Land characteristics and management for the development of Geragai Agro Techno Park Jambi Province

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Abstract. Geragai Agro Techno Park (ATP), Jambi Province is a pilot area to accelerate agricultural technology transfer. The ATP pilot area is built in a swampland agro-ecosystem which requires optimal land management. The purposes of this study were to identify soil chemical properties at ATP, to build partitioned canals based on hydro-topography and land characteristics, and to contribute to land management at ATP. This study was carried out using a direct survey by observing field conditions, taking and analysing soil samples, interviewing farmers, and conducting a literature study in January - December 2016. Based on the results, the soil fertility rate at ATP was in the low to the moderate category with 80 to 120 cm pyrite layer depth. Based on soil survey, hydro-topographic survey, and land characteristics, it is recommended to build partitioned canals on these lands to prevent pyrite oxidation and maintain water availability during the rainy and dry seasons. With the partitioned canal, Geragai Agro Techno Park can increase the cropping index to 300 with the rice-secondary crop-secondary crop pattern adjusted to farmer preferences.

1. Introduction
Swampland is one of the potential areas for the development and expansion of crop cultivation, both for food crops, horticulture, and perennial crops. Swampland is divided into 2 (two) typologies, namely tidal swamp and freshwater swamp [1]. In Indonesia, swampland spreads across four major islands, namely Sumatra, Kalimantan, Sulawesi, and Papua, reaching 33.4 million ha, of which 20.1 million ha of tidal swamp and 13.3 million ha of freshwater swamp [2]. In general, Swampland has low fertility and productivity, so inputs are needed for agricultural development technology such as acid-tolerant, inundation-tolerant, high-salinity-tolerant varieties. In addition, canals and water management are also needed [3]. Non-tidal swampland is located on the river and creek side with flat topography, waterlogged in the rainy season, and drought in the dry season. The utilization of non-tidal swampland has problems because it can only be used in inundated water conditions up to a height of approximately 30 cm [4]. The utilization of swampland must be carefully planned and designed with the principle of long-term land use.

Water management is one of the determinants of agricultural development in swampland to optimize the use and preservation of land resources [5]. Water management aims to maintain water availability in the dry season, reduce soil acidity, prevent soil acidification due to pyrite oxidation, prevent salinity, prevent flooding, and leaching toxic compounds accumulated in the root zone of plants [6]. The groundwater level control strategy is directed at maintaining the groundwater level so that it is always...
above the pyrite layer. Water management also aims to smooth the flow for compound leaching and cropping pattern management [7].

The utilization of swampland requires reclamation (canal investigation survey) to be cultivated. The reclamation design or macro water system can be an “Anjir” system, a fork system, and a comb system or a combination of these systems. Land clearing or reclamation directly or indirectly changes the natural swampland ecosystem into a very complex artificial ecosystem with a fairly high dynamic. In this change, swampland reclamation can accelerate the formation of wetlands with new ecosystems that provide positive things, but sometimes negative things occur such as decomposition, subsidence, drought, loss of topsoil, pyrite layer on the land surface, and low crop productivity [8].

One of the non-tidal swampland developments that support national food security is the Geragai Agro Techno Park in Jambi Province. Agro Techno Park (ATP) is a government program in the form of a pilot area to accelerate agricultural technology transfer to be applied by farmers. ATP functions as a center for the application of agricultural technology as well as training, apprenticeship, technology dissemination, and business advocacy center for the wider community. This program is expected to be a trigger and impetus for farmers to increase agricultural productivity and management of agricultural businesses [9]. ATP as an independent Center for Technology and Information Development for Community Empowerment and a pilot area for implementing agricultural technology innovation requires improvement of facilities and infrastructure, proper and complete implementation of technology innovation, as well as improvement of the farmer and institutional capacity. Therefore, it is necessary to characterize land and improve infrastructure to optimize land management, so that agricultural cultivation activities in ATP can be sustainable.

The purposes of this study were to identified and informed soil chemical properties at ATP, to build partitioned canals based on hydro-topography and land characteristics, and to contribute to land management at ATP.

2. Materials and methods

2.1. Study area
This study was carried out in Agro Techno Park (ATP) in Lagan Ulu, Village, Geragai Sub-District, East Tanjung Jabung Regency, Jambi Province with an area of 7 ha in January until August 2016. The soil analysis was carried out at Soil Laboratory, Indonesian Agricultural Environment Research Institute, Pati, Central Java.

