Faculty of Agricultural Science, Nutritional Sciences and Environmental Management

Professorship of Agricultural Production Economics

of the Justus-Liebig University Giessen

Socio-economic Characteristics and Land Allocation on Tidal Swampland Agriculture in Indonesia

Inaugural-dissertation

to obtain the doctoral degree (Dr.agr.)

in the Faculty of Agricultural Science, Nutritional Sciences, and Environmental Management

Justus Liebig University Giessen

Submitted by

Ahmad Yousuf Kurniawan

from Indonesia

Giessen, 2024

With permission from the Faculty of Agricultural Sciences,

Nutritional Sciences, and Environmental Management

Justus-Liebig university of Giessen

Examination committee:

1. Referee: Prof. Dr. Joachim Aurbacher
2. Referee: Prof. Dr. Bernd Honermeier

Examiner: Prof. Dr. Martin Petrick

Examiner: Prof. Dr. Christian Herzig

Chairman: Prof. Dr. Jan Siemens

Date of Examination: 20.12.2023

ACKNOWLEDGEMENTS

First of all, I am grateful to Almighty Allah SWT who blessing me to complete this research.

I am most grateful to my advisor, Prof. Dr. Joachim Aurbacher, for his continuous guidance and suggestions for my research and also kindly support throughout the time of my study. I am thankful to my co-advisor, Prof. Dr. Bernd Honermeier for his valuable comments and suggestions and also to Prof. Dr. Martin Petrick and Prof. Dr. Christian Herzig for their precious comments and suggestions in my thesis.

I am also indebted to all the lecturers, staffs and technicians in the Faculty of Agricultural Science, Nutritional Sciences and Environmental Management, and also the International Studies Centre (ISC) and the Promotion staffs for their help towards the successful completion of my study.

This research and my study in JLU were supported by DAAD. The support to continue my study from Department of Agribusiness, Faculty of Agriculture, Lambung Mangkurat University in South Kalimantan, Indonesia is also appreciated. I am heartfelt thank Prof. Dr. S. Bauer for his helping in my early years of studying in Germany. I am heartfelt thank to fellow friends in DAAD Program in Agricultural Economics and Related Sciences in JLU for their help and warm kindness, also all Indonesian students and diasporas in Giessen-Frankfurt for sharing their joyful moments.

Most importantly, I would like to thank my father and mother, my foster father and mother, my brothers, and also my father and mother in law for their continuing prays and supports. Finally, I would like to devote my special gratitude to my dear wife, Ir. Hesti Wijayanti, Ph.D, who always gives me love, and strength with her constant support and also my daughters, Danish Yusfia Rahmi and Diandra Yusfia Rizki who always cheers me with happiness during my study.

Ahmad Yousuf Kurniawan

2024

Table of Contents

List of Tables

List of Figures

Abbreviations

ADB	Asian Development Bank
AIAT	Assessment Institute for Agricultural Technology
BCR	Benefit-Cost Ratio
CBS	Central Bureau of Statistic (Badan Pusat Statistik)
BULOG	National Logistics Agency (Badan Urusan Logistik)
CIA	Central Intelligent Agency of USA
DEA	Data Envelopment Analysis
FAO	Food and Agriculture Organization
FFS	Farmer Field School
GDP	Gross Domestic Product
GIZ	Deutsche Gesselshaft für Internationale Zusammenarbeit
GoI	Government of Indonesia
HYV	High Yielding Variety of rice.
IAARD	Indonesia Agency for Agricultural Research and Development
IDR	Indonesian Rupiah
Inpara	Inbreed Swampland Rice
IRR	Internal Rate of Return
IRRI	International Rice Research Institute
IR-42	Inbreed Rice released by IRRI in 1970s
ISARI	Indonesian Swampland Agriculture Research Institute (Balittra)
MoA	Ministry of Agriculture
MRP	Mega Rice Project
NPV	Net Present Value
OECD	Organization for Economic Co-operation and Development
PNG	Papua New Guinea
RCR	Revenue-Cost Ratio
RIDS	Rice Indonesia Data Service
RJPPP	Long Term Agriculture Development Plan *(Rencana Jangka Panjang Pembangunan Pertanian)*
UN	United Nations
UNDP	United Nation Development Project
USDA	United State Department of Agriculture
VEPA	Vietnam Environmental Protection Agency
WB	World Bank

1 INTRODUCTION

1.1 Background

Indonesia is an archipelagic country in Southeast Asia located between the Indian and Pacific oceans. This archipelago has 13,700 islands that expand 5,100 kilometers east to west and 1,931 kilometers north to south (MAPZONE, 2003). The land area is 1.91 million km^2, the marine territory is 3.26 km^2 (OECD, 2012a), and the marine exclusive economic zone (EEZ) is 2.9 million km^2 (CBS, 2012a). The population was 237.64 million in 2010, with a population density of 131.18 people per km^2 and a 1.49 % growth rate (1990-2010) (CBS, 2012a). Meanwhile the population increased to 270.20 million in the next ten year (2020), with a population density of 141 people per km^2 and a 1.25 % growth rate (CBS, 2020).

The Dutch East India Company (1602-1800), the Netherlands East Indies (1800-1942), and Japan colonized the Indonesian archipelago (1942-1945). Indonesia declared independence after Japan surrendered in 1945, but it took four years for the Netherlands to agree to a transfer of sovereignty in 1949, following some violence and negotiations mediated by the United Nations (UN) (RICKLEFS, 2001). The economy had achieved remarkable rapid growth, macroeconomic stability, and steadily declining poverty by the mid-1960s. Between 1966 and 1996, the average growth rate of the Gross National Product (GNP) per capita was more than 5 %, and poverty fell from 60 % to 11 %. (DARYANTO, 1999). Indonesian GNP reached $2,530 in 2010 and is expected to reach $4,140 by 2021 (MACROTRENDS, 2022a).

During the 1997-1998 economic crisis, Indonesia experienced a 13.7 % economic contraction, the highest inflation rate at 78.1 percent, and an increase in unemployment to 17.1 % and poverty from 17.1 % in 1996 to 24.1 % in 1999. (DARYANTO, 1999, SURYAHADI et al., 2012). Economic growth has gradually increased since the regime changed and several improvements in politics and economic policies were implemented. Between 2000 and 2010, the average real GDP growth rate was 5.2 %, with a 4.0 % increase in real GDP per capita (ELIAS & NOONE, 2011). Furthermore, it increased to 4.6 % between 2011 and 2020 (MACROTRENDS, 2022b). According to UNDP (2010), unemployment fell from 11 % in 2005 to slightly more than 8 % in 2009. It was reduced by nearly half to 4.28 % in 2020 (MACROTRENDS, 2022c). While poverty rates remain high, they are gradually decreasing. Meanwhile, the Indonesian Human Development Index (HDI) increased by an average of 1.4 % per year between 2002 and 2008. And it continued to rise at 0.76 % annual rate between 2010 and 2021 (CBS, 2021).

Indonesia recently surpassed China, Japan, and South Korea to become East Asia's fourth-largest economy (ELIAS & NOONE, 2011). It is one of the world's emerging market economies and a member of the G-20 major economies. In 2011, the rate of Gross Domestic Product (GDP) growth was 6.2 % (CIA, 2016; OECD, 2012b), and GDP per capita was US$ 3,643. Industry contributes the most to GDP (47.2 %), followed by services (38.1 %) and agriculture (14.7 %) (CBS, 2012). The GDP was US$ 3,873 in 2020 (MACROTRENDS, 2022b), however, services became the biggest contributor to GDP (42.18 %), followed by industries (40.48 %), and agriculture (13.7 %) (CBS, 2021). Furthermore, Indonesia achieved poverty reduction in 2019 by lowering the poverty rate by more than half since 1999, to 9.4 %. (WORLD BANK, 2020).

Agricultural progress in Indonesia from 1966 to 1996 was a success story. The implementation of Green Revolution technology has significantly increased productivity. According to AKIYAMA (2004), agricultural growth was 3.7 %, with land productivity accounting for 90 % of the increase. This outstanding performance significantly contributed to the achievement of Indonesian development goals, including food security, low and stable prices, employment opportunities, and foreign earnings/savings (DARYANTO, 1999). Food production was impacted by the 1997 and 1998 economic crises and the El Nino weather pattern. El Nino caused widespread crop failure and crop delays. In 1997, rice production fell by 4 %, and in 1998, it fell by 8 %. This decline was caused in part by an increase in food imports and the conversion of secondary food crop use from livestock feed to human consumption (DARYANTO, 1999).

Despite the rapid development of industry and services, agriculture remains an important part of the economy. Even though contributes only for 13.6 % of total GDP, agriculture employs 38.9 % of the labor force (CIA, 2016). Furthermore, SURYAHADI & HADIWIDJAYA (2011) discovered that agriculture contributes to poverty reduction in rural areas. This is significant because nearly half of the population lives in rural areas (ELIAS & NOONE, 2011).

Rice is one of the agricultural commodities that has become a source of concern in Indonesia. Rice is a commodity with not only an economic but also a political and social dimension (MASTUR et al., 2022). If this product is in short supply, it will have an impact on the social-economic and political stability of the community (SIDIK, 2004). Environmentally, Indonesia is severely impacted by heavy monsoon rain during the wet season and relatively little rain during the other periods, making it difficult to cultivate other staple crops.

Food security and national rice self-sufficiency remain top priorities for the Indonesian government. According to CBS (2012), Indonesia has the 7th highest per capita rice consumption rate in the world, at 133 kilograms per person. The Indonesian government also estimates that rice accounts for roughly half of its people's daily calorie and protein requirements, respectively. Domestic rice supply could represent food security in this country of 270.2 million people (CBS, 2021). However, according to the USDA (2012) and STATISTA (2022) total rice consumption has risen faster than total rice production in recent years (1990 – 2013), as the growth rate of national rice area and yield has lowered, and then the consumption has slightly decreased since 2014, but appears to be on the rise in the next following years (Figure 1.1). As a result, providing enough rice as a staple food remains a major challenge in Indonesia.

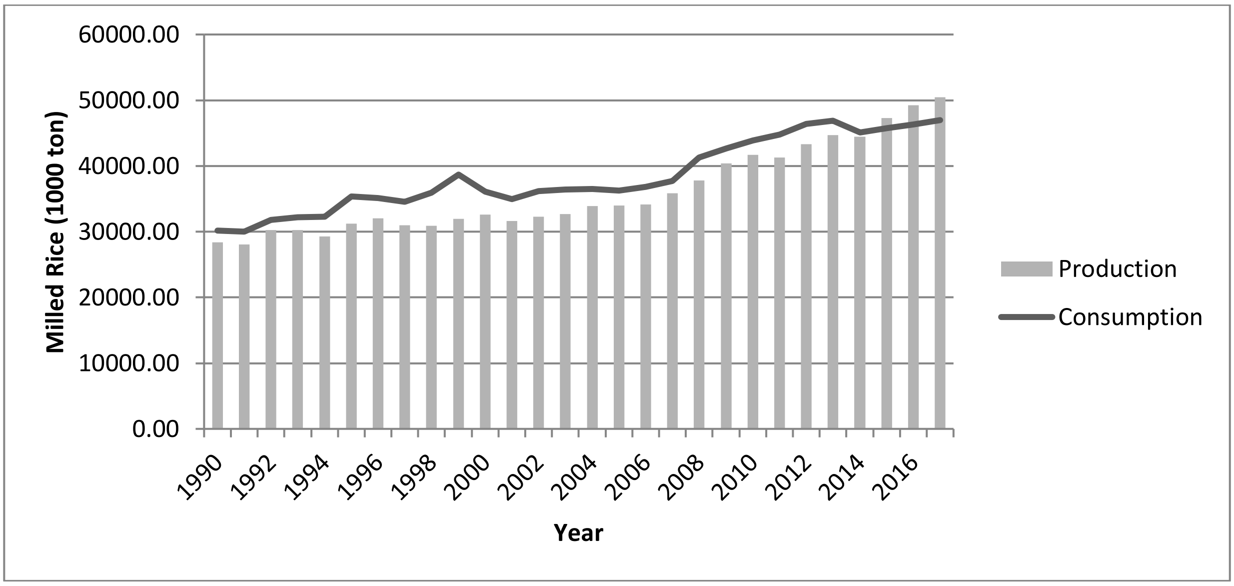


Figure 1.1 Rice production and consumption in Indonesia, 1990-2017
Source: USDA (2012) and STATISTA (2022)

In 2013, the government implemented the long-term agricultural development plan (RJPPP) for 2013-2045. Based on the identification of the picture and challenges of Indonesian agriculture up to 2045, the concept provides a clear and comprehensive direction for agriculture and related sector development, allowing agricultural problems to be anticipated (RIDS, 2012).

However, increasing farmers' prosperity by relying solely on rice as a source of income is challenging due to high input costs, low output costs, an inefficient trade system, and environmental issues. As a result, farmers' enthusiasm for rice cultivation has declined. Moreover, the low productivity of rice farming has triggered farmers to seek for alternative farming schemes that can increase their income (ADAM et al., 2013). High yielding intercropped alternative crops with rice should be introduced as an additional source of income (WILDAYANA et al., 2016).

1.2 Problem statement

Rice is one of Asia's most important cereal crops. According to WU et al. (2010), Asia's paddy rice fields accounted for more than 90 % of the total global rice cultivated area. The major rice-producing countries in Asia accounted for more than half of the world's population. Rice demand will rise over time, as DOBERMANN (2012) estimated that an additional 1 billion people will require 100 million tons of rice.

Indonesia, the world's fourth most populous country after China, India, and the United States (MASTUR et al., 2022), is more vulnerable to rice shortages since people rely on rice for calories and protein. Rice production is insufficient to meet local demand. Between 2002 and 2007, the average rice consumption was 27.83 million metric tons, with annual consumption per capita of 127.67 kg (MUTTAQIN & MARTIANTO, 2009). It increased to 134 kg per capita per year between 2009 and 2013 (FAOSTAT, 2007). From 2014 to 2021, it decreased to only 127 kg per capita per year (STATISTA, 2022).

Since 1992, Indonesia has imported rice, with the average amount increasing year after year. Indonesia imported 1478.35 million tons of rice per year between 1980 and 1999 (USDA, 2012). Between 1990 and 2020, imports fluctuated dramatically (Figure 1.2). Imports have been increased in recent years to compensate for the decline in rice production caused by El Nino. Climate change causes more frequent occurrences of abiotic stresses for rice such as drought, flood, salinity, and more frequent pests and diseases attack (SASMITA & NUGRAHA, 2020). This condition, however, has caused concern in the global rice market. According to CBS (2012b), imports reached 2.75 million metric tons in 2011. Over the last ten years, Indonesia has continued to require imports, although in varying amount (CBS, 2021).

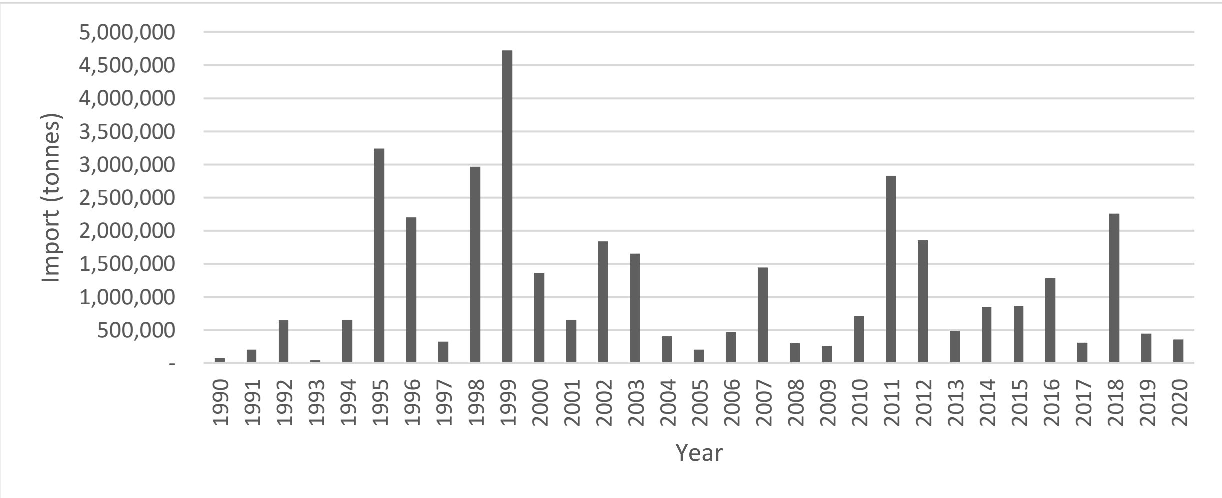


Figure 1.2 Rice import in Indonesia, 1990-2020.
Sources: FAOstat (2007) and CBS (2021)

Furthermore, while population growth continues, rice productivity remains stagnant. It has only increased from approximately 4.38 tons per hectare in 1993 to 4.98 tons per hectare in 2011 (CBS, 2012b). It was only slightly increased to 5.11

tons per hectare in 2020 (CBS, 2021). This slowdown in productivity improvement (see Table 1.1) is due to a number of factors, including the near completion of modern variety spread, declining fertilizer marginal productivity, a less favorable price environment, and a reduction in irrigation investment (PASANDARAN & ZULIASRI, 2001).

As a result, increasing production is one solution to the problem. Increasing rice production, however, presents some challenges. DOBERMANN (2012) noted that some megatrends are already emerging in the rice sector, such as land scarcity and rising input costs, necessitating an increase in productivity to improve labor, water, fertilizer, and energy efficiency.

Table 1.1 The percentage change (%) of harvested area, yields, and productivity of paddy (wetland and dryland), 1970-2000

Region	Item	1970–1975	1975–1980	1980–1985	1985–1990	1990–1995	1995–2000
Java	Harvested Area (%)	1.58	0.53	2.1	0.44	0.22	0.96
	Yield (%)	3.42	6.06	5.63	2.33	0.71	0.70
	Productivity (%)	1.81	5.50	3.45	1.88	0.49	-0.26
Outside Java	Harvested Area (%)	1.33	1.93	1.71	2.02	3.23	-0.34
	Yield (%)	3.96	5.45	5.68	3.98	3.7	0.67
	Productivity (%)	2.60	3.45	3.91	1.93	0.46	1.01
Indonesia	Harvested Area (%)	1.47	1.17	1.92	1.18	1.72	0.29
	Yield (%)	3.63	5.83	5.65	2.97	1.94	0.69
	Productivity (%)	2.13	4.6	3.66	1.76	0.22	0.27

Sources: PASANDARAN & ZULIASRI (2001)

Another issue in Indonesia is land scarcity caused by land conversion from agricultural to non-agricultural use. Massive land conversion has occurred. It has a significant impact on food production, particularly in paddy fields (FIRMAN, 2000). More than 106,000 hectares of land were estimated to have been converted in 1991-1993, including 58,000 hectares (54.7 %) of residential areas, 16,452 hectares (15.5 %) of industrial land, 5,210 hectares (4.9 %) of offices, and 26,774 hectares (25.3 %) of other urban land uses (MINISTRY OF ENVIRONMENT, 1997). During this decade, land conversion has reached approximately 100,000 ha per year. As reported in SASMITA & NUGRAHA (2020), the average arable land conversion to non-agricultural use was 96,512 ha per year. Approximately 79.3 % of that has occurred on Java Island (APRIYANA, 2011), which produces 60 % of national rice (HUSSAIN et al., 2006). This condition is also intensified by land erosion and sedimentation (LUKAS, 2014).

However, due to high population and food demand pressures, swampland utilization has emerged as an alternative method of developing agriculture and plantations. Indonesia has approximately 6 million hectares of tropical swamplands that can be used for agriculture (NOOR, 2004). Among them, 657,546 hectares were cultivated (SETIOBUDI & FAGI, 2009). South Kalimantan has a total area of 17,828 hectares, with acid-sulfate soil accounting for approximately 80 % of it. If managed properly, this area has economic value (AMALI et al., 2003). It can also be used for rice cultivation, which will help improve national rice production. Furthermore, Indonesia has the potential to play a significant role as a global rice supplier. The use of tidal swampland is an alternative method of increasing rice production and farmer income while also strengthening farmers' household economies and food security (ALIHAMSYAH, 2004). However, one of the major issues in rice cultivation is low productivity, which may be due to inefficient input use and land degradation. It was also due to the lack of some important factors, such as water management, better seeds, fertilizers, and farmers’ education and training (ADAM et al., 2013).

As a result, research on swampland for farming, particularly its marginal characteristics, was frequently published (VAN DEN EELAART, 1981, DENT & PONS, 1995, NOOR, 2007). Farmers must adapt to address this issue. Previous research has looked into the adaptation strategies used by farmers and other stakeholders to deal with swampland farming. MEGAWATY et al. (2012) and NOOR & SOSIAWAN (2020) proposed a water management technique. DARSANI & ANNISA (2018) optimized sulfated soil treatment in swampland areas. SAIDY & AZIZ (2009) investigated the Indonesian government's proposed strategy for dealing with sea-level rise in tidal swampland.

In addition to studies on the characteristics of tidal swampland and management strategies, the study of socio-economic aspects of swampland farming is intriguing and should be pursued further due to its contribution to agricultural productivity. In other words, how farmers adapt to increased income is an interesting issue that needs to be investigated.

So far, research on the socio-economic analysis of swampland in Indonesia has concentrated on macro-management (JOOSTEN & CLARKE, 2002). Meanwhile, socio-economic studies of farmers' adaptation to swampland conditions, particularly tidal swampland conditions, are still in the early stages.

1.3 Research objectives

Using the afore mentioned cases as the research foundation, the overall objective of this study is to investigate the socio-economic and land allocation strategies used by farmers to cope with marginal conditions in the swampland area of South Kalimantan, Indonesia. This can be accomplished by focusing on the following specific objectives:

1. To describe the socio-economic characteristics of a swampland area in South Kalimantan, Indonesia.
2. To determine a model of farmer households which has optimum gross margin under restricted resources in the tidal swampland area of South Kalimantan, Indonesia.
3. To simulate the fluctuation of gross margin as a result of crop price fluctuations in the tidal swampland area of South Kalimantan, Indonesia.

1.4 Significance of the study

Rice is one of the agricultural commodities that has become a source of concern in Indonesia. Rice is a commodity with both economic and political and social implications.

Furthermore, while population growth continues, rice productivity remains stagnant. Another issue in Indonesia is land scarcity caused by land conversion from agricultural to non-agricultural use, particularly on Java Island, where 60 % of the rice is produced (SASMITA & NUGRAHA, 2020)

Due to the high population and food demand, swampland utilization is an alternative way to develop agriculture and plantations. Indonesia has a lot of tropical swamplands that can be used for farming. However, increasing farmers' prosperity by relying solely on rice as a source of income is difficult due to high input prices, low output prices, an inefficient trade system, and environmental issues. As a result, farmers are less interested in growing rice as their primary crop. As a consequence, high-economic alternative crops intercropped with rice should be introduced as an alternative source of income (PERRY, 1985).

Furthermore, it is important to understand how land typology affects farm household land allocation. Therefore, policies can be tailored to the complexities of swamp farm households. Thus, this study was carried out in order to contribute to this issue and provide recommendations for managing land in the tidal swampland area. This study also investigates the impact of crop price changes on farmer households' income.

Moreover, this research was conducted on the Indonesian outlier of Kalimantan Island, which has the most marginal land. Because the majority of the development is concentrated on Java Island, this will contribute to further agricultural development as well as an effort to disperse national development. Rice production will be ensured by the establishment of a food production center outside of arable land on Java and Bali Island.

2 SWAMPLAND FOR AGRICULTURE IN INDONESIA

This chapter discusses swampland in general, including the definition of swampland agriculture, swamp characteristics, swamp utilization for agriculture, and a variety of socio-economic and environmental issues. Following that, a discussion of tidal swampland is presented, covering definition and characteristics, agricultural use, and agricultural farming practice.

2.1 Swampland distribution

A swamp is a forested wetland that is often located along large rivers and is critically dependent on natural water level fluxes (KEDDY, 2010, HUGHES, 2003). Several large swamps can be found along major rivers such as the Amazon, Mississippi, and Congo (KEDDY et al., 2009), as well as on the shores of large lakes (WILCOX et al., 2007). Water can be saltwater, brackish water, or freshwater. According to the USGS (United States Geological Survey), swamps are a type of forested lowland, spongy land that is generally saturated with water and covered with trees and aquatic vegetation that can tolerate periodic inundation.

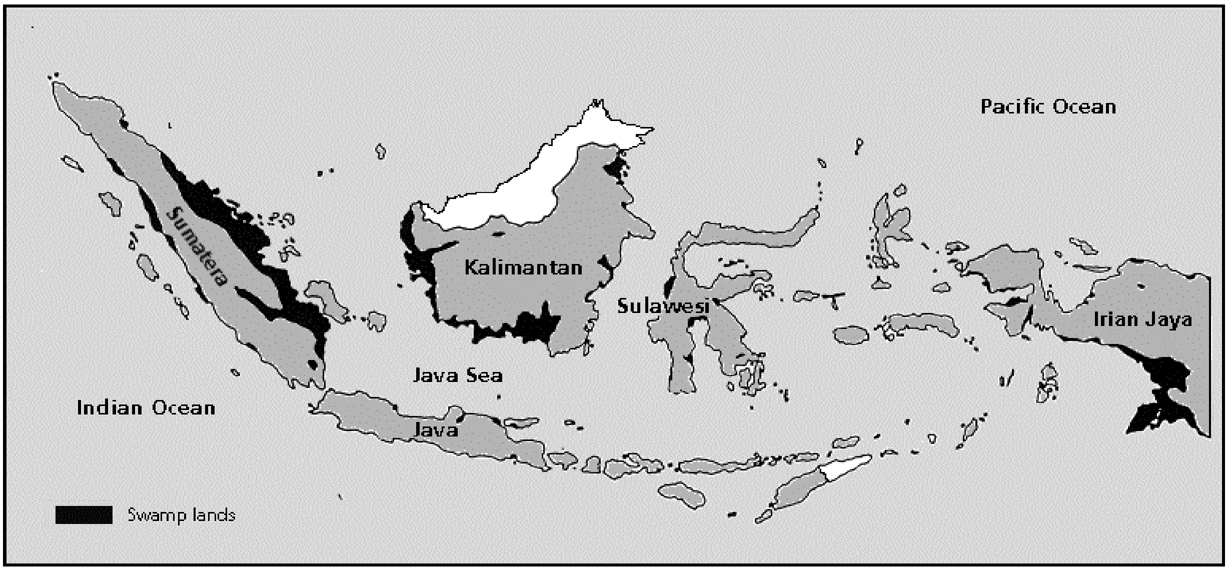


Figure 2.1. Swampland distribution in Indonesia
Source: SUSANTO (2003)

Swampland is a lowland area that is waterlogged all or nearly all of the year (SUBAGYO, 2006). The majority of the swamps are formed by a large river, and they are critically dependent on natural water level fluctuations, such as sea tide and rainfall.

According to VAN DEN EELAART (2014), swampland accounts for roughly 36 % of Indonesia's total coastal area. Agriculture accounts for approximately 15 % of the total land area. The majority of this reclaimed land is used for rice farming in the provinces of South Sumatera, Jambi, West Kalimantan, and South Kalimantan. Other undeveloped swamp areas can be found in Papua New Guinea (Irian Jaya). Figure 2.1 depicts the distribution of swamps across the Indonesian archipelago.

Several surveys, including NEDECO/EUROCONSULT-BIEC (1984), SUBAGYO et al. (1990), NUGROHO et al. (1991), and PUSLITTANAK (2000) have been conducted to estimate the total of swampland areas in Indonesia based on swamp classification and coverage to present a detailed estimation. According to their findings, the swampland area of four major Indonesian islands reached 33.41 million hectares, with 13.28 million hectares of lowland (monotonous) swampland and 20.13 million hectares of tidal swampland. Tidal swampland is divided into five land typologies based on soil formation: 10.90 million ha of peatland; 2.07 million ha of potential swampland; 4.34 million ha of potential acid sulfate; 2.37 million ha of actual acid sulfate; and 0.44 million ha of brackish.

The Ministry of Public Works and Housing reported the latest data in Table 2.1. As has been shown, the largest swampland is on Kalimantan (Borneo) Island, which contains 35.06 % of the total swampland. Thus, the focus of this research is on Kalimantan Island. Because swamp characteristics vary across the islands, the following discussion will focus on swampland in South Kalimantan.

The Government of Indonesia (GoI) has developed 1.80 million hectares of swampland, 49.44 % of which is in Kalimantan (Table 2.1). Meanwhile, the public and private sectors have developed over 2.4 million hectares (MAAS, 2003, NOOR & JUMBERI, 2005). More than 4.2 million hectares of swampland have been developed for agriculture.

Table 2.1 The swampland area in the major islands of Indonesia

Major Islands	Total Swampland (million ha)			Total developed for agricultural purposes by government (million ha)		
	Tidal	Monotonous	Total	Tidal	Monotonous	Total
Sumatra	6.60	2.78	9.37	0.69	0.11	0.80
Kalimantan	8.13	3.58	11.71	0.69	0.19	0.89
Sulawesi	1.15	0.64	1.80	0.07	0.01	0.08
Papua	4.22	6.31	10.52	-	0.02	0.02
Total	20.10	13.30	33.40	1.46	0.34	1.80

Source: MINISTRY OF PUBLIC WORK (2009)

In 2009, the swamp developed for agriculture accounted for 52.11 % of total agricultural wetland of 8.06 million hectares, or 16.62 % of the 25.27 million hectares of total agricultural land in Indonesia (MINISTRY OF AGRICULTURE, 2014). Thus, swamp agriculture is essential to Indonesian agriculture.

2.2 Swampland characteristics and problems

Swamp ecosystems have poor characteristics and are vulnerable to natural change (drought, fire, and flooding) as well as management failure (reclamation, opening, and improper cultivation). Swampland characteristics vary across Kalimantan. Some swamp areas have a peat layer with varying thicknesses and peat maturity, others have tidal problems, and still others have acidity problems.

The soil itself has a number of issues related to its formation. Swamp peatland is prone to irreversible drying, subsidence, and nutrient deficiency. The dried peat has a hydrophobic surface (unable to bind the water and nutrients optimally). Acid sulfate soils can be found in some areas. This soil is distinguished by its low pH and the presence of a sulfuric horizon with overlying sulfide materials, primarily pyrite (FeS_2)[1] (DENT & PONS, 1995, SHAMSHUDDIN et al., 2014). The soil becomes acidic (pH level 2-3) when the pyrite layer oxidizes, and the saturation of iron (Fe^{2+}) and aluminum (Al^{3+}) increases (NOOR & JUMBERI, 2005). This noxious water could seep into the drainage system and end up in the river. The soil is dominated by the low activity of clay, which has a weak structure and is prone to erosion (LEIWAKABESSY, 1989).

If proper precautions are not taken, swamp opening will result in over draining. Because of highly acidic conditions (pH decrease to 2-3), nutrient deficiency, and an increase in Al^{3+}, Fe^{2+}, H_2S, CO_2, and organic acids, soil fertility will decrease when the groundwater level below the pyrite layer and the peat becomes irreversibly dried and hydrophobic (NOOR & JUMBERI, 2005). However, by adding lime or basalt, replenishing organic matter, and managing water tables to increase soil pH, the land can still be used productively for rice and other crops (SHAMSHUDDIN et al., 2014). Based on these facts, swamp reclamation, land preparation, and farming techniques should be conducted properly.

---

[1] *Pyrite* (FeS_2) or iron sulfide is a sulfide mineral that is found below the top soil in swampland. It is formed by marine sedimentation a thousand years ago in brackish water that contains saturated sulfate compound (SO_4). If it is exposed to the air (O_2) and oxidized, it will create hydrogen sulfate which causes higher acidity on soil and water (AGUS & SUBIKSA, 2008).

2.3 Swampland used for agriculture in Indonesia

Swamp agriculture has a long history among Indonesian farmers (see Appendix 1). Archeological evidence suggests that in the 13th century, local people in the Pawan basin, West Kalimantan, opened swamp areas for agriculture and settlement (HARYONO, 2012).

The Bugis have used swampland for agriculture since the early twentieth century. They have many years of experience reclaiming lowland areas and dealing with the related soil and water management issues. The Bugisse, followed by the Banjarese and Malays, have reclaimed approximately 2 million swamplands along the eastern coast of Sumatera and along the western and southern parts of Kalimantan using traditional techniques (SURYADI & MOERWANTO, 2013). They produced rice at a rate of about 0.8-1 ton per hectare (MAAS, 2003).

In the 1680s, the first scientific swampland exploration discovered peat in Sumatera (NOOR, 2012). In 1895, detailed exploration was carried out in eastern Sumatera. It was then followed by surveys in the 1930s and 1950s on Kalimantan's western and southern coasts, as well as Sumatera's eastern coast. These surveys only looked at the ecology, flora and fauna, and other characteristics to make comparisons to the subtropical swamp (MAAS, 2003). In South Kalimantan, the Dutch East Indies government started the first large-scale swamp reclamation for agriculture and settlement in 1920. They dredged two canals that connect Kapuas Murung and the Barito River in 1936. They relocated people from Java to swamp areas in Kalimantan a year later to expand their colony program, distribute the population, and grow rubber and coconuts (NOOR & SARWANI, 2013). This effort was continued after Indonesia's independence in 1945.

The Government of Indonesia (GoI) divided the history of swampland reclamation into three periods: (1) the 1945-1960s; (2) the 1969-1995s; and (3) the 1995-2000s. The first era began with canal dredging to improve accessibility in Sumatera and Kalimantan. Three major canals (*anjir*) were dredged and widened in Kalimantan to connect two major rivers, the Barito and the Kapuas Murung. The community then dug up the sub-canals (*handil*) and cleared the land for agriculture. The sub-canals were 2-3 meters wide, 0.5-2.0 meters deep, and 2-3 kilometers long, with a distance of 200-300 meters between them (NOOR, 2012).

The second period (1969-1995) was marked by the launch of the Tidal Rice Field Reclamation Project (P4S)[2], despite widespread skepticism about its success

[2] P4S (Proyek Pembukaan Persawahan Pasang Surut) was a project to open peat swampland for agricultural purposes. The project was held on 1969 - 1984 under the World Bank (IBRD) sponsor. Major universities (IPB, UGM, and ITB) were involved to survey and design the

(SUBAGYO et al., 1996, NOOR, 2012). However, the government has recognized swampland as a potential agricultural resource since 1968. Initially, experts questioned this potential because of constraints including hydrology, thick peat, soil acidity, and low soil consistency, which resulted in soil subsidence, soil nutrient depletion caused by tidal movement, seawater intrusion, and inaccessibility, as summarized by NOTOHADIPRAWIRO (1994). However, inspired by the Bugis people's long experience and Thailand and Vietnam's success in opening the Delta Mekong, the government continued the reclamation. The P4S project was created to address a 2-million-ton rice deficit by reopening 5.25 million hectares of land. To support the project, the government also launched the transmigration program[3]. Until 1995, the government had reclaimed 1.18 million hectares of swampland and local communities had reclaimed 3.0 million hectares (NOOR, 2004). Some swamp areas have been developed into cities and regencies, with agriculture serving as the major sector.

The last phase (1996-2000s) was marked by the launch of the Mega Rice Project (MRP) in 1996. This project aimed to restore rice self-sufficiency by opening up more than 1 million hectares of peat swamp in Central Kalimantan Province. Since 1992, Indonesia has been a rice importer after achieving rice self-sufficiency in 1984. Rice imports risen rapidly from 0.6 million tons in 1994 to 1.8 million tons in 1995. The project began without a proper environmental impact assessment to determine the capacity of swamp peatland for rice production and to review the peatland conversion plan for the type of infrastructure development (HECKER, 2005). Around 13,500 migrant households from populated islands have been settled to work on this agricultural project. This project included the construction of 917 km of primary and secondary canals, as well as 11,839 km of tertiary ditches, which connected the peat dome to the sea (NOOR & SARWANI, 2013). The canal, however,

agriculture area layout (VAN DEN EELAART, 1981; SUBAGYO et al., 1996). During Pelita I (1969–1974), 32,000 hectares of swampland have been surveyed and 60 % of those have been converted into agricultural based settlement areas.

[3] Transmigration project is the resettlement project to redistribute families from the crowded island (Java, Bali, and Madura) to the sparsely populated islands of Sumatera, Kalimantan, Sulawesi, and Papua. The program was first initiated by the Dutch East Indies government in 1905 as part of the colonization to reduce population pressure in Java Island and provide cheap plantation workforce in sparsely islands (FEARNSIDE, 1997; HOLDEN et al., 1995). The project reached its peak under Soeharto's leadership (1968-1998), when 3,264,902 families have been trans-located to outlying and sparsely populated islands, including 279,580 families to Kalimantan (TIRTOSUDARMO, 2009; NUGROHO, 2013). The project was considered as the largest people migration in the world (MARR, 1990). At the end of the Soeharto period, 130,667 families were translocated to outlying islands during 1999-2007 (TIRTOSUDARMO, 2009).

was not constructed with sluice gates, which caused over-draining of the peatlands. Opening peat forests emits massive amounts of greenhouse gases due to their role in carbon storage (JAENICKE et al., 2008). During the dry season, the dried peat ignites peat forest fires since it is combustible. When El Nino hit Indonesia in 1997-1998, the forest fires in Kalimantan reached 3.06 million hectares, the majority of which were peat forests (LIEW et al., 1998). As a result, a massive amount of smoke haze spread to neighboring countries. The drained peat in Kalimantan released 0.81 to 2.57 gigatons of carbon, which is equivalent to 13 to 14 % of the average annual global carbon emissions from fossil fuels (PEAT PORTAL, 2004). Peat depletion also causes massive soil acidification, which reduces land fertility. Many migrant farmers have left the area due to high farm costs and low productivity as a result of a lack of knowledge about swampland farming practices (MAAS, 2003).

Approximately half of the first migrant households abandoned large areas of land. Because the tidal wave could not reach the rice plots during the dry season, the water level dropped rapidly. The seawater intrusion spread further inland. As a result, it is difficult for the indigenous people to obtain fresh water. Meanwhile, during the rainy season, this area experienced frequent flooding (NOOR & SARWANI, 2013). The remaining farmers left and began clearing new peat areas. Due to a lack of capital and a reliance on family labor, they used slash and burn land clearing, which reduced soil fertility. According to NOOR (2010), peat fire reduce land productivity as the peat degrades. Rice yields fell from 3.0–3.5 ton per hectare to 0.05–1.50 ton per hectare. As a result, these frequently burned lands lost their fertility and were eventually abandoned by farmers.

According to MAAS (2003), while swamp conversion begins with hydrology, hydro-topography, and soil assessment, the farming technique used to adapt to such conditions is the most important factor in its success. Farmers will achieve the highest yield only in the early years if traditional farming practices[4] are followed. Later, as organic matter depletes, soil fertility declines rapidly, and farmers tend to move to the new open area. As a result, many reclaimed swampland areas have been fallowed, making them vulnerable to forest fires. According to an integrated swamp development project (ISDP) report, nearly 60% of reclaimed swampland was fallowed between 1994 and 1999 (possibly 70% if the ex-MRP area was included) (MAAS, 2003). During the dry season, the fallow areas are vulnerable to forest fires. However, the government continues to see the swamp area as a potential land resource for increasing agricultural production, particularly rice production. The government cited a large undeveloped area, flat topography, water

[4] Based on the usual farming technology developed in Java Island. This technology is not adaptive to swampland environment

availability, and a low population as justifications for a large-scale swamp conversion.

If properly rehabilitated, the ex-MRP area has the potential to serve as a national food basket. SUHARTANTO (2007) proposed that the area be rehabilitated for several reasons: (i) migrant farmers face severe poverty; (ii) there are massive government assets (2.5 trillion IDR) as well as 1.45 million hectares of fallowed land; (iii) environmental damage causes ecological, economic, and socio-cultural problems; and (iv) the potential for further sustainable development. Furthermore, many farmers rely on their land for a living. In 2009, approximately 10,000 people (2,600 families) lived in 14 settlement areas along the Kapuas River's bank (MEDRILZAM et al., 2017).

As a result, the GoI issued Presidential Instruction (Inpres) No. 2/2007 to help accelerate swamp rehabilitation and revitalization. The ex-MRP area was divided into five zones by the GoI: Zone A (393,302 ha), Zone B (164,836 ha), Zone C (441,436 ha), Zone D (153,453 ha), and Zone E (424,269 ha).

ISARI surveyed an area of 563,248 ha (in total) from Zones A, B, and D of the ex-MRP area in 2012. They discovered that 29 % of the surveyed area is suitable for rice, 19 % for secondary crops and vegetables, 20 % for perennial crops and plantation, and 32% for conservation area and limited types of plants.

Large-scale swamp reclamation tents cause environmental and human disasters. Simultaneously, abandoning the reclaimed area without treatment introduces a new adversity. Thus, rather than creating new swamp forests, maximizing productivity and existing reclaimed swampland is the best choice (see Appendix 2).

2.4 Tidal Swampland

Tidal swampland accounts for roughly 20.1 million hectares (12.31 %) of Indonesia's 162.4 million hectares of land resources (SURYADI, 2006, MINISTRY OF PUBLIC WORK, 2009). The following explanation goes into greater detail about tidal swampland.

2.4.1 The nature of tidal swampland

Tidal swampland is a swampland area where water movement caused by regular tidal fluctuation influences the water in wells and canals (VAN DEN EELAART, 1981). The depth of the water is controlled by both tides and rainfall. Tidal swampland can be divided into four typologies based on the prevailing water levels in fields (*hydro-topography*) (see Figure 2.2) (NOORSYAMSI, et al., 1984, VAN GILST, 1992, WIDJAJA-ADHI, et al., 1992, WIDJAJA-ADHI & KARAMA, 1994):

- Type A area is directly affected by tidal movement and always flood. During the spring tide, the water depth can fluctuate by up to 2.5 meters in 24 hours.
- Type B area is directly affected by tidal movement but only floods during the spring tide.

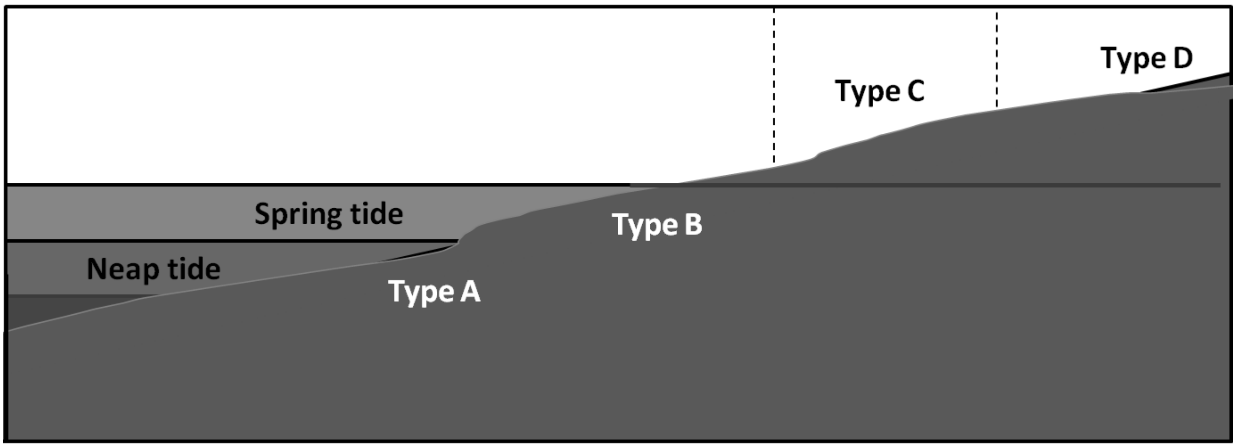


Figure 2.2. Swampland typology based on water prevailing in the field
Source: Modified from SUYAMTO (2007)

- Type C area is indirectly affected by the tidal movement. Where the depth is less than 50 cm, the tide influences the ground-water table. Rainfall has a greater impact on the water table than tides.
- Type D area is not affected by high tide. The only source of surface water is rainfall. The ground-water table is more than 50 cm deep.

