INTEGRATED AGRICULTURE AND AQUACULTURE DEVELOPMENT IN BREBES COASTAL AREA, CENTRAL JAVA, INDONESIA

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ASBTRACT

Rapid urbanization growth combined with the uncontrolled land use change and impacts of the changing climate pose one of the coastal areas in northern part of Central Java that will continue to result in coastal floods with overwhelming loss and damages to property, ecosystems and livelihoods. This paper presented the case study in Brebes, Central Java which experienced a serious flood in 2018 because of the combined effect of heavy rainfall and high water spring tides. Besides a hydrological analysis of the heavy rainfall, a hydrodynamic model was used to check the maximum capacity of the main urban drainage system in Brebes. Next to rice, Brebes is also well known as the largest producer of red onion in Indonesia. On the coastal area of Brebes, aquaculture development is also taking place.. Flood caused serious damages to agriculture, as well as aquaculture and urban area in Brebes. Based on the result of hydrodynamic model simulations, several possible measures have been evaluated.

It is concluded that next to the increase of the drainage capacity, polder system could be considered for Brebes area. Another important step to be taken is to reduce the extraction of groundwater in the coastal area of Brebes. The next step is to consider polder system is mainly to cope the flood problem especially due to the high rate of land subsidence. Polder system can be developed as a compartment system which will consider the natural drainage conditions and its boundaries. The polder system with a compartment system has to be operated and maintained in an integrated way in order to avoid any negative impact from one compartment to another because of improper operation and maintenance of the system.

Keywords: Integrated coastal zone management, Agriculture, Aquaculture, Land Use, Land Lost

1. INTRODUCTION

Indonesia as an archipelago country comprises of 17,508 islands and has a longest coastlines in the world 81,000 km and relatively flat (Dahuri, R et al., 1996). According to the Indonesian Ministry of Agriculture (2015), out of 191,09 million ha of land in Indonesia, dry land 144,5 million ha, lowland about 34.1 million ha, wetland about 9.4 million ha, and the remaining are settlement/urban, mining areas and water body (lake, reservoir, rivers and streams). Particularly related to the potential of lowland in Indonesia, Java Island has a coastal area of 896,122 ha for agriculture (BBSDLP, 2014) there are some strategical and potential values for development in order to be the new resources for agriculture commodity development based on several reasons and factors which are: (1) availability of the relatively large surface area, (2) Availability of water resources, (3) Topographical conditions which are mostly flat, (4)

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Connectivity and accessibility to other development centres in Java Island (by road and/or water infrastructure), and (5) Land suitability and agronomical conditions of the related coastal area. with several advantages, among other are (1) there is wide enough available and is in fairly wide expanse of scale units, (2) water availability, (3) flat or flat topography, (4) access to development with its infrastructure (land and waterways) to facilitate the distribution channel, and (4) land suitability and agronomy are appropriate.Poorly written

Based on the potential of tidal irrigation in Indonesia, it is projected that if properefforts are made to optimize tidal irrigation system supported by proper management, technology and innovation an increase in the Cropping Index to 200 (IP 200) can be realized and the production of food crops can be obtained up to 2,44 million tons (Susilowati A, et all., 2016). On the other hand, coastal areas also have a significant potential in the aquaculture sector with potential of 3 million tons per year (Adisanjaya NN, 2010).

Next to the agriculture land use, one of the important land use in the coastal area is urbanization., . More than 70% of the major cities in the world are situated in these regions and more than 80% of industrial estates in Indonesia are located in coastal areas (Wahyudi, et all., 2009). According to Rudyanto (2004) with all the potentials, coastal area could be linked with the economic growth and population so that causing coastal areas to be the center of activities. However, this integration have to be consider about the space and time.. Not proper integration plan may cause a problem of land use in the coastal areas, including uncontrolled conversion of land from agricultural land into industrial or urban designation areas.

The development of coastal area in Brebes District is a dynamics process with the its complexity both in terms of utilization and vulnerability aspects of the region to disaster factors such asflood and draught.

2. PROBLEM STATEMENT

Brebes District is located in Central Java Province, has an area of 1,663 km^2 and consists of 17 sub-districts, 297 villages.The topographical conditions is ranging from the lowlands (bordering with the Java Sea) to the highlands (> 1500 m+Mean Sea Level (MSL)). The average annual rainfall in Brebes District is 1900 mm with an average days of raining is about 180 The Rainy Season starting in October-March, and the Dry Season in April-September (BPS, 2018). The economic structure in Brebes District is influenced by the agriculture and fisheries sector where the total population in Brebes of 1.8 million and around 17.5% are farmers.

