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CHALLENGING CONSTRAINTS OF LIVELIHOODS FOR FARMERS IN THE SOUTH SUMATRA PEATLANDS, INDONESIA

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Abstract

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One of the most important socio-economic functions of peatlands can be used for agricultural cultivation. The research aimed to analyze the challenging constraints of livelihoods for farmers on the South Sumatra peatlands. The research results can be used for the Governmental inputs in making the management policy oriented to the community. The research was conducted on peatlands in OKI district and the sampling technique has been done by multi-stage method, followed by Focus Group Discussion (FGD) and interview by questionnaire. Evaluation of land suitability was carried out by matching method between growth requirements of plants with the survey data. The research resulted that the peatlands belong generally to lebak swamps (meaning free from tidal influences or non-pyritic layers) with the thickness of mostly less than 2.0 m and sapric to humic maturity levels. The diversification of livelihood sources can be grouped as rice farming, rubber plantation, oil palm plantations, forest extraction, and fisheries. The challenging constraints of livelihoods for farmers are divided into constraints in agronomic, technological and management, socio-economic aspects. The general peatland limiting factors for plant growth are especially inundation, inadequate rooting systems, and low nutrient availability. Land suitability for rice, rubber and oil palm was classified as "marginally suitable (S_3)" with limiting factors of nr_3 (nutrient availability at level 3); fh_3 (danger of flood/inundation during planting and harvesting at level 3); rc_3 (inhibited drainage at level 3). Land suitability for commodities with less human intervention is classified as "very suitable (S_1)" with limiting factors of nr3 (nutrient availability at level 3) for forestry and xc_2 (toxicity at the level 2) for fishery. These limiting factors (constraints) are global, comprehensive, integrated, and holistic and beyond the ability of farmers to manage them, thus it is needed proactive problems-solving by the governmental intervention to overcome.

Key words: challenging constraints; livelihoods; farmers; peatlands

Introduction

Peatlands are defined as the accumulation of plant residues both identifiable in forms and unrecognized for decomposition, and are generally determined in water-saturated and buried water catchment (basins) for thousands to millions of years ago (Adam et al., 2013; Abson et al., 2014; Bruni and Santucci, 2016). Water saturated conditions in the water catchment make anaerobic conditions, so the process of accumulating organic matter is faster than the rate of decomposition. Peatlands are able to function as growing media of plants (Altarawneh, 2016; Bazitov et al., 2016; Armanto and Wildayana, 2016; Angelsen et al., 2014).

Peatlands in Indonesia were originally utilized for rice farming by indigenous people, such as Dayaknese in Kalimantan, Sumatranese, and Bugisnese in Sulawesi. Along with the increasing population and the science and technology development (Armanto et al., 2013; 2016; 2017; Wildayana et

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al., 2016; 2017), the use of peatlands becomes more diverse such as industrial raw materials, mining, alternative fuels, energy, agriculture, horticulture, plantations, fisheries and others (Wildayana and Armanto, 2017).

Potential of peatland utilization can be seen from two aspects, namely from acreages and functions. Peatland areas in the world are estimated approximately 400 million ha and Indonesia belongs to the country with the fourth largest peatland in the world and the largest areas in the tropical zone. Peatlands in Indonesia has an area of around 18.32 million ha, spread in Sumatra of around 6.24 million ha, Kalimantan of around 5.07 million ha, and Papua of about 7.01 million ha (Margono et al., 2012; Laumonier et al., 2010.

The ecological function of peatlands can be mentioned as growing media of plants, as absorber and storage of water, as a carbon sink, as flood control and drought and as living place to flora and fauna. The socio-economic functions of peatlands are beneficial for humans to meet their living needs. One of the most important socio-economic functions of peatlands is as agricultural cultivation (Bendlin et al., 2016; Boyaci and Yildiz, 2016; Darani et al., 2017). Intensive agriculture currently under peatland development is plantation because plantation can provide high opportunities for farmers to generate greater profits (Dewees et al., 2010; Donato et al., 2011; Ferrara, 2017; Fusaro et al., 2016), while peatland for food crops such as indigenous rice farming takes a long time to produce relatively small profits when compared with the advantage of growing superior rice in mineral soils or plantation yields (Galluzzo, 2017; Galon et al., 2016; Zwolak, 2016). Indigenous rice varieties on peatlands are planted once a year, and produce poor rice quality (*pera* rice). However indigenous people living in the peatland area prefer pera rice rather than superior rice, and the price of indigenous rice varieties is more expensive than the superior rice, so farmers do not lose the desire to keep growing the indigenous rice or *pera* rice (Withey and Kooten, 2014; Sarno et al., 2017; Sudrajat et al., 2017).

The utilization and management of peatlands have to still pay attention to environmental rules because there are a lot of utilization constraints (Terziev and Arabska, 2016; Silva et al., 2017). The uses of peatlands especially for agriculture, that do not pay attention to environmental rules, will cause damage and loss from the environmental and socio-economic benefits (Meijaard et al., 2013; Trendov et al., 2017; Vasylieva and Pugach, 2017). Some negative impacts will result from improper management, namely land and forest fires, haze, floods, losses of endangered species, and loss of livelihoods of the indigenous people who are mostly dependent on peatlands (Galon et al., 2016; Keenam et al., 2015; Kolka et al., 2016; Koutev and Nenov, 2016).

