FINAL REPORT - 2024

ENHANCEMENT OF COMMUNITY-LED MANAGEMENT SYSTEM FOR THE SUSTAINABLE RESTORATION IN PERIGI SITE

Center of Excellence Peatland Conservation and
Productivity Improvement (CoE PLACE)
Universitas Sriwijaya

Palembang, December 2024

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Foreword

One of the nations with the largest peatlands in the world is Indonesia. The Indonesian government has committed to protecting and restoring peatlands in a number of significant ways. Growing biomass on wet peatlands, or paludiculture, may be a good solution for restoration. In addition to creating goods like food, fiber, bioenergy, and other Non-Timber Forest Products (NTFPs), the agroforestry technology helps to create peat, which increases the carbon stock.

Low-impact agricultural methods are already being used on shallow peatlands. A robust and sustainable peatland usage model can be created by honoring this kind of traditional knowledge in conjunction with modern paludiculture system technologies. To determine whether these technologies are practical for preventing peat soil degradation and whether they assist communities socioeconomically, more research must be done.

Unsri and NIFoS have begun initiating collaborative activities related to peatlands restoration. Both parties have been carrying out an action research on restoration of degraded peatlands using climate smart agrosilvofishery approach and the activities carried out gradually have shown positive impact. Based on the MoU signed by both parties on June 21st 2023, UNSRI and NIFoS agree and acknowledge the collaboration in the programs such as collaborative research project, Joint scientific conferences, seminars, and workshops, exchange of research publications and information, exchange of research personnel, and other programs of mutual interest. This MoU was then followed by a Research Agreement in 2024 with the title "*Enhancement of a community-led management system for the sustainable restoration in Perigi site ", through* research activities, namely: Effect of water level and duration on the growth of forest tree species on peat soil, The impact of climate anomalies on the dynamic of hydro climatological parameters in peat land in South Sumatra, and Developing Model for Soil and Water Management in Lowland Agriculture under various soil and hydro climatic condition. This Final Report is prepared as a report on the collaborative activities that have been done this year and also some researches proposed to be carried out in 2025.

Palembang, December 2024

Prof. Dr. Rujito Agus Suwignyo
Director of CoE Place

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I. INTRODUCTION

Peatlands are terrestrial wetland environments where plant matter cannot completely decompose due to the presence of water. As a result, there is a net buildup of peat because the generation of organic matter outpaces its breakdown. Peatland ecosystems are typically found between two huge rivers, allowing spilling water to flood the area for an extended length of time. Peatlands are mapped using the Peat Hydrological Unit (KHG) because of the presence of this ecosystem. There are approximately 14.91 million hectares of peatlands in Indonesia, which are distributed over Papua 3.69 million hectares (25%), Kalimantan 4.78 million hectares (32%), and Sumatra 6.44 million hectares (43%). Peatlands in Indonesia are thought to make up 84% of all peatlands in Southeast Asia and half of all peatlands in the tropics. South Sumatra province has a peatland area of 1.28 million ha, 0.78 million ha of which is degraded peat covered with grasses and scrub. The requirement for an integrated and sustainable management of peatland ecosystems derives from the fact that fires on peatlands always happen during the extreme dry season. This problem is always repeated and becomes a very serious problem in South Sumatra Province.

Furthermore, it is evident that addressing everyday needs is at the heart of the peatland fire issue. When the environment is exploited without considering its carrying capacity, environmental sustainability is neglected. This phenomenon needs to increase our awareness of the need to rectify current socio-ecological thought patterns and practices while simultaneously keeping an eye on the socio-ecological future of peatlands through initiatives that will benefit the local population. The connection between humans and the environment is the cause of the environmental issues that arise, which makes this action crucial. Peatland fires also affect many aspects of people's lives, therefore developing a comprehensive plan is crucial to preserving the ecosystem for future generations.

Indonesia has made a number of significant pledges to protect and restore peatlands because it recognizes how urgent it is to take action. Growing biomass on wet peatlands by agroforestry and paludiculture may be a practical restoration strategy. While creating goods like food, fiber, bioenergy, and other Non-Timber Forest Products (NTFPs), these methods also aid in the creation of peat, which raises the carbon stock. On shallow peatlands, low-impact agricultural best practices are already in place. A resilient and sustainable peatland usage model can be created by honouring this kind of traditional knowledge in conjunction with modern agroforestry and paludiculture technologies. To determine whether these technologies are practical for preventing peat soil degradation and whether they assist communities socioeconomically, more research must be done.

Perigi village is situated in the Ogan Komering Ilir district of South Sumatra Province's Pangkalan Lampam subdistrict (**Figure 1.1**). For a long time, the residents of Perigi village have grown rice cultivation called "sonor" shifting cultivation. The farmers usually burn the land before rice seeds are broadcasted. This village has become one of the areas in the province of South Sumatra that is thought to be a source of hotspots during peatland fires of dry season. Degraded peatlands with reduced hydrological, production, and ecological functions can be found in Perigi village. The chemical, physical, and biological characteristics of this peatlands have deteriorated, reducing their productivity and rendering certain regions unusable. The peatland degradation in this village has inspired collaborative activities between Unsri and NIFoS, especially to improve the productivity of peatlands and also to improve the welfare of its people.

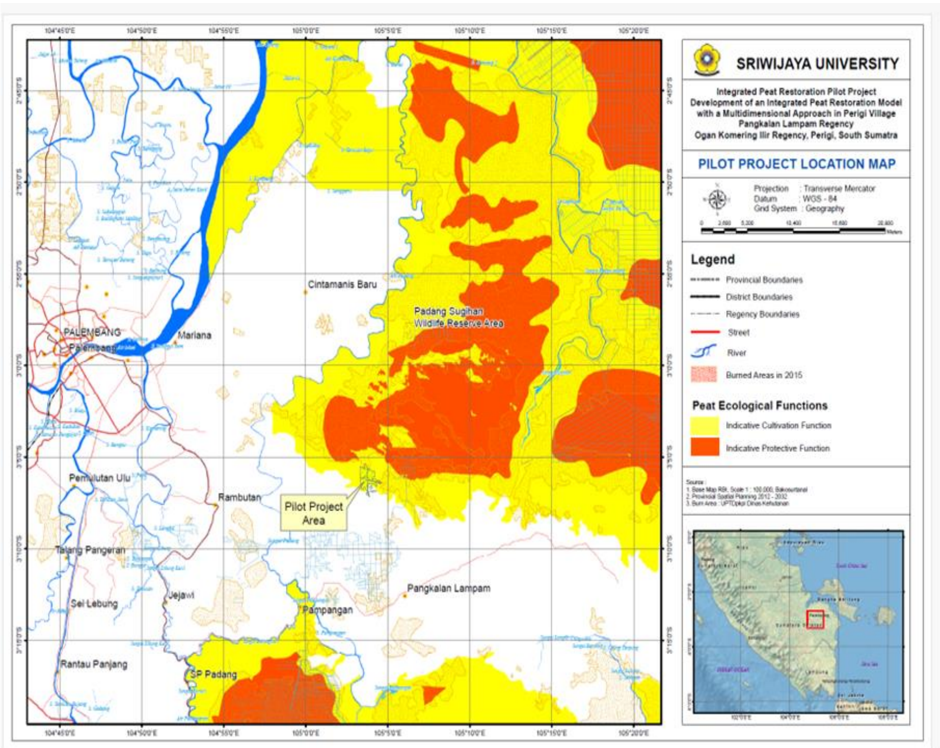


Figure 1.1. Map of the location of peat restoration activities in Perigi Village, Pangkalan Lampam District, Ogan Komering Ilir Regency, South Sumatra Province

In order to carry out peatlands restoration activities, we not only need to pay attention to peatlands productivity improvement, but also really need to actively involve the community. We have to do a combination of participatory and field based action research approaches and various research strategies such as household surveys, focus group discussions and informal meetings. We have learned that farmers expressed their interest in participating in our approach. Farmers are also expected to benefit from the plants they grow as the choice is based on their wishes. Restored peatlands are expected to contribute to reducing greenhouse gas emissions while producing a variety of socio-economic and environmental benefits to rural communities.

UNSRI and NIFoS have begun initiating collaborative activities related to peatlands restoration. Both parties have been carrying out an action research on restoration of degraded peatlands using climate smart agrosilvofishery approach and the activities carried out gradually have shown positive impact. Positive outcomes from the activities include: trees planted have grown and thrived, agricultural productivity (pineapple and paddy yield) has increased, the community has actively participated in program implementation, the community has helped protect the land from fires during the dry season, etc.

UNSRI and NIFoS were signed the MoU on June 21st 2023. Both parties agree and acknowledge the collaboration in the programs such as collaborative research project, Joint scientific conferences, seminars, and workshops, exchange of research publications and information, exchange of research personnel, and other programs of mutual interest. This MoU was then followed by a Research Agreement in 2024 with the title "Enhancement of a community-led management system for the sustainable restoration in Perigi site ", through research activities, namely: Effect of water level and duration on the growth of forest tree species on peat soil, The impact of climate anomalies on the dynamic of hydro climatological parameters in peat land in South Sumatra, and Developing Model for Soil and Water Management in Lowland Agriculture under various soil and hydro climatic condition. This Final Report was prepared as a report on the collaborative activities that was carried this year and some research activities proposed to be carried out in 2025.

II. RESEARCH ACHIEVEMENTS

As previously mentioned, in 2024, NIFoS and CoE PLACE Unsri agreed to conduct 3 research activities, namely: (1) Effect of water level and duration on the growth of forest tree species on peat soil, (2) The impact of climate anomalies on the dynamics of hydroclimatological parameters in peat land in South Sumatra, and (3) Developing a Model for Soil and Water Management in Lowland Agriculture under various soil and hydroclimatic conditions. This section will explain the achievement of deliverables from each research conducted from January 2024 to December 2024.

2.1. Effect of water level and duration on the growth of some tree plant species

2.1.1. Introduction

Indonesia is a country that has the largest peatlands in the tropics. The existence of peatlands is essential not only for Indonesia but also for the world. Peatlands experience various pressures so that many are degraded. Many factors cause peatland degradation. Peatland can be degraded because of the application of sonor farming by local people, causing negative impacts on the ecosystem and people. Efforts to improve the function of degraded peatland ecosystems are through restoration. One way that can be done is by carrying out peatland restoration based on agrosilovofishery method. Agrosilvoforestry has gained more attention to sustainably use of the peatland restoration. Conducting agrosilvoforestry in peatland is challenging due to dynamic hydrologic conditions. Understanding the adaptation ability of agrosilvoforestry species in peatland under different water level and duration should be preceded, which is very limited. The goal of this research is investigate the effect of water level and duration on the early growth of tree plant species. The Purpose of this research is to have a better understanding of the adaptation ability of tree plant species planted in agrosilvoforestry under dynamic hydrologic conditions and provide easy guidelines to local people.

2.1.2. Research Methodology

A. Preparation

Initial growth before treatment have done on 13th April – 12th July, 2024

(a) Polybag and Media Preparation

The experiment utilized polybags measuring 25 cm in height and 18 cm in diameter, each equipped with bottom drainage holes. The media was prepared using top peat soil (0-50 cm) sourced from degraded peatland in Perigi Village. GPS coordinates were recorded, and photographs of the peatland were taken. Prior to filling the polybags, the peat soil was amended with dolomite at a rate of 2 tons per hectare to enhance the pH. Subsequently, the polybags were filled with the treated peat soil. A total of 800 polybags were prepared for the experiment. (**Figure 2.1**).

Figure 2.1. Polybag and Media Preparation

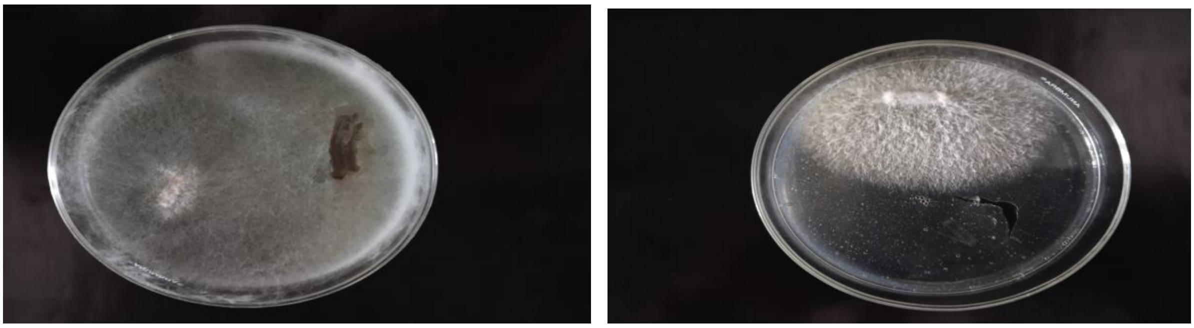
(b) Seed preparing

The experiment involved four species: Jelutung, Nyamplung, Malapari, and Belangeran. Jelutung was sourced from Jambi Province, Nyamplung from South Sumatra, Malapari from Bali, and Belangeran from Dompu and South Sumatra. The seeds were initially soaked in water for 24 hours, followed by a 3-hour soak in a fungicide solution (Decis at a concentration of 2 ml/L). Subsequently, the seeds were sown into the prepared polybags (**Figure 2.2**).

(a) (b) (c) (d)

Figure. 2.2. Seed Species (a) Malapari, (b) Nyamplung, (c) Jelutung, and (d) Blangeran

Figure 2.3. Some Issue Found during pre-Nursery Phase, Fungus infection in Malapari and some Jelutung didn't grow well



(a) (b)

Figure 2.4. Fungus was identified as Trichoderma (a) and Fusarium (b)

Unfortunately, three out of four species did not demonstrate satisfactory growth: Jelutung, Malapari, and Belangeran. Specifically, the germination of Jelutung was characterized by the breakage of the leaf petiole (**Figure 2.3**). In the case of Malapari, the seeds exhibited fungal infection, identified as Trichoderma and Fusarium, attributed to poor seed quality (**Figure 2.4**). A similar issue was observed with Belangeran, where there was a complete absence of seed germination.

Figure 2.5. Planting the Seed of Nyamplung, Jelutung, Malapari and Belangeran

(c) Shading House and Water Tank Preparation

The shading house (3°13'11"S, 104° 38' 52"E) and water tank (3°13'11"S, 104° 38' 50"E) are located on the Indralaya campus. Vinyl plastic was installed over the water tank and within the shading house to mitigate the effects of precipitation on the treatments. Additionally, a water installation was established in the water tank. (**Figure 2.6**).

Figure 2.6. Shading House and Water Tank Location

(d) Pre-Nursery Monitoring and Watering

- **Watering**

  Watering was conducted by carefully measuring the volume of water applied, ensuring a gradual distribution until the soil moisture reached an optimal level of 80%, as monitored throughout the process.

- **Sunlight and Air Temperature.**

  Light exposure was quantified using a lux meter data logger, while air temperature was recorded with a Temp U007 data logger. Measurements were taken daily.

- **Plant monitoring.**

  Plant monitoring involved assessing several parameters, including germination rate, survival rate, plant height (measured from the soil surface to the apex), stem diameter at soil surface level (i.e., root collar diameter), number of leaves, and greenness index. Monitoring was performed on a daily basis.

- **Soil analysis.**

  Soil analysis was conducted at three intervals: on fresh peat, prior to treatment, and after three months of treatment. Five random replicates were collected from a depth of 0-50 cm, and analyses included soil moisture, bulk density, soil pH (H2O), total organic carbon, C/N ratio, total nitrogen, available phosphorus, calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), sodium (Na^{+}), and cation exchange capacity (CEC).

(e) Flooding duration and depth treatments

Flooding treatment commenced on September 2, when the seedlings were three months old, in accordance with Decree of Director of Forest Seed Production, numbered SK.36/PTH-3/2015, about the Physical-Physiological Quality Standards for seeds and the Quality Standards for forest seedlings., on peatlands, a minimum water depth of 50 cm is recommended and for transplanting in forested areas, the plants should achieve a minimum height of 30 cm. The study included three flooding duration treatments: 1, 2, and 3 months. Additionally, six water depth treatments were implemented for the non-flooding conditions, -5 cm, -15 cm, 0 cm, 5 cm, and 15 cm (see **Figure 2.7 and Table 2.1**).

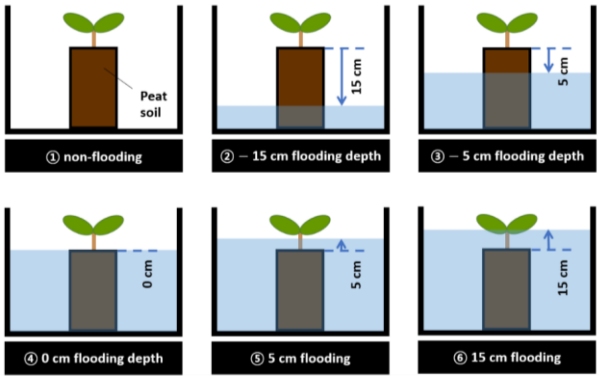


Figure 2.7. Flooding duration and depth treatments

Tabel.2.1. Numbers of Total Treatment of Tree Species

Species		Jelutung	Nyamplung	Malapari
Peatland native		Yes	No	No
Flooding Duration	Flooding Depth	Number of seedlings		
1-month (1st Sept 2024 ~ 30 Sept 2024)	Non Flooding	4	9	9
	-15cm	4	9	9
	-5cm	4	9	9
	0 cm (soil surface)	4	9	9
	5cm	4	9	9
	15cm	4	9	9
3-months (1st Sep 2024 ~ 30th Nov 2024)	Non Flooding	4	9	9
	-15cm	4	9	9
	-5cm	4	9	9
	0 cm (soil surface)	4	9	9
	5cm	4	9	9
	15cm	4	9	9
5-month	Non Flooding	4	9	9

(1st Sep 2024 ~ 30th Jan 2025))	-15cm	4	9	9
	-5cm	4	9	9
	0 cm (soil surface)	4	9	9
	5cm	4	9	9
	15cm	4	9	9
Total (320)		72	162	162

(f) Plant monitoring

Plant parameters were measured including Germination rate, Survival rate, Plant height (from the soil surface to the top of aboveground), Stem diameter at soil surface 0 cm (i.e., root collar diameter), Number of leaves, Greenness index and photographs of morphological adaptation of each species. At the end of each flooding duration, harvest the treatments (e.g., harvest all seedlings at 1-month flooding duration treatment) at a single day and measured wet and dry stem and above biomass, wet and dry root biomass per each 5 cm of soil depth (0–5 cm depth, 5–10 cm depth, 10–15 cm depth, 15–20 cm depth). For this purpose, polybags were sliced at 5 cm intervals to carefully extract both main and fine roots. The harvested biomass was dried at 80 °C for over 72 hours prior to measurement. Daily monitoring of water levels, soil moisture, and weather data was conducted using a data logger (as seen on **Figure 2.8 and 2.9.**).

