Analysis of monthly rainfall to study planting time of paddy in swamp area

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Abstract. Rainfall is one of the climate factors that strongly affect swampland paddy cultivation regarding its water conditions in the rainy season. The research aimed to identify the paddy planting time in freshwater and tidal swampland based on monthly rainfall. Rainfall data were obtained from Climate Hazards Center Infrared Precipitation with Stations data (CHIRPS) for 20 years (2000 to 2019). Planting area and planting time data were collected from field surveys through interviews with local farmers and agricultural extension agents. This study has conducted a descriptive analysis of harvest area data and annual rainfall rate. The Result showed paddy cultivation in freshwater affected by land typology and monthly rainfall. Planting time of paddy in shallow swamp begin in March or April. In the medium swamp area, planting time starts in June. While planting time in the deep swamp starts in August. In the tidal swamp, paddy cultivation for type C was more affected by rainfall. Local farmers in freshwater swamp plant paddy once a year, while in the tidal swamp, farmer can cultivate crop twice a year, namely paddy and corn.

1. Introduction
Transition in agricultural landuse for non-agricultural and non-food purposes has decreased productive agricultural land in the agricultural sector [1]. This transition also particularly impacts rice production, where paddy fields are no longer fully reliable for growing rice. Another alternative to still producing rice is to take advantage of existing swamps [2].

Swamps are divided into two types, namely tidal swamps and non-tidal swamps. Based on data from Ritung et al. [3], the area of swamplands in Indonesia is around 34,125,189 ha, which spread across Sumatra, Java, Kalimantan, Sulawesi, Maluku and Papua. In South Sumatra, the total swamps area is 3,358,604 ha, consisting of 855,359 ha of tidal swamps and 2,503,245 ha of non-tidal swamps [3]. This large area of swampland has the potential to be developed and utilized in the agricultural sector, so that the goal of making swamplands a national food barn can be realized [4].

One of the factors affecting swamp farming is climate, where climate change will cause changes in rainfall patterns. According to Wakhid et al. [5], changes in rainfall patterns will affect the tidal movement of sea and river, which will affect agriculture in tidal swamps. Whereas in freshwater swamps, changes in rainfall patterns will affect the intensity of the erratic period of drought (El Nino) or wetness (La Nina) [6].
The impact of this climate change is the occurrence of shifts in the beginning and end of the planting season. It has a negative effect on cropping patterns and crop productivity [6], so it is necessary to identify the right planting time in tidal and non-tidal swamps to increase productivity. The purpose of this paper is to analyse the planting time of rice in tidal and freshwater swamps based on rainfall, so that it can be an alternative for rice cultivation in South Sumatra.

2. Materials and methods
This research was conducted by using two types of data, which were primary and secondary data. The primary data included planting area and planting time data as result of interviews with 30 agricultural extension agents and farmers. The interview was done with purposive sampling method from June till September 2019 in freshwater swamp area of SP Padang Subdistrict, Ogan Komering Ilir Regency and tidal swamp area of Muara Sugihan Subdistrict, Banyuasin Regency. Both places are located in South Sumatra, Indonesia. Major questions in the interviews were about planting time, plant rotation, and main problem of agriculture in tidal swamp and freshwater swamp. Meanwhile, the secondary data included rainfall data from Climate Hazard Center Infrared Precipitation with Stations Data (CHIRPS) for 20 years (2000-2019) and annual harvest area numbers from 2004 till 2019, which are obtained from BPS of Ogan Komering Ilir Regency and Banyuasin Regency. Those data are analysed descriptively by correlating harvest area data and annual rainfall rate.

3. Results and discussion

3.1 Land characteristics
Muara Sugihan and SP Padang are the subdistricts located in South Sumatera Province. Muara Sugihan is located in Banyuasin Regency which consists of 22 administrative villages with 66,141 ha areas. Muara Sugihan is bordered by the sea in the north (Bangka Bay) and surrounded by Salek River and Sugihan River in the west and east. Therefore, most of Muara Sugihan region are located in tidal swamps. The rice fields in Muara Sugihan are located in 3 types of tidal swamp that are A, B and C, which reached 26,923 ha in 2016 [7]. Type A is tidal swamp area that is always affected by sea tides. Type B is tidal swamp area which is affected only during the single-season tides (spring tides). Type C is tidal swamp area that is indirectly affected by tides of water infiltration through soil whose groundwater level is less than 50 cm from land surface [8].