Peatlands belong to a marginal land; inherent characteristics of peat chemistry are limiting factors that require enormous energy input to increase productivity as agricultural land or plantation land. Marginalization process of the peatlands means that it will continue to marginalize the human life in the agro-ecosystem (Armanto, 2014; Kosolapova et al., 2016).

Peatland is one of the natural resources having the functions of hydro-orology and other ecological functions that are important for the life of all living things. This important value making peatlands has to be protected and maintained its sustainability. To be able to utilize the natural resources of peatlands wisely requires careful planning. Application of suitable technology with suitable management with a wise step is the quality and sustainability of the peatland resources. Information on critical and fragile properties is an important reference for more accurate planning, optimization of utilization and conservation efforts.

One of the biggest constraints to peatlands is low soil pH. How to overcome the constraints of peatlands is including drainage channels, mixing peatlands with mineral soil, fertilization and liming, and the use of tolerant varieties. In relation to the above description, the research aimed to analyze the challenging constraints of livelihoods for farmers on the South Sumatra peatlands. It is expected that the research results can be used by the Government as inputs in making the peatland management policy oriented to the community. For the private sector, this research can be used for benchmark data to make peatland management more environmental oriented and orienting to the wider community. For the community, this research can be considered before managing peatland.

Materials and Methods

The research was conducted on peatland area in Ogan Komering Ilir (OKI) district from June to August 2017. The sampling technique has been done by multi-stage sampling method. This method used various random sampling methods together as efficiently and effectively as possible because the research themes belong to complex socio-economic problems. Sampling of respondents was done by direct interviews at the district level. The first stage of the process was to determine the cluster sampling, and secondly the stratified cluster samples consisted on four sub-district level and thirdly it was followed to determine eight village levels. At the village level interviews were conducted with respondents and followed by Focus Group Discussion (FGD).

FGD aimed to obtain information and data on livelihood diversification, demographics, gender role, agricultural practices, commercial activity, trading, land tenure, major development, ecological resource conditions, fire patterns and drainage systems. About five respondents were invited to represent formal and informal leaders to be involved in the FGD discussions.

Quantitative data were collected through a household survey of around 102 randomly selected respondents. To facilitate the data collection, then questionnaire was used to facilitate the process of collecting data as well as to improve communication among researcher and respondents. Subsequent evaluation of land suitability was carried out by matching method between growth requirements of plants with data and information obtained from the results of this research.

Results and Discussions

Results and discussions of this research focus on the general condition of research area; diversification of livelihoods for farmers and land suitability of peatlands for agriculture.

Conditions of research area

This research is located in Talang Sepucuk peatlands flanked by Komering River and Sibumbung River, so this area is often referred to as landscape in peatland hydrological unity of rivers of Komering and Sibumbung of OKI district South Sumatra (Figure 1). Our research location can be divided into some components, namely rivers, terrain zone and peat domes with sedimentation zones enriching natural vegetation with soil nutrients. The location of this study was chosen because it is in the Hydrological Unity of Peat that prioritized to be restored by the Peat Restoration Agency (BRG).

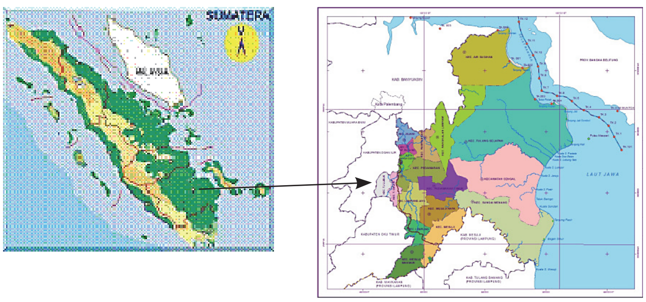

Fig. 1. Research location in OKI District, South Sumatra Indonesia

The peatlands belong generally to *lebak* swamps which are relative free from tidal influences (non-pyritic) with the thickness of mostly less than 2.0 m and sapric to humic maturity levels. The infiltration of seawater carrying sulfate ions which permits the formation of a sulphate-rich layer of soil does not occur in the peatlands in research area, nor is the consequence of other dissolved salts. It is further stated that peatlands are estimated to be about 76% of its district, which is relatively free from tidal influences.

The peatlands in terms of decomposition levels are grouped into fibric, hemic, and sapric. The hemic and sapric peatlands are mostly formed by sea level rise followed by lifting of land. The two types of peatlands are the widest of the parts. Low slow drainage pores are reflected by low water availability. High permeability provides an illustration of low water availability, thus peatlands are included in the level of hemic and sapric decomposition having the potential to be developed.

