Farming Systems in Swampland Ecosystems: A case study in South Borneo, Indonesia[1]

Nuri Dewi Yanti[2], Sarah Lumley[2], and Dennis Rumley[3]

Abstract

In Indonesia, agriculture makes a significant contribution to the economy. The sector generates about twenty percent of gross domestic product (GDP), is a major employer, and produces foreign exchange from non-oil exports. However, with increased population pressure, especially in the densely populated island of Java, the area of land for agriculture has decreased and cultivation has been forced to expand to marginal land outside Java. To facilitate expansion, the Indonesian government carried out a long-term transmigration programme, which was intended to distribute people from the crowded inner islands of Java and Bali. In Southern Borneo, some of transmigrants are settled on tidal swampland. Because the characteristics of swampland are different from the agricultural land of Java, an appropriate farming system should be employed to accommodate their unique environmental conditions. This paper aims to assess the existing farming systems of indigenous farmers in South Borneo and to compare these with transmigrant farming systems in two different types of swamplands on the island.

Keywords: swampland ecosystem, farming systems, transmigration, Indonesia.

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[1]Paper contributed at the 47th Annual Conference of The Australian Agricultural and Resource Economics Society, Perth (Frematle, 12–14 February, 2003)

[2]Nuri Dewi Yanti, School of Agricultural and Resource Economics, The University of Western Australia, 35 Stirling Highway, Crawley 6009, WA
E-mail address: yantin01@agric.uwa.edu.au
phone: (08) 9380 2536

[2]Sarah Lumley, School of Earth and Geographical Sciences, The University of Western Australia, 35 Stirling Highway, Crawley 6009, WA
E-mail address : slumley@agric.uwa.edu.au
phone: (08) 9380 2504

[3]Dennis Rumley, School of Social and Cultural Studies, The University of Western Australia, 35 Stirling Highway, Crawley 6009, WA
E-mail address: drum@arts.uwa.edu.au
phone: (08) 9380 7957

INTRODUCTION

The agricultural sector plays a significant role in Indonesian economic development. In 1999, agriculture contributed about 20 percent of gross domestic product (GDP), absorbed 45 percent of the labour force, and produced 26 percent of foreign exchange from non-oil and gas exports. Within the agricultural GDP, the share from food crops is constant at more than 50% of the total agricultural value added (Badan Pusat Statistik, 2001).

During the last two decades, the government has placed a major effort on agricultural development, especially on increasing rice production, because maintaining the rice self-sufficiency achieved in 1984 is important to Indonesia. Experiences showed that the instability of rice supply would affect not only the economic but also the political aspects of the country. Therefore, the production and supply of rice plays a central role in food policy.

Rice consumption continually increases together with the accelerating population growth and per capita consumption. In 2001, it is estimated that rice production in Indonesia will have decreased from 51.8 million tons in 2000 to 50.8 million tons, while the country requires 52.0 million tons for domestic consumption (Dursin, 2001). Thus, the need for the areal expansion of agriculture cannot be avoided to ensure Indonesia's food sufficiency and food security.

One of potential areas for agricultural expansion is swamp reclamation outside Java. There is about 39 million ha of swampland in Indonesia located mainly in Sumatra, Kalimantan, and Irian Jaya (Noorsyamsi and Sarwani, 1989). About 20.1 million ha of the total area are affected by tides, but about five million ha of these are considered to have potential for agricultural production (Widjaja-Adhi *et al.*, 1992). Increased production efforts are in line with the former national development programs which aimed to resettle landless farmers from the inner islands of Java, Madura, and Bali to the more sparsely populated outer islands through transmigration programmes (Babcock, 1986; Balai Penelitian Tanaman Pangan, 1995).

Indonesia is an archipelagic country consisting of 13,667 big and small islands. However, only seven per cent of those islands are inhabited. This includes the large islands of Sumatra, Java, Kalimantan, Sulawesi and Irian. Like other less developed countries, Indonesia also faces an overpopulation problem. In fact, Indonesia is the fourth most populous country in the world, behind China, India, and the United States. Indonesia's population problem is further exacerbated by the uneven distribution of population over the Indonesian archipelago.

About 59 per cent of the country's population resides in Java, which comprises less than seven per cent of the land area of Indonesia. The population density in Java is around 946 people per square kilometre, and for Jakarta, the capital city of Indonesia, the density is almost 13,000 people per square kilometre. In contrast, the densities of other big islands outside Java are less than 100 people per square kilometre. This situation compelled the national government to seek other areas in which to resettle people from these densely populated islands to the less-populated outer islands such as Borneo (Kalimantan) with only has a population density of 20 people per square km (Badan Pusat Statistik, 2001). This strategy was in accordance with the program of areal expansion for agricultural production outside Java.

