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POLICY OPTIONS FOR AGRICULTURE IN FACING THE IMPACTS OF SEA LEVEL RISE IN THE SOUTH KALIMANTAN PROVINCE

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ABSTRAK

Sebagian lahan rawa pasang surut di dekat wilayah pesisir Indonesia telah direklamasi untuk digunakan sebagai lahan pertanian yang punya nilai ekonomi penting. Selama 25 tahun terakhir luasan lahan rawa di Kalimantan Selatan yang telah direklamasi untuk kegiatan pertanian, khususnya untuk pertanaman padi sebagai komoditas utama mencapai 89.036 ha. Lahan pertanian ini menghadapi risiko berupa kenaikan muka air laut (SLR).

Survey rumahtangga petani dilakukan untuk mengetahui tingkat kesadaran petani terhadap SLR dan pengaruhnya terhadap lahan pertanian. Hasilnya menunjukkan 35% dari total 1.222 responden mengerti dan menyadari adanya SLR dan pengaruhnya terhadap sawah mereka. Hal ini mengindikasikan akan perlunya diseminasi tentang SLR kepada para petani di wilayah pesisir pantai.

Data satelit (GIS) juga digunakan untuk memprediksi hilangnya hasil pertanian akibat SLR 0,5 – 1,0 m. Kabupaten Banjar, Barito Kuala, Kotabaru, Tanah Bumbu, Tanah Laut dan Kota Banjarmasin, Provinsi Kalimantan Selatan memiliki areal pertanian yang terkena dampak SLR. Hasil analisis juga menunjukkan bahwa Kabupaten Barito mengalami kehilangan hasil pertanian terbesar.

Tujuan lain dari penelitian ini adalah melakukan penilaian ekonomi terhadap pilihan kebijakan bagi pertanian dalam menghadapi SLR berupa pembangunan tanggul pada lahan pertanian yang ada dan pembangunan areal pertanian yang baru. Hasil analisis biaya dan manfaat menunjukkan bahwa pembangunan tanggul menghasilkan NPV yang positif, sedangkan pembangunan areal pertanian baru menghasilkan NPV yang negatif. Hal ini mengimplikasikan bahwa secara ekonomi kebijakan pembangunan tanggul lebih layak dilakukan dibanding kebijakan membangun areal pertanian baru.

Kata kunci: pertanian, kenaikan muka air laut (SLR), dampak, tanggul, penilaian, ekonomi

ABSTRACT

Economical importance of the Indonesian coast is significant as a large of tidal swamp land near coastal areas have been reclaimed for agricultural purposes. Physical achievement after 25 years of swamp reclamation has been that 89,036 ha of swamp land in the Province of South Kalimantan have been reclaimed for agricultural areas with rice as a main commodity. These agricultural areas have been at risk due to Sea Level Rice (SLR). Household survey was carried out to determine awareness level of farmers on the SLR and its effect on the agricultural lands. Out of the total number of 1,222 respondents, 35% understood the SLR and effect of the SLR on their rice fields. This indicates requirement of dissemination on the SLR issue to the farmers in the coastal areas.

Geographic information system (GIS) was also employed to predict agricultural loss impacted by 0.50 – 1.0 m SLR. Banjar, Banjarmasin, Barito Kuala, Kotabaru, Tanah Bumbu, and Tanah Laut Regencies in South Kalimantan Province had agricultural areas that received impact of SLR. Result of analysis also revealed that the Barito Kuala experienced the largest loss of agricultural product.

Another objective of this research is to conduct the economic assessments on policy options for agriculture in facing SLR impacts by investing of farm-dikes installation and new agricultural areas establishment. Results of cost and benefit analysis showed that farm-dikes installation had positive NPVs, whereas establishment of new agricultural areas experienced negative NPVs. This implies that farm-dike establishment policy is a more economically viable in response to the SLR of 1 m compared to the new agricultural areas establishment policy.

