# Predicting the Economic Values of Sea Level Rise's Impact on Agricultural Sector at Subang Coast, Indonesia: A Basic Reference for Adaptation and Mitigation Policies

Jimy Kalther*, Firdhan Aria Wijaya, Fajar Dwi Noviandri, and Egnas Sukma

***Abstract*—**Climate change is a serious threat for the low elevation coastal zones due to the rise of sea level. It will increase the frequency of various disasters such as storms, floods, salt water intrusions, etc. Many human activities in coastal areas will be affected, including the agricultural sector. Some of Indonesian coastal zones are vulnerable to sea level rise while on the other hand social activities are focused in those areas. Subang is one of the most vulnerable areas to sea level rise in Indonesia, where most of their coastal area used for agriculture. Thirty seven percent of their GDP came from the agricultural sector. Therefore, agriculture is an important sector at Subang. This paper discusses about the economic impact of sea level rise on the agricultural sector at Subang due to inundation of agricultural land at Subang Coast. The area that will be inundated if the sea level rose by 0.6 meters (according to the SRES B2 Scenario), were predicted using geographic information system (GIS) techniques by processing the Digital Elevation Model (DEM) data and overlaid it with the land cover map of Subang. The result of this study shows that the impact of sea level rise without adaptation or mitigation policies will be billions rupiahs. It also illustrated that the costs that have to be paid to the impact of sea level rise will be greater than the costs of mitigating it.

***Keywords*—**Agriculture, climate change, economic impact, Indonesia, sea level rise, Subang.

## I. Introduction

THE effect of climate change that will affect the most to the archipelagic countries is the rise of sea level. Reference [1] predicted that the sea level will rise by 0.8 meters in 2095. In 2007, IPCC reassessed the potential rising of sea level due to climate change. It was predicted to rise up to 0.6 meters in 2100. Many different opinions about the intensity of sea level rise because every researcher used different models and methods [2]. However, they have one thing in common, that the sea level rise is a threat for coastal ecosystem.

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The sea level rise will inundate the coastal area, especially which lies in the low elevation zones (LECZs/Low Elevation Coastal Zones) [3]. In the specific region, the sea level rise will increase the frequencies of many disasters, such as floods, storms, salt intrusions, etc. [2]. Reference [4] said that the rise of sea level also will cause the degradation of natural resources and disturb the socio-economic aspect of coastal society.

Studies about the impact of the sea level rise due to climate change has been developed for a long time. However, most of them only concern about the direct loss of coastal ecosystem. Reference [5] has studied about the economic impact of the sea level rise but only generally. In Indonesia, [6] has conducted a research related to the economic impact of sea level rise in Cirebon Coast, but also in global scale. The study, which specifically concern about the impact of the sea level rise in agricultural sector in Indonesia has not been developed while on the other hand, agriculture is a sector that vulnerable to the climate change and climate variability [7], including the sea level rise.

The sea level rise will lead to loss of the agricultural land due to inundation. Reference [8] has predicted that agricultural land which affected by the sea level rise is approximately 23.43%. Indonesia itself was predicted by [8] to lose more than 5% of its coastal agricultural land due to the sea level rise whereas Indonesia depends mostly on agricultural sector. In 2007, more than 43% of the labor force in Indonesia were related to this sector and contribute more than 13.7% of its GDP [9]. In other words, agriculture is considered as an important sector in Indonesia and has to be protected from any disruptions. Therefore, mitigation and adaptation policies have to be formulated.

This research was conducted to assess physical and economic damage of agricultural sector in Indonesia because of the sea level rises. However, this study suffers from two limitations. First, this study only assesses the economic impact of sea level rise on agricultural sector due to inundation of agricultural land. Other possible impacts such as saltwater intrusion which can lead to higher level of

salinity is out of the scope of this research. Second, the agricultural land term in this research only refers to the rice field. Another kind of agricultural land, such as Agroforestry, is not included. The results of this research could be used as a reference to formulate mitigation and adaptation plan.

This study gives the information about the value of potential loss of agricultural land due to the sea level rise. Then, the policy maker can decide what the best plan to prevent worse impact based on cost-benefits analysis.

## II. Study Area

Subang is one of the regencies in West Java, Indonesia that uses coastal area as agricultural land which will be affected by sea level rises [10]. It is caused by not only the regency has low elevation, but also has rapid growth in infrastructure [11].