OBJECTIVES

The objectives of this paper are to assess the existing farming systems of local indigenous and transmigrant farmers in two different types of swamplands (A and B), and at the same time to explore the similarities and differences between the systems carried out by the two groups of farmers in South Kalimantan. One goal of this is to see which of the farming systems is more sustainable. Another goal is to attempt to develop sustainability indicators to assist with promoting socially and environmentally sound agricultural practices.

SOUTH BORNEO (KALIMANTAN): A CASE STUDY

Kalimantan, otherwise known as Borneo is the largest island in Indonesia and it comprises four provinces: South Borneo, West Borneo, East Borneo, and Central Borneo. Among these four provinces, South Borneo is considered as the gateway to other provinces in Kalimantan, because its location is strategic to other parts of Indonesia, especially Java. In addition, the facilities and infrastructure, such as transportation and communication in this province are relatively developed compared to the other provinces.

Geography

South Kalimantan (South Borneo) is located between 114^0 9'13" – 116^0 33' 28" East Longitude and 1^0 21' 49" – 4^0 10' 14" South Latitude. The province is bordered by East Kalimantan Province to the north, with Java Sea to the South, with Maccasar Strait to the East, and with Central Kalimantan to the West (see map in appendix 1). South Kalimantan consists of 11 administrative regions, where nine are major districts, and the other two are municipalities; 117 subdistricts and 2.153 villages (Badan Pusat Statistik, 2001).

South Kalimantan, the province of a thousand rivers, has a total area of 37,660 square kilometres, which is less than two percent of the total area of Indonesia. It comprises about 21,000 square kilometres of forest and mountain range with 1,000 to 1,500 metres altitude above sea level or 57 per cent of the total area (Pusat Data Kalimantan, 1998). The remaining land is used for rice fields (13 per cent), plantations (12.6 per cent), house compound (1.4 per cent), and other uses (15.3 percent).

Climate

Like other parts of Indonesia, South Kalimantan which is close to the equator has two seasons; the rainy or wet season occurs between December to March and the dry season occurs from June to September. The transitional periods between the two seasons are April to May and October to November. The climate of South Kalimantan is humid-tropicals with an annual rainfall of 2,100 to 3,200 mm, 83 to 169 rainy days, and of 7 to 9 wet months. During the wet season, the monthly rainfall average is 250 mm, while during the dry season it is 100 mm. In 2000, the daily temperature in South Kalimantan ranges between 20.8 to 34.9 with an average of 26.5. The relative humidity varies between 77 to 91 per cent (Badan Pusat Statistik, 2000).

Population

In 2000, the total population in South Kalimantan was 2,969,028 with a rate of growth of 2.32 per cent during 1990 – 2000. All districts in South Kalimantan showed a significantly decreasing rate of growth during the last decade, from 2.32 per cent in the period of 1980 to 1990, to 1.40 per cent annually in 1990 – 2000. The average population per square kilometre in South Kalimantan is 79.11 people. The figure is much smaller compared to the population density of Indonsia as a whole which has a mean of 106 people per square kilometre. Banjarmasin is the capital city of South Kalimantan and has the highest density in the region, of 7,326 people per square kilometer. The lowest density is in Kotabaru with only 28.32 people per square kilometer (Badan Pusat Statistik, 2000)

CHARACTERISTICS OF TIDAL SWAMPLAND

Indonesia has very large areas of swampy lands along the coastal regions of Sumatra, Borneo, and Irian Jaya which are estimated to cover nearly 39 million ha. There are 20.1 millions ha of tidal swamplands and the the rest is occupied by monotonous swamplands (Widjaja-Adhi *et al*., 1992).

In South Kalimantan alone, there are about 800,000 ha of swamplands. These comprise 500,000 ha of non-tidal swamplands, 200,000 ha of tidal swamplands, and 100,000 ha of rain fed swamplands. They lie in the six districts of Tapin, Banjar, Tanah Laut, Barito Kuala, Kotabaru, and Banjarmasin which most of them are in Barito Kuala and Banjar District, 67.28 per cent and 17.03 per cent respectively (Dinas Pertanian Tanaman Pangan, 1997).

The tidal region comprises that part of the coastal plain where inundation and drainage are determined by the tidal fluctuations of the water level in the sea or in the large river. Along the sea, on either side of the mouth of the rivers, frequent flooding occurs throughout the year at high tide. The water level in the tidal swampland rises as the rainy season starts, usually in October and reaches its maximum in January or February. Subsequently, it declines in March or April and remains stagnant until June. The water table drops when the dry season arrives (Noorsyamsi and Hidayat, 1974; Van Wijk, 1951).

The tides are a periodic rise and fall of all ocean waters, which are caused by gravitational attractions of the moon and the sun upon the water and the earth. The moon has more influence than the sun because it is closer to the earth (Encarta Ensyclopedia, 2000). The movement of the moon with respect to the earth causes variation in the level of these forces, hence producing different tidal levels. During the new moon and again during the full moon, the moon, the sun, and the earth are aligned and the forces are maximal, yielding tides of highest-level. They are called spring-tides (Davis, 1973). The neap tide occurs in between the two spring tides, twice in one day. The magnitude of the neap tides depend on the strength of the moon and the sun movements, hence at one point the neap tides become the spring tide (Noor, 1996).

