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DYNAMICS OF LANDUSE CHANGES AND GENERAL PERCEPTION OF FARMERS ON SOUTH SUMATRA WETLANDS

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Abstract

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The research aimed to gain some insight into the use of wetlands, approaches and wetland management of what has been experienced for four decades since the wetlands were reclaimed. This study used intensive field surveys with quantitative and qualitative approaches. The research resulted that the greatest wetland transformation was done through transmigration schemes, where public infrastructure has been built to wetlands reclamation for agricultural purposes in a broad sense. Not all wetlands are suitable for food crops, if they are not suitable for food crops and are still cultivated for food crops, then wetland degradation and farming costs will be very high. Agricultural constraints faced by farmers are more of physical constraints, namely water management, soil acidity, Al and Fe toxicity, pest and diseases, thick peats, and soil subsidence. Almost all constraints decreased rice yields of around 20-85% and income of farmers in the range of 30-100%.

Key words: dynamics; landuse changes; perception; farmers; wetlands

Introduction

The complex ecosystems characterizing wetlands are areas of intimate interaction between aquatic and terrestrial ecosystems, and are zones of high inherent biological productivity and complexity (Altarawneh, 2016; Bachev, 2017). They are among the most complex, diverse and biologically productive ecosystems in the biosphere, and among the least understood and most fragile as well as are liable to severe damage from unsuitable development schemes (Boyaci and Yildiz, 2016; Bruni and Santucci, 2016).

Approximately 40,263 ha of wetlands in Banyuasin District, South Sumatra has been reclaimed for transmigration program since 1960 for food crops, especially rice, corn and cassava (Armanto et al., 2013; 2016a). The research area consists of two areas, namely *lebak* and tidal wetlands, located in the eastern part of South Sumatra (Armanto et al., 2017a; Armanto and Wildayana, 2016). Due to the reclamation projects, the wetlands disappear rapidly and have created tensions between economic development and the conservation, and becoming stronger due to population growth.

The landuses have undergone many changes due to the rapid population growth and behavioral patterns of different communities (Anik et al., 2017; Bazitov et al., 2016). From the field experience, some wetlands are less suitable for food crops (Imanudin et al., 2010a). The main failure of wetlands is that the lands are less understood in terms of the soil characters and properties as well as their tidal swamp water either in forms of spatial or temporal phenomena (Dahmardeh et al., 2017; Imanudin et al., 2010b; 2011). The reclamation program tended to be forced on the biophysical conditions that did not fit with the needs of plants. In other words, the soils are not suitable for food crops (Armanto, 2014; Latifah et al., 2017; Koutev and Nenov, 2016).

As a consequence of increasing land shortage combined with an ever-growing demand for goods and services, to-

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gether with national and regional policies, many wetlands (or at best as marginal areas) are becoming the focus of economic and social development schemes (Bagum et al., 2017). The less population of Banyuasin has been increasingly determined by the better economic diversification and social infrastructure of those areas (Firmansyah et al., 2016; Adriani and Wildayana, 2015). Thus it is now widely maintained that the major development problem is the less utilization of natural resources of Banyuasin, a linkage will be effected by differential capital investment and through implementation of the transmigration policy (Armanto et al., 2017b; Wildayana, 2017).

The main problem of developing wetlands for agricultural business is that the water regime condition is fluctuating and often difficult to predict, the hydro topography is diverse and generally not well laid out, especially in shallow groundwater surface and peatlands (Jambor and Gibba, 2017). Utilization of wetlands for agricultural business is generally still not optimized and varies from one region to another (Terziev and Arabska, 2016; Trendov et al., 2017). Under these conditions, the development of wetlands for agricultural business, especially food crops in large scale requires the arrangement of land and water network and the application of technology in accordance with the conditions of the region in order to obtain optimal results (Vasylieva and Pugach, 2017; Verter, 2017; Mitova et al., 2017). In addition to land issues, the wetland development for agriculture also faces various constraints, including socio-economic conditions of society and supporting institutions and infrastructure that are generally not adequate or even not yet exist (Galluzo, 2017a; 2017b; 2017c; Hurmak and Yakubiv, 2017). This is mainly related to land ownership, limited manpower and working capital and ability of farmers to understand the characteristics and technology of land management, provision of production facilities, water and transportation infrastructure and farming, post-harvest and marketing of agricultural products (Sarno et al., 2017; Maroeto et al., 2017).