![Figure 1. Map of study area in Muara Sugihan and SP Padang.](image)

SP Padang Subdistrict is located in Ogan Komering Ilir Regency whose 40% area is a river basin and 60% area is lowland [9]. According to BPS [10], SP Padang has 11,155 ha rice fields, where all
are located in freshwater swamps. The rice fields spread over shallow, medium and deep swamps. The type of freshwater swamp is based on length and height of inundation. Shallow swamp is a swampland which is inundated less than 50 cm for 1 to 3 months. Medium swamp is a swampland which is inundated 50 to 100 cm for 3 to 6 months. Meanwhile, deep swamp is a swampland which is inundated higher than 100 cm and duration of inundation less than 6 months [8].

![Figure 2](image-url)

**Figure 2.** Average monthly rainfall rate from 2000 to 2019 based on CHIRPS data: (a) Muara Sugihan and (b) SP Padang.

One of the factors that influence the height and duration of inundation in swamp area is rainfall. Based on average monthly rainfall for 20 years, SP Padang and Muara Sugihan have an equatorial rain pattern with rainfall amount 2,800 mm year\(^{-1}\) (Muara Sugihan) and 2,700 mm year\(^{-1}\) (SP Padang). Equatorial type has two peaks of rain in a year, in November to December and March to April (figure 2). Those two peaks are associated with ITCZ (Inter-Tropical Convergence Zone’s Southward and Northward Movement) [11]. While the transitional periods between two seasons are April to May and October to November.

3.2 Rainfall analysis

The average monthly rainfall data from 2000 to 2019 based on CHIRPS data [12], showed that the dry season in Muara Sugihan and SP Padang starts from May to October, while the rainy season happens from November to April. Rainfall characteristics can be related to rice planting patterns in each sub-district. In tidal swamp, the dynamics of inundation height and water quality in rice fields are influenced by sea tides, regional rainfall, and rainfall from upstream areas. Meanwhile, freshwater swamp is more influenced by regional rainfall because it’s generally located in the basin area [8].

![Figure 3](image-url)

**Figure 3.** Monthly Rainfall in El Nino Southern Oscillation (ENSO) year (2010, 2015, 2016, 2019) based on CHIRPS: (a) Muara Sugihan and (b) SP Padang.
Rainfall conditions in Indonesia are influenced by several global climate phenomena. One of the phenomenon is El Nino Southern Oscillation (ENSO), that consist of three phases: El Nino, La Nina, and Normal [13]. El Nino phase often causes drought in Indonesia due to lower rainfall and longer dry season than normal conditions. Strong and weak El Nino in 2015 and 2019, causes drought in several regions in Indonesia [14]. An example of this impact can be seen in figure 3, when in 2015 and 2019, monthly rainfall on SP Padang and Muara Sugihan was lower than the average, decreased more than 500 mm year\(^{-1}\) (SP Padang) and 400 mm year\(^{-1}\) (Muara Sugihan). The dry season, which usually ranges from May to October, has shifted to a longer one until December. If a longer dry season usually causes drought on other agricultural land types, but in freshwater swamp area, that condition will increase the potential rice planting [15]. In 2015, the potential rice planting in Indonesia increased by 237,700 ha from the previous year. One of the provinces which its potential planting area increased is South Sumatra. While in tidal swamp, El Nino phase can also cause drought so that acid sulfate soils often cause pyrite poisoning [4].

On the other hand, the La Nina phase can be a threat to swampland. La Nina can increase rainfall, thus cause Indonesia to be wetter [16]. Examples of the La Nina phase in Indonesia occurred in 2010 and 2016 [17]. Figure 3 shows that in 2010, rainfall on Muara Sugihan and SP Padang has increased more than 100 mm per month during the dry season (May – November). Rainfall increase also occurred in La Nina 2016, from July to November in these sub-districts.