2.2. Tools and material
The tools and materials used for this study are soil auger, hoe, excavator, Munsell Soil Colour Chart, peroxide acid, roll meter and rope.

2.3. Methods
This study was carried out using a direct survey by observing field conditions, taking and analysing soil samples, interviewing farmers, and conducting a literature study. The stages of this study were:

2.3.1. Land Characteristics Survey. Canal construction in the Swampland, topographical conditions and land characteristics should come in mind to be the first consideration. The soil survey was conducted to determine the method and technique of canal construction. Soil samples were taken in three different points, namely, one sample of mineral soil and two samples of peat soil due to significant differences based on peat depth. One kg of soil was sampled each in 7 ha land unit. Then, soil samples were analyzed to determine chemical properties such as pH, ash, organic carbon, total nitrogen, potential phosphorous, potential potassium, available phosphorous, exchangeable base, exchangeable acidy, cation exchange capacity, total iron, total manganese, and total aluminum. In the field, soil observation was carried out using height difference observation, soil auger, and actual condition observation. 30% peroxide solution (H$_2$O$_2$) was dropped to determine the presence of pyrite in the soil. The presence of pyrite is characterized by effervescence. The more bubbles, the higher the pyrite content is.
2.3.2. Water flow design and canal partition measurement. Water flow direction was determined after knowing the type and characteristics of the soil, especially the pyrite layer depth and slope. Canal construction planning was preceded by drawing a schematic of water flow direction on the paper then followed by measuring the points of the partitioned canals based on differences in land slope or land height (elevation). The distance between the partitions at the site was 100 m.

2.3.3. Canal construction. Partitioned canal is a technology to regulate water availability in the rainy season and maintain the water level during the dry season. The partitioned canal is made on the subsidiary drain with a 2% slope. The canal height is 10 cm below the ground with a distance of 100 m. The width of the canal door is adjusted to the trench width. The canal has a partition with a thickness of 1 (one) meter. The edge of the partition is covered with wooden planks while the middle part is filled with soil. The canal partitions were constructed around the ATP with a width of 1 to 2 m. The soil in the canal partition was elevated from the excavated soil with an excavator. To prevent the pyrite layer, the canal was constructed 1 meter deep. At the end of the canal, the canal partition was constructed higher than the partition at a distance of 100 m. This partition functions as a wooden sluice.

3. Results and discussion

3.1. Land characteristics of Geragai Agro Technology Park

Based on height and period of inundation due to rainfall or flooding, the land is included in the lowland swamp. This is based on observations and interviews that the inundation height was less than 50 cm with an inundation period of less than 3 months. Lowland swamp generally has a cropping index of 100 or only planted once a year, to be precise, at the beginning of the dry season depending on the height of the inundation. At the location, farmers use the rice cropping pattern. In order to develop agriculture in Geragai Agro Techno Park, it is necessary to increase the cropping index, so that it can become a model and become a source of income for farmers. One of the efforts to increase the cropping index is to build a partitioned canal.

The soil chemical properties obtained can be seen in table 1. Based on several soil chemical properties such as organic C, total N, available P, exchangeable base, and cation exchange capacity, mineral soil had moderate to high soil fertility rate, whereas peat soil (2 samples) had low to moderate soil fertility rate. Both soils had a high acidity level due to high exchangeable H. In general, total N was moderate to high level, P was low to moderate level, K was moderate level. Based on interviews, every year, the land was covered by silt. Therefore, even though the land had a moderate soil fertility rate, the soil had very high variance, so that there were differences in organic matter content, Cation Exchange Capacity, base saturation, and nutrient availability. This is in line with a statement by Noor [10] and Noor [11].

The land is slightly flat with a slope of 2.5%. Based on the land characteristics, soil types, and soil horizon characteristics, mineral soil for secondary crop and rubber was classified into Gley humic and peat soil for rice with wet and slightly domed conditions was classified into Sapric Haplohemists (table 2). The soil horizon characteristics can be seen in table 3.