Rivers provide the main access for the community, which used the riverbank as a temporary settlement and the surrounding area for rice farming. Indigenous peoples have been closely associated with rivers, so almost all of their life activities are associated with the presence of rivers ranging from upstream to downstream. The development of roads, drainage and transportation in the last three decades has provided opportunities for local communities to conduct economic activities on the mainland. However, rivers and canals are still regarded by local communities as the main transportation route. This is due to the road construction carried out on land that is not in accordance with the allocation, so that the land transportation routes are badly damaged or road access is less in accordance with the needs of local communities. The road development does not follow the spatial pattern causing the utilization of roads to be less optimal. However, the construction of primary and secondary drainage channels crossing the peat dome can be used as a boundary between one block and another block that has effectively opened the peat dome.

The main utility constraints of peatlands for agricultural activities in a broad sense were generally identified, among others peatlands have generally high acidity with average pH value of less than 4.36, thus the balance of soil nutrients was disrupted due to soil acidity and nutrient-poor peats; Peatlands are susceptible to bio geophysical and chemical degradation due to reclamation management through drainage and wetting process; Peatlands are rapidly experiencing changes in the physical and chemical environment after reclamation and environment of peatlands is very fragile to any kind of human treatments. Under such conditions, it is highly demanded that high caution in managing and utilizing peatland for agricultural purposes in a broad sense.

Diversification of livelihoods for farmers

Diversification of livelihoods for farmers is relatively various according to present conditions of peatlands. In general, the diversification of livelihood sources can be grouped as rice farming, rubber plantation, oil palm plantations, forest extraction, and fisheries.

Rice farming

Rice farming often done farmers on peatlands is relatively less developed because naturally peatlands themselves are not really suitable media for rice growth. The try and error approach has been done by farmers in several generations and the technological touch has been also applied on peatlands, however all of these are not able to improve optimal rice production and income of farmers. In general, the average rice production only ranges from the average of 2.40-3.00 tons dry milled grains (DMG)/ha in a year and the average income of farmer was around 2.50 million in a year, while the rice cropping index is relatively difficult to increase beyond one time of rice planting in a year.

Most of rice farming was carried out by slash and burn cultivation, which in the indigenous term is called *sonor* system. This system belongs to the oldest form of shifting cultivation in South Sumatra Province. The indigenous population has been practicing this system for generations and is still practiced today. The system practice is characterized by intensive fire use to prepare field cultivation and subsequent followed by fallow phase of the field. Based on field observations, peatland productivity continues to decline due to depletion of soil fertility and weak application of technology.

In the past, fallow periods in the systems were ranging from 10-20 years in order to give relatively sufficient time to restore soil fertility. At the present time, the average fallow period is less than five years due to limited land resources, so farmers have to return to the land that have been processed. The peatland clearing and preparation is conducted during the dry season from July to September.

Various components of activities in the system are grouped into, i.e. to clear the forest or fallow trees; to slash and to cut the vegetation; to burn biomass; and to clean the unburnt plants. After that, the activity is continued by planting seeds from October to November. Indigenous rice varieties are commonly used, such as IR-64, Sokam, Batang Lembang, Ciherang, Surya, Kuning, Padang, Lampung and Pandak Kuning. Indigenous rice cultivars have response to very low to fertilization, in contrast to superior cultivars that have a high response to fertilization.

Indigenous rice cultivars have been planted for decades and are adapted by natural indigenous condition. They are favored by farmers because some of them have a good adaptability to the sub optimal environment such as peatland ecology, good rice taste, fragrant aroma, and good rice quality, although the rice production is not as high as superior rice cultivars. They are naturally tested for their resistance to pests and diseases and thus they are a valuable collection of genetic resources. In addition new cultivars are less favored by farmers because they require intensive maintenance, higher production inputs and labor, and less tasty rice flavor, and are not cheap. The average number of rice seeds was sown around 30-40 kg seed/ha. Planting activity is called "*manugal*" in indigenous language. There is no maintenance and no fertilizing and no weeding for plants and farmers come back to their rice fields for harvesting done in March to April.

The main agronomic constraints faced in *sonor* system are increasingly recorded (Table 1). Prior to 1975, when peatlands were not yet intensively reclaimed by drainage system to regulate water management, agronomic constraints faced by farmers were pests, lacks of capital and technology. Various pests often attacking rice farming are pigs, rats, birds, monkeys, brown plant hopper, green leafhoppers and lice, while non-technical includes capital. In 1980-2000, these agronomic constraints remain to be found and coupled with the emergence of environmental constraints and weeds, such as floods, fires, climate change, and decreased soil fertility. At present, agronomic constraints are increasingly complex and coupled with environmental constraints, including fires, floods, climate change, droughts and unpredictable wet seasons, decreased soil fertility.

