

Water-system changes in swampy rice agro-ecosystems area and their economic impacts on farmers in South Sumatra, Indonesia

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Water-system changes in swampy rice agro-ecosystems area and their economic impacts on farmers in South Sumatra, Indonesia

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Abstract. Conversion of land encompasses not only changes in the use of land for cultivation of food to non-food product but also includes the conversion of land in use to unused land. Changes in the management of water in the area of agro-ecosystem in Ogan Komering Ilir (OKI) District has resulted in a change of use of paddy swampy land. Research was aimed :1) to analyze the differences in the income of farmers of rice due to the changes management water in the area of agro-ecosystems; and 2) to analyze the level of welfare of the rice farmers after adapting to the current environmental conditions. Research was carried out in the Belanti Village, Sirah Pulau Padang District, Ogan Komering Ilir District, South Sumatra Province, Indonesia. Location was selected purposively as the village was exposed to routine annual flood since 2008. The farmers has experinced crop and harvest failure, despite the fact that it has served as rice granary since 1992. As survey method with structured questionnaires was applied in this research. Sampling was conducted purposively against 42 rice farmers who experienced crop failure. The primary and secondary data were collected and then subjected to land rent value analysis and t-test analysis. Results showed that: 1) changes in water management have reduced household income of farmers by 50.06%; and 2) the level of welfare of rice farmers is still low even though they have made adaptation efforts. To improve the quality of living for farmers affected by flooding, there is a need for integrated cooperation between the government of the country, palm plantation companies, and farmers.

1. Introduction

Even though land conversion is generally a logical consequence of the development of an area, it must also be considered that agricultural land conversion has negative impacts on humans and the environment. Apart from having a negative impact on national food security [1,2], the agricultural land conversion also has a negative impact on economic and social conditions [3,4]. The original landowners and farm laborers lost their jobs and could not find better jobs [5]. In addition, the conversion of paddy fields also affects the rice field landscape which results in changing natural conditions, such as: temperature fluctuates, precipitation and run-off decreases, and the climate changes from warm wet to warm dry [6] as well as flood stress [5].

Conversion of land encompasses not only changes in the use of land for cultivation of food to non-food product but also includes the conversion of land in use to unused land. It normally occurs as a result of changes in the biological and physical conditions of the soil. That was the case in Indonesia's



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South Sumatra province's Ogan Komering Ilir (OKI) District. The rice fields in OKI District are classified as follows: ups and downs, marsh swampy, cistern rain, and land dry. Only South Sumatra that have wealth although it has suboptimal rice producing soil typology. However the soils can be optimized to become a rice producer. As a result, OKI District has become the second-largest granary of food in South Sumatra, while South Sumatra is the fifth largest granary of food in Indonesia.

However, the opening of oil plantations on peat soil ecosystem in OKI District is widely regarded as one of the major causes of changes in water management system in this area. According to data from the Department of Crops and Livestock, the OKI District in 2018 had 56 large coconut palm estates that received permission and are still in operation, covering a total land area of 529,674.87 hectares. The business, which covers an area of 26,000 ha and is dominated by PT. Waringin Agro Jaya (WAJ), is based in the Sub-District Kayuagung and the Sub-District Sirah Pulau Padang. It began operations in 2008. According to [7], clearing of land to reach thousand-hundreds of hectares will certainly affect the quantity, quality, availability (QQA) of water in an ecosystem and the area of agro-ecosystems wetlands, which are detrimental, especially for the lives of residents of the settlements around the oil palm concession.

The area of paddy swamp lowland was exposed to the impact of inundation flooding is an area of approximately over 5,000 hectares which includes four sub-districts and 20 villages. The Village Belanti in the Sub-District Sirah Pulau Padang, with an area of around 2,708 ha, is the village most severely affected by the floods. Since 2008, the village of Belanti has been continuously flooded throughout the year until the time of this study. In 2017, with as many as seven sluice gates, so that by the end of 2018, farmers had begun to grow rice, despite the fact that only 80% of the total area of swampy rice fields could be planted. According to WALHI [8], the village of Belanti has existed since the period of "Keresidenan Palembang" (1879-1932). Later in 1965, locals and newcomers began farming in the swampy Belanti, which was officially designated as a paddy granary in 1992.