Tidal swamplands have unique characteristics in which they are influenced by water movement because of the sea tides. The water depths in the tidal swamplands are controlled by the tides, as well as by rainfall. Based on the prevailing water levels in the fields, tidal swamplands can be classified into four groups i.e. types A, B, C, and D (Noorsyamsi *et al*., 1984; Widjaja-Adhi *et al*., 1992; Widjaya-Adhi and Karama, 1994).

- Type A swamplands are directly affected by sea tides and always flood the lands during spring and neap tides. The water depth fluctuates by as much as 2.5 meters within 24 hours near the rivers during the spring tide.
- Type B swamplands are directly influenced by the sea tide, but flooded only during the spring tide.
- Type C swamplands never flood, hence they are only influenced indirectly by the sea tide. Tides indirectly affect them by water infiltration through the soil. Water levels are affected more by rainfall than by the tides. Furthermore, the ground-water table is less than 50 cm from the land surface.
- Type D is those swamplands not affected by sea tides. No water infiltration occurs through the soil. The ground-water table is deeper than 50 cm below the land surface.

A major environmental issue with tidal swamplands is the highly complex nature of soil characteristics and the uncontrolled hydrology regime. Tidal swamplands are characterized by high soil acidity (low soil pH), and the availability of pyrite, aluminium and iron, which therefore may pose acidity problems. In addition, tidal swamplands have deep organic layers, which can be more than 200 cm thick (Folkertsma, 1998).

Soil and water conditions vary greatly in tidal swampland areas. Soil fertility depends primarily on the depth of the peat layer and the existence of a cat-clay layer underneath. The deeper the peat layer, the greater the need for a good drainage system to increase soil pH (Anwarhan, 1981). The soils at the study sites are mostly marginal which means that potential productivity is limited by high variability in physical, biological, and social-economic constraints (Partohardjono, 1993).

Even though the productivity of the reclaimed swampland is much lower than in irrigated areas, it is still promising for agricultural crop production in the future. With the abundant water, especially during the wet season, plus its hydrological and topographical setting, tidal swampland is suitable for wet ricefields and other selected crops such as coconuts, and for secondary crops planted in the dikes (Djamhari, 1998).

METHODOLOGY

In order to achieve the objectives stated earlier, a farmers' survey was conducted in selected areas of tidal swamplands in South Kalimantan. Although there are four different types of swamplands, this survey only focusses on types A and B. These involve indigenous and transmigrant farmers. Among six districts with tidal swamplands, the Barito Kuala and Banjar District have a large proportion of this type of land. They consist of more than 80 per cent of the total tidal swampland in South Kalimantan. Therefore, these two districts were selected as the survey locations.

The sample populations consist of the socio-economically and culturally distinct indigenous (local) and transmigrant farmers. To complete a full comprehensive survey off all farmers would be too costly and time consuming, so it was decided to choose a cluster sampling as a less expensive alternative design (Keller *et al*., 1994). Samples were identified by random selection in each cluster (group).

There are four different categories of respondent. These are indigenous (local) farmers in type A and type B swamplands, and the transmigrant farmers in the same type of swamplands. In order to have a better picture of the farming systems in the area, two villages of each category were chosen randomly, making a total of eight villages surveyed for this research.

Table 1. Names of villages selected for the farmers' survey

Tidal swamp	*Respondent*	*Location*		
		Village	*Sub-district*	*District*
Type A	Indigenous farmers	T. Muara	Tabunganen	Barito Kuala
		Aluh-aluh Besar	Aluh-aluh	Banjar
	Transmigrant farmers	Tanggul Redjo	Tabunganen	Barito Kuala
		Danda Jaya	R. Badauh	Barito Kuala
Type B	Indigenous farmers	Sungai Tunjang	Cerbon	Barito Kuala
		Gampa Asahi	R. Badauh	Barito Kuala
	Transmigrant farmers	Karang Indah	Mandastana	Barito Kuala
		Danda Jaya	R. Badauh	Barito Kuala

Source: Data collection, 2002.

The formal survey instrument used for data collection was a questionnaire comprising closed-ended questions, whereby all respondents were asked the same questions in the same order, so the answers are comparable. In addition, an extensive consultation and discussion with key informants was also conducted in order to yield a comprehensive picture of the farming systems in the study area. The questionnaire comprised seven sections eliciting basic data on respondents' demographics, agricultural production practices, water management and other information related to their farming systems. The informal survey was conducted by having discussions with farmers about their farming systems and their relation to sustainable agriculture and farmers' attitudes to the wider environment.