Table 1
Agronomic constraints of rice farming

Nr	Period	Constraints	
		Technical	Non-technical
1	Before 1975	Pest (mouse, pigs, bird, brown plant hopper, monkey, green leafhopper, insects)	Technology, capital
2	1980-2000	Pest (mouse, pigs, bird, brown plant hopper, monkey, rice bug, green leafhopper, insects), weeds	Technology, manpower, capital, flooding, water management, fire, climate change
3	2000-2017	Fire for land clearing, pest (mouse, pigs, bird, brown plant hopper, monkey, rice bug, green leafhopper, insects), weed	Manpower, technology, capital, flooding, water management, fire, climate change, unpredictable climate, declining soil fertility

Note: Field survey results (2017)

In addition, farmers get difficulty to estimate when the wet season and dry season will come, so this condition raises the uncertainty when farmers have to cultivate their peatlands and when to avoid harvest, especially in the wet season. Overall, these have implications for unsuccessful cropping due to climatic irregularity. Beside that the Government has issued regulations to ban land clearing by burning. This regulation can suppress the implementation of *sonor* system. There are indications that land clearing of peatlands has led to an increase in rice pest attacks in the research area.

Rubber plantations

The change from sonor system to rubber plantation in the 1940s was triggered by Chinese colonialists and merchants who have managed to show rubber as a global commodity. Therefore, farmers are beginning to be interested in growing rubber on their land. The sonor system is still working, but rice planting is only done during the first two years for financing the development of rubber plantation. Since 1975, when rubber prices increased, farmers plant rubber with rubber agroforestry systems, using indigenous wood trees. Farmers have used local seed, and only a few farmers have started using grafting and clonal options. Rubber is usually grown in mineral soil, and at present farmers also grows rubber on peatlands which previously were rice farming. There are two types of rubber plantations made by farmers, namely rubber monoculture and rubber mixed system.

Farmers use rubber monoculture to ensure better rubber tree growth in hopes of increased rubber productivity. When rubber is mixed with oil palm, the rubber tapping is only started after 8-9 years and tapping process is difficult to be done because it is constrained by oil palm. This is the reason why farmers prefer to make rubber monocultures. Farmers grow monoculture rubber at plant spacing 4x4 m. Now there are many clonal rubber seedlings planted by farmers and farmers do not take care of their rubber trees intensively and continuously throughout the year.

Farmers do not conduct rubber tapping in tidal conditions because latex obtained tends to be small. The best time to plant rubber in the peatlands is from August to October because at that time there is still a lot of water dwelling and avoided from the drought in the peatlands. The tapping results depend on the climate and conditions of rubber trees and plantations. The productivity of rubber decreases with the age of the trees. Good maintenance including weeding and fertilization can improve growing of rubber and able to yield a lot of latex.

The mixed rubber system is mostly found on old rubber plantations that have not been built using certain spacing. Trees in rubber plantations originate from native forest vegetation and are selectively maintained and not planted trees. The fruit trees found include: cempedak (*Artocarpus champeden L.),* acid mango *(Mangifera indica L.),* mangosteen *(Garcinia hombroniana Pierre),* durian *(Durio zibethinus L.),* rambutan *(Nephelium lappaceum L.),* jackfruit *(Artocarpus heterophyllus Lam), rambai (Baccaurea angulata Merr),* kecapi *(Sandoricum koecape),* duku *(Lansium domesticum Corr),* petai *(Parkia sp.),* jambu biji *(Psidium guajava L.),* and acid kandis *(Areca catechu L.).*

The indigenous rubber that adapts very well with peatlands is a *jelutung* plant. Jelutung harvest period is when the plant was seven years old. Unlike other rubber plants, jelutung produces better quality rubber latex and can neutralize acidic peat soil conditions. In addition, jelutung is also relatively water efficient. We harvest jelutung sap which is better quality than rubber with the cheapest price is around US$ 3.00/kg (Rp 40.000). One jelutung tree can produce one kg of jelutung sap. Peatlands where the jelutung is planted cannot be planted with other perennials, except acacia, so monoculture jelutung is the right choice.

Oil palm plantations

Oil palm planting has been practiced by farmers before 1990 on peatlands, was cultivated and driven by two important reasons, namely good prices and harvested continuously (harvested every two weeks). Oil palm can be harvested after 6 years and some farmers think they feel rubber is more profitable and reliable. Maintaining oil palm is considered more tedious as oil palm requires tree maintenance, weeding and fertilizing.

Agronomic constraints reported by farmers on rubber and oil palm plantations have increased over the years (Table 2). The main constraints faced by farmers today are floods, fires, soil fertility, pests, lack of investment capital, and fluctuated prices of latex. Very important aspects of peatlands for oil palm are how we can manage the water system in the peatlands. Water is an essential media for nutrient uptake for plant growth and is the highest component of plants. Besides functioning directly in the process of growing plants, water on peatlands also plays a role in controlling weeds, washing toxic compounds, supplying nutrients, fish culture media, preventing fires, preventing pyrite oxidation, and transportation. On the other hand, water also becomes a constraint if the volume is excessive, its existence is unruly, and its quality is not good. All these factors must be considered.

Peatland reclamation for annual crops requires a macro drainage network controlling water governance in one area and micro drainage to control water levels at the farm level. Suitable and correct drainage systems are needed on peatlands, both for food crops and plantations. Improper drainage system will accelerate peatland degradation.