Tidal swampland is classified as marginal land (HIDAYAT et al., 2010), which means that its potential productivity is limited by the high variability of physical, biological, and socio-economic factors (PARTOHARDJONO, 1993). The primary environmental issues with tidal swampland, according to FOLKERTSMA (1998), YANTI (2002) and NUGRAHA et al. (2016), are the highly complex nature of the soil characteristics, the uncontrolled hydrologic regime, and the high level of acidity and the toxicity of metal substances, such as aluminum, iron, and manganese. Tidal swampland is distinguished by high soil acidity (low pH) and the presence of a high concentration of *pyrite*, Al^{3+} and Fe^{3+}, and quartz/sand. Tidal swamplands may also have deep organic layers (peat) that are more than 200 cm thick. As a result, these characteristics pose numerous constraints to agriculture due to the low and unbalanced nutrient status of plants (crops) required. Plants may also be poisoned by the soil.

According to PRASETYO et al. (1990) the soil can be classified into two major soil types. The soils on the relatively low-lying waterlogged interior, i.e. the alluvial-marine plains and old riverbeds, are the first to be considered. These soils have a brown layer (20-60 cm) overlying a gray layer that is generally *pyritic*. Pyrite content can reach up to 8% iron sulfide (FeS_2). They have a (silty) clayey texture, are high in organic matter (5-14 %), are poorly drained, half to nearly ripe, and are mottled in most cases. The acidity (pH) level is between 3 and 4. Most of these soils are covered by a thin peat layer (10-20 cm). Second, higher ground soils, such as river levees and coastal ridges, differ from lower ground soils. These soils are similar to the first, but they are nearly ripe. They contain 4 % and 6.5 % organic matter, respectively, and have a low pyrite content ($FeS_2 < 1.5$ %). Because the pH level is around 5-6, the soil reaction is slightly acidic to neutral. At greater depths (> 125 cm), these soils are overlain by a gray pyritic subsoil. These soils were classified as *tropaquepts* by the Soil Taxonomy. The deeper the peat layer, the greater the need for a proper drainage system to increase soil pH (ANWARHAN, 1981).

2.4.2 Tidal swampland for agriculture

Unlike the traditional farming practice on Java Island, which employs gravity full-irrigated systems, farming in a tidal ecosystem deals primarily with less arable land, tidal hydrology, and acid soil. The hydrology of different areas varies greatly and can change over time. The difference between high and low tides in the secondary channel, according to ANWAR & MAWARDI (2011), ranges from 42 to 204 cm depending on the typology, season, and distance from the primary riverbank. As a result of their distinct characteristics, farmers must implement an appropriate farming system in tidal ecosystems (YANTI, 2002).

Even though the productivity is lower than in irrigated areas, reclaimed swampland is still promising for crop production in the future. The managed swamp area was estimated to be approximately 1,044,695 hectares in 2005 (SYAUKAT, 2011). The crops that can be grown in this area are limited. To produce an adequate yield, selected crops should be tolerant of adverse soil conditions such as high salinity and acidity. Concerning the sulfide layer, DENT & PONS (1995) proposed that farmers keep the soil moist to limit oxidation and manage the hydrology to ensure better acid leaching.

Tidal swamplands are suitable for wet rice fields and other selected crops such as coconuts, oranges, and several secondary crops planted in the dikes due to the availability of abundant water, especially during the wet season, the hydrology properties, and the flat topographical setting (DJAMHARI, 2002). DARSANI et al. (2020) proposed that approximately 1.05 million hectares of swampland could be cultivated for rice with one year of planting and productivity of 4-5 ton per hectare.

However, the total contribution of swampland to the national rice production is only 4-5 million ton per year (DARSANI et al., 2020).

VAN DEN EELAART (2014) proposed swampland as an alternative for rice cultivation for several reasons. To begin with, it avoids the potential limitation of increasing gravity-irrigated coverage. Most gravity-irrigated rice fields are concentrated on Java Island, where land conversions occurred quickly. Second, the expansion of gravity-irrigated areas outside Java (e.g. South Sulawesi and North Sumatra provinces) for increasing rice production is considered as having no significant prospects at a competitive cost due to a number of issues, including the excessive soil problems that many irrigation projects have experienced, the limitation of physio-geography landscape, and the hydrology and topography of the adjoining rivers and basins, which are not suitable or only have very limited for irrigation. Moreover, the costs of maintenance and investments to increase rice production should be considered. As a result, in areas other than Java, the swamp scheme application may be more profitable than the gravity-irrigated one.

Furthermore, physical conditions have a significant impact on rice yields. Most of the developed swampland is found in tidal river sections along the sweet water. In general, only one harvest results in a year with yields of 1.5-2.5 tons/ha. Besides that, the results are significantly lower than those of gravity-irrigated land. The land is then abandoned under stagnant water conditions with high acidity.

Historically, the best yields have been found near rivers, where frequent flooding with fresh water may occur during high tide (VAN DEN EELAART, 2014).

In the long-term, the rice yield productivity may be lower (less than 3 tons/ha) due to several factors, including: (1) inadequate water management at the primary system level; (2) several reclaimed areas are not mature enough due to a lack of water arrangement; (3) a lack of appropriate credit facilities; (4) a lack of infrastructure and post-harvest facilities and management; (5) severe pest and disease attacks; and (6) labor shortages (SUPRIYANTO et al., 2010).

The Telang project (South Sumatera, Indonesia) achieved 6 tons/ha of optimum yields using improved rice varieties despite frequent tidal flooding. However, non-tidal flooded areas that made some improvements, such as installing water control structures, building more tertiary drains, and upgrading existing canals, obtained the same results. These systems most likely produced two crops per season. Even though pump irrigation has yet to be used in the area, the introduction of mechanized land preparation could be a significant factor (VAN DEN EELAART, 2014).

According to VAN DEN EELAART (2014) and SUPRIYANTO et al. (2010), several factors influence land fertility, including (i) tidal flooding (tidal irrigation) ability, (ii) land levels related to the average water level due to the neap tide, and (iii) land levels related to the average water level due to the spring tide. These aforementioned factors are primarily concerned with water supply and percolation rates. Furthermore, water supply and percolation rates influence the severity of toxic and acidic conditions. The worse conditions, such as higher acid and toxic levels, were caused by insufficient water supply and percolation quantities. In addition, primary infrastructure maintenance and on-farm water management contribute to yields. The presence of high acidity soil layers in acid sulfate soils, on the other hand, had no significant effect.

Fisheries are dependent on the quality of water in rivers and canals. The ecosystems that feed the swamps are dominated by freshwater fishing. Canals near large rivers, with their primary catchment in the uplands, are suitable for freshwater shrimp farming. Near the coast, brackish water fisheries such as shrimp, milkfish, and crab farming are feasible. However, due to high acidity, shrimp farming was not feasible in areas with acid-sulfated soils. Otherwise, blackfish that can survive in extremely acidic water for a few months were a better choice. It should be noted that the benefits to fisheries are limited in rivers with most of their catchment area in peat domes (ombrogenous peat soil) (VAN DEN EELAART, 2014). However, fish farming necessitates massive investment to maintain a consistent freshwater supply, dam construction, and feed.

2.4.3 Agricultural practice in tidal swampland ecosystem

The main factor in tidal swampland farming is water control. A water arrangement can also be used to leach toxic substances, reduce pyrite oxidation, and land subsidence, and keep saltwater out of the field. Given these facts, one-way water control is appropriate for tidal swampland, particularly typologies A and B (SARAGIH, 2013).

The secondary and tertiary channels in the system (Figure 2.3) are protected by one-way flap gates. Water enters the irrigation channel through the inlet flap gates while the outlet flap gates are closed. At low tide, water thrust automatically closes the inlet flap gates, while the outlet flap gates open and water flows out (SARAGIH, 2013). This system optimally supports water circulation and toxic leaching.

Agriculture in swamp areas differs from agriculture in gravity-irrigated areas. To manage swamp areas, tide hydrology and the presence of pyrite must be properly considered. Agricultural practice, particularly rice cultivation, exhibits several characteristics. In swamp areas, local rice varieties are generally preferred because they can withstand deep flooding and acidity (high adaptability), require fewer inputs (easy to cultivate by the farmers), and are more profitable (SUMAWINATA, 1992, KHAIRULLAH, 2020). These varieties include *bayar putih, bayar kuning*, and *lemo*, which take 7-9 months from seedling to harvest. They have long, slim grains with a delicious flavor and aroma (SUMAWINATA, 1992, KHAIRULLAH et al., 2013). These varieties are the most popular in South and Central Kalimantan, so their prices are higher than others (KHAIRULLAH, 2020).

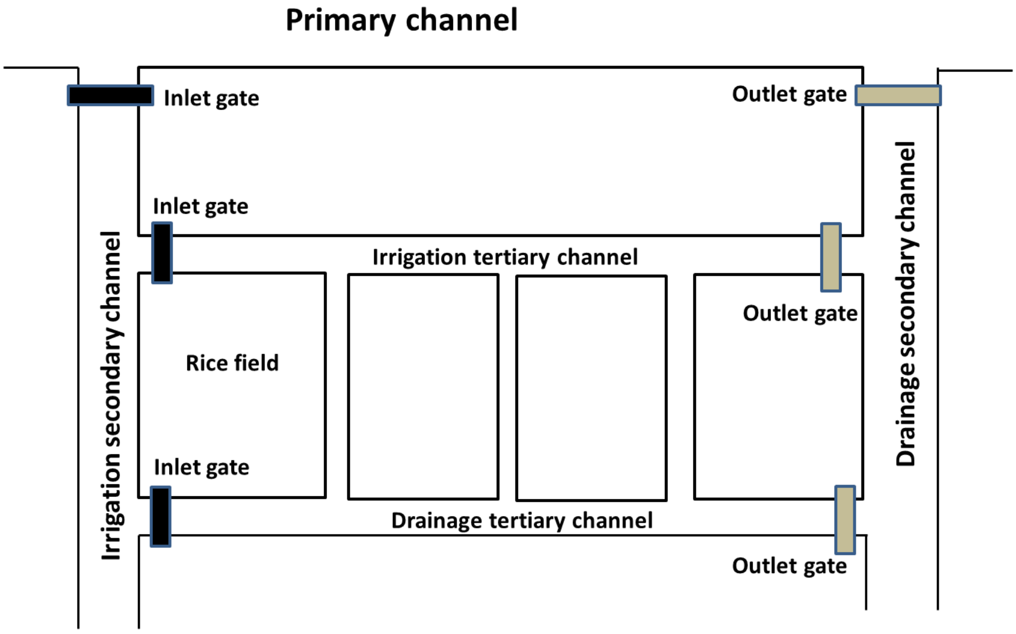


Figure 2.3. One-way water system
Source: SARAGIH (2013).

Weeds and grass are cut with a scythe-like tool (*tajak*) or a long knife (*parang*) when the water level is higher than 30 cm. The grass cuttings are then decomposed by dispersing them throughout the plots and submerging them for 15-20 days. The rotten grasses are piled into a mound and left half-submerged for 15-20 days. The piles are then turned over and stored for the next ten days. Finally, the decomposed grasses are distributed across the plots.

To deal with the seasonal hydrology situation, multiple seedling stages are used. Using this method, farmers require only 5 kg of seeds for a hectare of rice plot. The first seedbeds (*teradakan*) are usually prepared in October in normal years, or in November in El Nino years. Seedbeds are classified into two types: those prepared on dry soils with dry seeds and those prepared on the raft with pre-germinated field bunds. The first method is used in relatively high locations, such as dykes or paddy field bunds. Following the removal of the grass, 60-70 seeds are placed in a hole and covered with soil and ash. *Tetujah* (goat's hoof) is used to make the holes. The holes are separated by about 10 cm and left for 40 days. The other technique is performed on a mud-covered floating raft. Pre-germinated seeds are sown on the mud surface and allowed to germinate for 15 days. The seedlings are then transferred to the second seedbed (*ampakan*) in one corner of each rice plot. Typically, the planting space is 20-30 cm. They are kept there for 40 days to help the seeds grow and multiply. On the periphery of each paddy plot, the third seedling (*lacakan*) is prepared. The seedlings are kept there for 60 days before being planted (*tanam*) on the others. Two lacakan are normally placed 30 x 30 cm apart in a single hole. Planting should be completed by February in the type A area and by March through April in the types B and C areas. Harvesting occurs in August and September after about 4-5 months of development. As a consequence of climate change, some steps (e.g., *lacakan*) should be overlapped to match the water table level. As a result, the amount of seeds needed per hectare will rise (SUMAWINATA, 1992, KHAIRULLAH et al., 2013).

Farmers can also cultivate it twice a year by intercropping it with high-yielding rice varieties (HYVs). This arrangement is known as *sawit dupa* (once seedling–twice harvesting) in the local language. Local and HYV seeds are planted (typically in October) (KHAIRULLAH et al., 2013). The HYVs seeds are planted in the rice plot while the local variety seeds are still in the second and third seedling stages. After 90 days, the HYVs are harvested, and the local variety is planted on the plot. The water level in the plots is controlled by simple water gates built in a primary ditch by piling up tree trunks or branches. Similar but smaller water gates are built in the secondary ditch, which is dug at an angle to the main ditch. When the rainy season begins in early November, the water gates are kept open. The acids produced during the dry season, according to SUMAWINATA (1992), can be leached out and drained off through the main ditch. The water gates are closed in late December, and the fields are submerged. Farmers prepare the land in submerged fields by cutting the grass and successively transplanting seedlings. The final transplant is scheduled for March. The water gates will be shut down until June. As a result, the plots are submerged from the time the land is prepared until the end of the vegetative phase. Thus, the plots are submerged from the land preparation to the end of the vegetative phase. In addition, microchannels should be dug in the plot in swampland type B. SARWANI (2003) found that the microchannels accelerate the acidity leaching since the plots are only flooded on the spring tide.

Raised beds for vegetables, fruits, and perennial crops such as coconut and orange can be established in a rice plot. This system is known locally as the *sorjan* system (see Figure 2.4). These raised beds can also be used to control the excess mud that enters the plot every year (HIDAYAT, 2010). In the rice plot, the mud layer should be about 30 cm thick. The raised bed measures 2-3 meters wide by 0.5-0.75 meters tall. To compensate for the high cost, the farmer typically constructs one raised-bed per year until he has 5-8 raised-beds in a hectare. Raised beds are built during the dry season and then left to leach to reduce soil acidity. To improve soil fertility, lime and organic matter are added. Rainfall will remove the acidity matter at the beginning of the wet season. One month before planting, holes are dug with a 5-meter space between them in orange farming. The size of the hole varies depending on the soil type and layer beneath. The topsoil and organic fertilizer mixture is then inserted and left for a week. The grafted seed is then planted. Farmers can plant 200-250 orange trees per hectare of land, depending on the swamp type. Every year, rice straw is spread over muddy soil and manure to maintain the raised bed.

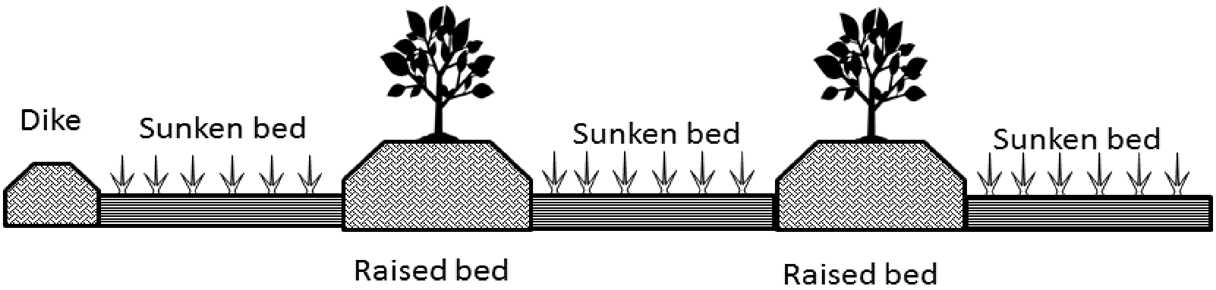


Figure 2.4. The *sorjan* system
Source: Own description based on the field survey (2014)

2.5 Swampland for agriculture: some countries' experience

Agriculture on swampland dates to the prehistoric era. Archaeologists discovered the transition of farming from highland to drained wetland gardens in Kuk Swamp, Papua New Guinea (BOURKE, 2009). In another part of the world, Maya farmers on the Yucatán peninsula intensively modified swamps to make a living (BEACH, et al., 2009). The reclamation of the swamps continued in accordance with the increase in population. The advance of technology accelerated the conversion. Around half of the world's wetlands have been reclaimed for agricultural, settlement, industrial, and urban purposes (VERHOEVEN & SETTER, 2010). The reclamation has negative consequences because the environment and biodiversity status have deteriorated significantly. Reclamation, on the other hand, has positive outcomes such as improved economic conditions, reduced poverty, increased food production, and accelerated rural development. The following sub chapters describe some countries' experiences with swampland reclamation.

2.5.1 Papua New Guinea

In Papua New Guinea (PNG), the swamp forest is located on the northern lowland, between the central range to the south and the Pacific Ocean to the north (WIKRAMANAYAKE et al., 2002). According to archeological research, the Kuk Swamp area has been used for taro starch cultivation since 10,000 years. An arrangement of small island beds was built 7,000 years ago to breed water-tolerant plants such as banana and swamp gardens (BOURKE, 2009).

According to WATSON (1965) and BALLARD (2001), the introduction of sweet potatoes was critical in a dramatic change from highlands to drained wetland farming three centuries before the first contact in the 1930s. Based on the archeological findings, the indigenous people constructed a network of drainage ditches, boundary markers, roads, and pig tracks. The spatial constraint was accommodated by these structures (BALLARD, 2001). This was followed by a movement from the highlands to the lowlands (MAY, 2004). In the 2000s, nearly half of the rural population lived in lowland areas (ALLEN & BOURKE, 2009).

Because they are staple foods for the locals, sweet potato, banana, cassava, and swamp taro dominate lowland food production. According to a 2000 survey, sweet potatoes provide approximately 66 % for staple foods (BOURKE et al., 2009). Because the environment in PNG is ideal for mixed species planting, it is widely used. This method is quite efficient, resulting in higher total yields and lower labor input (ALLEN & BOURKE, 2009).

The introduction of new cultivars has a significant impact on both the shortening of the fallow period and the lengthening of the cropping period. Agricultural production rises sharply when soil maintenance techniques (e.g., composting, managed tree fallow, crop rotation, and erosion control) are used (BOURKE, 2001). The agriculture sector employs 85 % of the population and accounts for 25 % of the country's GDP (ADB, 2015).

2.5.2 West Africa

West Africa has 1.2 million hectares of mangrove swamps, with 200,000 hectares cleared for rice cultivation in Nigeria, Guinea Bissau, Gambia, Guinea, Senegal, and Sierra Leone over the last century. This region contributed 10% of total regional rice production (AGYEN-SAMPONG, 1994). Domesticated rice varieties from Niger and its neighbors were improved in order to increase yield (JOHNY et al., 1981). Nigeria is currently the largest rice producer on the subcontinent, accounting for 40% of total rice production (NWAOBIALA, 2010, FAOSTAT, 2007). In Nigeria, swamp and rain-fed lowland rice production accounts for half of total rice production (TASHIKALMA, 2014). Furthermore, swamp agriculture serves as not only a primary source of food but also as an employer and source of labor.

WARDA (West Africa Rice Development Association), the current AfricaRice, has been developing the lowlands as part of the West-Africa Development Project since the early 1970s. They have released new adaptable varieties that have been continuously integrated with international rice research. They also work on rice trade improvement and development hubs across African countries as representatives of primary rice-growing environments and various market opportunities (AFRICARICE, 2015).

Because it is in a tidal area, the farming outcome is dependent on salt-free periods, which affect the length of rice growth. In the favorable season, the yield reaches 2 tons per hectare, which is higher than 1 ton per hectare in the non-swamp area (AGYEN-SAMPONG, 1994).

Physical constraints (e.g., Al and Fe toxicity, phosphorus and nitrogen deficiency, salinity, brown spot infestation, and acidity), biological constraints (e.g., low yield and susceptibility to pest and environmental stresses), and socio-economic constraints (e.g., limited labor, accessibility, extension and education, and credit) all limit production (AGYEN-SAMPONG, 1994, ONIAH et al., 2008). In this case, the adaptive rice variety should be introduced along with a suitable extension service. The yield cycle should be shortened to compensate for the decrease in rainfall. This condition, on the other hand, is similar to the tidal swamps located in South Kalimantan, Indonesia.

2.5.3 Rwanda

Rwanda's economy is heavily dependent on agriculture, which accounts for 34 % of national GDP and 70 % of exports. Agriculture employs more than 80 % of the population (MUHINDA, 2013). In 2010, the national poverty line poverty headcount ratio was 44.9 % of the population (WORLD BANK DATA, 2015). Based on these facts, agriculture will be the backbone of poverty reduction and economic development by 2020 (WORLD BANK, 2011).

Swamp and marshland in Rwanda were converted into a highly productive rice scheme. This World Bank program to improve to reduce poverty through agricultural development. The swamp was drained by diverting small rivers into two peripheral canals from which small-holder plots were gravity-irrigated (SEEBOERGER, 2014). In 2013, approximately 23,683 hectares of marshland were developed for agriculture, with a projected increase to 65,000 hectares by 2017 (MUHINDA, 2013).

They learned from this experience that: (1) 10-20% of the swamps and marshland should be left for ecological buffering and nature; (2) the slope of the straightened main river-bed should have some stable speed-breakers/drop-structures; (3) intensive production necessitates a careful biological and mineral-fertilizer based soil fertility strategy; and (4) the silt-load of the rivers after heavy storms should be used systematically to re-fertilize the plots (5) The environmental impact of greenhouse gases in irrigated rice should be closely monitored; (6) the schemes can also be used for conventional intermittent irrigation rather than long-term submersion of rice plots. (7) A contour line-oriented plot layout can cut land-leveling work in half. (8) The majority of the work could be done by hand, e.g., cash-for-work; (9) According to local poverty-ranking-tools, the allocation of the many new plots is best for the poor (BERNHARD MEIER ZU BIESSEN, 2015, ESIRU, 2014, SEEBOERGER, 2014). Because the project is still in its early stages, no side effects of swamp reclamation have been observed.

According to MUHINDA (2013), one of the challenges in the agricultural sector is a lack of private sector investment. Private and public sector financial institutions are hesitant to enter the credit market. Another challenge is the lack of farmer skills in modern and sustainable farming.

2.5.4 Vietnam

Since 1968, Vietnam has recognized wetlands for their significant contribution to socio-economic development. They have contributed to the agricultural transition from rice importers to rice exporters from 1976 to 2003. Tourism and fishing are two other roles (VEPA, 2005).

The Mekong Delta and the Red River Delta are Vietnam's most important swamps. The Mekong Delta was one of Southeast Asia's first civilizations (TORELL & SALAMANCA, 2003). In that order, the deltas cover 3.9 million hectares and 302,318 hectares (76 % is estuarine wetland) (VEPA, 2005). However, artificial wetlands (rice plots, fishponds) have increased, resulting in a decrease in natural wetlands, according to the MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT (2001). Rice cultivation expanded from 2 million hectares in 1976 to 3.82 million hectares in 2004. According to preliminary statistics, 50% of reclaimed wetlands in Vietnam were used for crops, 25% for aquaculture, and 10% for artificial lakes and reservoirs (VEPA, 2005).

For decades, paddy rice cultivation has dominated the Mekong Delta. Because of the harsh environment, only a small population lived there at first. Canals were dredged in the 1930s and 1940s to drain swamp areas, make them available, and connect them to cities and neighboring districts (NI et al., 2003). Rice cultivation began in the 1960s with traditional dwarf rice, and multiple rice cropping was introduced in the 1970s.

Nguyen Chi Thahn classified swamps in 1993 based on the body of water, geomorphology, and hydrologic characteristics. In 2004, the Ministry of

Agriculture adopted this classification as the agricultural development standard (VEPA, 2005). This expansion caused the construction of additional canals, the relocation of people, and the improvement of infrastructure (NI et al., 2003). As a result, agriculture occupied approximately 83 % of the Mekong Delta, utilizing an extensive network of canals, irrigation, drainage, and village connectors. Rice cultivation, on the other hand, is the area's primary source of agricultural household income (TORELL & SALAMANCA, 2003).

Despite increased agricultural production, wetlands in Vietnam face significant challenges, such as population growth, low policy implementation, a lack of integration among intersectoral parties, a lack of research and development, agrochemical pollution, and natural disaster impacts (VEPA, 2005). Low yields are caused by environmental issues, and poverty increases among small farmers as they lose their land due to debt. Direct assistance for landless farmers has failed, as they have lost both their money and their land. As a result, direct aid should be accompanied with education, technical assistance, and short-term financial assistance (NI et al., 2003).

2.5.5 Thailand

Thailand has 3,660,000 hectares of wetland (7.5 % of its total land area) (TRISURAT, 2006). Peat swamps cover 56,475 hectares of the total (YOSHINO et al., 2010). For generations, the wetlands have supported the Thai people's livelihood. During the 19th and 20th centuries, the government reclaimed freshwater wetlands and mangrove forests. Because of the importance of wetlands, the country ratified Ramsar Convention[5] in 1998 in order to develop a national policy and action plan for wetland management (TRISURAT, 2006).

From the 1960s to the early 1980s, large amounts of new land, including swampland, were made available for farming. Agriculture was the main driver of the economy at the time, accounting for 70 % of employment. Rural poverty fell from 60 % in the 1960s to 10 % in the 2000s (LETURQUE & WIGGINS, 2010) as a result of high agricultural growth since the mid-1980s (KASEM & THAPA, 2012).

According to YOSHINO et al. (2010) estimated that 45 % of the tropical swamps in Malaysia and Thailand's peninsula have been converted into industrial forests, built-up areas, and agricultural lands.

[5] *Ramsar Convention* is an intergovernmental treaty to provide the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Currently, 169 parties are involved to protect 214.94 million hectare of wetlands in 2,231 Ramsar sites (Ramsar.org).

Wetland rice cultivation is common in agricultural areas, particularly along the Chao Phraya River. This swamp area has helped Thailand's economy transition from a rice importer to a well-known Southeast Asian rice exporter. Rice exports stimulated economic development and integration into the global economy (FLAHERTY et al., 1999). The government aided rice, cassava, and sugarcane production by providing credit, inorganic fertilizers, and pesticides, as well as guaranteeing minimum prices (KASEM & THAPA, 2012).

However, in other places, rapid growth is offset by the depletion of environmental and natural resources. As a result, the Thai government promotes for sustainable agriculture. Crop diversification with high-value crops is encouraged, and so are the livestock and fisheries. Chemical fertilizers and pesticides have been reduced by raising awareness about balanced chemical use, discouraging the use of inorganic fertilizers, and reducing inorganic fertilizer imports. In addition, the government promotes organic fertilizer and healthy food (KASEM & THAPA, 2012). Other issues in Thailand include the effects of forest conversion to agriculture on the river basin (WILK et al., 2001) and the transition from agriculture to industry (KASEM & THAPA, 2012).

2.5.6 India

India's total wetland area is approximately 58.3 million hectares, with rice plots accounting for 71% of this total (BASSI et al., 2014). Most inland wetlands are directly or indirectly dependent on major rivers such as the Ganga, Brahmaputra, Narmada, and others. Himalayan wetlands, coastal wetlands, and reservoirs are the other types of wetlands (PRASAD et al., 2002). They are important in a variety of sectors, including food baskets (agriculture and fishing), water storage and supply, wildlife habitat, environmental buffer, tourism, and fuel (BASSI et al., 2014).

Development and population growth, agriculture, deforestation, and over-irrigation all contribute to wetlands degradation in India (PRASAD et al., 2002). In Punjab, for example, most wetlands have degraded due to inadequate ecological restoration (LADHAR, 2002). Meanwhile, due to over drainage, artificial wetlands for agriculture are prone to drought (MABWOGA & THUKRAL, 2014). In the 1950s, natural wetlands covered approximately 60,000 ha in Punjab. The wetlands now only cover about 15,000 ha. The area of agricultural wetlands has increased from 6,500 ha in the 1960s to 8,000 ha recently (LADHAR, 2002). Recently, approximately 84 % of the wetlands have been cultivated, with the remaining 5.7 % being forested (JERATH et al., 1995; LADHAR, 2002).

The lesson learned is that short-term drainage of low land will have an adverse effect on the environment. Modern agriculture that drains the water flow to the surrounding area endangers agricultural sustainability. Monoculture leads to excessive use of chemical fertilizer and pesticides (LADHAR, 2002). This agricultural run-off, as well as erosion silt, harms the local flora and fauna.

To address the issue, a legal framework and policy support are required, and a qualified organization should be involved. The first policy support for wetland conservation was enacted by the government in 2000. Reduced agricultural run-off containing pesticides and fertilizers is part of the policy (BASSI et al., 2014). In addition, several rules were issued and gradually improved to meet the Ramsar Convention. However, because these rules were not tailored to local rights, the community and local stakeholders were not heavily involved (BASSI et al., 2014).

2.5.7 USA

During the period of European settlement in the 1600s, the United States had nearly 90 million hectares of wetland (DAHL & ALLORD, 1997). There were only 41.8 million hectares left in the mid-1980s (DAHL et al., 1991, ZEDLER, 1996). This acreage represented only 47% of the wetland status in the 1780s. This area is still deteriorating, owing primarily to extensive and massive agriculture in the drained wetland (DAHL, 1990). DAHL et al. (1991) estimated that agriculture was responsible for 54% of the loss. The large scale of wetland conversion occurred between 1800 and 1860 because of high population growth and massive migration to the lower area, which resulted in a high demand for land. This conversion was accelerated by technological advances, such as steam-powered canal dredging and mechanical farming tools (DAHL & ALLORD, 1997).

One of the most notable tidal swamps in the United States is reported in Maryland, where a significant change has occurred. Before European settlement, it was estimated that there were 485,622 hectares of tidal swamp, but this was reduced to 50 %. It happened as a result of deep-water habitat conversion, saltwater and freshwater impoundments, ditching, and a lack of government regulation (TINER & BURKE, 1995, HARRISON et al., 2004).

Based on the facts, the government should prioritize wetlands mitigation. Preserving wetland habitat, replacing wetland losses, and mitigating upland losses are all part of the process (ZEDLER, 1996). However, there is still considerable disagreement about which should be prioritized, and which technique is more efficient than others.

2.5.8 Lesson to be learned

Humans have a long history of dealing with swampy environments. Many cultures developed around swamp agriculture. Swampland is still used as a resource for economic development in many countries today.

The swamp is commonly exploited in developing countries. They recognize that the swamp contributes to agricultural development, reducing rural poverty and unemployment. Several countries, including Thailand, Indonesia, Vietnam, and India, have had success in reclaiming swamps, despite the fact that there are still many environmental problems. They have paid more attention in the last decade to restoring nature and implementing sustainable swamp agriculture. Their works are examples of how they attempted to address environmental issues. Their efforts can be served as a model for Rwanda and Papua New Guinea.

On the other hand, developed countries' priorities and values for swamp areas have shifted from exploitation to preservation and mitigation. They are aware that the rapid reduction in swamp area may have an adverse effect on the ecology. Furthermore, uncontrolled exploitation will harm the economy in the long run. The bitterness of large-scale swamp reclamation has been felt in the United States. Swamp preservation is a difficult task that must be done on a continuous basis. All stakeholders must work together to solve numerous interconnected problems with limited funds and resources. The challenges for swamp rehabilitation are choices and priorities. An intervention is a factor that will affect others simultaneously.

Swamps can be beneficial to food production if they are managed properly. However, its reclamation and use must be carefully considered. The reclamation should reconsider the soil, hydrology, and plants cultivated. The proportion of converted and forested swamp should be maintained. Humans have a long history of dealing with swamp agriculture. They have local knowledge which could be used to guide future development.

Crop selection is also important. Crops should be economically valuable and resistant to harsh environmental conditions (acidity, salinity, dryness, inundation). Because swamp agriculture can only use a limited amount of land, crop selection and land use are critical issues.

3 RESEARCH DESIGN

3.1 Location of the study area

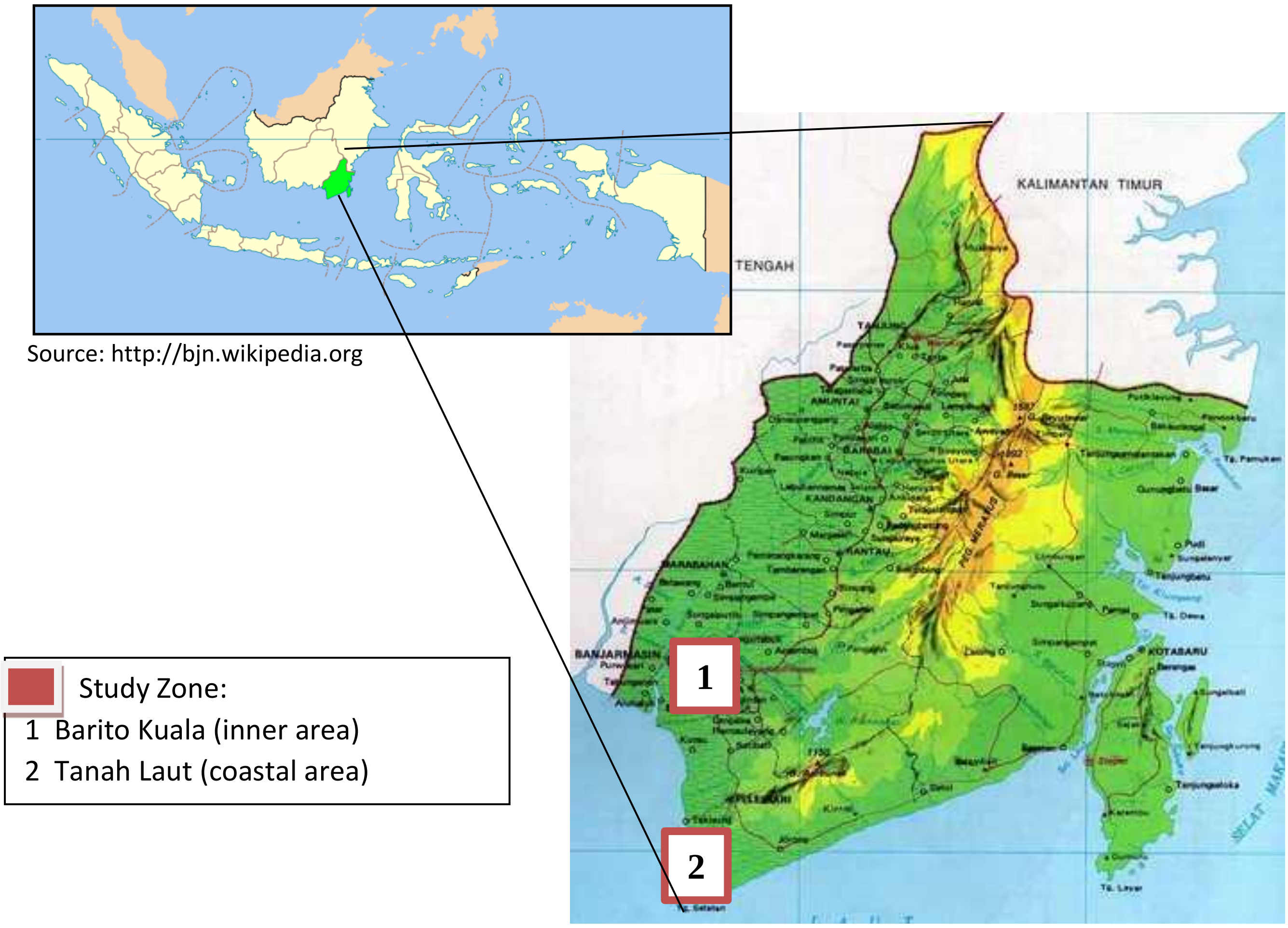
The research was carried out on Kalimantan Island, which has extensive tidal swampland rice farming. According to Wösten et al. (2008), Kalimantan has approximately 6 million hectares of peatland, primarily tidal swampland. The swamp areas are located in the southern part of Kalimantan, specifically in the provinces of South Kalimantan and Central Kalimantan. Based on the BPS report (2016), the planted area of tidal swampland for rice in South Kalimantan was 166,324 ha, which produced 602,709.19 tons of rice (Ningsih et al., 2020). South Kalimantan is the island's smallest province. It is considered the island's gateway due to its strategic location to other parts of Indonesia, particularly the main island (Java). This province has a large tidal swamp area that is used for farming (Agricultural Bureau of South Kalimantan, 2012). As a result, the research focuses on a tidal swamp area in South Kalimantan (the green area on the map in Figure 3.1). Furthermore, the study concentrated on the regencies of Barito Kuala and Tanah Laut.

3.2 Rationale for choosing the study area

South Kalimantan Province was chosen for this study. In 2009, the swampland area in this province was approximately 553,551 ha; those are spread out in Barito Kuala (239,830 ha), Tapin (102,322 ha), Tanah Laut (80,467 ha), and Banjar (52,592 ha) (Khairullah et al., 2021a). However, from the survey in 2019, there was a change in the distribution: Barito Kuala, Banjar, Tanah Laut, and Tapin account for 226,899, 74,273, 56,430, and 37,295 ha, respectively (Khairullah et al., 2021a). As a result, Barito Kuala and Tanah Laut regencies was chosen as the primary focus due to some reasons:

- Barito Kuala has extensive tidal swampland farming, whereas Tanah Laut has extensive type A swamp farming.
- Tidal swampland has been used since the 1900s (Sutikno & Noor,1997) and became widely available in the 1970s (Wösten et al., 2008). As a result, farmers in this area have experience of the challenges associated with cultivating rice in a specific environment.
- Tidal swampland accounted for 196,419 hectares, or approximately 29.60 % of rice fields in South Kalimantan. It is distributed to 54.29 % in Barito Kuala, 18.37 % in Banjar, 12.92 % in Tapin, and 14.14 % in other regencies (CBS of South Kalimantan, 2009).

- The area has become the intention for agricultural development in order to increase the production through the implementation of government programs run by the Indonesian regency, regional, and central governments.



Source: http://bjn.wikipedia.org

Source: National Spatial Planning

Figure 3.1. Map of the study area

3.3 Data collection

The method of data collection is critical for obtaining accurate and valid data. As a result, the sampling procedure is a critical step in data collection. The sampling is performed to verify a representative image of rice farming in tidal swampland.

The data was collected from both primary and secondary sources. From October 2013 to February 2014, a field survey was conducted in the two regencies. The data collection procedures are depicted in Figure 3.2.

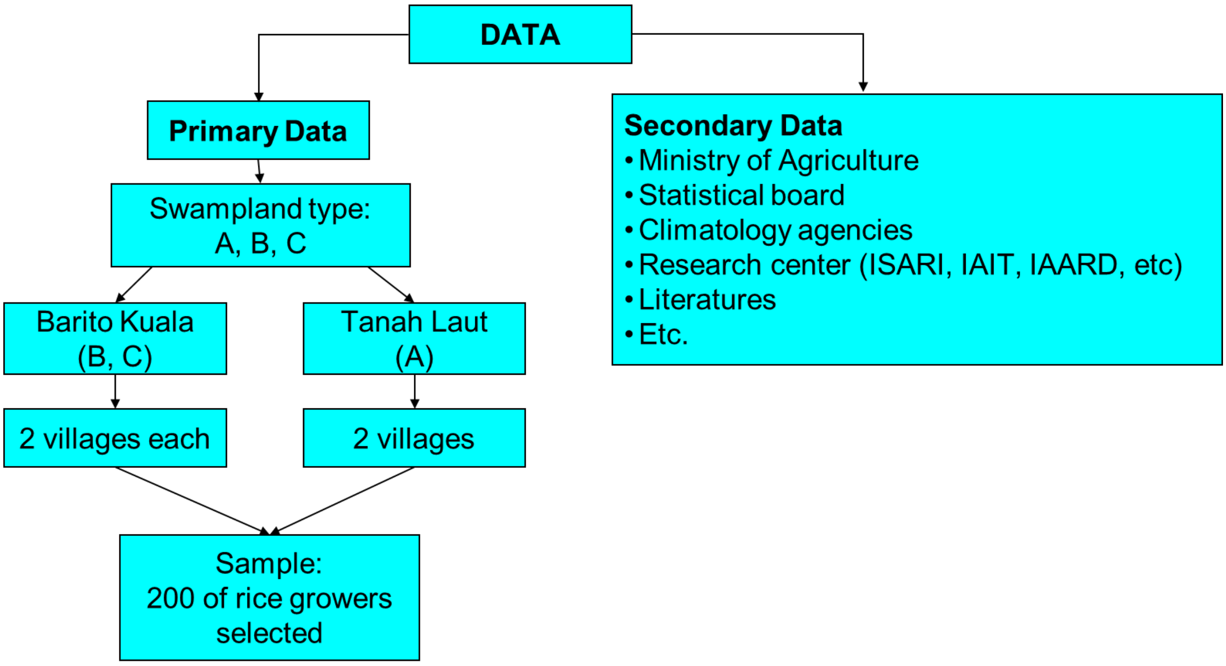


Figure 3.2. Data collection
Source: Own depiction

3.3.1 Primary data collection and sampling design

The sample farmers were chosen using a multistage sampling procedure, as shown in Figure 3.2. First, two regions with large swampland areas were purposefully selected (i.e. Barito Kuala and Tanah Laut). WIDJAJA-ADHI et al. (1992; 1994) proposed a swampland typology based on flooding, which was also taken into account in sampling. Rice is primarily grown in swampland types A (deep flooding), B (medium flooding), and C (shallow flooding), with a small amount grown in swampland type D (not affected by flooding). Two villages were chosen from each region to represent those types of swamplands. In the third stage, some steps were taken to ensure a high level of representativeness. Initially, a sampling frame of farmers was created with the help of extension officers, village chiefs, and other stakeholders.

The information was gathered through deep interviews, focus group discussions (FGD), and structured questionnaire interviews during the field survey (see Appendix 4). The questionnaire interview included 200 household heads from each of the three swamp typologies: 72 from typology A, 64 from typology B, and 64 from typology C. According to ethnicity, 129 household heads were locals and 71 were transmigrants. They were primarily questioned about their detailed activities for a single crop calendar year (August 2012 to July 2013). Their activities from the previous year and the two years before were also documented.

A standardized questionnaire was used to interview farmers. They were asked about household general characteristics, farming experience, information on land ownership and land use, household assets, employment including non-farm activities, farm management, farm distance from home, cropping patterns at the present and five years before, physical cultural system, cost and returns of rice farming, prices of inputs and outputs, membership in the farmer group and cooperative, information sources, access to credit, role of the government for farming management, problems of rice farming, etc. Appendix 5 contains the complete questionnaire.

3.3.2 Secondary data collection

Secondary data was gathered from non-governmental organizations' literature and reports, administrative offices including the Ministry of Agriculture, research centers, statistical yearbooks, and annual reports.

3.4 Data analysis

The data was analyzed using two techniques: descriptive analysis and household modeling analysis.

3.4.1 Descriptive analysis

The primary goal of the descriptive analysis is to gain in-depth knowledge of the study area and household socio-economic circumstances. Instead of going straight to the analytical results, this approach describes the state of the targeted respondents. Descriptive analysis was used in this study to present the social-demographic and economic characteristics of the surveyed farm households. Both were the primary parameters for further empirical investigation.

The MS-Excel package was used to calculate statistical parameters such as the percentage, mean, standard deviation, and F-test. The standard deviation was applied to assess the difference within the tidal swampland typology. Meanwhile, the F-test was used to analyze the difference among the tidal swampland typologies A, B, and C. The analysis describes the household characteristics, farm characteristics, and land-use system. Farm management, as well as a few farming technologies applied, are also clearly explained.

3.4.2 Household modelling analysis

To evaluate land allocation in swamp agriculture, a household modeling based on linear programming was developed. The objective function is to calculate the gross margin. According to HAZELL & NORTON (1986), the linear programming model can be written as follows:

$$maxZ = \sum_{j=1}^{n} c_j X_j \tag{3.1}$$

In such a way that

$$\sum_{j=1}^{n} a_{ij} X_j \leq b_i, all\ i = 1\ to\ m \tag{3.2}$$

and

$$X_j \geq 0, all\ j = 1\ to\ n \tag{3.3}$$

In this study, the objective of this mathematical modelling is to maximize Z, that is, gross margin. A detailed explanation of it would be explained further in Chapter 6. However, maximization of Z (gross margin) should not violate any of the fixed resource constraints expressed by equation 3.2 (i.e., farm household activities in tidal swampland area). The resource constraints also do not have any negative activity levels, as expressed by equation 3.3. These resource constraints include land availability, labor capacity, capital capacity, and home consumption in a certain season (dry and rainy season). Furthermore, the details of these resource constraints will be explained in Chapter 6.