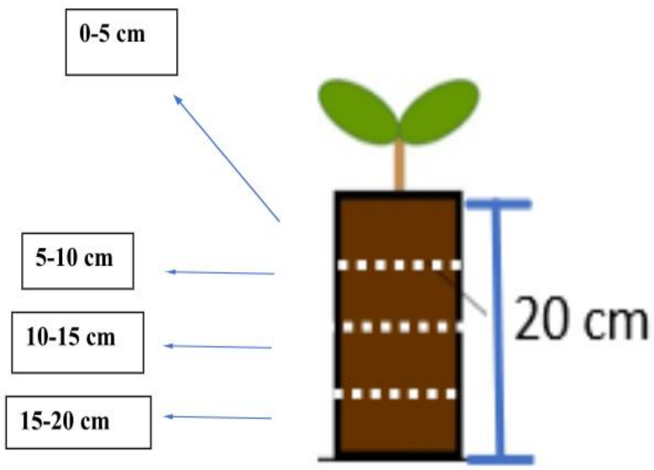


Figure 2.8. Biomass harvesting scheme for aboveground and belowground plant parts

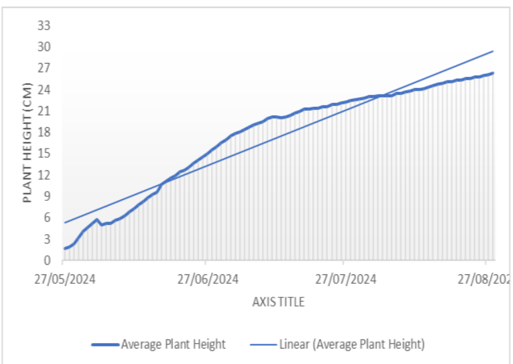
Figure 2.9. Hypertrophied lenticels and adventitious roots

2.1.3. Result and Discussion

A. Nyamplung

(a) Pre-Nursery Result

Based on the pre-nursery activity result, the plant height of Nyamplung experienced a gradual improvement, in the 1st month the average of Nyamplung plant height was about 14 cm, in the 2nd month was about 21 cm and the 3rd month was about 24 cm (**Figure 2.10.a**). The Nyamplung plant height improvement followed by the gradual improvement of total leaves (**Figure 2.10.b.**). In the 3rd month, the average number of total leaves was about 18. This improvement was also followed by the improvement of root collar diameter (**Figure 2.10.c.**) and greenness index (**Figure 2.10.d.**). Based on the result, the Nyamplung germination rate was good, about 80% (**Figure 2.10.e**)



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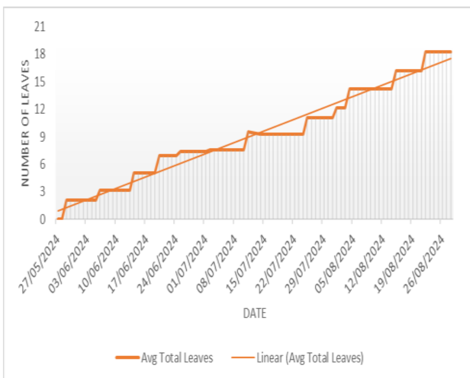

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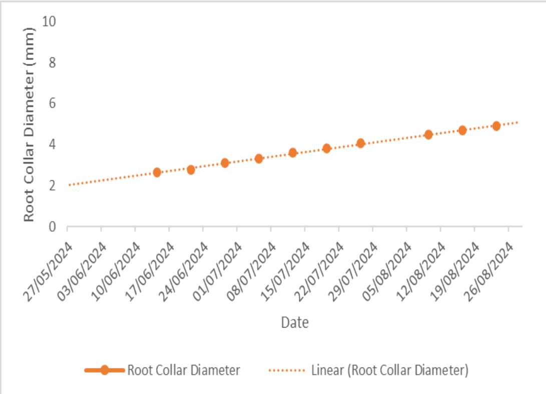

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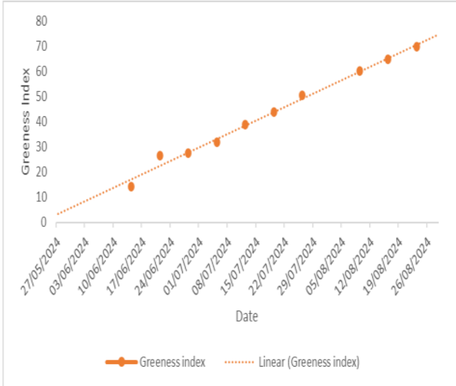

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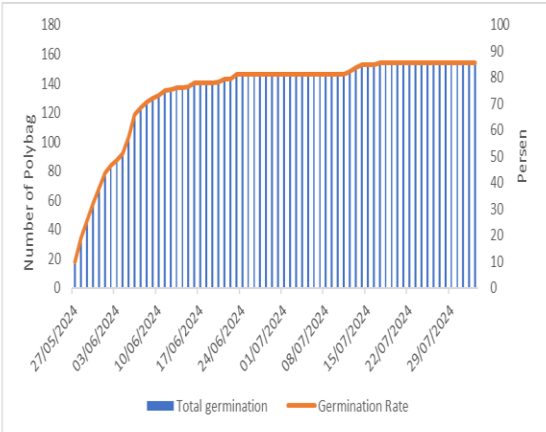
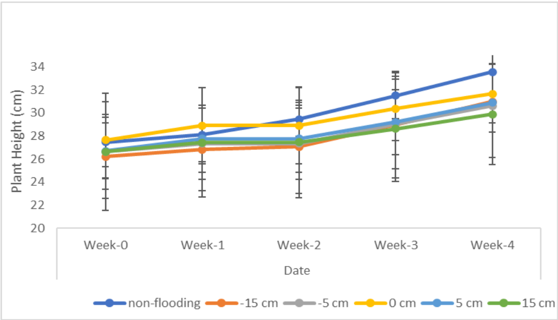


(e)

Figure 2.10. Pre-Nursery Result of Nyamplung

(b) Flooding Treatment Result, Nyamplung, 1 Month Treatment

Based on the treatment result, in general, the highest average plant height of Nyamplung in 4th week observation was found in non flooding treatment, followed by 0 cm treatment, 5 cm treatment, -15 cm treatment, -5 cm treatment and 5 cm treatment. In the number of leaves parameters, the highest value was found in non-flooding treatment, -5 cm treatment, 5 cm treatment, 0 cm treatment, -15 cm treatment and 15 cm treatment. In the root collar diameter parameter, the highest value was found in non-flooding treatment, followed by -15 cm treatment, -5 cm treatment, 15 cm treatment, 5 cm treatment and 0 cm treatment. In the greenness index parameter, the highest value was found in -5 cm treatment, non-flooding treatment, -15 cm treatment, 0 cm treatment, 15 cm treatment and 5 cm treatment (See **Figure 2.11**).



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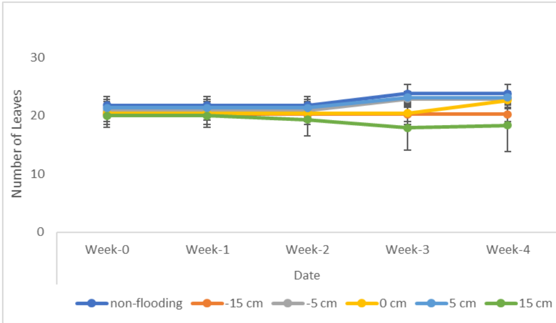

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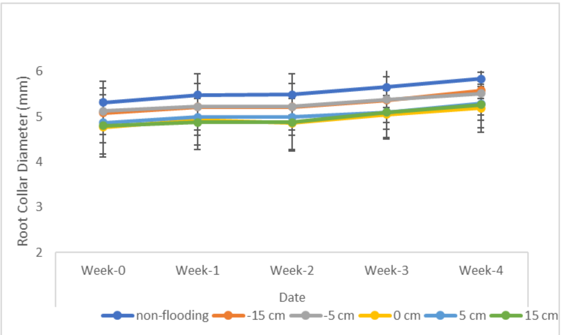

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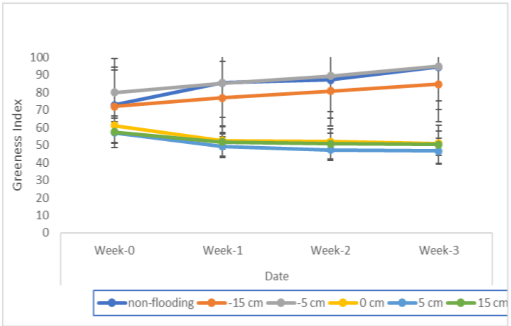


(d)

Figure 2.11. Flooding Treatment Result of Nyamplung after 1 months flooding

(c) Flooding Treatment Result, Nyamplung, 3 Month FloodingTreatment

Based on the treatment result, in general, the highest average plant height of Nyamplung in 12th week observation was found in -15 treatment, followed by -5 cm treatment, non-flooding treatment, 5 cm treatment, and 15 cm treatment. In the number of leaves parameters, the highest value was found in -15 cm treatment , non-flooding treatment, -5 cm treatment, 5 cm treatment, 0 cm treatment, and 15 cm treatment. In the root collar diameter parameter, the highest value was found in non-flooding treatment, followed by -15 cm treatment, 0cm, -5 cm treatment, 5cm treatmen and 15 cm treatment. In the greenness index parameter, the highest value was found in -15 cm treatment, non-flooding treatment, -5 cm treatment, 0 cm treatment, 15 cm treatment and 5 cm treatment.

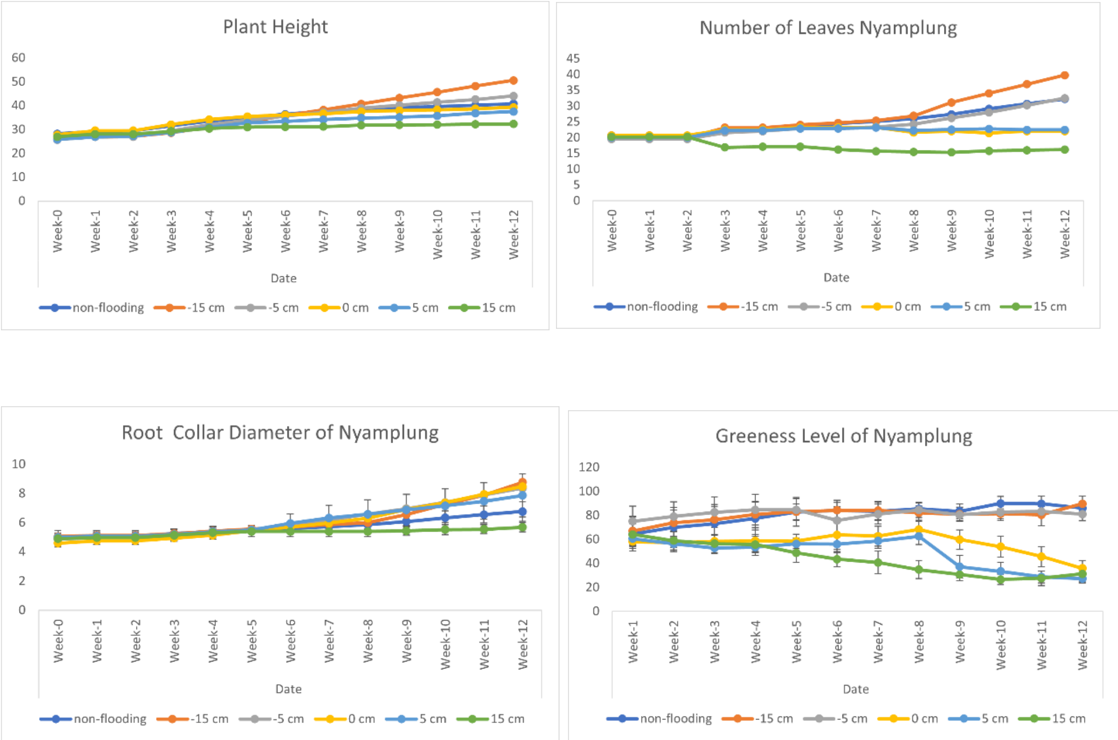
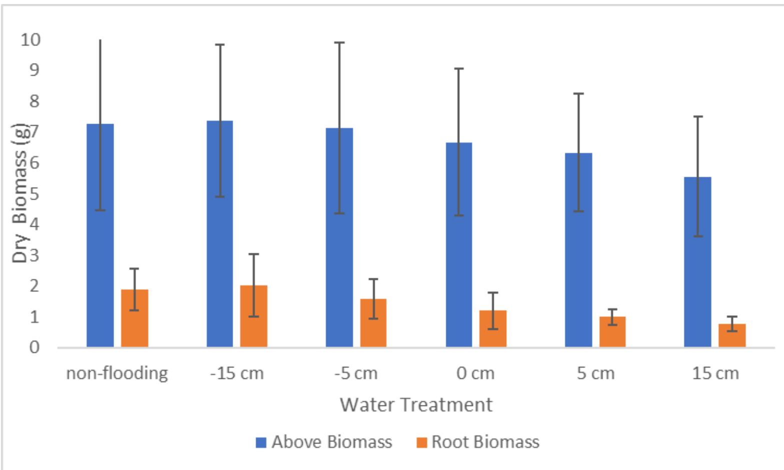


Figure. Flooding Treatment Result of Nyamplung after 3 months flooding

© Result of Nyamplung Biomass in 1 months

Based on the result, the highest above biomass average was found in -15 cm treatment, non-flooding treatment, -5 cm treatment, 0 cm treatment, 5 cm treatment and 15 cm treatment. In root biomass, the highest average was found in -15 cm treatment, non-flooding treatment, -5 cm treatment, 0 cm treatment, 5 cm treatment and 15 cm treatment (See **Figure 2.12 a and 2.12. b**).



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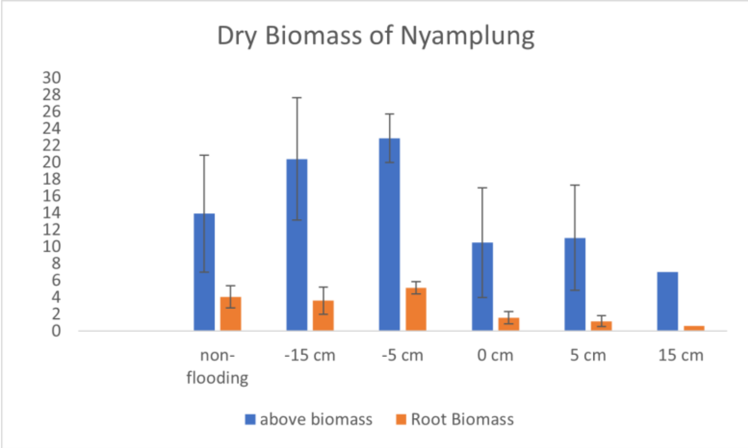


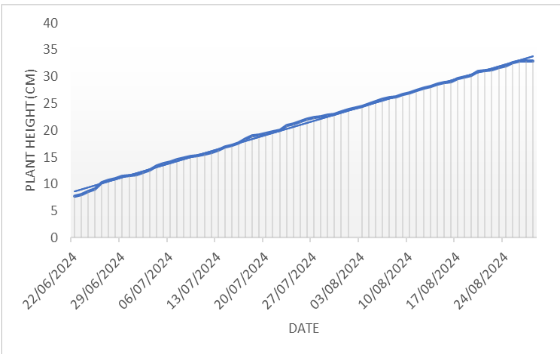
(B)

Figure 2.12. Result of Nyamplung Biomass after 1 months flooding (A) and 3 months flooding (B)

B. Malapari

(a) Pre-Nursery

Based on the Malapari pre-nursery activity, the average plant height in Malapari after 3 months in nursery was about 34 cm. The average number of leaves in Malapari was about 13. The Malapari greenness index was gradually increased, after 3 months of nursery the greenness index was 50. The average root collar diameter in Malapari after 3 months of nursery was 4 mm. Malapari germination rate was 90% as seen on **Figure 2.13**.



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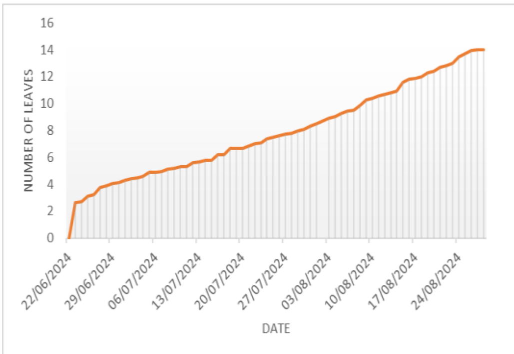

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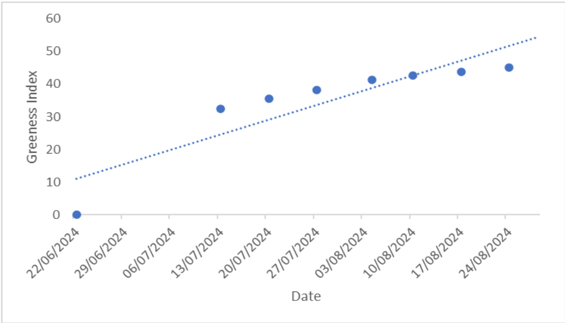

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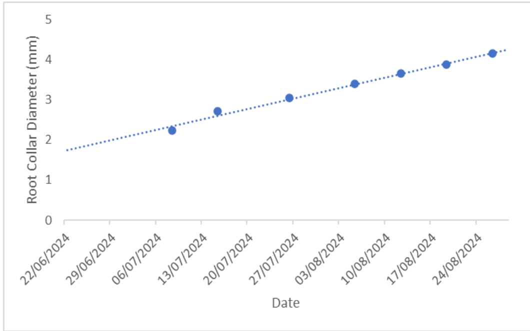

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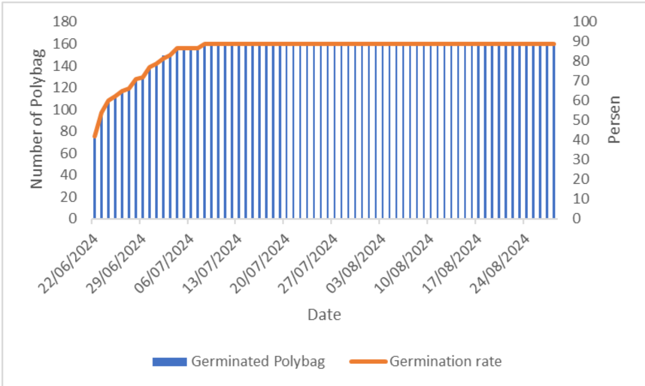
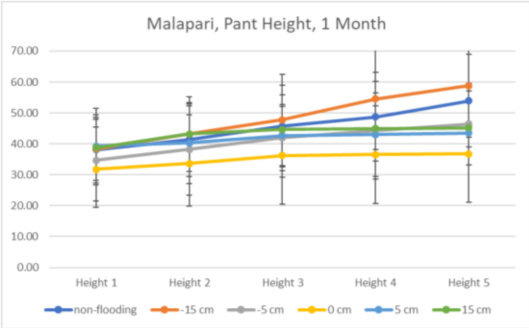


(e)

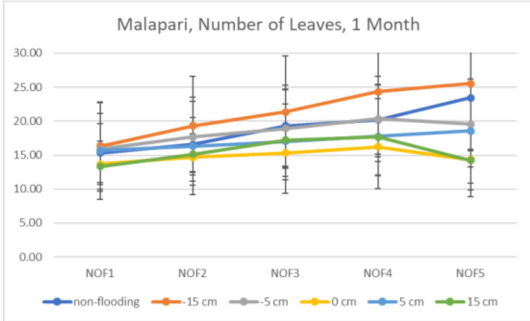
Figure 2.13. Pre-Nursery Result of Malapari

(b) Flooding Treatment Result, Malapari, 1 Month Treatment

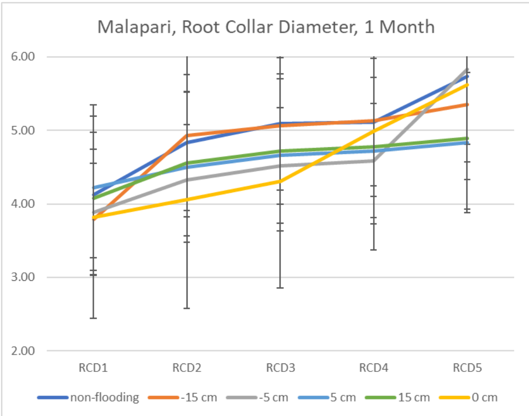
Based on the treatment result, in general, the highest plant height average of Malapari in 4th week observation was found in -15 cm treatment, followed by non-flooding treatment, -5 cm treatment, 15 cm treatment, 5 cm treatment and 0 cm treatment. In the number of leaves parameters, the highest value was found in -15 cm treatment, followed by non flooding treatment, -5 cm treatment, 5 cm treatment, 0 cm treatment and 15 cm treatment. In the root collar diameter parameter, the highest value was found in -5 cm treatment, non-flooding treatment, 0 cm treatment, -15 cm treatment, 15 cm treatment and 5 cm treatment. In greeness index parameter, the highest value was found in -15 cm treatment, followed by -5 cm treatment, 5 cm treatment, non-flooding treatment, 15 cm treatment and 0 cm treatment.