Subang is located at the north area of West Java Province (Fig. 1), Indonesia covers a total area of 205,176.95 hectares (approximately 6.34% of West Java), a half of this total area lay in the low elevation zone, which makes Subang as vulnerable area to the sea level rise [10]. This regency is divided into 30 sub-districts [10] where the two of them are considered as the most vulnerable area to the sea level rise [12]. Agricultural sector in those areas uses up to 7,630 hectares of the total area (16,398 hectares) [10].

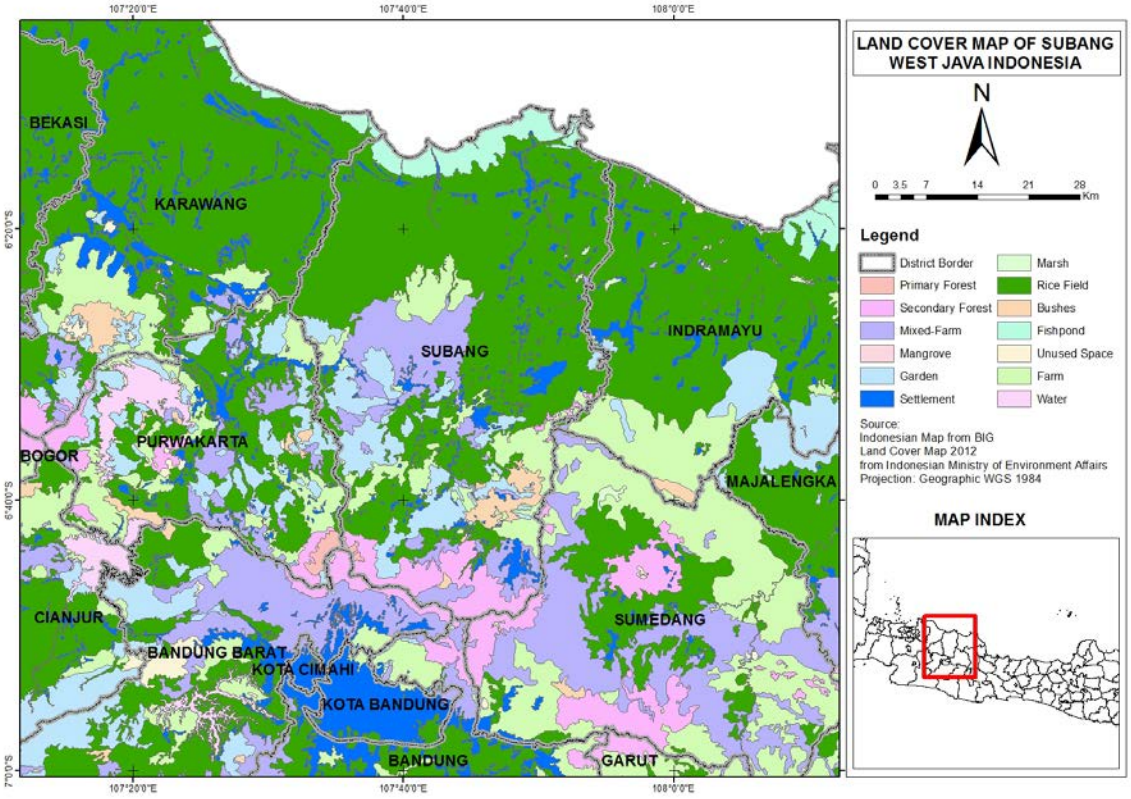


Fig. 1 Land cover patterns in Subang.

From the total area used for agriculture, we can guess that Subang highly depends on this sector. It's also proven by the fact that more than one-third of Subang's GDP in 2011 are contributed by the agricultural sector [10]. Therefore, it can be said that agriculture is extremely important to the economics of Subang.

On the other hand, Subang already suffers from the impact of sea level rise, although it is caused mostly by tidal effects. Every month, there are times when the salt water flooding the coastal area of Subang. Many peoples affected by this phenomenon, even though it has not yet affected the agricultural land. However, it has been projected that in 2050 or 2100, most part of Subang Coast will be submerged.

Consequently, an adaptation and mitigation policy has to be made in order to prevent the worst possible impact of the sea level rise at Subang Coast. The result of this study may help the policy maker to determine the best way to mitigate it or adapt to it.

## III. Data And Methods

### A. Predicting the Inundated Agricultural Land

Digital elevation model (DEM) data were used to predict the area that will be inundated by the sea level rise. It was interpolated by its altitude. The area with altitude under 2.09 meters was assumed as the inundated area.