This research attempted to predict future crop prices based on stochastic numbers in the simulated crop price prediction by using average crop price data from the previous few years and the Cholesky Decomposition method. The GAMS solver runs the average prices only once. Appendix 6 contains the GAMS code that was used in this model. The simulated crop prices were then used to compute a simulated gross margin. This procedure will be thoroughly explained in Chapter 6.

GAMS ver. 25.1, STATA 14, and MS-Excel 2010 were used for the household modeling and crop price simulation.

4 REVIEW OF STUDY AREA CONDITIONS

This chapter presents the condition of South Kalimantan with a focus on the Barito Kuala and Tanah Laut regencies. The purpose of this chapter is to describe the study area's geographic, climate, and socio-economic conditions, including population and labor, agricultural production, institutions, social services, and infrastructures.

4.1 Geography and climatology

The study was conducted on Kalimantan (Borneo) Island. Because the island is so close to the equator, it has a tropical climate with high humidity. Kalimantan has a total land area of 737,188 km^2 (GAVEAU et al., 2014). Geographically, the island is shared by Indonesia, Malaysia, and Brunei. Indonesian territory (known as Kalimantan) accounts for 72.36 % of the island's area (GAVEAU et al., 2014) and 69.5 % of its population (CBS, 2014). West Kalimantan, North Kalimantan, East Kalimantan, Central Kalimantan, and South Kalimantan are the five provinces of Kalimantan (CBS, 2013). The swamp covers 11.37 million hectares and is spread across all provinces (MINISTRY OF PUBLIC WORK, 2009).

South Kalimantan has approximately 250,000 ha of tidal swampland agriculture potential. Only 177,148 ha (70.86 %) of swampland has been reclaimed, with 133,702 ha used for agriculture (AR-RIZA et al., 1997). Barito Kuala, Banjar, Tanah Laut, Tapin, Kotabaru, and Banjarmasin are the six regencies in which they are located. The Barito Kuala and Banjar regencies have the most tidal swampland in South Kalimantan, accounting for 67.28 % and 17.03 %, respectively (AGRICULTURAL BUREAU OF SOUTH KALIMANTAN, 2012).

4.1.1 Geography

South Kalimantan is located between 114^{o}19’13”–116^{o}33’28” East Longitude and 1^{o}21’49 –4^{o}10’14” South Latitude. In terms of area, it is the smallest province on Kalimantan Island. It covers 37,530.52 km^2, or 6.98 % of Kalimantan Island and 1.9% of total Indonesian territory.

The territory comprises 42.99 % of the forest, 22.14 % of savanna (including fallowed land), 17.55 % of agriculture, and 11.63 % of plantation (CBS OF SOUTH KALIMANTAN, 2012) (Figure 4.1).

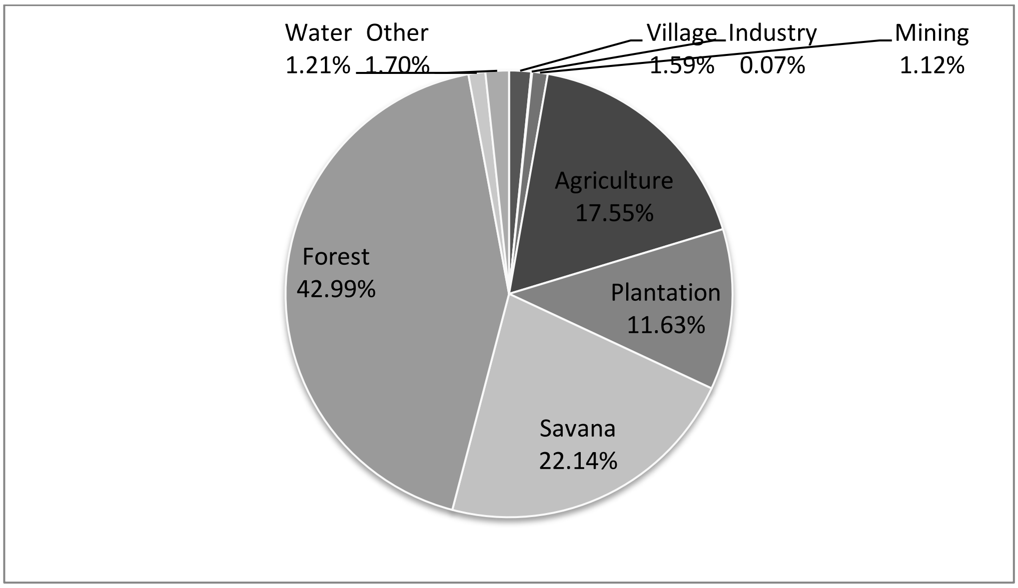


Figure 4.1. Land use in South Kalimantan, 2011
Source: CBS OF SOUTH KALIMANTAN (2012)

South Kalimantan's geography is divided into two major geographical areas: the lowland, which includes swamps and peatlands, and the mountainous area. The majority of the land (74.81 %) is flat, with a slope ranging from 0 to 15%. South Kalimantan is divided into eleven regencies (Barito Kuala, Tanah Laut, Kotabaru, Banjar, Tapin, Hulu Sungai Selatan, Hulu Sungai Tengah, Hulu Sungai Utara, Tabalong, Tanah Bumbu, and Balangan), as well as two cities (Banjarmasin and Banjarbaru) (CBS OF SOUTH KALIMANTAN, 2012). The research was carried out in the regencies of Barito Kuala and Tanah Laut, which have a large swampland area with distinct typologies.

Barito Kuala is located in the western part of the province of South Kalimantan, between 114º20’50” E until 114º50’18” E and 2º29’50”–3º30’18” S. With a total area of 2,996.96 km^2, the region accounts for approximately 7.99 % of the total area of South Kalimantan. Its topography is mostly flat lowland with a 0.20 % slope and an elevation of 0.20-3.00 meters above sea level (CBS OF BARITO KUALA, 2014). The majority of the district is tidal swampland with a thin peat layer in a few places. The dominant soil type is *alluvial*[6], which covers approximately 60-64 % of the total area, with the remaining part being *organosol*[7] (CBS OF BARITO KUALA, 2014).

[6] Alluvial soil is formed by the sedimentation of sand and mud from the basin river. The area is the best for tidal agriculture (CBS OF BARITO KUALA, 2014).

[7] *Organosol* or well-known as peat soil, is formed from decaying plant fibric which is waterlogged for a long period of time. The acidity is relatively high (CBS OF BARITO KUALA, 2014).

The Barito Kuala Regency is located on the banks of the Barito River. Tamban, Serapat, and Talaran are the three main canals (*anjir*) that connect the Barito and Kapuas rivers. Tidal movement, rainfall, and the state of land use on the river's banks and headwaters all have a significant impact on its hydrology. Water from the Barito River floods almost all areas through the canals and sub-canals during the rainy season and at high tide. Tidal movement occurs twice per day in the river basin area, causing the water table surface difference between low and high tide to be about 1-3 meters. Farmers have taken advantage of the tidal movement to irrigate their fields by digging sub-canals (*handil*) (GOVERNMENT OF BARITO KUALA, 2010; ANWAR & MAWARDI, 2011). This area is home to typical swampy vegetation. The mangrove and *Cacuarina sp*. grow in coastal areas. Palm-like plant, such as *nipah* (*Nypa fruticans*) and *nibung (Oncosperma tugillarium*), can be found in the brackish area, whereas *jingah* (*Glutharengas*), *rambai* (*Baccaurea motleyana*), *gelam* (*Melaleuca sp*), and *purun tikus* (*Fimbristyliss sp*) grow in the area with an acidity level (pH) in between 3.50–4.50 (GOVERNMENT OF BARITO KUALA, 2010).

Tanah Laut is located in South Kalimantan Province, between 114º30'20" E and 115º23'31" E and 3º30'33" S–4º11'38" S. The total area is 3,361.35 km^2 or 9.71% of the total area of South Kalimantan (CBS OF TANAH LAUT, 2014). The geomorphology varies from coastal and swampy areas (0-10 meters above sea level) in the south and west to mountainous areas in the north and east (more than 250 meters above sea level). Approximately 77.90 % of the area is flat (slope 0-3 %) (CBS OF TANAH LAUT, 2013). This type of slope is ideal for wetland agriculture, such as rice cultivation.

The most common soil type is *podsolic*[8] (33% of total land area), followed by *alluvial* (32%), *latosol*[9] (29%), and *organosol* (6%). It is influenced by a number of major rivers (including the Maluka, Tabanio, Sabulur, and Swarangan), lakes, and swamps (CBS OF TANAH LAUT, 2013). During the rainy season, tidal swampy areas are prone to flooding.

4.1.2 Temperature and climate

South Kalimantan has two seasons due to its proximity to the equator: rainy and dry. The rainy season lasts from December to March, and the dry season lasts from

[8] *Podsolic* soil is characterized by high content of clay, low organic matter, low pH (4 – 5.5) and vulnerability to erosion (CBS OF BARITO KUALA, 2014).

[9] *Latosol* soil is characterized by higher organic matter (3 – 9%), soil reaction (pH) between 4.5 – 6.5, and weak structure. In general, *latosol* soil is more fertile than *podsolic* (CBS OF BARITO KUALA, 2014).

June to September. The *pancaroba* (seasonal transition) occurs in April-May and October-November. The monthly temperature ranges from 20.0–35.8 °C, the relative humidity is 68.0-97.0 %, and the precipitation totals 58.20-409.80 mm (CBS OF SOUTH KALIMANTAN, 2012). The change of seasons is currently difficult to predict. El-Nino and La-Nina events cause the rainy season to start 2-4 weeks later or earlier.

The local climate, geographic conditions, and airflow all influence rainfall in South Kalimantan. The most rain usually falls in December, while the least falls in September (BANJARBARU CLIMATOLOGY STATION, 2013). The total annual rainfall in South Kalimantan from 1978 to 2012 is depicted in Figure 4.2. The average amount of rain was 2222 mm. The highest recorded rainfall was 3539 mm in 2010, and the lowest was 1244 mm in 1980. The maximum temperature in Barito Kuala ranged from 31.3 °C to 37.3 °C, while the minimum temperature ranged from 21.5 °C to 23.5 °C. The monthly temperature ranged from 25.5 °C to 28.5 °C. Tanah Laut's high temperature ranges between 30.5 °C to 32.5 °C, while the low temperature ranges between 22.7–24 °C. Temperatures varied according to altitude and distance from the coast.

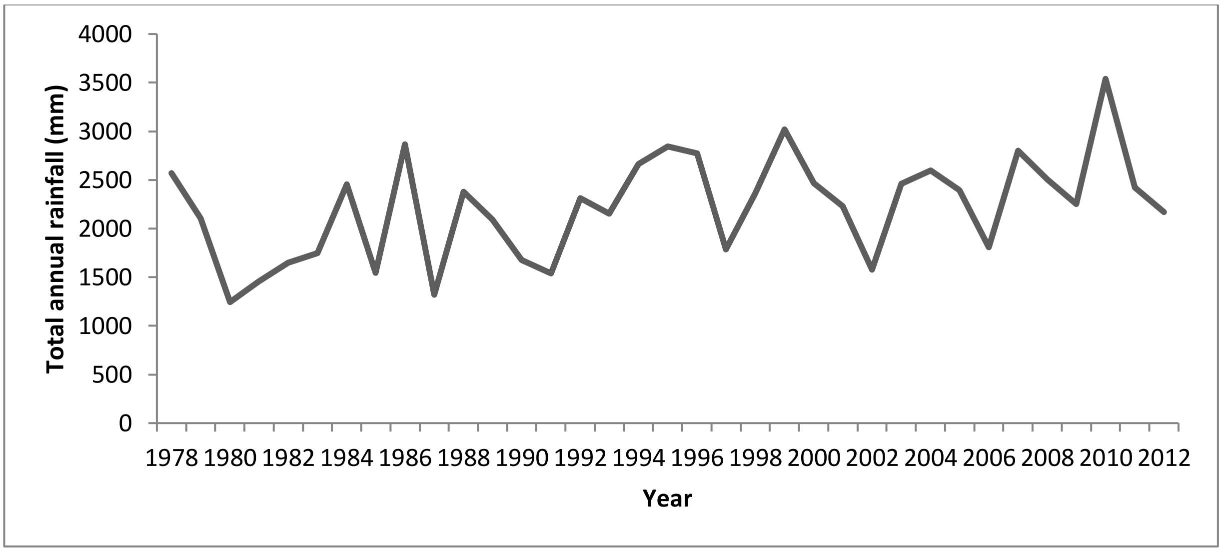


Figure 4.2. Rainfall in South Kalimantan, 1978-2012
Source: BANJARBARU CLIMATOLOGY STATION (2013)

4.2 Population and labor

In general, Kalimantan Island has a lower population density than the national average. According to CBS OF SOUTH KALIMANTAN (2012), there are 3.69 million residents, accounting for 38.61 % of Kalimantan's population and 1.50 % of all Indonesians. It has 1.87 million males and 1.82 million females, with a male to female ratio of 102.60. South Kalimantan has the highest population density, with

93.59 people per km². This number was lower than the national average density (131.18 people per km²). Meanwhile, population growth on Kalimantan Island was 1.45 % between 1990 and 2000, the lowest on the island and lower than the national average (1.49 %). The population age structure is dominated by young people, as is typical of developing countries. Male and female age structures are nearly identical (Figure 4.3).

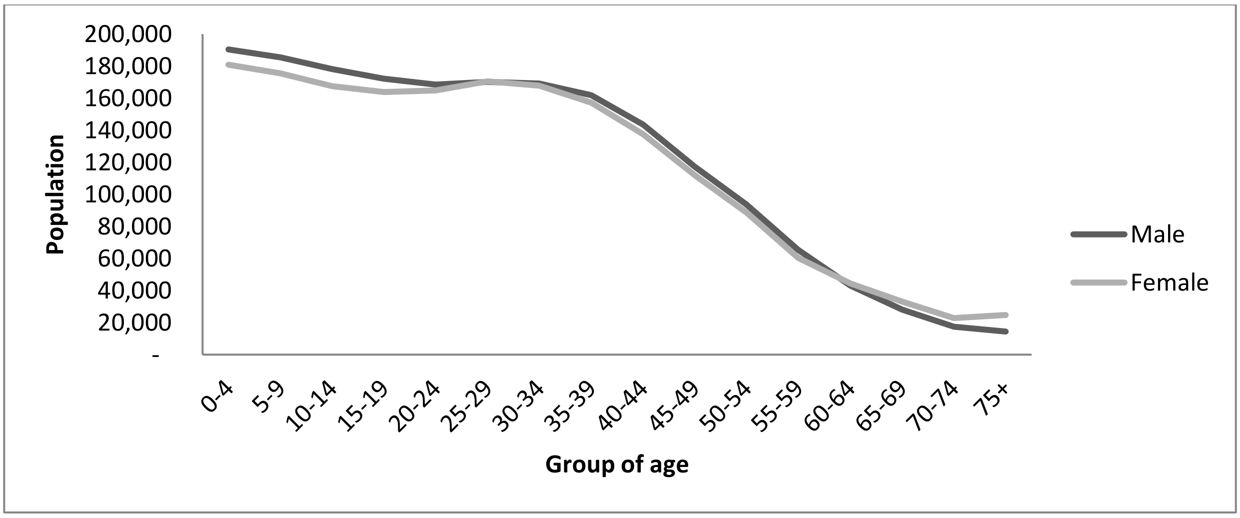


Figure 4.3. Population structure by age group in South Kalimantan, 2012.
Source: CBS OF SOUTH KALIMANTAN (2013)

In 2012, the population of Barito Kuala was 286,075 people living in 78,949 households. The population density was 95.56 people per km², which was lower than the national average of 131.18 people per km². The gender ratio was 100.28 (CBS BARITO KUALA, 2014). From 2005 to 2010, population growth ranged between 0.36 and 1.56 % (GOVERNMENT OF BARITO KUALA, 2010). The productive age (15-65 years) accounted for 67.86 % of the population, followed by 28.08 % of the 0-14-year group and 4.07 % of the elderly group (more than 65 years). However, 27.5 % of the productive age groups were unemployed. Poverty has been reduced by half, from 12.33 % in 2000 to 5.72 % in 2010 (CBS BARITO KUALA, 2014). The population was made up of both native and migrant people. The ethnic *Banjar* (74.90 %) and *Bakumpai* (7.68 %) made up the majority of the natives, while the rest were migrants from *Java* (5.10 %), *Sunda* (0.51 %), *Madura* (0.12 %), *Bugis* (0.09 %), and others (1.61 %) (HIDAYAT, et al., 2010).

Meanwhile, Tanah Laut had a population of 308,818 people, divided into 87,207 households. Between 2000 and 2010, population growth and density were 2.51 % and 85 per km², respectively. The majority of the population was concentrated in the capital city and industrial areas. In 2012, the gender ratio was 106, indicating that males outnumbered females (CBS TANAH LAUT, 2012). *Banjar* (62.62 %), *Java* (32.13 %), *Madura* (1.44 %), *Sunda* (1.20 %), and others (2.60 %) make up the ethnic group (Government of Tanah Laut, 2012). The productive age group (between 15 and 65 years old) dominated the population, accounting for 54.5 % of the total population, while the workforce accounted for 55.5 % of the total population (CBS Tanah Laut, 2014). In 2010, the unemployment rate was 4%, with high school graduates accounting for the majority of the unemployed.

4.3 Agricultural Production

Appropriate weather conditions with low rainfall support increased agricultural productivity in South Kalimantan. Food crop productivity was the main factor of this sector's improved performance. The agricultural sector grew at a rate of 3.86 % per year. It was higher than the 3.66 % annual growth rate recorded in the first quarter of 2011 (Investment Coordination Board, 2011). Agriculture is important in South Kalimantan. Agriculture provides a living for approximately 45 % of the 975,141 households (Agricultural Bureau of South Kalimantan, 2012).

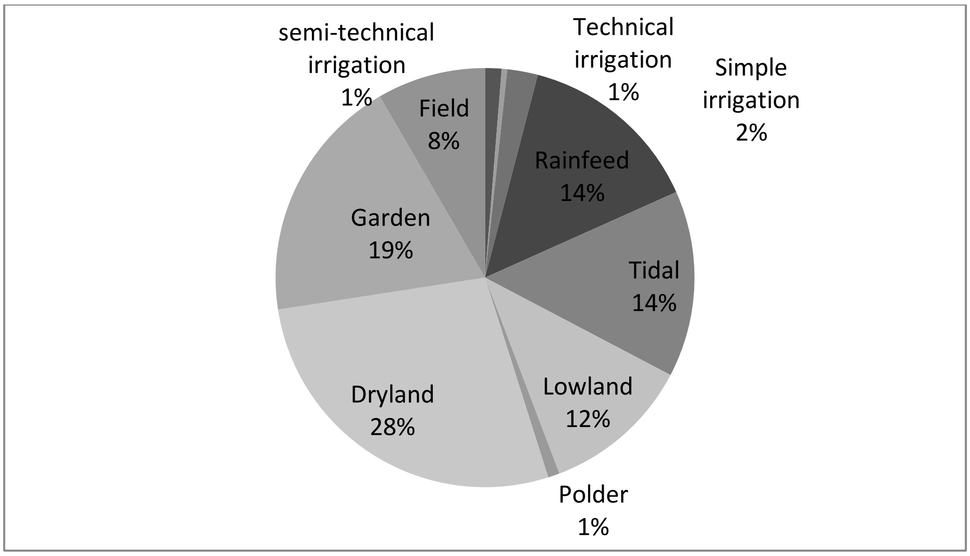


Figure 4.4. The percentage of the agricultural area by type in South Kalimantan, 2011.
Source: Agricultural Bureau of South Kalimantan (2012).

Excluding plantations, the province has 970,490 hectares of agricultural land. It is made up of 53.45 % wetland (technical irrigation, semi-technical irrigation, simple irrigation, rain-fed, tidal swamp, lowland, and polder (monotonous swamp) and 47.55 % dry land (gardens and crop fields) (Figure 4.4).

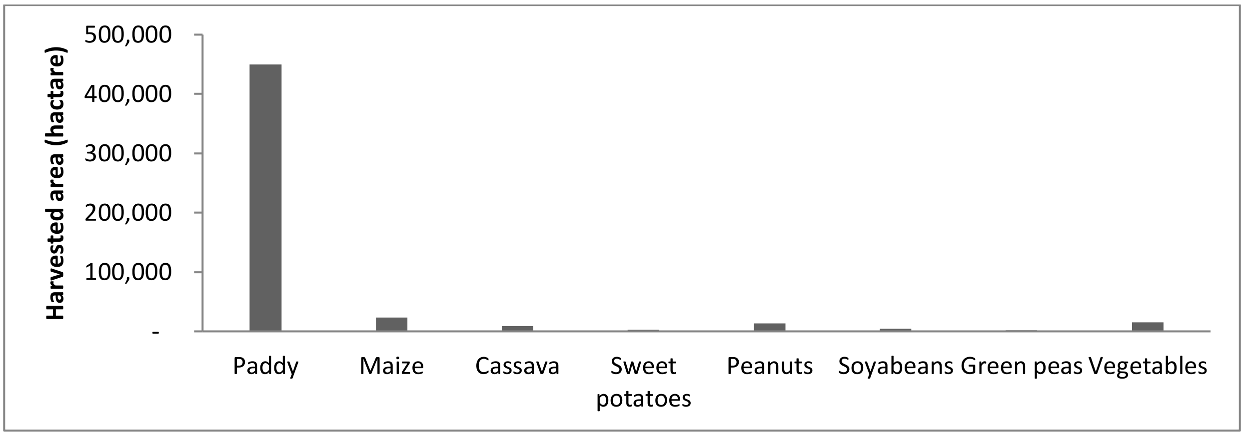


Figure 4.5. The harvested area of main and secondary crops, 2011
Source: AGRICULTURE BUREAU OF SOUTH KALIMANTAN (2012).

In South Kalimantan, rice is the most important commodity. As a result, paddy occupied the majority of the land in this province, followed by maize and vegetables (Figure 4.5). Rice production increased slightly from 1.19 million tons in 1995 to 2.09 million tons in 2012. It was caused by an increase in land use and productivity (Table 4.1). Rice production fell sharply between 1998 and 2010 due to El Nino, which brought a longer dry season and lower rainfall than in previous years. Meanwhile, other crops produced less than 200,000 tons per year (Figure 4.6).

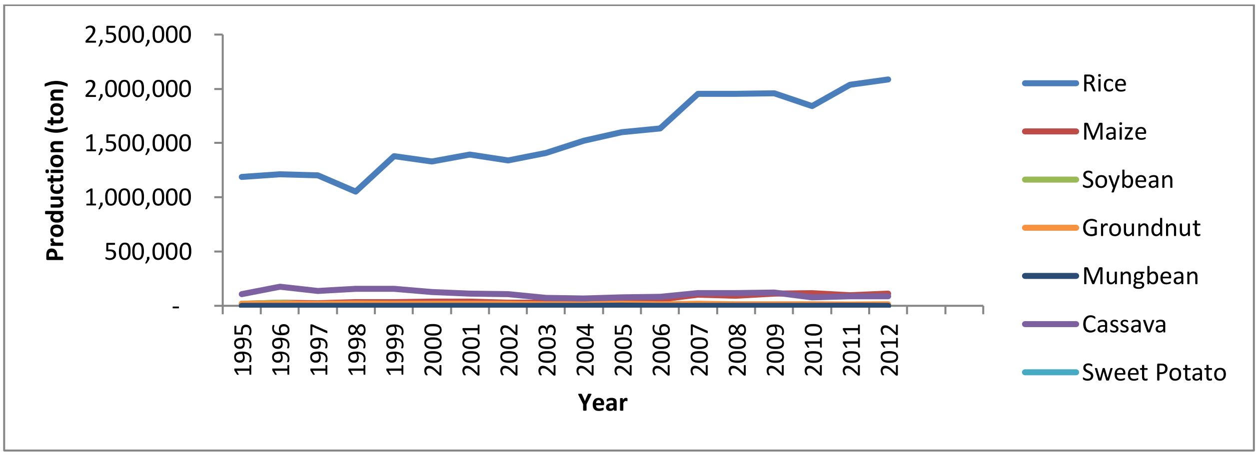


Figure 4.6. Production trend of selected crops in South Kalimantan
Source: AGRICULTURE BUREAU OF SOUTH KALIMANTAN (2013).

Rice productivity increased slightly from 2.99 tons per hectare in 2000 to 4.21 tons per hectare in 2012 (Figure 4.7), outperforming other provinces on Kalimantan Island (AGRICULTURE BUREAU OF SOUTH KALIMANTAN, 2013).

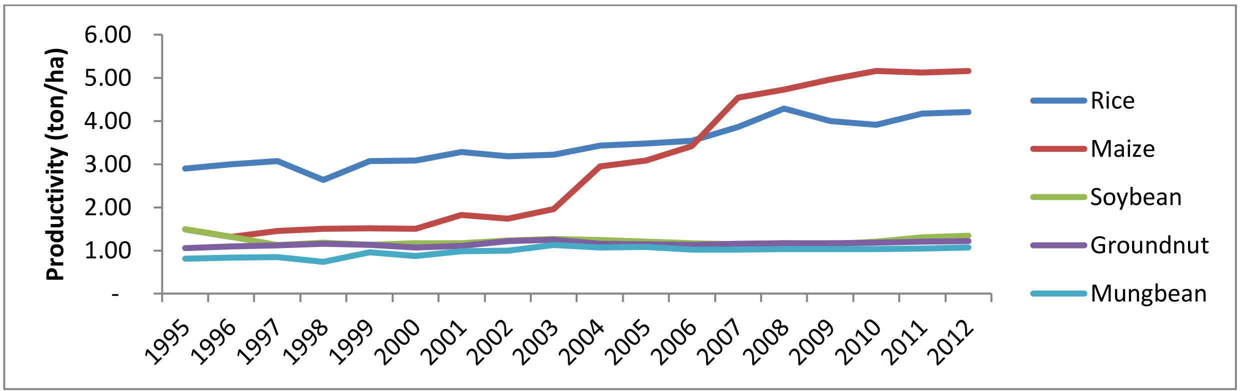


Figure 4.7. Productivity of selected crops in South Kalimantan
Source: AGRICULTURE BUREAU OF SOUTH KALIMANTAN (2013).

The agriculture sector, like the province level, is the main sector in the study area. Agriculture and plantation work was estimated to employ 28.46 % of the population (GOVERNMENT OF BARITO KUALA, 2010).

Table 4.1. Land use in Barito Kuala

Land Utilization	**2008**	**2009**	**2010**	**2011**	**2012**
Wet land					
Swampland (ha)	100,220	101,424	100,183	99,794	118,898
Percentage (%)	43.44	43.65	43.36	42.66	51.46
Temporary fallowed (ha)	20,241	19,219	20,779	20,300	20,487
Percentage (%)	8.77	8.27	8.99	8.68	8.87
Dry land					
House yard (*pekarangan)* (ha)	23,517	23,537	24,095	25,308	
Percentage (%)	10.19	10.13	10.43	10.82	
Dry field (*Tegalan*) (ha)	11,610	12,559	13,359	13,336	13,218
Percentage (%)	5.03	5.41	5.78	5.70	5.72
Dry field (*Ladang/Huma)* (ha)	1,805	1,825	1,928	123	114
Percentage (%)	0.78	0.79	0.83	0.05	0.05
Pasture (ha)	9,278	14,597	13,444	13,336	12,781
Percentage (%)	4.02	6.28	5.82	5.70	5.53
Temporary fallowed (ha)	14,973	13,313	8,590	8,631	7,804
Percentage (%)	6.49	5.73	3.72	3.69	3.38
Others (ha)	49,082	45,861	48,689	53,105	57,744
Percentage (%)	21.27	19.74	21.07	22.70	24.99
Total	230,726	232,335	231,067	233,933	231,046

Source: CBS OF BARITO KUALA (2014)

In 2012, agriculture contributed 35.86 % of regional GDP. In comparison to the others, it was the largest (CBS BARITO KUALA, 2014). It was primarily made up of food crops and fisheries. Rice is the main product, and production increased slightly from 280,121 tons in 2006 to 365,627 tons in 2012 (Figure 4.8). In 2012, rice production in this area accounted for 17.58 % of total rice production in the province. Other crops grown in specific areas include maize, soybean, groundnut, cassava, and sweet potato (see Figure 4.9). Fruits such as orange, mango, rambutan, banana, and pineapple are also cultivated. As a result, Barito Kuala serves as a hub for South Kalimantan and neighboring provinces.

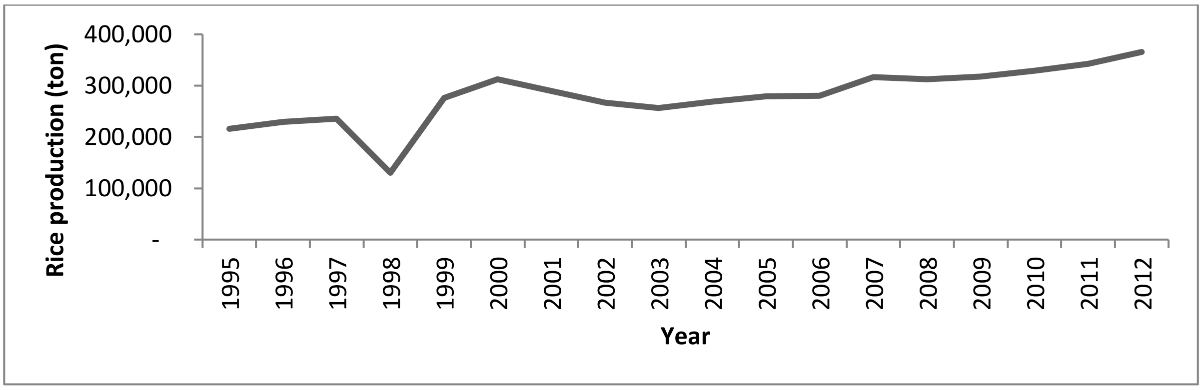


Figure 4.8. Rice production in Barito Kuala, 1995-2012.
Source: AGRICULTURAL BUREAU OF SOUTH KALIMANTAN (various years)

During the period 1995-2012, soybean, groundnut, and green bean production was very low, averaging only a few hundred tons per year. The government launched a program to increase secondary crop production in 2000. Production of maize, sweet potato, and soybean increased rapidly in the first year of the project, but then declined due to market failure and pest infestation (Figure 4.9).

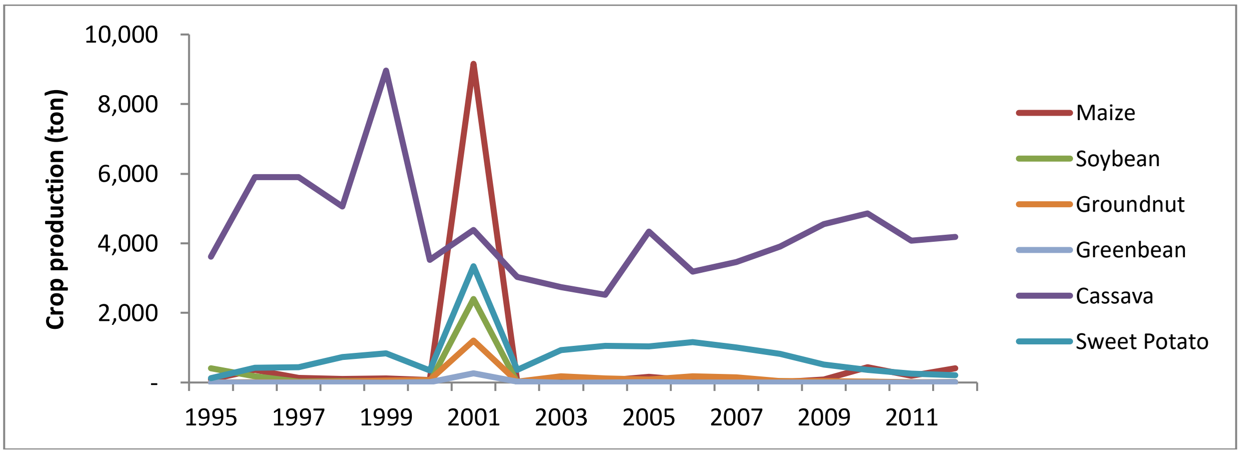


Figure 4.9. Secondary crops production in Barito Kuala, 1995-2012.
Source: AGRICULTURAL BUREAU OF SOUTH KALIMANTAN (various years)

4.4 Institutions, social services, and infrastructures

The survey covered six villages in three sub-districts, two of which are in the Barito Kuala Regency and the other in the Tanah Laut regency. The extension, social, and infrastructure descriptions only covered the Barito Kuala regency. This is due to the lack of disaggregated data for each sub-district. However, because almost all of the Barito Kuala area is swampland, it is thought to represent the swampland area's institutional, service, and infrastructure status.

4.4.1 Agricultural extension service

The extension service's purpose is to provide farmers with advice, primarily on how to introduce new technology and increase production. The Government Extension Service Office provides the advice for free.

ISARI (Indonesia Swampland Agriculture Research Institute) developed the swamp farming technologies, which AIAT evaluated, combined, and tested locally. Finally, AIAT spreads those partnered with the agricultural agency, extension service, and food security bureau. However, these institutions are poorly coordinated. Coordination between agricultural bureau extension services and *Bapeluh* (Extension Office of Agriculture, Fishery, and Forestry) is also lacking. Both government extension offices have distinct responsibilities and occasionally develop programs that overlap. As a result, farmers are frequently confused about which extension to pursue.

Other challenges to serving all farmers is a lack of human resources and infrastructure. There were only 171 extensionists to serve 1,596 farmer groups organized into 204 farmer group unions (CBS OF BARITO KUALA, 2014).

According to the field survey, only 79 farmers received routine extension service visits, while the remaining 121 farmers were only rarely or never visited by the service. The majority of the farmers visited were transmigrants, who are more cooperative than local farmers when it comes to adopting new farming technologies and participating in agricultural development projects.

4.4.2 Education and health facilities

In 2012, the overall literacy rate was 92.29 %. However, gender data was not available. The average length of schooling was 6.91 years, implying that the majority of people completed primary school (CBS OF BARITO KUALA, 2014).

Barito Kuala Regency had 270 primary schools, 58 junior high schools, 17 senior high schools, and three vocational schools in 2012. There were approximately 4,121 teachers available to teach 48,405 students in both public and private schools. As a result, the pupil-teacher ratio was 11.75 (CBS OF BARITO KUALA, 2014). Lambung Mangkurat University, Antasari Islamic University, Achmad Yani University, and Kalimantan Islamic University are the four state universities available at the provincial level.

4.4.3 Transportation and irrigation facilities

Accessibility is one of the challenges to developing swamp areas. The fragile soil structure makes road, bridge, and dam construction and maintenance expensive. Furthermore, during the dry season, river/canal transportation is unavailable.

In 2011, the road length composition in Barito Kuala Regency included 62 km of state road, 68.94 km of provincial road, and 628.13 km of regency roads. According to the road structure, 352.84 km were paved, 162.27 km were gravelled, and the remaining 109.02 km were dirt roads. Because the swamp soil structure is unstable and fragile, many roads have been severely damaged. Approximately 222.64 km were damaged, with 92.78 km severely damaged (CBS of Barito Kuala, 2014). This condition is a major barrier to providing access throughout the region.

Canals and sub-canals have been constructed to improve access and irrigate the fields. However, most of the sub-canals are only accessible during the rainy season. Barito Kuala Regency had 2,598.71 km of rural water canals in 2012, 31.12 % of which were damaged. This condition resulted in only 54,712 hectares of land being irrigated out of a total potential of 111,228 hectares (CBS of Barito Kuala, 2014). *Tabat* (small dams) in sub-canals are built by communities in swamp typologies C and D to harvest rainwater.

.

5 SOCIO-ECONOMIC ANALYSIS OF FARM-HOUSEHOLDS IN TIDAL SWAMPLAND

Based on their swampland typology, the selected socio-economic characteristics of the households are presented. According to WIDJAJA-ADHI et al. (1992), the typologies are distinguished based on the amount of water present on the field. These typologies are A, B, and C, as described in Chapter 2.

5.1 Household characteristics of farm households surveyed

An overview of the surveyed households' characteristics is presented in Table 5.1.

Table 5.1. Household characteristics of the 200* surveyed households

Items	All Samples	Swampland Typology			F-Test
		A	B	C	
Household size (person)	3.44 (0.99)	3.54 (0.99)	3.02 (0.93)	3.75 (0.89)	6.971**
Dependency ratio	0.52 (0.43)	0.57 (0.45)	0.43 (0.44)	0.56 (0.38)	1.145
Age of Household Head (year)	45.75 (11.32)	43.44 (0.93)	48.41 (9.96)	45.67 (11.54)	2.216
Ethnicity/origin:					
- Local (%)	64.5	100	50	61	
- Migrant (%)	35.5	0	50	39	

Note: The number in the brackets represents the Standard Deviation
The dependency ratio is calculated by enumerating the number of elderly (male and female) (>65 years) and children (≤15 year) divided by household family size.
* 200 households across the three swamp typologies (72, 64, and 64 samples from typology A, B, and C, respectively).
** significant at α = 5%
Source: Field survey (2014)

5.1.1 Household size

Kalimantan is a less populated island, as evidenced by the family size of the surveyed farm households. In general, the average household size is 3.44 people. The variation within the typology is nearly identical. Families in typology C have the largest family size (3.75 people), followed by families in typologies A and B, which have 3.54 and 3.02 people, respectively. According to the F-test, this difference between typologies is significant (Table 5.1). The number of household members will influence food consumption expenditures from both own farming and purchasing (WILDAYANA et al., 2016).

5.1.2 Dependency ratio

The average dependency ratio is 0.52, implying that every two working-age people (husband and wife) only care for one dependent. It could be advantageous. However, because farming relies heavily on family labor, they are only able to acquire a small amount of land and cultivate local rice to meet their family labor capacity. The dependency ratio of the B type is lower than that of the A and C types, possibly because B type areas have fewer elderly people and children than A and C type areas. The difference, however, is not significant.

5.1.3 Age of the head of household

The age of farmers is closely related to their experience and skills in managing their farming system to be more efficient, effective, and sustainable (WILDAYANA et al., 2016). As the farmer ages and gains experience, the farm may become more productive with improved managerial abilities, but it may then decline later in life (TAUER, 1995). The optimum farmers' age for reaping the benefit of farming is thought to be between 40 and 50 years old (WILDAYANA et al., 2016). The average farmer age in the study site varied across typologies, but they were all still productive (under 65 years old). Farmers in typology A are the youngest (43.44 years old), followed by farmers in typologies C (45.67 years old) and B (48.41 years old) (Table 5.1). At 54 years old, those farmers are younger than the national average (CBS, 2013). Furthermore, the age ranges in typology A are 25-84 years old, 29-77 years old in typology B, and 29-84 years old in typology C. The age of the household head of type C varies more than that of types B and A based on its standard deviation.

5.1.4 Ethnicity and origin

As shown in Table 5.1, the household respondent represents the ethnicity/origin community in the region. The majority of respondents (64.5 %) are of the local Banjar ethnicity, with the remainder being transmigrants from East and Central Java. Transmigrants were relocated to the region through the transmigration project at the end of the 1980s.

Ethnicity is considered because of its relationship to farming practices. Local farmers typically cultivate indigenous rice varieties and employ indigenous farming practices. According to WILDAYANA et al. (2017), most of local farmers behave as subsistent farmers. Subsistent farmers are lack of initiative and patience because they are always satisfied with their conditions, so changing their mindset for agriculture system is relatively difficult. Transmigrants, on the other hand, who come from different backgrounds, cultures, and agricultural lands, may use more diverse agricultural practices than locals. They attempt to strike a balance between their ancestral farming practices, indigenous techniques, and applicable modern farming practices. The transmigrants gradually influence local farmer mindset into more business-like farming. Therefore, the government has instituted an all-encompassing policy for the advancement of swampland development, without any regard to the ethnic backgrounds of the participating farmers. However, the involvement of migrant farmer in government pilot project was rather higher than the local.

5.1.5 Education and farming experience

Table 5.2 summarizes the farmers' educational and professional backgrounds. The average household head has only completed primary school. Farmers in swampland typology C have the most formal education (7.42 years), followed by farmers in typology A (5.90 years) and typology B (4.82 years). This finding implies that farmers have a low level of formal education. The low level of education significantly limits farmers' ability to understand and implement new technologies in agriculture (WILDAYANA et al., 2017) However, their standard deviation is high, indicating a wide range of formal education for the household head within the typology.

Table 5.2. Education and farming experience of the sample farm households

Items	All Samples	Swampland Typology			F-Test
		A	B	C	
Education of Household Head (year)	6.09 (2.88)	5.90 (2.46)	4.82 (3.33)	7.42 (2.31)	13.246*
Informal education					
Yes	32	2	28	28	
No	168	70	36	36	
Farming experience (year)	26.39 (10.68)	26.46 (12.47)	28.02 (8.51)	24.67 (8.71)	1.048
Farming experience in tidal swampland (year)	24.15 (0.99)	25.86 (12.47)	22.66 (8.51)	23.72 (7.99)	1.186

Note: The figure in the brackets represents the Standard Deviation
The dependency ratio is calculated by enumerating the number of elderly (male and female) (>65 years) and children ($\leq$15 year) divided by the household family size.
* significant at $\alpha = 5\%$
Source: Field survey (2014)

Informal education (farmer education program) is a government policy mechanism that aims to increase agricultural productivity while reducing environmental damage (FEDER et al., 2004). These farmer field schools (FFS) cover topics such as integrated farming, organic plant protection, and climate change. Previous studies in Asia and Africa, cited by FEDER et al. (2004), claimed that the FFS increased yield and profit while reducing pesticide use. According to the survey site, only 32 out of 200 farmers attended the FFS. The majority of FFS participants are migrant farmers from swamp typologies B and C.

Despite their lack of formal education, farmers have extensive experience in tidal swampland farming, having worked on average for more than 20 years. Farmers' experiences determine farmers' ability to manage the farm so that the probability of failure in agricultural activities can be minimized (WILDAYANA et al., 2016). Even though the variation within the type is considerably high, farmers in typology A are the most experienced (25.86 years), followed by farmers in typology C (23.72 years) and typology B (22.66 years). However, the F-test results show that this difference is not statistically significant.

5.1.6 Farmer affiliation

The farmer affiliation denotes the farmer's association with farmer organizations, extension services, research institutes, and credit institutions. It depicts their market access, information on new technology, and credit availability (cooperative). Table 5.3 depicts the farmer's interactions with various stakeholders. Farmers in typologies B and C are typically more interested in relating to the farmer group than farmers in typology A. It could refer to the ease at which members of the group can obtain subsidized fertilizer, government assistance, relaxed credit, and regular extension services. Meanwhile, farmers in Typology A, who use less fertilizer than the others, see joining farmer groups as less beneficial because it requires them to put more effort to regular group meetings and other group activities. This condition relates to the characteristics of the surveyed farmers as shown in Table 5.1.

Table 5.3. Selected farmer relations of the sample farm households

Items		All Samples	Swampland Typology			F-Test
			A	B	C	
Farmer group membership	Yes (%)	50.0	11.1	82.8	60.9	58.07*
	No (%)	50.0	88.9	17.2	39.1	
Extension service from government	Yes (%)	27.5	6.9	78.1	45.3	54.09*
	No (%)	72.5	93.1	21.9	54.7	
Extension service from research institute	Yes (%)	3.0	0.0	9.4	0.0	8.226*
	No (%)	97.3	100.0	90.6	100.0	
Access to credit	Yes (%)	42.0	0.0	78.1	10.9	135.28*
	No (%)	58.0	100.0	21.9	89.1	

Note: *significant at $\alpha = 5\%$
Source: Field survey (2014)

The typology A consisted of 100% local farmers, while typologies B and C also had some proportion of migrant farmers alongside the local ones. This composition results in varying acceptability of farmer affiliation among the various typologies. The government offices offer a free extension service. Because human resources are limited, the service is only available to members of farmer groups. Another limited service is provided by research institutions (for example, ISARI and AIAT), which have set up field experiments and demonstration plots. Table 5.3 shows that farmers in typology B are the most well served by government services, with 78.1% receiving a routine visit, while farmers in typology A receive the least (6.9 %).