Shallow swamps and mineral soils from marine sediment usually have a pyrite layer (FeS2) which is harmful to plants and toxic when found on the soil surface. Based on the survey, the pyrite layer is at a depth of 80 to 120 cm. If the soil with sulfuric acid or pyrite is located below the soil surface in a submerged water condition, the presence of pyrite will not harm the plants. This condition is called a potential acid sulphate soil. If there is excessive water, the surface of the groundwater cannot be avoided, so that pyrite is exposed to the air and oxidizes in the dry season, so that the potential acid sulphate soil changes to actual acid sulphate soil. This soil has a low pH and high toxicity with Fe²⁺ and Al³⁺. According to Sutandi et al. [12] pyrite oxidation produces sulfuric acid and jarosite with an acidity that can interfere with plant growth. Therefore, Alihamsyah [13] stated that reclamation and land management must be done carefully so that plants can grow and produce.
### Table 1. Characteristics of Geragai Agro Techno Park, Jambi Province, 2016.

| No  | Characteristics                                      | Samples          | Mineral Soils | Peat Soil | Peat Soil |
|-----|------------------------------------------------------|------------------|---------------|-----------|-----------|
| 1.  | pH                                                   |                  | 3.5           | 3.5       | 2.8       |
| 2.  | Ash (%)                                              |                  | 86.85         | 48.01     | 63.61     |
| 3.  | Organic C (%)                                        |                  | 2.66          | 19.54     | 13.19     |
| 4.  | Total N (%)                                          |                  | 0.16          | 0.24      | 0.28      |
| 5.  | Potential P (mg 100 g⁻¹)                             |                  | 13.90         | 16.80     | 9.90      |
| 6.  | Available P (ppm)                                    |                  | 43.42         | 12.29     | 4.84      |
| 7.  | Potential K (mg 100 g⁻¹)                             |                  | 198.00        | 122.45    | 201.30    |
| 8.  | Exch-K ( cmol (+) kg⁻¹)                              |                  | 0.51          | 0.75      | 0.28      |
| 9.  | Exch- Ca                                             |                  | 4.41          | 6.79      | 10.81     |
| 10. | Exch-Na (cmol (+) kg⁻¹)                              |                  | 3.41          | 2.17      | 2.65      |
| 11. | Exch-Mg (cmol (+) kg⁻¹)                              |                  | 1.06          | 4.29      | 10.48     |
| 12. | Exch-Al (cmol (+) kg⁻¹)                              |                  | 0.45          | 0.00      | 0.00      |
| 13. | Exch-H ( cmol (+) kg⁻¹)                              |                  | 1.08          | 3.60      | 5.08      |
| 14. | Total Fe (%)                                         |                  | 0.38          | 0.19      | 0.12      |
| 15. | Total Mn (ppm)                                       |                  | 19.70         | 12.48     | 8.20      |
| 16. | Total Al (%)                                         |                  | 1.60          | 1.47      | 0.47      |
| 17. | Cation Exchange Capacity                             |                  | 7.60          | 45.11     | 31.59     |
| 18. | Previous condition                                   |                  | Rubber plantation | Rice field | Rice field |
| 19. | Water condition                                      |                  | Dry moist     | Inundated | Inundated |
| 20. | Topography                                           |                  | Slightly flat | Basin     | Basin     |
| 21. | Land Map Unit                                        |                  | Typic Sulfaquepts | Typic Endoaquepts | Typic Endoaquepts |
| 22. | Pyrite layer depth (cm)                              |                  | 80            | 100       | 120       |

### Table 2. Soil classification at Geragai Agro Techno Park, Jambi Province, 2016.

| Number of Land Unit | Classification Soil Taxonomy | Landform       | Shape Region (Slope%) | Parent material | Drainage / Permeability | Groundwater Depth | Land Use | Code Mapper / Location | Position UTM (48m) |
|---------------------|------------------------------|----------------|-----------------------|-----------------|-------------------------|-------------------|----------|------------------------|--------------------|
| 1                   | Sapric Haplohemists          | Freshwater peat dome topogen | Rather flat (2%) | Organic deposit | Poor/ Slow              | Shallow (5 cm)    | Paddy    | SP 11 / Grg Tanjabtim | S116.383-E103.44335 |
| 2                   | Typic Humaquepts             |                 |                       |                 | Poor/ Slow              | Shallow (10 cm)   | Crops    | SP 11 / Grg Tanjabtim | S116.246-E103.44299 |

### Table 3. Characteristics of soil horizons based on field.

| Horizon Symbol | Descriptions                                                                                           |
|----------------|--------------------------------------------------------------------------------------------------------|
| Sapric Haplohemists | 0-10 cm black (10Y2/1); sapric; pH 5.15                                                                    |
| Oa               | 11-175 cm dark brown (10YR 3/3); sapric; pH 5.15                                                        |
| Oa1              | 176 - unlimited cm grey (10YR 5/1); clay; plastic sticky (wet conditions); pH 5.65                      |
| Typic Humaquepts | 0-5 cm black 10Y2/1, clay; pH 4.93                                                                       |
| Oa               | 6 – 50 cm grey (10YR 5/1; clay; pH 4.93; plastic sticky (wet)                                            |
The above soil chemical properties become the basis for recommended for fertilization and cropping patterns, as well as partitioned canal design based on pyrite layer depth so that it is not exposed to the land surface.