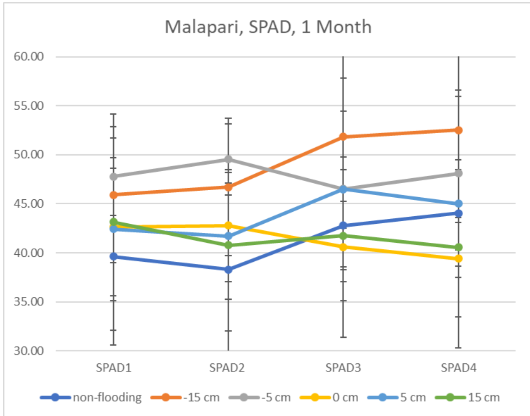
(A)



(B)



(C)



(D)

Figure 2.14. Flooding Treatment Result Malapari after 1 month flooding

(c) Flooding Treatment Result, Malapari, 3 Month Treatment

Based on the treatment result, in general, the highest plant height average of Malapari in 12th week observation was found in -15 cm treatment, followed by non-flooding treatment, -5 cm treatment, 15 cm treatment, 5 cm treatment and 0 cm treatment. In the number of leaves parameters, the highest value was found in -15 cm treatment, followed by non flooding treatment, -5 cm treatment, 5 cm treatment, 0 cm treatment and 15 cm treatment. In the root collar diameter parameter, the highest value was found in -5 cm treatment, -15 cm treatment, 5 cm treatment , 0 cm treatment, non-flooding treatment and 15 cm treatment. In greeness index parameter, the highest value was found in -15 cm treatment, followed by -5 cm treatment, non-flooding treatment, 5 cm treatment, , 15 cm treatment and 0 cm treatment (**Figure 2.15)**.

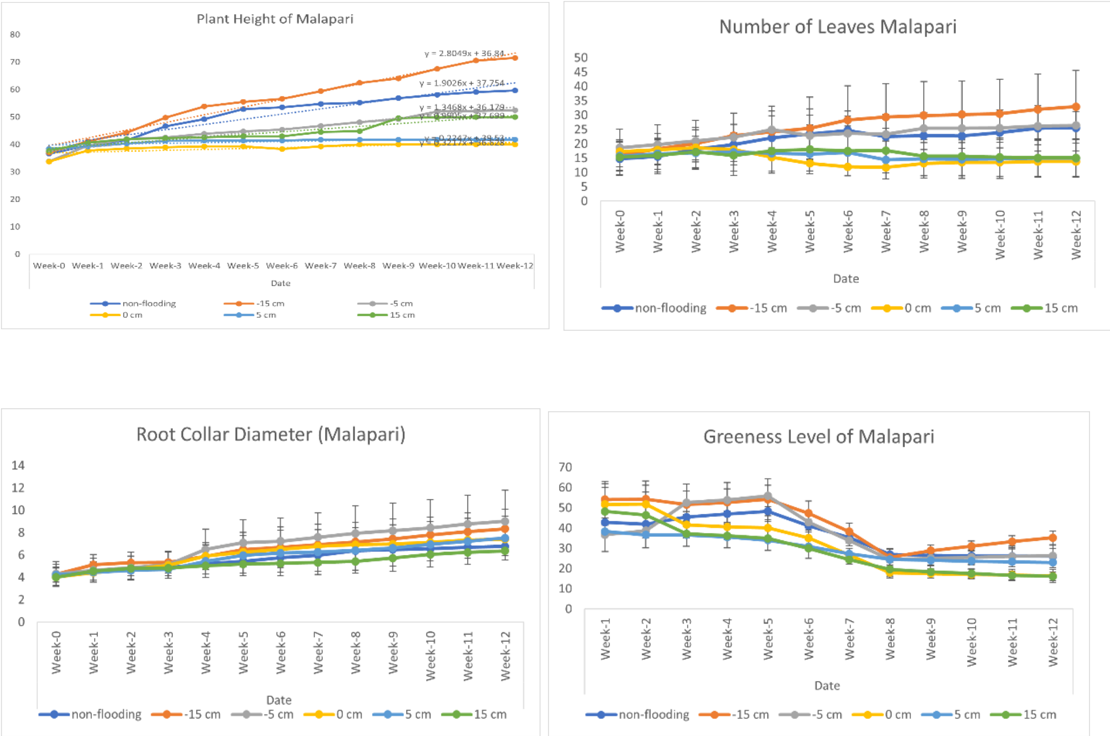
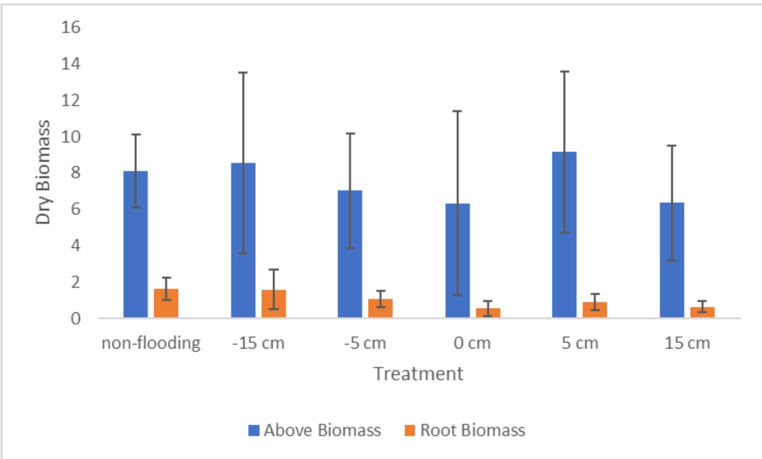
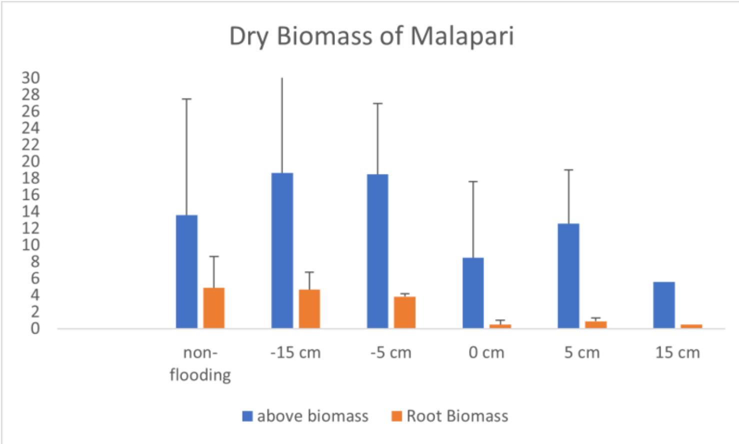


Figure 2.15. Flooding Treatment Result Malapari after 3 month flooding

(c) Result of Malapari Biomass After 1 months Flooding and 3 months Flooding



(A)



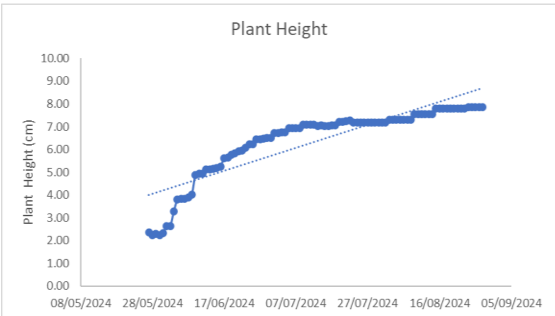
(B)

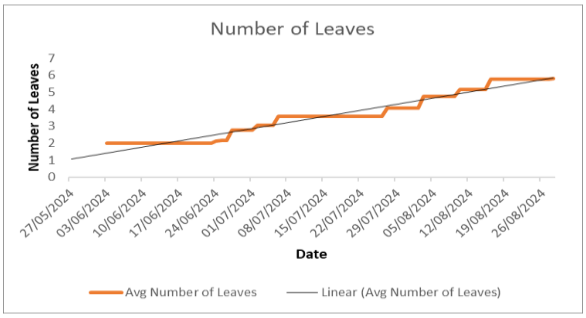
Figure 2.16. Result of Malapari Biomass after 1 months flooding (A) and 3 months flooding (B)

C. Jelutung

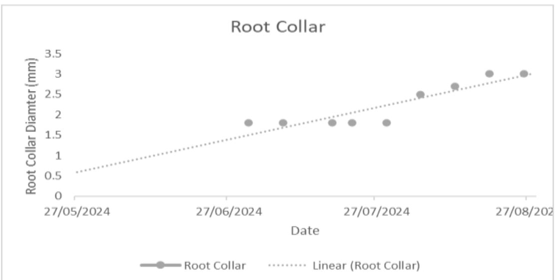
(a) Pre-Nursery

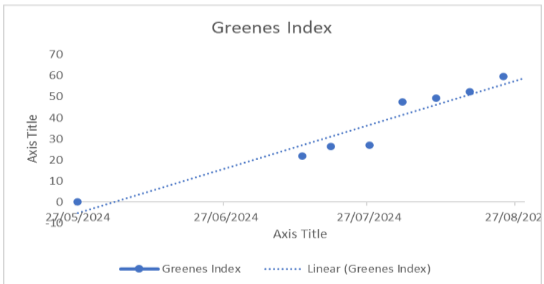
Based on the pre-nursery result, the average of Jelutung plant height was about 7 cm, the average number of leaves was about 5, the root collar diameter was about 5 mm and the average of greenness index was about 60 as seen in **Figure 2.17.**





(A) **(B)**



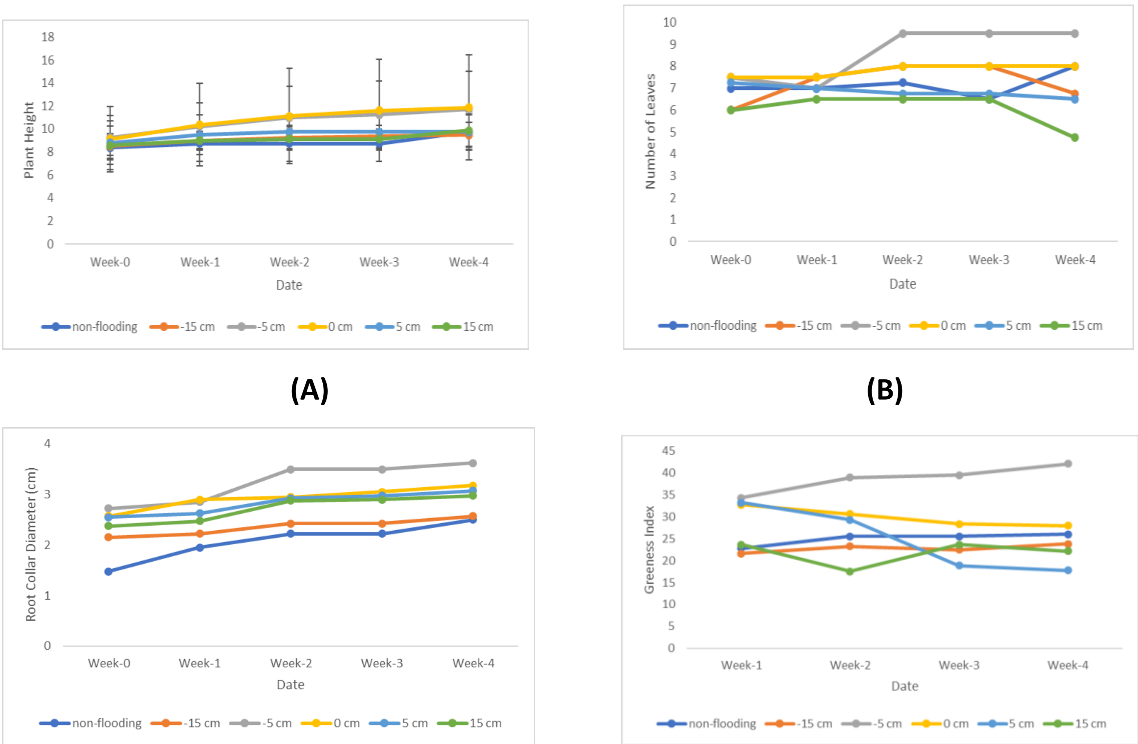


(C) **(D)**

Figure 2.17. Pre-Nursery Result Jelutung

(b) 1 Month of Flooding Duration

Based on the treatment result, in general, the highest plant height average of Jelutung in 4th week observation was found in 0 cm treatment, followed by -5 cm treatment, 15 cm treatment, non flooding treatment, 5 cm treatment and -15 cm treatment. In the number of leaves parameters, the highest average was found in -5 cm treatment, followed by 0 cm treatment, non flooding treatment, -15 cm treatment, 5 cm treatment and 15 cm treatment. In the root collar diameter parameter, the highest value was found in -5 cm treatment, 0 cm treatment, 5 cm treatment, 15 cm treatment, -15 cm treatment and non flooding treatment. In grenness index parameter, the highest value was found in -5 cm treatment, followed by 0 cm treatment, non-flooding treatment, -15 cm treatment, 15 cm treatment and 5 cm treatment. See **Figure 2.18.**



(A) (B)

(C) (D)

Figure 2.18. Flooding Treatment Result Jelutung after 1 month

(c) 3 Month of Flooding Duration

Based on the treatment result, in general, the highest plant height average of Jelutung in 12th week of flooding treatmentt observation was found in 0 cm treatment, followed by -5 cm treatment, 5 cm treatment, non flooding treatment, -15 cm treatment. In contrast, in

15cm flooding treatment, the incresement of plant height was stagnated in 8 cm. In the number of leaves parameters, the highest average was found in 0 cm treatment, followed by -5 cm treatment, -15 cm treatment, non-flooding cm treatment, 5 cm treatment and 15 cm treatment. In contrast of 15cm flooding treatment, the number of leaves was decrease since week 5 and become 0 in week 9. In the root collar diameter parameter, the highest value was found in -5 cm treatment, 0 cm treatment, 5 cm treatment, non flooding treatment and - 15 cm treatment. In the other side, 15 cm treatment the root collar diameter was stagnant in 2 mm. In grenness index parameter, the highest value was found in -15 cm treatment, followed by 0 cm treatment, non-flooding treatment, 5 cm treatment. In the 15 cm treatment,the greeness level was decrease per week. See **Figure 2.19 .**

Figure 2.19. Flooding Treatment Resultf after 3 months

(b) Result of Jelutung Biomass 1 months flooding duration

Based on the result, the highest dry above biomass in Jelutung was found in -5 cm treatment, 0 cm treatment, 5 cm treatment, non-flooding treatment, -15 cm treatment and 15 cm treatment. In dry root biomass of Jelutung, the highest was found in 0 cm treatment, -5 cm treatment, non flooding treatment, -15 cm treatment, 5 cm treatment and 15 cm treatment as seen on **Figure 2.20**.

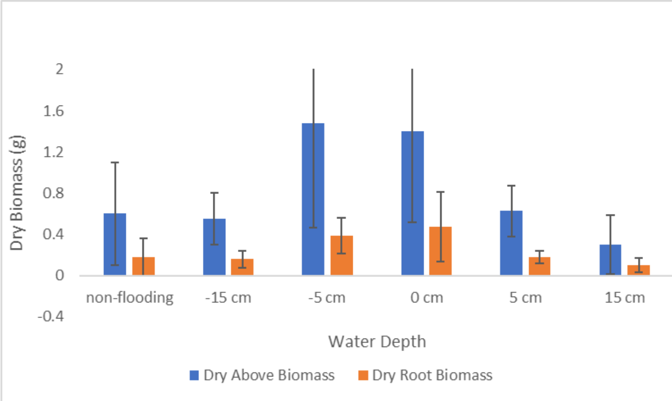


Figure 2.20. Result of Jelutung Biomass

(c)Result of Jelutung Biomass 3 months flooding duration

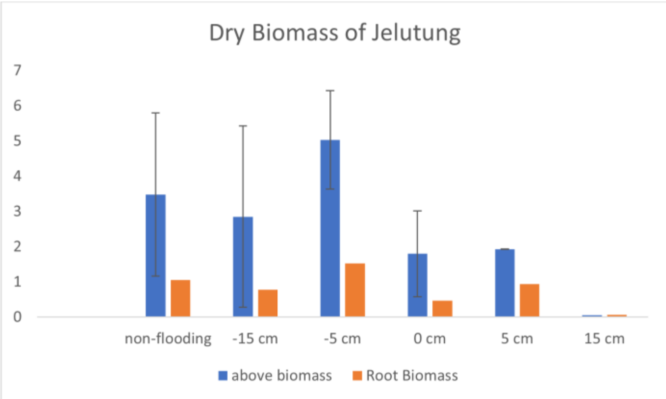


Figure 2.21. The result of Jelutung Biomass after 3 Months Flooding

D. Belangeran

(a) Seedling preparation

Figure 2.22. Belangeran Seedling was the seedlings obtained from the South Sumatra Forest Seed Center

The belangeran seeds were unable to germinate due to their poor quality. The seeds we acquired were from the most recent harvest, which occurred between December and February. As a response to that issue, the seedlings were obtained from The South Sumatra Forest Seed Center on 30 August 2024. Based on the information, The seedlings were sown on February, 2024 which means the seedlings were 6-month ages when they were obtained. The height has reached 27 cm. The media used to cocopeat. The seedlings, was transplanted into polybag 20 x 18 cm which fulfilled with peat soil. The seedlings was monitored for 1 months included Germination rate, Survival rate, Plant height (from the soil surface to the top of aboveground), Stem diameter at soil surface 0 cm (i.e., root collar diameter), Number of leaves, and Greenness index.