The majority of the credits given to farmers to cultivate HYV of rice or oranges are subsidized by the government. As a result, the farming credit is only available to farmers in typologies B and C who would like to cultivate the selected crops.

5.1.7 Farmer mobility

The level of earned income from farming will affect farm household consumption. If the income is low, then the farmers will be encouraged to look for ways to gain additional income to meet household needs (WILDAYANA et al., 2016). Alternative income from outside the farming sector is recommended to stabilize household income, particularly when agricultural product prices are uncertain (WILDAYANA et al., 2017).

Table 5.4. The proportion of farmers who have activities outside their home village

Side jobs	All		Swamp Typology					
			A		B		C	
Hodging/ wood cutting	42	(21.00)	0	(0.00)	0	(0.00)	42	(65.63)
Daily worker*)	8	(4.00)	3	(4.17)	4	(6.45)	1	(1.56)
Miner	1	(0.50)	1	(1.39)	0	(0.00)	0	(0.00)
Fisherman	10	(5.00)	9	(12.50)	1	(1.61)	0	(0.00)
Construction worker	4	(2.00)	1	(1.39)	1	(1.61)	2	(3.13)
Motorbike transporter (*ojek*)	6	(3.00)	3	(4.17)	2	(3.23)	1	(1.56)

Note: Figures in the bracket are the percentage of farmers having activities outside their home village
*) Daily labor in plantation company, wood industry, or livestock enterprises
Source: Field survey (2014)

Farmer mobility is associated with farmers' efforts to support their income by working in other villages or nearby cities. The distance between the side-job location and their home ranges from half a kilometer to more than ten kilometers. Except for fishermen, who may spend two weeks on each sail, they commute daily.

They perform the work following the planting or harvesting season in their village. Table 5.4 shows the side activities that the farmers have engaged in. If the side-activity is more appealing than farming, it may have an impact on farmers' concerns about cultivating their own land.

Table 5.4 shows that hogging or wood cutting is a side activity for more than half of the farmers in typology C. Because their location is closer to the sea than the other typologies, approximately 12 % of farmers in typology A worked as fishermen.

5.2 Land resources

5.2.1 Land holding status

The land, waters, and natural resources contained therein are to be controlled by the nation and used for the benefit of the people, according to the Indonesian Constitution. Every Indonesian has the right to own a certain amount of land for their livelihood in order to achieve prosperity for its citizens. Several agricultural land rights are governed by the Basics of Agrarian Law (BAL). The right to ownership (*hak milik*) is the most powerful and timeless right. The property can be bought, sold, leased, mortgaged, or inherited. In addition, every citizen has the right to lease (*hak sewa*) and to open up the land (*hak membuka tanah*). The lease rights are agreed upon in a contract between the owner and lessee. In the case of an agricultural lease (*hak sewa pertanian*), the land must be used for agricultural purposes, and compensation is paid in cash or any other form. The government grants a few Indonesian citizens the right to use the land (*hak membuka lahan*) for clearing and using the land for a maximum of three cultivation periods (LOEFFLER, 1996). This right can later be transformed into the right to use (*hak pakai*), the right to exploit (*hak guna usaha*), or the right to ownership (*hak milik*).

The natives have been preparing the land for rice cultivation for hundreds of years. Swampland was considered undeveloped land at the time. People claimed as much land as they could under the unwritten rule of 'first come, first exploit.' They could afford a parcel of up to two hectares through traditional farming, depending on family labor availability and the sufficiency of their basic necessities (NOOR, 2012). Later on, the land became theirs, and they were able to pass it down to their heirs.

Fallow lands are considered "vacant" and "unused land" by the Indonesian government, and thus automatically belong to the government. The government can award or rent them to private companies, or it can allocate them to government projects like the migration program (LOEFFLER, 1996). The swampland was regarded by the government as unused land with the potential to feed the entire nation. Since 1950, the government has supported agricultural development by launching transmigration projects. Each farmer household receives two and a quarter hectare of land under the scheme. The two hectares of land will be used for agriculture, with the remaining portion for the house and garden. The first hectare (*Lahan Satu*) is close to the house and is usually planted with crops. The second hectare (*Lahan Dua*) is used for crops and plantations and is located 2-8 kilometers from the house (PERRY, 1985, LEIWAKABESSY, 1989, YANTI, 2002). After 15 years, the farmers can obtain full ownership.

The ownership acreage gradually changed over time. Some successful farmers increased their landholdings by buying or renting, whereas others saw their land shrink or even lose ownership (RINA, 2012). Only 29 farmers out of 200 in the survey were landless. As a result, they had to rent land for cultivation. The land tenure system in the region is typically based on a general arrangement in which the farmer, as lessee, pays or shares the harvest with the landowner. Typically, the landowner contributes no farming inputs.

The sampled farmers' land size was relatively small, with an overall average size of 1.76 hectare (standard deviation = 1.26) and a range of 0.28-12.00 hectares. Two cases were extremely valuable, with 12.00 and 8.00 hectares. As a result, the distribution of landholdings was positively skewed, as shown in Figure 5.1.

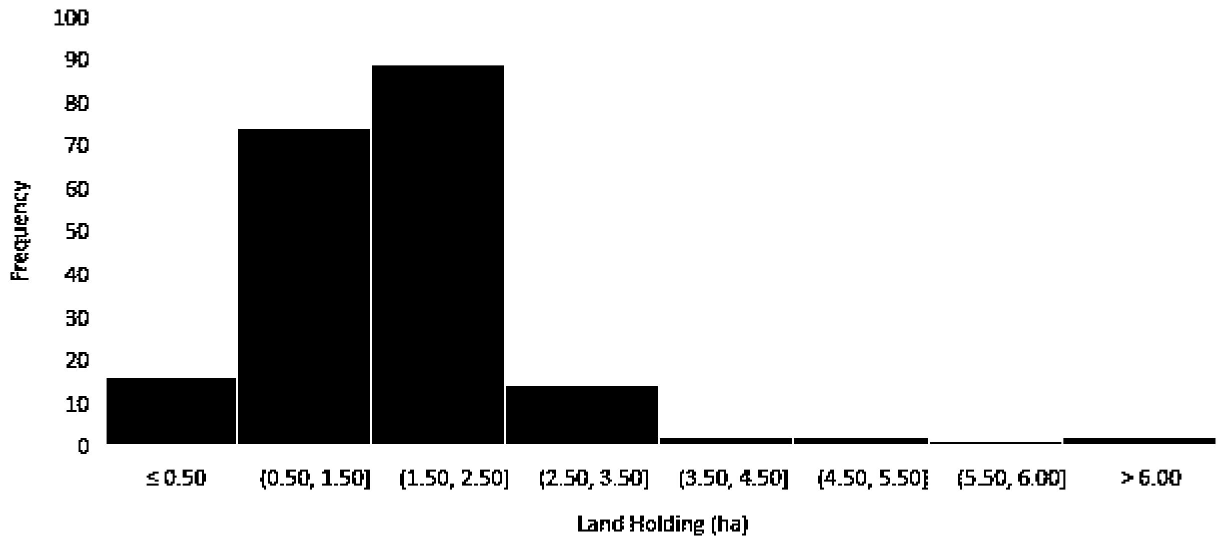


Figure 5.1. The distribution of landholding in the study area
Source: Own computation based on a field survey (2014)

The average size of land ownership and landholding in the three different typologies is depicted in Figure 5.2. The average area of landholding differs between swamp typology groups. Overall, farmers in type C held more land than their counterparts. Type C was dominated by transmigrant farmers. RINA (2012) confirmed this finding, discovering that successful transmigrant farmers tend to increase their landholding by buying or renting. According to RINA (2012), the average landholding increased from 2.18 ha in 2009 to 2.23 ha in 2011.

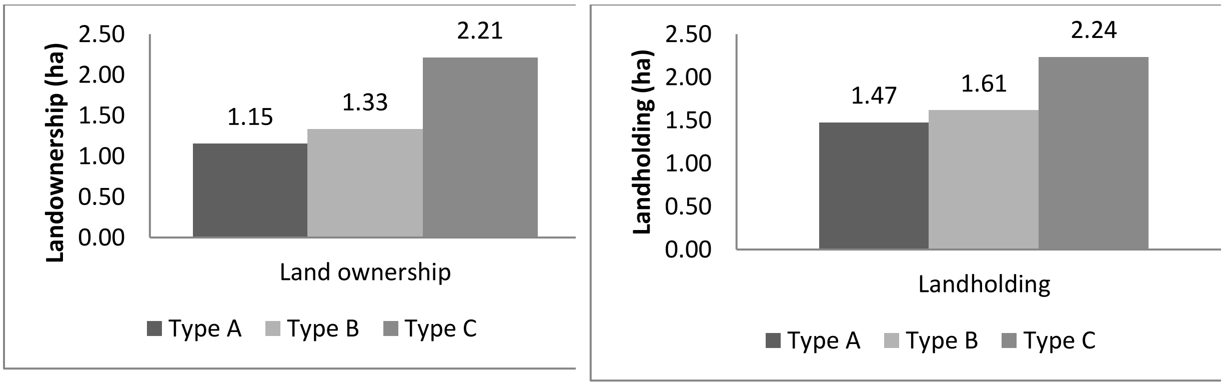


Figure 5.2. The average size of landownership and landholding of the respondents
Note: F – test: 14.142* and 7.344* for landownership and landholding, respectively (* significant at α = 5%)
Source: Field survey (2014)

Figure 5.2 also shows that farmers in tidal swampland type A had the smallest average landholding of 1.47 ha. Because of its proximity to the sea or major rivers, the soil is considered quite fertile, as regular water movement leaches toxic substances and brings organic matter from upstream. This alluvial soil is ideal for rice farming. The area is, however, prone to flooding during the wet season and seawater intrusion during the dry season. The farming activity stage (land preparation and planting) must be completed on time so that the paddy can tolerate the salinity; otherwise, the paddy will produce empty grain. As a result, the farmer only holds a relatively small area in order to match their family labor availability and ensure that the farming stages are completed on time.

Farmers can exceed the break-even point (BEP)[10] and the poverty line with that much rice farming acreage. According to CBS (2012), states that the minimum acreage areas for rice, maize, and soybean to reach BEP are 0.51, 0.41, and 0.46 hectares, respectively. The minimum acreages required to generate income equal to or greater than the poverty line is 0.65, 1.12, and 0.74 hectares, respectively.

5.2.2 Soil fertility

Soil fertility is critical for agricultural production and also contributes to land productivity. The use of swamplands for agriculture has had a significant impact on and changed the fertility of the soil. It has experienced land degradation and needs improvement (HAIRANI & NOOR, 2020). The soil type and compound, the

[10] BEP (Break-Even Point) is a condition where the farmer does not get any profit or experience any loss. In other words, the gross margin is equal to production cost.

presence (and depth) of pyrite, the distance to the main canal/river, and the typology all influence soil fertility in the swampland area.

Table 5.5. Farmer's appraisal of soil fertility

Farmer's perception of their land	All		Swamp Typology					
			A		B		C	
Fertile	71	(35.50)	63	(87.50)	7	(10.94)	1	(1.56)
Rather fertile	22	(11.00)	9	(12.50)	8	(12.50)	5	(7.81)
Moderate	106	(53.00)	0	(0.00)	48	(75.00)	58	(90.63)
Rather infertile	1	(0.50)	0	(0.00)	1	(1.56)	0	(0.00)
Total	200	(100.00)	72	(100.00)	64	(100.00)	64	(100.00)

Note: Figures in parentheses are the percentage
Source: Field survey (2014)

Farmers are generally aware of the presence of pyrite (also known as *racun tanah*, which translates to "soil toxin"), which causes high acidity in soil and water when exposed to air. The farmers' decision to build raised beds (sorjan system) is influenced by their knowledge of the depth of the *pyrite* layer. *Pyrite* exposure should be kept to a minimum to avoid an increase in acidity. To reduce acidity, more lime and manure are required. As a result, they developed land preparation practices such as omission or minimum tillage, managing water levels and circulation, and retaining plant residue as an organic source to avoid excessive *pyrite* exposure. Farmers, particularly those in typology C, must apply lime on a regular basis to reduce soil acidity.

The appraisal (Table 5.5) determines how farmers treat their land. Farmers with more fertile soil use less fertilizer and are often unaware of the importance of preserving soil fertility. This typical case was discovered in A farmer's typology. Their counterparts, on the other hand, tend to maintain the fertility of their land by adding extra chemical fertilizer, manure, and lime on a regular basis. The highest amount of fertilizer was used in typology C.

5.3 Household agricultural production

Because rice is the most important staple food for farmers and society, the government encourages increased rice productivity. Several assistance programs are available, ranging from agricultural extension to integrated farming and pest control field schools, seed and fertilizer credit, fertilizer subsidy, machinery assistance, and the most recent climate change adaptation field schools. Recognizing that farmers cannot rely solely on rice farming, the local government provides assistance in developing a variety of other commodities, including oranges and coconuts, to be intercropped with rice.

5.3.1 Crops production

The previous study by OTSUKA (2017) revealed that the types of varieties and the proportion of planting area in swamps varied depending on the type of swamp. Rice, particularly local varieties, is the main crop grown in the area. This plant was chosen for several reasons: (i) the cultivation technique has been passed down through generations; (ii) the varieties require less intensive care; (iii) the varieties have high adaptability to swamp ecosystems and high resistance to disease and pest attacks; (iv) the sales price is relatively higher compared to other seasonal crops; and (v) it is preferred by consumers (KHAIRULLAH et al., 2021b). However, local rice has a long planting season (8-10 months), and its productivity is low at around 2-2.5 ton per hectare (KOESRINI et al., 2021).

Several farmers grew HYV rice in typologies B and C. Farmers in typology A with tidal flats do not cultivate HYV, because waterlogging is impossible (FAHMID et al., 2022). Farmers in typologies B and C can achieve HYV yields of 1.72 and 2.27 tons per hectare, respectively (see Table 5.6). This low productivity is caused by several reasons. Most of farmers cultivate HYV such as IR-42 and *Ciherang* variety which has potency 3-5 tons per ha. Those varieties are, unfortunately, still prone to blast disease (*Pyricularia grisea*) and rat infestations (YASIN et al., 2020), as well as sparrow bird infestations. According to the experts' interviews, those HYV will reveal its potential of 3-5 tons per ha if the cultivation area is greater than 100 hectares in one area. If the cultivated area is less than the specified threshold, the remaining cultivated area will be vulnerable to severe pest attacks. Those drawbacks make the adoption of HYV is not a preferred choice among farmers. Farmers reluctantly cultivate HYV when they observe their neighbors refraining from its cultivation. Among the respondents, only 32 farmers in type B and 15 farmers on type C cultivated HYV of rice, with the majority were being participants in government agricultural projects. The genetic potential of this new varieties seems not to used sufficiently.

Table 5.6. The average of rice productivity (ton/ha)

Crops	All		Swamp Typology						F-test
			A		B		C		
Local Rice	2.86	(0.70)	3.28	(0.86)	2.55	(0.60)	2.71	(0.34)	26.397*
HYV	1.83	(0.81)	-	-	1.72	(0.67)	2.27	(1.16)	1.739

Note: Figures in parentheses are the standard deviation
* significant at $\alpha = 10$ %
Source: Field survey (2014)

IAARD has launched *Inpara* rice variety to tackle this problem. *Inpara* is a variety that is suitable for swampland environments but has a shorter cultivation period (115 to 135 days after sowing).

In terms labor use, HYV required more intensive labor during 100 days of cultivated period. According to Table 5.7, farmers require approximately 94 man-days per hectare on average. Typology A requires the most labor, followed by typologies B and C, which require 102.98, 98.34, and 81.89 man-days, respectively. Certainly, the cultivation of local paddy rice demands a greater amount of labor compared to HYV rice. However, it's important to note that this labor is spread over a period of 8-10 months, making it less labor-intensive when compared to the HYV counterpart. The high labor intensity associated with HYV cultivation often restricts farmers from engaging in additional side jobs.

Table 5.7. Labor needed to cultivate paddy rice (man-hours/ha)

Crops	All		Swamp Typology						F-test
			A		B		C		
Local Rice	94.00	(25.88)	102.98	(28.42)	98.34	(19.28)	81.89	(22.34)	14.878*
HYV	54.74	(28.62)	-	-	46.21	(22.09)	75.17	(39.24)	10.785*

Note: Figures in parentheses are standard deviation
* significant at α = 10 %
Source: Field survey (2014)

Even though the productivity was lower compared to their potency, the local and HYV rice farming is still financially feasible. Farmers obtained RCR[11] as high as 1.94, 1.40, and 1.57 from these yields for typologies A, B, and C, respectively (Table 5.8).

Table 5.8. Revenue Cost Ratio (RCR) of rice

Crops	All		RCR						F-test
			Typology A		Typology B		Typology C		
Local rice	1.65	(0.53)	1.94	(0.65)	1.40	(0.41)	1.57	(0.29)	22.547*
HYV rice	1.52	(0.56)	-	-	1.36	(0.44)	1.86	(0.65)	9.729*

Note: Figures in parentheses are standard deviation
* significant at α = 10 %
Source: Field survey (2014)

The government introduced and encouraged the cultivation of several secondary crops in 2000, including corn, soybeans, groundnuts, vegetables, and pulses. The production of those crops increased dramatically the following year (see Figure 4.9). However, due to market price uncertainty, changing environmental and climate patterns, and pest attacks, most farmers stopped cultivating those after a

[11] RCR (Revenue-Cost Ratio) is a ratio between revenue (gross margin) to production cost. It is usually used to assess financial feasibility of seasonal crops (SOEKARTAWI, 2002).

few years. Only a few farmers currently cultivate corn and vegetables in raised beds.

5.3.2 Perennial crops

Farmers are unable to sustain themselves if crops are their sole source of income (PERRY, 1985). Perennial crops provide the farmer with a relatively stable source of income.

On the raised bed, perennial crops such as orange, coconut, rambutan fruit, and banana are grown. Coconut is best suited to coastal and swamp typologies A and B, while orange is best suited to typologies B and C. Few farmers in typology C grow rambutan fruit because it requires drier land. Table 5.9 shows the productive perennial crops in each typology.

Perennial crops help farmers maintain their farming operations. However, the cultivation did not thrive due to the high cost of constructing raised beds and the scarcity of high-quality but affordable seeds. The investment budget for a hectare (200 trees) of orange cultivation was IDR 51.98 million, 38 % of which was allocated for land preparation, raised bed construction, and seed provision. After the fourth year, the oranges can be harvested. The benefit-cost ratio (BCR) is 2.95 after 16 years of cultivation at a 10 % interest rate; the net present value (NPV) is IDR 129.31 million; and the internal rate of return (IRR) is 28.12 % (Table 5.10).

Table 5.9. The average number of productive trees per household

Perennial crops	All		Swamp Typology					
			A		B		C	
Coconut	5.80	(17.50)	5.31	(40.28)	8.17	(9.38)	0.00	(0.00)
Rambutan fruit	5.07	(7.00)	0.00	(0.00)	7.00	(3.13)	128.18	(17.19)
Banana	8.31	(7.50)	4.74	(26.39)	2.00	(3.13)	17.07	(21.88)
Orange	139.47	(31.00)	0.00	(0.00)	180.67	(51.56)	92.59	(45.31)
Palm oil	122.83	(3.00)	4.50	(5.56)	0.00	(0.00)	357.50	(3.13)

Note: Figures in parentheses are the percentage of total sample households having productive perennial crops.
Source: Field survey (2014)

Coconut farming is not as extensive as orange farming. Because raised beds are built more simply and require less maintenance, the investment budget for each hectare (120 trees) is IDR 21.98 million, which is less than orange. However, coconut cultivation is less promising than orange cultivation. After the fifth year, the crops can be harvested. The BCR for 16 years at a 10 % interest rate is 2.12; the NPV was IDR 30.22 million, and the IRR was 24.54 % (Table 5.10).

Table 5.10. The BCR, NPV, and IRR of perennial crops in swampland areas during a-16-year period with the interest rate of 10 %

Perennial Crops	BCR	NPV (IDR million)	IRR (%)
Orange	2.95	129.31	28.12
Coconut	2.12	30.22	24.54

Source: Own calculation based on field survey data (2014)

5.3.3 Livestock and fishery

The average number of livestock per household for each typology is shown in Table 5.11. Livestock in rural areas contributes to household consumption, small cash income, draft power, and manure sources. However, livestock is uncommon in the swampland due to a lack of consistent freshwater and grass. During the dry season, most typology A areas' water becomes saline, and most typology B and C areas' water becomes extremely acidic. As a result, only a few farmers herd cattle and goats near freshwater sources. The *itik tambak petelur* (swamp laying duck) adapts well to its swampy surroundings. Table 5.11 explains the livestock contribution for each typology. It is raised by approximately 41 farmers (56.94 %) in typology A. During 300 days of traditional rearing, they can generate IDR 3.71 million (RCR = 1.82) per 25 ducks.

Table 5.11. The average number of livestock per household

Livestock categories	All		Swamp Typology A		Swamp Typology B		Swamp Typology C	
Cattle and goat	1.00	(1.50)	0.00	(0.00)	0.00	(0.00)	1.00	(1.56)
Chicken	16.67	(45.50)	8.05	(29.17)	27.50	(53.12)	11.47	(56.25)
Duck	18.44	(20.50)	18.44	(56.94)	0.00	(0.00)	0.00	(0.00)
Fish	237.00	(2.00)	0.00	(0.00)	237.00	(6.25)	0.00	(0.00)

Note: Figures in parentheses are percentage of the total sample household having livestock
Source: Field survey (2014)

Because the field is frequently flooded and the soil structure is fragile, fish farming is uncommon in typology A. As a result, specific embankment and dam construction should be planned, as well as intensive treatment to meet the challenges ahead. In exchange, some farmers go fishing in the river or along the coast to meet their protein needs and increase their family income. In Typology A, nine farmers out of 72 had a side job as fishermen. A few farmers in Typology B created an artificial pond by covering it with a plastic or tarpaulin shield. They raised catfish (*Clarias gariepinus* and *Pangasius sp.*), freshwater pomfret fish (*Colossoma macropomum*), and tilapia (*Oreochromis niloticus*). In a 3-month cycle, this aquaculture can generate a profit of up to IDR 5,000 per m^2 (RCR = 1.36) in a 3-month cycle. Other farmers go fishing and fish trapping, but they consider it's a recreational activity.

5.3.4 Plantation

Since 2002, the local government has invited private companies to invest in natural rubber and palm oil plants. As a result, the plantation area has increased significantly over the last ten years, as shown in Table 5.12.

Table 5.12. The land area of smallholding plantations in Barito Kuala

Year	Palm Oil (hectares)				Natural Rubber (hectares)			
	Immature plant	Plant produce	Not Produce	Total	Immature plant	Plant produce	Not Produce	Total
2008	286			286	1541	54	107	1702
2009	336		32	365	1470	164	25	1679
2010	450			450	1472	284	10	1701
2011	668	5	32	705	1787	231	32	2160
2012	1366	5	6	1377	1837	343	32	2216

Source: PLANTATION AGENCY OF BARITO KUALA (2013)

Later, in order to support the investments, the government established a competitive price market. Then, some farmers converted their rice plots to cultivate those commodities in the intention of achieving a higher and more consistent income.

Converting rice fields into plantations creates problems because food crop production may suffer. In 2008, an act was passed to limit conversion. Six of the respondents had previously planted palm oil, but not produced yet.

5.4 Household Income and Expenditures

5.4.1 Household income

Household income is the sum of farm, off-farm, and non-farm income. The details of those incomes are explained below.

5.4.1.1 Farm income

Farm income is the difference between farm output gross receipts and farm production costs. Apart from the main crops (local rice and HYV rice), perennial crops (coconut and orange), other crops, and livestock all contribute to farm income. Table 5.13 presents yield and price data for typologies A, B, and C to calculate farm output.

The farm output is calculated using an equation (5.1)

$$P_F = (Q_R * P_R) + (Q_C * P_C) + (Q_O * P_O) + (Q_L * P_L) \quad (5.1)$$

Where,

P_F farm output (IDR)

Q_R rice crop output (ton)

P_R rice unit price (IDR/ton)

Q_C perennial crop output (unit)

P_C perennial unit price (IDR/unit)

Q_O other crop output (ton)

P_O others crop unit price (IDR/ton)

Q_L livestock output (unit)

P_L livestock output unit price (IDR/unit)

Table 5.13. The average of main crops yields and prices in the different typology

Crop	Typology					
	A		B		C	
	Yield (ton)	Price (IDR/ton)	Yield (ton)	Price (IDR)	Yield (ton)	Price (IDR)
Local rice	3.23	4,736,430	2.73	4,122,590	2.71	4,947,500
HYV rice			1.72	5,743,750	2.05	5,090,910
Coconut	7.48	3,241,940				
Orange			16.38	3,742,420	7.48	5,162,070

Source: Field survey (2014)

Several cost-related components should be considered when calculating farm production costs. These components are described further below.

Land preparation cost. This cost was calculated using the traction cost for rice farming and the raised-bed cost for perennial crops. Land rent also contributes to this cost. Land rent should vary depending on the type of land and the crop. According to the field study, the land rent for rice in typology B is IDR 500,000/ha/year. However, data for types A and C were unavailable. Land rent data for orange and coconut farms also appeared. It was also unavailable because it requires a long-term rental, so it will be priced similarly to rice land rent.

labor costs. There are two kinds of labor (family and hired labor). Even if family labor is not paid, it is not considered a cost in developing countries. This custom is known as *Gotong royong* in Indonesian culture. The term of *Gotong royong* refers to the practice of villagers performing agricultural and other unpaid work for each other (BOWEN, 1986). In the basic model, both types of labor are considered labor costs, but in one scenario analysis, only hired labor is considered labor cost. Land preparation, sowing, weeding, applying fertilizer and insecticides, harvesting, threshing, and transporting crops are all labor costs. The yield is sold to the farmer's house by middlemen traders (village traders). Labor costs for perennial crops include labor for raised-bed maintenance, cleaning and tilting, holder fixing, fertilizer and pesticide application, and cutting. Harvesting is not included because it is performed by the middleman buyer.

Fertilizer costs. Fertilizer costs for major crops typically include urea (nitrogen) and mixed fertilizer (NPK).

Pesticide costs. Pests are a problem in tidal swamp farming. Insecticides, herbicides, and rodenticides are all included in the price.

Credit costs. The government provides credit in the form of subsidized fertilizer. The government provides assistance to obtain perennial seeds for perennial crops.

Other costs. Other costs in crop farming include lime to reduce acidity, organic fertilizer, advanced fertilizer, and others. Other costs for perennial crops include lime to reduce acidity, organic fertilizer, advanced fertilizer, holder maintenance, and manual pest control.

Therefore, the farm's production cost can be calculated as follows:

$$PCr_{c,s} = Landprep_{t,c} + seed_{t,c} + chemfer_{t,c} + orgfer_{t,c} + pesticide_{t,c} + labor_{t,c} + credit_{t,c} + other_{t,c} \quad (5.2)$$

Where,

$PC_{t,c}$	production cost of crop *c* in the growing season *t* (IDR/ha)
$Landprep_{t,c}$	land preparation cost of crop *c* in the growing season *t* (IDR/ha)
$rseed_{t,c}$	seed cost of crop *c* in the growing season *s* (IDR/ha)
$rchemfer_{t,c}$	chemical fertilizer cost of crop *c* in the growing season *t* (IDR/ha)
$rorgfer_{t,c}$	organic fertilizer cost of crop *c* in the growing season *t* (IDR/ha)
$rpesticide_{t,c}$	pesticide cost of crop *c* in the growing season *t* (IDR/ha)
$rlabor_{t,s}$	labor cost of crop *c* in the growing season *t* (IDR/ha)
$rcredit_{t,c}$	credit cost of crop *c* in the growing season *t* (IDR/ha)
$rother_{t,c}$	other cost of crop *c* in the growing season *t* (IDR/ha)

Table 5.14 shows the farm production cost of the main corps in the different swamp typologies.

Table 5.14. The farm production cost of the main crops (IDR per ha)

	Land preparation	Seed	Chemical Fertilizer	Organic Fertilizer	Pesticide	Others	Total Cost
Type A							
Local rice	350,000	50,819	131,505	0	74,972	137,816	745,112
Coconut	3,000,000	1,710,000	398,400	800,000	460,000	2,000,000	8,368,400
Type B							
Local rice	350,000	47,547	536,640	123,298	181,089	759,181	1,997,755
HYV rice	150,000	45,451	507,548	105,187	130,401	166,725	1,105,312
Orange	3,000,000	3,000,000	1,400,000	2,000,000	870,000	2,000,000	12,270,000
Type C							
Local rice	350,000	59,557	691,534	176,516	284,700	137,816	1,700,123
HYV rice	150,000	79,912	897,151	105,187	528,106	257,033	2,017,389
Orange	3,000,000	3,000,000	1,400,000	2,000,000	870,000	2,000,000	12,270,000

Source: Field survey (2014)

Farmers rarely cultivated other crops (*palawija*) intensively. Those crops are typically grown on raised beds as the farmer's land borders. They cultivate those with the remaining input (fertilizer, etc.) from the main crops. The farmer does not keep good records of his input usage.

Table 5.15. The income from other crops (*palawija*) (in million IDR)

Other crops	All		Swamp Typology					
			A		B		C	
Corn	0.66	(0.10)	-	-	-	-	0.66	(0.10)
Cassava	0.58	(0.18)	-	-	-	-	0.58	(0.18)
Vegetables	0.14	-	-	-	-	-	0.14	-

Source: Field survey (2014)

This condition is also seen in livestock, such as cows, goats, chickens, laying ducks, and fish. Farmers use kitchen waste and crop waste as fodder. Chickens and ducks are commonly reared in farmers' back yards. Table 5.16 shows the annual income from livestock based on the survey.

Furthermore, the farm income is calculated in terms of gross margin using equation (5.3).

$$GM = P_F - PCr \times Lt \tag{5.3}$$

Where Lt is total land used for farming. The results of this calculation are presented in Table 5.18.

Table 5.16. The income from livestock (in million of IDR)

Livestock	All		Swamp Typology						F-test
			A		B		C		
Cow/goat	8.00						8.00		
Chicken	1.02	(0.86)	0.37	(0.20)	1.84	(0.86)	0.60	(0.29)	59.023*
Duck	0.91	(0.72)	0.91	(0.76)	0.91	(0.36)	-	-	1.191
Egg (chicken/duck)	1.99	(1.68)	2.09	(1.73)	1.12	(0.81)	-	-	
Fish pond	3.79	(1.16)	-	-	3.79	(1.16)	-	-	

Note: Figures on parentheses are the standard deviation
* Significant at α = 5%
Source: Field survey (2014)

5.4.1.2 Off-farm and non-farm income

Farmers earned off-farm income by working on farms other than their own, while non-farm income came from non-agriculture jobs. Both of these jobs are in their hometown. Table 5.17 shows the income from off-farm and non-farm sources for various swamp typologies.

Table 5.17. The annual off-farm and non-farm income within the farmer's home village (in million IDR)

Income	All		Swamp Typology					
			A		B		C	
Off-farm	13.54	(7.11)	11.25	(11.59)	14.84	(6.94)	13.80	(2.89)
Non-farm								
- Kiosk	21.74	(16.37)	31.2	(13.57			7.56	(4.75)
- Motorbike transporter	14.33	(2.67)	20.00	(16.40)	5.20	(-)	15.60	(-)
- Handicraft	5.51	(8.88)			3.16	(1.46)	36.00	(-)
- Renting equipment	5.88	(3.52)	7.17	(2,92)	2.00	(-)		

Note: Figures on parentheses are standard deviation
Source: Field survey (2014)

The off-farm and non-farm income is calculated in equation (5.4)

$$I_{ONF} = I_{OF} + I_{NF} \tag{5.4}$$

I_{ONF} off-farm and non-farm income (IDR)

I_{OF} off-farm income (IDR)

I_{NF} non-farm income (IDR)

Then, the household income (I_H) is the summation of equations (5.3) and (5.4) as follows:

$$I_H = GM + I_{ONF} \tag{5.5}$$

Table 5.18 shows the average household income in Indonesian Rupiah (IDR) by swampland typology, calculated using season 2012/2013 prices. The percentage of farm income from crops and livestock is also shown. Farm income and family income make up the household income. Family income is derived from the income of all family members earned outside of their own farm (off-farm and non-farm). The average farm income and family income per year are 28.63 million IDR and 35.34 million IDR, respectively. The F-test reveals statistically significant differences in farm typologies. Farmers in swamp typology B have the highest income compared to the others, according to the swamp typology, because the majority of farmers in this typology have cultivated high-income perennial plants such as oranges.

Table 5.18. The average and share income of the farm household samples

Average	**All**	**Typology**			**F-test**
		A	**B**	**C**	
	Income per year (million IDR)				
Farm income	28.63	18.21	38.81	37.58	8.66**
	(30.31)	(15.83)	(38.35)	(30.51)	
Family income	35.34	26.78	42.74	33.71	4.82*
	(31.59)	(22.03)	(36.40)	(33.70)	
	Share of farm income (%)				
Local rice	73.70	88.89	51.22	79.09	38.17**
	(30.08)	(13.94)	(34.93)	(24.74)	
HYV rice	3.53	0.00	6.76	4.34	11.15**
	(10.76)		(11.70)	(9.19)	
Other crops (*palawija*)	0.10	0.00	0.06	0.24	0.03
	(0.55)		(0.24)	(0.92)	
Livestock & fishery	7.64	10.24	10.32	2.04	5.52**
	(14.63)	(13.66)	(20.07)	(4.01)	
Perennial	15.01	0.87	31.64	14.28	31.06**
	(26.36)	(2.96)	(32.50)	(24.88)	
	Share of family income (%)				
Farm	75.66	72.41	76.65	78.34	0.32
	(23.33)	(25.97)	(27.09)	(14.32)	
Off-farm	24.34	27.59	23.35	21.66	0.32
	(23.33)	(25.97)	(27.09)	(14.32)	

Note: Figures on parentheses are standard deviation
 * Significant at 10%
 **Significant at 5%
Source: Field survey (2014)

Table 5.18 shows the typologies' disaggregated farm and household income from various sources. Overall, local rice accounts for 73.70 % of farm income, followed by perennial crops (15.01 %), livestock and fishing (7.64 %), HYV rice (3.53 %), and other crops (0.10 %).

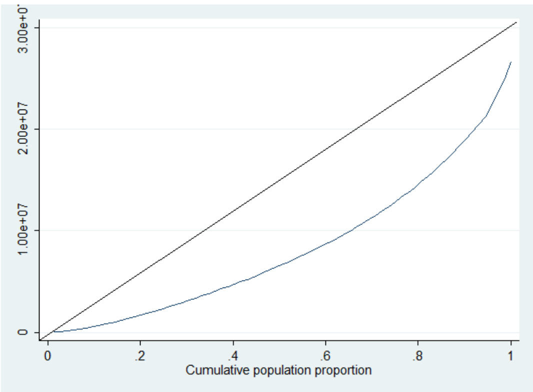
Table 5.18 also shows the trend of farm income in various typologies. Farmers in typology A focus on local rice because the variety of adaptable crops is limited. They raise swamp ducks, which are adapted to saline and waterlogged environments, to increase their income. Farmers in typologies B and C can grow perennial crops alongside rice. Perennial crops in typology B account for 31.64 % of farm income. Perennial crops such as oranges can significantly increase farm income with better management and farming techniques. In typology C, perennial crops have a high share. Despite a limited selection of adaptable crops, orange can be grown successfully by maintaining the water level and adding lime and organic fertilizer to reduce soil acidity.

Table 5.18 shows that 75.66 % and 24.34 % of the household income comes from on-farm and off-farm activities, respectively. The kiosk, motorbike transporter, handicrafts, and renting equipment generate the majority of the income from off-farm activities. The activities listed in Table 5.17 did not contribute to non-farm income because the farmers who did them considered them additional activities that were not on a regular schedule and yielded inconsistent results. As a result, they did not properly record the output.

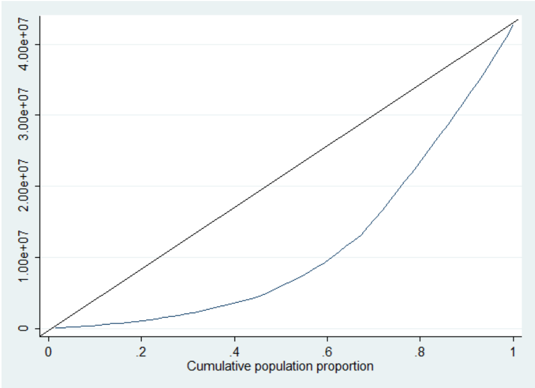
Table 5.18 shows the breakdown of household incomes by typology. The variation is statistically significant. Typology C had the highest agricultural contribution to family income (78.34 %), followed by typology B (76.65 %) and typology A (72.41 %). Farmers in typologies C and B are more concerned about their farm activities because they grow a variety of crops. Farmers in typology A, on the other hand, are less concerned with their farm activities. Farmers in typology A only plant local rice varieties that require little care, giving them more time to engage in off-farm activities such as farm labor on other farms or off-farm jobs.

The Gini index is a measure of income inequality. It assesses the degree to which an economy's income distribution among households deviates from a perfectly equal distribution. Lorenz curves plot the cumulative percentage of total income versus the total number of households, beginning with the lowest-income household (WORLD BANK DATA, 2015). Figure 5.3 depicts the curves.

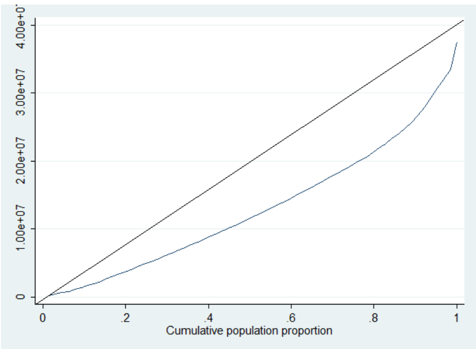
The Gini index of total income across typologies A, B, and C was 0.38, 0.47, and 0.31, respectively (Table 5.19). It means that income inequality was relatively high across all typologies. These ratios were in the middle of the country's level, which accounted for 0.41 percent (UNDP, 2020).



Typology A



Typology B



Typology C

Figure 5.3. The Lorentz curve of household income inequality in different tidal swamp typologies

Source: Own computation based on the field survey (2014)

Table 5.19 shows that the inequality was highest in typology B. It's for a variety of reasons. The selection of high-value crops is more variable than in other typologies. More than half of the farmers grow oranges, which increases their income significantly, while others continue to grow only local rice. This explains why the farm income Gini ratio in typology B is the highest. Second, there are numerous off-farm job opportunities. Most typology B areas are located near cities and business centers. While some farmers focus solely on farming, others work in non-farm businesses. The Gini index in typology C, on the other hand, is the lowest, indicating that income inequality in farm and off-farm income is the lowest. Most farmers rely solely on local rice farming activity due to a lack of crop varieties and off-farm opportunities.

Table 5.19. Gini ratios across tidal swamp typology

	Typology A	Typology B	Typology C
On-farm income	0.42	0.53	0.35
Off-farm income	0.67	0.72	0.40
Total income	0.38	0.47	0.31

Source: Field survey (2014)

5.4.2 Farm household expenditure

Figure 5.4 depicts the breakdown of household expenditures by cost items. Food expenditure accounts for 61 % of household expenditures, indicating the household's poor financial situation. The cost of energy (electricity, cooking fuel, and transportation fuel) accounts for 15% of total expenditure.

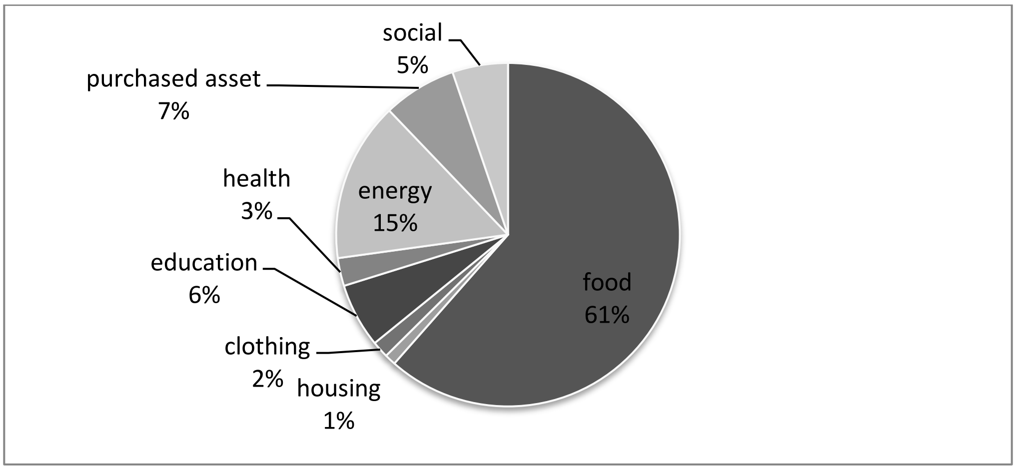


Figure 5.4. Household expenditure by cost item
Source: Field survey (2014)

Table 5.20 shows the expenditure for farmers in various typologies. Farmers in typology A spent more on food (63.1%) than farmers in typology C (62.7 %) and typology B (55.4 %). This pattern supports the hypothesis that lower-income households spend more money on food.

The second-largest expenditure category was energy. It includes the electricity bill, cooking fuel, and transportation. Rural areas' lack of public transportation contributes to the high cost of fuel for their motorcycles.

Table 5.20. The contribution of various cost items to total household expenditure (%)

Expenditure items	All	Swampland Typology			F-test
		A	B	C	
Food	60.4	63.1	55.4	62.7	7.505*
Housing	1.1	5.0	1.8	0.9	9.207*
Clothing	1.9	2.1	2.5	1.0	16.355*
Education	5.6	5.0	5.8	5.8	0.247
Health	2.8	2.7	2.8	2.9	0.318
Energy	15.6	15.1	16.1	15.6	0.237
Purchased asset	7.9	8.7	8.4	6.6	2.259
Social	4.8	2.9	7.3	4.5	23.370*

*Significant at 5%
Source: Field survey (2014)

6 MATHEMATICAL MODELLING OF A TIDAL SWAMPLAND FARM HOUSEHOLD

This chapter describes the mathematical programming model, which consists of equations and parameter models. In Chapter 5, the socio-economic data from different tidal swamp typologies (A, B, and C) served as the parameters for the mathematical programming model. The model's results, as well as further discussion of them, are also explained.

6.1 Mathematical programming model

A model is one of the most important tools for decision-making. A model is a simplified representation of the real world that is used to describe a particular problem (TENURE et al., 2013, STERMAN, 2000). Farm households in the agriculture sector face a complex problem related to integrating production, consumption, and labor allocation. They must carefully consider whether their production, consumption, and labor allocation can achieve maximum preference/utility within a budget constraint. Unlike a corporation, which seeks maximum profit, the goal of a farm household is to maximize utility.

Many empirical studies on socio-economic optimization in household farming systems have been conducted from various perspectives. In general, these studies employed linear programming-based household models. It addresses the problem of maximizing or minimizing a linear function with many constraints in the form of linear functions.

Previous research on crop allocation in various farming conditions has been conducted in a number of countries. FELIX et al. (2013) used a linear program to simulate the livelihood of a small farm in Zimbabwe. This model was developed to identify the best cropping patterns and crop enterprise combinations for maximizing income and sustainable production. ALLISON-OGURU et al. (2006) used linear programming in another study to determine the optimal crop mixture that would maximize farm enterprise in a different location. In terms of resource productivity and output, as well as profitability, mixed and intercropping are more advantageous than sole cropping. IGWE & ONYENWEAKU (2013) used a linear programming model to maximize gross margins from a variety of arable crop and livestock combinations in Nigeria. KARUNAKARAN et al. (2012) investigated the use of a bio-economic model to measure alternative cropping patterns, maximizing farmers' income while requiring less water, land, and causing less environmental damage. BHENDE & VENKATARAM (1994) investigated the effect of diversification (via dairying) on the level of income and magnitude of risk on dry land farms in an Indian study region. They modeled farming in dry land areas using time-series cross-section data. GYLES & MONTECILLO (1999) built a resource allocation model to maximize net income in an irrigated catchment case study in the Shepparton irrigation region using a linear programming model. DORWARD (1999) developed a peasant farm-household model in northern Malawi using a linear programming model for conditions involving embedded risk in peasant agriculture. WIDIATI (2006) used a linear programming model to investigate the best resource allocation for beef cattle farmers in Yogyakarta, Indonesia. She came to the conclusion that the model could identify the interrelationship of many farmers' activities in the beef cattle farming system. WU & LI (2013) examined land use modeling approaches for assessing the economic and environmental consequences of agricultural intensification. MELLAKU et al. (2018) assessed the impact of cropland allocation decisions on the performance of rural smallholder crop production systems in Abaro Kebele, Ethiopia, using a linear programming model.