Investment policies for infrastructure development and new institutions are indispensable for achieving food security and poverty reduction goals (Supriyadi et al., 2017; Sudrajat et al., 2017; Ezihe et al., 2017). With these problems and challenges, this paper aims to gain some insight into the use of wetlands, approaches and wetland management of what has been experienced for four decades since the wetlands were reclaimed (Ferrara, 2017; Dirimanova and Radev, 2017). This needs to be examined as there is often a conflict of interest between economic development and the wetland conservation (Wildayana et al., 2017a; 2017b). By doing this research, we will get some answers to questions about: What lessons can be learnt since wetlands were reclaimed four decades ago; What are the issues and alternatives that can be understood and managed to improve the various alternatives for sustainable utilization and management of wetlands? This paper is useful for reviewing institutions and policies of poverty reduction and food security.

Materials and Methods

The research was conducted in July to December 2017 located in Banyuasin District, South Sumatera Province (Figure 1). This study used intensive field surveys with quantitative and qualitative approaches. Primary data collection was assisted with Landsat imagery interpretations in 1987 and 2016 and several thematic maps (1: 50 000 scale) as well as planimetric calculations. The research was involving various stakeholders (involved in the management and utilization of wetlands) and from relevant policy documents, reports and focus discussions as well as literature review. Respondents were randomly determined in the field using purposive sampling. Interviews with respondents were recorded using open and closed questionnaires. All collected data were analyzed in narrative and tabular forms.

Results and Discussions

The research results and discussion focused on important aspects related to the theme, namely general descriptions of Banyuasin district; wetland transformation through the transmigration scheme; dynamics of land use changes; agricultural constraints based on general perception of farmers; and evaluation of wetlands for development.

General Descriptions of Banyuasin District

Banyuasin has a land surface of approximately 1 183 300 ha of which around 338 419 ha belong to wetlands (tidal and *lebak* wetlands). Around 197 961 ha (about 58.50%) is under permanent ricefields (consisting of 166 172 ha for tidal wetlands and 31 249 ha for *lebak* wetlands) and the remaining areas of around 140 458 (41.50%) is cultivated for other uses or not cultivated areas. Further, around 65% of agricultural areas in Banyuasin are concentrated on the agriculturally rich wetlands. If we look further at this area, it is striking that wetlands are surrounded by the mainland, some deltas and islands and some little (uninhabited) islands. Therefore the wetlands are characterized by the fact that is 'locked up' by the islands and that the seawater comes in and out through the gap between the islands (Figure 1).

Banyuasin accounts for around 275.00 km (48%) of the South Sumatra's coastline. Some coasts, like the east coast, have population densities of 65 people/km^2 and are among

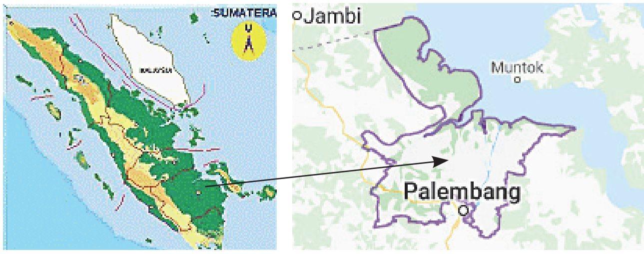


Fig. 1. Demarcation of South Sumatra Province, Indonesia (*Source*: Google website)

the most less populated areas on South Sumatra, whereas others, such as the wetlands of South Sumatra, have around 100-200 people/km^2. Further with a population growing at a rate of 1.44% in a year, Banyuasin belongs to the less populated districts in South Sumatra.