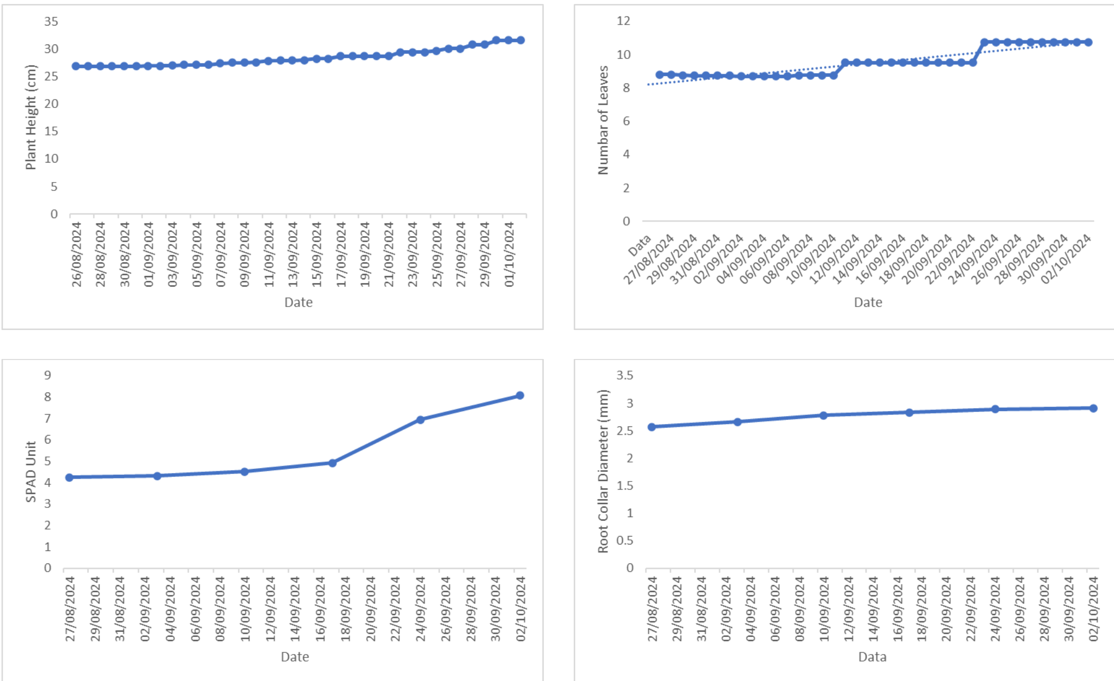


Figure 2.23. Growth of Belangeran Seedlings

(d) 1 Month of Flooding Duration

Based on the treatment result, in general, the highest plant height average of Belangeran in 4th week observation was found in -5cm cm treatment, followed by -15 cm treatment, 15 cm treatment, non flooding treatment, 0 cm treatment and 5 cm treatment. In the number of leaves parameters, the highest average was found in -5 cm treatment, followed by -15cm treatment, non flooding treatment, 15 cm treatment, 5 cm treatment and 0 cm treatment. In the root collar diameter parameter, the highest value was found in -15 cm treatment, -5 cm treatment, non flooding treatment, 15 cm treatment, 0 cm treatment and 5cm treatment. In grenness index parameter, the highest value was found in -5 cm treatment, followed by non-flooding treatment, 5 cm treatment, 15 cm treatment and 0 cm treatment. See **Figure.2.24.**

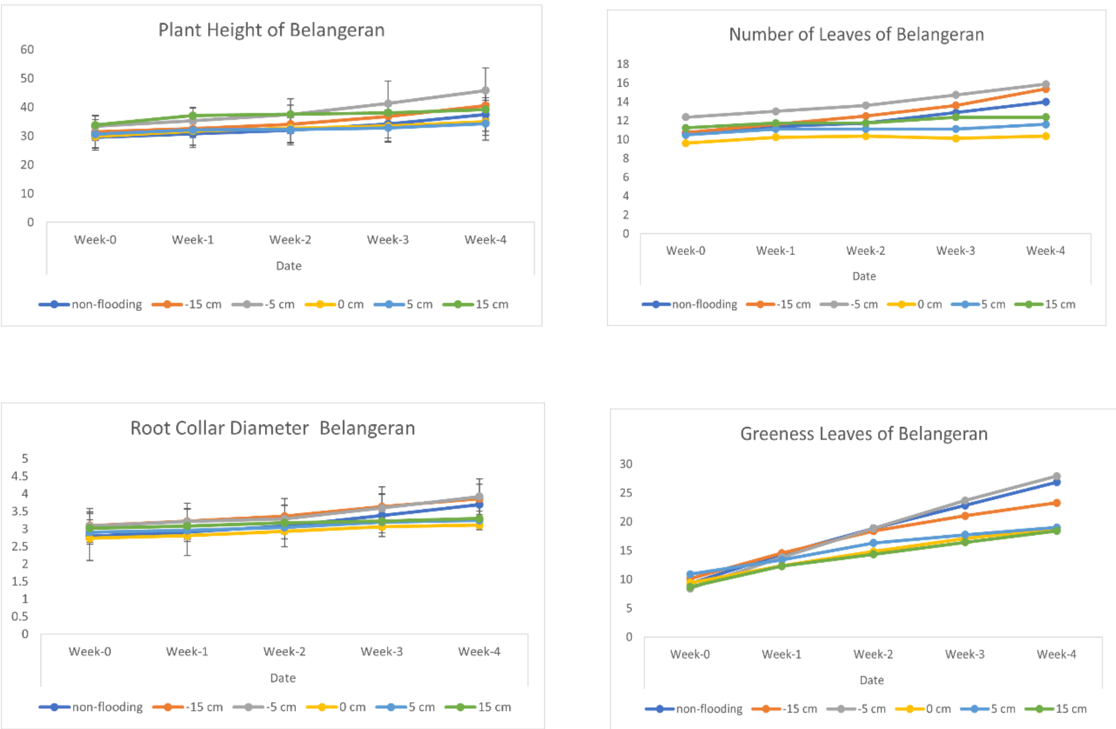


Figure 2.24. The result of Blangeran after 3 Months Flooding

(E) Result of Belangeran Dry Biomass 1 months flooding duration

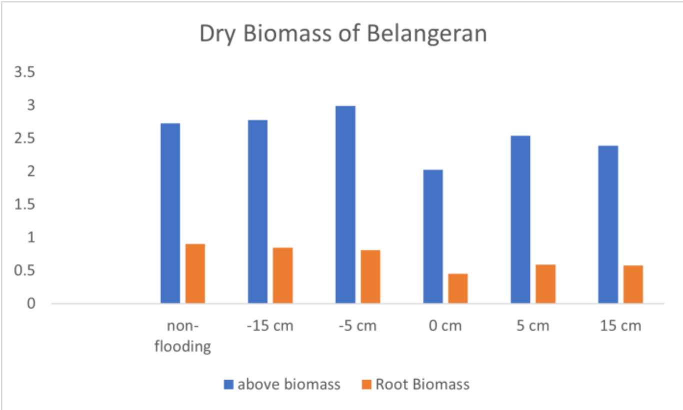


Figure 2.25. Result of Belangeran Dry Biomass 1 months flooding duration

E. Temperature and Humidity

Air Temperature and humidity was recorded by data logger every 30 minutes every day (**Figure 2.26)**. The data was collected and anaylyze as a daily data. Based on the data, the highest temperature was 33°C in September and the lowest was 29°C in October. The highest humidity was 88% in November and the lowest humidity was 58% in September. It showed that, during September was in still dry season and the rainy season started in October.

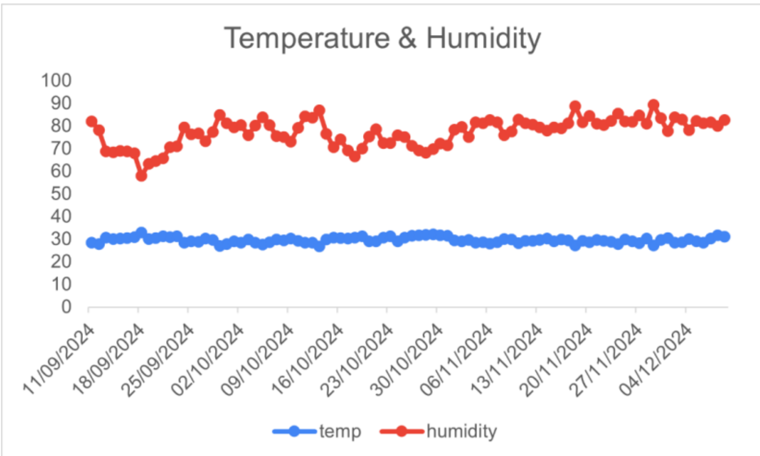


Figure 2.26. Daily Tempeature and Humidity Data

F. Soil and Water Properties

Table 2.2. Peat Soil Characteristic

Date	Status	Sampling No.	Soil moisture	Bulk density	Soil pH (H2O)	Total organic carbon	Total N	Available P	Ca+2	Mg+2	K+	Na+	CEC+
Unit			*%*	*g/cm3*		*%*	*%*	*ppm*	*Cmol+/kg*	*Cmol+/kg*	*Cmol+/kg*	*Cmol+/kg*	*Cmol+/kg*
5/4/2024	Fresh peat dummy (0-50 cm depth)	1	77.80	0.24	4.09	45.66	1.65	15.63	1.36	0.78	0.17	0.13	65.15
5/4/2024	Fresh peat dummy (0-50 cm depth)	2	76.89	0.31	3.79	44.79	1.61	12.01	1.10	0.34	0.16	0.14	59.46
5/4/2024	Fresh peat dummy (0-50 cm depth)	3	76.13	0.26	4.00	45.18	1.76	10.51	1.36	0.57	0.21	0.18	72.86
5/4/2024	Fresh peat dummy (0-50 cm depth)	4	76.79	0.23	3.78	43.83	1.52	12.80	1.19	0.46	0.21	0.13	60.77
5/4/2024	Fresh peat dummy (0-50 cm depth)	5	77.88	0.23	3.85	46.07	1.66	13.87	1.29	0.55	0.22	0.13	67.65
average			77.10	0.26	3.90	45.10	1.64	12.96	1.26	0.54	0.20	0.14	65.18

Table 2.3. Water Characteristic

Date	Status	Sampling No.	Water pH	Total N	Ca+2	Mg+2
Unit			*Please fill*	*mg/L*	*mg/L*	*mg/L*
5/4/2024	Water	1	6.18	0.57	2.15	0.53
5/4/2024	Water	2	6.18	0.57	2.13	0.51
5/4/2024	Water	3	6.16	0.57	2.78	0.60
5/4/2024	Water	4	6.18	0.57	2.25	0.55
5/4/2024	Water	5	6.22	0.57	2.35	0.53
average			6.18	0.57	2.33	0.54

Based on the measurement, the peat soil that used in this research have average of 77.10% soil moisture, 0.23 g/cm^3 bulk density, 0.26 soil pH value, 45.10% total organic content, 1.64 % total N, 12.96 ppm available P, 1.26 Cmol+/kg Ca^{+2}, 0.54 Cmol+/kg Mg^{+2}, 0.54 Cmol+/kg K^{+}, 0.14 Cmol+/kg Na^{+}, 65.18 Cmol+/kg CEC^{+}. The water characteristic that used in this research have 6.18 Water pH, 0.57 mg/L total N, 2.33 mg/L Ca^{+2} and 0.54 mg/L Mg^{+2}

Tabel. 2.4 Peat Soil Properties Before Treatment

Species	**Replicate**	**Code**	**Bulk Desnsity**	**Moisture ***	**pH H_2O**	**Total-N (%)**	**Total-Organic Carbon (%)**	**Available P-Bray II (ppm)**
			g/cm3	%		%	%	(ppm)
Malapari	1	M1	0.36	72.61	4.42	1.37	43.89	61.11
Malapari	2	M2	0.39	76.64	5.18	1.33	43.65	91.92
Malapari	3	M3	0.39	74.72	5.76	1.40	45.47	108.45
Malapari	4	M4	0.25	69.59	5.68	1.42	42.38	127.37
Malapari	5	M5	0.26	54.44	5.47	1.34	43.80	168.78
Average			0.33	69.60	5.30	1.37	43.84	111.53
Jelutung	1	J1	0.37	74.04	5.84	1.27	42.67	115.65
Jelutung	2	J2	0.37	66.00	6.15	1.15	43.59	68.81
Jelutung	3	J3	0.44	73.75	5.30	1.28	42.71	168.01
Jelutung	4	J4	0.24	74.55	5.86	1.31	43.61	125.91
Jelutung	5	J5	0.25	75.46	6.02	1.39	43.87	139.19
Average			0.33	72.76	5.83	1.28	43.29	123.52
Nyamplung	1	N1	0.39	41.68	5.03	1.43	43.04	130.55
Nyamplung	2	N2	0.38	75.74	4.91	1.47	46.11	239.59

Nyamplung	3	N3	0.34	76.54	5.06	1.64	43.41	328.34
Nyamplung	4	N4	0.31	74.73	5.30	1.82	41.13	112.84
Nyamplung	5	N5	0.29	70.86	6.21	1.22	42.24	178.44
Average			0.34	67.91	5.30	1.52	43.19	197.95
Belangeran	1	B1	0.21	68.94	5.47	1.2	39.04	54.88
Belangeran	2	B2	0.21	72.47	5.60	1.17	33.25	144.12
Belangeran	3	B3	0.24	67.39	4.83	1.33	34.82	116.21
Belangeran	4	B4	0.25	74.32	5.46	1.14	32.76	122.38
Belangeran	5	B5	0.22	67.25	5.07	1.30	34.11	158.23
Average			0.23	70.07	5.29	1.23	34.80	119.16

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F. Morphological Adaptation

The seedlings adapted to flooding by forming hypertrophied lenticels and adventitious roots on submerged portions of stems, as well as forming new roots on preexisting roots. Based on the observation, most Malapari seedlings on 0, 5cm, and 15 cm, they form lenticel. The Adventitious roots were formed on day 28. The flood-induced adventitious roots on stems originated in denovo in the ray parenchyma of the secondary phloem. , the adaptation of Jelutung Seedlings in flooding condition, we observed 50 seedlings formed lenticel on 0, 5cm, and 15 cm water treatment, but none formed The Adventitious roots. Nyamplung formed lenticel on the stem during 1 month flooding treatment. The **Figure 2.27.** was shown it.

(A)

(B)

(C)

(D)

Figure 2.27. Lenticel Form of Malapari (A), Adventitious Roots Form of Malapari (B), Lenticel Form of Jelutung (C), Lenticel Form of Nyamplung (D)

(A)

(B)

(c)

Figure 2.28. Plant condition after 3 months of flooding nyamplung (A), Jelutung (B), and malapari (C)

2.1.4. Conclusion

The quality of seeds used will determine the characteristics of the seedlings. High-quality seeds will result in high germination rates and influence the plant's adaptability in the field. For the selected species (Nyamplung, Malapari, Jelutung, and Belangeran), the seeds are classified as recalcitrant, meaning that prolonged storage of the seeds will cause a decline in germination potential. Additionally, the length of storage will affect both the germination rate and the speed of germination. This occurs due to membrane leakage, which results in the lack of materials that can be broken down into energy. The availability of this energy will influence germination, as well as the quality of germination (normal or abnormal).

The reduction in plant growth due to abiotic stress is a natural plant response. Stress conditions, such as submergence or waterlogging, experienced by Nyamplung, Malapari, and Jelutung plants, will lead to a decrease in oxygen concentration (hypoxia) or a lack of oxygen availability (anoxia). This occurs because the soil pores, which should be filled with air, become saturated with water, thereby blocking air circulation. This change in condition will reduce the oxygen diffusion rate. As a result, the plant's respiratory metabolism will shift from aerobic respiration, which produces 36 ATP, to anaerobic respiration, which only produces 2 ATP under normal conditions.

2.1.5. Research Plan on 2025 (To be discussed)

2.2. The impact of climate anomalies on the dynamic of hydroclimatological parameters in peat land in South Sumatra

2.2.1. Introduction

Indonesia has very extensive tropical peatlands spread across almost all the islands in Indonesia. For the island of Sumatra, the largest peatlands are in South Sumatra province, especially in Ogan Komering Ilir (OKI) Regency. Indonesia's position between the Indian Ocean and the Pacific Ocean means that climate conditions in Indonesia are influenced by the IOD phenomenon in the Indian Ocean and the ENSO phenomenon in the Pacific Ocean.

In the 2019-2023 period, there has been a climate anomaly due to the interaction between the sea and the atmosphere in the Indian and Pacific oceans. In 2019, there was a Positive Indian Ocean Dipole (IOD+) event in the Indian Ocean, which caused very minimal rainfall in most parts of Indonesia. In 2019, there was a drought in the peatlands, resulting in massive fires in South Sumatra. In 2020-2022, a La Niña event occurred in the Pacific Ocean, which caused above average rainfall in most parts of Indonesia. As a result, runoff can occur on peatlands. In 2023, IOD+ and El Niño occurred simultaneously which caused quite severe drought in the South Sumatra region, including in Ogan Komering Ilir Regency. Fires on peatlands occur massively.

This research was designed to assess the impact of climate anomalies that occurred during the 2019-2023 period on the dynamics of hydro-climatological parameters on peatlands to mitigate fire and runoff disasters on peatlands in South Sumatra. Hydro-climatological parameters, consisting of rainfall, water level and soil moisture, play an important role in peatland management. The data used in the first year of this research was secondary data originating from the SESAME observation station and from satellite data. Until December 2023, all data for this first year has been downloaded. This data consists of rainfall, groundwater level, soil moisture, and hotspots. This data has also been processed and analyzed and written in the form of two international conference papers and two international journal articles.

In this first year, field data measurements were also carried out in Perigi Village using water levels and drones. This data will later be combined with data from measurements in the second year to be processed and analyzed and written in the form of a journal article in 2025.

Several activities have been carried out to meet the first year targets and activities to support second year activities. Details of the activities achieved for the first year of research and to support the second year of activities are described below.

2.2.2. Research Methodology

This research was conducted to study the relationship and impact of climate change on hydro-climatology parameters on peatlands in Indonesia, especially in South Sumatra. The data used are the results of measurements of a measurement system called SESAME. The hydro-climatology parameters that are the main parameters of this study are rainfall, groundwater level, and soil moisture. In addition, hotspot parameters from MODIS satellite measurements are also used.

In July 2017, the Indonesian Government initiated the implementation of several in-situ measurement stations to monitor hydrometeorological parameters in peatland areas across the country, including South Sumatra. This measurement system, known as the Sensory Data Transmission Service Assisted by Midori Engineering Laboratory (SESAME), encompasses the monitoring of temperature, rainfall, groundwater level (GWL), and soil moisture. This integrated measurement system was established to predict and mitigate fire disasters in peatland and is managed by the Peat Restoration Agency (BRG). BRG launched a Peatland and Water Monitoring System (SIPALAGA) in seven Indonesian provinces, including South Sumatra, at the end of 2018. SIPALAGA incorporates the SESAME measurement system (http://www.sipalaga.brg.go.id). A photograph of the SESAME equipment system installed in peatland in South Sumatra is shown in **Figure 2.29.** Meanwhile, the distribution of SESAME stations can be seen in **Figure 2.30**.

Figure 2.29. SESAME equipment

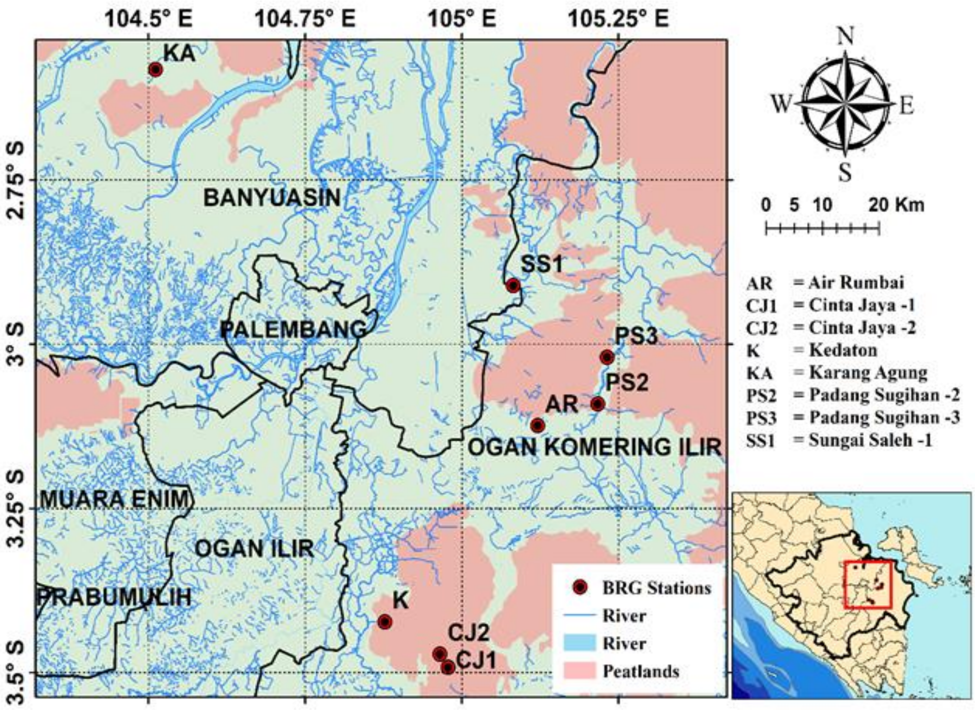


Figure 2.30. Map of BRG station

The dynamics of hydro-climatological parameters from SESAME measurements were analyzed statistically using linear regression, linear correlation, and t-test. The dynamics of these parameters were analyzed and associated with natural phenomena that occur related to climate change. These natural phenomena are El Nino Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD). The ENSO phenomenon consists of El Nino and La Nina which are located in the Pacific Ocean. The IOD phenomenon consists of IOD+ and IOD- which are located in the Indian Ocean. Indonesia is graphically located between the two oceans so that natural phenomena, both ENSO and IOD, affect Indonesia's climate conditions. El Nino and IOD+ have the same impact, namely reduced rainfall. La Nina and IOD- have the same impact.