All previous research focused on maximizing income under various conditions and constraints. They could optimize which conditions would result in the highest income. The linear programming mathematical model was used in this study to determine the optimum gross margin under limited resources in tidal swampland conditions and to simulate how crop price fluctuations affect gross margin fluctuations. Crop prices become the primary focus in this swampland area due to their high volatility in comparison to input prices.

6.2 Model description

A mathematical programming model was created to maximize farmers' gross margins in tidal swampland areas with limited resources.

Based on the prevailing water levels in fields (hydro-topography), the model is divided into three different tidal swamp typologies: type A represents deep flooding, type B represents medium flooding, and type C represents shallow flooding. Different farming techniques, cultivated crops/varieties, and input use result from these various typologies. These distinctions should be considered when determining the best land use for maximum gross margin.

The model's structure is the same for all typologies, but the activity level, available resources, and resource productivity vary by type. The model's primary and secondary data were derived from cross-sectional data collected during the field study and presented in Chapter 5. Only data from main crops (local and HYV rice) and perennial crops are used in the model (coconut and orange). Other crop income, livestock income, off-farm and non-farm income are not included in this model, but this information was used to calculate the farmer's capital capacity.

The crop calendar year is divided into two growing seasons: the dry season (locally known as *kemarau* season) from April to October and the rainy season (locally known as *hujan* season) from November to March. In the swamp area, the dry season is mostly rain-fed, and the rainy season is mostly tidal-irrigated. Rainy crops provide a significant portion of the cereal food supply. Rice is Indonesia's staple food. As a result, farmers grow rice in both seasons, along with other crops such as fruits and vegetables.

In this model, different varieties of rice crops in the rainy and dry seasons are considered by taking average data from the respondents. Rice production costs, yields, and prices are roughly the same for all varieties. Farming practices, such as natural variability and market differences, cause some differences. However, due to the insignificant difference between varieties, those are omitted from the model.

The variables in the model can be divided into two types. The given resources from primary and secondary data can be classified as exogenous variables, whereas the value of the variables generated by the model can be classified as endogenous variables. The analytical framework of the mathematical model is depicted in Figure 6.1. Table 6.1 also lists the endogenous and exogenous variables in the mathematical programming model.

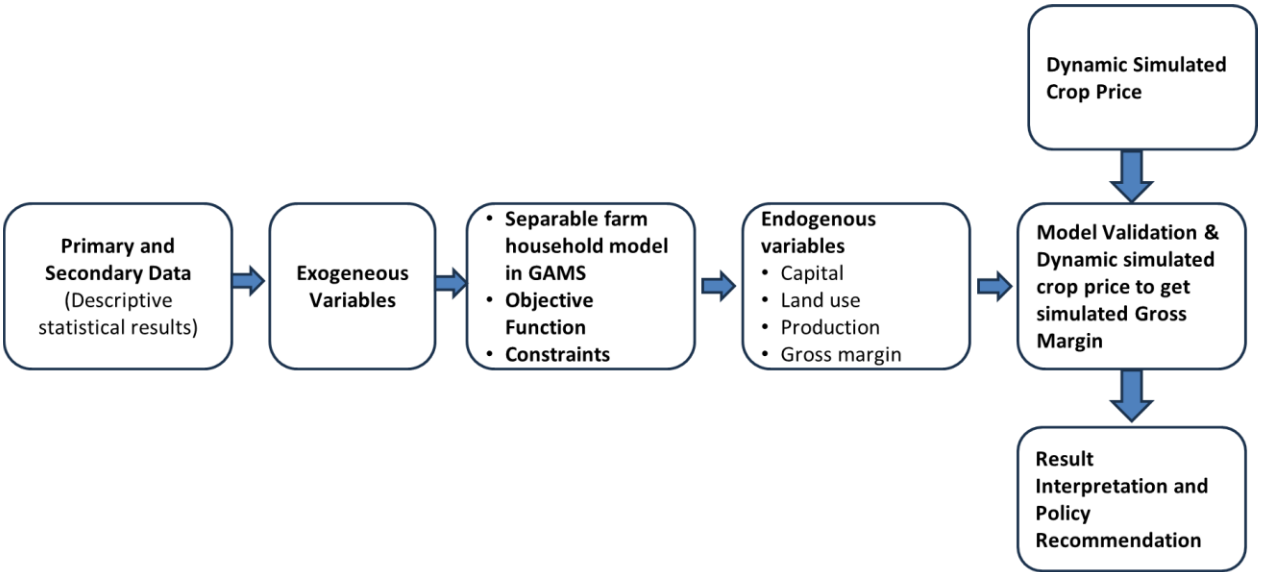


Figure 6.1. The analytical framework of the mathematical model
Source: Own depiction

Farmers have recently begun intercropping and gradually switching their rice fields to perennial crops such as orange and coconut. Farming perennial crops is a capital-intensive but profitable business. As a result, farmers who use their land for perennial crops are limited to rice farming. Although some farmers grow other crops (such as corn, cassava, and some vegetables), they are excluded from the model because they use insignificant amounts of land and rely on leftover inputs (such as fertilizer, etc.) and waste from the main crops.

Table 6.1. The list of endogenous and exogenous variables in the mathematical programming model

Variables	Interpretation	Equation symbol	Unit
Indices	Crops	c	
	Seasons	t	
Exogenous	Required commodities by the household	Commodities_req	ton per farm
	Maximum home supplied capital	avhcapital	IDR per farm
	Home supplied or credit in dry season	capital_nd_d	IDR per ha
	Home supplied or credit in rainy season	capital_nd_r	IDR per ha
	Capital requirement for crop farming	rcapitalc	IDR per ha
	Capital requirement for orange farming	rcapitalo	IDR per ha
	Credit used for farming	Implicit_credit	IDR per ha
	Chemical fertilizer cost	chemfer	IDR per ha
	Organic fertilizer	orgfer	IDR per ha
	Total labor used	tlabor	md per ha
	Hired labor used	hlabor	md per ha
	Family labor used	flabor	md per ha
	Total labor requirement in dry season	rlabord	md per ha
	Total labor requirement in rainy season	rlaborr	md per ha
	Hired labor wage rate for rice	wlaborri	IDR per md
	Hired labor wage rate for orange and coconut	wlaborro	IDR per md
	Yearly available family labor in dry season	avflabord	md per farm
	Yearly available family labor in rainy season	avflaborr	md per farm
	Interest rate for crop loan	cinterest	percent
	Land preparation cost	landprep	IDR per ha
	Land available for all crops farming	fsize	Ha
	Purchase of crop in the growing season	purch	
	Price of commodities	price	IDR per ton
	Yield of commodities	yield	Ton per ha

Table 6.1. Continued

Variables	Interpretation	Equation symbol	Unit
Endogenous	Gross margin from farming activities	gmargin	IDR
	Total revenue from farming activities	trevenue	IDR
	Total production cost from crops and perennial crops farming	tcost	IDR
	Income from farming and non-farming activities	income	IDR
	Labor cost in a year	labcost	IDR
	Crop credit cost in a year	crdcosts	IDR
	Total capital needed	tcapital	IDR per ha
	Land rent cost	landcost	IDR per ha
	Pesticide cost	perticide	IDR per ha
	Other cost	other	IDR per ha
	Seed cost	seed	IDR per ha
	Area of selected crop in the growing season	X	ha
	Objective function	Z	IDR

IDR=Indonesian Rupiah, ha=hectare, md=man-days

6.2.1 Objective function

Farmers cannot sustain if crops are their only source of income (PERRY, 1985). As a result, they are considering diversifying their cultivated crops in order to increase their family income.

Farmers are assumed to be rational, which means they make decisions solely to maximize their monetary utility and profits (AGUERRE & DENEGRI, 1996). Farmers, for example, tend to convert their land into orange, coconut, palm oil, or rubber plants, according to interviews conducted during the field study.

The objective function of the model is to maximize utility, which is defined as the expected total gross margin. The model was created to maximize crop farmers' gross margins in the region. The gross margin from each crop was the most important factor in crop selection. As shown in equations 6.1 and 6.5, the model's objective function was to maximize the gross margin.

$$gmargin_{t,c} = trevenue_{t,c} - tcost_{t,c} \text{ for all t,c} \quad (6.1)$$

$$trevenue_{t,c} = Qs_{t,c}price_{t,c} \text{ for all t,c} \quad (6.2)$$

$$tcost_{t,c} = mvcost_{t,c} + labcost_{t,c} + crdcost_{t,c} \text{ for all t,c} \quad (6.3)$$

$$mvcost_{t.c} = landprep_{t,c} + seed_{t,c} + chemfer_{t,c} + orgfer_{t,c} + pesticide_{t,c} + other_{t,c} \text{ for all t,c} \quad (6.4)$$

$maximize\ Z = \sum_{t=1}^{2}\sum_{c=1}^{n} gmargin_{t,c}X_{t,c}$ for all t,c (6.5)

where,

$gmargin_{t,c}$	gross margin of commodity c in the growing season t (IDR/ha)
$trevenue_{t,c}$	revenue of commodity c in the growing season t (IDR/ha)
$tcost_{t,c}$	production cost of commodity c in the growing season t (IDR/ha)
$Qs_{t,c}$	crops production which is sold (ton)
$price_{t,c}$	crops price (IDR/ton)
$mvcost_{t,c}$	monetary value of measured physical input cost in the growing season *t* (IDR/ha)
$labcost_{t,c}$	labor cost in the growing season *t* (IDR/ha)
$crdcost_{t,c}$	credit cost in the growing season *t* (IDR/ha)
$landprep_{t,c}$	land preparation cost in the growing season *t* IDR/ha)
$seed_{t,c}$	seed cost in the growing season *t* (IDR/ha)
$chemfer_{t,c}$	chemical fertilizer cost in the growing season *t* (IDR/ha)
$orgfer_{t,c}$	organic fertilizer cost in the growing season *t* (IDR/ha)
$pesticide_{t,c}$	pesticide cost in the growing season *t* (IDR/ha)
$other_{t,c}$	other cost in the growing season *t* (IDR/ha)
$X_{t,c}$	area of selected crop *c* in the growing season *t* (ha)
c	crop commodity (c = 1, 2, …, n)
t	growing season 1 1 = dry season; 2 = rainy season

6.2.2 Resource Constraints

To analyze land allocation decisions, the following constraints were included in the model:

1. Land Availability
   Farmers want to keep a certain amount of land for crop farming in both seasons to ensure that they have enough cereal food to eat. Figure 5.2 depicts the average land availability.

Land availability is fixed and limited for a specific period due to restrictions on opening new rice fields. Furthermore, because of the swampland nature, it took several years for the newly opened land to be productive after several cycles of acid leaching. This limitation restricts crop cultivation to the amount of land available on the farm.

According to equation 3.2, the amount of land used should not exceed the amount of land available. This restriction is stated as follows:

$$\sum_{c=1}^{n} X_{t,c} \leq fsize_t \text{ for all t} \quad (6.6)$$

Where,

$X_{t,c}$	area of selected crop *c* in the growing season *t* (ha)
$fsize_t$	total land available for crop *c* (ha)

2. Labor Capacity
Family labor and hired labor are the two types of labor. Family labor is not compensated in developing countries. Furthermore, *Gotong royong* is a tradition in Indonesian culture. *Gotong royong* refers to the practice of villagers performing agricultural and other unpaid work for one another (BOWEN, 1986). Land preparation, sowing, weeding, applying fertilizer and insecticide, harvesting, and transporting crops are all examples of labor use. The crop is typically sold to a middleman trader (village trader) who visits the farmer's home. Labor costs in perennial cases include labor for raised-bed maintenance, cleaning and tilting, holdering, fertilizer and pesticide application, and cutting. Harvesting is excluded because it is carried out by the middleman buyer.

Family labor capacity ($flabor_{t.}$) is determined by the number of family members who farm and the number of working days available (260 days per year or 130 days per season, on average). The amount of labor used should not be greater than the family's labor capacity. The labor capacity is calculated using equation 3.2 as follows:

$$\sum_{c=1}^{n} tlabor_{t,c} X_{t,c} - hlabor_{t,c} \leq flabor_t \text{ for all t,c} \quad (6.7)$$

Where,

$tlabor_{t,c}$	labor used for crop *c* in the growing season *t* (md/ha)
$X_{t,c}$	area used for crop *c* in the growing season *t* (ha)
$hlabor_{t,c}$	hired labor for crop *c* in the growing season *t* (md/ha)
$flabor_t$	family labor capacity in the growing season *t* (md/ha)

3. Capital Capacity
   Farmers own capital capacity, which is typically used to fund farming activities. If this capital is insufficient to cover all of the crops' production costs, they will generally receive funding from agricultural credit. The capital constraint is expressed as follows in relation to equation 3.2:

$$\sum_{t=1}^{2}\sum_{c=1}^{n} tcost_{t,c}X_{t,c} - Cr \leq capital\_nd \text{ for all t,c} \quad (6.8)$$

Where,

$tcost_{t,c}$	production cost of crop c in the growing season *t* (IDR/ha)
$X_{t,c}$	area used for crop *c* in the growing season *t* (ha)
$capital\_nd$	home supplied operating cost (IDR/ha)
Cr	credit capacity (IDR/ha)

4. Home Consumption
   Home consumption is part of the agricultural yields consumed by households (own consumption). The consumption may exceed the household's own production, so the household needs to purchase additional food. This constraint is expressed as follows:

$$\sum_{c=1}^{n} yield_{t,c} + \sum_{c=1}^{n} purch_{t,c} \geq commodities\_req_{t,c} \text{ for all } t \quad (6.9)$$

Where,

$yield_{t,c}$	total production of crop *c* in the growing season *t* (ton)
$purch_{t,c}$	purchase of crop *c* in the growing season *t* (ton)
$commodities\_req_{t,c}$	home consumption of crop *c* in the growing season *t* (ton)

5. Interest rate of credit: perennial farming is capital intensive farming. A significant portion of the funds are required to purchase seed, raised-bed establishment, lime, and organic fertilizer. In this case, farmers may receive credit from the dealer in exchange for a higher price for purchased goods. The extra cost is determined by the interest rate.
6. Market price: the market price is constantly fluctuating, but it is increasing.
7. Production: Production yield varies year to year, but the farmer cannot actually remember the exact yield for the last 3 years. As a result, the model used the average value of the most recent harvest prior to the survey. The assumption is that the production function is linear.

$$Qm_{t,c} = X_{t,c}Yield_{t,c} \text{ for all t} \quad (6.10)$$

Where, $Yield_{t,c}$ is the production yield of crop c in the growing season t (ton/ha). This $Qm_{t,c}$ will be divided into $Qs_{t,c}$ which is sold and $Cons_{t,c}$ that is consumed by the farmers themselves. Therefore, the one that is put in the Gross Margin equation is only $Qs_{t,c}$, as shown in equation 6.2.

Three sets of average data parameters from three different farming typologies are presented in Appendix 3.

6.2.3 Prediction of simulated crops price

The steps for simulating crop prices were developed using stochastic simulation in MS Excel and GAMS ver.25.1. Using the subject's random distribution, repeated simulations with different values were performed in this stochastic simulation. First, random numbers were generated based on time series data of output prices.

Table 6.2 displays the prices of main crops as reported by the South Kalimantan Agricultural Agency. This data was used as the basis of the model simulation.

Table 6.2. The price of rice, orange, and coconut (Million IDR/ton) in South Kalimantan

Year	HYV Rice	Local Rice	Orange	Coconut
2009	3.40	4.11	3.54	2.48
2010	5.09	6.09	3.69	3.88
2011	4.74	5.25	3.76	5.98
2012	4.07	4.70	3.74	3.83
2013	4.99	5.67	3.88	3.24
Mean (μ)	4.46	5.16	3.72	3.88
St. Dev (SD)	0.71	0.78	0.12	1.30
Coeff. of Variation (CV)	0.16	0.15	0.03	0.34

Source: SOUTH KALIMANTAN AGRICULTURAL AGENCY (various years).

Table 6.3 depicts the existing output price correlation of South Kalimantan's main crops (HYV and local rice) and perennial crops (orange and coconut). Both HYV and local rice prices have a strong positive correlation. Typically, fluctuations in the local rice price are followed by fluctuations in the HYV price, or vice versa. On the other hand, the prices of the perennial crops have a weak correlation with the rice price (see Table 6.3).

Second, Cholesky Decomposition is used to generate the predicted prices based on the random numbers. According to SHIROTA et al (2016) Cholesky Decomposition is used to efficiently simplify linear algebra. It guarantees the positive definiteness of the covariance matrices in the stochastic volatility model application.

Table 6.3. The correlation of existing output price in South Kalimantan

	HYV Rice	Local rice	Orange	Coconut
HYV Rice	1.00	0.97	0.74	0.47
Local rice		1.00	0.60	0.33
Orange			1.00	0.37
Coconut				1.00

Source: Own computation, 2020.

The generated simulated prediction prices were then used in the next run. Figure 6.2 depicts a flow chart of the steps:

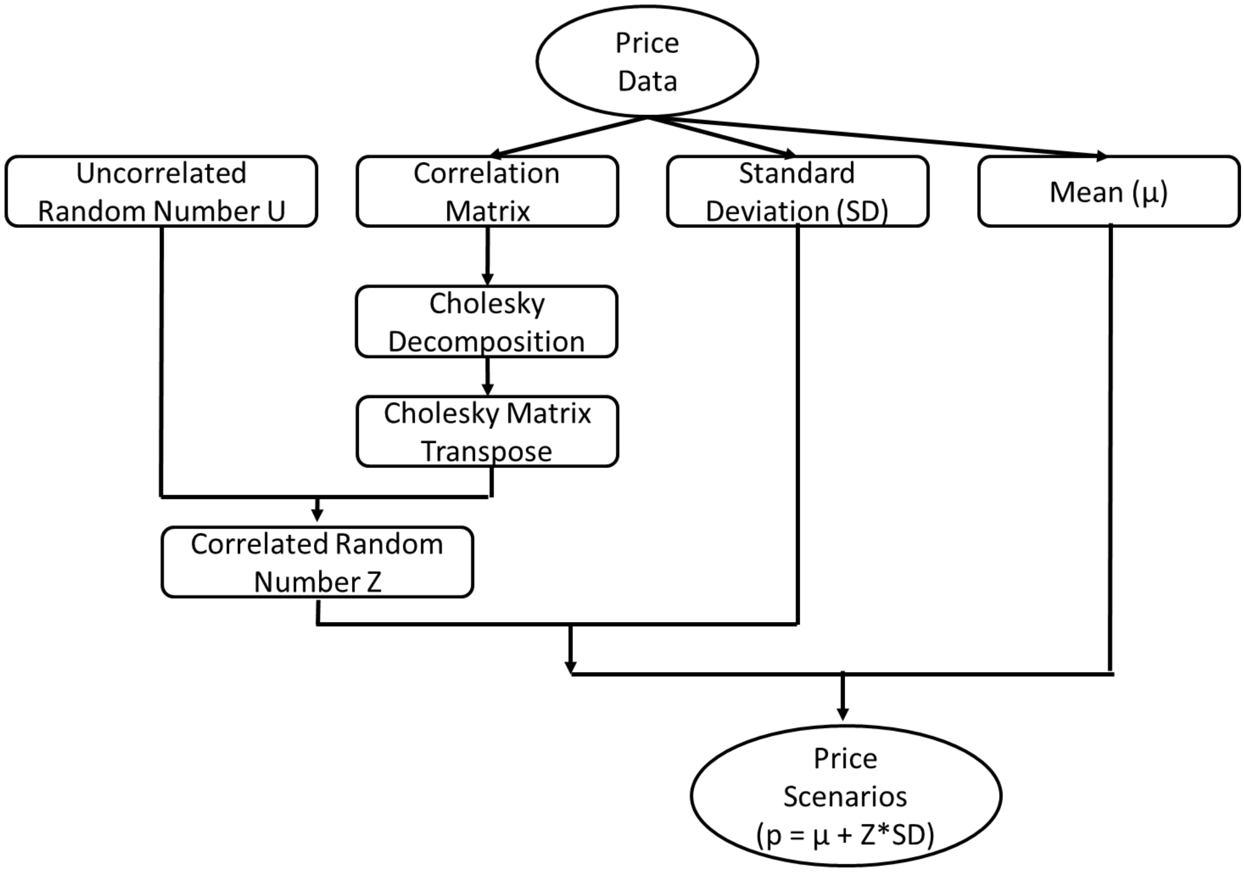


Figure 6.2. Steps in determining the simulated prediction crops price
Source: Own depiction

The price data used in this step is presented in Table 6.2, while uncorrelated and correlated random numbers are presented in Appendix 4. The simulated predicted crop price for gross margin simulation modeling is then shown in Figure 6.3 and Appendix 4.

6.3 The modelling results

The results of the mathematical programming model are presented in this section. The model assumes utility maximization within the constraints. The previous section describes the model's description and parameters (section 6.2). The model produces the optimum results for the three types of tidal swampland. Moreover, the model validation and its limitations are discussed. Furthermore, gross margins are simulated as a result of crop price fluctuations for each typology.

6.3.1 The model's base solution (optimum) result

The optimum model results, as shown in Table 6.4, show that farmers in typology B had higher gross margins, followed by farmers in typologies C and A. Typologies B and C, on the other hand, required more capital. Perennial crops such as orange in typologies B and C and coconut in typology A are the main sources of income for farmers.

Table 6.4. Base solution (optimum) level

	Swamp typology A	Swamp typology B	Swamp typology C
Capital needed (IDR)	2,846,536	3,357,114	3,112,534
Land use (ha)			
- Local rice	0.341	0.141	0.384
- HYV rice	-	0.141	0.384
- Orange	-	1.196	1.185
- Coconut	1.129	-	-
Production (ton)			
- Local rice	1.10	1.13	1.04
- HYV rice	-	0.71	0.79
- Orange	-	19.59	13.885
- Coconut	8.44	-	-
Gross Margin (IDR)	22,140,160	64,599,440	54,614,170

Source: Field survey (2014)

Furthermore, Table 6.4 shows that swamp type B has higher rice farming productivity, both for local and HYV rice and orange cultivation. This is due to lower land use but higher production when compared to other swamp types.

Table 6.5 depicts total labor, which includes hired (non-family and paid) and unpaid family labor. In both the rainy and dry seasons, family labor dominates labor use in the area. Because hired labor is limited and expensive, it is usually only used to meet labor needs.

Table 6.5. Base solution of labor use in various swamp typologies

Swamp typology	Labor	Dry season (man-days)	Rainy season (man-days)
A	Total Labor	50.264	16.942
	Hired Labor	11.090	5.647
	Family Labor	39.174	11.294
B	Total Labor	61.865	54.923
	Hired Labor	19.548	18.17
	Family Labor	42.317	36.753
C	Total Labor	79.919	84.469
	Hired Labor	22.204	22.400
	Family Labor	57.715	62.069

Source: Field survey (2014)

6.3.2 Model validation

Model validation is carried out in this study by comparing model results to real-world values. For the real values, the observed data from the field study is acceptable, while the optimum solution from the predicted model results is used as the model results. The percentage absolute deviation (PAD) is a straightforward measurement for assessing model fitness. Although the value of PAD cannot prove the model's acceptance or rejection, it can provide an overview of the differences discovered between the predicted model and field study results (IBRAHIM, 2013).

This study's model validation results are presented in Table 6.6. The outputs and inputs used for crop cultivation are included in the results. The inputs are capital and land use for both the main and perennial crops. While the outputs are crop production and the farm's gross margin.

The comparison of model results and field study data is shown in Table 6.6. In general, the amount of capital used in the model was higher than the existing (field study), particularly at swamp types A and B. It was, however, only slightly higher in type C.

Due to rice's role as a staple food in this area, farmers in all swamp types allocate the majority of their land to main crops (local and HYV rice) rather than perennial crops (as shown in Table 6.6). However, Table 6.4 shows that perennial crops were more productive in tidal swamp areas than local and HYV rice. Thus, it can be concluded that farmers in all tidal swampland typologies obtained lower gross margins than the model's optimum value.

Table 6.6. Model results and their PAD

	Swamp typology A			Swamp typology B			Swamp typology C		
	Model	Existing	PAD*	Model	Existing	PAD*	Model	Existing	PAD*
Capital used (million IDR)	2.85	1.42	100.70	3.36	1.36	147.06	3.11	2.75	13.09
Land use (ha)	1.47	1.47	0.00	1.48	1.60	7.63	1.95	2.21	11.63
- Local rice	0.34	1.37	75.11	0.14	0.33	56.62	0.38	0.87	55.61
- HYV rice	-	-	-	0.14	0.33	56.62	0.38	0.87	55.61
- Orange	-	-	-	1.20	0.95	25.89	1.19	0.48	146.88
- Coconut	1.13	0.10	1,029.00	-	-	-	-	-	-
Production (ton)									
- Local rice	1.10	1.11	1.27	1.13	0.36	209.82	1.04	1.04	0.04
- HYV rice	-	-	-	0.71	0.24	192.55	0.79	0.79	0.15
- Orange	-	-	-	19.59	19.60	0.04	13.89	8.87	56.57
- Coconut	8.44	6.75	25.04	-	-	-	-	-	-
Gross Margin (million IDR)	22.14	18.21	21.58	64.60	38.81	66.45	54.61	37.58	45.32

*PAD = Percentage Absolute Deviation by comparing the optimum model solution against the existing value (from field survey)

Source: Field survey (2014)

6.3.3 Gross margin simulation with crop price fluctuations

The price was considered and treated as stochastic parameters in the simulation of the gross margin procedure, which means it will be unknown in the future. The price level in this case is random. It is assumed that the farmers expect the result to be the average price, but they might be surprised by the price fluctuation.

Repeated simulations with different values generated using the random distribution were used in this stochastic simulation. Subchapter 6.2.3 explains the steps (Figure 6.2). In this study, 100 runs were generated by correlating a vector of uncorrelated random numbers using the Cholesky decomposition. Vectors of simulated product prices were generated as a result of this step. The calculation of these steps for all crops is listed in Appendix 4.

Then, the simulated prices for all crops are shown in Figure 6.3. This figure presents the price histograms of the main and perennial crops. The normality test using the Kolmogorov-Smirnov method with the $\alpha = 5$ %, shows that the crop prices are normally distributed. Figure 6.3 also depicts the price volatility for the crops studied. The statistical analysis in Table 6.7 confirms these findings.

Table 6.7. The statistical parameters of simulated crop prices (in million IDR/ton)

Price	Mean	Standard Deviation	Minimum	Maximum
Local Rice	5.18	0.76	3.05	6.90
HYV Rice	4.46	0.72	2.55	6.16
Orange	3.71	0.12	3.47	4.00
Coconut	3.87	1.39	0.67	8.72

Source: Own calculation, 2021

The simulated crop prices show almost the same values compared to the observed crop price distribution listed in Table 6.2. This result validated the simulated crop prices that have been generated by assuming the input price data is normally distributed.

Furthermore, Figure 6.3 shows a correlation between the prices of HYV and local rice. As shown in Table 6.8, the correlation between the two prices is high at 0.98. The prices of perennial crops, on the other hand, have a weak correlation with the price of rice.

Table 6.8. Simulated price correlation of the main and perennial crops in South Kalimantan

	HYV Rice	Local rice	Orange	Coconut
HYV Rice	1.00	0.98	0.66	-0.004
Local rice		1.00	0.66	-0.005
Orange			1.00	0.16
Coconut				1.00

Source: Own computation, 2021

According to crop prices, the simulated price of oranges was the most stable among the others. The orange price had the lowest standard deviation and the narrowest price range when compared to other crops. In comparison to the others, the simulated price of coconut was the most volatile. This result is supported by the wider simulated coconut price interval and the highest standard deviation when compared to the simulated prices of HYV rice, local rice, and orange.

Furthermore, it is assumed that the farmers' 100 simulated crop prices generated by the GAMS solver were entered into the gross margin equation to calculate the simulated gross margin for each swampland typology. Figure 6.4 depicts the outcomes of these steps.

Figure 6.4 shows the farmers' gross margins for each typology. Farmers in type B earned the highest gross margins, followed by farmers in types C and A. This figure reveals that the gross margin fluctuation in type A is greater than that in types B and C, owing to the higher crop price fluctuation in type A (Figure 6.2). Table 6.9 shows the statistical analysis of these results.

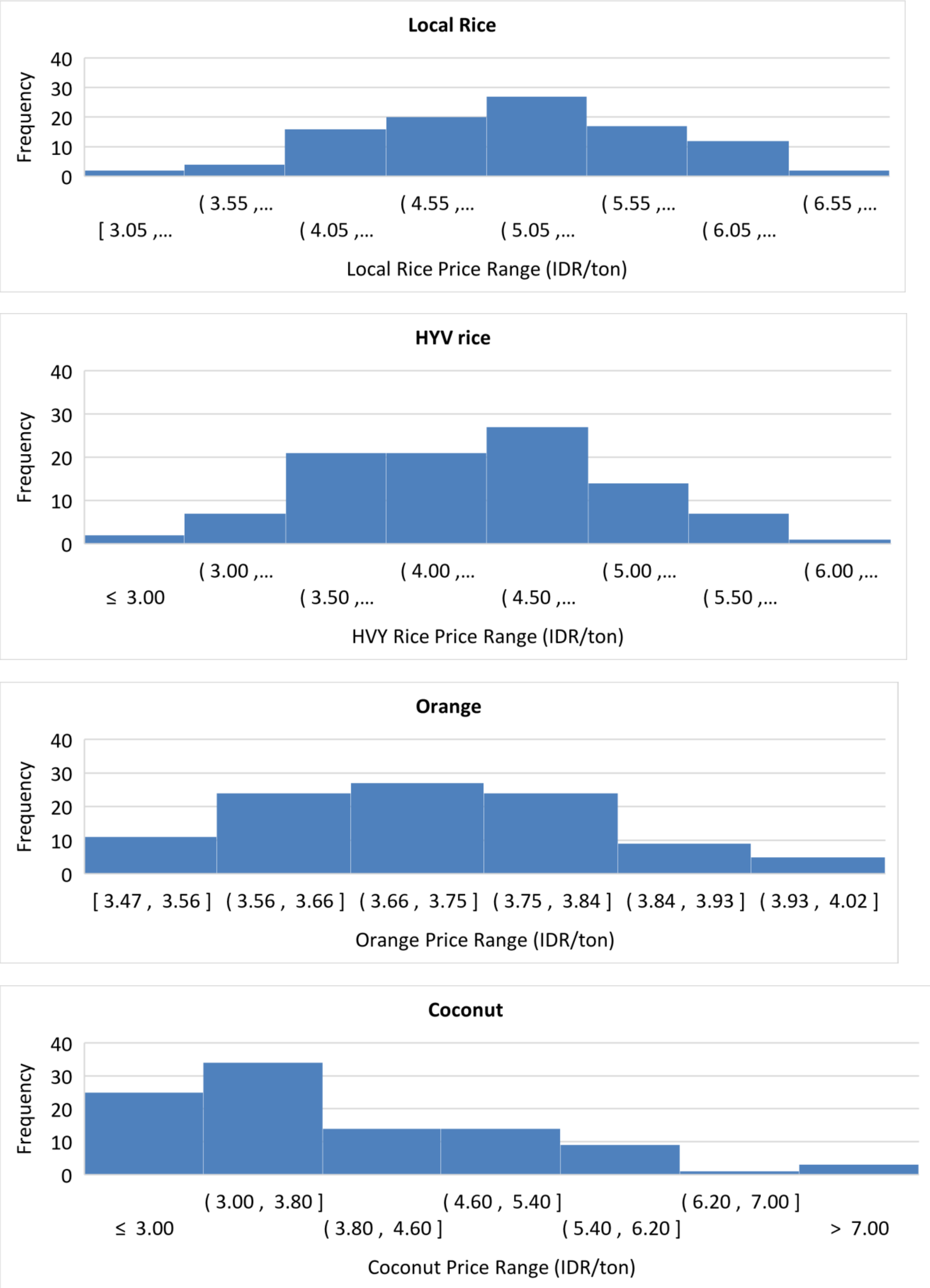


Figure 6.3. Histograms of price change of the crops
Source: Own calculation, 2021

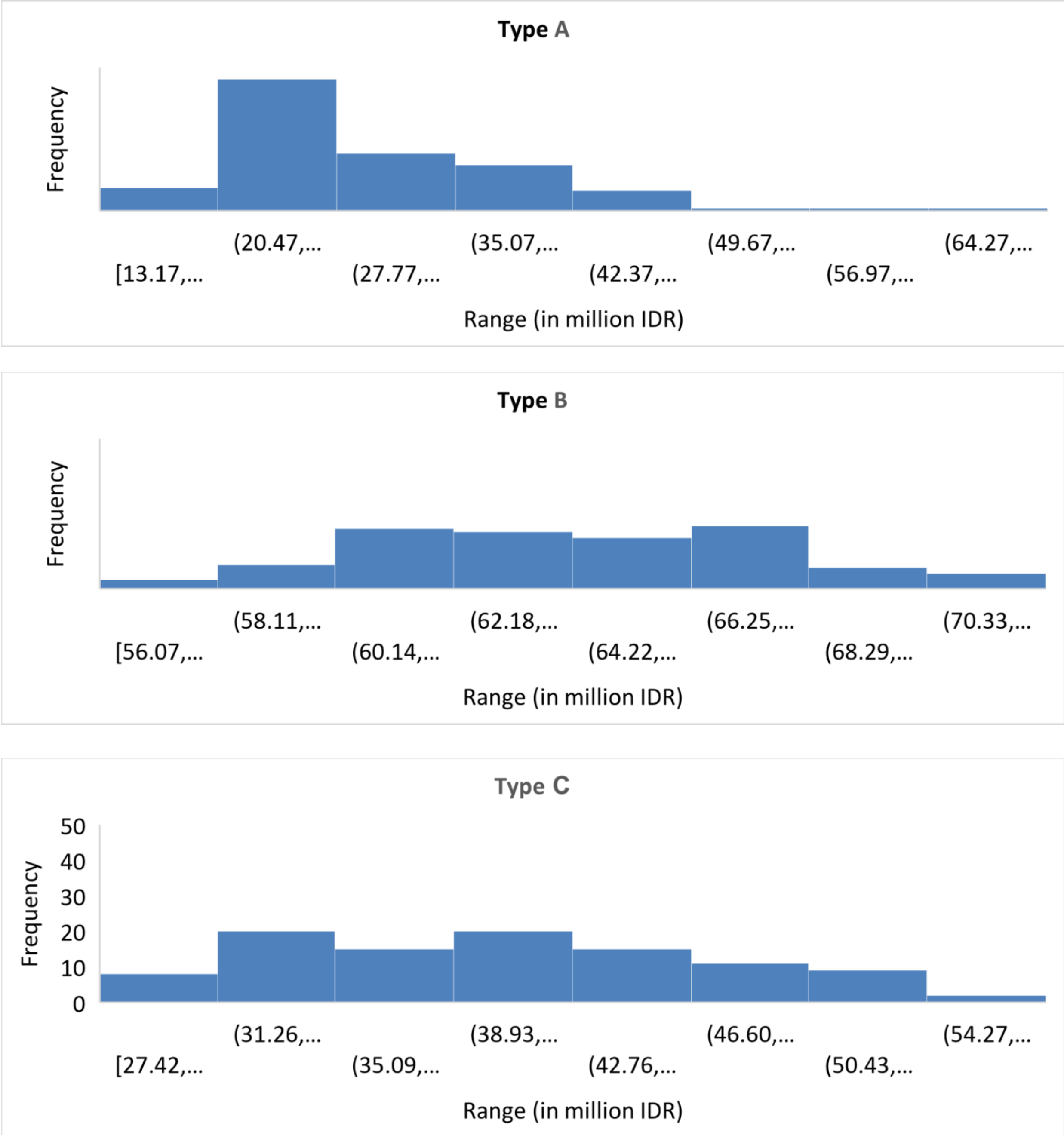


Figure 6.4. The gross margin distribution of farmers for each typology of swampland
Source: Own calculation, 2021

Table 6.9. The statistical parameters of simulated gross margin (in million IDR) for various typologies

Gross Margin	Optimum solution model	Mean of Simulation Run	PAD*	Standard deviation	Minimum	Maximum
Type A	22.14	30.17	36.27	9.68	13.17	69.54
Type B	64.60	64.33	0.42	3.49	56.07	72.36
Type C	54.61	40.48	25.87	7.07	27.42	58.10

*PAD = Percentage Absolute Deviation by comparing the optimum solution against the mean simulation run result.

Source: Own calculation, 2021

Table 6.9 shows that, in addition to having the highest gross margin, swampland type B also had the most stable gross margin when compared to types A and C. The smallest PAD between the optimum solution and the mean of simulation confirms this. This result is further supported by the fact that it has the lowest standard deviation and the narrowest gross margin range. Table 6.10 also shows the fluctuation of crop prices (the main and perennial crops) and farmers' gross margins for different typologies.

Table 6.10. The percentage of fluctuation of crops's price and gross margin

	Mean of simulation run	Standard deviation	Coefficient of variation
Crops:			
Local Rice	5.18	0.76	14.67
HYV Rice	4.46	0.72	16.14
Orange	3.71	0.12	3.23
Coconut	3.87	1.39	35.92
Gross Margin:			
Type A	30.17	9.68	32.08
Type B	64.33	3.49	5.43
Type C	40.48	7.07	17.47

Source: Own computation, 2021

Table 6.10 shows that the coconut price fluctuated the most, followed by HYV rice, local rice, and orange. The price histogram in Figure 6.3, as well as the statistical analysis in Table 6.8, support the findings. Table 6.10 shows that among the swamp typologies, farmers in type A experienced the greatest variation in gross margin coefficient of variation. Type B farmers, on the other hand, had the lowest gross margin fluctuation. This outcome is consistent with the gross margin distribution shown in Figure 6.4 and the statistical analysis in Table 6.9.

6.4 Discussion of the modelling results

This section discusses the modelling results that are presented in Section 6.3. The discussion is divided into two subsections. First, the optimum model results in terms of the optimum gross margin obtained by farmers in all tidal swampland typologies are discussed, and then the simulation of gross margin gained by farmers in each typology under crop price fluctuation is also discussed.

6.4.1 The model's base solution (optimum) result

Previous research by ALLISON-OGURU et al. (2006) and IGWE & ONYENWEAKU (2013) discovered that mixed and intercropping are more advantageous than sole cropping in terms of resource productivity and output, as well as profit obtained. This has been particularly the case in most of Africa, Asia, and Central America. FAHRI et al. (2021) stated that in swampland farming, farmer income is inadequate if it only relies on rice as a commodity due to its low productivity. Thus, rice diversification with secondary crops or by fisheries and livestock could increase farmers' income. This finding is supported by the current study. More crops were grown, resulting in increased income for farmers. It is because farmers will be able to reduce the high risk of crop failure since they still get income from other crops (YULIANI & NAPISAH, 2020). It is in agreement with WILDAYANA et al. (2017) who observed the farmers' household income in South Sumatra wetlands. A previous study conducted by SULAIMAN et al. (2019) discovered that mixed orange and coconut with rice farming resulted in the higher farmer income rather than solely cultivating rice. Furthermore, the current study discovered that crop prices and crop land productivity both contributed to income growth.

Farmers in swamp typologies B and C who cultivate HYV rice in addition to local rice and orange as perennial crops have a higher gross margin than type A (Table 6.4). The higher price of HYV rice compared to local rice (as shown in Table 5.13) increases farmers' income. The price of oranges, which is higher than the price of coconut, also supports this condition. Despite the fact that swamp B and C types grew the same crops (rice and orange), swamp B took advantage of its typology, which is better suited for rice farming than swamp C. Because of its typology, swamp type C has lower gross margins and lower rice farming productivity. The water sources in type B come from the flow of rivers and rainfall, while type C's water supply is only dependent on rainfall. Thus, the washing process for toxins such as Fe, SO_4, and other organic acids in type B is easier than that in type C (KOESRINI et al., 2021). Type A, on the other hand, had the lowest gross margin. This could be due to the extreme conditions (oversupply of water, high intrusion of seawater, low depth of the pyrite layer, etc.) (FAHRI et al., 2021, NOOR et al., 2020) that are not favorable to rice farming. Furthermore, due to its fluctuating price, coconut, which is commonly planted in this area, is not a favorite crop among farmers (as shown in Figure 6.3).

Types B and C, on the other hand, require more capital than type A, as shown in Table 6.4. Capital is primarily used in production costs such as fertilizer, land preparation, hired labor, and seeds. According to the explanation in sub chapter 5.3.2, the investment budget for orange is nearly 60 % higher than that of coconut. Furthermore, according to Table 5.1, approximately half of the farmers in type B and 60 % of the farmers in type C areas were transmigrants. WILDAYANA et al. (2016) observed that the newcomers (transmigrants) were more active and had more initiative to work than the local farmers. They also have highest formal education who were more open to the new farming techniques and technology introduced by extension services. This finding supports WOLF & NOWAK's (1999) finding that farmers in more productive areas received more technical support from extension services and input suppliers due to their more innovative characteristics. The innovative characteristics could be attributed to the transmigrant farmers' level of education and open-mindedness observed in this study. According to the field study, they are also quite active and responsive to farmer group activities. As mentioned by CASEY & LYNNE (1997), the likelihood of farmers adopting new technology increases when they receive more support from others. However, these activities require additional costs, as observed by SURAHMAN et al. (2020), the application of new technology usually increases farmers' input costs, which reduces their profit. These conditions could be the primary reason they used more capital than type A farmers.

Because hired labor is rare and expensive, the labor allocation presented in Table 6.5 concludes that family (unpaid) labor dominates labor use in the tidal swampland area. Most Indonesians have traditionally relied heavily on their neighbors and families (EFFENDI, 2013). Furthermore, *Gotong royong* is a tradition in Indonesian culture. As a cultural value, *Gotong royong* emphasizes doing hard work together and showing care for one another in order to support collectivism, collaboration, and cooperation (DUWATA, 2013). In the context of the village economy, the term "*Gotong royong*" refers to villagers who perform agricultural and other activities for one another without pay (BOWEN, 1986). Because of this, the labor cost calculation is biased. It is dependent on their farming schedule because these *Gotong royong* activities are done alternately. Furthermore, the number of farmers who took part in these activities is unpredictable (depends on their own farming schedule). This issue was not accommodated in the model. During the planting and harvesting seasons, farmers typically hire labor. Overall, swamp type C had the highest labor use due to higher land use than swamp types A and B. This finding is consistent with WILDAYANA et al. (2016), who stated that more land owned and managed by farmers would increase the demand for labor.

Furthermore, during the rainy season, when there is an abundant supply of water from rainfall, more labor is required in the type C region. Swamp types A and B, on the other hand, require more labor during the dry season because, while the optimum planting time is during the rainy season, the harvesting time is during the dry season. Moreover, the dry season coincides with the peak of orange harvesting and post-harvesting treatment.

The model results from Table 6.6 show that the farmers in all swamp types of tidal swampland areas are expected not to allocate their land based on the nature of their typology. According to the findings of the field study shown in Table 6.6, farmers in all typologies allocated more land for rice farming than the model suggested. Farmers of types A, B, and C used 75, 56, and 55 % more land than the model predicted. On the other hand, they allocated land for perennial crops below the model values, particularly on type C and even more on type A. Due to the role of rice as the staple food, farmers allocate most of their land to main crops (local and HYV rice) rather than perennial crops (orange and coconut). Farmers of type A do not cultivate HYV, because the condition for waterlogging is not possible (FAHMID et al., 2022). Despite the fact that perennial crops in addition of rice farming were more productive and appropriate for tidal swamp areas than only cultivate local and HYV rice (DARSANI et al., 2020, YULIANI & NAPISAH, 2020). The tidal swamp's marginal condition requires additional treatment for cultivating local and HYV rice. Meanwhile, oranges and coconuts are better suited to this environment. Coconut is suitable for type A, while orange is suitable for types B and C (HAIRANI & NOOR, 2020). Perennial crops, according to this study, are important in increasing the gross margin and contributing more to the farmer's income. As a result, farmers in all tidal swampland typologies obtained lower gross margins than the model's optimum value.