Wetland Transformation through the Transmigration Scheme

Transmigration program was called as an ambitious scheme to relocate large numbers of people. Massive infrastructural investments were now being made to reclaim wetlands to place the transmigrants. Although initially it was seen as a means of reducing population pressure and the associated detriments of landlessness, lack of economic opportunity and the degradation of renewable resources and the environment on the three overcrowded islands, the continued in-migration to Java prompted a revision of the fundamental objectives of transmigration, which is now principally viewed as the promotion of regional development to the sparsely populated.

In addition to satisfying a strategic need for national defense, this would also serve, along with the BIMAS (Agricultural Intensification) program, to both augment the national supply of foodstuffs and raw materials, as well as providing land for the landless. Transmigration schemes are also used to absorb populations displaced by either natural disasters or by development projects as well as communities that must be resettled to reduce pressures on damaged or fragile watersheds, particularly those upstream of critically important agricultural zones or densely settled areas. Both Government-sponsored schemes to geographically redistribute population, as well as ‘spontaneous migration’, are officially termed ‘transmigration’. The history of agricultural planning for wetlands development is summarized in Table 1.

In Sumatra island, it is estimated around 40 million ha of potentially productive wetlands. Agricultural land, a large percentage of which is tidal wetland, is considered to be available for development, particularly for irrigated rice. The definition, and-therefore the estimates of the area of wetlands, vary considerably, and accurate assessment of their extent and type is severely hampered by a dearth of scientific knowledge about them. Recently it was estimated that there are some 43.5 thousands ha of wetlands in Banyuasin. Further the area of wetlands directly influenced by sea tides.

Despite various changes in program design, the overall scope of the transmigration schemes was large, the Third Five Year Plan (1979-84), for example, aiming to relocate 2.5 million people to some 250 resettlement sites, mostly in Sumatra, Kalimantan and Sulawesi. As one of the major focus for its transmigration projects, since 1968, with the organization of the ‘Project for Opening Tidal Wetlands for Rice Production’, it had become an integral part of government policy to reclaim areas of tidally influenced peat soils as zones for rice production. So important it had tidal wetlands become in the overall scheme that between 13% and 20% of all transmigrants are now assigned to such areas. However, it was noteworthy that to 1976 some 300,000 ha of tidal wetlands has also been converted to agricultural production by spontaneous migrants, more than double that developed under the Government-sponsored schemes to 1980.

Table 1
Agricultural planning for coastal wetlands development

Year	Program activity
1968	FAO Agriculture Land & Water Resource Department established a mission activities with emphasis on Musi river basin in South Sumatra
1969-74	Public works tidal irrigation project reduced to 500 000 ha over a 5-year period (Repelita I). Actual area opened over this period was 13 198 ha for 7180 transmigrant families and including Delta Upang was developed
1974	By presidential instruction, a plan was developed by the Ministry of Public Works to open 1 000 000 ha of wetlands in 1974-1979 (Repelita II). Survey activities, training and massive equipment purchases were initiated quickly
1975	Canal excavation was started in areas adjacent to Repelita I pilot projects
1976	Downward revision of land opening project was to 250 000 ha by 1979
1975-76	Request to World Bank for design and survey assistance resulted in 3.2 million dollar loan for studies on 300,000 ha in Sumatra; complemented by 3 million dollar hydrological studies and training from government of the Netherlands

Sources: Government of Republic Indonesia and South Sumatra Government (2017)

During 1970 and 1971 each transmigrant family arriving in the Upang Delta received 2.75 ha of land. Official plans required that 0.25 ha be used for a yard garden area, 0.75 ha for various dry land crops, and 1.75 ha planted to tidally irrigated rice. This has not been adhered to, since many settlers have acquired additional land away from the scheme. Further, since the tidal irrigation system has failed to function as designed, rice production depends almost entirely on rainfall. Hence only a wet-season crop can be taken, and yard garden areas are almost entirely devoted to rice for household subsistence needs.

