|--------------|---------------------------------------------------------------------------|-------|
| 10     | Land         | Strategic Economic Region                                                  | 5     |
|        |              | Socio-Cultural Strategic Area                                              | 4     |
|        |              | Strategic Area of Natural Resources                                       | 3     |
|        |              | Defense and Security Strategic Area                                        | 2     |
|        |              | Strategic Area of the Environment                                         | 1     |
| 11     | Land Status  | Not Registered                                                             | 5     |
|        |              | Cultivation Rights                                                         | 4     |
|        |              | Building rights                                                            | 3     |
|        |              | Usage Rights                                                               | 2     |
|        |              | Right of ownership                                                         | 1     |
| 12     | Road System  | 0 – 200 meter away from the road system                                     | 5     |
|        |              | 201 – 400 meter away from the road system                                   | 4     |
|        |              | 401 – 600 meter away from the road system                                   | 3     |
|        |              | 601 – 801 meter away from the road system                                   | 2     |
|        |              | > 800 meter away from the road system                                       | 1     |
| 13     | Clean Water System | 0 – 500 meter away from the clean water system                              | 5     |
|        |              | 501 – 1000 meter away from the clean water system                           | 4     |
|        |              | 1001 – 1500 meter away from the clean water system                          | 3     |
|        |              | 1501 – 2001 meter away from the clean water system                          | 2     |
|        |              | More than 2001 meter away from the clean water system                       | 1     |
| 14     | Processing Industry | 0 – 2 Km away from the processing industry                                 | 5     |
|        |              | 2,1 – 4 Km away from the processing industry                               | 4     |
|        |              | 4,1 – 6 Km away from the processing industry                               | 3     |
|        |              | 6,1 – 8 Km away from the processing industry                               | 2     |
|        |              | More than 8 Km away from the processing industry                           | 1     |
| 15     | Fisherman Settlements | 0 – 3 Km away from the fisherman settlements                               | 5     |
|        |              | 3,1 – 5 Km away from the fisherman settlements                              | 4     |
|        |              | 5,1 – 7,5 Km away from the fisherman settlements                            | 3     |
|        |              | 7,6 – 10 Km away from the fisherman settlements                             | 2     |
|        |              | More than 10 Km away from the fisherman settlements                         | 1     |
| 16     | Boats        | 0 – 500 m away from the boats                                               | 5     |
|        |              | 501 – 800 m away from the boats                                             | 4     |
|        |              | 801 – 1000 m away from the boats                                            | 3     |
|        |              | 1001 – 1200 m away from the boats                                           | 2     |
|        |              | More than 1200 m away from the boats                                        | 1     |
| 17     | Fishing Gear Location | 0 – 500 m away from the fishing gear location                             | 5     |
|        |              | 501 – 800 m away from the fishing gear location                            | 4     |
|        |              | 801 – 1000 m away from the fishing gear location                            | 3     |
|        |              | 1001 – 1200 m away from the fishing gear location                           | 2     |
|        |              | More than 1200 m away from the fishing gear location                       | 1     |
| 18     | Market Location | 0 – 300 m away from the market location                                   | 5     |
|        |              | 301 – 1000 m away from the market location                                 | 4     |
|        |              | 1001 – 2000 m away from the market location                                | 3     |
|        |              | 2001 – 3000 m away from the market location                                | 2     |
Overlay analysis with weighted sum tools can be done after reclassifying each variable. In using the weighted sum tools, each aspect is carried out including every variable in that aspect along with the weight of each variable. Model builder tools can be used to facilitate the process in ArcGIS 10.3.

Because there is only one variable in policy aspect, that variable is not included in the weighted sum analysis process. The next step is analyze the weighted sum result with the input from all the results of the previous results, such as physical environment aspect, infrastructures aspect, social aspect, economy aspect, and sum with policy aspect.

After the weighted sum process, the result of analysis is the location for fish port in Surabaya. Reclassify tools will easier the classification of the class as seen at the table below.

### Table 10. Classification of suitability location criteria of fish port

| Number | Score   | Suitable    | Explanation                                                      |
|--------|---------|-------------|------------------------------------------------------------------|
| 1      | 0 – 1   | Unsuitable  | Unsuitable with the location criteria of fish port               |
| 2      | 1,1 – 2 | Least Suitable | Least Suitable with the location criteria of fish port         |
| 3      | 2,1 – 3 | Quite Suitable | Quite suitable with the location criteria of fish port       |
| 4      | 3,1 – 4 | Suitable    | Suitable with the location criteria of fish port                |
| 5      | 4,1 – 5 | Very Suitable | Very suitable with the location criteria of fish port     |

The result of reclassify is the conformity of location for fish port in Surabaya. There are five suitable class: unsuitable class with total of 88 hectare, least suitable class with total of 7733 hectare, quite suitable class with total of 11424 hectare, suitable class with total of 2266 hectare, and very suitable class with total of 236 hectare. For more details can be seen in the following table.

### Table 11. The area of each location criteria of fish port

| Number | Suitable     | Land Area (Ha) | Sea Area (Ha) | Total Area (Ha) |
|--------|--------------|----------------|---------------|-----------------|
| 1      | Unsuitable   | 0.00           | 88.47         | 88.47           |
| 2      | Least Suitable | 694.41        | 6886.38      | 7580.79         |
| 3      | Quite Suitable | 7159.75       | 4421.36      | 11581.11        |
| 4      | Suitable     | 1490.01       | 810.88       | 2300.89         |
| 5      | Very Suitable | 196.71        | 5.24         | 201.95          |

To visualize the location of fish port in Surabaya, can be seen in the following figure.
Figure 1. Overlay analysis in Surabaya shows the results of conformity for the location of fish port in Surabaya.

The very suitable class marked by dark green color became the most ideal location to build the fish port. It is because this class has a score more than 4. The locations are Romokalisari Village (Benowo District), Tambak Sarioso Village and Genting Kalianak Village (Asemrowo District), Tambak Wedi (Kenjeran District), Bulak Village, Bulak Banteng Village, Kenjeran Village, Tanah Kali Kedinding Village, Sukolilo Baru Village (Bulak District). All of these locations are in coastal areas, and all of them directly adjacent to the sea. For the location with light green color has a score within 3 to 4. These location can be a back up or alternative for establishment of fish port. The location is around the coast which has a greater area coverage than the very suitable class. For the quite suitable, least suitable, and unsuitable class, it is not recommended to establish the fish port because these location do not meet the criteria for the variables for determining the location of fish port.

4. Conclusion
Location development to be used as fish port complex is recommended to be in location with the most suitable according to the weighted criteria that is adopted from ICZM approach consists of: shipping, wave, temperature, salinity, bathymetry, mangroves, coral reefs, seagrass beds, fisheries locations, land status, road systems, clean water systems, processing industry, fishermen settlements, boats, fishing gear locations, market locations, raw material locations, facilities of integrated coastal. The most suitable category where fish port is relevant to be build is in the Benowo District, Asemrowo District, Bulak District, and Kenjeran District with certain coordinates that resulted from the overlay process.

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