This result suggests that the farmers' gross margins could be optimized. There are two ways to increase the gross margin based on the relationship between capital used, land use, and production. First, for the main crops (local and HYV rice), farmers should increase land productivity by doing some steps below, despite the fact that this first suggestion would require more capital (as suggested by the model):

1. Increasing fertilizer use to meet the optimal requirement. FAHRI et al. (2021) suggests applying 250 kg NPK, 100 kg urea, 0.5 kg lime, and 1 ton of manure per hectare of agricultural land. NPK and urea are used to provide sufficient nutrients for plant growth. Lime is important to stabilize the soil acidity level, and manure is used to enrich the soil with nutrients and accelerate the decomposition of plant remnants.
2. Improving technology related to water management. Water management was developed to maximize the use of a one-flow system that suitable for tidal swampland (DARSANI et al., 2021, HAIRANI & NOOR, 2020). The others are applying ameliorant material, raised bed (*sorjan*) system, shallow drainage system for swampland type C (HAIRANI & NOOR, 2020). It is also suggested that light machinery tools be used to compensate for the scarcity of hired labor during the planting and harvesting season.
3. Using suitable seeds that are adaptive to tidal swampland environments such as *Inpara* (Inbred Rice Swampland). *Inpara* is a variety released by the Indonesian Agency for Agricultural Research and Development (IAARD) that is suitable for

swampland environments but has a shorter cultivation period (115 to 135 days after sowing (DAS). IAARD has released ten Inpara varieties with various characteristics, including plant morphology, grain shape, rice texture, rice color, pest resistance, and adaptability to swampland environments (KOESRINI et al., 2021). The introduction of *Inpara* will solve the weakness of IR-42 and *Ciherang* rice variety (as mentioned in section 5.3.1).

4. Increasing labor that is needed by the farmers. The land acreage would theoretically affect the total household income (WILDAYANA et al., 2016), because as more land is cultivated by the farmers, more labor will be needed. However, the scarcity of hired labor during planting and harvesting hindered farmers from increasing their cultivation area. Thus, providing rented light machinery for planting and harvesting will be a great help to the farmer. The introduction of light combine harvesting and transplanting machinery will help farmers reducing manpower and labor cost.

Second suggestion, for perennial crops (coconut and orange), farmers could increase production by expanding the cultivated area. Because perennial crops are better suited to the swampy environment.

6.4.2 Gross margin simulation with crop price fluctuations

In developing countries, price fluctuations observed in agricultural commodities have become one of the most important aspects of the agricultural economy. The changes in agricultural product prices will affect product supply and farmers' decision about their production (ARISOY& BAYRAMOGLU, 2017). Furthermore, it is difficult because the time between production and utilization of farming products is typically long following harvest cycles (ASSEFA et al., 2015). Previous research in several countries concluded that production yields, climate conditions, and the integration of local markets with regional markets were some of the factors that caused crop price fluctuations (ARISOY& BAYRAMOGLU, 2017, CEDREZ et al., 2020, GIWA & CHOGA, 2020).

WOSSEN et al. (2018) concluded that, in addition to climate variability, price variability has a negative impact on household income and food security. CHAND & RAJU (2008) stated that crop prices, in addition to production fluctuations, are important in causing income variations for the farmers. According to FAFCHAMPS (2000), fluctuations in a single commodity price primarily affect farmers who specialize in that commodity, whereas highly diversified farmers should not suffer significant revenue loss. This result implies that growing more crops will reduce farmers' losses due to fluctuating prices, resulting in an increase in their income. Farmers who plant more crops will earn more money (gross margin) than farmers who plant fewer crops. The present study discovered not only the number of crops that have an impact on a farmer's income (gross margin), but also the magnitude of their fluctuation. Furthermore, crop price fluctuations have a significant impact on the fluctuation of gross margin. Farmers who grow more volatile-priced crops will have a more volatile gross margin. Farmers who choose a less volatile-price crop, on the other hand, will see less fluctuation in their gross margin. Table 6.10 shows that the order of price fluctuation from highest to lowest is: coconut, HYV rice, local rice, and orange.

Farmers in type A, who only grow two commodities, local rice as a main crop and coconut as a perennial crop, had the lowest gross margin and the highest gross margin fluctuation (Table 6.4). Meanwhile, farmers in types B and C have a higher gross margin (Table 6.4) and lower gross margin fluctuations than farmers in type A because they cultivate three crops, including oranges as perennial crops in addition to both rice (local and HYV). Furthermore, farmers in type B, who grow more orange than farmers in type C (Table 6.4), had a higher gross margin but a smaller gross margin fluctuation than farmers in type C. This is because the orange price fluctuated the least compared to the other crop prices. This low fluctuation contributed to the farmers in type B obtaining the highest gross margin as well as the lowest gross margin fluctuation.

To summarize, the perennial crops that are suitable for land conditions as suggested by the model and explained in 6.4.1 are insufficient to increase farmers' income in tidal swampland areas. According to the explanation in 6.4.2, crop price fluctuations also have a significant impact on the size and fluctuation of farmers' income in these tidal swampland areas.

6.5 Model limitations

The model looked into crop land allocation (main and perennial). In various cases, the model predicted utility values, cropping patterns, resource use, and crop production levels. The model, however, did not include all of the observed corps. Local rice and HYV rice are the main crops, while orange and coconut are perennial crops. The excluded crops were usually for own use and did not require much land or resources. Furthermore, these crops were grown in farmers' backyards, making it difficult to estimate the resources used in their cultivation.

In terms of labor cost calculation, the use of the *Gotong royong* (family labor sharing method) biased the results. This condition was not included in the model, as previously explained in subchapter 6.4.

Furthermore, there were some data collection issues during the field study. Not all farmers keep detailed records of their agricultural activities. Farmers frequently rely on their short-term memory or peer disruptions. According to VAN WINSEN et al. (2013), traditional farmers appear to be using qualitative rather than quantitative data due to a lack of accurate quantitative data as well as computational data treatment that is neither easy nor convenient for them. The gross margin simulation only considered fluctuations in simulated crop prices; it did not account for other fluctuations that farmers may face, such as crop yield fluctuations. Because the farmers only remember their most recent two years' yield, the yield fluctuation is not included in the model. The same reason also makes it difficult to obtain quantitative data for non-measurable activities such as leisure and farming activities to avoid risk. As a result, this model only considers profit as a target function, while leisure and risk-aversion factors, which may play an important role, are excluded. In most cases of small-scale farming in underdeveloped and developing countries, leisure and risk-aversion are important factors.

Furthermore, this model assumed only one model for each farm typology. The developed model did not take into consideration heterogeneity within the farm group in one typology. As a result of the aforementioned limitations, the validation results show a certain deviation from the observation data.

7 CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the conclusions drawn from the study’s findings. Some recommendations are suggested for the government, farmers, and other policymakers, as well as for further research in the future.

7.1 Conclusions

The study's findings provide a new perspective on socio-economic conditions and how farmers allocate their lands to maximize gross margins, as well as the impact of crop price fluctuations on gross margins in the tidal swampland area of South Kalimantan, Indonesia.

1. Farmers in Type B swampland boast the highest income, with those in Type C and A following closely. The primary drivers of income growth include land productivity, diverse crop varieties, and the fluctuation in crop prices. Type B have the highest productivity, the broadest array of cultivated crop variety, and experiences the least fluctuation in crop prices compared to other types.
2. The models see the possibilities to optimize the farming income. The model indicates a reduction in land allocation for rice farming and a simultaneous increase for perennial crops across all swampland types.
3. The simulated gross margin analysis indicates that Type A experiences high fluctuations, Type B maintains stability at a higher level, and Type C demonstrates stability at a lower price.

The present study discovered not only the number of crops that have an impact on a farmer's income (gross margin), but also the magnitude of their price fluctuation. Furthermore, crop price fluctuations have a significant impact on the fluctuation of gross margin. The land allocation for perennial crops that are suitable for tidal swampland environments and have a stable price alongside rice as the main crop will be beneficial to increasing the farmers’ income. Recommendations

7.1.1 Policy recommendation

Even though this research was conducted in a tidal swampland area in South Kalimantan, the findings are applicable in other parts of Indonesia with a great potential of swampland as long as the model assumptions are met. Some of the following recommendations are derived from the research findings:

1. The model suggest farmer has possibility to increase gross margin by allocate more land on perennial crops. However, support is needed especially extension service and inputs (i.e. advanced seedling and fertilizer).

2. Perennial crops are rewarding; however, perennial crops need high level of inputs at the early stage of cultivation, requiring extra care and more labor. Therefore, they need more credit support, better cultivation techniques, and marketing. The unstable price that might be occurred can be solved if government introduce farming insurance and open new market.
3. Rice is highly important to income as well as own consumption. Support are needed to increase rice production, i.e.: introducing new cultivar and its input needed, extension services, credit access, upgrading suitable technology, and also establishing better and stable floor prices.
4. Policymakers and other research institutions should introduce more suitable crops (especially more suitable rice varieties) to cultivate in each typology of tidal swampland.

7.1.2 Recommendations for further research

There are some issues those are not considered in this study that can be addressed in future research, such as:

1. This research considers the tidal swamp in South Kalimantan. Further research can be carried out in other tidal swamp environments in Indonesia, such as in Central Kalimantan, West Kalimantan, Eastern Sumatra, and Papua.
2. Future research could apply this model using other relevant crops, including secondary and other perennial crops.
3. Future research could investigate other sources of risk and uncertainty (not only the crops price).
4. Future research should be conducted on price-crop mechanisms that are not only reasonable but also profitable for farmers.
5. Stabilization of coconut price (including simulation with optimum land use, different price level effects, combination and risk effects).

8 SUMMARY

The summary covers a brief background of the research, the main findings of the field survey, and the modelling results.

8.1 Research background and framework

Indonesia, the world's fourth most populous country after China, India, and the United States, is more vulnerable to food supply issues, particularly rice, because people rely on this commodity for calories and protein. Rice production is insufficient to meet domestic demand. Since 1992, Indonesia has imported rice, with the average import increasing year after year. Indonesia imported 1478.35 million tons of rice per year between 1980 and 1999 (USDA, 2012). Between 1990 and 2020, imports fluctuated dramatically. Furthermore, as the population grows, the rate of rice productivity tends to stagnate. It has risen only slightly from 4.38 tons per hectare in 1993 to 4.98 tons per hectare in 2011 (CBS, 2012). It was only slightly increased to 5.11 tons per hectare in 2020 (CBS, 2021). Another issue in Indonesia is land scarcity as a result of land conversion from agricultural to non-agricultural use, particularly on Java Island, where 60 % of the rice is produced. As reported in SASMITA & NUGRAHA (2020), the average arable land conversion to non-agricultural use was 96,512 ha per year. In contrast, Indonesia has approximately 6 million hectares of agricultural tropical swampland (NOOR, 2004). Among them, 657.546 hectares were already cultivated (SETIOBUDI & FAGI, 2009).

Swampland in Indonesia is an area that is waterlogged all year or almost all year (SUBAGYO, 2006). Swamplands have marginal characteristics and are vulnerable to natural change (drought, fire, floods) as well as poor management (reclamation, opening, and intensive cultivation). Swamplands in Kalimantan have a variety of characteristics. Some swamp areas have peat layers of varying thickness and maturity; others have tidal problems; and still others have acidity problems. However, by adding lime or basalt, replenishing organic matter, and managing the water table to increase the soil pH value, the land can be used productively for rice and other crops (SHAMSHUDDIN et al., 2014).

Furthermore, the effort to provide food, particularly rice, is under increased pressure. This effect is quite alarming in South Kalimantan. Rice fields in tidal swampland areas are prone to flooding, pest infestations, and seawater intrusion. The effects are expected to affect not only production but also farmers' income and other socio-economic factors. Farmers must manage their land properly as an adaptation strategy to address this issue.

Based on the aforementioned cases, this research aims to describe the socio-economic characteristics of the swampland area, determine a model of farmer households with an optimum gross margin under limited resources in the tidal swampland area, and simulate the fluctuation of gross margin as a result of crop price fluctuation in the tidal swampland area of South Kalimantan, Indonesia.

The socio-economic characteristics of the surveyed farm households were presented using descriptive analysis in this study. They were the primary variables for further empirical investigation. The linear programming-based model was developed to assess land allocation across three types of tidal swampland, with the gross margin as the objective function.

8.2 Research findings from the field study

According to this study, the socio-economic characteristics of farmers in tidal swampland areas of South Kalimantan, Indonesia, differ depending on swampland typology. The dependency ratio, age of the household head, and farming experience are relatively similar among farmers in those three typologies, but household size varies significantly. The formal education of household heads varies by 6.09 years on average among farmers. The average household head has only completed primary school. This implies that farmers have a low level of formal education. Farmers in swampland typology C have the most formal education (7.42 years), followed by typology A (5.90 years) and typology B (5.90 years) (4.82 years). Furthermore, the vast majority of farmers (86 %) received no informal education.

In terms of farmer affiliation, half of farmers belong to a farmer group, but only 27.5 % of them receive extension services, particularly farmers in typologies B and C. This also applies to research institute extension services. These distinctions between typologies are statistically significant. Landholding within the various swamp typology groups is unequal, with an average of 1.76 ha per household. Farmers of type C held a larger parcel of land than their counterparts. This was due to the fact that transmigrant farmers dominated type C.

Furthermore, farmers' perceptions of soil fertility influence their land-management practices. Farmers who believe they have more fertile soil tend to use less fertilizer and are unaware of the importance of preserving soil fertility. This typical case was discovered in A farmer's typology. Their counterparts in types B and C, on the other hand, tend to preserve their land fertility by adding extra chemical fertilizer, manure, and lime on a regular basis. The highest amount of fertilizer was used in typology C.

8.3 Research findings from the modelling results

According to the model results, farmers in all swamp types of tidal swampland areas are not expected to allocate their land based on the nature of their typology. Farmers in all typologies allocated their land for rice farming, exceeding the model's suggested values. Farmers of types A, B, and C used 75, 56, and 55 % more land than the model predicted. They did, however, allocate land for perennial crops below the model values, particularly on type C and even more on type A. This result suggests that the farmers' gross margins could be optimized. There are two ways to increase the gross margin based on the relationship between capital used, land used, and production. First, for the main crops (local and HYV rice), farmers should increase land productivity by increasing fertilizer, improving technology, using appropriate seeds, and increasing labor. Second, for perennial crops (coconut and orange), farmers could increase production by expanding the area under cultivation because the perennial crops are more suitable in the swampland environment.

Perennial crops, according to this study, are important in increasing the gross margin and contributing more to the farmer's income. As a result, farmers in all tidal swampland typologies obtained lower gross margins than the model's optimum value.

The perennial crops, in addition to the main crops suggested by the model, are insufficient to increase farmers' income in tidal swampland areas. Crop price fluctuations also have a significant impact on the size and fluctuation of farmers' income in these tidal swampland areas.

This study was conducted in a tidal swampland area in South Kalimantan, however, the findings are applicable in other parts of Indonesia with high swampland potential, as long as the model assumptions are met. Some of recommendations are the government should give more support to establish rice as the main crop in tidal swamp areas, by giving more support to develop it (such as through extension services, credit access, upgrading suitable technology, and also establishing better floor prices). Farmers could increase land allocation for perennial crops that suitable in tidal swampland to maximize gross margin. Policymakers and other research institutions should introduce more suitable crops (especially more suitable rice varieties) to cultivate in each typology of tidal swampland

ABSTRACT

Indonesia, as the world's fourth most populous country after China, India and the USA, has higher susceptibility to food supply, especially rice. Rice production is not sufficient to cover the local demand. Furthermore, the population continues to increase while the rice productivity tends stagnate.

Kalimantan Island has a large scale of tidal swampland rice farming. Swampland across Kalimantan has varied characteristics. Rice fields in the tidal swampland area are vulnerable to flooding, pest attacks, and seawater intrusion. The effects are predicted not only on production, but also on farmers' income and other social-economic aspects.

This research aims to describe the socio-economic characteristics of swampland area, determine a model of farmer households which has optimum gross margin under restricted resources in the tidal swampland, and simulate the fluctuation of gross margin as the result of crops price fluctuation in the tidal swampland area of South Kalimantan, Indonesia.

The modelling based on linear programming was formulated to assess land allocation across three typologies of tidal swampland with the gross margin as the objective function. The tidal swampland typologies observed were type A (directly affected by tidal movement and always floods), type B (directly affected by tidal movement but only floods during the spring tide) and type C (indirectly influenced by the tidal movement).

This research found that the socio-economic characteristics of farmers in tidal swampland areas in South Kalimantan, Indonesia, are different based on the swampland typology. It was found that farmers in all typologies allocated their land for rice farming exceeding the values suggested by the model. On the other hand, they allocated land for perennial crops below the model values, especially on type C and even more on type A. As the results, the farmers in all typologies of tidal swampland obtained lower gross margin than the optimum value that resulted from the model. This result suggests that the farmers could optimize their gross margin. There are two ways to increase the gross margin. First, for the main crops (local and HYV rice), the farmers should increase their land productivity through intensive farming. Secondly, for the perennial crops (coconut and orange), the farmers could optimize their production by expanding the area used to cultivate them. Because the perennial crops are more suitable in the swampland environment.

ZUSAMMENFASSUNG

Indonesien als viert-bevölkerungsreichstes Land der Welt nach China, Indien und den USA, hat eine hohe Anfälligkeit der Nahrungsmittelversorgung. Die Reisproduktion reicht nicht aus, um die lokale Nachfrage zu decken. Hinzu kommt, dass die Bevölkerung weiterwächst, während die Reis-Produktivität stagniert.

Auf der Insel Kalimantan wird in großem Umfang Reis in Gezeiten-Sumpfgebieten angebaut. Sumpfland in ganz Kalimantan hat unterschiedliche Eigenschaften. Reisfelder im Gezeiten-Sumpfgebiet sind anfällig für Überschwemmungen, Schädlingsbefall und das Eindringen von Meerwasser. Die Auswirkungen werden nicht nur auf die Produktion, sondern auch auf das Einkommen der Landwirte und andere sozioökonomische Aspekte prognostiziert.

Diese Studie zielt darauf ab, 1. die sozioökonomischen Merkmale von Sumpfgebieten von Süd-Kalimantan, Indonesien zu beschreiben, 2. ein Modell von landwirtschaftlichen Haushalten zu erstellen, das unter begrenzten Ressourcen im Gezeiten-Sumpfland einen optimalen Deckungsbeitrag bestimmt, und 3. die Schwankung des Deckungsbeitrags als Ergebnis der Schwankungen der Produktpreise im Gezeitengebiet zu simulieren. .

Sie waren die primären Parameter für die weitere empirische Analyse. Die auf linearer Programmierung basierende Modellierung wurde formuliert, um die Landzuweisung über drei Typologien von Gezeiten-Sumpfgebieten mit dem Deckungsbeitrag als Zielfunktion zu bewerten. Die beobachteten Typologien von Gezeiten-Sumpfgebieten waren Typ A (direkt von Gezeitenbewegungen betroffen und immer von Überschwemmungen), Typ B (direkt von Gezeitenbewegungen betroffen, aber nur während der Springflut von Überschwemmungen) und Typ C (indirekt von Gezeiten-Bewegungen beeinflusst).

Diese Untersuchung ergab, dass sich die sozioökonomischen Merkmale von Landwirten in Gezeiten-Sumpfgebieten in Süd-Kalimantan, Indonesien, je nach Typologie der Sumpfgebiete unterscheiden, und zwar in Bezug auf die. Es hat sich gezeigt, dass die Landwirte aller Typologien ihr Land über die vom Modell vorgeschlagenen Werte hinaus dem Reisanbau zugewiesen haben. Andererseits haben sie den mehrjährigen Kulturen Flächen unterhalb der Modellwerte zugewiesen, insbesondere bei Typ A und etwas geringer bei Typ C . Infolgedessen erzielten die Landwirte in allen Typologien des Gezeiten-Sumpflandes niedrige Deckungsbeiträge, die unter den vom Modell ermittelten, optimalen Werten lagen. Dieses Ergebnis deutet darauf hin, dass die Landwirte ihre Deckungsbeiträge optimieren könnten. Es gibt zwei Möglichkeiten, diese zu erhöhen. Erstens sollten die Landwirte bei den Hauptkulturen (lokaler und HYV-Reis) ihres Landes die

Produktivität durch intensive Landwirtschaft steigern. Zweitens könnten die Landwirte bei den Dauerkulturen (Kokosnuss und Orangen) ihre Produktion weiter erhöhen.

REFERENCES

ADAM, H., SUSANTO, R. H., LAKITAN, B., SAPTAWAN, A. and M. YAZID (2013). The problems and constraints in managing tidal swampland for sustainable food crop farming (a case study of transmigration area of Tanjung Jabung Timur Regency, Jambi Province, Indonesia). International Conference on Sustainable Environment and Agriculture IPCBEE, 57: 67-72. IACSIT Press, Singapore.

ADB [ASIAN DEVELOPMENT BANK] (2015). Papua New Guinea: Economy. Asian Development 2015 Update.

AGRICULTURAL BUREAU OF SOUTH KALIMANTAN (various years). Agricultural Yearbook. Agricultural Bureau of South Kalimantan, Banjarbaru, Indonesia.

AGUERRE, M. and G. DENEGRI (1996). Deforestation in the Chaquena Region in Argentina. In: PALO, M. and G. MERY (eds.). Sustainable Forestry Challenge for Developing Countries. Kluwer Academic Publishers.

AGUS, F. AND I. G. M. SUBIKSA (2008). Lahan gambut: potensi untuk pertanian dan aspek lingkungan (In Indonesian language). Research and Development Bureau of Agriculture, Bogor, Indonesia.

AGYEN-SAMPONG, M. (1994). Mangrove swamp rice production in West Africa. In: C. S. MARIE-CHRISTINE (ed.). Dynamique et usages de la mangrove dans les pays des rivières du Sud (du Sénégal à la Sierra Leone), Paris, ORSTOM.

AKIYAMA, T. (2004). Growth in the Agricultural Sector: Are the Peculiarities with Southeast Asia. In: AKIYAMA, T., and D. F. LARSON (eds). Rural Development and Agricultural Growth in Indonesia, the Philippines and Thailand. Canberra: Asia Pacific Press, the Australian National University.

ALIHAMSYAH, T. (2004). Potensi dan pendayagunaan lahan rawa untuk peningkatan produksi padi. Ekonomi padi dan beras Indonesia (In Indonesian language). Badan Litbang Pertanian, Jakarta, Indonesia

ALLEN, B. and R. M. BOURKE (2009). People, land and environment. In: BOURKE and HARWOOD (eds) Food and Agriculture in Papua New Guinea. ANU Press, Canberra.

ALLISON-OGURU, E. A., IGBEN, M. S. and E. C. CHUKWUIGWE (2006). Revenue maximising COMBINATION of crop enterprise in Bayelsa State of Nigeria: a linear programming application. Indian Journal of Agricultural Economics, 61(4): 667-676.

AMALI, N., ANSYARI, I., ROHAENI, E. S. and S. SARAGIH (2003). Pengelolaan tata air satu arah pada usahatani padi lahan pasang surut (In Indonesian language). Assessment Institute for Agricultural Technology in South Kalimantan. Banjarbaru.

ANWAR, K., and MAWARDI (2011). Dinamika tinggi muka air dan kemasaman air pasang surut saluran sekunder sepanjang Sungai Barito (In Indonesian language). Indonesian Soil and Climate Journal, Special Edition: Swampland, July 2011.

ANWARHAN, H. (1981). Food crops research in tidal swamp areas. Indonesian Agricultural Research Development Journal, 3.

APRIYANA, N. (2011). Land Conversion Control Policy for Maintaining National Food Security. Ministry for National Development, Jakarta.

ARISOY, H. and Z. BAYRAMOGLU (2017). Determination of the effect of price fluctuations on producer income-the case of potatoes. Turkish Journal of Agriculture – Food Science and Technology, 5(11): 1342-1349. DOI: https://doi.org/10.24925/turjaf.v5i11.1342-1349.1356.

AR-RIZA, I., RAMLI, R., ANWAR, K. and R.S. SIMATUPANG (1997). Kesesuaian lahan pasang surut, potensi, kendala dan kesiapan teknologi sistem usahatani di wilayah Kalimantan Selatan (In

Indonesian language). Proyek Penelitian Pertanian Lahan Pasang Surut dan Rawa Swamps II. Pusat Penelitian dan Pengembangan Tanaman Rawa, Balai Penelitian Tanaman Pangan Lahan Rawa, Banjarbaru, Indonesia.

ASSEFA, T. T., MEUWISSEN, M. P. and A. G. O. LANSINK (2015). Price volatility transmission in food supply chains: a literature review. Agribusiness 31: 3-13.

BALLARD (2001). Wetland drainage and agricultural transformation in the Southern Highlands of Papua New Guinea. Asia Pacific Viewpoint, 42 (2/3), August/December 2001: 287-304.

BANJARBARU CLIMATOLOGY STATION (2013). Rainfall in South Kalimantan (In Indonesian language), 1978-2012 Report**.**

BASSI, N., KUMAR, M. D., SHARMA, A. and P. PARDHA-SARADHI (2014). Status of wetlands in India: A review of extent, ecosystem benefits, threats and management strategies. Journal of Hydrology: Regional Studies, 2(2014): 1-19. doi:10.1016/j.ejrh.2014.07.001.

BEACH, T., LUZZADER-BEACH, S., DUNNING, N., JONES, J., LOHSE, J., GUDERJAN, T., BOZARTH, S., MILLSPAUGH, S. and T. BHATTACHARYA (2009). A review of human and natural change in Maya Lowland wetlands over the Holocene. Quaternary Science Reviews, 28 (17-18): 1710-1724.

BHENDE, M. J. and J. V. VENKATARAM (1994). Impact of diversification on household income and risk: a whole-farm modelling approach. Agricultural Systems, 44: 301-312.

BOURKE, R. M. (2001). Intensification of agricultural systems in Papua New Guinea. Asia Pacific Viewpoint, 42 (2/3): 219-235.

BOURKE, R. M. (2009). History of agriculture in Papua New Guinea. In: BOURKE AND HARWOOD (eds) Food and Agriculture in Papua New Guinea. ANU Press: Canberra.

BOURKE, R. M., GIBSON, J., QUATERMAIN, A., BARCLAY, K., ALLEN, B. and J. KENNEDY (2009). Food production, consumption and imports. In: BOURKE AND HARWOOD (eds) Food and Agriculture in Papua New Guinea. ANU Press: Canberra.

BOWEN, J. R. (1986). On the Political Construction of Tradition: Gotong Royong in Indonesia. The Journal of Asian Studies, 45(3): 545-561.

CASEY, F., and G. D. LYNNE (1997). Factors Affecting Investment in Drip Irrigation Technology: A Multiple Utility Approach. Economic Report 97-1. University of Florida, Gainesville.

CBS (2012a). Monthly Report of Social and Economy. 25th edition, June 2012. Central Bureau of Statistic, Jakarta.

CBS OF BARITO KUALA REGENCY (2014). Barito Kuala in Figures 2013. CBS of Barito Kuala Regency, Marabahan, Indonesia.

CBS [CENTRAL BOARD OF STATISTIC] OF SOUTH KALIMANTAN (various years). South Kalimantan in figures. CBS of South Kalimantan, Banjarmasin, Indonesia.

CBS OF SOUTH KALIMANTAN (2012). South Kalimantan in Figures (2011) CBS of South Kalimantan, Banjarmasin.

CBS OF TANAH LAUT REGENCY (2013). Tanah Laut in Figures 2012. CBS of Tanah Laut Regency, Pelaihari, Indonesia.

CBS OF TANAH LAUT Regency (2014). Tanah Laut in Figures 2013. CBS of Tanah Laut Regency, Pelaihari, Indonesia.

CBS (2020). Indonesian Statistics. CBS, Jakarta.

CBS (2021). Indonesian Statistics. CBS, Jakarta

CEDREZ, C. B., CHAMBERLIN, J. and R. J. HIJMANS (2020). Seasonal, annual, and spatial variation in cereal prices in Sub-Saharan Africa. Global Food Security, 26, 100438: 1-9. https://doi.org/10.1016/j.gfs.2020.100438.

CHAND, R. and S. S. RAJU (2008). Instability in Andhara Pradesh agriculture-a disaggregate analysis. Agricultural Economics Research Review, 21: 283-288.

DAHL, T. E. (1990). Wetlands losses in the United States, 1780's to 1980's. United States Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA.

DAHL, T. E., JOHNSON, C. E. and W. E. FRAYER (1991). Wetlands status and trends in the conterminous United States, mid-1970's to mid-1980's. United States Department of the Interior, Fish and Wildlife Service, Washington, D.C., USA.

DAHL, T. E. and G. J. ALLORD (1997). Technical aspects of wetlands: History of Wetlands in the counterminous United State. United States Geological Survey Water Supply Paper 2425. US Geological Survey.

DARSANI, Y. R. and W. ANNISA (2018). Management optimization technology of acid sulphate tidal swampland for improving farmers income (case study of Sidomulyo Village Tamban Catur District Kapuas Sub-district). In Proceedings of the International Workshop on Tropical Wetlands: Innovation in Mapping and Management, 19-20 October 2018, Banjarmasin, Indonesia.

DARSANI, Y. R., SOSIAWAN, H., YUSUF, W.A. and M. ALWI (2020). Economic feasibility analysis of rice farming in swampland. In: LESTARI, P., MULYA, K., UTAMI, D. W., SATYAWAN, D. SUPRIADI and MASTUR (eds) Strategies and Techologies for The Utilization and Improvement of Rice. IAARD Press, Jakarta: 109-120.

DARSANI, Y.R., YUSUF, W. A. and H. SOSIAWAN (2021). Optimal use of tidal swampland by implementing technology innovation “Panca Kelola” to enhance farmer’s income in Central Kalimantan Indonesia. IOP Conference Series: Earth and Environmental Science, 648 012045. DOI: 10.1088/1755-1315/648/1/012045.

DARYANTO, A. (1999). Indonesia’s crisis and the agricultural sector: The relevance of Agricultural Demand-Led Industrialization. Paper No.2. UNEAC Asia.

DENT, D. L. and L. J. PONS (1995). A world perspective on acid sulphate soils. Geoderma, 67: 263 – 276.

DJAMHARI, M.R. (2002). Banjarese system dalam pertanian lahan rawa (In Indonesian language). Banjar International Vol. 2002.

DOBERMANN, A. (2012). Looking ahead: Mega trends in the rice sector. Paper presented on Tropentag 2012 organized by Georg-August Universität Göttingen and University of Kassel, Göttingen, 19-21 September 2012.

DORWARD, A. (1999). Modelling embedded risk in peasant agriculture: methodological insights from northern Malawi. Agricultural Economics, 21: 191-203.

DUWATA, N. (2013). Aktualisasi Nilai Kekeluargaan (Persaudaraan) dan Nilai Kegotongroyongan dalam Permainan Tarik Tambang pada Warga Masyarakat RT24 RW06 Sidikan Umbulharjo Yogyakarta tahun 2012 (In Indonesian language). Jurnal Citizenship, 2(1).

EFFENDI, T. N. (2013). Budaya Gotong-Royong Masyarakat dalam Perubahan Sosial Saat Ini (In Indonesian language). Jurnal Pemikiran Sosiologi, 2(1): 1-18.

ELIAS, S. and C. NOONE (2011). The growth and development of the Indonesian economy. Reserve Bank of Australia Bulletin, December Quarterly 2011.

FAFCHAMPS, M. (2000). Farmers and Price Fluctuations in Poor Countries. Department of Economics, University of Oxford, England.

FAHMID, I. M., WAHYUDI, AGUSTIAN, A., ALDILLAH, R. and E. GUNAWAN (2022). The potential swampland development to support food estates programmes in Central Kalimantan, Indonesia. Environment and Urbanization ASIA, 1-12. DOI: 10.1177/09754253221078178.

FAHRI, A., YUSUF, R., ANGGRAINI, R. S. and SALWATI (2021). Technology innovation implementation for increasing rice cropping index on swampland of Riau Province. IOP Conference Series: Earth and Environmental Science, 648 012026. DOI: 10.1088/1755-1315/648/1/012026.

FEARNSIDE, P. M. (1997). Transmigration in Indonesia: Lesson from its environmental and social impacts. Environmental Management, 21 (4): 553-570.

FEDER, G., MURGAI, R. and J. B. QUIZON (2004). Sending farmers back to school: The impacts of farmer field schools in Indonesia. Review of Agricultural Economics, 26 (1): 45-62. DOI:10.1111/j.1467-9353.2003.00161.x

FELIX, M., JUDITH, M., JONATHAN, M. and S. MUNASHE (2013). Modelling a small farm livelihood system using linear programming in Bindura, Zimbabwe. Research Journal of Management Sciences, 2(5): 20-23.

FIRMAN, T. (2000). Rural to urban land conversion in Indonesia during boom and bust periods. Land Use Policy, 17(1): 13-20.

FLAHERTY, M., VANDERGESST, P. and P. MILLER (1999). Rice paddy or shrimp pond: Tough decisions in rural Thailand. World Development, 27(12): 2045-2060.

FOLKERTSMA, S. (1998). Experience with farmer managed water systems in the tidal lowlands of Indonesia. Indonesian National Committee on Irrigation and Drainage, Directorate General of Water Resources Development, Ministry of Public Works: 11.

GAVEAU, D. L. A., SLOAN, S., MOLIDENA, E., YAEN, H., SHEIL, D., ABRAM, N. K., ANCRENAS, M., NASI, R., QUINONES, M., WIELAARD, N. and E. MEIJAARD (2014). Four decades of forest persistence, clearance and logging on Borneo. PLoS ONE, 9 (7). DOI: 10.1371/ journal.pone.0101654.

GIWA, F. and I. CHOGA, I. (2020). The impact of food price changes and food insecurity on economic welfare: a case of selected Southern African Countries. Journal of Reviews on Global Economics, 9: 77-93.

GOVERNMENT OF BARITO KUALA (2010). Profil Daerah Kabupaten Barito Kuala (In Indonesian language). Government of Barito Kuala, Marabahan, Indonesia.

GYLES, O. and O. MONTECILLO (1999). Linear programming and future land use scenarios: an irrigated catchment case study. Australian Agricultural and Resource Economics Society 43rd Annual Conference, Christchurch, New Zealand, 20-22 January 1999.

HAIRANI, A. and M. NOOR (2020). Water management on peatland for food crop and horticulture production: research review in Kalimantan. IOP Conference Series: Earth and Environmental Science, 499 012006. DOI: 10.1088/1755-1315/499/1/012006.

HARRISON, J. W., STANGO III, P. and M.C. AGUIRE (2004). Forested tidal wetlands communities of Maryland’s Eastern Shore: Identification, Assessment and Monitoring. The United State Environmental Protection Agency.

HARYONO (2012). Lahan Rawa: Lumbung Pangan Masa Depan Indonesia (In Indonesian language). IAARD Press, Jakarta.

HAZELL, P. B. R. and E. D. NORTON (1986). Mathematical Programming for Economic Analysis in Agriculture. Macmillan Publishing Company, New York.

HECKER, J. H. (2005). Promoting environmental security and poverty alleviation in the peat swamps of Central Kalimantan, Indonesia. Institute for Environmental Security, The Netherlands.

HIDAYAT, T., PANDJAITAN, N. K., DHARMAWAN, A. H., WAHYU, and F. SITORUS (2010). Kontestasi sains dengan pengetahuan local petani di lahan pasang surut Kalimantan Selatan (In Indonesian language). Sodality Journal, 4(1): 1 – 16.

HOLDEN, S., HVOSLEF, H. and R. SIMANJUNTAK (1995). Transmigration settlements in Siberida, Sumatera: Deterioration of farming system in a rain forest environment. Agricultural Systems, 49(1995): 237-258.

HUGHES, F.M.R. (ed.) (2003). The flooded forest: Guidance for policy makers and river managers in Europe on the restoration of floodplain forests. FLOBAR2, Department of Geography, University of Cambridge, Cambridge, UK.

HUSSAIN, I., WIJERATHNA, D., ARIF, S. S., MURTININGRUM., MAWARNI, A. and SUPARMI (2006). Irrigation, productivity and poverty linkages in irrigation system in Java, Indonesia. Water Resources Management, 20: 313-336.

IBRAHIM, A. H. (2013). Impact of microcredit on poverty alleviation in Rural Sudan: an applied modelling approach in North Kordofan, Central-West Sudan. Farming & Rural Systems Economics, 141. Margraf Publishers, Germany.

IGWE, K. C. and C. E. ONYENWEAKU (2013). A linear programming approach to food crops and livestock enterprises planning in Aba Agricultural Zone of Abia State, Nigeria. American Journal of Experimental Agriculture, 3(2): 412-431.

INVESTMENT COORDINATION BOARD (2011). Investment potencies in South Kalimantan. Investment Coordination Board, Jakarta.

JAENICKE, J., RIELEY, J. O., MOTT, C., KIMMAN, P. and F. SIEGERT (2008). Determination of the amount of carbon stored in Indonesian peatlands. Geoderma, 147: 151-158.

JERATH, N., LADHAR, S. S., PARWANA, H. K., DUA, D. K., JAIN, S. K. and P. KAUR (1995). Punjab Environment: Status Report 1995. Punjab State Council for Science and Technology, Chandigarh.

JOHNNY, M., KARIMU, J. and P. RICHARDS (1981). Upland and swamp rice farming systems in Sierra Leone: the social context of technological change. Africa, 51(2): 596-620.

JOOSTEN, H and D. CLARKE (2002). Wise Use od Mires and Peatslands. International Mire Conservation Group and International Peat Society.

KARUNAKARAN, K. R., NEDUMARAN, S. and M. CHANDRASEKARAN (2012). Is the current land use pattern in crop agriculture is sustainable in the Bhavani basin of Southern India?: Application of Bio-economic model. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

KASEM S., and G. B. THAPA (2012). Sustainable development policies and achievements in the context of the agriculture sector in Thailand. Sustainable Development, 20 (2012): 98-114.

KEDDY, P.A. (2010). Wetland Ecology: Principles and Conservation (2nd edition). Cambridge University Press, Cambridge, UK.

KEDDY, P.A., FRASER, L. H., SOLOMESHCH, A. I., JUNK, W. J., CAMPBELL, D. R., ARROYO, M. T. K. and C.J.R. ALHO (2009). Wet and wonderful: the world's largest wetlands are conservation priorities. BioScience, 59: 39-51.

KHAIRULLAH, I., FAHMI, A., THAMRIN, M. and D. CAHYANA (2013). Pengembangan Kalender Tanam Lahan Rawa Terpadu (In Indonesian language). Annual Research Report. Indonesian Swamp Agriculture Research Institute, Banjarbaru-Indonesia.

KHAIRULLAH, I. (2020). Indigenous knowledge cultivation of local rice varieties "Siam Mutiara" and "Siam Saba" at tidal swampland. BIO Web of Conferences, 20: 01007. https://doi.org/10.1051/bioconf/20202001007.

KHAIRULLAH, I., ALWI, M., ANNISA, W. and MAWARDI (2021a). The fluctuation of rice production of tidal swampland on climate change condition (case of South Kalimantan Province in Indonesia). IOP Conference Series: Earth and Environmental Science, 724 012009. DOI: 10.1088/1755-1315/724/1/012009.

KHAIRULLAH, I., SALEH, M. and MAWARDI (2021b). The characteristics of local rice varieties of tidal swampland in South Kalimantan. IOP Conference Series: Earth and Environmental Science, 762 012009. DOI: 10.1088/1755-1315/762/1/012009.

KOESRINI, S., NURZAKIAH, V. and Y. RINA (2021). The adaptability of rice varieties on tidal swampland in South Kalimantan. IOP Conference Series: Earth and Environmental Science, 648 012027. DOI: 10.1088/1755-1315/648/1/012027.

LADHAR, S. S. (2002). Status of ecological health of wetlands in Punjab, India. Aquatic Ecosystem and Health Management, 5: 457–465. DOI: 10.1080/14634980290002002.

LEIWAKABESSY, F. M. (1989). Management of acid humid tropical soil in Indonesia. In: E. T. CRASWELL and E. PUSHPARAJAH (1989). Management of Acid Soils in the Humid Tropics of Asia. Australian Center for International Agricultural Research (ACIAR): Canberra.

LETURQUE, H, and S. WIGGINS (2010). Thailand's progress in agriculture: Transition and sustained productivity growth. Overseas Development Institute, London.

LIEW, S. C., LIM, O. K., KWOH, L. K. and H. LIM (1998). A study of the 1997 forest fires in South East Asia using SPOT quick look mosaics. IEEE International Geoscience and Remote Sensing Symposium Proceedings (Cat. No.98CH36174)

LOEFFLER, U. (1996). Land tenure development in Indonesia. Sector Project on the Important of Land Tenure in Development Cooperation. Deutsche Gesellschaft für Technical Zusammenarbeit (GTZ), Berlin.

LUKAS, M.C. (2014). Eroding battlefields: Land degradation in Java reconsidered. Geoforum, 56: 87-100.

MAAS, A. (2003). Peluang dan konsekuensi pemanfaatan lahan rawa pada masa mendatang (In Indonesian language). Gadjah Mada University, Yogyakarta, Indonesia.

MABWOGA, S. O. and A. K. THUKRAL (2014). Characterization of change in the Harike wetland, a Ramsar site in India, using satellite data. Springerplus 3 (2014): 576. DOI: 10.1186/2193-1801-3-576.

MASTUR, UTAMI, D. W. and P. LESTARI (2020). Biotechnology on rice in Indonesia: current progress and future potency for farmer. In: LESTARI, P., MULYA, K., UTAMI, D. W., SATYAWAN, D. SUPRIADI and MASTUR (eds) Strategies and Techologies for The Utilization and Improvement of Rice. IAARD Press, Jakarta: 51-65.

MAY, R. J. (2004). State and Society in Papua New Guinea: The First Twenty Five Years. ANU Press, Canberra.

MEDRILZAM, M., SMITH, C., AZIS, A. A., HERBOHN, J. and P. DARGUSCH (2017). Smallholder farmers and the dynamics of degradation of peatland ecosystems in Central Kalimantan, Indonesia. Ecological Economics, 136: 101-113.

MEGAWATY, SUSANTO, R. H., SURYADI, F. X. and NGUDIANTORO (2012). Optimizing operation and maintenance Telang II tidal reclamation scheme in relation to agricultural development. Agricultural Science, 3(2): 287-298.

MELLAKU, M. T., REYNOLDS, T. W. and T. WOLDEAMANUEL (2018). Linear programming-based cropland allocation to enhance performance of smallholder crop production: a pilot study in Abaro Kebele, Ethiopia. Resources, 7(4): 76-91.

MINISTRY OF AGRICULTURE (2014). Statistics of Agricultural Land 2009-2013. Ministry of Agriculture, Jakarta.

MINISTRY OF ENVIRONMENT (1997). Agenda 21-Indonesia: a national strategy for sustainable development State Ministry for Environment and United Nations Development Programme, Jakarta.

MINISTRY OF PUBLIC WORKS (2009). Potential and challenges of swamp development in Indonesia. Paper at the Workshop Seminar on Swamp Management in Supporting National Food Security. Hotel Nikko Jakarta. Deputy for Infrastructure Coordination and Regional Development, Coordinating Ministry for Economic Affairs.

MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT (2001). Wetlands with high biodiversity and environmental value in Viet Nam. Hanoi.

MUHINDA, J. J. M. (2013). Rwanda agricultural sector and its impacts on food security and economy. Workshop on Asian Lessons and Agriculture Transformation in Rwanda, Kigali, 31 January 2013.

MUTTAQIN, A.Z. and D. MARTIANTO (2009). Consumption, demand, and national rice adequacy in Indonesia 2002-2007. Journal of Nutrient and Food, 4(3): 118-122.

NEDECO/EUROCONSULT-BIEC (1984). Final Report. Nationwide Study of Coastal and Near Coastal Swampland in Sumatra, Kalimantan, and Irian Jaya. Volume 3 Maps. August 1984. Government of the Republic of Indonesia. Ministry of Public Works. Direct. General of Water Resources Development.