Land reclamation was started in the 1970s wetlands in Banyuasin have been reclaimed through a transmigration program devoted to rice farming. The area cultivated for rice farming was about 226 518.79 ha (almost 67% of the total wetlands area). Each farmer gets a per capita cultivation area of about 2.00 ha. The average per capita area continues to decline as the population increases as some of the wetlands have been sold by farmers or have been converted to non-food activities. If such a continuous action is undertaken by farmers and less attention from the government, the amount of rice farming will shrink to 44.42% by 2050. Most of the decrease in ricefields is due to agricultural structural changes, namely ricefields converted to oil palm and rubber plantations or fish ponds. However, most of the losses are caused by industrial and urban expansion and most of these changes occur in coastal and central areas, while the western region is less stable than in cultivated areas.

Since the 1980s, transmigration scheme has been carried out on wetlands and has affected the process of agricultural restructuration, rural industry process, urbanization and economic reforms as well as has led to the decrease of agricultural area. Converting fertile wetlands into non-agricultural uses is a major threat for Banyuasin to produce enough rice as a rice center (rice barn, *lumbung pangan*). The impact of conversion of cultivated land on food security has become a serious issue that needs to get government attention. Satellite image analysis of changes in cultivated areas and agricultural productivity between 1985 and 2010 illustrates a net increase in the cultivation area (approximately 0.95%), which almost offset the decline in productivity (approximately 2.05%). Thus conversion of cultivated land is not necessarily detrimental to food security. Changes in recent cultivation areas also have little adverse effects on food security. The cultivation area has decreased at a surprising rate. Changes in agricultural areas and rice harvesting areas in particular, have occurred across Banyuasin, with implications that vary geographically.

Around the 1980s most of the planned reclamation of wetlands has been completed. However, not all reclamation areas of wetlands are completely equipped with water management infrastructure, such as water gates; tertiary channels; reliable water management equipment and others. In areas that facility lack of public infrastructure, water and land management faced high constraints, thus consequently farmers have difficulty regulating the precise time of planting and harvesting because the water presence is not in accordance with the needs of the plant growth. As a result that wetland productivity declined and aggravated by pest and disease attacks. It is estimated that at least 25% of reclaimed wetlands areas were experiencing the above-mentioned problems; therefore the daily needs of farmers have to be subsidized by the Government through rice for poor program (*raskin*).

With an average of 2.75-4.00 tons DMG/ha/year (DMG: weight of dry milled grain), transmigrants obtained higher rice yields in the mid-2016 than either the Buginese (2.50-3.80 tons DMG/ha/year) or the local people (2.50-3.50 tons DMG/ha/year). This, however, does not indicate the relatively greater success of the transmigration scheme, since both the Buginese and the local people undertake many alternative and complementary economic activities which absorb much of their time and capital, whereas the transmigrants are limited almost exclusively to rice production.

Dynamics of Land Use Changes in Banyuasin Districts

Government-sponsored transmigrants live in official settlements of several hundred families in the center of a former wetlands previously drained and partially deforested by Government contractors. They are given land that having opened up with a drainage infrastructure and excavated by heavy machinery and the forest has been partially felled, sun-dried and either already removed or made ready for burning by the settlers. Commercially valuable species of vegetation are firstly removed. Part of the assigned land remains to be cleared of timber and scrub by the migrants during the slack period of the agricultural cycle. The first rice crop of such newly opened land may be anticipated in either one or two years. Most official transmigrants are Javanese, Balinese and Sundanese.