Keywords: agriculture, sea level rise (SLR), impact, farm-dike, economic assessment

INTRODUCTION

Background

The Indonesian Government introduced the Tidal Swamp Land Development Project since 1960s in order to achieve rice self-sufficiency. Four Ministries (Ministry of Public Works, Ministry of Internal Affairs, Ministry of Agriculture, and Ministry of Transmigration) were appointed to plan and execute a program known as *Paddy Field Development Project on Tidal Swamp through Transmigration.* The physical achievement after 25 years of swamp development has been that 89.036 ha of swamp land in the Province of South Kalimantan have been reclaimed for agricultural areas with rice as a main commodity (Ministry of Settlement and Regional Infrastructure, 2006). Rice production in the reclaimed tidal-swampy land accounted for 38% of total rice production in the Province of South Kalimantan (Statistics Board of South Kalimantan Province, 2006).

As noted by the International Panel on Climate Change (IPCC, 2007), continued growth of green house gas emissions and associated global warming will lead to climate change. Climate change will have many negative effects, including greater frequency of heat waves; increased intensity of storms, floods and droughts; and rising sea levels. SLR (SLR) poses a particular threat to countries with heavy concentrations of population and economic activity in coastal regions. SLR would increase the susceptibility of coastal populations and ecosystems through the permanent inundation of low-lying regions, amplification of episodic flooding events, and increased beach erosion and saline intrusion (Mclean *et al.*, 2001). SLR will lead to decline coastal line hundreds m into mainland, and this will cause lost of agricultural land in tidal swampy land. Freshwater will be difficult to gain as soil will be polluted by intrusion of sea water; therefore, this will affect water quality. Ultimately, this may lead to the displacement of millions of people, significant damage to property and infrastructure, and a considerable loss of coastal ecosystems by the end of the 21st Century (Nicholls and Lowe, 2004).

Several measures should be proposed to reduce the risk of loss of life or damage in order to maintain economic activities in coastal areas. General proposal for maintaining economic and environment in coastal areas is including the protection through hard structures such as dikes and sea walls. For example, maintenance and investments of coastal defense structures as well as the monitoring of beach and dune pollution in Belgium raises costs to about 25 million Euros (Lebbe and Meir, 2000). In addition, Kojima (2004) proposed 115 billion US$ would be needed to protect port-related facilities alone against 1 m sea-level rise in Japan.

Establishment of coastal protection in Indonesia as options to the adaptation is mostly neglected. Establishment cost of coastal protection is very expensive as coastal line in Indonesia has been approximated 81,000 kms. For comparison, Lau (2005) reported that costs for a 500 km dike to prevent losses from a 1 m-SLR for the North China Plain were estimated with an equivalent of 370 Million US$. While there is no hard structures have been built in Indonesia for coastal protection, farm-dikes established by the Ministry of Settlement and Regional Infrastructure in collaboration with Ministry of Agriculture could reduce impact of the SLR on agriculture areas in tidal swamp land. Water management determined successfulness agricultural management in swamp land; therefore, farm-dikes completed with flap-gate from fiber is frequently installed in drainage system to control water availability in rainy and dry season (Susanto *et al.*, 1999). Based on its function, installation of flap-gate could be used to reduce the impact of SLR on the agricultural areas. Alternative option to reduce the impact SLR on agriculture is to establish new agricultural areas in inland that cannot be influenced directly by SLR. The Indonesia' Government has long experience for people relocation through agricultural development in relocated areas. However, there is no information on the cost and benefits for farm-dike installation and establishment of new agricultural areas.

Aims of the Study

The general objective of the research is to conduct the economic assessments on policy options for agriculture in facing SLR impacts in the South Kalimantan Province by investing of farm-dikes installation and new agricultural areas establishment.. The specific objectives are:

1. To determine the level of awareness of farmers about the SLR and its effect to their agricultural land.
2. To predict agricultural loss caused by the SLR of 1 m if there is no adaptation effort done.
3. To provide estimates cost and benefit for protection of agricultural areas nearby coastal areas through farm-dike establishment.

To provide estimates cost and benefit for establishment of new agricultural areas (paddy field) in inland

RESEARCH METHODS

Awareness of Farmers on SLR

Focus Group Discussions

Two focus group discussions (FGDs) were carried out before household survey. The first was with government agencies, namely: The Agricultural Regional Office of South Kalimantan Province, The Agricultural Regional Office of Kabupaten Banjar, The Agricultural Regional Office of Kabupaten Barito Kuala, The Agricultural Regional Office of Kabupaten Tanah Laut, The Settlement and Regional Infrastructure Regional Office of South Kalimantan Province and Transmigration Regional Office of South Kalimantan Province.