Table 2
Main constraints of smallholder plantations

Nr	Period	Constraints	
		Technical	Non-technical
1	Before 1975	Seeds, pests (deer, pigs, termites, monkeys)	Capital, flood, knowledge and technology
2	1980-2000	Seeds, labor, pest (deer, wild pigs)	Knowledge and technology, flood, fire, price uncertainty
3	2000-2017	Pests (termite, deer, wild pigs), Declining soil fertility	Capital, fire, flood, knowledge, technology, fertilizers, high cost of pesticide uses and price uncertainty

Note: Field survey results (2017)

An important component in the regulation of peatland water management is to build water gates in each channel. The water gates serve to regulate the water table, so it is not to be too shallow and not too deep. Annual plants require drainage channels of different depths. Rubber plants require a micro drainage channel of about 20 cm, coconut plants as deep as 30-50 cm, whereas oil palm requires drainage channels as deep as 50-80 cm. The thick peatland of more 3 (three) m is designated as a conservation area according to Presidential Decree No. 32/1990, due to the fragile environment of the deep peatlands if they are converted to agricultural land.

The utilization of peatlands in the cultivation area shall further be adjusted to the typology, i.e. firstly potential peatlands, shallow peatlands to a depth of 75 cm can be arranged for ricefield, secondly, peatlands with depth of 75-150 cm for horticulture, rice, *palawija* (food crops), and annual crops, thirdly, peatlands to a depth of 2.50 m only for plantations such as coconut, oil palm, rubber, and fourthly, peatlands more than 2.50 m should be used for the forestry. Large scale of oil palm plantation has been developed on peatlands with a thickness of between 1-5 m. The production of oil palm on peatland is relatively lower than standard and varies around 12-20 tons fresh fruit bunches (FFB)/ha in a year. In the thick peatlands in the eighth year, FFB could be harvested about 14 tons/ha in a year.

Peatland compaction is required for oil palm, coconut and rubber. Low ground bearings capacity from peatlands can cause trees to fall easily and to reduce production. The existence of peatland compaction for oil palm crops is needed, so that the density of peatland is increased and the roots are stronger to grasp the soil, so that the falling plants can be reduced. Soil compaction will also increase yield due to greater absorption.

Forest extraction

Indigenous people refer to forest resources as a source of open access. Based on this perception, individuals of their own group can access and extract forest products irrespective of the territorial ties they originate. However, this view is clearly contrary to government regulations in the forestry sector, so that all rules and regulations made by the government have been ignored by indigenous people.

Prior to 1975, indigenous people only used forest wood for their own purposes and were not commercial, for example to build boats and house construction. In addition, they also harvest non-timber forest products for their own purposes, for example for food, herbs, medicines, and the necessity of their religious activities. Various non-timber forest products have been extracted, among others dammar *(Shorea sp.),* jelutung *(Dyera costulata), katiau (Ganua motleyana), hangkang (Palaquium leiocarpum bl.)* and any others.

Beginning in 1975, there has been the wood commercialization and has peaked in the period 1990-1995. The types of plant species found in peatland forest have the highest commercial value such as ramin (*Gonystylus bancanus*), *jelutung* (*Dyera costulata*), *belangiran* (*Shorea belangiran*), *ulin* wood (*Eusideroxylon Zwageri*), *kemedang* (*Litsea spp*.), *kruing* (*Dipterocarpus sp*.) and *meranti* (*Shorea spp*.). However it was but due to intensive uncontrolled logging activities recently and without adequate monitoring and controlling from the Government, all this has resulted in the seriously structured, planned degradation of peatland forest and the existence of these species is now threatened with extinction.

Indigenous investors recruit villagers to cut and to record timber from the peatland forest; and they are motivated and interested because their income from agricultural and fishery sectors were much lower compared with the daily wage earned from logging. Most of farmers have concentrated fully on logging and have neglected their rice farming.

In the period of 1990-2000, there were difficult conditions to obtain valuable timber sources, so that non-timber forest products, such as oil palm and rubber, became more dominant than wood. In the year 2000 until now, due to intensive logging without followed by replanting, the majority of peatland forest has been a severe damage. This is because the demand for timber is quite high, while the wood supply in the forest is almost destroyed, so big private investors are doing illegal logging on the protected forest or conservation forest, so logging will again be rampant, for example wood like meranti, kruing, and kemedang, but these forest products are lower than non-timber forest products. All this leads to extensive forest destruction in all forest types. This forest destruction is exacerbated by land clearing by burning activities for palm oil planting, land clearing for rice farming activities through sonor systems, forest and land fires, and others.

Fishery

The fishery type in the research area belongs to a traditional way to catch fish without being followed by fish farming and fish catch is used by indigenous people for sale and self-fulfillment. Fishing became livelihood after the government banned indigenous people from illegal logging. In addition fishing activities are supported by increasing fish prices and collecting traders continually come to the villages to buy fish catch results directly from indigenous people. There are various species of fish caught, but fish species with high commercial value are presented in Table 3. Common fishing sites in the peatlands are rivers and canals, lake, basin (*embung*, depression), small well, peatland forest, *lebak lebung* (deep swamp) and others (Table 4).