Planners have generally assumed that tidally irrigated rice fields in reclaimed wetlands could be eventually double-cropped. But such optimism is partly merited by the evidence. Increasing problems of pest infestation attack, together with the lessons of the long Buginese and Banjarese experience, make it doubtful whether the agricultural system envisaged for use by transmigrants, based exclusively on irrigated rice, will ever be either ecologically or economically viable. Nor will it permit double-cropping. A further constraint is imposed by water shortages in the dry season; a crop-destroying drought is caused by rainfall failure being likely every five years. A comparison of local residents, spontaneous migrants and officially sponsored transmigrants cultivating irrigated rice on reclaimed wetlands is presented in Table 2 and Figure 2.

In several areas of Banyuasin revealed many of the practical problems involved in the effective reclamation of such areas for agricultural use. Compared with rice cultivators on Java, all three groups obtain lower yields per ha and harvest only one annual crop (as opposed to two on Java), and therefore experience far lower economic rates of return per unit area cultivated. Further, they received (2017) an average monthly income of only Rp 2.50-4.80 million/year from all sources (i.e. rice fields plus complementary activities). This was too low to support a household. By the mid-2017 it is likely that incomes will decline owing to decreasing crop yields and the greater probability of crop loss. Production costs are probably higher in the reclaimed wetlands than on Java because of greater weed and pest infestation, and the risk of catastrophic flood or drought is greater than on Java. Determinant factors from landuse increased land conversion; landfill for industry/infrastructure; and land reclamation, while decrease of cultivated wetlands because wetlands were converted to build-up area; rural constructions; housing of farmers; forestry, plantation; and land loss/water body.

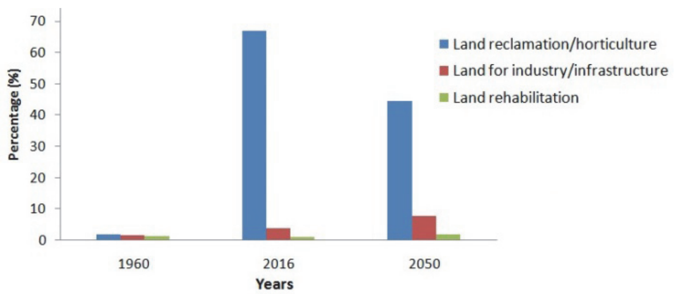
Agricultural Constraints based on General Perception of Farmers

Tidally influenced peats and wetlands are mostly as dome-shaped interfluvial structures or shallower marine deposits, approximately 50-60% of which have already been developed for rice, coconut and vegetable cultivation by Banjarese or Buginese spontaneous settlers. Based on

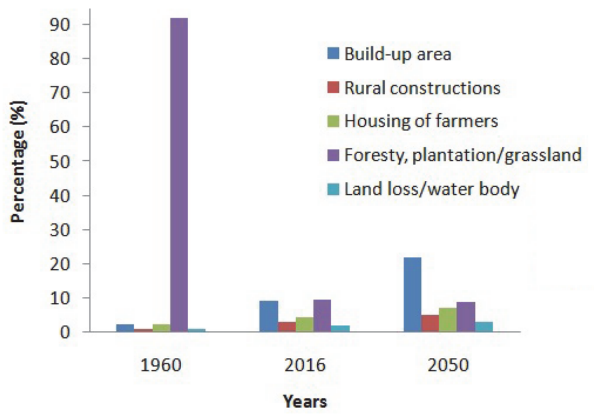
Table 2
Dynamics of landuse changes in Banyuas in wetlands

Development	Year of 1960[a]		Year of 2017[b]		Year of 2050[c]	
	ha	%	ha	%	ha	%
Cultivated wetland increase, converted from:						
Land reclamation/horticulture	0.00	0.00	226.519	66.93	150.326	44.42
Landfill for industry/ infrastructure	4.701	1.39	12.293	3.63	25.946	7.67
Land reclamation	499	0.15	3.295	0.97	5.674	1.68
Cultivated wetland decrease, converted to:						
Build-up area	7.632	2.26	31.338	9.26	74.448	22.00
Rural constructions	3.400	1.00	10.293	3.04	17.396	5.14
Local housings	8.100	2.39	15.143	4.47	24.122	7.13
Forestry, plantation	310.887	91.86	32.246	9.53	30.214	8.93
Land loss/water body	3.200	0.95	7.293	2.16	10.293	3.04
Total	338.419	100.00	338.419	100.00	338.419	100.00