The second FGD was attended by 12 farmers from different district (*kecamatan*) of the South Kalimantan Province. The participants were recruited through agricultural field officer. There were representatives from three regencies that have largest proportion of reclaimed swamp land in the Province of South Kalimantan. This FGD served as a venue to discuss the objectives of the project with the invited household farmers, to determine their level of awareness regarding SLR.

Household Survey

Design of the sample for household survey used a three-stage process. The Statistics Board of South Kalimantan Province and Agricultural Regional Office of South Kalimantan Province generated the sample used for household survey. The first stage involved the selection of regency (*kabupaten*) from 13 regencies in the Province of South Kalimantan, while the second stage focused on the selection of district from each regency. The third stage was to select village in where household survey to be carried out.

Three regencies: Barito Kuala, Tanah Laut, and Banjar were selected from 13 regencies in the Province of South Kalimantan. These three regencies appeared to be the four largest rice productions in this province. Tapin was not included for household survey since this regency was not situated nearby coastal areas.

Agricultural Loss Caused by SLR (Base Case)

Geographic information system (GIS) software was employed to determine total agricultural areas influenced by the SLR. The GIS was used to overlay land-use data with the inundation areas projected for 1.0 m-SLR.

Estimates of agricultural loss due to SLR were carried out through identification and quantification of agricultural activity in the impacted areas. Rice fields, fish/shrimp pond, fruits, and animal husbandry in each regency were considered as agricultural activities which impacted by SLR. Agricultural productivity of each regency was taken into calculation due to each kabupaten/regency has slight different agricultural productivity. Secondary data of agricultural productivity and prices of each commodity were supplied by the Agricultural Regional Office of Province of South Kalimantan.

Influence of SLR on rice production occurred throughout two mechanisms. Firstly, when SLR occurred in rice fields, sea water containing high concentration of salts could enter into rice fields. As a result, growth of rice in those areas could be prohibited. The effects of high concentration of salts on rice growth have been reported in several researches (for examples: Saidy *et al.* (2004), Asch and Woperies (2001) and Khan *et al.* (1997)). Saidy *et al.* (2004) reported that increase salt concentration to 2 dSm^{-1} in rice field of the South Kalimantan Province led to reduction 60-70% of rice growth. Higher SLR will increase higher concentration of salt entering rice field and lead to increase in reduction of rice growth. Secondly, SLR influenced rice production throughout oxygen availability for rice growth. Growth of most rice variety will be completely prohibited when SLR increase more than 45 cm in where rice plant will go down under water and could not obtain oxygen for their growth.

Different to that of rice production, loss of fruit and fish/shrimp production was assumed to occur when SLR increase more than 45 cm. Fruits were mostly cultivated in raised bed soils that generally have surface 45-50 cm higher than the surface of rice fields (Saidy *et al.*, 2004). Therefore, loss of fruit production is assumed to be observed when SLR reached 45 cm. Fish/shrimp pond is generally protected by a 40-75 cm concrete bank; thus, production of fish/shrimp is assumed to be influenced when SLR reach to more than 40-45 cm.

Determination of time frame for effect of SLR occurred in study areas is one of the crucial issue in this analysis. There is a little study on increase in the SLR in specific areas in Indonesia. Nurmaulia *et al.* (2005) using satellite data of altimetric topex (1992-2002) reported that the most suitable predicted mean SLR will be 15 mm per year in the Java Sea. Therefore, effect SLR of 0.50 m in the study areas will occur in 2039, while effect of 1.0 m SLR will occur in 2072.

Estimation Costs and Benefits for Agricultural Areas Protection and for Establishment of New Agricultural Areas

Cost-Benefit Analysis (CBA) is employed in this study in assessing the farm-dike investment to protect agricultural areas from SLR impact and for assessing the establishment of new agricultural areas in adapting the impact of SLR.. From an economic perspective, the assessment of this investment is conducted on with and without bases to reflect the true welfare change attributable to the project (Gittinger, 1992).