Annual rainfall and harvest area number were presented in figure 4. There is an increase in harvest area number every year from 2008 to 2017 in Muara Sugihan subdistrict. The highest harvest area number occurred in 2016. According to sea surface temperature analysis by BMKG, there was La Nina phenomenon in 2016 which increased rainfall rate that caused significant increase in harvest area in 2016. Referring to data showed in figure 4, the paddy harvest area in Muara Sugihan Sub-district was influenced by rainfall. The higher the rainfall, the higher the harvest area and rice production will be. Rainfall affected mostly at tidal swamp type C. In normal time when La Nina is not present, during dry season the tidal swamp area type C can not be planted because of water shortage. But when La Nina happened, those areas could be cultivated although cropping pattern is shifted, so that the harvest area increased [4].

Opposite from tidal swamp, the harvest area in SP Padang Subdistrict decrease when rainfall is high. That is proved by La Nina phenomenon which occurred in 2010 that caused significant rainfall increase and harvest area decrease. The high amount of rainfall caused land inundation for a long time, so that farmers could not plant paddy. Increased rainfall also occurred when La Nina happened in 2016, from July to November in these sub-districts. When La Nina happened, the part of rice field in freshwater swamps that could be planted decreased because the inundation area was wider that often caused flood [4]. The decrease in planting area was found in shallow and moderate freshwater swamp [18]. El Nino phenomenon in 2015 caused a significant decrease in rainfall. This condition did not increase the harvested area because even though the land was not inundated, the need for water to
plant rice was not fulfilled, especially in shallow swamps. On the other hand, in this condition, deep swamps could be planted.

### 3.3 Planting time of paddy in swamp water

Planting time of paddy in fresh water swampland is influenced by monthly rainfall. SP Padang subdistrict is one region in South Sumatra Province whose all of agricultural areas are swampy. There are three fresh water swampland types, namely shallow swamp, medium swamp, and deep swamp. The differences of those swamplands are planting times of paddy, as shown in figure 5. Shallow swamp was planted early than other typologies of swampland. In shallow swamp, farmers start planting of paddy in March or April, and seedbed is done by February. In those months (March-April), monthly rainfall became lower than January and February. Otherwise, water in medium and deep swamps had not receded because the topography of medium and deep swamps was more concave than shallow swamp. Based on rainfall analysis, paddy is planting from April in the shallow swamp, a month delay from the farmers is usually carried out.

| Time       | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Shallow    |     |     |     | 1st planting time (rice) | 1st planting time (rice) |     |     |     |     |     |     |     |
| Medium     |     |     |     | 1st planting time (rice) | 1st planting time (rice) |     |     |     |     |     |     |     |
| Deep       |     |     |     | 1st planting time (rice) | 1st planting time (rice) |     |     |     |     |     |     |     |
| Tidal Swamp|     |     | 2nd planting time (rice) | 2nd planting time (comparable land) | 1st planting time (rice) |     |     |     |     |     |     |     |