Then, it was overlaid with the land cover map of Subang. Therefore, the inundated agricultural land could be known and the area could be calculated. It worth to mention that the DEM data of Subang were provided by the Indonesian

Geological Survey Center and the land cover map of Subang was provided by Indonesian Ministry of Environment Affairs.

### *B. Valuation of Economic Impact of Sea Level Rise in the Inundated Agricultural Land*

The total economic values (TEV) of agricultural land were calculated and it represented the total loss of agricultural land due to sea level rise. TEV can be divided into two different values, use value and non-use value. The use value consists direct use value (DUV) and indirect use value (IUV)

DUV was calculated from the contribution of agricultural land (its resources and environment) which can be directly used [13]. Direct use values arise from human direct utilization of ecosystems for example, through the sale or consumption of a piece of fruit. All production services and some cultural services (such as recreation) have direct use value [14].

IUV is the use of natural ecosystem which indirectly supports the direct use value [13]. Non-use values (NUV) that are not associated with actual use, or even the option to use a good or service. Existence value is the non-use value that people place on simply knowing that something exists, even if they will never see it or use it.

## IV. Result and Discussion

Based on the result of DEM processing, it could be known that the areas that will be inundated due to the sea level rise at the Subang Coast (in the two sub-districts: Blanakan and Legonkulon) are approximately 15,715 hectares. Forty percent of these areas are agricultural lands, which are approximately 5,985.93 hectares. Those agricultural lands, which are predicted as the inundated agricultural lands, lied in the two sub-districts that are considered as the most vulnerable areas to the sea level rise.

Overall, it can be seen that the inundated agricultural lands in Legonkulon are bigger, whereas the agricultural lands in this sub-district are lesser than the agricultural lands in the other sub-district (Fig. 2). In other words, the proportion of the inundated agricultural land and the total agricultural lands are bigger in Legonkulon than its proportion in Blanakan. It was caused by the fact that Legonkulon lied in lower elevation than Blanakan (Fig. 3). The proportion mentioned earlier indicated that the agricultural sector in Legonkulon is more threatened than the agricultural sector in Blanakan.

The economic valuation of sea level rise's impacts on the agricultural sector on Subang Coast was calculated using the total economic values (TEV). Direct use value (DUV), which is part of TEV, was calculated based on the average of annual agriculture productivity in Subang per hectare minus the production cost (variable cost and fixed cost of agriculture process). In addition to DUV, indirect use values was also been calculated. It was based on the willingness to pay of non-farmers societies at Subang Coast to preserve the agricultural lands and its ecosystem services in their district. Another value which was included in TEV is the non-use value. The NUV was calculated based on the willingness to accept of farmer societies at Subang Coast to lose their agricultural lands and all positive aspects because of the sea level rise.

The benefit transfer method was used to calculate the direct use value of the inundated agricultural lands in Subang Coast. The annual productivity of agricultural lands was collected from [10] and the average of agriculture production cost was collected from [15] in 2010. From the total inundated agricultural lands, it was predicted that the DUV loss due to the sea level rise is IDR 84,651,712,287.96.

The Indirect use value of the inundated agricultural lands was calculated using benefit transfer method (using the result of previous study). The willingness to pay value was assumed as how much money, which the non-farmer societies are willing to pay for preserving the indirect use and ecosystem services of agricultural lands. Based on the previous study by [16], the average WTP of non-farmer societies in Indonesia to preserve agricultural lands is IDR 16,330. Thus, the indirect use value of the inundated agricultural lands at Subang Coast is IDR 1,004,050,050.00.

The calculation of the non-use value was based on the willingness to accept of farmer societies in Subang Coast. It was assumed to be the representation of how much money that non-farmers societies are willing to accept if they lose their agricultural lands. The WTA of farmer societies in Indonesia was based on previous study by [16]. The average WTA value on Indonesian farmer societies to lose their agricultural lands is IDR 3,100,000.00. After it has been calculated, then the non-use value of the inundated agricultural lands at Subang Coast is IDR 83,498,500,000.00.

The total economic values were calculate from the values above (DUV, IUV, and NUV). The TEV of the inundated agricultural lands at Subang Coast are IDR 169,154,262,337.96 (see Table 1).