The survey was conducted over a four months period from June to October 2002. One hundred and twenty questionnaires were completed for analysis. Data were edited, coded and processed for further analysis. In the preliminary results, a qualititative assessment of indigenous and transmigrant farming practices is presented. In addition, similarities and differences between the systems in both type A and B swamplands are compared and contrasted.

RESULTS (PRELIMINARY FINDINGS)

To achieve ecologically sustainable agriculture in tidal swamplands, the farming systems should follow appropriate management practices which accommodate the specific environmental conditions of these areas. This also follows the selection of suitable crops varieties and species. Most of the crops adopted here are based on monocropping of rice with only one harvest per year.

The practice of growing secondary crops in the so-called *sorjan* is becoming increasingly common with farmers. The small dikes separating the rice fields are raised and suitable for planting secondary crops, namely cassava, chilli, sweet corn, egg-plant and other vegetables or even fruit trees such as coconut and mandarin, mostly for household consumption. At present, most of the yield values were lower than the potential yield and varied between the type of farmers and land locations. This was due to variations in the agro-physical condition and farmer’s management ability. Such variation suggests that each type of tidal swampland needs an ecosystem-location specific technology and management practice.

Overview of Indigenous Systems

The indegenous Banjarese and Bugenise from Kalimantan and Sulawesi are the first people to settle and spontaneously use the tidal swamplands of the coastal areas of the Indonesian archipelago. These local indigenous farmers have been able to utilize tidal swamplands for generations (Anwarhan, 1981). Their first stage in land reclamation is intended to support water control by clearing a forest strip where a narrow drainage waterway is dug so that the land can be drained. This is done to facilitate the flushing and leaching process of toxics elements from the field. At the same time, fresh water from the river flows into the field where the wetland rice is planted (Noorsyamsi and Hidayat, 1974).

Traditional local farmers have been able to use tidal swamplands for hundreds of years. In their first years, indigenous farmers cultivate rice, and then shift gradually to coconut plantations (Anwarhan, 1981; Watson and Willis, 1985). Meanwhile, farmers open another tidal swampland for rice cultivation. Again, for the next three to five years this field will be adapted to coconut farming. Nowadays, most farmers have abandoned their coconut plants due to the low prices of coconuts. As a staple food, farmers always first cultivate rice on their land in order to have food security at the household level. Hence, the manner of rice cultivation practice is very important in the area to ensure that the farming system is ecologically sustainable.

Indigenous farmers adapt their agricultural practice based on the geographical and hydrotopographical conditions. Land management is very simple but is considered for its suitability to ecological conditions. It makes use of tidal movement which brings organic matter and nutrients cycled from the weeds and rice straw. Farmers stated that this system reduces labour requirements and is relatively cheap.

There is a multiple transplanting of rice from seeds to young plants before they are planted in the field. Traditionally, local farmers grow only one season of rice monocultures using photo-period sensitive varieties. These varieties only flower when the sunlight duration is at its shortest compared to other months in the year. For countries located in the southern hemisphere like Indonesia, this occurs in June (Noor, 1996).

In general, these photo-period sensitive varieties produce strong tall seedlings that resists water depths of more than 30 cm at planting times (Anwarhan, 1981) and produce numerous tillers. Consequently, they can tolerate the deep flooding which often occurs in the swampy coastal areas. They are also relatively tolerant to pests and diseases and to the salty and acid conditions of the tidal swamplands. Weeds are not a major problem, because local rice varieties have taller stems (about 150–200 cm) with drooping leaves (Watson and Willis, 1985). These tend to overshadow weeds, so they cannot grow well. Furthermore, these rice varieties have a good eating quality, and thus have a high financial value for farmers.

On the down-side, local varieties need a long time to mature. They require nine to ten months of growth and are transplanted two or three times during the vegetative period. Production yields of these varieties range from 17.82 to 29.04 kw per ha and include - Siam Unus, Siam Pontianak, Siam Pandak, and Siam Palas. In tidal swampland areas, the indigenous cropping pattern is relatively stable and sustainable. Rice yields of the farming systems for each type of tidal swampland are presented in table 1.

Table 1. Rice grain yield of local varieties in study area.

No.	*Tidal swampland*	*Farmer*	*Rice yield*	
			Blek/borong	*kw/ha*
1	Type A	Local	8.8	29.04
		Transmigrant	5.5	18.15
2	Type B	Local	6.7	22.11
		Transmigrant	5.4	17.82

Source: Data collection, 2002.

The difference in yield is due to different management practices and soil location and fertility. These yields are considered to be quite satisfactory given the diverse features of the ecosystems. However, yields are expected to rise with the improvement in management practices especially with regard to water and land conditions.