The total area of paddy fields is about 63,321 ha, which is consist of irrigated fields around 45,984 ha and rainfed fields covering an area around 17,337 ha. As the aquaculture sector, with a coastline of 65 km, the coastal area in Brebes District has an area of approximately 11,000 ha and spread over 5 sub-districtsand 14 villages. Besides, , Brebes District supports regional and national food security by being able to contribute 624,840 tons of rice production or 5.7% of Central Java Province's production. Moreover, from the horticulture sector Brebes District is well known as "shallot city" in Indonesia. The total contribution is about 25% of national shallot production where it is came from average planting area of 33,000 ha with a potential of shallot production of around 338,496 tons. The aquaculture sector which is supported by around 11,250 house hold, capture fisheries production, aquaculture (inland and marine) output increased significantly till 2016 and unfortunately decreased in 2017 as shown in Figure 1. One of the reasons is inproper the water management of the aquaculture both fresh water and salt water (quantity and quality).

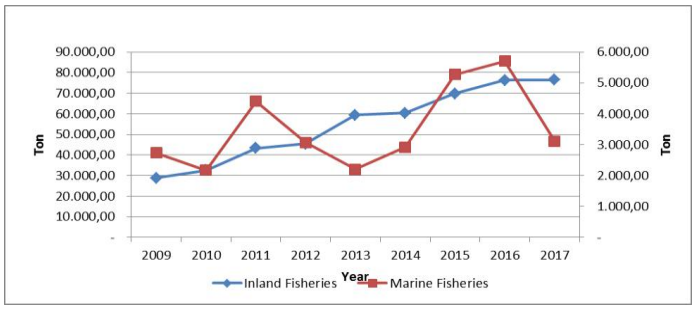

Figure 1. Production of Inland and Marine Fisheries (2009-2017)

The potential of land resources in the coastal region of Brebes District are Losari, Tanjung, Bulakamba, Wanasari and Brebes Subdistricts (See Figure 2), the potential for agriculture (food crops, horticulture) and aquaculture (including salt mining) in that subdistrict has significant impact on supporting economic growth in Brebes District.

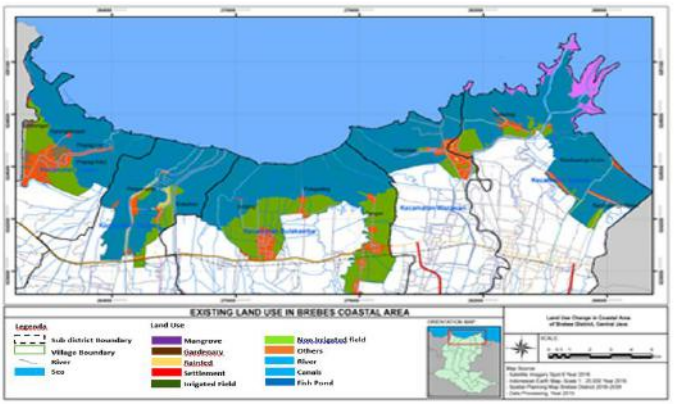

Figure 2. Land use in coastal area of Brebes District

The total area of irrigated field in the coast of Brebes District is covering an area of 21,782 ha (48.9%). The irrigated fields are distributed almost evenly in all coastal sub-districts because the majority of the people's livelihoods are farmers. In more detail, the total production of strategic commodities of Brebes District for rice, shallot and aquaculture is presented in Table 1 below.

Table 1. Production in Brebes District in 2018 (ton) (BPS, 2018)

No	Sub District	Rice	Shallot	Inland Fisheries	Salt
1	Losari	35,295	9,720	12,011	13,459
2	Tanjung	16,731	20,769	1,787	11,352
3	Bulakamba	40,052	34,132	2,110	43
4	Wanasari	19,136	58,790	972	14,530
5	Brebes	14,673	31,855	58,267	8,149

Besides, this various potentials in the coastal area of Brebes District, some factors might be counter productive such as the issue of uncontrolled land use change, development of the settlement, land subsidence, sea level rise and unpredictable natural disaster. The increasing demand of land for various purposes are in line with the increasing of the population and rapid economic development, especially around the city and around industrial centers. Land demand for infrastructure development

(roads, industry, offices) and settlement and residential areas influenced the intensive paddy fields that was the centers of rice production (Sutomo, 2004; Irawan, 2005). Especially in the northern coastal area of Central Java, rice fields are one of the conversion targets for urban development, because land is generally flat, high accessibility and close to water resources.