**Figure 5.** Planting time in freshwater swamp (SP Padang) and tidal swamp (Muara Sugihan) based on interviews.

According to Irmawati et al. [19] research, planting season for shallow swamp in South Sumatra was started when water level in the field receded. Farmers are start planting paddy in June or July in the medium swamp, in line with planting time based on rainfall analysis. In those months, the dry season began and monthly rainfall became low. In the deep swamp, planting time of paddy based on rainfall analysis is on August, this is appropriate to planting time that is usually applied by farmers. However, deep swamp could not be planted every year. Based on interview, it has been two years since last time the deep swamp was planted and can only be planted this year (2019). This planting time can change every year due to unpredictable weather. Sometimes, the seeds which are planted by farmers are too old because they did not plant quickly because the water has not receded. Irreversible water is the main problem in freshwater swamp, because it cannot be measured that farmers sometimes experience crop failure because drought in dry season or flood in rainy season [20]. Infrastructure in freshwater swamp in the study area is still less developed, causing water volume cannot be regulated. Therefore, in freshwater swamp rice fields is more like rain-fed, especially in shallow swamp. Paddy crop condition in shallow swamp in June is presented in figure 6 (a). Meanwhile, in medium swamp, rice would be planted in June (b). In that month, water in the land had started to recede. In deep swamp, water in the land in July was still high so that farmers could not plant paddy.
On other hand, Muara Sugihan Subdistrict is tidal swamp area located in South Sumatra. There are four types of tidal swamp. Types are A, B, C and D [21]. Muara Sugihan consists three types of tidal swamp from type A to C. Every condition affects farmers’ habit in paddy cultivation. Criteria to determine planting time in tidal swamp based on rainfall analysis is the amount of rainfall. Planting time in tidal swamp with type A and B can be started when the amount of rainfall occurs 50 mm 10-days\(^{-1}\) in 2 times consecutively. For tidal swamp type C, planting time can begin when rainfall amounts occur 50 mm10-days\(^{-1}\) three times consecutively [22]. Therefore, initial planting time based on monthly rainfall analysis in Muara Sugihan starts in September or October when monthly rainfall amount more than 100 mm month\(^{-1}\) (figure 2). That is similar to the interviews describing that the main time for paddy cultivation started in September or October, depending on rainfall and type of tidal swamp area. According to farmer experience, in some places, if paddy is planted before October when the rain usually still did not fall, there would be a decrease in yield that reaches almost 50%.

That condition occurred at the harvest time in December was overlap with rat pest outbreak. On top of that, direct plant technique as their indigenous way to plant couldn’t be done if the soil is still too dry. Also, dry soil condition could decrease effectivity of pre-growth herbicide that is mainly used.

Some areas of Muara Sugihan Subdistrict could plant paddy for the second time, which started in February. But at that time, the yield is still not as good as at the main planting time. That condition could be happened in area that close to the river (type A). Meanwhile, farmers who live in the middle part of subdistrict prefer to plant corn as their second crop. They started to plant in June (figure 5).

Majority of farmers in Muara Sugihan Subdistrict plant paddy at the beginning of the rainy season that usually happen in September or October. This is related to water sufficiency level as the main growth requirement for paddy. The ecosystem of the rice field will be performed as soon as the rain falls. The data shown in figure 5 illustrated that condition and explained the correlation between monthly rainfall and planting time. The rainy season starts in October (figure 2). The farmers would not plant crops as soon as the first rainfall because they have to wait the occurrence of the pyrite as the side effect of tidal land tillage is leached. The presence of pyrite in the rice field will threaten the life of the plant as it is toxic. After that, the presence of the rainwater in rice field will keep the pyrite still. It is supported by Irmawati et al. [19] which informed that salinity intrusion in Banyuasin District tidal swamp area during dry season (especially from July until September) would be naturally overcome when rainy season started. Soil water acidity would be another problem during rainy season where pH will be around 4 [19].

Water management is the main key for plant cultivation in tidal swamp area [23]. As explained in the previous part, all channels, including prime channel, secondary channel, tertiary channel, village irrigation channel and public drainage channel have to function well to guarantee the good plant growth and development. But almost all villages in Muara Sugihan Subdistrict faced the same big problem: the silting of the public drainage channel. The silting made the water drainage system failed and caused flood, especially in the rainy season. Normalization is a way to restore the function. When
the water system works well, there will be an increase in annual planting and harvest area with the support of good cultivation technology.

Figure 7. Canal conditions in Muara Sugihan: (a) Primary canal (b) secondary canal (c) tersier canal (d) drainage canal.

4. Conclusions
Muara Sugihan and SP Padang have equatorial rainfall pattern with the two peaks rainfall in March and December. Rainfall condition in those subdistricts is affected by El Nino and La Nina. When El Nino happened, rainfall decreased so that the land became drier. Meanwhile, when La Nina happened, the rainfall increased and caused flood. La Nina phenomenon could increase harvest area in tidal swamp and could decrease harvest area in freshwater swamp. Strong El Nino phenomenon could reduce harvest area in tidal swamp, especially in C type which are affected by rainfall. El Nino phenomenon could not significantly increase harvest area in freshwater swamp. Planting time in shallow swamp started from the end of the rainy season (March or April), in medium swamp started from early dry season (June), and in deep swamp started from peak dry season (August). Planting time in all types of tidal swamp is almost the same, in the early rainy season (September or October).

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