Note: a/ before transmigration program; b/ existing condition; c/ It was predicted and interpreted on the basis of Banyuasin landuse map (1:250 000 scale), Landsat images 2015 and 2016
Source: The field survey results (2017)



A. Cultivated wetland increase



B. Cultivated wetland decrease

Fig. 2. Dynamics of landuse changes in Banyuasin wetlands

survey results on perceptions of farmers, some agricultural constraints faced by farmers in reclaimed wetlands can be summarized in Figure 3. In general, agricultural constraints faced by farmers are more of physical constraints and can be ranked on the basis of constraint importance level (1: very important; 2: important; 3: middle important; 4: little important; 5: less important). Based on the above criteria, water management was classified as very important; soil acidity belongs to important to very important; Al and Fe toxicity and pest and disease are mentioned as little important to important; thick peats belongs to middle to little important; lastly soil subsidence is stated as little to less important.

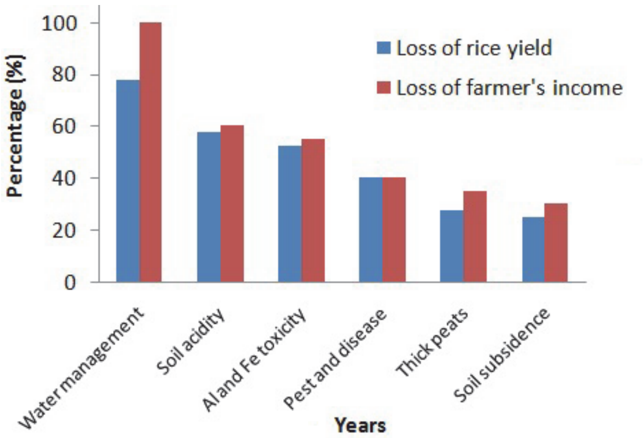


Fig. 3. Constraints of wetlands based on general perception of farmers

Water management

The main objectives of water management are for controlling floods and droughts, water storage, salinity and water supply in accordance with the needs of plants. In reclaimed tidal wetlands, water management includes drainage and irrigation. Drainage is the single most important factor required to promote suitable conditions for agricultural commodities. However, if drainage is not carefully designed, implemented and managed, it can lead to high rates of peat subsidence as well as to undesirable and irreversible changes in the reclaimed area. As an initial step which is an important step in the development of wetlands, the identification and characterization of the area needs to be done in detail about the biophysical condition of the land, farming system and cropping pattern, potential commodities, institutions and supporting facilities and infrastructures, socio-economy of farmers including their perception and marketing prospects of agricultural commodities.

Based on farmer perception, water management is the first important constraint in wetlands. This means that if the water management problem cannot be controlled, it can be estimated that there will be a loss of rice yield of around 70-85% and the income of farmers decrease by 100% of average income of farmers. This is because wetlands cannot be cultivated at all and the rice productivity is generally still low, due to low soil fertility, flooding in the rainy season and drought in dry season, as well as pest and disease talks which belong to the important limiting factors.

Soil Acidity

Typical pH values for wetlands are in range of 3.56-4.01 classified as very acid to acid. In many shallow wetlands are underlain by mineral soils with acid sulphate potential, which on aeration causes acid sulphate conditions and renders them virtually useless for agriculture. The oxidized mineral soils are acid sulphate soils with pH values under 3.00. If such soils are reclaimed both by traditional and modern technologies, then the soils have been abandoned as sleeping wetlands (unproductive soils) because the soils would be extremely difficult to be managed and often too expensive to either leach out or to neutralize excess of acidity over many years effort that may not be economically justifiable when balanced against the risk of crop failure and low yields from treated lands. Even the frequently advocated cultivation of wet rice to reclaim acid sulphate soils is no longer recommended.