Related to the irrigation infrastructure, although 48.9% of paddy field in the coastal area of Brebes District is technical irrigation, and is a "tail end" of an irrigation network system, the average rice planting index (IP) in the region is still 100% (IP 100) with an area of 14,500 ha (DPTPH Brebes, 2015). It means that the agriculture performance of Brebes District is good and can be increased to IP 200 in order to support the food security program of country.

In general, as part of the northern coast of Central Java, the Brebes coastal area is also considered as a flood-prone area (Brebes BPBD, 2016). Coastal floods, coastal erosion and sedimentation (Zahro, 2017) and land subsidence (as the impact of over extraction of groundwater) of 2 cm/year (Wibowo et all, 2015) are the main problems in this coastal area. About 2,115 ha of coastal area in Brebes District experienced coastal erosion and about 2,900 ha experince coastal sedimentation. This condition may cause conflicts of spatial use (land owner), degradation of coastal ecosystems and coastal resources and finally will influence the coastal vulnerability (Mashuri et all, 2018).

It means that by considering those factors, an integrated coastal zone management should be considered concerning how should be the future land use plan and projection related to cope with the coastal disaster factors and new spatial management policy which will be the input to the Local Government.

3. METHODOLOGY

The method required in this research is descriptive method, which aims to obtain information and make descriptions of situations and events systematically from some secondary data and literature related to the problem definition. This research was conducted at Brebes District, Central Java with the specific focus only related to the coastal areas with the aim of obtaining information related to the land use changes caused by policy in spatial land use and the patterns by the local government and the existence of natural factors and influence which may have influences on the land use changes. Some assumptions are followed for this research;:i) the rate of land subsidence of 2 cm / year (Wibowo et all, 2015), ii) the sea level rise of 2 mm/year (IPCC, 2007), iii) the present conditions of changes in coastline 2003-2015 (Ferdiansyah, 2017) and iv) the available result of the value of coastal vulnerability (Mashuri et all, 2018).

Based on the above assumptions, in this research some scenarios have been developed and examined:

- Scenario 1, based on the projection of changes in existing land use due to the rate of change in shoreline, sea level rise and land subsidence;
- Scenario 2, where the projected change in land use due to the new spatial pattern policy (2018-2039) prepared by the Government of Brebes District;
- Scenario 3, namely the projected change in land use which is a combination of Scenario 1 and Scenario 2.

4. DATA COLLECTION AND MODELLING

Data which are used in this research are shown in Table 2:

Table 2. Data used in this research
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No	Data	Source
1	Indonesian Earth Map Scale 1: 25.000, Year 2016	Geospatial and Information Agency (Badan Informasi dan Geospasial)
2	Spatial Planning Map of Brebes District (2018-2039)	Govt. of Brebes Disrict
3	Topography	Digital Elevation Model (DEM)
4	Satelite Imaginary Spot 6, Year 2016	Geospatial and Information Agency (Badan Informasi dan Geospasial)

The flow chart od the methodology of this research is presented in Figure 3.

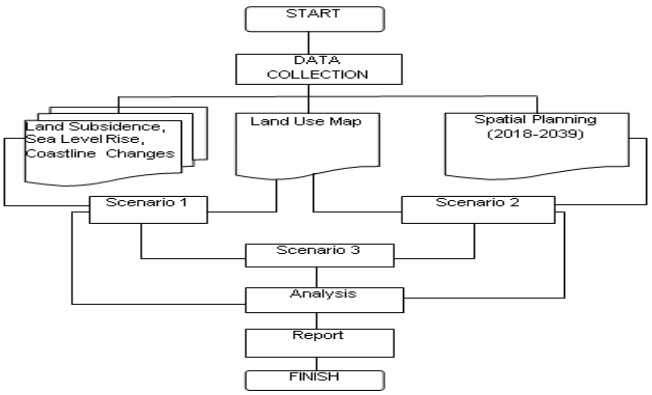

Figure 3. Flow Chart of Research Methodology

5. ANALYSIS, DISCUSSION AND EVALUATION

Scenario 1:

Based on the assumptions and the available data, the projected change in land use in the northern coastal region of Brebes District in the period 2018-2039 using Scenario 1 is presented in Figure 4.