RESULTS AND DISCUSSION

Awareness of Farmers on SLR

Among others things, this study sought evaluate the level of famer's awareness on SLR. Out of the total number of 1,222 respondents, 35% knew what SLR is and effect of SLR on their rice fields. Most farmers who aware of the SLR obtained information on the SLR and its effect on agricultural land from mass media (newspaper and television) (59%), while the remaining obtained information on the SLR from neighbors, extension officer, and others.

The result also showed that when the farmers asked changes in river surface surrounding their rice fields, 25% of them observed no changes in river surface. Most farmers (75%) observed increase, decrease, and fluctuation in river surface surrounding their rice fields. For the farmers who observed changes in river surface surrounding farmer' rice fields, 45% and 41% of them considered that the changes were related to variation in season and effect of SLR, respectively.

Agricultural Loss Caused by SLR (Base Case)

Out of 13 regencies in the South Kalimantan Province, six regencies: Banjar, Banjarmasin, Barito Kuala, Kotabaru, Tanah Bumbu, and Tanah Laut had agricultural areas that received impact of SLR. Banjarmasin, Barito Kuala, Kotabaru and Tanah Bumbu are the most seriously impacted by the SLR. Up to 60% of agricultural areas in these regencies would be impacted by a 1.0 m SLR. Most of this impact is observed in the Barito Kuala in which 68% of agricultural lands would receive impact of 1.0 mater SLR. Regarding to provincial level, 36% agricultural areas in the South Kalimantan Province influenced by the SLR effect of 1.0 m.

Estimation of agricultural product loss (total net loss) impacted by the SLR in the South Kalimantan Province reached IDR 910.65 billion with a 0.5 m SLR and reached IDR 1,506.42 billion with a 1.0 m SLR.

Results of analysis revealed that the Barito Kuala experience the largest loss of agricultural product. Even with a 0.5 m SLR, IDR 630.26 billion of agricultural product of the Barito Kuala would be lost. This number reached IDR 729.42 billion under a 1.0 m SLR scenario.

Protection of Agricultural Areas by Farm-Dike Installation

Measuring Incremental Benefits of Farm-Dike Installation

Benefit assessment of farm-dikes installation in relation to reduction of SLR effect on agricultural areas consisted of additional or incremental benefit obtained from estimation of the loss of net return of paddy field, fish/shrimp ponds, and fruit farms that could be saved by installation of farm-dikes and scrap value of farm-dikes at the end of the project.

Agricultural benefits are generally measured by changes in net returns corresponding to the changes in crop yields as a result from changes in agricultural area with and without farm-dikes installation. However, in this analysis it would be logically assumed that costs of production per unit of area planted, including those of agricultural management and technology employed in agricultural areas with and without farm-dikes installation remain the same.

Fish/shrimp pond is generally constructed with dikes to prevent sea water/flooding water entering the ponds. Height of the dikes is normally 35-50 cm; therefore, construction farm dikes will lead to more benefits to the fish/shrimp ponds. Fruits were generally planted in the raised bed soils. However, it is reasonably assumed that installation of farm-dikes will prevent rotten of fruit root due to submerged root-system in water.

Another benefit considered in this analysis is residual value of farm-dike at the end of the project, which is value of farm-dike installed from 2007 to 2072. These farm-dikes have been only used between 1 year and 6 year instead of 15 years; therefore, their economic values still exist.

Total of additional benefits of farm-dikes installation that consisted of paddy field, fish/shrimp ponds, fruit farms, and residual value for period of the project 2007-2072 is summarized in Figure 1.

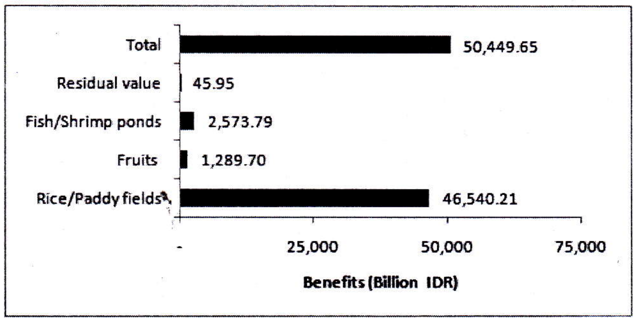

Figure 1. Additional benefits of farm-dikes construction in response to the SLR in the South Kalimantan Province