Changes in water management system are caused by a number of factors, including the establishment of large-scale plantations, the creation of infrastructure roads that obstruct river flow, dense residential populations in the river's vicinity, and the growth of infrastructure in the form of permanent structures. As is well established, the peat soil environment has a peculiar feature in that it acts to store water during the rainy season and to supply water during the dry season, similar to a sponge. Improper processing of soil at the massive opening of oil palm plantations have damaged the ecological function of peat soil. Therefore, it is necessarily important to conduct more research on this matter, so that the results of the findings can be recommended to the policy maker so that land resources asset can be used to maintain the resilience of the food and the economy; but also managed in a sustainable ways.

2. Materials and Method

2.1. Field Work

Sampling was conducted in Belanti Village, Sirah Pulau Padang Subdistrict, Ogan Komering Ilir District, South Sumatra Province, Indonesia (Figure 1). The location was chosen with consideration that the village was affected by flooding approximately 2,708 ha of 5,000 ha area affected. According to 2017 statistics, The Village Belanti covered a land area of 25.98 km² and had the total population of as many as 879 heads of families and as much as 97% have a livelihood as rice farmers. The village Belanti is situated at an altitude \pm 13 meters above sea level. Condition of topography in general is lowland which has an average temperature of 22°-30° Celsius. Belanti village has a tropical climate. Dry season generally ranges from May to October and the rainy season from November to April. Since Belanti is located in a lowland region, rivers provide water to the village.



Figure 1. Map of sampling site

A survey method with structured questionnaires was applied in this research. Sampling was conducted purposively against 42 rice farmers who experienced crop failure in 11 years ago. The last cultivation was in dry season 2007 and being recultivated in 2018 dry season. Primary and secondary data were collected in this research. Secondary data were obtained from the official publication issued by the related agency, such as: the Central Bureau of Statistics, Food and Horticulture Security Service; Department of Plantation and Livestock, all of OKI District; along with the official online publication from the respected agencies.

2.2. Data analysis

A Paired Simple T-Test [9] was used to compare the income of farmers in season planting in 2007, which has been compounded to the year 2019 based on time value of money analysis [10], with the income of farmers in dry season planting in 2019. The T-test were performed by using the Statistics SPSS program version 25. The farmer income analysis formula [11] is:

$$\pi = TR - TC$$

Where:

- π = net income (Rp)
- TR = total revenue (Rp)
- TC = total cost (Rp)

While it is, the formula compounding factor used is the formula of the future value [12]:

$$F = P (1 + i)^t$$

Where:

- F = future value (Rp)
- P = present value (Rp)
- i = interest rate (%)
- t = time (years)

The second aim of the study was to compare the monthly income of a farmer's household with the monthly expenses of a farmer's household [13]. The data used for the revenue and expenditure of farmers' households is from the year 2019, when the farmers began harvesting on the farm at the end of the planting season in 2018. The expenditures of a farmer's household include both food and non-food products. Rice, sugar, coffee, tea, pans, vegetables, and seasoning herbs make up the spending food. Electricity, fuel, oil property, coal, cigarettes, health, education, communication, taxes, and snacks are examples of non-food expenditures.

3. Result and Discussion

3.1. State of territory

The paddy fields in the village of Belanti is a non tidal swamp lowland. Swampy lowland is characterized by the presence of a pool of for a sufficiently long period of time. The water that has accumulated is not from the tide, but rather from run-off water surface in the well region of the surrounding city, where topography is much lower. The swamp lowland is classified into three categories based on the depth and length of inundation: a) shallow swamp, with depth of water less than 50 cm for less than 3 months; b) middle swamp, with depth of water between 50-100 cm for 3-6 months; and c) deep swamp, with depth of water greater than 100 cm for more than 6 months [14].

Swampy rice field in this village is experiencing dry season for 6 months and wet season for another the six months. If a flood occurs, the water will recede for a long time. First rice planting was conducted in the month of April-September and the second in the month of November- March. However, the field was still flooded during the harvest in October. Therefore, farmers are forced to postpone the next planting time. Rice planting in shallow swampy land which is usually done in May had to be postponed in July. Middle swamp which should be planted in April should be postponed in June. While the Valley in which usually just be planted in June have to experienced planting withdrawal to August.