Fishing in the river is commonly done by local people; however amount of fishing result in the wet season was much lower than in the dry season. The man-made channels are used to manage the water system of the peatlands and always flooded by water. This channel is created in the framework of peatland reclamation to regulate the water system and farmers catch fish in canals. Usually the number of fish catches in canals is much lower than other places in the peatlands because the canals themselves are not natural, so the breeding and feeding places of in-canal fish are less naturally conditioned.

The lake is defined as peatland area and flooded by water throughout the year and commonly not covered by vegetation. Farmers catch fish in the lake throughout the year. A basin area (*embung*) is representable as a flooded area which generally looks like a small lake with an area of less than 5 ha and a diameter of less than 25 m. A basin is usually channeled into the river during the wet season when the surface

Table 3
Fish species caught on peatlands area

Nr	Local name	Other name	Latin name
1	Gabus, haruan	Snakehead fish	*Channa striata Bloch*
2	Baung, duri	Baong, baon, bawon	*Bagridae Hemibagrus Bleeker*
3	Tambakan, biawan	Kissing gourami	*Helostoma temminckii Cuvier*
4	Sepat rawa	--	*Trichogaster trichopterus Pallas*
5	Gurame, kalui	Giant gouramy	*Osphronemus gouramy Lacepede*
6	Toman	Giant snakehead	*Channa micropeltes Cuvier*
7	Patin siam	Jambal siam	*Pangasius hypophthalmus Sauvage*
8	Betok, papuyu, bethok, bethik	Climbing gourami, Climbing perch	*Anabas testudineus Bloch*
9	Lele, keli	Catfish	*Clarias batrachus Linnaeus*
10	Nila	Nile Tilapia	*Oreochromis niloticus Linnaeus*
11	Tapah, wallago	--	*Wallago attu Bleeker*

Note: Field survey results (2017)

Table 4
Fish species caught on peatlands area

Nr	Fish location	Government intervention	Descriptions
1	Rivers and canals	Intensive in order to regulate the peatland water system	Used as water transport lines
2	Lake	Less attention from the government, whereas the lake can be used as a source of regional income	Used water storage for drinking water and household needs
3	Basin (*embung*)	Intensive because there is already a local regulation that regulates the fishery to generate regional income	For preventing floods and water shortage
4	Small well	The local government less concerns because of small scale and intended for indigenous people	For drinking water and household needs
5	Peatland forest	The central government is concerned in conducting national peatland restoration	For irrigation and drainage system
6	*Lebak lebung*	Intensive because there is already a local regulation that regulates the fishery to generate regional income	For preventing floods and water storage

Note: Field survey results (2017)

of the surface water is high, so it will lead many fish that can enter the basin. However, during the dry season, there will be a decrease in the surface of the water, so many fish will be trapped and can easily be caught.

The small well (natural holes or small pond) has a size less than 2.50 m in diameter which is made either intentionally to take water in the dry season or accidentally due to hole made after a big tree is pulled up or where the puddle (play area) of buffalo. In period of the wet season if there are overflow of the large rivers, the small well is filled with water and in the dry season, the small well is still storing water and farmers can catch fish trapped when the surface water receded.

The peatland forest is always flooded with water in the whole of year and is naturally linked directly to the river through tidal movements, which directly affects the water level on peatland forest. However, the main factor regulating the peatland forest water dynamics is the amount of rainfall and the number of rainy days, so that the water surface will automatically rise during the wet season and at the moment a large number of fish move into the peatland forest for spawning and feeding (to lay eggs and breed). In the dry season the limited amount of rainfall meaning the water supply to the peatland forest is reduced and has a direct impact on the decrease of the water level, so most of the fish can no longer return to the big river and trapped in the peatland forest. So fishing reaches the maxim during the dry season.

Lebak lebung is a pond in the peatlands and becomes waterlogged during the wet season when the river overflows, in which produce fish production naturally. In period of the wet season, especially if the high tide happens, many fish are gathered in the *lebak lebung*, this give good opportunity for indigenous people to catch fish there. Most of *lebak lebung* has been utilized for agricultural cultivation and plantation. *Lebak lebung* functions not only as an ecological area, but can form local culture. Especially through the interaction of farmers with nature that is built based on the values of wisdom to nature. The farming system built in the *lebak lebung* culture is an integrated system of annual crops (rice, palawija, and vegetables), livestock (buffalo and ducks), and fishing effort. While trees, such as coconut, mango, durian and duku, can only be planted on unflooded land, for example on the banks of the river. The planting season in *lebak* can be done only once a year. Palawija and vegetables are planted in conjunction with rice planted in rice farming. In the wet season, farmers catch fish, graze cattle, or make handicrafts, such as woven traditional clothing, woven mats, and other household items.