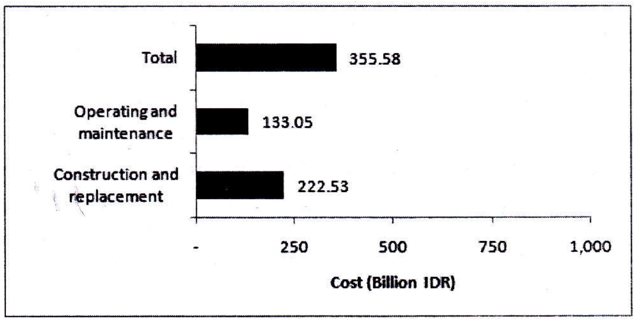

Figure 2. Additional costs of farm-dikes installation expressed in 2007 constant price

Assessing Cost of Farm-Dike Installation

All reclaimed tidal-swamplands have been generally completed with drainage canal. This canal function to drain excess water and to irrigate dry-agricultural areas. In order to improve land productivity, the Ministry of Settlement and Regional Infrastructure installed flap-gate for improvement of farm-dikes function to control water availability in agricultural areas. Farm-dikes with flap-gate are successful to drain excess surface and/or groundwater, to provide flood-protection, to prevent salt intrusion and to control water quality.

Cost of agricultural protection by farm-dike installation is economic cost associated with the investment. Just as for benefits, the cost analysis is based on incremental cost to allow for comparison between agricultural areas with and without farm-dikes installation. Estimation of cost for farm-dike installation was carried out followed the stages of the construction. In this analysis, the incremental analysis associated with farm-dikes installation comprise procurement cost (material preparation, construction, transportation and installation) and maintenance and operating cost. Each farm-dike can be economically used for 15 years and after 15 years, it should be replaced with the new one. Therefore, incremental costs incurred each year is total of procurement cost, operation and maintenance cost of farm-dike installed previous year and cost of replacing farm-dike after 15 years. Composition of farm-dikes installation cost expressed in 2007 constant price is summarized in Figure 2.

Net Benefit and Present Value of Farm-Dike Installation

Stream of net benefits is difference between total additional benefits gained and total additional costs incurred in each year during the project period (2007-2072). Total net benefits resulted from farm-dike installation to reduce effect of 1.0 m SLR on agricultural areas in the South Kalimantan Province during project period 2007 – 2072 is approximately IDR 50,094.06 million. From a benefit-cost perspective, this is satisfactory as the benefits gained outweigh the cost incurred, thereby increasing social welfare.

After stream of net benefits was calculated, discount rate has been to be used for calculating the Net Present Value (NPV). NPV for this project at different discount rates is described in Table 1.

Table 1. Net Present Value (NPV) for protection of agricultural areas by building of farm-dikes

Discount Rate	NVP (billion IDR)
NPV at 8%	2,654.80
NPV at 12%	1,000.17
NPV at 16%	476.50

Table 1 showed that NPV for protection agricultural areas by farm-dikes building at discount rate of 8% is greater than zero. It implies that the protection project by farm-dike installation is feasible or the project could be economically conducted. When sensitivity analysis conducted using higher discount rate of 12% and 16%, this project is still economically sound. However, the NPVs decreased drastically at higher discount rates. It implies that this project is sensitive to the change of discount rate

Relocation of Agricultural Areas

Measuring Incremental Benefits of Relocation of Agricultural Areas

Benefits gained from relocation of agricultural areas are expressed as incremental or additional benefits. These benefits are estimated from loss of net returns for paddy farms, fruit farms, and fish/shrimp ponds that could be avoided by relocation of agricultural areas and residual value of housing and other infrastructure in relocated areas. Benefits of agricultural relocation program are summarized in Figure 3.

Incremental benefit from paddy fields in 2007 is minus IDR 1,315.61 billion and increased to IDR 1,319.07 billion in 2072. Total incremental benefits of paddy field during project period from 2007 to 2072 is IDR 13,585.91 billion, while total incremental benefit of fruits farm is IDR 688.88 billion and total incremental benefit of shrimp ponds is IDR 2,088.38. Another benefit from relocation of agricultural areas is residual values of paddy fields and housing. Total additional benefit of residual values is IDR 943.42 billion. In general, total additional benefits from relocation of agricultural areas for project period (2007-2072) is IDR 17,306.59 billion.