NI, D. V., MALTBY, E., STAFFORD, R., TUONG, T. P., and V. T. XUAN (2003). Status of the Mekong Delta: Agricultural development, environmental pollution and farmer differentiation. In: TORELL ET AL (eds) Wetland Management in Vietnam: Issues and Perspective. WorldFish Center.

NINGSIH, R. D., NOOR, A. and M. YASIN (2020). The contribution of swampland rice for food security in South Kalimantan. In: LESTARI, P., MULYA, K., UTAMI, D. W., SATYAWAN, D. SUPRIADI and MASTUR (eds) Strategies and Technologies for the Utilization and Improvement of Rice. IAARD Press, Jakarta: 83-92.

NOOR, M. (2004). Lahan Rawa (In Indonesian language). Raja Grasindo Persada. Jakarta.

NOOR, M. (2007). Pertanian Lahan Gambut: Potensi dan Kendala (In Indonesian language). Kanisius, Yogyakarta, Indonesia.

NOOR, M. (2010). Lahan Gambut: Pengembangan, Konservasi, dan Perubahan Iklim. Gadjah Mada University Press, Yogyakarta, Indonesia.

NOOR, M. (2012). Sejarah Pembukaan Lahan Gambut untuk Pertanian di Indonesia (In Indonesian language). In: HUSEN, E. et al (eds). Proceeding of National Seminar on Sustainable Peatland Management, Bogor, 4 Mei 2012. Institute of Agricultural Land Resources Research Development, Bogor.

NOOR, M. and A. JUMBERI (2005). Persoalan Memajukan Pertanian Lahan Rawa (In Indonesian language). Balittra, Banjarbaru, Indonesia.

NOOR, M. and M. SARWANI (2013). Pertanian di lahan gambut: Masa lalu, kini dan besok (In Indonesian language). Climate Change, Forest and Peatlands in Indonesia. Wetlands International.

NOOR, M. and H. SOSIAWAN (2020) Water management in tidal swamps farming: from indigenous knowledge to improved technology. In: SULAEMAN et al. (eds) Tropical Wetlands-Innovation in Mapping and Management. Taylor&Francis Group, London, ISBN 978-0-367-20964-3.

NOOR, M., SOSIAWAN, H. and I. KHAIRULLAH (2020). Soil properties and productivity of paddy fields in the tidal swamplands of Kalimantan. In: LESTARI, P., MULYA, K., UTAMI, D. W., SATYAWAN, D. SUPRIADI and MASTUR (eds) Strategies and Technologies for the Utilization and Improvement of Rice. IAARD Press, Jakarta: 163-176.

NOORSYAMSI, H., ANWARHAN, H., SULAIMAN, S. and H.M. BEACHELL (1984). Rice cultivation in the tidal swamps of Kalimantan. In: W. H. SMITH and G. S. ARGOSINO (Eds), Conference paper Workshop on Research Priorities in Tidal Swamp Rice. Los Banos, Philippines, International Rice Research Institute: 17-28.

NOTOHADIPRAWIRO, T. (1994). Pengembangan lahan rawa pasang surut untuk tujuan pertanian (In Indonesian language). Research & Development, Ministry of Public Work, Jakarta.

NUGRAHA, Y., ARDIE, S. W., GHULAMMAHDI, M. and H. ASWIDINNOOR (2016). Nutrient culture media with agar is effective for early and rapid screening of iron toxicity in rice. Journal of Crop Science and Biotechnology, 19: 61-70.

NUGROHO, A. S. (2013). Evaluation of Transmigration (Transmigrasi) in Indonesia: Changes in socio-economic status, community health and environmental equalities of two specific migrant populations. Kagoshima University Repository, Kagoshima.

NUGROHO, K., ALKASUMA, PAIDI, WAHDINI, W., ABDULRACHMAN, SUHARDJO, H. and I P.G. WIDJAJA-ADHI (1991). Penentuan areal potensial lahan pasang surut, rawa, dan pantai. Skala 1:500.000 (In Indonesian language). Technical Report No. 1/PSRP/1991. Research Project of Land Resource, Indonesian Research Center on Soil and Agroclimate.

NWAOBIALA, C. U. (2010). Economic analysis of swamp rice production in Ebonyi Southern Agricultural Zone of Ebonyi State, Nigeria. Journal of Agriculture and Social Research, 10(2): 135-141

OECD (2012a). OECD review of agricultural policies: Indonesia. Organization for Economic Co-operation and Development.

OECD (2012b). OECD economics survey: Indonesia. Organization for Economic Co-operation and Development.

ONIAH, M. O., KUYE, O. O. and I. C. IDIONG (2008). Efficiency and resource use in small scale swamp rice production in Obubra Local Government Area of Cross River State, Nigeria. Middle-East Journal of Scientific Research, 3 (3): 145-148, ISSN 1990-9233.

OTSUKA, K. (2017). Changing issues of rice economy in Asia: roles of social science. Centenary Annual Conference of Indian Economic Association, Guntur, 27-29 December 2017, Andhra Pradesh, India.

PARTOHARDJONO, S. (1993). Integrated Farming Systems Research and Development on Reclaimed Swampland in Indonesia. In: Technical Pre-Seminar on Lowlands Development and Management: 1-18. Ministry of Public Works, Directorate General of Water Resources Development and JICA, Jakarta, Indonesia.

PASANDARAN, E. and N. ZULIASRI (2001). Development Perspectives of Irrigated Agriculture in Indonesia. In HUSSAIN, I. and E. BILTONEN. Irrigation against Rural Poverty: An Overview of Issues and Pro-poor Intervention Strategies in Irrigated Agriculture in Asia. Proceedings of National Workshops on Pro-poor Intervention Strategies in Irrigated Agriculture in Asia, International Water Management Institute (IWMI), Colombo, Sri Lanka.

PERRY, D. H. (1985). The economics of transmigrant farming. Bulletin of Indonesian Economic Studies, 21 (3): 104 – 117, DOI: 10.1080/00074918512331335093.

PLANTATION AGENCY OF BARITO KUALA (2013). Palm Oil and Rubber Plantation Data 2008-2012. Plantation Agency of Barito Kuala Report, South Kalimantan, Indonesia.

PRASAD S. N., RAMACHANDRA, T. V., AHALYA, N., SENGUPTA, T., KUMAR, A., TIWARI, A. K., VIJAYAN, V. S. and L. VIJAYAN (2002). Conservation of wetlands of India - a review. Tropical Ecology, 43 (2002):173–186.

PUSLITTANAK (SOIL AND AGROCLIMATE RESEARCH CENTER) (2000). Atlas sumberdaya tanah: Eksplorasi Indonesian, Scale 1:1.000.000 (In Indonesian language). Agricultural Research and Development, Ministry of Agriculture, Jakarta.

RICKLEFS, M.C. (2001). A history of modern Indonesia since c.1200. Palgrave Macmillan, Hampshire.

RINA, Y. (2012). Usahatani Pola Tanam Sawit Dupa dalam Perpektif Peningkatan Produksi di Lahan Pasang Surut Tipe Luapan B (In Indonesian language). Balittra, Banjarbaru, Indonesia.

SAIDY, R.A and Y. AZIS (2009). Sea level rise in South Kalimantan, Indonesia: An economic analysis of adaptation strategies in agriculture. EEPSEA Research Report No. 2009-RRI. Economy and Environment Program for Southeast Asia (EEPSEA), Singapore.

SARAGIH, S. (2013). Empat kunci sukses pengelolaan lahan rawa pasang surut untuk usaha pertanian berkelanjutan (In Indonesian language). Balittra, Banjarbaru.

SARWANI, M. (2003). Agricultural practice on peatlands of South Kalimantan: The farmers' knowledge. Proceeding of Workshop on Wise Use and Sustainable Peatlands Management Practices, on Bogor-Indonesia, October 13-14, 2003. Wetland International, Wildlife Habitat Canada, and Indonesian Ministry of Forestry, Jakarta.

SASMITA, P. and Y. NUGRAHA (2020). Rice breeding strategy for climate resilience and value addition in Indonesia. In: LESTARI, P., MULYA, K., UTAMI, D. W., SATYAWAN, D. SUPRIADI and MASTUR (eds) Strategies and Techologies for The Utilization and Improvement of Rice. IAARD Press: Jakarta, 67-82.

SEEBOERGER, K. U. (2014). Consolidation of Marshland Development in Huye, Ruhango and Muhanga Districts, South Province, Rwanda (Consolidation phase ESIRU). Evaluation Report RWA 1037. Welthungerhilfe.

SETIOBUDI, D. and A.M. FAGI (2009). Irrigated rice fields water management: Anticipation of water scarcity. Agricultural Research and Development, Ministry of Agriculture, Jakarta.

SIDIK, M. (2004). Indonesia rice policy in view of trade liberalization. Paper presented at FAO Rice Conference, 12-13 February 2004, Rome, Italy.

SHAMSHUDDIN, J., AZURA, A. E., SHAZABA, M. A. R. S., FAUZIAH, C. I., PANHWAR, Q. A. and U.A. NAHER (2014). Properties and management of acid sulphate soils in Southeast Asia for sustainable cultivation of rice, oil palm, and cocoa. Advance in Agronomy, 214: 91-142.

SHIROTA, S., OMORI, Y., LOPES, H. F. and H. PIAO (2017). Cholesky realized stochastic volatility model. Econometrics and Statistics, 3: 34-59.

SOEKARTAWI (2002). Prinsip Dasar Manajemen Pemasaran Hasil-Hasil Pertanian Teori dan Aplikasinya (In Indonesian language). PT Raja Grafindo Persada. Jakarta, Indonesia.

STERMAN, J. D. (2000). System dynamics: thinking system and modelling for complex world. Irwing/McGraw-Hill, Boston.

SUBAGYO, H. (2006). Klasifikasi dan penyebaran lahan rawa (In Indonesian language). In: S. DIDI-ARDI et al. (eds). Karakteristik dan Pengelolaan Lahan Rawa (In Indonesian language).

Research and Development Institute for Agriculture Land Resource, Ministry of Agriculture, Bogor.

SUBAGYO, H., SUDJADI, M., SURYATNA, E. and J. DAI (1990). Wet soils of Indonesia: 248-259. In Kimble, J.M. 1992 (ed.). Proceed of the VIII International Soils Coalition Meeting (VIII ISFORM): Characterization, Classification, and Utilization of wet Soils. USDA-Soil Conservation Service, National Soil Survey Centre, Lincoln, NE.

SUBAGYO, MARSOEDI and A.S. KARAMA (1996). Prospek Pengembangan Lahan Gambut untuk Pertanian (In Indonesian language). Presented on Seminar Pengembangan Teknologi Berwawasan Lingkungan untuk Pertanian pada Lahan Gambut, 26 September 1996. Bogor, Indonesia.

SUHARTANTO (2007.) Rencana Implementasi tentang Percepatan Rehabilitasi dan Revitalisasi Kawasan PLG Provinsi Kalimantan Tengah (In Indonesian language). *In:* Prosiding Seminar Nasional Pertanian Lahan Rawa Revitalisasi Kawasan PLG dan Lahan Rawa Lainnya untuk Membangun Lumbung Pangan Nasional (In Indonesian language), Kuala Kapuas, 3-4 August 2007.

SULAIMAN, A. A., SULAEMAN, Y. and B. MINASNY (2019). A framework for the development of wetland for agricultural use in Indonesia. Resources 8(34): 1-16. DOI: 10.3390/resources8010034.

SUMAWINATA, B. (1992). Adaptive agricultural practices and land use cycles on pyretic sediments in South Kalimantan. Southeast Asian Studies, 3 (1): 93-104.

SUPRIYANTO, H., E. RAVAIE, S. G. IRIANTO, R. H. SUSANTO, B. SCHULTZ, F. X. SURYADI, and A. VAN DEN EELAART, A. L. J. (2010) Land and water management of tidal lowlands: Experiences in Telang and Saleh, South Sumatra. Irrigation and Drainage, 59: 317-335. DOI: 10.1002/ird.460.

SURAHMAN, A., SUSANTI, M. A. and DARSANI, Y. P. (2020). Prospect of rice farming for degraded peatlands management in Central Kalimantan, Indonesia. In: LESTARI, P., MULYA, K., UTAMI, D. W., SATYAWAN, D. SUPRIADI and MASTUR (eds) Strategies and Techologies for The Utilization and Improvement of Rice. IAARD Press: Jakarta, 189-216.

SURYADI, F. X. (2006). Soil and Water Management Strategies for Tidal Lowlands in Indonesia. A.A. Balkema, Rotterdam, Netherland.

SURYADI, F. X. and A. MOERWANTO (2013). Lowland Development in Indonesia, in the Past, Present and Future. Proceeding on 8th THAICID National Symposium, Bangkok.

SURYAHADI, A. and G. HADIWIDJAYA (2011). The role of agriculture in poverty reduction in Indonesia. Working Paper May 2011. SMERU Research Institute, Jakarta.

SURYAHADI, A., HADIWIDJAJA, G. and S. SUMARTO (2012). Economic growth and poverty reduction in Indonesia before and after the Asian Financial Crisis. Working Paper June 2012. SMERU Research Institute, Jakarta.

SUSANTO, R.H. (2003). Agricultural Drainage Towards an Interdisciplinary and Integrated Approach : A Case of South Sumatera, Indonesia (Paper presented at International Seminar And Exhibition On Prospectives Of Lowland Development In Indonesia, Palembang, 8-9 December 2003) ISBN: 979-97066-1-0.

SUTIKNO, H. and M. NOOR (1997). Strategi pelestarian lahan gambut pasang surut. Air, Lahan, Lingkungan, dan Mitigasi Bencana (In Indonesian language), 1: 21-27.

SUYAMTO (2007). Pengelolaan Tanaman Terpadu (PTT) Padi Lahan Pasang Surut (In Indonesian language). Ministry of Agriculture, Jakarta.

SYAUKAT, Y. (2011). Irrigation in Southern and Eastern Asia in Figure: Indonesia. FAO Water Reports, FAO.

TASHIKALMA, A. K., GIROH, D. Y. and V. A. UGBESHE (2014). Swamp rice production in Ogoja Local Government Area of Cross River State, Nigeria: An imperative for rice value chain of the agricultural transformation agenda. International Journal of Agricultural Policy and Research, 2 (8): 281-287.

TAUER, L. (1995). Age and farmer productivity. Review of Agricultural Economics, 17 (1): 63-69.

TENURE, S., NABINGER, C. and J. L. BECKER. (2013). Bioeconomic model of decision support system for farm management. Part I: Systemic conceptual modeling. Agricultural System, 115 (2013): 104-116.

TIRTOSUDARMO, R. (2009). Mobility and human development in Indonesia. Human Development Research Paper 2009/19. UNDP, New York.

TINER, R.W. and D.G. BURKE (1995). Wetlands of Maryland. U.S. Fish and Wildlife Service, Ecological Services, Region 5, Hadley, MA and Maryland Department of Natural Resources, Annapolis, MD. Cooperative publication.

TORELL, M. and A. M. SALAMANCA (2003). Wetland management in Vietnam's Mekong Delta: An overview of the pressures and responses. In: TORELL et al. (eds) Wetland Management in Vietnam: Issues and Perspective. WorldFish Center.

TRISURAT, Y. (2006). Community based wetland management in Northern Thailand. The International Journal of Environmental, Cultural, Economic and Social Sustainability, 2 (1): 49-62.

VAN DEN EELAART, A. L. J. (1981). Problems in reclaiming and managing tidal lands of Sumatra and Kalimantan Indonesia. Euroconsult, Arnhem, Netherlands.

VAN GILST, T. B. (1992). Tidal swamp development by pump irrigation and gravity drainage, acid sulphate soils, Kalimantan, Indonesia. Faculteit der Civiele Techniek, Technische Universiteit Delft.

VAN WINSEN, F., DE MEY, Y., LAUWERS, L., VAN PASSEL, S., VANCAUTEREN, M. and E. WAUTERS (2013). Cognitive mapping: a method to elucidate and present farmers' risk perception. Agricultural Systems, 122: 42-52.

VEPA [VIETNAM ENVIRONMENTAL PROTECTION AGENCY] (2005). Overview of wetlands status in Viet Nam following 15 years of Ramsar Convention implementation. Vietnam Environment Protection Agency, Hanoi.

VERHOEVEN, J. T. A. and T. L. SETTER (2010). Agricultural use of wetlands: Opportunities and limitations. Annals of Botany, 105: 155 – 163. DOI: 10.1093/aob/mcp172.

WATSON, J. B. (1965). From hunting to horticulture in the New Guinea Highlands. Ethnology, 4(3): 295-309. ISSN 1832-2077

WIDIATI, R. (2006). The Integration of beef cattle farming system on the farm household in Merapi volcanic slope, Sleman Yogyakarta. Proceedings of The 4th ISTAP Animal Production and Sustainable Agriculture in The Tropic, Faculty of Animal Science, Gadjah Mada University, 8-9 November 2006.

WIDJAJA-ADHI, I.P.G., RATMINI, N. P. and I.W. SWASTIKA (1992). Soil and water management in tidal swampland. Board of Agricultural Research and Development, Jakarta.

WIDJAJA-ADHI, I. P. G., NUGROHO, K., DIDI-ARDI, S. and A.S. KARAMA (1992). Sumberdaya lahan rawa: Potensi, keterbatasan, dan pemanfaatan (In Indonesian language). In: S.

PARTOHARDJONO, and M. SYAM (eds): Monograph of National Meeting on the Development of Tidal and Inland Swampland for Agriculture. Cisarua, Indonesia, 3-4 March 1992.

WIDJAJA-ADHI, I. P. G. and A. S. KARAMA (1994). Development of coastal plains in Indonesia: Research needs and priorities. Indonesian Agricultural Research and Development, 16 (3): 37-47.

WIKRAMANAYAKE, E., DINERSTEIN, E. and C. J. LOUSCKS (2002). Terrestrial ecoregions of the Indo-Pacific: A Conservation Assessment. Island Press.

WILCOX, D.A, THOMPSON, T. A., BOOTH, R. K. and J. R. NICHOLAS (2007). Lake-level variability and water availability in the Great Lakes. USGS Circular 1311. United State Geological Survey (USGS), Virginia.

WILDAYANA, E., IMANUDIN, M. S., JUNEDI, H., ZUHDI, M. and M. E. ARMANTO (2016). Parameters affecting household income diversity of farmer's tribes in South Sumatra tidal wetland. Sriwijaya Journal of Environment, 1(3): 47-52. DOI: http://dx.doi.org/10.22135/sje.2016.1.3.47-52.

WILDAYANA, E., ADRIANI, D. and M. E. ARMANTO (2017). Livelihoods, household income and indigenous technology in South Sumatra wetlands. Sriwijaya Journal of Environment, 2(1): 25-30. DOI: http://dx.doi.org/10.22135/sje.2017.2.1.25-30.

WILK, J., ANDERSON, L. and V. PLERMKAMON (2001). Hydrological impacts of forest conversion to agriculture in a large river basin in northeast Thailand. Hydrological Processes, 15: 2729-2748.

WOLF, S. A. and P. NOWAK (1999). Institutional Failure in Agro-environmental Management. Research in Social Problems and Public Policy, 7: 293-310.

WORLD BANK (2011). Rwanda Economic Update: Seeds for Higher Growth. Spring Edition, April 2011. The World Bank.

WOSSEN, T., BERGER, T., HAILE, M. G. and C. TROOST (2018). Impacts of climate variability and food price volatility on household income and food security of farm households in East and West Africa. Agricultural Systems, 163: 7-15. DOI: http://dx.doi.org/10.1016/j.agsy.2017.02.006.

WOSTEN, J. H. M., CLYMANS, E., PAGE, S. E., RIELEY, J.O. and S. H. LIMIN (2008). Peat-water interrelationships in a tropical peatland ecosystem in Southeast Asia. Catena, 73: 212-224.

WU, J. J. and M. LI (2013). Land use change and agricultural intensification: key research questions and innovative modelling approaches. The International Food Policy Research Institute 200002.000.180 515-01-01.

WU, W., SHIBASAKI, R., YANG, P., TANG, H. and K. SUGIMOTO (2010). Modeling changes in paddy rice sown areas in Asia. Sustainability Science, 5: 29 – 38.

YANTI, N. D. (2002). Sustainability Analysis of Farming Systems in Tidal Swamplands: A Case Study in South Kalimantan, Indonesia. PhD Thesis. The University of Western Australia, Perth.

YASIN, M., YULIANI, N., NINGSIH, R. D. and A. SABUR (2020). Increasing rice productivity using technology package of "Jajar Legowo Super" in tidal swamp areas of South Kalimantan. In: LESTARI, P., MULYA, K., UTAMI, D. W., SATYAWAN, D. SUPRIADI and MASTUR (eds) Strategies and Techologies for The Utilization and Improvement of Rice. IAARD Press, Jakarta: 251-263.

YOSHINO, K., ISHIDA, T., NAGANO, T. and Y. SETIAWAN (2010). Land cover pattern analysis of tropical peat swamp lands in Southeast Asia. International Achieve of the Photogrammetry, Remote Sensing and Spatial Information Science, 38 (8): 941 – 946.

YULIANI, N. and K. NAPISAH (2020). Soil chemical properties in acid sulfate land with intercropping system of rice and citrus. In: LESTARI, P., MULYA, K., UTAMI, D. W., SATYAWAN, D. SUPRIADI and MASTUR (eds) Strategies and Techologies for The Utilization and Improvement of Rice. IAARD Press, Jakarta: 265-276.

ZEDLER, J. B. (1996). Ecological issue in wetland mitigation: An introduction to the forum. Ecological Application, 6 (1): 33-37.

Websites

AFRICARICE (2015). Annual Data Reports. https://www.africarice.org/annual-reports . Accessed on 3 August 2016.

BERNHARD MEIER ZU BIESSEN (2014). Online Discussion: Swampland Farming in Central Africa. https://www.researchgate.net/post/Are_there_any_success_and_bad_stories_about_swamp_reclamation_for_agriculture_outside_of_Indonesia. Discussed on September 2015.

CBS (2012b). Productivity-Production of Rice in Indonesia. National of Statistical Bureau. http://www.bps.go.id. Accessed on 14 November 2012.

CIA (2016). The World Fact Book: Indonesia. https://www.cia.gov/the-world-factbook/countries/indonesia/. Accessed on 6 March 2016.

FAOSTAT (2007). Statistical database of food balance sheet. www.fao.org. Accessed on 13 January 2015.

MACROTRENDS (2022a). Indonesia GNP 1969-2023. https://www.macrotrends.net/countries/IDN/indonesia/gnp-gross-national-product Accessed on 9 December 2022.

MACROTRENDS (2022b). Indonesia GDP 1967-2023. https://www.macrotrends.net/countries/IDN/indonesia/gdp-gross-domestic-product Accessed on 9 December 2022.

MACROTRENDS (2022C) Indonesia Unemployment Rate 1991-2023. https://www.macrotrends.net/countries/IDN/indonesia/unemployment-rate Accessed on 9 December 2022

MAPZONES. (2003) Country's profile. Available by Mapzones. http://atlas.mapzones.com/indonesia/.

MARR, C. (1990) Uprooting people, destroying culture: Indonesia's transmigration program. *The Multinational Monitor*, 11 (10). http://www.multinationalmonitor.org/hyper/issues/1990/10/marr.html. Accessed on 12 March 2015.

PEAT PORTAL (2004) Project Information Sheet-Indonesia-Wetlands International http://wetlands.or.id/PDF/Flyers/Project%20Information%20Sheet.pdf. Accessed on 25 January 2014.

RAMSAR.ORG (2014) About the convention on wetlands https://ramsar.org/about-the-convention-on-wetlands-0 . Accessed on 2 May 2014.

RIDS [Rice Indonesia Data Service] (2012). Rice Indonesia. http://www.riceindonesia.com/News-1.html. Accessed on 13 November 2012.

STATISTA (2022). Rice consumption per capita in Indonesia from 2011 to 2020, with estimates until 2031. https://www.statista.com/statistics/1225366/indonesia-rice-consumption-per-capita/. Accessed on 12 December 2022.

UNDP (2020) Republic of Indonesia and the United Nations System in Indonesia https://www.id.undp.org/content/dam/.../INS-UNPDF%202016-2020.pdf

Accessed on 20 December 2020.

USDA (2012) Indonesia: Stagnating rice production ensures continued need for imports. Commodity Intelligence Report March 19, 2012. United State Department of Agriculture. http://www.pecad.fas.usda.gov/highlights/2012/03/Indonesia_rice_Mar2012. Accessed on 19 November 2012.

USGS [United State Geological Service] (2014). Wetland and Aquatic Research. http://www.nwrc.usgs.gov/fringe/glossary.html. Accessed on 12 December 2014.

van den Eelaart, A. L. J. (2014). Swampland in Indonesia. www.eelaart.com. Accessed on 12 December 2014.

World Bank Data (2015) World Bank Open Data: Rwanda. https://data.worldbank.org/ . Accessed on 17 March 2015.

World Bank. (2020). Indonesia Overview. https://www.worldbank.org/en/country/indonesia/overview. Accessed on January 2020.

APPENDICES

Appendix 1. Historical time of swamp reclamation in Indonesia

Era	Remarks
Pre-colonization (before 1680)	• The *Majapahit* kingdom (1293-1527) opened swamp area for settlement and agriculture on Pawan basin, West Kalimantan, in the 13th century[1]. • Swamp reclaimed by community pioneered by Bugisse people. They produced rice around 0.8 - 1 ton per ha[2,3].
Colonization era / Dutch Rule (1680-1945)	• Exploration to identify peat in Sumatera in the 1680s, and followed the detailed exploration in 1895[4]. • First peatland reclamation for agriculture and local settlement in South Kalimantan in 1920[5]. • Detailed survey in southern Kalimantan 1930s[3]. • Swamp reclamation was begun in 1936 by dredging a canal which connected Kapuas Murung River and Barito River, then was followed by trans locating farmers from Java to dredge the sub-canals and to open agricultural area[5].
Old Order (1945-1965)	• Canals dredging for better accessibility in Sumatera (850 km) and Kalimantan (760 km)[1]. • Three major canals (*anjir*) were dredged connecting Barito and Kapuas River in Kalimantan[4]. • The communities opened the land by digging the sub-canals (*handil*) in along the main canals. Their size were 2 – 3 meter width, 0.5 – 1.0 depth and 2 – 3 km long, and the distance between sub canals was 200 – 300 meters[4].
New Order (1966-1994)	• The swampland acknowledged as a potential resource for agriculture in 1968[6]. • The Tidal Ricefield Reclamation Project (P4S) was launched in 1969. The project was intended to solve 2 million ton rice deficit by opening 5.25 million hectares of swampland in Kalimantan and Sumatera. The project opened 1.24 million ha of swamp area in Kalimantan (29 water scheme) and Sumatera (26 water scheme)[4,7]. • Several fork-shape canal systems were dredged[4]. • Until 1995, 1.18 million hectares of swampland had been reclaimed by government and 3.0 million hectares by local communities[4].

Appendix 1.Continued

Era	Remarks
New Order (1995-1998)	• The launch of Mega Rice Project (MRP) in 1995 to open more than 1 million hectares of peat swamp in Central Kalimantan to regain self-sufficiency of rice[8]. • Within this project, 917 km of primary and secondary canals and 11,839 km of tertiary ditches were dug up. The canals connect the peat dome and sea[5]. • About 13,500 households from populated islands have been settled to work on this agricultural project[5]. • Canals dredging caused over-drained peat swamp and lead to massive swamp forest fires and environmental degradation[4,9]. • Loss of land fertility as the peat worn-off, drought and flood triggered most of the farmers abandon their land[3,4,5].
Reformation Order 1999 - 2015	• The MRP was suspended in 1999[3], but it still has potency for rehabilitation[10]. • Rehabilitation and revitalization of 600,000 – 800,000 ha of fallowed land in 2001[1]. • The acceleration of rehabilitation and revitalization in 2007 – 2011[11].
Summary	Since 1969, 3.82 million hectares of swamp have been reclaimed by the government and community. Among them, approximately 600,000-800,000 hectares have been fallowed. Around 50 % of ex-MRP areas were almost fallowed. Most water networks which were built in 1970 – 1995 were damaged[1].

Sources: [1]HARYONO (2012); [2]SURYADI (2013); [3]MAAS (2003); [4]NOOR (2012); [5]NOOR & SARWANI (2013); [6]NOTOHADIPRAWIRO (1994); [7]SUBAYO et al. (1996); [8]HECKER (2005); [9]JAENICKE et al. (2008); [10]SUHARTANTO (2007); [11]ISARI (2013).

Appendix 2. Estimation of additional rice contribution of tidal and monotonous swamp in 10 provinces; Riau, Jambi, South Sumatera, Lampung, South Kalimantan, Central Kalimantan, East Kalimantan, West Kalimantan, West Sulawesi, and Central Sulawesi.

Swamp Typology	Additional production (unhusked rice ton/year)	Contribution (unhusked rice ton/year)		
		Land extension	Productivity increase	Planting index
Tidal swamp	6,489,061	2,439,858	1,349,743	2,699,469
Monotonous	2,059,822	891,624	891,624	778,899
	8,548,883	3,331,482	1,739,482	3,478,368

Source: INDONESIA AGENCY FOR AGRICULTURAL RESEARCH AND DEVELOPMENT (IAARD), 2011.

Appendix 3. Parameters Value for the Model

	Unit	Typology A	Typology B	Typology C
Land availability (fsize)	ha	1.47	1.61	2.24
Yearly family labor availability in dry season (avflabord)	man-days/farm	297	258.7	304.2
Yearly family labor availability in rainy season (avflaborr)	man-days/farm	297	258.7	304.2
Hired labor wage rate for rice (wlaborri)	IDR/man-days	45000	40000	45000
Hired labor wage for orange (wlaboro)	IDR/man-days	50000	65000	65000
Hired labor for local rice in dry season ($hlabor_{lrice\_d}$)	man-days/ha	9.35	27	24
Hired labor for local rice in rainy season ($hlabor_{lrice\_r}$)	man-days/ha	-	-	-
Total labor for local rice in dry season ($tlabor_{lrice\_d}$)	man-days/ha	104.48	83	97
Total labor for local rice in rainy season ($tlabor_{lrice\_r}$)	man-days/ha	-	-	-
Hired labor for HYV rice in dry season ($hlabor_{hrice\_d}$)	man-days/ha	-	-	-
Hired labor for HYV rice in rainy season ($hlabor_{hrice\_r}$)	man-days/ha	-	15	10
Total labor for HYV rice in dry season ($tlabor_{hrice\_d}$)	man-days/ha	-	-	-
Total labor for HYV rice in rainy season ($tlabor_{hrice\_r}$)	man-days/ha	-	46	75
Hired labor for coconut in dry season ($hlabor_{coconut\_d}$)	man-days/ha	7	-	-
Hired labor for coconut in rainy season ($hlabor_{coconut\_r}$)	man-days/ha	5	-	-
Total labor for coconut in dry season ($tlabor_{coconut\_d}$)	man-days/ha	13	-	-
Total labor for coconut in rainy season ($tlabor_{coconut\_r}$)	man-days/ha	15	-	-
Hired labor for orange in dry season ($hlabor_{orange\_d}$)	man-days/ha	-	7	7
Hired labor for orange in rainy season ($hlabor_{orange\_r}$)	man-days/ha	-	10	10
Total labor for orange in dry season ($tlabor_{orange\_d}$)	man-days/ha	-	23	23
Total labor for orange in rainy season ($tlabor_{orange\_r}$)	man-days/ha	-	30	30

Capital requirement for local rice in dry season ($capital\_nd_{lrice\_d}$)	IDR/ha	4179235	4055275	4055275
Capital requirement for local rice in rainy season ($capital\_nd_{lrice\_r}$)	IDR/ha	-	-	-
Credit for local rice ($implicit\_credit_{lrice}$)	IDR/ha	-	-	131791
Total capital requirement for local rice ($tcapital_{lrice}$)	IDR/ha	4179235	4055275	4187066
Capital requirement for HYV rice in dry season ($capital\_nd_{hrice\_d}$)	IDR/ha	-	-	-
Capital requirement for HYV rice in rainy season ($capital\_nd_{hrice\_r}$)	IDR/ha	-	5064970	2001128
Credit for HYV rice ($implicit\_credit_{hrice}$)	IDR/ha	-	552999	977063
Total capital requirement for HYV rice ($tcapital_{hrice}$)	IDR/ha	-	5617970	2978191
Capital requirement for coconut in dry season ($capital\_nd_{coconut\_d}$)	IDR/ha	4732471	-	-
Capital requirement for coconut in rainy season ($capital\_nd_{coconut\_r}$)	IDR/ha	2366235	-	-
Credit for coconut ($implicit\_credit_{coconut}$)	IDR/ha	1152941	-	-
Total capital requirement for coconut ($tcapital_{coconut}$)	IDR/ha	8251647	-	-
Capital requirement for orange in dry season ($capital\_nd_{orange\_d}$)	IDR/ha	-	4732471	4732471
Capital requirement for orange in rainy season ($capital\_nd_{orange\_r}$)	IDR/ha	-	2366235	2366235
Credit for orange ($implicit\_credit_{orange}$)	IDR/ha	-	1152941	1152941
Total capital requirement for orange ($tcapital_{orange}$)	IDR/ha	-	8251647	8251647
Home supplied capital (avhcapital)	IDR/farm	7200688	15512350	7949664
Interest rate for crop loan (cinterest)	%	0.10	0.10	0.10

Required local rice by the household ($commodites\_req_{lrice}$)	ton/household	1.10	1.13	1.04
Required HYV rice by the household ($commodites\_req_{hrice}$)	ton/household	-	0.27	0.18
Required coconut by the household ($commodites\_req_{coconut}$)	ton/household	0.01	-	-
Required orange by the household ($commodites\_req_{orange}$)	ton/household	-	0.20	0.20
land preparation cost of local rice ($landprep_{lrice}$)	IDR/ha	350000	350000	350000
land preparation cost of HYV rice ($landprep_{hrice}$)	IDR/ha	-	150000	150000
land preparation cost of coconut ($landprep_{coconut}$)	IDR/ha	3000000	-	-
land preparation cost of orange ($landprep_{orange}$)	IDR/ha	-	3000000	3000000
seed cost of local rice ($rseed_{lrice}$)	IDR/ha	50819	47547	59557
seed cost of HYV rice ($rseed_{hrice}$)	IDR/ha	-	45451	79912
seed cost of coconut ($rseed_{coconut}$)	IDR/ha	1710000	-	-
seed cost of orange ($rseed_{orange}$)	IDR/ha	-	3000000	3000000
Chemical fertilizer cost of local rice ($rchemfer_{lrice}$)	IDR/ha	131505	536640	691534
Chemical fertilizer cost of HYV rice ($rchemfer_{hrice}$)	IDR/ha	-	507548	897151
Chemical fertilizer cost of coconut ($rchemfer_{coconut}$)	IDR/ha	398400	-	-
Chemical fertilizer cost of orange ($rchemfer_{orange}$)	IDR/ha	-	1400000	1400000
Organic fertilizer cost of local rice ($rorgfer_{lrice}$)	IDR/ha	-	123298	176516
Organic fertilizer cost of HYV rice ($rorgfer_{hrice}$)	IDR/ha	-	105187	105187
Organic fertilizer cost of coconut ($rorgfer_{coconut}$)	IDR/ha	800000	-	-
Organic fertilizer cost of orange ($rorgfer_{orange}$)	IDR/ha	-	2000000	2000000
Pesticide cost of local rice ($rpesticide_{lrice}$)	IDR/ha	74972	181089	284700

Pesticide cost of HYV rice ($rpesticide_{hrice}$)	IDR/ha	-	130401	528106
Pesticide cost of coconut ($rpesticide_{coconut}$)	IDR/ha	460000	-	-
Pesticide cost of orange ($rpesticide_{orange}$)	IDR/ha	-	870000	870000
Other cost of local rice ($rother_{lrice}$)	IDR/ha	137816	759181	137816
Other cost of HYV rice ($rother_{hrice}$)	IDR/ha	-	166725	257033
Other cost of coconut ($rother_{coconut}$)	IDR/ha	2000000	-	-
Other cost of orange ($rother_{orange}$)	IDR/ha	-	2000000	2000000

Appendix 4. Generated process of Price Scenario in Swamp Typology B

S	Uncorrelated Random Number U			Correlated Random Number Z			Price Scenario		
	Hrice	Lrice	Orange	Hrice	Lrice	Orange	Hrice	Lrice	Orange
1	-0.557	-3.054	1.214	-0.557	-1.236	1.687	4,062,710	4,188,056	3,929,538
2	-0.045	-0.085	-1.149	-0.045	-0.063	-0.498	4,426,251	5,108,070	3,663,120
3	-1.459	0.466	-0.393	-1.459	-1.315	-1.487	3,421,810	4,125,739	3,542,462
4	1.153	-0.853	0.026	1.153	0.930	1.297	5,277,712	5,887,274	3,882,004
5	-0.672	1.625	0.584	-0.672	-0.286	-1.068	3,980,614	4,933,250	3,593,591
6	-0.112	0.413	0.285	-0.112	-0.015	-0.167	4,378,914	5,145,822	3,703,411
7	-0.958	-0.185	1.120	-0.958	-0.975	-0.116	3,777,344	4,392,128	3,709,606
8	-0.240	-0.900	-0.681	-0.240	-0.438	-0.018	4,287,764	4,813,985	3,721,562
9	0.404	0.590	1.119	0.404	0.528	0.491	4,745,649	5,571,864	3,783,727
10	-0.695	0.410	-0.404	-0.695	-0.584	-0.900	3,964,616	4,699,706	3,613,994
11	-0.421	-0.814	0.191	-0.421	-0.595	0.190	4,158,827	4,690,451	3,746,981
12	-0.206	1.172	0.103	-0.206	0.066	-0.705	4,311,951	5,209,130	3,637,774
13	1.217	1.663	0.365	1.217	1.563	0.209	5,323,356	6,384,504	3,749,304
14	0.977	-0.734	-0.505	0.977	0.784	0.871	5,152,200	5,773,357	3,830,095
15	-0.733	0.487	-1.400	-0.733	-0.603	-1.408	3,937,544	4,684,225	3,552,125
16	0.738	-1.051	-2.136	0.738	0.480	0.137	4,982,558	5,534,493	3,740,477
17	1.344	0.532	-0.122	1.344	1.430	0.665	5,413,297	6,279,789	3,804,873
18	0.482	-0.056	-0.489	0.482	0.457	0.168	4,801,075	5,516,523	3,744,260
19	0.221	0.466	-0.276	0.221	0.321	-0.198	4,615,227	5,409,601	3,699,697
20	0.183	0.631	0.384	0.183	0.322	-0.017	4,588,595	5,410,283	3,721,670
21	0.300	-0.450	0.345	0.300	0.191	0.603	4,671,758	5,307,226	3,797,405
22	-1.378	-1.357	-1.275	-1.378	-1.650	-0.885	3,479,444	3,862,946	3,615,820
23	-0.655	1.282	-1.691	-0.655	-0.347	-1.885	3,993,213	4,885,712	3,493,918
24	0.437	-0.662	0.611	0.437	0.275	0.930	4,768,512	5,373,521	3,837,223
25	-0.472	1.179	0.206	-0.472	-0.192	-0.859	4,122,908	5,006,908	3,619,029
26	0.484	-1.076	0.877	0.484	0.227	1.294	4,802,052	5,335,730	3,881,656
27	-0.864	1.222	0.535	-0.864	-0.564	-1.025	3,844,205	4,714,823	3,598,769
28	0.611	-0.736	0.083	0.611	0.428	0.863	4,892,452	5,493,537	3,829,100
29	-1.409	1.784	0.250	-1.409	-0.968	-1.839	3,456,915	4,398,230	3,499,443
30	0.748	0.472	-1.118	0.748	0.836	-0.184	4,989,937	5,813,703	3,701,362
31	-0.394	-0.779	1.353	-0.394	-0.560	0.706	4,178,674	4,718,128	3,809,914
32	0.986	0.673	-0.496	0.986	1.113	0.163	5,158,798	6,031,119	3,743,728
33	-1.015	-0.508	0.000	-1.015	-1.104	-0.489	3,736,739	4,290,912	3,664,207
34	-0.348	0.748	-2.039	-0.348	-0.169	-1.540	4,210,761	5,024,731	3,535,917
35	1.430	0.152	-0.643	1.430	1.427	0.692	5,474,439	6,277,862	3,808,220
36	1.243	0.283	0.422	1.243	1.275	0.958	5,341,543	6,158,217	3,840,676
37	-0.801	1.987	-0.290	-0.801	-0.329	-1.734	3,888,880	4,899,204	3,512,282
38	0.674	-0.640	-0.592	0.674	0.512	0.562	4,937,567	5,559,341	3,792,382
39	-2.620	0.607	0.383	-2.620	-2.414	-2.072	2,596,487	3,262,993	3,471,104
40	0.465	0.002	1.478	0.465	0.453	0.995	4,788,488	5,513,346	3,845,105
41	0.177	0.057	0.206	0.177	0.185	0.192	4,584,010	5,303,071	3,747,238
42	0.147	1.776	1.097	0.147	0.546	-0.314	4,562,804	5,586,572	3,685,472
43	1.894	-0.632	1.232	1.894	1.701	2.263	5,804,119	6,492,962	3,999,828

44	1.590	-1.158	0.368	1.590	1.286	1.926	5,587,981	6,166,625	3,958,739
45	-0.889	1.330	-0.844	-0.889	-0.564	-1.708	3,826,644	4,715,156	3,515,483
46	1.507	-0.027	-0.539	1.507	1.462	0.887	5,529,404	6,305,132	3,831,928
47	0.571	0.476	-0.374	0.571	0.665	0.013	4,864,291	5,679,286	3,725,329
48	-0.427	0.771	0.471	-0.427	-0.241	-0.500	4,154,962	4,968,669	3,662,769
49	0.219	0.217	-0.522	0.219	0.262	-0.180	4,613,835	5,363,663	3,701,836
50	1.511	-0.139	1.551	1.511	1.440	1.870	5,531,782	6,287,687	3,951,893
51	-1.240	1.761	1.179	-1.240	-0.808	-1.293	3,577,418	4,523,862	3,566,141
52	0.063	-0.383	-0.890	0.063	-0.026	-0.151	4,502,936	5,137,475	3,705,342
53	-0.073	0.118	-1.172	-0.073	-0.044	-0.632	4,406,429	5,122,915	3,646,722
54	0.618	-0.880	0.215	0.618	0.402	1.000	4,897,179	5,472,972	3,845,774
55	0.442	-0.367	0.483	0.442	0.347	0.727	4,772,163	5,429,980	3,812,431
56	-0.284	-0.992	1.093	-0.284	-0.502	0.781	4,256,540	4,763,851	3,819,034
57	-0.773	0.508	-0.459	-0.773	-0.637	-1.032	3,909,255	4,657,495	3,597,976
58	0.563	1.356	-1.252	0.563	0.856	-0.832	4,858,162	5,829,423	3,622,360
59	1.767	-0.951	-0.090	1.767	1.505	1.748	5,713,706	6,338,842	3,937,016
60	0.133	0.468	0.592	0.133	0.235	0.120	4,552,485	5,342,455	3,738,430
61	-2.685	-0.306	0.718	-2.685	-2.684	-1.505	2,550,732	3,051,026	3,540,276
62	-1.408	-0.780	0.188	-1.408	-1.548	-0.556	3,457,939	3,942,679	3,655,970
63	0.248	0.063	-0.197	0.248	0.255	0.063	4,634,223	5,358,154	3,731,519
64	-0.891	0.130	1.309	-0.891	-0.838	-0.144	3,825,513	4,500,104	3,706,222
65	0.598	-0.117	0.574	0.598	0.556	0.754	4,883,056	5,593,812	3,815,789
66	-1.923	1.621	0.450	-1.923	-1.505	-2.047	3,091,664	3,976,392	3,474,143
67	-0.208	0.721	-0.132	-0.208	-0.039	-0.580	4,310,841	5,127,431	3,653,114
68	-0.373	1.231	0.330	-0.373	-0.084	-0.758	4,193,183	5,091,889	3,631,293
69	0.025	0.427	-1.646	0.025	0.122	-0.927	4,476,327	5,253,176	3,610,751
70	-1.204	-0.102	0.614	-1.204	-1.196	-0.564	3,602,646	4,219,112	3,655,013
71	0.623	0.177	-1.054	0.623	0.647	-0.097	4,900,737	5,665,213	3,711,922
72	0.808	-0.398	1.327	0.808	0.697	1.386	5,032,616	5,704,534	3,892,846
73	1.846	0.717	-0.536	1.846	1.961	0.757	5,770,080	6,696,624	3,816,164
74	1.292	-1.404	-0.713	1.292	0.939	1.354	5,376,125	5,894,874	3,889,000
75	-1.046	-0.302	1.688	-1.046	-1.088	0.130	3,715,011	4,304,212	3,739,616
76	-0.175	1.125	-1.374	-0.175	0.085	-1.312	4,333,817	5,224,218	3,563,838
77	1.499	-1.106	-1.211	1.499	1.209	1.135	5,523,348	6,106,381	3,862,211
78	-0.092	1.631	-0.855	-0.092	0.281	-1.279	4,393,230	5,378,253	3,567,825
79	1.333	-0.797	-1.618	1.333	1.117	0.674	5,405,178	6,034,300	3,806,037
80	0.122	0.510	0.886	0.122	0.234	0.221	4,544,703	5,341,503	3,750,727
81	1.403	-0.444	-1.390	1.403	1.265	0.646	5,455,025	6,150,842	3,802,640
82	1.078	1.919	-1.177	1.078	1.486	-0.706	5,224,243	6,323,618	3,637,631
83	-0.644	-0.068	-0.533	-0.644	-0.643	-0.676	4,000,729	4,653,427	3,641,390
84	0.993	-0.123	0.129	0.993	0.939	0.852	5,164,030	5,894,919	3,827,731
85	2.393	-0.488	-0.455	2.393	2.220	1.812	6,158,519	6,899,732	3,944,762
86	-0.974	-1.202	-1.613	-0.974	-1.222	-0.817	3,766,160	4,199,044	3,624,166
87	0.726	1.105	1.193	0.726	0.958	0.498	4,974,528	5,909,866	3,784,561
88	-0.537	1.401	-0.875	-0.537	-0.205	-1.498	4,076,535	4,996,542	3,541,053
89	-0.580	0.827	1.266	-0.580	-0.377	-0.290	4,046,291	4,861,778	3,688,388
90	-1.031	0.605	-0.140	-1.031	-0.867	-1.131	3,725,730	4,477,428	3,585,840

91	-1.424	1.913	1.922	-1.424	-0.952	-1.177	3,446,684	4,410,281	3,580,192
92	-0.799	-0.303	1.174	-0.799	-0.847	0.085	3,890,676	4,493,129	3,734,159
93	1.104	-0.073	-0.135	1.104	1.059	0.792	5,242,973	5,988,786	3,820,340
94	-0.809	-1.016	-0.813	-0.809	-1.019	-0.437	3,883,392	4,358,214	3,670,560
95	-1.289	0.292	2.140	-1.289	-1.189	-0.154	3,542,237	4,224,298	3,705,071
96	-0.921	-1.911	0.431	-0.921	-1.331	0.488	3,803,720	4,113,030	3,783,344
97	-0.755	0.040	-1.434	-0.755	-0.726	-1.210	3,921,989	4,587,798	3,576,193
98	0.284	-0.463	0.991	0.284	0.171	0.884	4,660,016	5,292,280	3,831,591
99	-1.739	0.211	0.786	-1.739	-1.646	-1.042	3,222,359	3,865,638	3,596,689
100	-0.290	-0.231	-1.762	-0.290	-0.335	-0.875	4,252,009	4,894,577	3,617,107

Appendix 5. Questionnaire

ASSALAMMUALAIKUM and WISH THE PROSPERITY UPON OF YOU, my name is ______________________and I'm one of the team who want to learn agriculture in tidal swamp area. Your participation is highly valued. Your answer, together to other 200 participant will be stay SECRET and only used for research purpose. This research is not related to the aid from government/foundation/NGO, credit offer or tax issues. If you agree, can we start?
If you any question, doubt, or comment regarding to this survey, kindly contact:
Ahmad Yousuf Kurniawan, Faculty of Agriculture = Universitas Lambung Mangkurat, Mobile: 0821 5707 3743. Email: yousufkurniawan@yahoo.com.