3.2. **Partitioned canal design in Geragai Agro Techno Park**

Planning based on hydro topographic conditions and flood type is required for the development, utilization, and management of land in Geragai Agro Techno Park. Water management is not only needed to reduce or increase the availability of surface water, but also to reduce soil acidity, to prevent soil contamination due to pyrite oxidation, prevent salinity, flooding, and leaching of toxic compounds that accumulate in the root zone [6]. Control of groundwater level is directed to keep groundwater above the pyrite layer and leaching the soil through a controlled canal system. The desired water level conditions depend on the crop, soil type, and hydrological conditions of the local area [14].

Partitioned canals can support the development of a rice-secondary crop pattern in the shallow swamp to increase cropping index and land productivity. Based on land characteristics, canal construction with partition is carried out to maintain water availability, so that it can be used for agricultural crops throughout the season according to water availability. The canal uses a modification of the canal partition [15, 16] by making a pattern and then excavating the canal with an excavator. Partition construction is based on a slope at a distance of about 100 m for each partition. The canal partitions can be seen in figure 1 and figure 2. This partitioned canal serves to maintain water availability both in the rainy and dry seasons. The canal width is 100 to 120 cm with a depth of 60 to 120 cm to prevent pyrite oxidation.

![Partitioned canal design](image_url)

**Figure 1.** Partitioned canal design.
3.3. Land management recommendation

Water management through the construction of partitioned canals must be supported by optimization of land management to achieve productivity target. The recommended optimization of land management is the application of cropping patterns and fertilization. Cropping pattern is an arrangement of land use with plants in a certain period of time. Syaharuddin [17] mentioned that the cropping pattern requires several data, namely hydrology (rainfall data), climatological data (temperature data, air humidity data, wind speed data, light exposure time), and commodities (crop coefficient value and productivity level). Cropping pattern planning must be performed so that plants will avoid drought or flooding resulting in crop failure.

Geragai Sub-district, East Tanjung Jabung Regency is located in the B Agroclimatic zone based on the amount of rainfall per month with 8 wet months (months with rainfall > 200 mm) and 2 dry months (months with rainfall <100 mm) [18]. Based on rainfall characteristics and partitioned canal construction, the Geragai Agro Techno Park can achieve IP 300 or 3-time planting a year. With the partitioned canal, the water can be arranged with a partition so that it does not overflow during the rainy season and remains available in the dry season. In dry season conditions, the partitions can be opened, so that water flows into the land. Based on this and interviewing farmers, the cropping pattern recommended at Geragai Agro Techno Park is rice-secondary crop-secondary crop.

Table 4. Recommendations for fertilization of rice and soybean based on soil analysis.

| Ameliorant     | Rice (kg ha\(^{-1}\)) | Soybean (kg ha\(^{-1}\)) |
|----------------|-----------------------|--------------------------|
| Lime           | 500                   | 750                      |
| N (Urea)       | 150                   | 50                       |
| P (SP-36)      | 100                   | 75                       |
| K (KCl)        | 75                    | 75                       |
| Organic matter | 1,000                 | 1,000                    |
Based on the results of soil analysis and fertilization calculations, the recommended fertilization dose at Geragai Agro Techno Park can be seen in table 4 for fertilization efficiency and optimal plant productivity.

4. Conclusions
The land in Geragai Agro Techno Park consists of two types of soil, namely Sapric Haplohemists and Typic Humaquepts, with low to moderate soil fertility rate, moderate to high organic matter content, and 80 to 120 cm pyrite layer depth. Based on soil survey, hydro-topographic survey, and land characteristics, it is recommended to build partitioned canals on these lands to prevent pyrite oxidation and maintain water availability during the rainy and dry seasons. Because of partitioned canal, Geragai Agro Techno Park can increase the cropping index up to 300 with the rice-secondary crop-secondary crop pattern adjusted to farmer preferences.

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