2.2.3. Result and Discussion

2.2.3.1. Achievement for the first year target

In the first year (2024), activities are focused on analysing the impact of the IOD and 3ENSO phenomena on hydro-climatological parameters consisting of rainfall, groundwater level, soil moisture, and hotspots on peatlands in South Sumatra. The data used is secondary data originating from the SESAME system and satellite data. The target to be achieved is the publication of two scopus indexed journals and two international proceedings. Then we have also conducted direct measurements in the field regarding water levels and conducted mapping using drones at the research location in Perigi Village. Several research results are:

A. Dynamics of Peatland Fires in South Sumatra in 2019: Role of Groundwater Levels

A.1. Hotspot distribution

Figure 2.24 depicts the time series data for hotspots, mean precipitation, and climate indices during the dry season (J-A-S-O) from 2001 to 2020. As shown in a previous study, peat fires in South Sumatra occurred nearly every year during the dry season, varying in intensity. Three major fire occurrences were observed during the study period in 2006, 2015, and 2019, with 12, 118, 19, 942, and 7,563 hotspots, respectively (**Figure 2.31**).

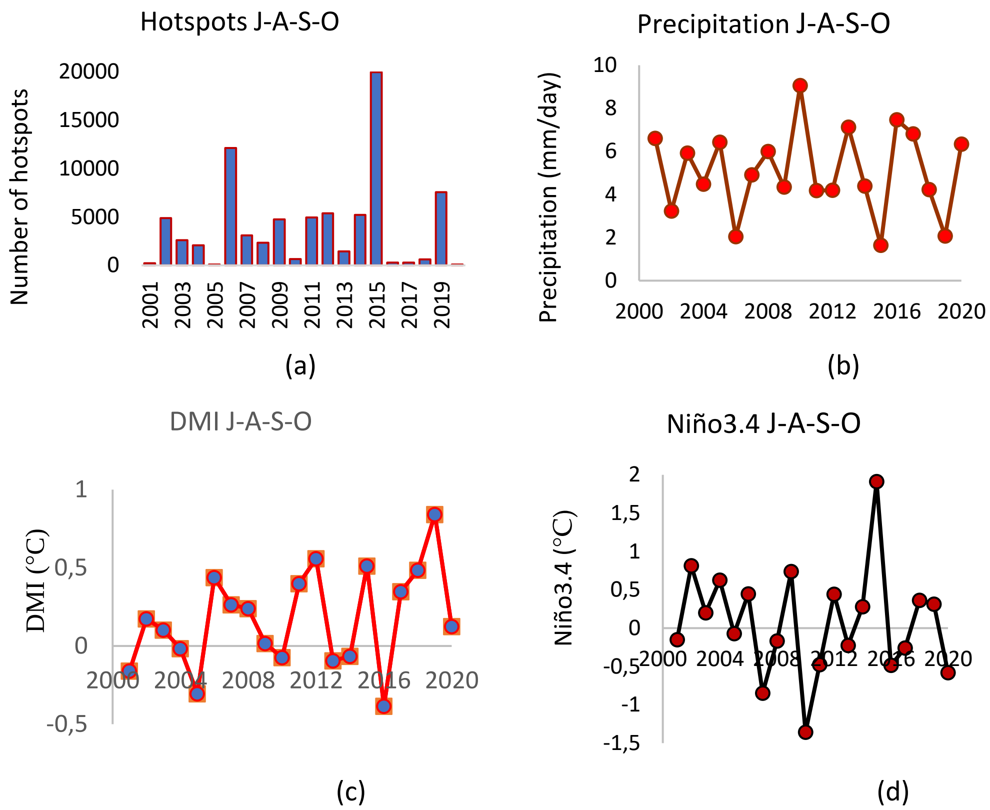
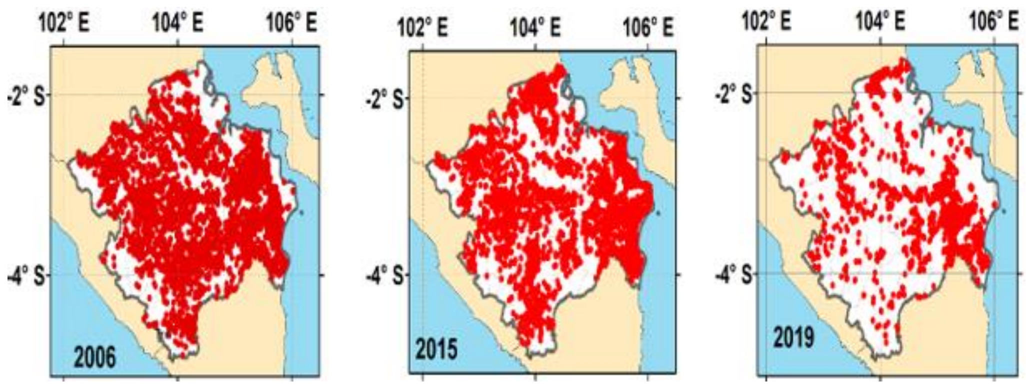


Figure 2.31. Time series of hotspots, rainfall, DMI, and Niño 3.4 in 2001–2020

Peat fires have a detrimental impact on the environment, leading to haze pollution and disrupting daily activities, such as transportation and public health. It is worth noting that the three largest fire events coincided with a lack of precipitation (Figure 2.24b). Specifically, in 2015, the highest number of hotspots was observed during the driest conditions with the lowest observed precipitation intensity. Previous studies have shown that Indo-Pacific climate modes, namely the IOD and ENSO, are linked to the deficit precipitation observed across the Indonesian region. Figures 2.24c and 2.24d display the IOD and ENSO indices, respectively, with the magnitude of the indices reflecting the intensity of the events. It is evident that the 2006 and 2019 peat fires were associated with strong positive IOD events, whereas the 2015 fire was linked to an extreme El Niño event. The number of hotspots during the 2015 El Niño event nearly doubled (or tripled) that of the 2006 (or 2019) IOD event, suggesting that the influence of El Niño was more significant. However, determining the extent to which ENSO or IOD impacts peat fire occurrence is beyond the scope of this study.



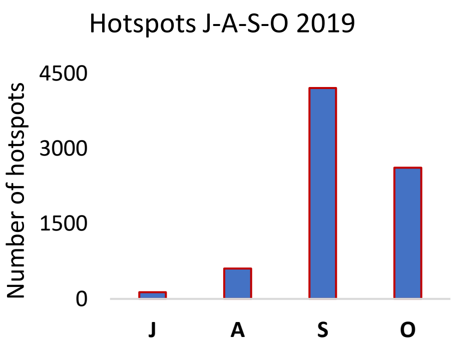
(a) (b) (c)

Figure 2.32. Distribution of hotspots in South Sumatra during the extreme dry season J-A-S-O 2006, 2015, and 2019.

To analyze the distribution of peat fires in South Sumatra, we present distribution maps of hotspots during the peak phase of the events (J-A-S-O season) in 2006, 2015, and 2019 (**Figure 2.32**). Among these fire events, the 2019 event had the lowest number of hotspots (**Figure. 2.32c**). The hotspots appear to be more concentrated in the eastern part of South Sumatra, as indicated by the denser concentration. As shown in Figure 2.25, the eastern part of South Sumatra is dominated by peatland, suggesting that severe peatland fires occurred during these three extreme dry seasons.

A.2. Dynamics of the 2019 peatland fires

The Indonesian Government has implemented various measures to prevent peatland fires during the dry season, particularly during extreme dry seasons. One such measure is the establishment of in-situ measurement stations for hydrometeorological parameters in peatland across the country, known as the SESAME measurement system. Fortunately, the SESAME stations in South Sumatra recorded several hydrometeorological parameters during the severe fire events in 2019. Therefore, in this section, we examine the potential role of GWL in controlling peatland fires.



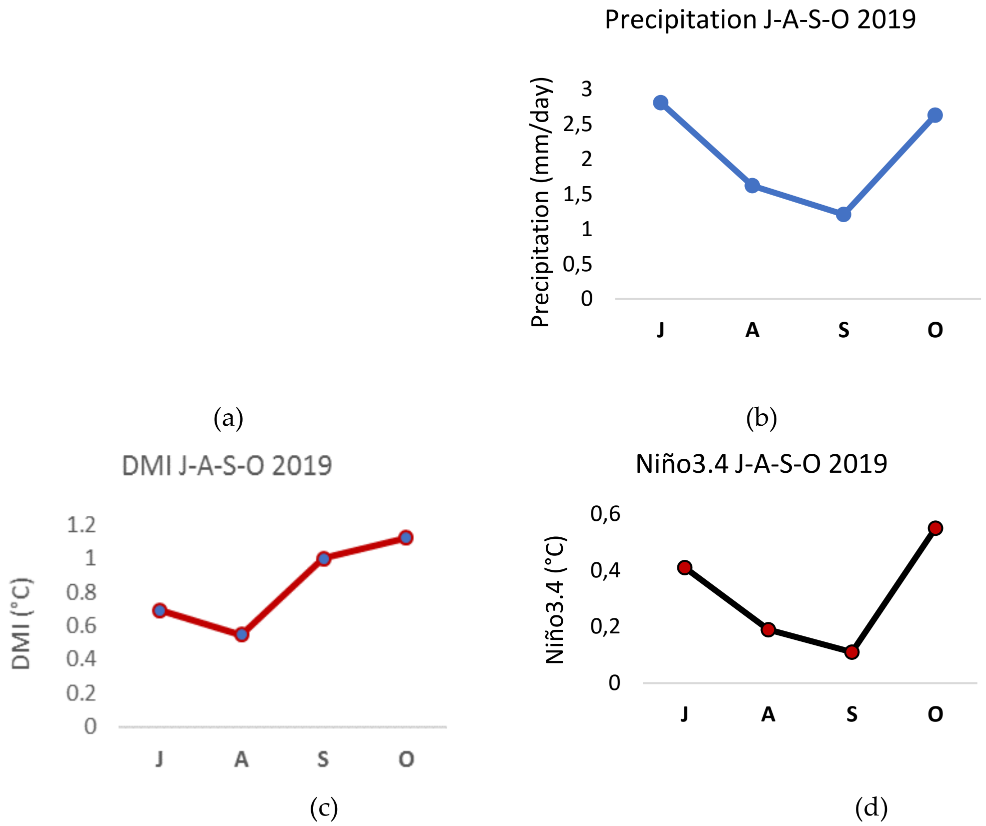


Figure 2.33. Time-series of hotspots, rainfall, DMI, and Niño 3.4 during the 2019 J-A-S-O period

Figure 2.33 illustrates the time series of the monthly observed number of hotspots, precipitation, and climate indices during the 2019 J-A-S-O season. It is evident that the number of hotspots gradually increased from July to August, sharply rose in September, and then decreased in October (Figure 2.26a). The highest number of hotspots, observed in September 2019, coincided with the lowest recorded precipitation (Figure 2.26b). As the intensity of precipitation increased in October, the number of hotspots gradually decreased. As shown in an earlier section, the peatland fires in 2019 were attributed to the positive IOD event (Figure 2.26c) rather than the El Niño event (Figure 2.26d). Interestingly, the highest number of hotspots was observed prior to the peak phase of the IOD in October, and the number of hotspots decreased once the IOD reached its peak phase. This suggests that other factors may also play a role in controlling the increase or decrease in hotspots.

First, we examined the possible relationship between rainfall and GWL observed at the SESAME stations. **Figure 2.34** shows the time series of observed rainfall and GWL from July to October 2019. Rainfall had an impact on the temporal variability of GWL. When there was no rainfall observed at these stations, the GWL rapidly increased at all stations. An increase in

GWL indicates that GWL is rising relative to the Earth's surface. Interestingly, even a short period of rainfall could influence GWL, as indicated by intermittent increases in GWL. For example, an immediate response of the GWL to rainfall was observed in early October 2019 at station Cinta Jaya 2. The GWL increased in response to increased rainfall and vice versa (Figure 2.27b).

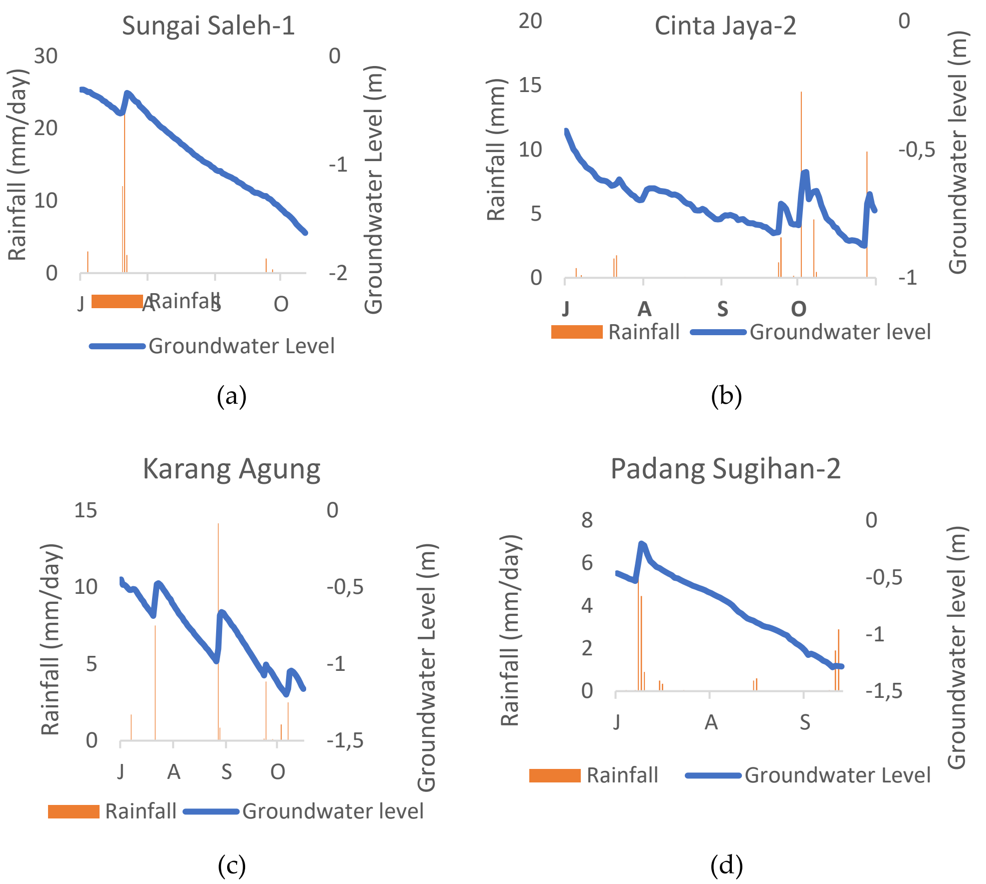


Figure 2.34. Overlay graph of groundwater level and rainfall in the 2019 J-A-S-O period

A.3. Relationship between groundwater level and hotspots in the 2019 J-A-S-O period

Figure 2.35 presents an overlay graph showing the relationship between GWL and the number of hotspots. The data used for this analysis were collected from July to October 2019 at six measurement stations: Cinta Jaya-1, Cinta Jaya-2, Sungai Saleh-1, Padang Sugihan-2, Padang Sugihan-3, and Karang Agung. The graph indicates that, in general, as the GWL increased, the number of hotspots tended to decrease, and vice versa. This suggests a clear relationship between GWL and the number of hotspots, making it possible to use GWL as a parameter for managing hotspot emergence in peatland. By maintaining groundwater at a certain level, it is expected that the occurrence of hotspots could be prevented. Therefore, it is crucial to determine the critical GWL necessary to avoid the emergence of hotspots.

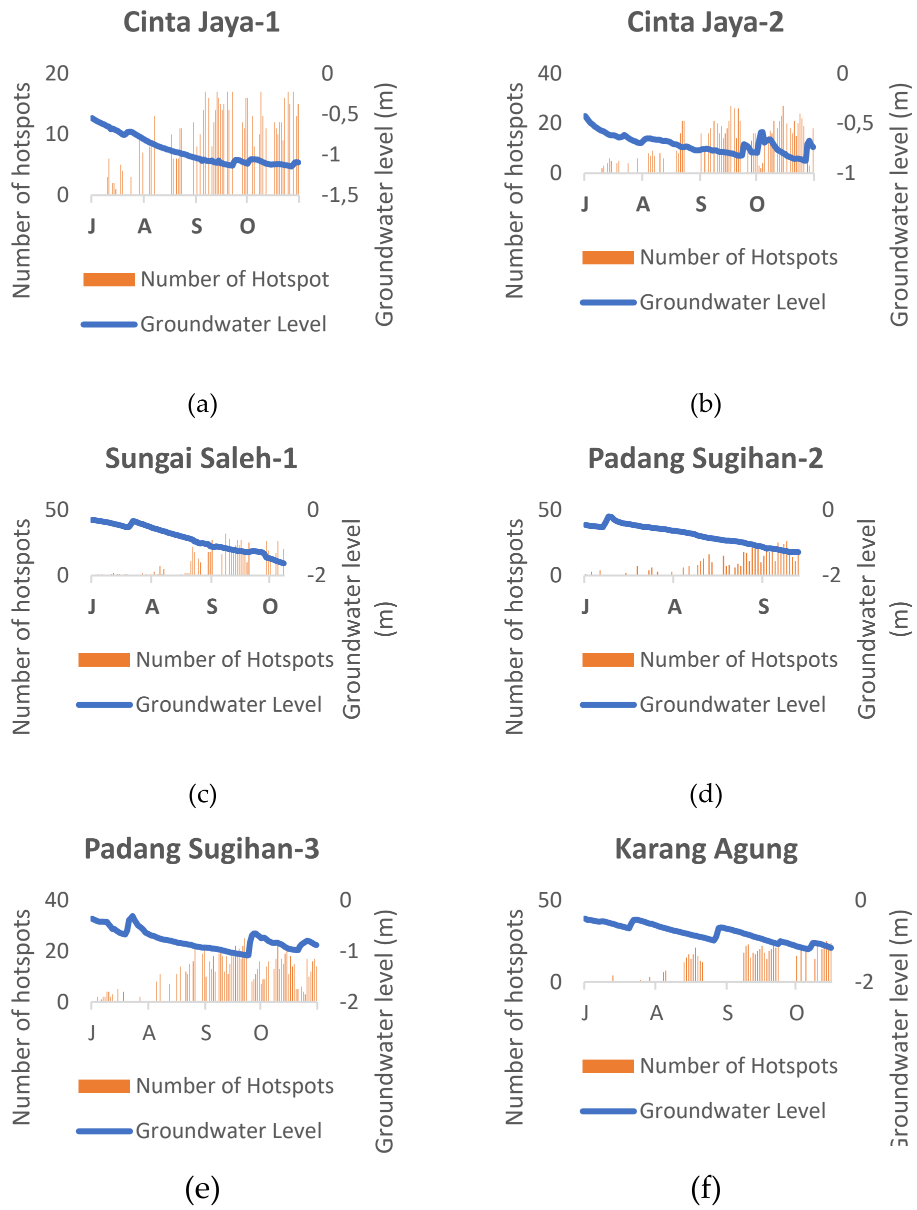
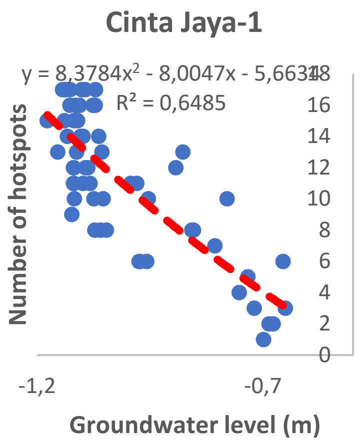


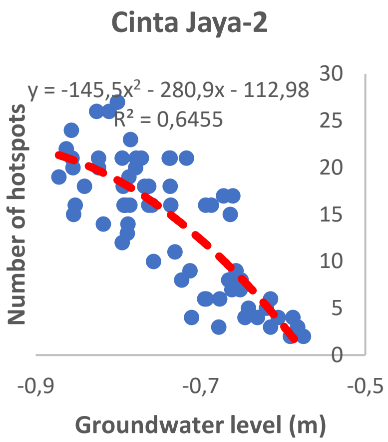
Figure 2.35. Overlay graph of groundwater level and hotspots in the J-A-S-O period of 2019