Soil acidity is mentioned as the firstly and secondly important limiting factor found in wetlands. If soil acidity cannot be managed properly and in accordance with the terms of growing the plant, there will be a loss of rice yields of around 45-70% and loss of income of farmers by 60% of the average income of farmers. Rice yield loss and income of farmers are stimulated through imbalance of almost all soil nutrients, which resulted in the soil nutrients becoming fixed and are not available for plant growth.

Al and Fe Toxicity

Toxic concentrations of Al and Fe together with low nutrient levels are able to inhibit crop production more than low pH does. Management of potential acid sulphate soils is directed through careful management of the water table, either at preventing oxidation and subsequent acid production or at ameliorating conditions by leaching with fresh water. Liming must be carefully controlled and requirements are crop-specific. Moreover, applications that raise the pH values beyond 5.5 have been demonstrated to reduce the availability of trace elements particularly boron, manganese, phosphorus and zinc. Draining and ridging for agriculture can result in the formation of acid sulphate soils. In wetlands with a pronounced seasonality of rainfall, oxidation can penetrate deep into the soil profile, leading to an annual regeneration of acid sulphates. But depending on the acid sulphate potential as well as on climatic, hydrological and other factors, such acid-tolerant crops as oil palm, rubber, coffee, pineapple, cassava and coconuts can be grown successfully on wetland reclaimed by draining and ridging, if water tables are carefully managed to prevent acids and salts from reaching root-zone level.

Al and Fe toxicity includes the secondly to fourthly important limiting factor depending on the location where the wetlands are located. Al and Fe toxicity is very necessary to be controlled, so that the loss of rice yield (40-65%) and income loss of farmers (55%) can be minimized.

Pest and Disease

Once wetlands are drained and chemically treated, for example conditions for micro-organisms - some beneficial and others are not - enhanced. Similarly, weeds (especially *Scirpus* sp.) in rice fields, as well as mammalian and insect pests, can reduce crop yields by competition and consumption or destruction the crops, respectively. Further, the alteration of wetland habitat also creates new niches for the vectors of malaria and other arthropod-borne diseases in humans, since one general aspect of the ecology of human diseases is that their vectors are to be found in man-made or man-modified environments. The large-scale clearances of mangroves, for example, in many parts of Banyuasin have created suitable conditions to the breeding of malaria vectors. On the other hand, malaria vectors are not endemic in Banyuasin mangroves that are relatively undisturbed or where clearings are small or temporary.

Pest and disease can be mentioned as the secondly to fourthly important limiting factor depending on the location where the wetlands are sited. Wetlands located near the stagnant water are more dominant to create problems not only for human life, but also for plant growths because there are a lot of pest and disease well distributed. Pest and disease is very necessary to be controlled, so that the loss of rice yield (30-40%) and income loss of farmers (40%) can be minimized.

Thick Peats

Most peatlands are chemically rich eutrophic peats that are organically highly productive when managed properly. Most peatlands are already under cultivation, since for the most part the Banjarese and Buginese have carefully selected them for their spontaneous agricultural settlements. Peatlands that remain available for settlement are mostly the relatively nutrient-poor, interfluvial oligotrophic peats.

The traditional agricultural technology of the Banjarese and Buginese, developed empirically in coastal wetlands over many decades, if not longer, does not appear to be deleterious in eutrophic peatlands; but even the minor perturbations that such technologies can induce in oligotrophic peat cause major and rapid deterioration. Further, earlier efforts to reclaim oligotrophic peats and areas underlain by potentially acid sulphate soils have a dismal record, several hundred thousand ha of wetlands having been created as a result. As it has been demonstrated, reclamation of infertile tidal wetlands is problematical even where acid sulphate potentials are absent, and such soils remain marginal economically when reclaimed. However, problems can be avoided if soils remain permanently inundated, as under normal swamp forest conditions, and undrained peats can be used to produce sustained yields of sago palms *(Metroxylon* sp.). Rice can also be produced on undrained peats; but results have been disappointing, and poor plant growth and weed infestation need to be overcome by sophisticated and expensive reclamation, drainage and continuous leaching measures.