Overview of Original Transmigrant Systems

Within the transmigration program, the government introduced High Yielding Varieties (HYV) to plant in the area. The transmigration program was intended to boost rice production. At first, it seemed promising since on their original farms, transmigrants used to plant the same rice varieties two or even three times in a year. HYV is an early maturing variety which only needs 120–125 days from planting to harvest, thus it is possible to increase cropping intensity by up to 300 per cent per year. However, because of the biophysical environments and socio-economic constraints, HYV is seldom adopted by farmers in tidal swampland areas.

In the study area, only a small number of transmigrant farmers were planting HYV in their fields, that is only five percent of transmigrant farmers in type A swampland and 12 per cent of transmigrant farmers in type B swampland. This is quite understandable since they are risk averse and mostly constrained by limited funds available for their farming. Like most farmers in less developed countries they only produce their crops at a subsistance level.

Rice Cultural Production Practices.

The information presented below focuses on the main similarities and differences in the rice farming practices by indigenous and transmigrant farmers in type A and type B swamplands, respectively.

Land preparation

Cultivation practice begins with land preparation. Land preparation as part of land management should be conducted very carefully, so that the pyritic layer is not exposed as this results in oxidation of the soil. In general, land preparation is carried-out in the rainy season from November/December until February the following year.

Indigenous (local) cultivation

The soil in type A is usually covered with soft, loose mud from the tides. Therefore, local farmers only need to cut the paddy-straws and/or weeds with a machete and then immerse them into the soil using their feet to enable the decomposition process. This usually takes 45 to 60 days to complete. However, when the planting time is due, and mulch decomposition is not complete, the remaining weeds or paddy-straws should be removed from the field so that they do not cover the young plants or block the canals. (Djamhari, 2001) regarded this system as one form of soil conservations in tidal swamplands because green manuring will enrich the soil with mineral plant nutrients every year.

In type A, the water from the sea or river will flood the paddy-field bringing organic matter which enhances soil fertility. However, farmers still apply some fertilizer, especially Urea to their crops. Sometimes farmers use Urea only for the third seedling (*tangkar anak*), in order to produce more young plants. In this location, farmers do not apply lime to their fields.

On the other hand, land preparation by local farmers in type B swampland is done by using a tool called a *tajak*. The tool can be operated even when the field is inundated with 5–10 cm of water. This flooded state is considered most appropriate for land preparation as the pyritic layer is still in an anearobic condition. Farmers cut the paddy-straws and/or weeds using the *tajak* up to five cm or so below the soil surface (minimum tillage). The straws and weeds are chopped and left for about 20 days. After that period, they are gathered and made into strips (called *baluran*). The strips are left for about 15 days to decompose. Following the first decomposition, the strips are inverted and left for another 10 to 15 days to allow further decomposition. The strips are then distributed over the entire field and used as compost. The next day, lime is scattered over the field and left for about a week or so to allow absorption of the lime into the soil. The field is now ready for planting. The application rate of lime is between 100 and 200 kg per ha. Apart from decreasing soil acidity, lime also accelerates the mulch decomposition process (Hidayat, 2001).

Soil in type B is typically less fertile than in type A swampland because the water from the sea or river only floods the field when there is spring tide. Fertilizers used, in general, are Urea. SP 36 and KCl are rarely applied. Furthermore, the amount of Urea is much smaller than generally recommended, the average being about 92 kg per ha. In fact, the recommendation of Urea is 200 kg – 250 kg per ha (Saderi *et al*., 1999). The fertilizer is applied between 15 to 30 days after the final rice planting. According to the farmers, fertilizer is not very important in the tidal swampland as long as minimum tillage is used for land preparation and nutrients are recycled to enhance soil fertility. The other reason for fertiliser being "under" used is that most farmers cannot afford much fertiliser.

Transmigrant cultivation

Transmigrant farmers use prepararation techniques different from those of local farmers. They start by cutting and chopping the weeds and paddy-stems from the previous harvest and leave them for about 15 days. These are then gathered into bundles called "*puntalan*". About 15 days later, the *puntalan* are inverted and left for another 10 to 15 days so that, both sides of the *puntalan* decompose to become compost. Subsequently, the compost is distributed over the whole field. After a week or so, the field is ready for planting. Lime and fertiliser are applied simultaneously when the plants are about 30 days old. Farmers consider that this reduces labour and also they know which parts of the field have been fertilised. The ratio of Urea to lime is one to one.

In the last five years, transmigrant farmers, especially in type B, have used machinery for land preparation. Due to the nature of the land, only hand tractors can be operated in the tidal swamplands. Since their capital is limited, the government supplies the tractors while the farmers pay only the operating costs for petrol and operator fees. It appears that this is suitable for transmigrant farmers, because on their island of origin they are used to dealing with machinery. This method also saves labour. However, this technique exposes the pyritic layer to some extent. Consquently, farmers need to apply more lime to their fields in order to counterbalance the soil acidity.