A.4. Critical value for groundwater level

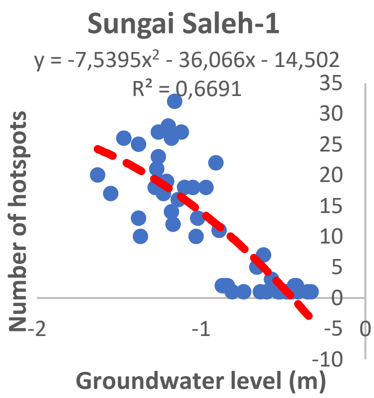
A graph depicting the correlation between these two parameters is shown in Figure **2.36**. The graph also shows the empirical equations obtained and the values of the coefficients of determination. The results of the statistical analyses are presented in **Table 2.5.** In this table, n represents the amount of data, r is the correlation coefficient, t signifies the t-value based on the calculations, and t is the t-value from the t-test table. As shown in **Table 2.6**, the correlation between GWL and hotspots is significant at all study locations, therefore, the empirical equations obtained can be applied in further related studies. The critical value of GWL can be calculated based on the empirical equation describing the correlation between GWL and the number of hotspots obtained. By assigning a value of Y = 0 to the empirical equation, the corresponding value of X can be obtained. In this case, the Y variable represents the number of hotspots and the X variable represents the GWL. Statistical data calculated for critical GWL are presented in **Table 2.6.**



(a)



(b)



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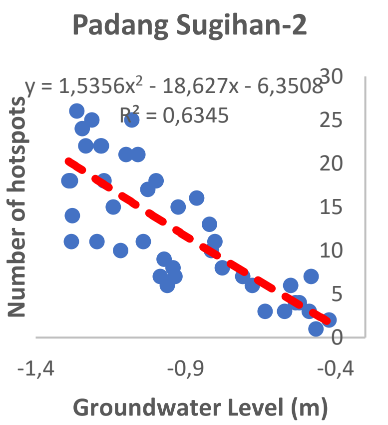

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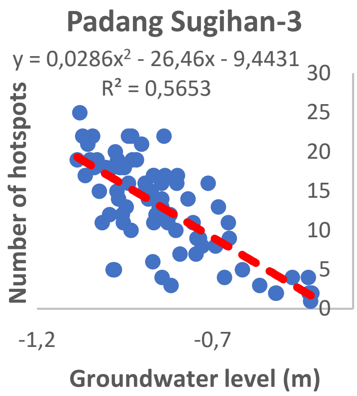
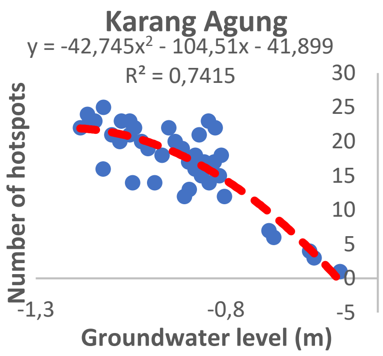


(e)



(f)

Figure 2.36. Correlation between groundwater level and hotspots in the period J-A-S-O 2019

Table 2.5. Statistical data for the correlation between GWL and number of hotspots

Station Name	*n*	*r*	*t*-count	*t*-table	Significance
Sungai Saleh-1	48	0.82	9.72	2.01	Significant
Cinta Jaya-1	50	0.81	9.57	2.01	Significant
Cinta Jaya-2	68	0.80	10.83	2.00	Significant
P. Sugihan-2	42	0.80	8.43	2.02	Significant
P. Sugihan-3	72	0.75	9.47	1.99	Significant
Karang Agung	40	0.86	10.39	2.02	Significant

Table 2.6. Statistical data for determining critical groundwater level

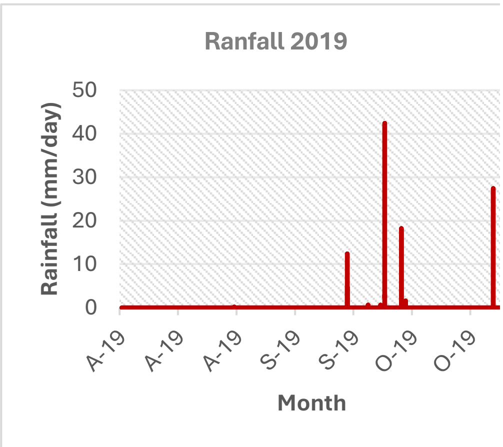
Station Name	Empirical Equation of GWL vs. Hotspots	Critical of GWL (m)
Sungai Saleh-1	Y = −7.5–95X² – 36–066X – 14.502	−0.44
Cinta Jaya-1	Y = 8.3–84X² – 8.–047X – 5.6634	−0.47
Cinta Jaya-2	Y = −14–.5X² – 28–.9XX – 112.98	−0.57
Padang Sugihan-2	Y= 1.5–56X² – 18–627X – 6.3508	−0.33
Padang Sugihan-3	Y = 0.0–86X² – 2–.46X – 9.4431	−0.36
Karang Agung	Y= −42.–45X² – 10–.51X – 41.899	−0.50

The data obtained from critical GWL calculations at the six study locations were averaged and analyzed with the inclusion of standard deviation. Consequently, the average critical GWL value was determined to be (−0.45 ± 0.09) m

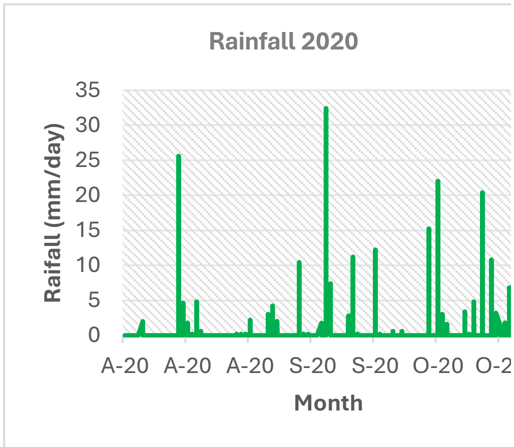
B. Peatland Hydro-climatological Parameters Variability in Response to 2019–2022 Climate Anomalies in the OKI Regency

B.1. Rainfall Dynamics

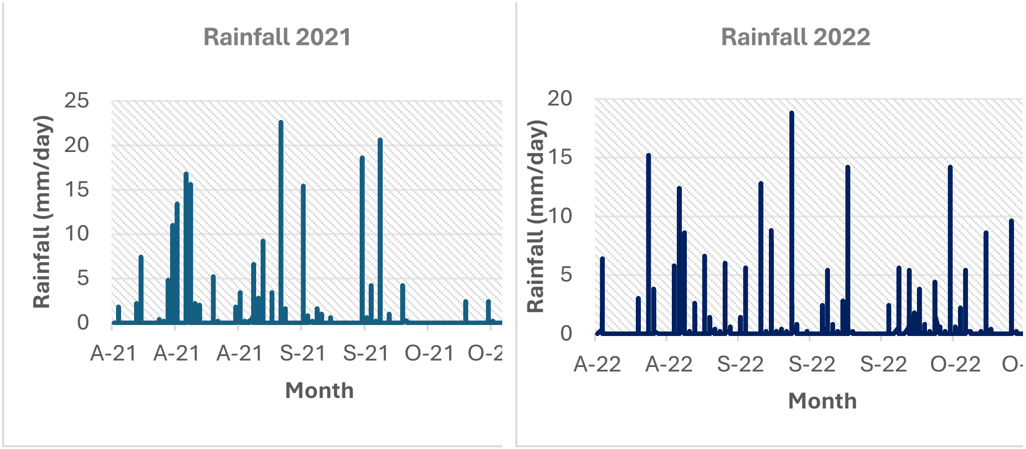
Figure 2.37 presents a rainfall time series graph for the August–October periods of 2019–2022**. Figure 2.37 (A)** illustrates extremely low rainfall, particularly in August 2019, when there was almost no rainfall. In the August–October period of 2019, the amount of rainfall that occurred was only 130.4 mm. In 2020–2022, the La Niña and IOD+/IOD– phenomena occurred, resulting in more rainfall during the dry season of August–October than that observed in 2019. This is illustrated in Figures 2.9 (b)–(d). The rainfall amounts during the dry seasons of 2020, 2021, and 2022 were 294 mm, 317 mm, and 371.6 mm, respectively. In 2022, the amount of rainfall was the highest due to the occurrence of moderate La Niña and moderate IOD phenomena. In 2020, a moderate La Niña and weak IOD+ occurred, whereas in 2021, a moderate La Niña and weak IOD– phenomenon occurred.



(A)



(B)

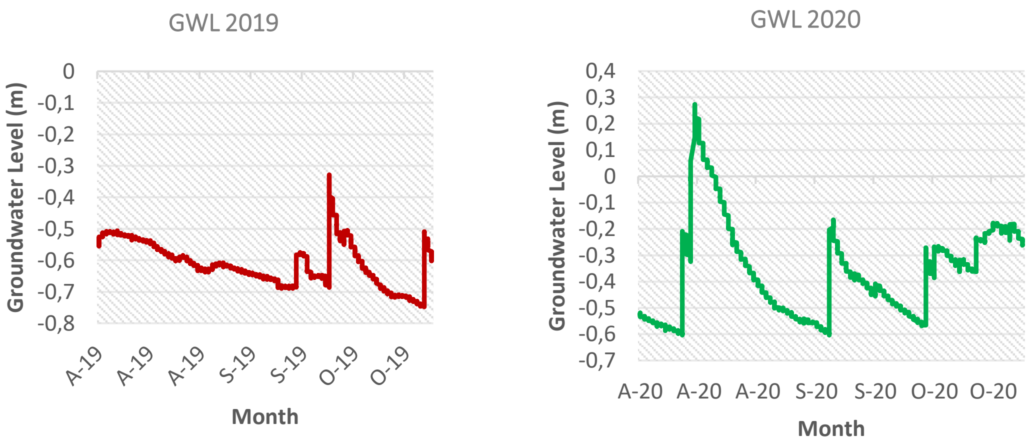


(C) (D)

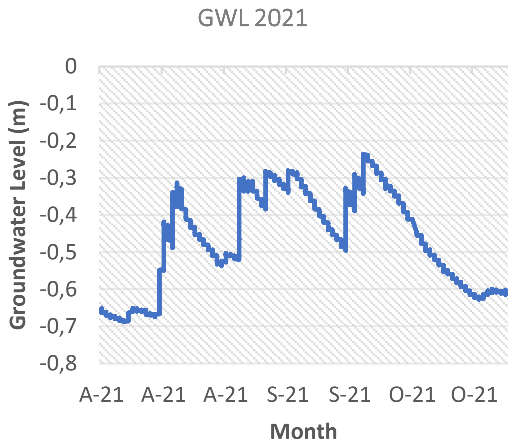
Figure 2.37. Time series graph of rainfall in August–October periods of 2019–2022

B.2. Groundwater Level Dynamics

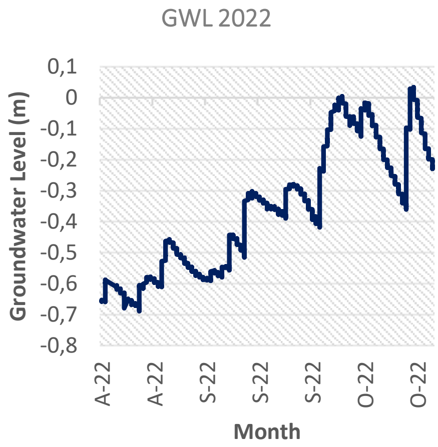
Figure 2.38 displays the GWL time series graph for the August–October periods of 2019–2022. **Figure 2.38 (A)** shows that the graph depicting the decrease in GWLs between August and September closely approximates a straight line. This can be attributed to the minimal rainfall during this period. The graph exhibits an irregularity in October because of the onset of rainfall. The lowest GWL reached was −0.748 m on October 29, 2019. In Figures 2.31 (b)–(d), the irregular graphic shape of the decrease in GWL can be attributed to the rain caused by La Niña and IOD+/IOD− during that period. In general, the groundwater level was still below ground level throughout 2019–2022, except on October 26, 2022. On that specific date, the GWL was 0.012 m higher than the ground level. This can be attributed to the higher amount of rainfall in 2022 compared to that in 2019–2021.



(A) (B)



(C)



(D)

Figure 2.38. Time series graph of groundwater levels in the August–October periods of 2019–2022

B.3. Rate of Groundwater Level Decline in 2019

There was only one rain event for the period August 1 to September 24, 2019, namely on August 29, 2019, with only 0.2 mm of RF. Because of the minimal RF (close to 0), the GWL reduction graph appears almost linear. Statistical analysis was used to produce a linear regression graph, depicted in **Figure 2.39**, with the line represented in green. Figure 2.32 displays the linear line equation for the decreasing GWL: Y = -0.0033X + 143.96. This equation can be used to determine the rate of decrease in the GWL. The period of decreasing GWL (ΔX) spanned from August 1 to September 24, 2019, totaling 55 d. In this equation, if X = 1, then Y1 = -0.0033 (1) + 143.95 = 143.9467 m. If X = 55, then Y55 = -0.0033 (55) + 143.95 = 143.93357 m. The decrease in GWL during this period was ΔY = Y1-Y55 = 143.9467 - 143.9335 = 0.0132 m = 1.32 cm. Therefore, the rate of GWL decline is VGWL= ΔY/ΔX = 1.32 cm / 55 d = 0.024 cm/d = 0.24 mm/d. Research on calculating the rate at which GWLs decline has been carried out at another location, namely at Kedaton OKI. This study found that the rate of GWL decline was VGWL = 0.71 cm/d. The rate of GWL decline in CJ2 is lower compared to that in Kedaton. The difference in this value can be attributed to the greater tree density found at the CJ2 location compared to Kedaton. Consequently, the roots of the trees in CJ2 exhibited increased resilience despite the decreasing GWLs.

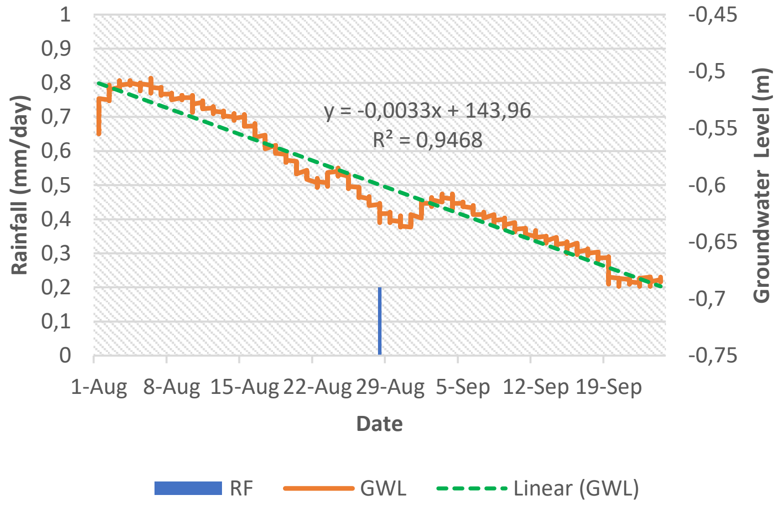
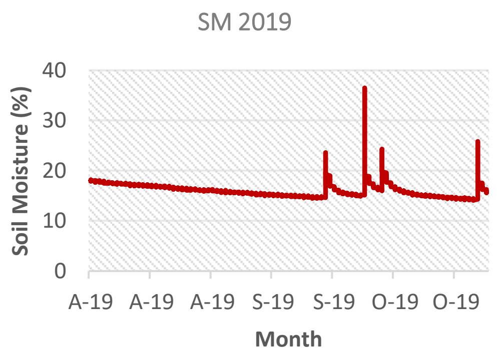


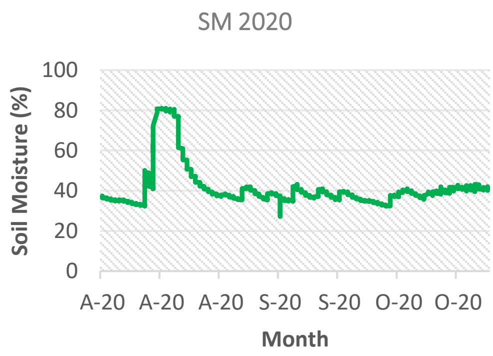
Figure 2.39. Decreasing groundwater levels in August–October 2019

B.4. Soil Moisture Dynamics

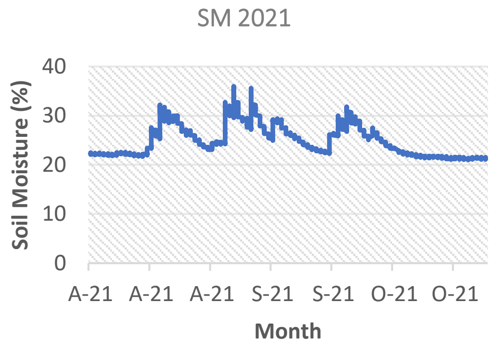
Figure 2.40 displays an SM time series graph for the August–October periods of 2019–2022. In **Figure 2.40 (A)**, the SM value in the August–September 2019 period was below 20%. This condition was caused by low GWLs due to minimal rainfall during that period and resulted in the peatlands on the surface becoming extremely dry, rendering them highly susceptible to catching fire. Figures 2.40 (B)–(D) show that SM was generally above 20% during the same periods in 2020–2022. Based on this graph, it can be concluded that in order to prevent catching fire easily, the surface SM of peatlands should be maintained at a minimum of 20%. Previous research at the OKI-1 location in 2019 reported a low SM value of 10% with a maximum GWL depth of -1.14 m. At the CJ2 location, the minimum SM was 20%, and the GWL reached a maximum depth of -0.748 cm.



(A)



(B)



(C) (D)

Figure 2.40. Time series graph of soil moisture in the August–October periods of 2019–2022

B.5. The rate of soil moisture decline in 2019

Figure 2.41 displays a time series graph illustrating Soil Moisture reduction from August 1 to September 24, 2019, spanning a total of 55 d. The X-axis represents time, and the Y-axis denotes the SM values (%). When X = 1, then Y1 = -0.0622 (1) + 2734.9 = 2,734.8378%. When X = 55, then Y55 = -0.0622 (55) + 2,734.9 = 2,731.479%. ΔY = 2,734.8378 − 2,731.479 = 3.3588% and ΔX = 55 d. Therefore, the rate of decrease in SM was VSM = 3.3588% / 55 d = 0.06%/d.

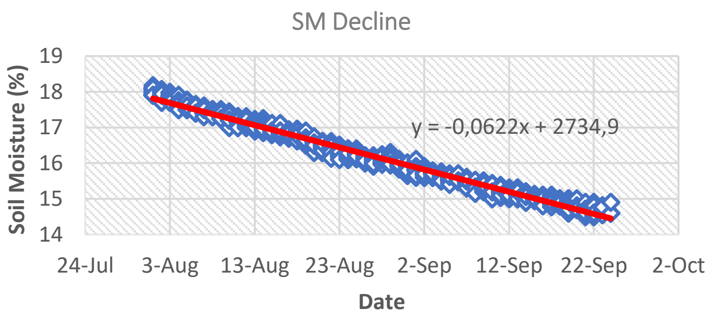
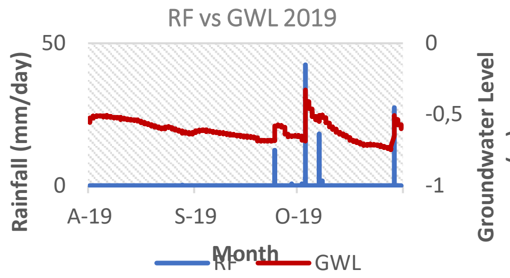


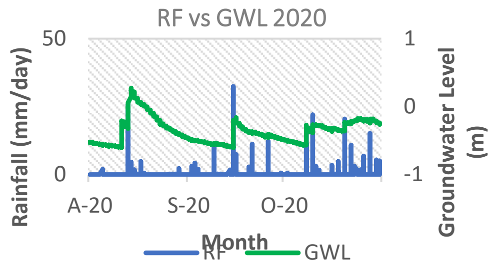
Figure 2.41. Graph of soil moisture decreasing from August 1 to September 24, 2019

B.6. Relationship between Rainfall and Groundwater Level

Figure 2.42 displays the relationship between rainfall and GWLs in the August–October periods of 2019–2022. In general, the four graphs suggest a relationship between rainfall and GWL, indicating that higher rainfall is associated with higher GWLs and vice versa. Therefore, in the next section, we determined the magnitude of the correlation between these two parameters.