Since 2008, paddy farmers in the village of Belanti have experienced crop failure. It's because paddy swamp lowland farmers have stagnant water almost all year (Figure 2, Left). The opening of land plantations of palm is huge allegedly strong trigger water overflow to paddy farmers, causing damage to the sponge feature on peat land in the region of agro-ecosystems. Aside from that, the issues in the fields are the "Setiduk" " (Figure 2, Right) clump grass, which needs a high running cost to eliminate. If the fields become too dry, new grass species will be lost. Since the grass makes it impossible to remove the equipment as is, poison grass is used to turn it off, then burned, and finally rolled. Nonetheless, as a result, burning has been prohibited as a method of land clearing.



Figure 2. Left, most of the fields are inundated by a flood; Right, the grass "Setiduk"

3.2. Farmers' swampy rice field income

Swampy rice field farmers in the Belanti village have experienced crop failure since 2008. Previously this village was one of the granaries of paddy in OKI District. Even, personal labors from other areas such as Indramayu-West Java were brought into this village before the 80-'s up to the year 2005. Initially Indramayu were employed for preparing the swampy rice field before planting. But then the workers have settled in the village and finally became rice farmers in that area. Since 2008 farmers not only had harvest failure but also crop failure. It lasted for 11 years. In year 2017, seven water-gates have been built to regulate the flow of water and at the end of 2018 farmers have already started to plant rice again; with 80% of newly land that have already could be planted (Figure 3).

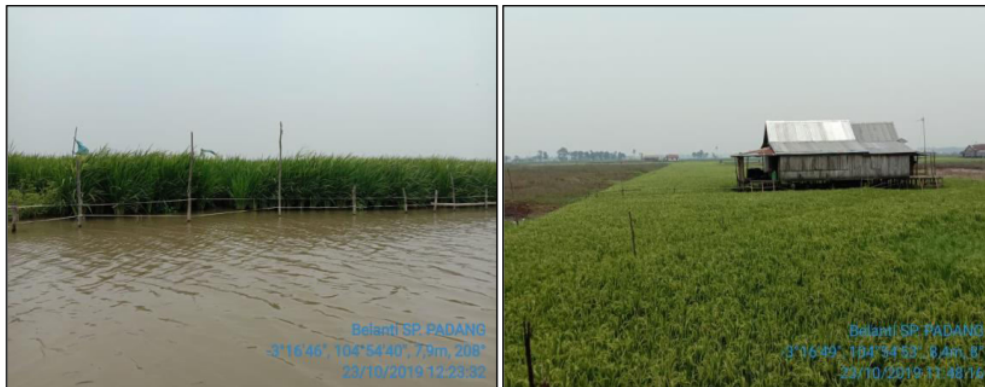


Figure 3. Swampy rice field

Farmer' income average who counted in the year 2008 in the research have been multiplied by the interest rate, which apply in order to do a comparison with earnings in the year 2019. Rated future value that is obtained through the calculation of the year 2008 until 2019 is amounting to 1.74. Revenues were obtained farmer in the village of Belanti in the year 2008 and the year 2019 can be seen in Table 1. Income in the year 2019 experienced a decline compared to the year 2008, the case is due to the reception and the total production of rice in the year 2019 is smaller than in the year 2008 thus affecting the income of farmers.

Table 1. The average of paddy farmers' income in Belanti village, 2019

No.	Items	2008		2019	
		(Rp/lg*/year)	(Rp/ha/year)	(Rp/lg/year)	(Rp/ha/year)
1.	Total revenue	13,100,000	15,845,646	11,375,000	23,669,289
2.	Fixed costs	149,824	195,912	161,179	274,218
3.	Variable cost	2,374,202	2,286,398	2,412,240	3,358,955
4.	Total production costs	2,524,026	2,482,310	2,573,419	3,633,173
5.	Income	18,394,023	23,241,879	8,801,581	20,036,116

Note: lg = the area of land cultivated (in units of hectare area)

Source: [15]

A paired simple T-test (SPSS Version 25) was applied to analyze differences in **changes in the income of farmers**. The result of the T-test can be seen in Table 2. The correlation value between two samples was 0.213. As the value is larger than alpha (0.05), it can be concluded that there was a

significant relationship. It also can be seen that there were income of the farmers in 2008 and 2009 were significantly differed. The average difference of income was found to 8,343,993.810. If the value is positive then the the average income value after flooding is small compared with the average income value before flooding or it can be inferred that income of rice farmers declined after flooding.