The local government has claimed the area of *lebak lebung* as its property, thus the local government also controls the source of natural fish in *lebak lebung*. For this purposes, the OKI government has issued a regional regulation (*Perda*) related to fishing in *lebak lebung* by implementing the auction and retribution systems. This regulation eliminates access of farmers to natural resources on peatlands that are actually their customary right. Generally, the auction winner can be predicted that they belong to local groups who have strong capitals.

In general in peatlands, the number of fish catches from year to year decreases. This is due to the way the natives catch fish regardless of the conservation rules that ultimately damage the livelihoods of farmers and are not sustainable. Over-fishing is done by farmers by catching non-selective fish (no fish size limit, all fish captured), using dangerous fishing gear, e.g. using electricity and toxins, which are capable of killing all fish both large and small sizes. The sustainability of fish resources stops by itself. In addition the impact of waste from industrial activities and oil palm factories have polluted rivers and also contributed to the destruction of fishery resources.

In catching fish, they use fishing rods or other traditional fishing traps. At the peak of the fish, between September-December, the average per month get money around Rp 5-7 million per month, while in the other months the income of farmers were about Rp 3-4 million/month. Prior to 1980, indigenous people lived by fishing and becoming fish suppliers to communities in Palembang and even to Java and only a few indigenous people were doing farming here. After the arrival of concessionaires and the activities of large private plantation companies, the peatlands were opened to agriculture and extensive plantations and activity of fishing is decreasing because total quantity of fish is also decreasing.

Fishermen besides to catch fish, they also often burn peatland especially in the dry season with the aim that the fish "can be directed to one direction" to then be netted. The long-term impact, however, is that the environmental condition is damaged, and the fish lose their habitat, and the population declines sharply. Fishermen realize that the act of burning to herd the fish is a very detrimental action to indigenous people. However, they said that such work was done by fish seekers (fishermen) from outside the peatland area. In addition to burning, the migrant fisherman did the electric shock and used the poisonous materials; so many small fishes were automatically killed. Some even hunted fish puppies (e.g. *toman* fish) to be sold to the market as seeds.

The indigenous fishermen did not carry out the burning method in catching fish, but they made temporary barriers in small tributaries in search of fish during the dry season. The barriers are not permanent because they are made from tree branches and mud. In order to prevent the invasions of outsiders who illegally planted plantations and agriculture by engaging in land-burning practices, the government made closure of canals connecting with the Komering River. This channel also connects several other channels that cause access to peatland more open to the public. The canal becomes the entrance of an outsider to this region. For example, those looking for large quantities of fish by burning peatlands, so that *embung* or puddles where fish gather can be found quickly and easily.

Land suitability of peatlands for agriculture

Land suitability is the level of suitability of peatlands for the use of certain crops. Land suitability is able to be assessed for current condition (present) or after improvement. Specifically the land suitability is evaluated from the physical properties of peatlands, consisting of climate, soil, topography, hydrology, and/or drainage according to the type of productive farming or commodity. Land suitability is different from land capability. Land capability is more emphasis on the capacity of various landuse in general which can be cultivated on peatlands. So the more types of plants can be developed or cultivated on peatlands, and then the land capability is higher. For example, peatlands with flat topography, deep rooting, are not affected by floods and the climate is quite wet. Land suitability is the suitability of a plot for a particular type of utilization, so it should consider the management aspect.

The easiest assessment of land suitability can be done in matching between land quality and land characteristics as parameters with land suitability criteria that have been prepared based on the requirements of growing plants or other commodities evaluated. The result of land suitability class of some agricultural commodities with matching method can be concluded in Table 5.

Rice farming

Land suitability for rice farming is included in the unit class of S_3nr3, fh_3, which means classified as S_3 class (marginally suitable). Land has a dominant limiting factor and will have an effect on its productivity and require a lot of additional input, while the dominant limiting factor is nutrient availability at level 3 (nr_3), which is very low and the danger of flood/inundation during planting and harvesting at level 3 (fh_3).

To overcome the limiting factor in S_3 requires high capital, so it needs a help to farmers to overcome them. If soil ameliorant is done, land suitability can be increased to S_2nr_2 unit class, fh1, it means that land suitability can be increased to S_2 class (quite suitable) with dominant limiting factor is nutrient availability at level 2 (nr_2), that is classified low total N and P_2O_5 content classified as moderate and flood hazard/puddle at harvest time at level 3 (fh1), that is puddle height 25-50 cm and long inundation < 7 days.