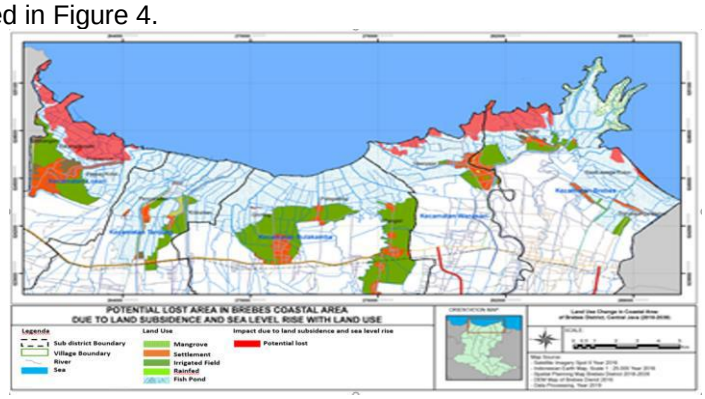

Figure 4. Potential Lost Area Using Scenario 1

From Figure 4 it is clear that due to the changes in coastline, land subsidence and sea level rise, in the period of the next two decades, there are several coastal areas (sub-districts of Losari, Wanasari, Brebes) which have an area of 1,497 ha (ponds) and 20 ha are settlements being "lost" or permanently flooded by high tides. This is in accordance with the results of the calculation of coastal vulnerability levels that in the three regions are most vulnerable to coastal erosion (Mashuri et al., 2018). The land subsidence is mainly due to the over extraction of groundwater for different uses (urban, industrial). To control the land subsidence, groundwater extraction has to be limited and balance to the recharge capacity of the aquifer system. By considering the loss of fish pond area of 1,497 ha and using the average annual production factor of aquaculture, it is predicted that a reduce in aquaculture production will be about 7,164 tons. In this case, the paddy fields are still not affected, only one thing that must be carefully considered that the possibility of the salt intrusion to the rice fields.

Scenario 2:

The development plan has been prepared by the Brebes District Government which also covered the coastal area development plan through regional spatial management by determining regional priorities and growing potential sectors in the area based on the potential of regional resources including the availability of regional facilities and infrastructure. With the development plan of the area, it can be seen in Table 3 that almost 3,500 ha of agriculture land and 800 ha of irrigated rice fields in the Brebes coastal area will turn into industrial uses. To fulfill the settlement needs plan, an area of 3,500 ha of paddy fields is planned to be converted into residential areas. In this case, every stakeholder may influence each other in positive as well as negative related to the coastal zone development in Brebes area.

The result of Scenario 2 (presented in Figure 5) as the result of overlaying the existing land use with the 2018-2039 spatial planning which was prepared by the Brebes District Government.

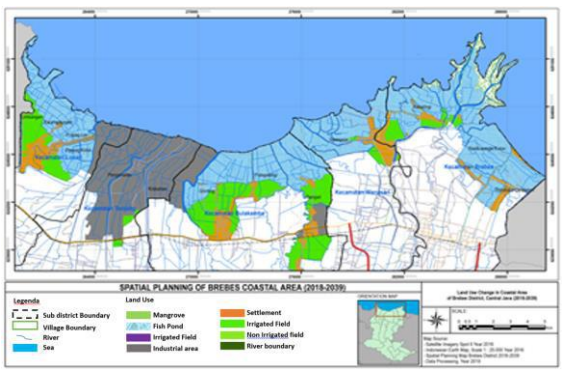

Figure 5. Spatial Planning Map of Brebes District (2018-2039)

From the total planned change in land use under Scenario 2, it is projected that the number of aquaculture production from fish ponds will decrease by 18,788 tons, while for agricultural production, using the assumption of the value of productivity of paddy rice is 5.5 ton/ha, the projected decrease in paddy production could be 27,379 tons.

Table 3. Existing land use change vs Spatial Planning (2018-2039)

No	2039 / 2018	Fish pond	Irrigated Field	Settlement	Rainfed	Industry	Mangrove	Riverine	Forestry	Others	Total
		1	2	3	4	5	6	7	8		18
1	Fish pond	7367,64	25,16	161,51	-	3504,21	64,14	187,91	-	122,25	11432,82
2	Settlement	8,66	188,04	6900,36	0,21	377,37	0	98,71	-	65,11	7638,47
3	Irrigated Field	78,57	16804,85	3521,75	10,95	829,1	-	267,16	-	270,2	21782,7
4	Non Irrigated field	-	-	0,0015	-	-	-	0,08	-	0,15	0,24
5	Rainfed	-	842,5	222,74	4,49	166,33	0	39,84	100,5	28,11	1404,72
6	Mix Gardenery	39,44	761,95	150	15,96	107,08	-	25,25	17,43	16,88	1134,03
7	Riverine	2,29	0,54	17,02	-	0,05	0,23	8,2	-	738,07	765,4
8	Mangrove	9,31	-	-	-	-	409,68	1,4	-	9,81	430,2
9	Others	-	-	-	-	-	-	-	-	20,44	20,44
	TOTAL	7506	18623	10973	31,61	4984	474	628,6	117,9	1271	44609

Scenario 3:

Based on the Geographical Information System (GIS) analysis for Scenario 3 as a combination of Scenario 1 and Scenario 2 and the result provides the information that from the area of industrial use (4,984 ha) in coastal areas, around 407 ha has a vulnerability to coastal hazards (coastal flood and land erosion).