Table 2. The result of the test for the difference in farmer income in Belanti Village, 2019

No.	Component	Component	Component	Component
1.	Farmers' paddy income in 2008 and 2019	0.213	0.000	8,343,993.810

Source: [15]

To add more income to their household in 2008, most farmers farmed fishes in the village Belanti. However, Unfortunately, in 2012 fishes were found dead in bulk prior to harvest. After suffering a significant loss as river was polluted, no farmers have dared to start a pond fish farming again. This causes farmers to be unable to take chances in order to return to fish farming because they believe the costs are greater than the income earned. Indeed, the income produced by the pond fish market, according to farmers, is very promising as an additional source of income.

Flooding has forced farmers to seek alternative sources of income in order to survive. Most farmers have become unskilled workers to support their families, while others have become carpenters, washing clothes from other households to supplement their income, and others have become entrepreneurs using money saved as a capital venture. Farmers also frequently worked outside of the village, either as household helpers or as regular laborers on the farm or in the center of the economy. During this time, they actually accepted the situation as it is. Table 3 shows the average income of farmers' household.

Table 3. Total incomes of farmers' household in the village of Belanti, 2019

No.	Type of Work	Before the flood (2008)		After the flood (2019)	
		Average (Rp/year)	Percentage (%)	Average (Rp/year)	Percentage (%)
1.	Rice Farming	18,394,023	73.33	8,801,581	70.08
2.	Fish Farming	2,094,716	8.35	0	0.00
3.	Traders	3,354,224	13.37	1,000,000	7.96
4.	labor Farmers	0	0.00	814,286	6.48
5.	Honor	248,461	0.99	642,857	5.12
6.	Plumbers Wash	0	0.00	442,857	3.53
7.	Catch Fish	993,844	3.96	857,143	6.83
	Total	25,085,268	100.00	12,558,723	100.00

Source: [15]

3.3. Welfare level of swampy rice field farmers

The level of farmers' welfare in this study was calculated by comparing the total revenue of farmers' households with their expenditures per month in 2019. The analysis was carried out with the purpose to see whether the efforts that have been made (such as: the building of water gate as much as 7 water-gates in the village) has been able to restore the welfare of the farmers as previously obtained before

flooding. Expenses for the farmers' household include both food and non-food products. Table 4 shows the total expenditures of farmers' households.

Table 4. Average expenditure and income of the farmers' household per month

Description	Food Expenditure	Non- Food Expenditure
	(Rp/month)	(Rp/month)
Expenditure	296.727,27	482.692,64
Total expenses per month	779.419,91	
Total income per month	733.465,04	

Based on Table 4, it appears that the income of farmers' household per month was much lower than the expenditure every month. It indicated that efforts were still needed to increase farmers' income. The installation of water gate to regulate water discharge, as well as river dredging to minimize river sedimentation are insufficient to restore the water supply to its pre-flood state. In addition to the available corporate social responsibility (CSR) funds by the palm plantation, each village needs additional extension power. So far, the extension only leave villages with high levels of unsolved problems. The provincial government should also press palm oil plantation companies to allocate CSR funds to the affected villages, both in terms of physical construction and non-physical production. The provincial government also recognized the need to increase agricultural resources and skills, as well as the skills of farmers and society in general, in order to increase household farmer income through product diversification and market penetration.

4. Conclusion

Changes in the water management system have a negative effect on the economy of farmers in the Belanti village's swamp rice agro-ecosystem. When compared to incomes prior to the floods, the total income of farmers' households has decreased by 50.06%. Despite the fact that attempts have been made to install water gate, farmer welfare remains poor. To improve the quality of living for farmers affected by flooding, there is a need for integrated cooperation between the government of the country, palm plantation companies, and farmers.

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