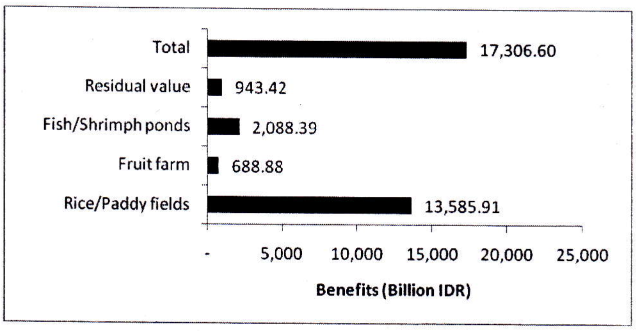

Figure 3. Benefits of relocation of agricultural areas for adaptation agriculture to the impact of SLR in the South Kalimantan Province

Assessing Cost of Relocation of Agricultural Areas

Establishment of agricultural areas in inland because of impact of SLR on agricultural lands nearby coastal areas has not been conducted previously by the Indonesia Government. However, the Government of Indonesia has long experience to relocate people from high-density areas to new areas. This program is known as transmigration.

Costs of relocation of agricultural areas are economic cost associated with the investment. Just as for benefits, the cost analysis is based on incremental cost to allow comparison between agricultural areas with and without relocation program. In this analysis, the incremental analysis associated with relocation comprise capital costs of rice field construction, fruits field construction, shrimp ponds construction, housing and other infrastructures construction, living costs and moving transport.

Total incremental costs during project period from 2007 to 2072 is minus IDR 18,717.29 billion.

Net Benefit and Present Value of Relocation of Agricultural Areas

Stream of net benefits is the difference between total incremental benefits gained and total additional costs incurred in each year during the project period (2007-2072). Total net benefits resulted from relocation of agricultural areas as impacted by the 1.0 m SLR in the South Kalimantan during project period from 2007 to 2072 is IDR 36,023.89 billion.

After estimation of stream of net benefits, discount rate has been to be used for calculating the Net Present Value (NPV). NPV for relocation of agricultural project at different discount rates (8%, 12% and 16%) is described in Table 2.

Table 2. Net Present Value (NPV) for relocation of agricultural areas

Discount Rate (%)	NPV (billion IDR)
NPV (8%)	-2,284.55
NPV (12%)	-2,579.60
NPV (16%)	-2,299.97

Table 2 showed that NPV for relocation of agricultural areas at discount rate of 8% is less than zero. It implies that the relocation project is not feasible or the project could not be economically conducted. When sensitivity analysis conducted using higher discount rate of 12% and 16%, this project is still not economically sound. However, its NPV is not drastically falling down at higher discount rates. It implies that this project is not sensitive to the change of discount rate.

Comparison between the NPVs of protection of agricultural areas using farm-dikes and those of establishment of new agricultural areas showed that the first policy is more preferable or more worthwhile for adaptation of agriculture to 1 m SLR.

CONCLUSIONS AND POLICY IMPLICATION

35% of farmers understood the SLR and effect of the SLR on their rice fields. This indicates requirement of dissemination on the SLR issue to the farmers in the coastal areas. Understanding of farmers on the SLR is essential for farmer involvement in implementation adaptive-strategy for reducing impact of SLR.

Total loss of agricultural product in the South Kalimantan Province reached IDR 1,506.42 billion as impacted by 1.0 m SLR. This information is valuable for the local authority to design the right policy for maintaining food sufficiency, which is evenly influenced national stability. Given the importance of food sufficiency, it is right time that people should realize the need to reduce or prevent the impact of the SLR on environment and economic.

Farm-dikes installation had positive NPVs, whereas establishment of new agricultural areas experienced negative NPVs. This implies that farm-dike establishment policy is a more economically viable in response to the SLR of 1 m compared to the new agricultural areas establishment policy.

In this study, the unsatisfactory results of the CBA of new agricultural areas establishment investments may stem from the fact that relevant impacts may not have been fully accounted for, such as impact to human health and other environmental impacts.

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