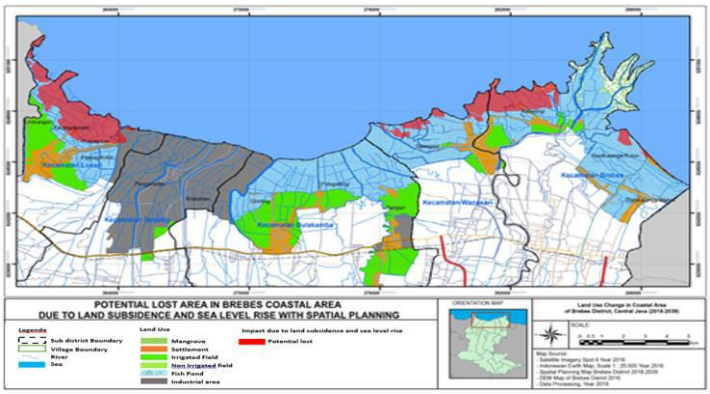

Figure 6. Potential Lost Area in Brebes Coastal Area (Scenario 3)

By analysing and comparing these three scenarios, generally speaking, there are two main issues/problems that need to be checked in detail related to the framework of the process of implementing and managing coastal areas in an integrated manner in Brebes District. First, the Brebes coastal area with all its potential has a vulnerability to the coastal disaster (coastal hazards) that threaten fish ponds, industries and settlement areas. Second, there is a need for getting efforts to optimize paddy fields in coastal area of Brebes District in order to increase the agricultural production of the area. For this purpose an integrated approach has to be prepared.

The actions that can be taken to support these strategies can be proposed as follows:

a. Protection, by installing hard structures (dikes and embankment, not rigid seawall, breakwater, sluice gate, tidal barries, sea water intrusion barrier and polder system) and not rigid structure (reforestation, increased mangrove planting, making retaining walls of wood and building with nature approach can be considered);

b. In case drainage by gravity is not possible anymore, the polder with pumping system should be considered for the most venerable coastal areas;

c. Since the polder system is recommended, the water management practices inside the polder should align modern drainage systems with natural water processes. So that it will make urban drainage systems in polder more efficient.

d. Improvement, include emergency planning, disaster protection, strict arrangements for disaster areas and improving irrigation network systems and agricultural/aquaculture supply and drainage systems;

e. Integration, means integrate all land uses, stakeholders and Brebes District authorities who involve in the planning and development plan and execution (what their problems, what their needs);

f. Retreat, involves increasing or setting back areas, removing threatened buildings, eliminating development in vulnerable areas, estimating the effect of sea level rise to Brebes coastal area, regulating realignment and creating buffer in the upland areas.

6. CONCLUSSION AND SUGGESTION

Based on the results of the scenarios analysis for Brebes coastal area, it can be concluded that:

- The total area of agricultural rice fields will experience the change of function into industrial estates and settlements which covered an area of about 4,900 ha with a potential loss of rice production of 27,379 tons per year;
- About 4,000 ha of agriculture land on the Brebes coastal area will experience conversion due to both natural factors and spatial planning factors, with a total potential loss of aquaculture production estimated at 18,788 tons;
- In terms of the vulnerability of the coastal region, there are three sub districts i.e. Losari sub district, Wanasari sub district and Brebes sub district that may have a high vulnerability to coastal disasters;
- In case drainage by gravity is not possible, polder with pumping system should be considered for the most vulnerable part of the Brebes coastal area;
- In the process of developing and managing coastal areas of Brebes, a protective, accommodative and retreat strategy is needed with the hope that implementing of the development plan without eliminating the negative possible effects on the ecosystem in Brebes coastal area can be avoided.

Based on the problem definition and scenarios analysis, some recommendations can be listed:

- Further studies need to be carried out by utilizing socio-economic and environmental parameters, especially related to fish ponds and agricultural sector stakeholders and aspects of disaster that have not been integrated in the existing coastal area development plan;
- In the process of land use change from agriculture fields to industrial estates, the government is suggested to carry out the studies related to the analysis of environmental impacts on coastal ecosystems carefully;

- Integration of studies between the role of irrigation network infrastructure to support the agricultural sector, the involvement of all related stakeholders and the study of coastal area protection from coastal hazard events need to be held in a frame integrated coastal zone management (ICZM) to ensure sustainable development.

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