(a)



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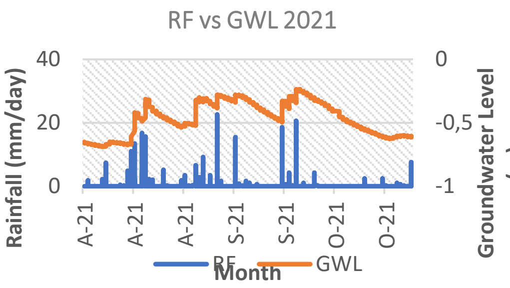

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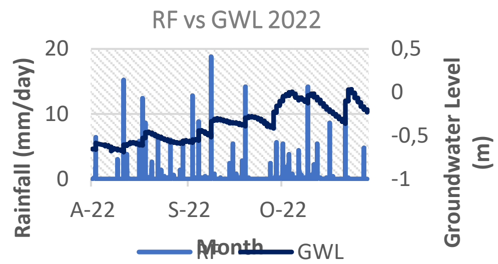
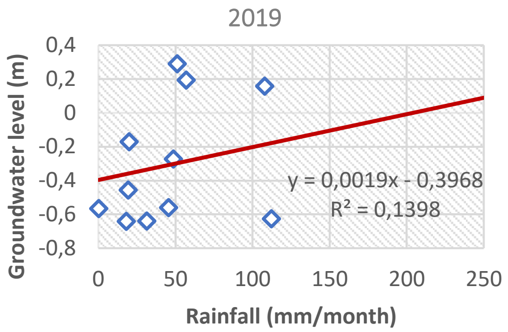


(d)

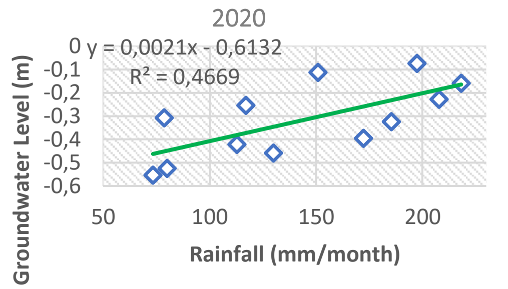
Figure 2.42. Graph of the relationship between rainfall and groundwater levels in the August–October periods of 2019–2022

B.7. Correlation between Rainfall and Groundwater Level

Figure 2.43 depicts a graph illustrating the correlation between rainfall and GWLs in the August–October periods of 2019 and 2020. **Figure 2.43** (A) displays the correlation between these two parameters in 2019 when a strong IOD+ event occurred, which caused an extremely dry season. The correlation coefficient (r) was only 0.37, indicating a weak correlation. **Figure 2.36** (B) displays the correlation between rainfall and GWLs in 2020, when a moderate La Niña event occurred, where there was a higher amount of rainfall compared to 2019. The correlation between these two parameters was quite strong, as indicated by r = 0.68. This demonstrates that the higher the rainfall, the better the correlation between rainfall and GWLs, and vice versa.



(A)

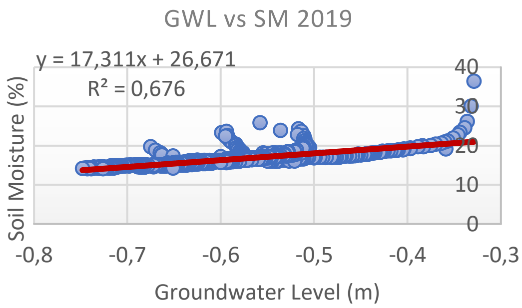


(B)

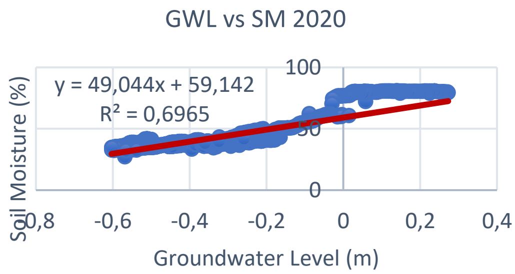
Figure 2.43. Correlation graph between rainfall and groundwater levels in the August–October periods of 2019–2020

B.8. Correlation between Groundwater Level and Soil Moisture

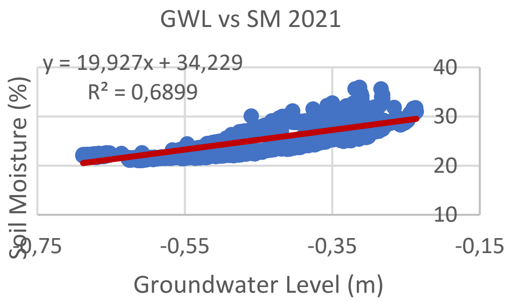
Figure 2.44 shows the correlation graph between GWLs and SM. Based on the four images, the correlation between GWLs and SM was relatively strong because of correlation coefficient values of r > 0.8. The r values for 2019, 2020, 2021, and 2022 were 0.822, 0.834, 0.830, and 0.814. Based on this r value, we can use the empirical equation between GWL and SM that has been generated to determine the SM value based on the GWL value.



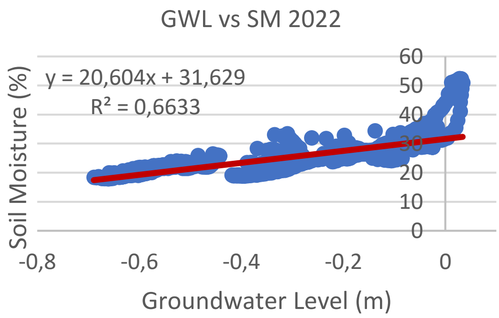
(A)



(B)



(C)



(D)

Figure 2.44. Correlation graph between groundwater levels and soil moisture in the August–October periods of **2019–2020**

Previous research on four peatland locations in Sungai Lumpur 1, Sungai Lumpur 2, Sungai Saleh 1, and Sungai Saleh 2 produced r values > 0.8 [43]. These results indicate a strong correlation between these two parameters. Based on the four empirical equations that were obtained, we selected the empirical equation for 2020 because it had the highest r-value. The empirical equation is Y = 49,044 X + 59,142, where Y is SM (%) and X is GWL or SM = 49.044 GWL + 59.142.

B.9. Hotspot Analysis

In **Figure 2.45 (A)**, it can be observed that in the August–October period of 2019, the GWL position consistently remained below -0.4 m. The lowest GWL position occurred on October 29, 2019, reaching a depth of −0.748 m. According to previous research, the GWL should be at a level above −0.4 m to prevent hotspots from appearing. During this period, many hotspots emerged, leading to extensive fires in the OKI peatlands. During the 2020–2022 period, the GWL did not consistently remain below −0.4 m; therefore, the occurrence of hotspots was relatively limited. The National Research and Innovation Agency of Indonesia (BRIN) provides information on the number of hotspots in Indonesia on its website (https://hotspot.brin.go.id/). These data are obtained from several satellites. The hotspot data for the August–October periods of 2019–2022 in the OKI Regency based on MODIS satellite data from the website (downloaded on April 20, 2024) were illustrated in Figure 2.38. Figure 2.38 shows that the highest number of hotspots occurred in 2019, which can be attributed to the strong IOD+ phenomenon. The lowest number of hotspots occurred in 2022 as a result of the moderate La Niña and moderate IOD− phenomena.

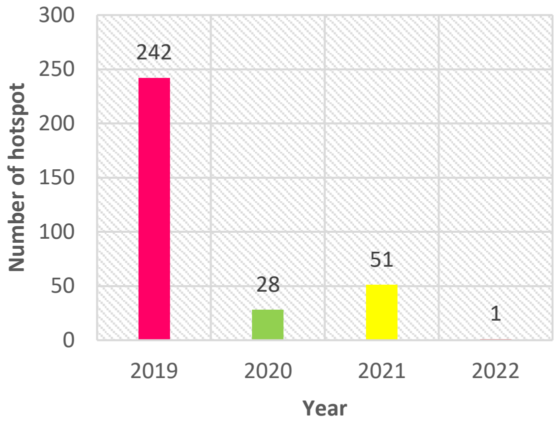


Figure 2.45. Number of hotspots in the OKI Regency in the August–October periods of 2019–2022

C. The Impact of Positive IOD and La Niña on Rainfall, Groundwater Level, and Soil Moisture in Peatlands in South Sumatra

C.1. Dynamics of rainfall

The dynamics of rainfall in 2019 and 2020 are displayed in the form of a time series graph as shown in **Figure 2.46**. The analysis in Figure 2.46 focuses on the months July to October (JASO) 2019 and 2020. In Figure 2.46 it can be seen that in 2019 the peak of the dry season occurred in September where the rainfall was only 10.6 mm. The peak of the dry season in 2020 occurred in August when rainfall amounted to 29.8 mm. In the JASO 2019 period there was 95 mm of rainfall and in JASO 2020 the amount of rainfall was 301.4 mm. If we compare the data, the amount of rainfall in the JASO 2020 period is much higher than in 2019. Based on two years of data, can it be concluded that the natural phenomena IOD+ 2019 and La Niña 2020 have indeed affected precipitation on peatlands in the study area.

Table 2.7. Monthly data on rainfall, groundwater level, and soil moisture

	Rainfall (mm/month)		Groundwater Level (m)		Soil Moisture (%)	
	2019	2020	2019	2020	2019	2020
January	169	167.6	0.07	-0.08	48.95	33.69
February	162.2	84.4	0.13	-0.01	55.09	41.4
March	209.8	161.8	0.05	-0.1	48.43	31.8
April	183.2	203.2	0.12	0.01	52.09	44.26
May	28	128	-0.1	-0.04	50.38	35.48
June	61	182.6	-0.11	-0.02	48.07	37.73
July	37.4	58	-0.3	0.06	40.87	34.45
August	22	29.8	-0.54	-0.31	31.89	28.95
September	10.6	133.6	-0.67	-0.23	23.63	29.3
October	25	80	-0.96	-0.17	20.46	31.16

November	95.8	99.6	-0.93	0	22.23	44.48
December	126.2	125.4	-0.31	-0.04	24.67	39.15

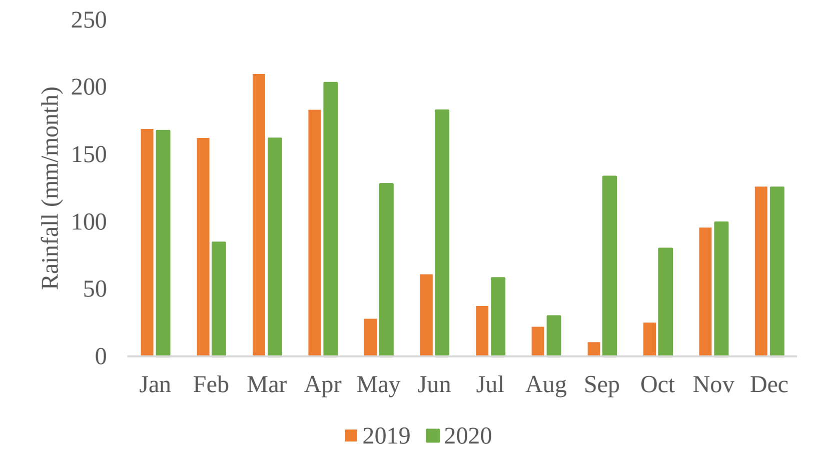


Figure 2.46. Time series of rainfall in 2019 and 2020

C.2 Dynamics of groundwater level

A time series graph regarding the dynamics of groundwater levels is shown in Figure 2.40. In this figure it can be seen that in the 2019 JASO period groundwater levels experienced a sharp decline and the peak occurred in October when it reached -0.96 m. In the 2020 JASO period groundwater levels also fell but not as sharply as in 2019. This shows that the IOD+ that occurred in 2019 had a big influence on the depth of groundwater levels which far exceeded the critical condition of -0.4 m. If groundwater levels exceed critical conditions, peatlands can easily catch fire. In 2020, the lowest groundwater level was -0.31 m, which is still above the critical point.

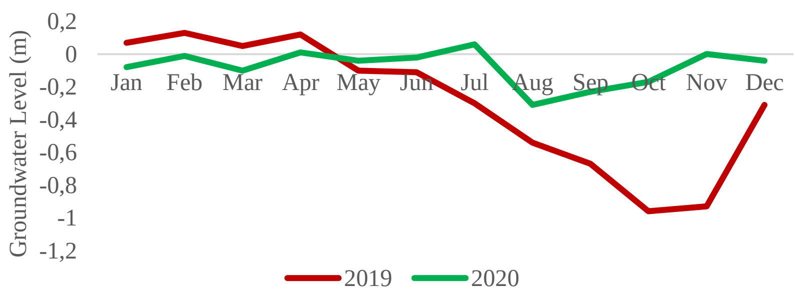


Figure 2.47. Time series of groundwater level in 2019 and 2020

C.3. Dynamics of soil moisture

Figure 2.48 displays a time series graph regarding the dynamics of soil moisture on the surface of peatlands in 2019 and 2020. In this figure it appears that in the 2019 JASO period soil moisture experienced a quite sharp decline. The lowest soil movement in 2019 occurred in October, namely 20.46%. This condition causes the surface of the peatland to become very dry. The decline in soil moisture in 2022 will not be as sharp as in 2019.

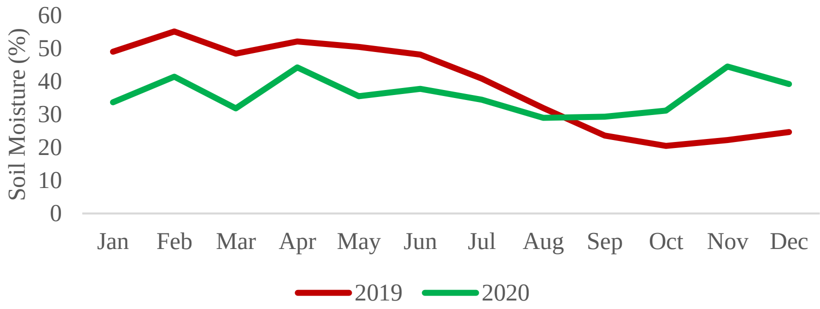


Figure 2.48. Time series of soil moisture in 2019 and 2020

C.4 Relationship between rainfall and groundwater level

A graphic of the relationship between rainfall and groundwater level is shown **in Figure 2.49**. In this figure it appears that there is a tendency that the higher the rainfall, the higher the groundwater level and vice versa. This shows that groundwater levels in peatlands are strongly influenced by rainfall. In the 2019 JASO period, it was clear that minimal rainfall caused groundwater levels to fall sharply.

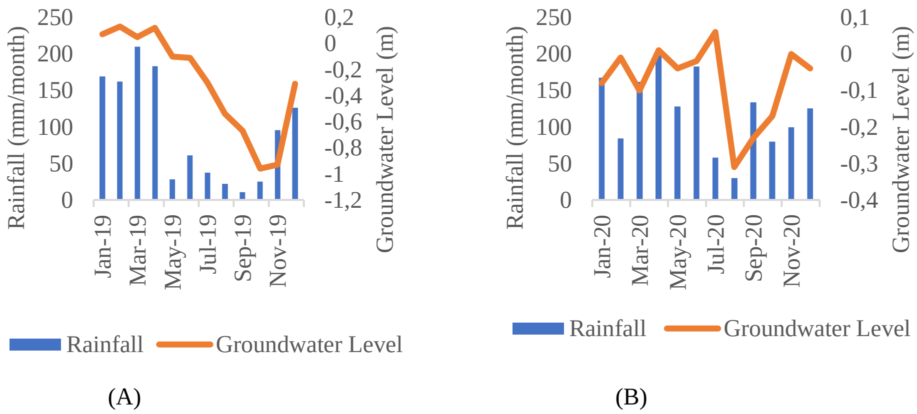
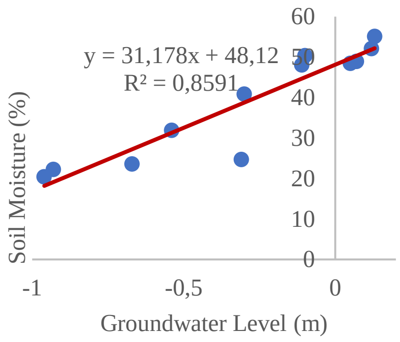


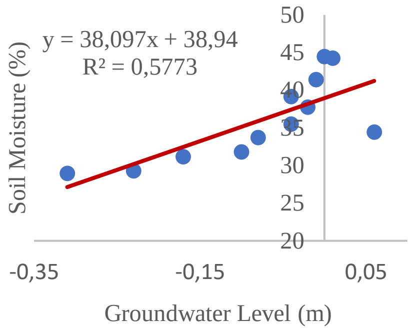
Figure 2.49. Relationship between rainfall and groundwater level in 2019 (A) and 2020 (B)

C.5. Correlation between groundwater level and soil moisture

The correlation graph between groundwater level and soil moisture is shown in **Figure 2.50**. The linear regression equation between groundwater level and soil moisture in 2019 is Y = 31,178 X + 48.12 and for 2020 it is Y = 38,097 + 38.94.



(A)



(B)

Figure 2.50. Correlation between groundwater level and soil moisture in 2019 (A) and 2020 (B)

The correlation coefficient between these two variables in 2019 was r = 0.93 and for 2020 it was r = 0.76. Based on the correlation coefficient (r) value in 2019 and 2020, it can be concluded that the correlation between groundwater level and soil moisture is quite strong. Especially in 2019, the correlation coefficient was very strong because the r value was almost close to 1. If you compare the correlation coefficient values in these two years, the correlation coefficient when the IOD+ phenomenon occurred was higher than when La Nina occurred. It can also be concluded that the correlation is stronger if the rainfall is minimal.

D. The Impact of Positive IOD and El Niño on Rainfall, Groundwater Level, and Soil Moisture in Peatlands in OKI Regency

D.1. Rainfall

The dynamics of rainfall are shown in **Figure 2.51.** In Figure 2.51 it appears that very minimal rainfall occurred in August 2023 until October 2023. In fact, from 26 August to 8 October (43 days) there was no rainfall at all (rainfall = 0). If we calculate the average rainfall for the period July to November (JASON) 2023, we get only 0.15 mm/month. This very minimal rainfall is because in 2023 two natural phenomena occurred at once, namely IOD+ in the Indian Ocean and El Nino in the Pacific Ocean. These two phenomena cause a lack of rainfall in most parts of Indonesia, including OKI Regency.

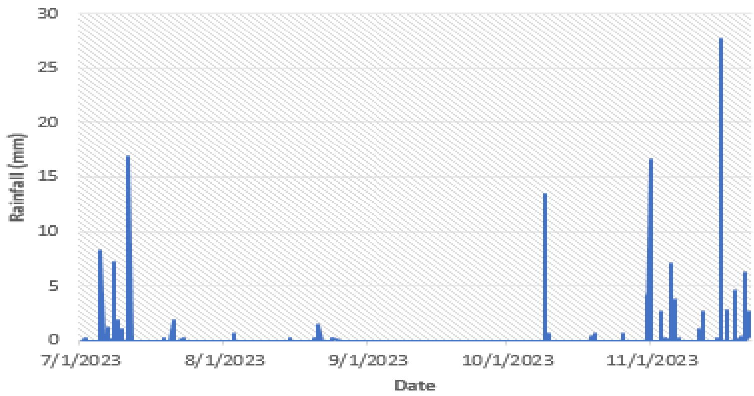


Figure. 2.51. Time series graph of rainfall.