Peats deeper than 2.00 m are generally so lacking in nutrients and so difficult to manage that the capital investment required to reclaim them for agriculture is not economically sound. Since chemical fertilizers are expensive, the surface peat is commonly burned to liberate plant nutrients, to raise pH values, to reduce pests and diseases, or to destroy toxic compounds. Opinions vary on the value of this practice. Certainly it is deleterious on shallower peats, where there exists a danger of exposing the underlying soils with an acid sulphate soils.

Based on farmer perception, peatlands are not suitable for rice farming; therefore farmers try to avoid peatlands for their agricultural activity. Therefore thick peats can be mentioned as the third to fourth important constraint in wetlands. This means that if the thick peats cannot still be avoided, it can be estimated that there will be a loss of rice yield of around 25-30% and the income of farmers decrease by 35% of average income of farmers. This is because thick peats cannot be cultivated at all and the rice productivity is generally still low, due to low soil fertility, flooding in the rainy season and drought in dry season, as well as pest and disease talks which belong to the important limiting factors.

Soil Subsidence

Soil subsidence in wetlands, however, is an inevitable and continuous result of drainage, a consequence that can be controlled, but never entirely halted. Two classes of subsidence have been recognized. ‘Initial subsidence’, a reorientation and denser packing of peat content, follows the lowering of water tables by drainage and may attain rates in deep peat of 2-4 cm a year. 'Continuous subsidence' then follows at lower and more gradual rates: it usually results from the gradual decomposition of peat accelerated by agricultural practices, and at rates determined by them in combination with climatic conditions and biophysical factors inherent in the peat. Rates of continuous subsistence are generally difficult to estimate, although those of 2-5 cm a year would threaten the viability, since little peat would remain by the mid-2017s.

The subsistence impact on the reclaimed wetlands is determined by a combination of factors, the principal of which are such physical elements as shrinkage, settlement and compaction, biochemical oxidation, together with burning and the removal of organic matter during land clearance and subsequent agricultural activities. As a consequence, irreversible changes may occur in the colloidal structure of soils, which affects their capacity to retain water, as well as the degradation of the organic matter into a fine power which is susceptible to accelerated erosion and is of low agricultural value. Initial subsidence can be controlled by maintaining water tables as high as crops will tolerate; hence wet rice is the usual crop planted on peat soils. Reduction of continuous subsistence depends on minimizing the exposure of the reclaimed surface to direct sunlight, usually by cover crops. Rates of peat loss could also be greatly reduced by eliminating burning and by up-grading other agricultural practices peatlands are usually acidic.

Soil subsidence belongs to the fourthly to fifthly important limiting factor found in wetlands. If soil subsidence cannot be managed properly and in accordance with the terms of growing the plant, there will be a loss of rice yields of around 20-30% and loss of income of farmers by 30% of the average income of farmers. Rice yield loss and income of farmers are stimulated through media loss for plant growth, which resulted in the soil nutrients becoming fixed and are not available for plant growth.

Conclusion

Based on the above research results and discussion, it can be concluded that the greatest wetland transformation was done through transmigration schemes, where public infrastructure has been built to wetlands reclamation for agricultural purposes in a broad sense. Not all wetlands are suitable for food crops, if they are not suitable for food crops and are still cultivated for food crops, then wetland degradation and farming costs will be very high. Agricultural constraints faced by farmers are more of physical constraints, namely water management, soil acidity, Al and Fe toxicity, pest and disease, thick peats, and soil subsidence. Almost all constraints decreased rice yields of around 20-85% and income of farmers in the range of 30-100%.

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