Multiple transplanting

Meanwhile, farmers also prepare bed-seedlings for multiple transplanting. The purpose of multiple transplanting is to adapt water level and water quality, since the field is often inundated when planting takes place. When the plants are in the field, they are relatively tall and strong enough to counter unfavourable conditions such as floods and soil acidity. In addition, multiple transplanting produces more tillers and thus saves on seed application. According to the farmers, for this method only seven to eleven kilogram of seeds are required for one ha of cultivations compared with the usual 25 to 30 kg (personal communication, 2002) .

Multiplanting processes can be conducted two or three times. It depends on the water level and the field location. Mostly triple transplantings are conducted either in type A or in type B. Double transplanting is usually carried out in type C tidal swamplands because the effect of tides in type C is more moderate than in types A or B.

Indigenous (local) practices

In type A, the first seedlings are prepared at the beginning of the rainy season in October. The bottom of the seedbeds (usually boxes about one *depa* x one *depa*) is filled with mud (about 10 cm thick) as the medium for seed germination. This is called *palaian.* Seeds are soaked overnight in order to soften the husk and enable sprouting. The next day, seeds are spread into the seedbed (*palaian*). Usually *palaian* are put near the farmer's house for monitoring. After a week, they are transplanted into the second seedbeds called *ampakan.*

The plants from *palaian* are divided into bunches (consisting of 30 to 40 tillers) and planted at 20 cm x 20 cm apart on *ampakan*. The location of *ampakan* is still around the house, but it is located where the tides can reach it. Mostly, the water level is about five cm above the soil. Sometimes *ampakan* can take place in the field, and, if so it is called *lacakan*. At this stage, the plants are kept for up to 30 days. The next stage is to transplant to the third seedling stage called *tangkar anak.* This involves planting the *ampakan (or lacakan)* into the rice field for about 50 to 60 days growth. The reason for doing the third transplanting is to produce more tillers for final transplantation.

Because of the soft and loose soil condition, the a*nakan* (tillers) in type A are placed in the middle of the field so as to enable farmers to distribute the *anakan* easily when planting in the final area. Planting times are usually in the middle of February or beginning of March. Planting should be timed in order to avoid the intrusion of salt water when the plants are in their generative phases. If planting is late, many of the stalks will produce empty panicles.

Like local (indigenous) farmers in type A, local farmers in type B also practice triple transplanting. However there is a small differences between the groups since the location of local farmers' fields in type B are further from the river mouth compared to the farmers' fields in type A. The distance of farmers fields in type B is about the same with transmigrant fields with regard to river mouth. So, their multi transplanting process also similar which explained below.

Transmigrant practices

The process of multiple transplanting starts with *teradakan* or *menugal* when the rainy season arrives, generally late October. *Teradakan* is carried out on relatively high places such as road side verges. About one handful of seeds is put into a hole, 20 x 20 cm apart. The holes are covered by ash or grass to protect the seeds from rats or birds. After twenty five or thirty days, the young plants are placed in the second seedbed called *lambakan.* At the *lambakan* stage, the plants grow for about 30–45 days before being tranplanted into the third seedbed called *lacakan*.

The young plants from *lambakan* are planted on *lacakan* 30–40 cm apart. According to farmers, the wider the spacing between plants the better, because plants produce more tillers. In this area, *lacakan* is planted at the edge of the field, because there the soil is more fertile. Furthermore, the soil is not totally mud, thus it is possible for the farmer to distribute the plants by him/herself.

Water management

In tidal swampland ecosystems, water management is considered as one of the key aspects of a stable and sustainable production (Noorsyamsi and Sarwani, 1989; Partohardjono, 1993). Geographically, swampland is located close to the sea or a large river, and poorly drained. (Anwarhan, 1981) suggests that the construction of canal systems for drainage is the first part of reclaiming tidal swampland. The early Banjarese farmers dug a narrow canal so that the land could be drained. The canals are widened and deepened each year until they are sufficient to convey water which either brings the organic materials from the sea tides, or leaches the toxic elements from the fields.

Local (indigenous) water management

Local farmers in type A rarely conduct water management. Their fields are mostly adjacent to the sea or the river mouth. The fields are always flooded during the spring tide and neap tide, and the water flows are very strong. To some extent, farmers can control the water by digging the land beside their fields for waterways perpendicular to the river or big canal, to a width of two to three metres and a depth of half to one metre. Every year, the troughs are cleared to facilitate water flow in and out of farmers' fields.

Farmers in type B tidal swamplands also use a canal system to control the water regime in the area. However, they put a gate in front of each trough so that the water can be kept or released according to plant requirements. Farmers decide among themselves when is the best time to open or to close the gates, which are operated manually. In type B, the fields are only flooded twice a month when the spring tide occurs. Water inundates the field for about three to five days each time, and for only three to four hours daily (Sarwani, 2001). In this case water is not always available throughout the year; therefore farmers need to ensure that they have adequate water for the plants, especially in the vegetative period.