TABLE 1
TOTAL ECONOMIC VALUES

| No | Values | Amount (IDR) |
|---|---|---|
| 1 | Direct use | 84,651,712,287.96 |
| 2 | Indirect use | 1,004,050,050.00 |
| 3 | Non use | 83,498,500,000.00 |
| Total Economic Values | | 169,154,262,337.96 |

The total economic values of the inundated agricultural lands at Subang Coast show that the economic values which will be lost due to the sea level rise is high. It is worth to mention that the total economic values which were calculated in this study is only the total economic values that will be lost because of the inundation, the TEV that lost by other cause (salt water intrusion, increasing frequency of disasters, etc.) were not included. It means that the real total economic values that will be lost because of the sea level rise are higher that the TEV that has been calculated in this study.

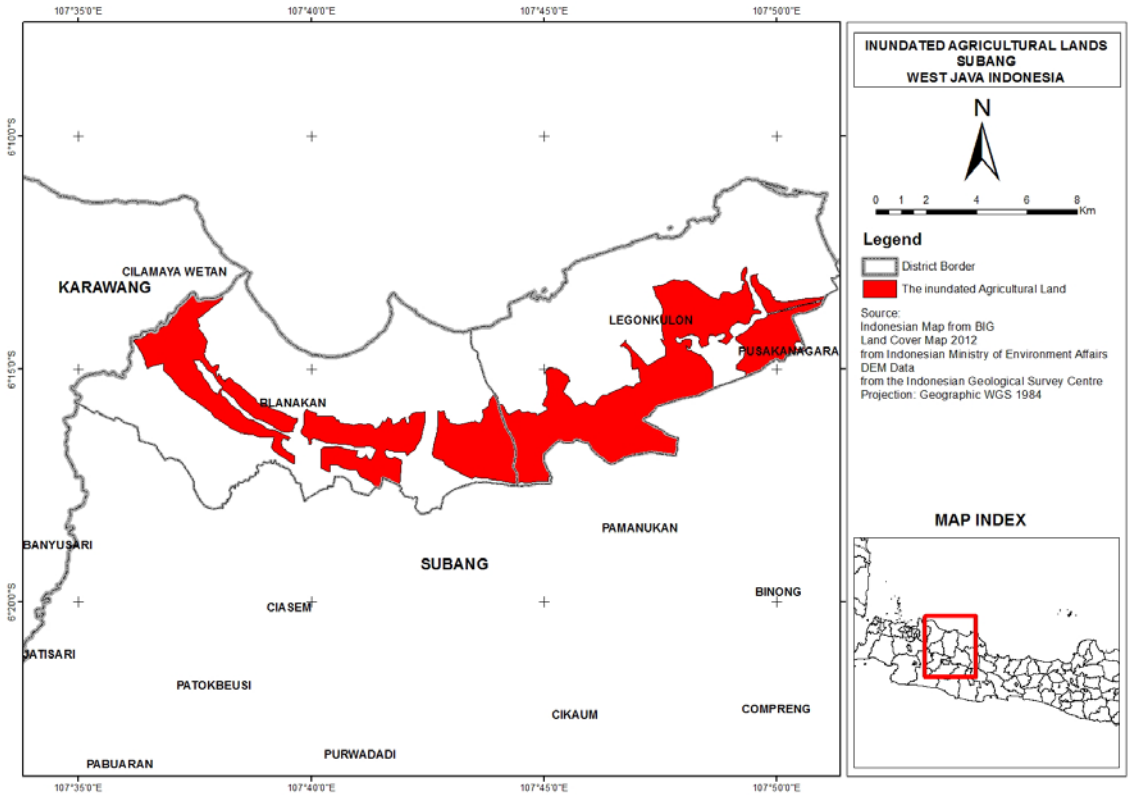


Fig. 2 The agricultural land that predicted to be inundated

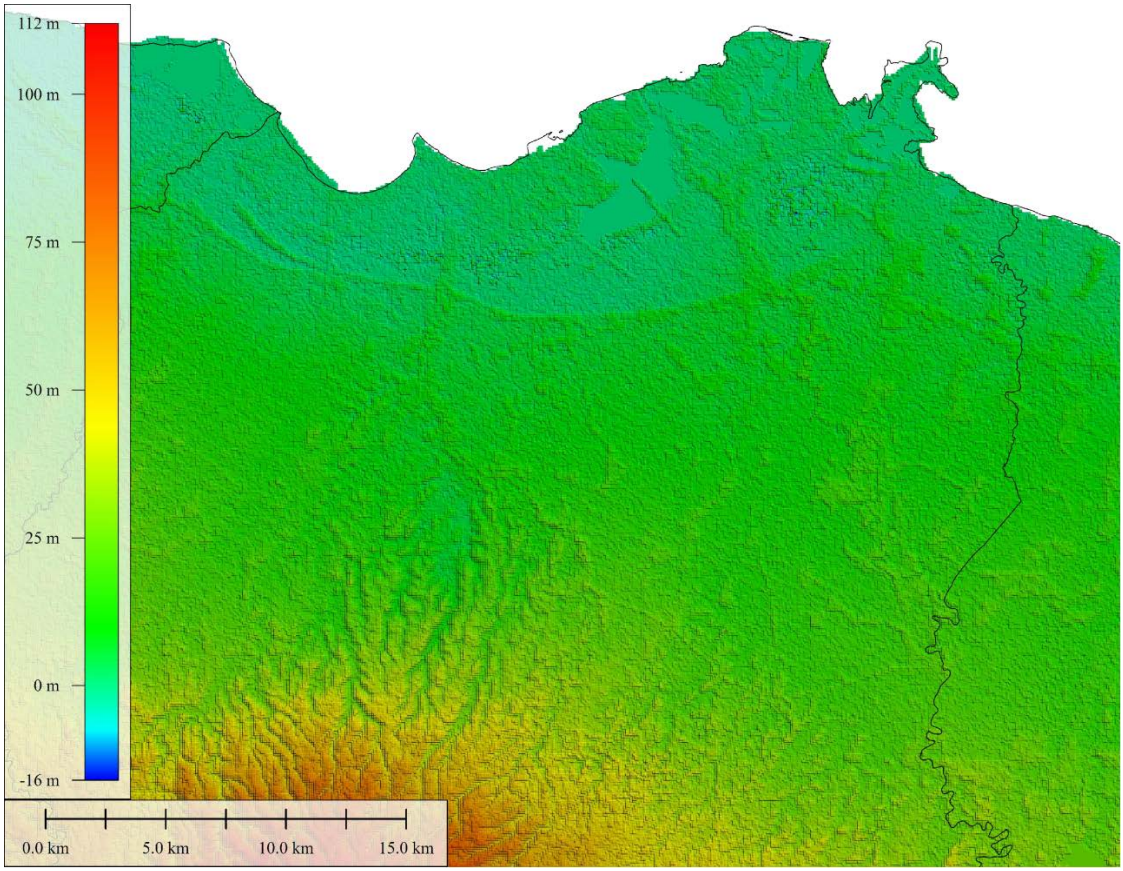


Fig. 3 Low elevation coastal zone at Subang Coast

The loss that caused by the sea level rise impacts make the government and societies have to develop the mitigation and adaptation plan. There are many options in how to cope with the problems that caused by the sea level rise. The first option is a sea dike construction. Sea dike is an infrastructure which is built as the barriers from sea water floods and saltwater intrusion. Based on the previous study conducted [17], to build a sea dike with a kilometer long and 2 meters high, it will cost approximately USD 1.157 million and USD 1.182 million based on [18] study. Further study about it which is based on cost-benefit analysis or suitability analysis, needs to be conducted in order to determine whether this option is applicable for this area or it is not.

The second option is relocation the society of Subang regency and change their livelihood. The government should find a new alternative location for their dwelling. The benefit for this action is the communities still can maintain their livelihood. Also, the sustainable agriculture can be introduced to the communities. In the fact, Indonesia still have many potential areas that can be used as agricultural land. Indeed, before doing this relocation, the government should conduct some research to find proper area that suitable for the communities.

The last option is development new paddy varieties which can cope to high salinity. So the paddy can grow up and the agricultural land can remain productive. Recently, there has been researches to investigate and develop seed varieties that are survive in saline soils.

## V. Conclusion

Climate change is the global issue that threats our world. One of the impact of the climate change is sea level rise. Subang Coast is area that is vulnerable to sea level rise. Meanwhile, the area of Subang has high potential of agriculture, especially the productivity of rice. Consequently, there are two vulnerable sub-districts, Blanakan and Legonkulon. The estimation of economic values because of its impact is 169,154,262,337.96 IDR. It consists direct use values (84,651,712,287.96 IDR), indirect values (84,651,712,287.96), and non-use values (83,498,500,000.00).

The recommendations to prevent that condition are building sea dikes construction, relocating the communities to proper area without changing livelihood, and developing new varities of paddy that can cope with salination.

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