Rubber and oil palm

Rubber and oil palm land suitability has the same level, which belongs to the unit class of S_3rc_3, nr_3. It was classified as the unit class of S_3 (marginally suitable), which has dominant limiting factors, namely rooting medium indicated by inhibited drainage (rc) at level 3 (rc_3) and nutrient availability at the level 3 (nr_3) classified as very low. The limiting factors will affect its productivity and require a lot of input addition,

If soil ameliorant and drainage action are taken, the land suitability can be increased to the unit class of S_3rc_1, nr2 for rubber and S_3rc_1, nr_2 for oil palm. This means that the land suitability class remains unchanged (S_3 class classified as marginally suitable), but the limiting factor level can be reduced. The limiting factor is the rooting medium (rc) may fall at the level 1 (rc_1), i.e. the land has a somewhat inhibited drainage criteria and nutrient availability at the level 2 (nr_2), classified as low to moderate. If these limiting factors are

Table 5
Land suitability class of some agricultural commodities on peatlands

Nr	Activity	Land suitability	
		Actual (present)	Improvement (potential)
1	Rice Farming	S_3nr_3, fh_3	S_2nr_2, fh_1
2	Rubber	S_3rc_3, nr_3	S_3rc_1, nr_2
3	Oil palm	S_3rc_3, nr_3	S_3rc_1, nr_2
4	Forestry	S_1nr_3	S_1nr_1
5	Fishery	S_1xc_2	S_1xc_1

Note: S_1 (very suitable); S_3 (marginally suitable); nr_3 (nutrient availability at level 3); fh_3 (danger of flood/inundation during planting and harvesting at level 3); rc_3 (inhibited drainage at level 3); xc_2 (toxicity at the level 2)
Source: Field survey results (2017)

not removed and rubber and oil palm are still grown on peatlands, then the plant will fall or cannot support generative (productive) growth.

In viewed from the chemical properties of peatlands, rubber and oil palm can be cultivated on peatlands. Naturally peatlands are not recommended for the development of rubber and oil palm. Major issues in the development of rubber and oil palm on peatlands are mainly constrained by inhibited drainage, soil pH and weak rooting system which cannot support tree canopy. Groundwater levels are too high to inhibit the development of aeration and root respiration that greatly affect plant growth in general. Rubber has a taproot system, so it requires deeper solum, and oil palm has respiratory disturbance in root system, where oxygen supply is inhibited to root system by water inundation. Making drainage system to lower groundwater levels always requires a high cost. The making of terrace is often unsuccessful because stockpile of peatlands will come back down as the soil compaction process. Making the absolute trench (tertiary canals) is necessary to drain the water, so the surface water level decreases and avoids the flooded roots. If the roots are inundated more than three days/week, oil palms can be ascertained or even die especially on young plants.

Soil acidity is also a main constraint in the cultivation of rubber and oil palm. Peatlands are usually acidic or very acid, so growth of rubber and oil palm is hampered or more severe into toxicity. Giving lime is usually a solution to increase the pH, but it is considered too costly because the soil pH is very acid and some liming materials will be removed by water movement. In addition, the rubber and oil palm is less resistant to very acid condition because usually in the assembly of some clones are tested in mineral soil. In the case of clonal selection, the suggestions of clones are relatively suitable for land with high water level (50-100 cm from the surface) or peatlands are often inundated during wet season, among others clones of BPM1; BPM24; PB217; PB340; IRR104; IRR 112 and IRR5.

The very important constraint is the ability of peatlands to support the canopy, this problem is often the main constraint to the oil palm in the peatlands causing the plant to grow inclined or even to fall to the ground and of course the production will decrease drastically because the plant cannot be harvested. In principle peatlands can be only utilized for the development of rubber plant and oil palm absolutely require some treatment, namely making drainage system to lower the groundwater surface and prevent the root from water inundation; to increase soil pH to 5.5-6.4, so that plant growth can be optimal; and to use superior clones that are relatively resistant acid to very acid condition of peatlands.

Forestry

Land suitability for forestry belongs to the unit class of S_1nr_3, meaning that the peatlands belong to S_1 class (very suitable). The low limiting factor for forestry will not affect the productivity and does not require much additional input, while the low limiting factor is the nutrient availability at the level 3 (nr_3), classified as very low. However, forestry commodities usually lack human touch; usually giving inputs will not increase peatlands productivity for forestry.

Fishery

Fishery is meant here if farmers make pond to cultivate fish, but most of fishery effort at research area is catching fish by fishing and other traditional ways. This way of fishing does not lead to the level of land suitability. However, land suitability for fish ponds belongs to the unit class of S_1xc_2, meaning that peatlands are classified as the S_1 class (very suitable). The low limiting factor possessed will not have an effect on its productivity and does not require much additional input, whereas the moderate limiting factor is the level of toxicity at the level 2 (xc_2), this toxicity is the soil acidity and salinity usually the input will not increase productivity of peatlands for fish pond because fish ponds are not affected by tidal sea water.

Conclusion

Based on the results and discussion of this research, it can be made various conclusions as follows:

- Generally the peatland land suitability level for all agricultural activities is classified as marginally suitable (S_3), while for the less human-touching agricultural commodities (fishery and forestry) can be mentioned as highly suitable (S_1). Improving peatland suitability level can be done with a lot of ameliorant materials and high cost.
- Challenging constraints of livelihoods for farmers can be grouped into constraints in agronomic, technological and management, socio-economic and peatland limiting factors for plant growth (especially inundation, inadequate rooting systems, and low nutrient availability).
- It is needed Government intervention to overcome the constraints because they are global, comprehensive, integrated, holistic and beyond the ability of farmers to manage them.

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