Transmigrant water management

In transmigrant settlements, the area was generally opened on a large-scale for direct cultivation by the incoming farmers. In order to reclaim tidal swamplands, the government is required to provide a water management system for the new settlers. In South Kalimantan, the government constructed and operated the Fork Water Management System (Noorsyamsi and Sarwani, 1989). This system consists of a primary canal connected directly to the river. The primary canal has two or three branches as secondary canals with a pond in each tail. The ponds are used to retain the water and leach out toxic substances from the fields. Each of secondary canals has tertiary canals to supply water directly to farmers' fields.

At present, this system does not function well because the primary and secondary canals are too long; thus, the ponds are too far from the major river. As a result, tides only reach the middle of the canals and cannot leach the toxic elements entirely from the field.

A few years ago, the government introduced a new system of water management. The project is divided into two level namely macro-water management and micro-water management. The system of macro-water management is under the government responsibility, while farmers carry out micro-water management. Farmer dug *shallow drainage* of 20 cm width and 15 cm depth at a distance of 6 to 12 metres. *Surround canals* are also required which function as water conveyor out from shallow drainage and as water supplier in to the field (Widjaya-Adhi and Karama, 1994). Again, this system did not work as expected because social and financial constraints of farmers.

As a substitute, farmers use a *gorong-gorong* system. Farmers build dikes around the field to retain the water when the spring tide arises. At the same time, farmers put plastic pipes of 10 - 15 cm diameter as a *gorong-gorong* (tunnel) below the ground to drain the water. *Gorong- gorong* functions using a lid that can be opened or closed according to the water level required in the field.

Harvesting

Farmers in type A usually harvest rice in early July to mid August, while in type B harvesting begins in mid July and continues until the end of August or early September. The difference between A and B is that in type A farmers need to plant the rice earlier than farmers in type B, to avoid the salt intrusion during the generative period of the plant.

Traditional (local) practice

Most of local farmers use a tool called *ranggaman* for harvesting. This is a small palm-held reaping knife for cutting rice stalks (Echols and Shadily, 1989). Local farmers have used this tool for many generations. All of of local farmer respondents use a *ranggaman* for harvesting.

The advantage of this tool is that farmers can selectively cut the ripe rice and leave the unripe in the field. This maximizes their harvest. Another advantage is that this method permits the farmers to use their feet to thresh the rice from its stalks. This is very important to farmer, since agricultural machines are very rare in the area. In addition, by using ranggaman, farmers only reap the head of the rice, so the long stalk is left in the field. This is good for nutrient recycling and enhances soil fertility and minimizes weed growth. Also, farmers do not need to bend when harvesting. However, the major drawback of this method is that it is time consuming. One farmer only harvests about four to five tin cans (*blek)* in a day, so it takes about 30 days to harvest one ha rice (assuming it is harvested by the farmer and his wife). As a result, there is always a labour shortage at harvesting time.

Transmigrant practices

Mostly transmigrant farmers use a grass-knife (*arit*) to harvest their crops. This tool has only been used for three or four years. The main benefit of using the *arit* is that farmers can harvest their crops in a very short time. A farmer and his wife can harvest one ha rice in only 10 – 11 days. It is three times faster than using a *ranggaman*. The major shortcoming of using this instrument is that the feet cannot thresh the crops. The stalks must be struck on the ground to detach the rice. Alternatively, it can be threshed with a threshing machine. In addition, the percentage of crops loss is bigger than with the traditional practices. Although this method resolves the labour shortage, its use is questionable because of some of the disadvantages.

CONCLUSION

Local indigenous farmers have maintained farming systems in tidal swamplands for hundreds of years. They thus have the knowledge and experience to overcome many of the constraints and problems associated with cultivating these areas. Local systems have been adapted for agricultural practices which maximize the use of on-farm resources. Agricultural sustainability in these areas is relatively good.

Unlike the local indigenous farmers, at first, transmigrant farmers practiced their own farming systems in this area, but always unsuccessfully. In their place of origin, transmigrant farmers had fully irrigated systems with relatively fertile soil, while in the tidal swampland they must adapt to less fertile, non-irrigated, and acid soils. Consequently, over the year, they have learned and implemented indigenous practices in order to survive in the tidal swamplands.