Interview date:	
Interviewer name	
Questionnaire No.	
Entry data code:	

PART I: INFORMATION ON FARMERS

1.1 Location

Code	**Question**	**Anwers**
1101	District	
1102	Sub District	
1103	Village	
1104	RT/RW	

1.2 Household head identity

Code	**Question**	**Answers**
1201	Name of the respondent:	
1202	Contact (*e.g. Phone No*)	
1203	Age (in year)	
1204	Gender	0_☐ Female 1_☐ Male
1205	Ethnic group	1_☐ Banjar 2_☐ Dayak 3_☐ Java/Madura 4_☐ Bali 5_☐ Others (______________)
1206	Place of birth	1_☐ This village 2_☐ Other village in the district 3_☐ Other district 4_☐ Other island
1207	Origin from	
1208	Stay in the area since (year)	
1209	Farming activities since (year)	
1210	Farming in the swamp are since (year)	
1211	Religion	1_☐ Islam 2_☐ Christian 3_☐ Hindu

		4_□ Other (*No need to specify*)
1221	Current marital status	1_□ Married 2_□ Single 3_□ Divorced 4_□ Widow
1222	What is the highest level of education achievement you have attained?	0_□ None 1_□ Primary education 2_□ Junior high 3_□ Senior high 4_□ University education 5_□ Other (________________)
1223	Year of education (total year of going to school)	
1224	Highest level of education in the household	
1225 1226	Non-formal education (e.g.: SLPHT, SLPTT, etc. If **yes**, please specify — Duration (month)	0_□ No 1_□ Yes *If YES, go to 1226*
1227	What is your main activity in the 12 past months?	1_□ Agriculture 2_□ Breeding 3_□ Hunting/Fishing 4_□ Hand works 5_□ Commerce 6_□ Other (________________)

1.3 Detailed Information of Family member *(live in one house and one kitchen)*

Code	Name	Age	Gender	Family status	Education (year)	Main Occupation
1301						
1302						
1303						
1304						
1305						
1306						
				1=head household; 2=wife; 3=children 4=brother/sister;		

1.4 Respondents Experience in agriculture

Code	Questions	Answers
1401	Experience in agriculture (in year)	
1402	Experience in swamp agriculture (in year)	
1403	Have you ever migrated for agricultural purposes?	0_□ No 1_□ Yes
1404	If yes, for which purposes and from where to where?	

		Crops	Had cultivated	Still cultivating
1405	Which type of crops do you grow?	Rice	0_☐ No 1_☐ Yes	0_☐ No 1_☐ Yes
1406		Maize	0_☐ No 1_☐ Yes	0_☐ No 1_☐ Yes
1407		Soybean	0_☐ No 1_☐ Yes	0_☐ No 1_☐ Yes
1408		Vegetables	0_☐ No 1_☐ Yes	0_☐ No 1_☐ Yes
1409		Cassava	0_☐ No 1_☐ Yes	0_☐ No 1_☐ Yes
1410		Groundnuts	0_☐ No 1_☐ Yes	0_☐ No 1_☐ Yes
1411		Others (____________)	0_☐ No 1_☐ Yes	0_☐ No 1_☐ Yes
1412		Others (____________)	0_☐ No 1_☐ Yes	0_☐ No 1_☐ Yes
1413		Others (____________)	0_☐ No 1_☐ Yes	0_☐ No 1_☐ Yes
1414	Do you change the cultivated crops		0_☐ No 1_☐ Yes	
1415	*If any changes in the cultivated crops, ask why?*			
1416	What is your current main crop?		1_☐ Rice 5_☐ 2_☐ Maize 6_☐ Cassava 3_☐ Soybean 5_☐ Vegetables 4_☐ 8_☐ Other (______)	
1417	*Reasons* :			

		Perennials crops	Size in ha	Age of plant	Mixed with
1418	Do you grow perennial crops	1_☐ Orange			
1419		2_☐ Rubber			
1420		3_☐ Palm oil			
1421		4_☐ Coconut			
1422		5_☐ *Rambutan*			
1423		6_☐ (			
1424		7_☐ (			

		Crops	Size in ha	Comment (Mixed with?)
1425	Size of land under cultivation	Rice		
1426		Maize		
1427 1428		Soybean		
1429		Vegetables		
1430		Cassava		
1431		Groundnuts		
1432		Others (______)		
1433		Under fallow		
1434	Size of land not in use (in hectare)			
1435	Average length of land exploitation (in year)			

1.5 Information about land

1. Code	2. Question	Answer			
3.	4.	Plot 1	Plot 2	Plot 3	Plot 4
1501	Acreage (ha)				
1502	Swampland type *(Type A, B, C, or D)*				
1503	Land status/right				

	(1 = owned, 2 = family owned, 3 = rent, 4 = shared in, 5 = fallowed)				
1504	If rent, how many the rent is (Rp)				
1505	If shared in, how many the share is (%)				
1506	Crop cultivated *(1 = rice, 2 =maize, 3 = soybean, 4 = groundnut, 5 = fallowed)*				
1507	Distance from main house (km)				
1508	Distance from main canal/river (km)				
	Distance from nearby city/market				
1509	Age of land *(in year, counted from the first opened)*				
1510	Peat thicknes (cm)				
1511	Pyrite layer depth (cm)				
1512	Irrigation facilities (yes/no)				
1513	Soil fertility *(1=fertile, 2=moderate, 3=not fertile)*				

1.6 Relations of the respondent

Code	Questions		Answers		
1601	Do you belong to any farmers' organization? *If no => question 1503*		0_□ No 1_□ Yes		
1602	*If yes, what type of organization and what this organization provides to you?*				
1603	Do you have access to the credit?		0_□ No 1_□ Yes		
1604	Average amount of credit				
1605	*If no, why?*				
1606	Are you in touch with any extension service?		0_□ No 1_□ Yes		
1607	*If no, why?*				
1608	If yes which type of extension service?	Extension	Y/N	Services	Frequency[12]
		Agric. Agency (BPP or BKP)	0_□No 1_□ Yes		
1609		Research institute (Balittra, BPTP, Uni)	0_□No 1_□ Yes		
1610		NGO (__________)	0_□No 1_□ Yes		
1611	Have you get any guidance about clmate change and planting calendar?		0_□ No 1_□ Yes		
1612	*If yes, when?*				

1.7 Family asset

Code	Question		Answer		
		Cattle	Quantity	Value (Rp)	Total value (Rp)
1701		Cattle/cow			

[12] Frequency: How many time their visit per month?

1702	How many animals do you have	Goat			
1703		Poultry			
1704		Bird			
1705					
1706					
	How many farming and transportation asset	Kind	Quantity	Age	Total value (Rp)
1707		Water pump			
1708		Sprayer			
1709		Hand tractor			
1710		Thresher			
1711		Cart/wagon			
1712		Bicycle			
1713		Motorcycle			
1714		Car			
1715		Boat			
1716					
1717					
1718	Traditional tools	*Cangkul*			
1719		*parang*			
1720		*arit*			
1721		*garu*			
1722		*Karung*			
1723		*Ember*			
1724		*Terpal*			
1725					
1726	What kind of other household asset do you have	Radio/TV			
1727		Cellphone			
1728		VCD			
1729		Refrigerator			
1730		Jewelery			
1731		Saving			
1732					
1733					

PART II. OVERVIEW OF RICE FARMING ACTIVITIES HISTORY

2.1 Plant rotation on 2012

Code	Question	Answer											
	Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2101	Rice												
2102	Maize												
2103	Ground nut												
2104	Vegetable												
2105	Soybean												
2106													
2107													

2.2 Plant rotation on 2011

Code	Question	Answer											
	Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2201	Rice												
2202	Maize												

2203	Ground nut												
2204	Vegetable												
2205	Soybean												
2206													
2207													

2.3 Plant rotation on 2010

Code	Question	Answer											
	Crop	Jan	Feb	Mar	Apr	May	Jun	Ju l	Aug	Sep	Oct	Nov	Dec
2301	Rice												
2302	Maize												
2303	Ground nut												
2304	Vegetable												
2305	Soybean												
2306													
2307													

2.4 Experience of 10 years rice farming

The harvest (rice) in the last 10 years

Code				
	Season Year	Harvest status	Detail	Price Status
2401	2001/2002	1_☐ Better 2_☐ Normal 3_☐ Bad		1_☐ Better 2_☐ Normal 3_☐ Bad
2402	2002/2003	1_☐ Better 2_☐ Normal 3_☐ Bad		1_☐ Better 2_☐ Normal 3_☐ Bad
2403	2003/2004	1_☐ Better 2_☐ Normal 3_☐ Bad		1_☐ Better 2_☐ Normal 3_☐ Bad
2404	2004/2005	1_☐ Better 2_☐ Normal 3_☐ Bad		1_☐ Better 2_☐ Normal 3_☐ Bad
2405	2005/2006	1_☐ Better 2_☐ Normal 3_☐ Bad		1_☐ Better 2_☐ Normal 3_☐ Bad
2406	2006/2007	1_☐ Better 2_☐ Normal 3_☐ Bad		1_☐ Better 2_☐ Normal 3_☐ Bad
2407	2007/2008	1_☐ Better 2_☐ Normal 3_☐ Bad		1_☐ Better 2_☐ Normal 3_☐ Bad
2408	2008/2009	1_☐ Better 2_☐ Normal 3_☐ Bad		1_☐ Better 2_☐ Normal 3_☐ Bad
2409	2009/2010	1_☐ Better 2_☐ Normal 3_☐ Bad		1_☐ Better 2_☐ Normal 3_☐ Bad
2410	2011/2012	1_☐ Better 2_☐ Normal 3_☐ Bad		1_☐ Better 2_☐ Normal 3_☐ Bad

PART III. SPECIFIC RICE FARMING ACTIVITIES

3.1 Application of soil and water management

(Give "√" on the respective techniques)

Code			
	Soil and water conservation	Yes/No	Detail
	Mechanical technique	0_□ No 1_□ Yes	
3101	**Not** applying slash and burn	0_□ No 1_□ Yes	
3102	Minimum tillage to avoid pyrite exposure	0_□ No 1_□ Yes	
3103	Raised bed	0_□ No 1_□ Yes	
3104	Keeping the filed inundated	0_□ No 1_□ Yes	
3105	Strengtened the dike	0_□ No 1_□ Yes	
3106	Improving sluice gate	0_□ No 1_□ Yes	
3107	Applying *worm channel*	0_□ No 1_□ Yes	
3108	Adding ameliorant regularly	0_□ No 1_□ Yes	
	Vegetative technique		
3109	Alley cropping	0_□ No 1_□ Yes	
3110	Mulsch	0_□ No 1_□ Yes	
	Cropping pattern		
3111	Monoculture	0_□ No 1_□ Yes	
3112	Intercropping	0_□ No 1_□ Yes	
3113	Crop rotation	0_□ No 1_□ Yes	

3.2. Local Rice Year 2013

3.2.1 General

Code	Question	Answer	
32101	How many acreage (ha)		
32102	Seed type	1_□ Local (_______________) 2_□ hybrid (_______________)	
32103	Source of seed	1_□ Own previous yield 2_□ Neighbour 3_□ Market	4_□ Certified 5_□ Other
32104	Planting frequency per year	1_□ Once	1_□ Twice

3.2.2 General Description of Local Rice Farming Management

Code	Question	Description
32201	How do you prepare the land?	

32202	How do you sow the seed?		
32203	Seedling duration		
32204	Place		
32205	How to do planting?		
32206	Age seedling		
32207	Number of seedling		
32208	Spacing		
32209	Depth		
	Plant treatment		
32210	- Re-planting		
32211	- Weeding		
32212	Fertilizing		
32213	Fertilizing time		
32214	Pest control		
	Harvesting		
32215	Age of planting		
32215	Form of yield		
32215	Tools used		
32215	Threshing		
	Pasca panen		
32215	Drying duration		
32215	Drying		
32215	Milling		
32215	Packaging		

3.2.3. Variable Costs

Code	Questions		Answers		
32301	Identify the variables costs and the quantities of inputs	Inputs	Used	Quantity[13]	Unit price
		Seeds	0_ No 1_ Yes		
32302		Urea	0_ No 1_ Yes		
32303		SP-36	0_ No 1_ Yes		
32304		KCl	0_ No 1_ Yes		
32305		NPK	0_ No 1_ Yes		
32306		Organic	0_ No 1_ Yes		
32307		Dolomite	0_ No 1_ Yes		
32308		Herbicides	0_ No 1_ Yes		
32309		Insecticides	0_ No 1_ Yes		
32310		Labor	0_ No 1_ Yes	*Refer to the next table!*	

3.2.4. Estimation of labor

Code	Questions	Answers

[13] Quantity units: Fertilizers in kg, Pesticides in Liter,

32401	Household labor	Activities	Male	Female	Children	Day (s) [14]
		Field preparation				
32402		Sowing 1				
32403		Sowing 2				
32404		Weeding 1				
32405		Weeding 2				
32406		Weeding 3				
32407		Fertilizing 1				
32408		Fertilizing 2				
32409		Harvesting				
32410		Others (___________)				
32411	Help labor	Activities	Male	Female	Children	Day (s) [15]
		Field preparation				
32412		Sowing 1				
32413		Sowing 2				
32414		Weeding 1				
32415		Weeding 2				
32416		Weeding 3				
32417		Fertilizing 1				
32418		Fertilizing 2				
32419		Harvesting				
32420		Others (___________)				
	Hired labor	Activities	Male	Female	Children	Day (s) [16]
32421		Field preparation				
32422		Sowing 1				
32423		Sowing 2				
32424		Weeding 1				
32425		Weeding 2				
32426		Weeding 3				
32427		Fertilizing 1				
32428		Fertilizing 2				
32429		Harvesting				
32430		Others (___________)				

3.2.5 Fixed costs

Code	Questions		Answers	
32501	Identify the fixed costs and the quantities of inputs	Inputs	Used	Cost
		Land (Rent)	0_□ No 1_□ Yes	
32502		Credit	0_□ No 1_□ Yes	Amount: Interest rate:
32503		Location materials	0_□ No 1_□ Yes	
32504		Wages (___________)	0_□ No 1_□ Yes	
32505		Other 1 (___________)	0_□ No 1_□ Yes	
32506		Other 2 (___________)	0_□ No 1_□ Yes	
32507		Assets	0_□ No 1_□ Yes	*Refer to the next table!*

3.2.6 Farming time management

[14] Day: For how many days did they work to complete the activity. Eg: 0.5 day for a half day work

[15] Day: For how many days did they work to complete the activity. Eg: 0.5 day for a half day work

[16] Day: For how many days did they work to complete the activity. Eg: 0.5 day for a half day work

Code	Question	Answers	
32601	Are you do your farm activities on- time as suggested?		
	Activities	Time	Status
32602	Land preparation		1_ earlier 2_ on-time 3_ late
32603	Planting (week, month)		1_ earlier 2_ on-time 3_ late
32604	Weeding I		1_ earlier 2_ on-time 3_ late
32605	Applying fertilizer I		1_ earlier 2_ on-time 3_ late
32606	Weeding II		1_ earlier 2_ on-time 3_ late
32607	Applying fertilizer II		1_ earlier 2_ on-time 3_ late
32608	Harvesting		1_ earlier 2_ on-time 3_ late
32609		*Example:* *2 Nov = 2nd week of November*	Based on : [ ] own experience [ ] following neigbourhood [ ] extension officer suggestion
32610	Any comment		

3.2.7 Output (Yield)

Code	Questions		Answers	
32701	How much is your yield? (In kg)			
32702	Could you estimate the yield without any adaptation strategy? *Only for farmers who said that they adapt*			
32703	Percentage of lost			
32704	Are you satisfied of your yield?		0_ No 1_ Yes	
32705	If No, why?			
	Orientation of the output	Orientations	Y/N	Percentage
32706		Self-consumption	0_No 1_ Yes	
32707		Market (when:	0_No 1_ Yes	
32708		Other 1 (_________)	0_No 1_ Yes	
32709		Other 2 (_________)	0_No 1_ Yes	
32710	*Any comments (regarding the yield, example: price, quality, pest attack, etc.*			
32711	The yield a year before (kg)			
32712	The yield 2 years before (kg)			

3.3 HYV Rice Year 2010/2011

3.3.1 General

Code	Question	Answer
33101	How many acreage (ha)	
33102	Seed type	
33103	Source of seed	1_ Own previous yield 4_ Certified 2_ Neighbour 5_ Other 3_ Market
33104	Planting frequency per year	1_ Once 1_ Twice
33105	Reason to cultivate	1_ self-awareness to get more income 2_ trial 3_ government project

		4_ others, ________________________

3.3.2 General Decription of Local Rice Farming Management

Code	Question		Description
33201	How do you prepare the land?		
33202	How do you sow the seed?		
33203	Seedling duration		
33204	Place		
33205	How to do planting?		
33206	Age seedling		
33207	Number of seedling		
33208	Spacing		
33209	Depth		
	Plant treatment		
33210	- Re-planting		
33211	- Weeding		
33212	Fertilizing		
33213	Fertilizing time		
33214	Pest control		
	Harvesting		
33215	Age of planting		
33215	Form of yield		
33215	Tools used		
33215	Threshing		
	Pasca panen		
33215	Drying duration		
33215	Drying		
33215	Milling		
33215	Packaging		

3.3.3 Variable Costs

Code	Questions		Answers		
33301	Identify the variables costs and the quantities of inputs	Inputs	Used	Quantity[17]	Unit price
		Seeds	0_ No 1_ Yes		
33302		Urea	0_ No 1_ Yes		
33303		SP-36	0_ No 1_ Yes		
33304		KCl	0_ No 1_ Yes		
33305		NPK	0_ No 1_ Yes		
33306		Organic	0_ No 1_ Yes		
33307		Dolomite	0_ No 1_ Yes		

[17] Quantity units: Fertilizers in kg, Pesticides in Liter,

33308		Herbicides	0_□ No 1_□ Yes		
33309		Insecticides	0_□ No 1_□ Yes		
33310		Labor	0_□ No 1_□ Yes	*Refer to the next table!*	

3.3.4 Estimation of labor

Code	Questions		Answers			
33401	Household labor	Activities	Male	Female	Children	Day (s) [18]
		Field preparation				
33402		Sowing 1				
33403		Sowing 2				
33404		Weeding 1				
33405		Weeding 2				
33406		Weeding 3				
33407		Fertilizing 1				
33408		Fertilizing 2				
33409		Harvesting				
33410		Others (___________)				
33411	Help labor	Activities	Male	Female	Children	Day (s) [19]
		Field preparation				
33412		Sowing 1				
33413		Sowing 2				
33414		Weeding 1				
33415		Weeding 2				
33416		Weeding 3				
33417		Fertilizing 1				
33418		Fertilizing 2				
33419		Harvesting				
33420		Others (___________)				
	Hired labor	Activities	Male	Female	Children	Day (s) [20]
33421		Field preparation				
33422		Sowing 1				
33423		Sowing 2				
33424		Weeding 1				
33425		Weeding 2				
33426		Weeding 3				
33427		Fertilizing 1				
33428		Fertilizing 2				
33429		Harvesting				
33430		Others (___________)				

3.3.5 Fixed costs

Code	Questions		Answers	
33501	Identify the fixed costs and the quantities of inputs	Inputs	Used	Cost
		Land (Rent)	0_□ No 1_□ Yes	
33502		Credit	0_□ No 1_□ Yes	Amount: Interest rate:
33503		Location materials	0_□ No 1_□ Yes	
33504		Wages (___________)	0_□ No 1_□ Yes	

[18] Day: For how many days did they work to complete the activity. Eg: 0.5 day for a half day work

[19] Day: For how many days did they work to complete the activity. Eg: 0.5 day for a half day work

[20] Day: For how many days did they work to complete the activity. Eg: 0.5 day for a half day work

33505		Other 1 (___________)	0_☐ No 1_☐ Yes	
33506		Other 2 (___________)	0_☐ No 1_☐ Yes	
33507		Assets	0_☐ No 1_☐ Yes	*Refer to the next table!*

3.3.6 Farming time management

Code	Question	Answers	
33601	Are you do your farm activities on- time as suggested?		
	Activities	Time	Status
33602	Land preparation		1_☐ earlier 2_☐ on-time 3_☐ late
33603	Planting (week, month)		1_☐ earlier 2_☐ on-time 3_☐ late
33604	Weeding I		1_☐ earlier 2_☐ on-time 3_☐ late
33605	Applying fertilizer I		1_☐ earlier 2_☐ on-time 3_☐ late
33606	Weeding II		1_☐ earlier 2_☐ on-time 3_☐ late
33607	Applying fertilizer II		1_☐ earlier 2_☐ on-time 3_☐ late
33608	Harvesting		1_☐ earlier 2_☐ on-time 3_☐ late
33609		*Example:* *2 Nov = 2nd week of November*	Based on : [ ] own experience [ ] following neigbourhood [ ] extension officer suggestion
33610	Any comment		

3.3.7 Output (Yield)

Code	Questions		Answers	
32701	How much is your yield? (In kg)			
33702	Could you estimate the yield without any adaptation strategy? *Only for farmers who said that they adapt*			
33703	Percentage of lost			
33704	Are you satisfied of your yield?		0_☐ No 1_☐ Yes	
33705	If No, why?			
	Orientation of the output	Orientations	Y/N	Percentage
33706		Self-consumption	0_☐No 1_☐ Yes	
33707		Market (when:	0_☐No 1_☐ Yes	
33708		Other 1 (_________)	0_☐No 1_☐ Yes	
33709		Other 2 (_________)	0_☐No 1_☐ Yes	
33710	*Any comments (regarding the yield, example: price, etc.*			
33711				
33712				

PART IV. HOUSEHOLD INCOME (NON-RICE INCOME)

4.1. Off-Farm Income

Code	**Questions**	**Answers**
4101	Are you and/or any household member engage as farm worker in MH 2012/2013 - MK 2013?	0_☐ No 1_☐ Yes

4102	Household member	Kind of farm work	Location	Gross income per year (Rp)
	Household head			
4103	Spouse			
4104	Son/Daughter 1			
4105	Son/Daughter 2			
4106	Others			

4.2. Fixed Income

	Are you and/or any household member has fixed job? (government employee or private sector) pada MH 2012/2013 - MK 2013?	0_ Tidak 1_ Ya
	Household member	Kinf of work	Gross income per year (Rp)
4201	Household head		
4202	Spouse		
4203	Son/Daughter 1		
4204	Son/Daughter 2		
4205	Others		

4.3 Other Non-farm income

Code	Kind of Business	Income per week	Gross income per year (Rp)
4301	Stalls / shops / kiosks		
4302	Agricultural trading		
4303	Motobike taxi		
4304	Industry/Craft (____________)		
4305	Car and machinery rent		
4306	Remittance		

4.4 Husbandry Business

Code	Kind of husbandry	Sold	Self-consume	Price	Gross income (Rp)
4401	Cattle				
4402	Sheep				
4403	Self-reared chicken				
4405	Duck				
4406	Fish				
4407	Chicken/duck layer				
4408	Other				

4.5 Perennial Crops

	Jenis Tanaman	Acreage (ha)	Amount of tree	Productive tree	Production (kg)	Price per kg	Gross income (Rp)
4501	Coconut						
4502	Rambutan						
4503	Banana						
4504	Orange						
4505	Rubber						
4506	Palm Oil						

4.6 Income of Secondary Crops

		MH 2012/2013	MK 2013

	Plant cultivated	Acreage	Production	Revenue (Rp)	Acreage	Production	Revenue (Rp)
4601	Corn						
4602	Cassava						
4603	Soybean						
4604	Vegetables						
4605	Ground nut						
4606	Pineapple						

4.7 Household Expense for Food

Code	Expense	Per	Amount	Price	Value	per Year
4701	Rice	Week				
4702	Sugar	Week				
4703	Coffee	Week				
4704	Tea	Week				
4705	Salt	Week				
4706	Side dish and vegetables	Week				
4707	Milik	Month				
4708	Spices and cooking oil	Week				
4709	Cigarette	Week				
4710	Herb	Week				
4711	Other	Week		xxxxx		
4712	JUMLAH	Xxxx		xxxx	xxxxxx	

4.8 Household Expense for Non-Food

Code	Expense	Unit	Price	Value	Multiply	Per Year
	CLOTHES	XXXX	XXXX	XXXX	XXX	XXXXXXX
4801	Scholl uniform	Year			X 1	
4802	Shoes and slippers	Year			X 1	
4803	Other	Year			X 1	
4804	**House maintenance**	3 Year			x 0.3	
	House Appliance	XXXX	XXXX	XXXX	XXX	XXXXXXXX
4805	TV	10 Year			x 0.1	
4806	Refrigerator	5 Year			x 0.2	
4807	Lighting	5 Year			x0.2	
4808	Motobike	10 Year			x 0.1	
4809	Bicycle	10 Year			x 0.1	
4810	Boat	10 Year			x 0.1	
4811	Furniture	10 Year			x 0.1	
4812	Sewing machine	10 Year				
4813	Kitchen tools	1 Year			X 1	
	LAIN-LAIN	XXXX	XXXX	XXXXX	XXX	XXXXXXX
4814	Sanitary and bathing.	Month	xxxxxx		x 12	
4815	Firewood	Week			X 52	
4816	Kerosene/Gas	Week			X 52	
4817	Fuel	Week			X 52	
4818	Education (fee, allowance, etc)	1 Month			X 12	

4819	Transportation	1 Year			X 1	
4820	Zakat.(religious donation)	1 Year			X 1	
4821	Donation	1 Year				
4822	Feast	1 Year			X 1	

PART V RESPONDEN MOBILITY

5.1 Work to other village (but commute)

Code	Month	Frequency	Distance	Acitvity*
5101	January			
5102	February			
5103	March			
5104	April			
5105	May			
5106	June			
5107	July			
5108	August			
5109	September			
5110	October			
5111	November			
5112	December			

*)The Activity can be filled with :
1= farming, 2=farm workingi, 3 = palm oil employee, 4= trading, 5= driver, 6=carpentry/construction worker, 7= Government employee/military, 8 = teacher/social worker, 9 = **....................**

5.2 Working but is not commute (tidak pulang setiap hari)

Code	Month	Frequency	Distance	Acitvity*
5201	January			
5202	February			
5203	March			
5204	April			
5205	May			
5206	June			
5207	July			
5208	August			
5209	September			
5210	October			
5211	November			
5212	December			

1= farming, 2=farm working, 3 = palm oil employee, 4= trading, 5= driver, 6=carpentry/construction worker, 7= Government employee/military, 8 = teacher/social worker, 9 = fisherman, 10 = **................**

THANK YOU

Thank you for your kind response. Hopefully, this research is useful for all.

Appendix 6. GAMS Code

```
$Title     LAND ALLOCATION MODEL IN TIDAL SWAMP TYPOLOGY B
$Ontext
version: 1.0
Purpose:
The model has been developed for the PhD reserach entitled,
"Socio-economic and Resource Allocation on Tidal Swampland Agriculture in Indonesia"
     Supervisor  : Prof. Dr. Joachim Aurbacher
     Institute   : Institut für Betriebslehre der Agrar- und Ernährungswirtschaft,
                   Justus-Liebig University Giessen, Germany
     Researcher  : Ahmad Yousuf Kurniawan
     Acknowledge : To DAAD for funding
          Dr. Ujjal Tiwari and Dr. Md. Salauddin Palash to introduce the initial model

$Offtext

Sets
    cm       commodities        /lrice         local rice
                                 hrice         high yield rice
                                 orange        siam orange/

    t        seasons                    /dry, rainy/
*dry season is started from April to October
*rainy season is started from November to March

    c(cm)    crops                      /lrice, hrice, orange/

    cb(cm)   Consumption of own produced crop commodities
                                 /lrice,hrice,orange/

    n    production inputs
                 /landcost         Land rent cost (IDR per ha)
                 hlabor            hired labor used (md per ha)
                 tlabor            total labor used (md per ha)
                 flabor            family labor used (md per ha)
                 seed              seed cost (IDR per ha)
                 landprep          land preparation cost (IDR per ha)
                 chemfer           chemical fertilizer cost (IDR per ha)
                 orgfer            organic fertilizer (IDR per ha)
                 pesticide         pesticide cost (IDR per ha)
                 tcapital          total capital needed (IDR per ha)
                 capital_nd_d      home suppliedor credit dry
                 capital_nd_r      home supplied capital rainy (IDR per ha)
                 implicit_credit   credit used for farming (IDR per ha)
                 other             other costs (IDR per ha)/

;
Scalars
    fsize        land availbale for all crops farming (ha)             /1.61/
    cinterest    interest rate for crop loan (percent)                 /0.10/
    wlaborri     hired labor wage rate for rice (IDR per man-day)      /40000/
    wlaboro      hired labor wage for orange (IDR per man-day)         /65000/

**calculation of maximum family labor: (member involved in farming *
**                                    available man-day per year)
**                                   = (1.99*260) = 517.4 md/farm

    avflabord     Yearly available family labor in dry season(MD per farm)   /258.7/
    avflaborr     Yearly available family labor in rainy season(MD per farm) /258.7/

**calculation of maximum home ss capital:  home ss capital for local rice/hh
**                                         + home ss capital for high yield rice/hh
**                                         + home ss capital for orange/hh

    avhcapital    maximum home supplied capital (IDR per farm)        /15512350/
;

Parameters
```

```
         yield(cm)    yields of commodities at the year of 2012-2013 (ton per ha)
                        /lrice          2.73
                         hrice          1.72
                         orange        16.38/
;

Parameters
        price(cm)       market price of commodities (IDR per ton)
                        /lrice          4122590
                         hrice          5743750
                         orange         3742420/
;

Parameters
         commodities_req(cm)   required commodities by the household (ton per hh)
                        /lrice          1.13
                         hrice          0.27
                         orange         0.20/
* Note: based on interview
*       measured in unhusked rice. Conversion factor from unhusked to rice is 58%
;

Table cland(c,t) season wise land use by crops (hectare)
                        dry  rainy
         lrice          1
         hrice                  1
         orange         1       1
;

************UNIT of cost items*************
*landcost = land use cost (IDR per ha), local rice land use cost is calculated
*           by dividing yearly per hectare cropland use cost by two season.
*landprep = tractor using cost plus man power (IDR per ha)
*hlabor = hired labor requirement (md per ha)
*tlabor = total labor requirement (md per ha)
*seed   = seed cost (IDR per ha)
*chemfer = chemical fertilizer cost (IDR per ha)
*orgfer = organic fertilizer cost (IDR per ha)
*Pesticide = pesticide cost (IDR per ha)
*other  = other costs (IDR per ha): lime, additional/advanced fertilizer, transport
(IDR per ha).

Table

         cost(cm,n)      monetary valued production cost items (per hectare)
            landprep   seed     chemfer  orgfer    pesticide  other
lrice        350000      47547   536640   123298   181089      759181
hrice        150000      45451   507548   105187   130401      166725
orange      3000000    3000000  1400000  2000000   870000     2000000
;

Table

  rlabord(cm,n)   total labor requirement in dry season (md per hectare)
                  tlabor  hlabor
  lrice           83      27
  orange          23       7
;

Table
  rlaborr(cm,n)   total labor requirement in rainy season (md per hectare)
                  tlabor  hlabor
  hrice           46      15
  orange          30      10
*labor for orange harvesting is excluded
;


Table
*the credit for hrice is in the form of fertilizer and seed
```

```
  rcapitalc(cm,n)      capital requirement for crop farming (IDR per ha)
                tcapital       capital_nd_d  capital_nd_r       implicit_credit
  lrice         4055275         4055275          0                  0
  hrice         5617970            0       5064970             552999
;

Table
  rcapitalo(cm,n)      capital requirement for orange (IDR per ha)
*credit mostly for NPK fertilizer
* 1/3
                tcapital      capital_nd_d  capital_nd_r      implicit_credit
  orange        8251647          4732471      2366235           1152941

;

*********Following parts are same for three swamp typology********************

$title MODEL ESTIMATION

Variables
         gmargin           gross margin from farming activites (IDR)
         trevenue          total revenue from crop and orange farming (IDR)
         tcost             total production cost from crop and orange farming(IDR)
         income            income from farming and non-farming activiteis (IDR)
         mvcost            monetary valued mesured production costs (IDR)
         labcost           labor cost in a year (IDR)
         crdcostc          crop credit cost in a year (IDR)

;
Positive variables
         xcomm(cm)         level of commodities activities in all season (ha)
         xlabord           hired labor requirement in dry season(md)
         xlaborr           hired labor requirement in rainy season(md)
*         xcredit           credit requirement in a year (IDR)
         output(cm)        producion of the commodities (ton)
         market_s(cm)      marketed surplus output in a year (IDR)
         output_s(cm)       production surplus in a year in (ton)
         crd_need_d        credit need
         crd_need_r
;

Equations
**       objective function
         e_gmargin         gross margin (objective function) in a year

**       calculation fo commodities production/output
         e_output          commodities production in a year

**       calculation of total revenue
         e_trevenue        total revenue in a year

**       calculation of total cost of production
         e_tcost           total cost of production in a year
         e_mvcost          total monetary valued measured cost itmes in a year
         e_labcost         total labor cost in a year
         e_credit_need_d   credit need
         e_credit_need_r
         e_crdcostc        crop credit cost in a year

***food requirement constraint***

         e_foodreq          commodities requirement in the household

**       resource endowment (land) constraints
         e_land(t)         land constraint in season

**       resource endowment (labor) constraints
         e_labord            labor balance in dry season
         e_laborr            labor balance in rainy season
```

```
**       Resource endowment (capital) constraints
*         e_capital          capital balance in a year

** calculation of marketed surplus
      e_market_s(cm)         marketed surplus in a year
      e_output_s(cm)         output surplus in a year

      e_min_pur_lab_d    minimum purchased labor dry
      e_min_pur_lab_r    minimum purchased labor rainy
;

*****************************equation definition******************************
**definition of objective function
**       objective function (nmargin) = total revenue - total cost
**       total revenue = output*price
**       total cost = sum of variable costs + fixed costs

e_gmargin..      gmargin =e= trevenue - tcost;

********************calculation of commodities production*********************

*calculation of commodities production/output

e_output(cm)..   output(cm) =e= xcomm(cm)*yield(cm);

*calculation of total revenue

e_trevenue..     trevenue =e= sum(cm,(output(cm)*price(cm)));


*******************calculation of total cost of production********************

*calculation of total cost of produciton

e_tcost..        tcost =e= mvcost + labcost + crdcostc;

*calculation of monetary valued measured production cost items

e_mvcost..       mvcost =e= sum((cm,n),cost(cm,n)*xcomm(cm));

*calculation of labor cost

e_labcost..      labcost =e=   (xlabord * wlaborri) + (xlaborr * wlaborri);

e_min_pur_lab_d.. xlabord =g=  sum(cm,rlabord(cm,"hlabor")*xcomm(cm));

e_min_pur_lab_r.. xlaborr =g=  sum(cm,rlaborr(cm,"hlabor")*xcomm(cm));

*calculation of crop credit cost

e_credit_need_d  ..  crd_need_d  =g=    sum(cm,rcapitalc(cm,"capital_nd_d")*xcomm(cm))-
avhcapital ;
e_credit_need_r  ..  crd_need_r  =g=    sum(cm,rcapitalc(cm,"capital_nd_r")*xcomm(cm))-
avhcapital ;
e_crdcostc..       crdcostc =e= (crd_need_d + crd_need_r)* 0.5 * cinterest;


*calculation of orange credit cost
*-----> how
*e_crdcostf..   crdcostf =e=  sum(cm,rcapitalf(cm,"credit")*xcomm(cm))*finterest;


**********************declaration of the food requirement*********************

e_foodreq(cm)$cb(cm).. sum(cb(cm),output(cm))    =g= commodites_req(cm);

*calculation of marketed surplus

e_market_s(cm)..   market_s(cm) =E= output(cm)*price(cm) -
                                commodites_req(cm)*price(cm);
```

```
e_output_s(cm)..    output_s(cm) =E= output(cm) - commodites_req(cm);

******************resource endowment constraints*******************************
*land constraint in dry and rainy seasons

e_land(t)..      sum(c, cland(c,t)*xcomm(c)) =l= fsize;

*labor constraints in a year

e_labord..        sum(cm,rlabord(cm,"tlabor")*xcomm(cm)) =l= avflabord+xlabord;
e_laborr..        sum(cm,rlaborr(cm,"tlabor")*xcomm(cm)) =l= avflaborr+xlaborr;


*credit constraint in a year

*e_capital..      tcost =l= avhcapital+xcredit;

*+fixedcost

*raised-bed establishment cost constraint

*e_raisedbed..         sum(cm,cost(cm,"orange")*xcomm(cm)) =l=fixedcost ;

*****************************model statement***********************************

Model Swamp_B /all/;

****************************solve statement************************************

Solve Swamp_B using LP maximizing gmargin;

Options decimals=3;

Display gmargin.l, output.l, trevenue.l, tcost.l, xcomm.l, market_s.l, xlabord.l
        xlaborr.l;


*****************************************************************************
* SENSITIVITY ANALYSIS: Output Price
*****************************************************************************

**GDXXRW
Set Scens /S1*S100/ ;

Parameter pricesens(scens,cm);

$call gdxxrw.exe pricesens.xls o=pricesens.gdx par=pricescens Rng=A1:D101 Rdim=1 Cdim=1
$gdxin pricesens.gdx
$load pricesens=pricescens
$gdxin

display pricesens;
File GDXSwampB /GDXSwampB-orange.csv/;
put GDXSwampB;

*crparea(cm).fx = croparea(cm).l


Display  Pricesens,  gmargin.l,  output.l,  trevenue.l,  tcost.l,  xcomm.l,  market_s.l,
xlabord.l
        xlaborr.l;

* Parameter for calculated simulated results:
Parameter gmargin_sim, trevenue_sim;


loop (Scens,
  Price (cm)= Pricesens(scens,cm) ;
*  Simulation Swamp_B
```

```
* New calculation of Gmargin as a function of prices (same calculation as in equations
above, output.l stays constant, tcost.l stays constant)
    trevenue_sim = sum(cm,(output.l(cm)*price(cm)));
  gmargin_sim  = trevenue_sim - tcost.l;

  put Scens.tl "," gmargin_sim  /  ;

*ReportScens(cm,scens) = gmargin.l;
);

putclose GDXSwampB;


***********************************Writing report*****************************

$Title          Report on LAND ALLOCATION MODEL IN TIDAL SWAMP TYPOLOGY B

Sets
                 actrep          activity report
                                 /nmargin, revenue, cost, level/
                 objective       objective value
                                 /objective/
;
Parameters
                 landrep         cropwise land use summary
                 actrepsum       activity report summary (variables summary)
                 resoursum       resources use summary
                 shadowland      shadow prices of land
                 constmarg       shadow prices of the resources (costant margin)
                 objfun          objective function value
;

************* the resoursum table reports the resource used amount************

* year wise labor use summary
             resoursum("tlabord")      =sum(cm,rlabord(cm,"tlabor")*xcomm.l(cm));
             resoursum("tlaborr")      =sum(cm,rlaborr(cm,"tlabor")*xcomm.l(cm));
*Used own labor:                     resoursum("tlabord")-xlabord;
****Though farm labor availabilty is 359 md/famr/year, but during the harvesting
****sowing and intercultural operations they need to hire some labor. Farmers
****are using their man-day in non-farm activites to earn money. In case of
****rice-orange farmer the percentage of using hired labor is 0.192. So, to find out
****the hired labor requirment in model predicted land allocation, multiplied
****the total labor requirment by the existing percentage of hired labor
****requirment.

         resoursum("hiredlabord")  =xlabord.l;
         resoursum("hiredlaborr")  =xlaborr.l;
         resoursum("familylabord") =resoursum("tlabord")-xlabord.l;
         resoursum("familylaborr") =resoursum("tlaborr")-xlaborr.l ;

* year wise operating capital usesummary
         resoursum("tcapital_d")   =sum(cm, rcapitalc(cm,"capital_nd_d")*xcomm.l(cm));
         resoursum("tcapital_r")   =sum(cm, rcapitalc(cm,"capital_nd_d")*xcomm.l(cm));
         resoursum("credit_d")     =  crd_need_d.l;
         resoursum("credit_r")     =  crd_need_r.l;


Display  resoursum;
```