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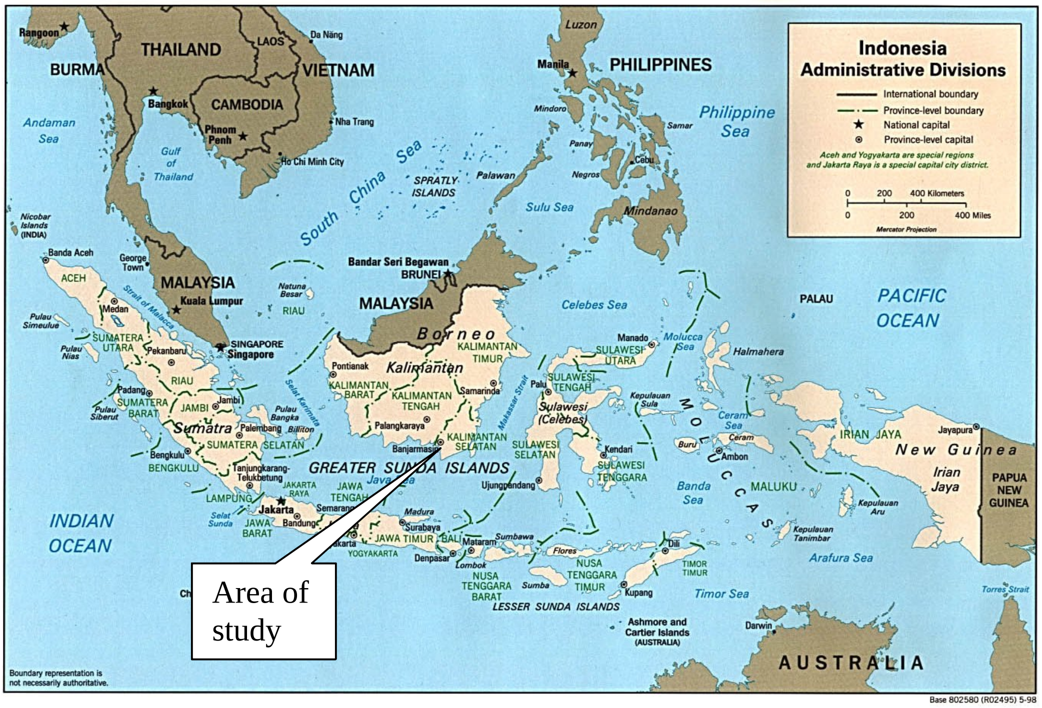
APPENDIX


Indonesia
Administrative Divisions
International boundary
Province-level boundary
National capital
Province-level capital
Aceh and Yogyakarta are special regions and Jakarta Raya is a special capital city district.
0 200 400 Kilometers
0 200 400 Miles
Mercator Projection
Area of study
THAILAND
BURMA
LAOS
VIETNAM
CAMBODIA
PHILIPPINES
MALAYSIA
BRUNEI
Rangoon
Bangkok
Da Nang
Phnom Penh
Nha Trang
Ho Chi Minh City
Luzon
Manila
Mindoro
Panay
Negros
Cebu
Samar
Palawan
Mindanao
Andaman Sea
Gulf of Thailand
South China Sea
Philippine Sea
Sulu Sea
Celebes Sea
Molucca Sea
SPRATLY ISLANDS
Nicobar Islands (INDIA)
Banda Aceh
George Town
Kuala Lumpur
Natuna Besar
Bandar Seri Begawan
PALAU
PACIFIC OCEAN
ACEH
Medan
Pulau Simeulue
Pulau Nias
SUMATERA UTARA
Pekanbaru
RIAU
SINGAPORE
Singapore
Padang
SUMATERA BARAT
Pulau Siberut
JAMBI
Jambi
Sumatra
Palembang
Pulau Bangka
Billiton
SUMATERA SELATAN
Bengkulu
BENGKULU
Tanjungkarang-Telukbetung
LAMPUNG
Selat Sunda
Jakarta
JAKARTA RAYA
JAWA BARAT
Bandung
Semarang
JAWA TENGAH
Java
Madura
Surabaya
JAWA TIMUR
YOGYAKARTA
BALI
Denpasar
Mataram
Lombok
Sumbawa
Sumba
Flores
NUSA TENGGARA BARAT
NUSA TENGGARA TIMUR
Kupang
Dili
TIMOR TIMUR
LESSER SUNDA ISLANDS
GREATER SUNDA ISLANDS
Borneo
Kalimantan
Pontianak
KALIMANTAN BARAT
KALIMANTAN TENGAH
KALIMANTAN TIMUR
KALIMANTAN SELATAN
Palangkaraya
Banjarmasin
Samarinda
Selat Karimata
Makassar Strait
Manado
SULAWESI UTARA
Palu
SULAWESI TENGAH
Sulawesi (Celebes)
SULAWESI SELATAN
SULAWESI TENGGARA
Kendari
Ujungpandang
Kepulauan Sula
Halmahera
MOLUCCAS
Ceram Sea
Ceram
Buru
Ambon
Banda Sea
MALUKU
IRIAN JAYA
Jayapura
New Guinea
Irian Jaya
Kepulauan Aru
Kepulauan Tanimbar
Arafura Sea
PAPUA NEW GUINEA
Torres Strait
Timor Sea
Ashmore and Cartier Islands (AUSTRALIA)
Darwin
AUSTRALIA
INDIAN OCEAN
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