D.2. Groundwater Level

The dynamics of groundwater levels in the JASON 2023 period are shown in **Figure 2.52**. In Figure 2.52. it appears that in the JASON 2023 period the trend of groundwater levels is decreasing. The lowest value of groundwater level achieved was -1.93 m which occurred on November 16. This value is much lower than the minimum groundwater level that must be maintained to prevent peatlands from burning, namely -0.4 m. Therefore, in JASON 2023 period there were severe fires on peatlands.

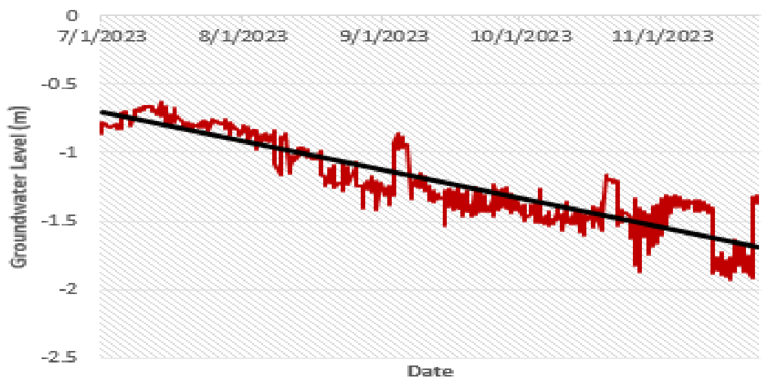


Figure. 2.52. Time series graph of groundwater level.

D.3. Soil Moisture

Figure 2.53 displays a time series graph regarding soil moisture dynamics. In the graph it appears that during the JASON 2023 period the trend of soil movement is decreasing. In JASON 2023 the lowest soil moisture was 7.87 % in November 14. The lack of rainfall causes groundwater levels to drop so that soil moisture on the peat surface also decreases so that the soil surface of the peat land becomes dry. This dry soil surface causes it to become flammable.

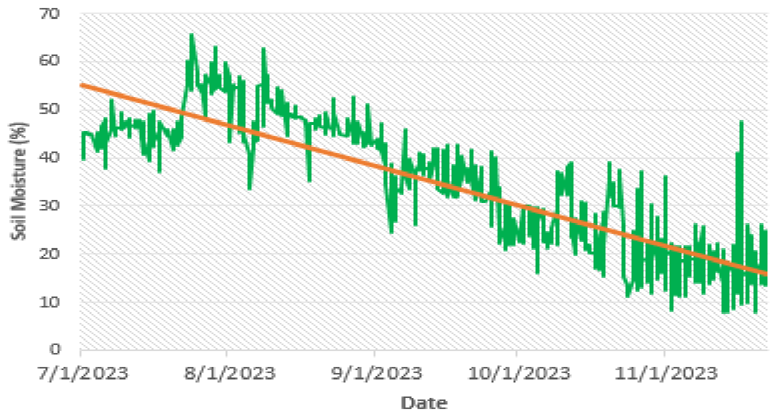


Figure. 2.53. Time series graph of soil moisture.

D.4. Correlation between Soil Moisture and Groundwater Level

Figure 2.54 displays a correlation graph between soil moisture (SM) and groundwater level (GWL) in the JASON 2023 period. In this figure it appears that groundwater level has a fairly close relationship with soil moisture where the correlation coefficient (r) = 0.75. The empirical equation which states the correlation between these two parameters is SM = 30.172 GWL + 70.119. It can also be seen in the picture that soil moisture is influenced by the groundwater level, where the higher the groundwater level, the higher the soil moisture.

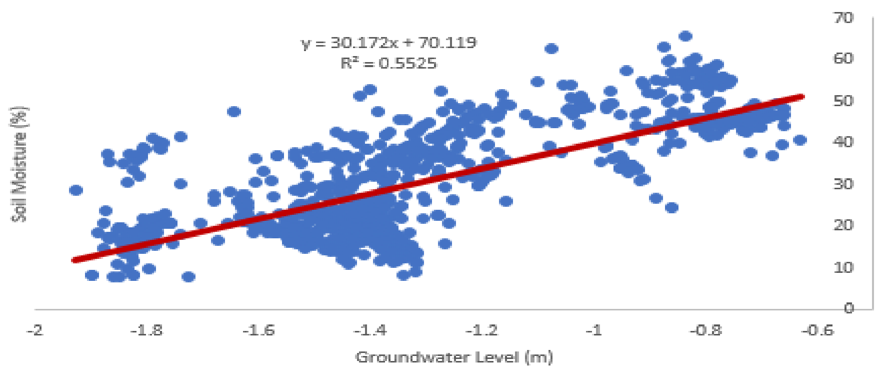


Figure. 2.54. Graph of correlation between soil moisture and groundwater level.

2.2.3.2. Achievement to support second year research

In this first year, field activities were also carried out in Perigi Village to support activities in the second year (2025). The types of activities and their explanations are:

1. Preparation and acquisition using: 1 unit of RGN Multispectral UAV, 3 Water Level Loggers units, Meter and Deep Water Level, and Other sampling equipment.

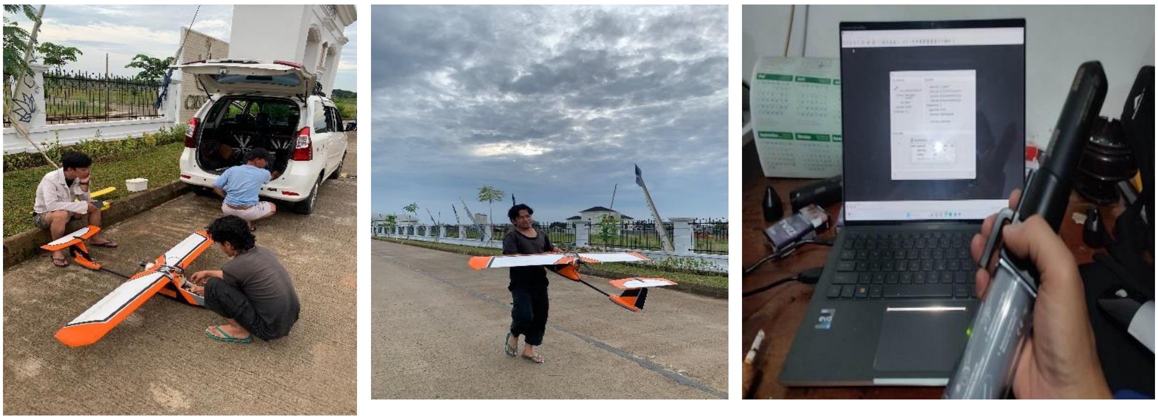


Figure 2.55. Setting of equipment

2. Implementation of Field Surveys: Installation of water level loggers at 3 sampling points and RGN Multispectral UAV survey of the planned area.

Figure 2.56. Installation of water and position of water level logger

3. Taking a water level logger and re-measuring aerial photos with a camera equipped with RGB and OCN image sensors.

Figure 2.57. Measuring aerial photos with a camera equipped

4. Measurement Results: Water Level, RGB Image Map from Drone Survey, and OCN Image Map from Drone Survey. Water level measurements at 3 location points (WL01, WL02 and WL03) were carried out using hourly sampling periods from June 3 to July 12 2024. The measurement results are presented as follows:

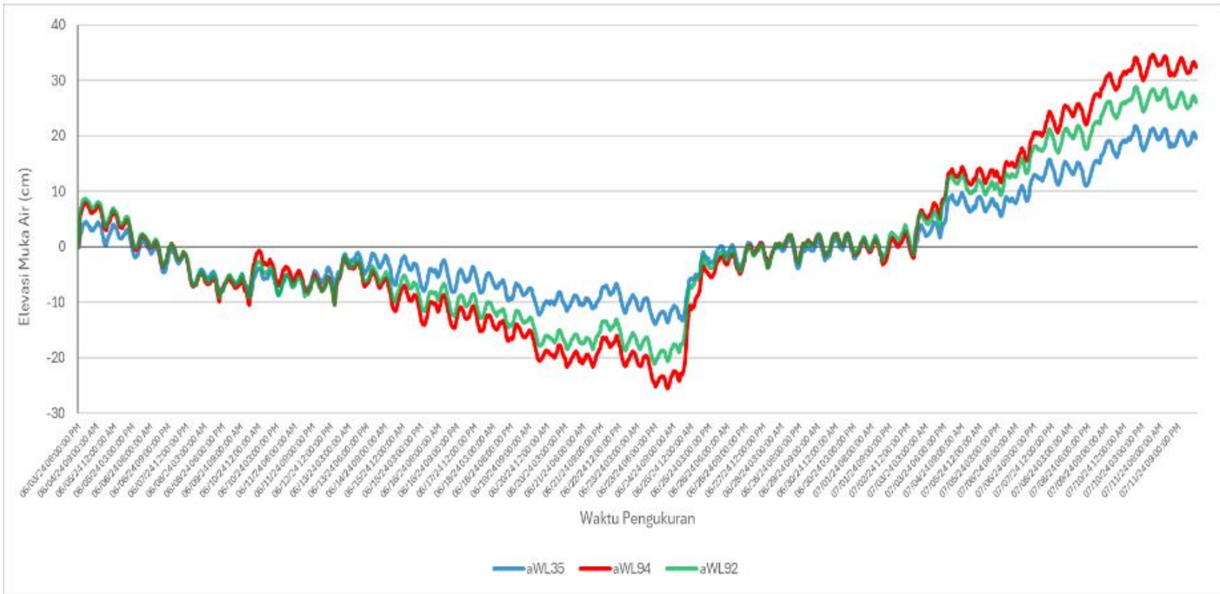


Figure 2.58. Time series of water level

The rainfall data used in the image above was taken by BMKG Palembang. As an initial illustration, Stations WL01 and WL03 are input channels from the water catchment area in the Study Area, while WL02 is an output channel. The increase in water level in the field will increase significantly when daily rainfall is above 15 mm. This is related to the limited output channel from the location to the river.

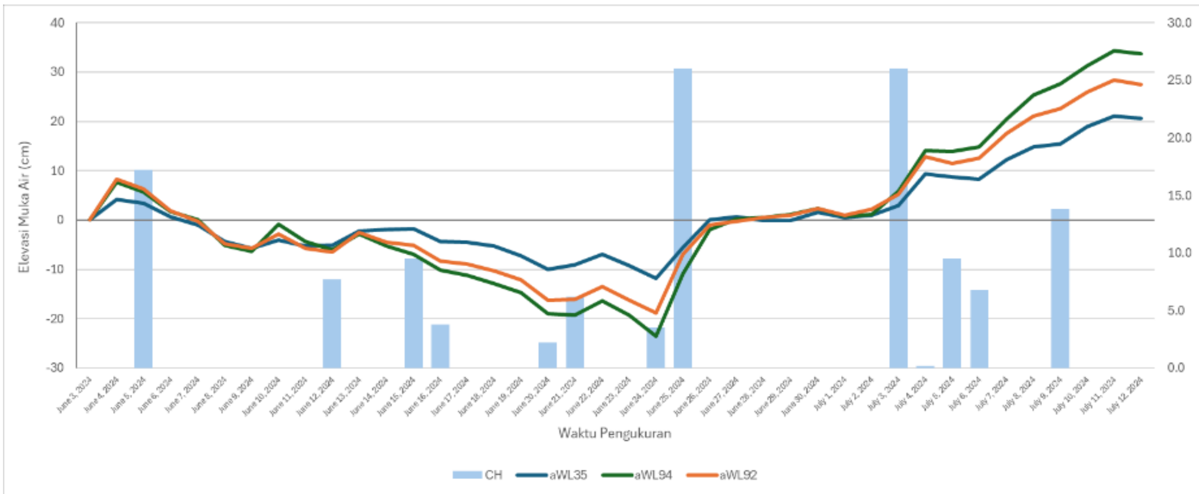


Figure 2.59. Time series of water level and rainfall

The RGB image map from the drone is quite good at describing the spatial area of the study location. Further analysis of the use of this data still needs to be carried out in describing the characteristics of the study area.

Figure 2.60. RGB Image Map from Drone Survey

The OCN image map is still being processed, the data above still contains many image overlays so that pre-processing still needs to be handled.

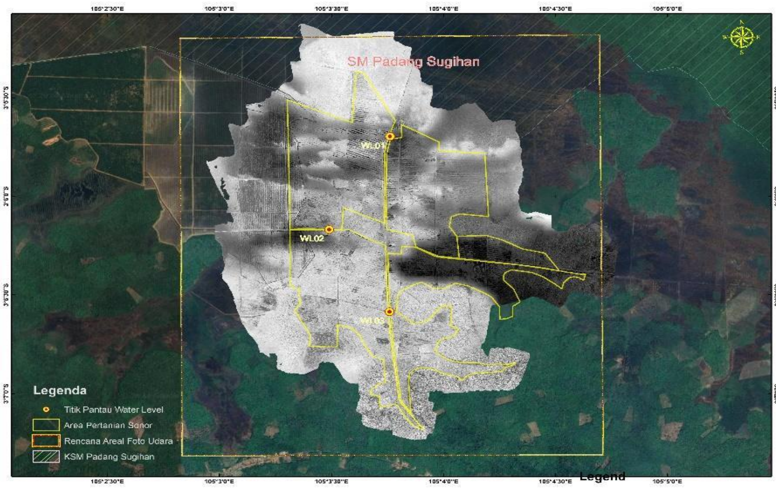


Figure 2.61. OCN Image Map resulting from Drone Survey

2.2.4. Conclusion

From 2019 to 2023, there are three natural phenomena, namely IOD+ in 2019, La Nina in 2020-2022, and IOD+ together with El Nino in 2023. When IOD+ and/or El Nino occur in the dry season, rainfall (RF) is minimal, groundwater levels (GWL) are very low, soil moisture (SM) is also very low, and many hotspots (H) emerge. When La Nina occurs in the dry season, RF is above average.

When the IOD+ phenomenon occurred in 2019, especially in the July to October (JASO) period, the values of RF, GWL and SM parameters fell sharply. Meanwhile, in the JASO 2020 period, the values of these three parameters did not decrease sharply. It was also found that RF greatly influences GWL. Then it was also found that in 2019 the correlation between GWL and SM was very strong. Meanwhile the correlation in 2020 is not as strong as in 2019.

When the IOD+ and El Niño phenomenon occurred in 2023, especially in the July to November (JASON) period, the values of RF, GWL and soil SM parameters fell sharply. It was also found that RF greatly influences GWL. Then it was also found that in JASON 2023 the correlation between GWL and SM was quite strong.

The study presents several novel findings. First, a positive correlation between RF and GWL was established, with a stronger correlation observed with higher RF. Second, the rate of GWL decline on peatlands in CJ2 OKI was 0.24 mm/d. Third, the rate of SM decline on peatlands in CJ2 OKI was 0.06%/ d, which prevented fires from occurring on peatlands in CJ2 OKI as long as SM was maintained at a minimum of 20%. Lastly, the empirical equation that connects GWL (m) with SM (%) on peatlands in CJ2 OKI was SM = 49,044 GWL + 59,142. This equation can be used to determine SM if the groundwater level is known for peatlands, especially in OKI Regency.

This research convincingly demonstrates a significant correlation between GWL and H in several peatland areas in South Sumatra. As a result, GWL can serve as a crucial parameter for controlling H and minimizing fires in peatland. Based on the study findings, **it is recommended to maintain a Groundwater Level (GWL) depth of −0.45 ± 0.09 m i**n peatland in South Sumatra to minimize the occurrence of hotspots.

2.2.5. Research Plan on 2025

Research activities by the climate change team in the second year generally consist of two activities. The first activity is more focused on Perigi village, namely "*Analysis of water balance and design of hydrological systems in the peatlands of Perigi village*". The details of the activities are:

2.2.5.1. Introduction

Based on the analysis of rainfall patterns in the area around the study area (results of the first year of research), it is indicated that the rainfall pattern is greatly influenced by the global climate phenomena ENSO and IOD. The combination of the influence of the El Nino and IOD+ phenomena causes the study area to experience severe and very severe drought conditions. Extreme drought conditions will always have an impact on increasing the level of vulnerability to forest and land fires. Based on hotspot data that occurred around the study location, it indicates that the extreme drought conditions are in line with the occurrence of forest and land fires in the study area and its surroundings. Indirectly, this indicates that the study area has characteristics that are highly dependent on the rainfall that occurs. In other words, it can be stated that the condition of the study area does not have the capacity and hydrological support so that during the dry season the area will immediately experience drought in line with the increasing potential for forest and land fires.

In the first year of research (2024), several activities have been carried out whose data will be used together with measurement data that will be carried out in the second year (2025). The activities are:

- Creation and analysis of the latest spatial data in the Perigi area using drones representing the dry and rainy seasons in 2024. Creation of spatial image maps at the study location is needed to see existing conditions. Mapping in wet and dry months is needed to see and/or calculate the distribution conditions of puddles/water in the study location. Another benefit of image data is to calculate the classification and area of existing land cover distribution. This will later be needed to be used as a parameter for calculating the evapotranspiration conditions that occur.
- Measurement of the water level elevation of the canal representing wet and dry conditions which concludes that the hydrological conditions in the Perigi area are very dependent and closely correlated to rainfall conditions. The main purpose of installing this water level device is to see the characteristics of the hydrological patterns that occur at the study location. Some things that can be concluded include:
  - ✓ Rainfall conditions play a very dominant role in the condition of water availability at the study location.
  - ✓ The pattern of the three study locations shows the same pattern so that the water conditions in each area are relatively the same and there is no intervention of water input from other sources other than rainfall that falls at the water catchment location.
  - ✓ There has been no treatment in managing water at the location.

2.2.5.2. Research Method

The research methods are:

- Monitoring and analyzing data from all hydro-climatology parameters that have been carried out and measured in the first year of research
- Carrying out a series of activities consisting of:

A. Evapotranspiration Calculation

1. Utilization of satellite data (sentinel).

   Calculation of NDVI (Normalized Difference Vegetation Index), LST (Land Surface Temperature), Solar Radiation (Rn) and Albedo as input parameters for calculating Evapotranspiration with the SEBAL (Surface Energy Balance Algorithm for Land) Model method using the SNAP/GE/Qqis tools. The results obtained are spatial patterns of evapotranspiration in the study area and its surroundings based on sentinel satellite data obtained in the time span in 2025.

2. Measurement of evapotranspiration in the field using a Piche Evaporimeter or Evaporation Pan.

   The equation used to calculate potential evapotranspiration (ETp) based on measured evapotranspiration data is ETp = kp x Eo

   Eo = class A pan evaporation (mm)

   kp = pan coefficient: 0.7-0.8

   The evapotranspiration measurement points are selected based on the division of land cover classification (minimum 3 points in each area of land classification results).

3. Correlation analysis between the measurement results of the Piche Evaporimeter tool and the variation in GWL measurements. At each evapotranspiration measurement point, a monitoring well was made (using a PVC pipe) and the groundwater level was measured. The measurement time for the variation in groundwater elevation was adjusted to the time of evapotranspiration data collection. The results of the GWL data variation will be correlated with the variation in evapotranspiration data that occurred.

4. Correlation analysis between the measurement results of the Piche Evaporimeter tool and the measurement results of the Sentinel Satellite. The results of the variation in

evapotranspiration data will be correlated with the spatial variations obtained from the sentinel data.

Points 1-4 are a unified process of calculation, verification and validation of evapotranspiration that occurs at the study location.

B. Runoff and flow rate calculations

1. Measurement and construction of BM (Bencmark) points at 4 locations if possible (3 at the same location in 2024 and 1 additional location around the canal divider that has been carried out by the hydrology team).
2. Creation of flow patterns and water catchment areas related to hydro-topographic conditions in the study area. The water catchment area will be made into 2 parts, one of which is the water catchment area affected by the creation of the canal divider that has been made.
3. Calculation of flow discharge. The flow discharge will be calculated in both areas, both in the area affected by the canal divider (WL04) and the area not affected by the canal divider (WL02). The flow discharge is calculated based on data on variations/elevation changes in the measurement area.

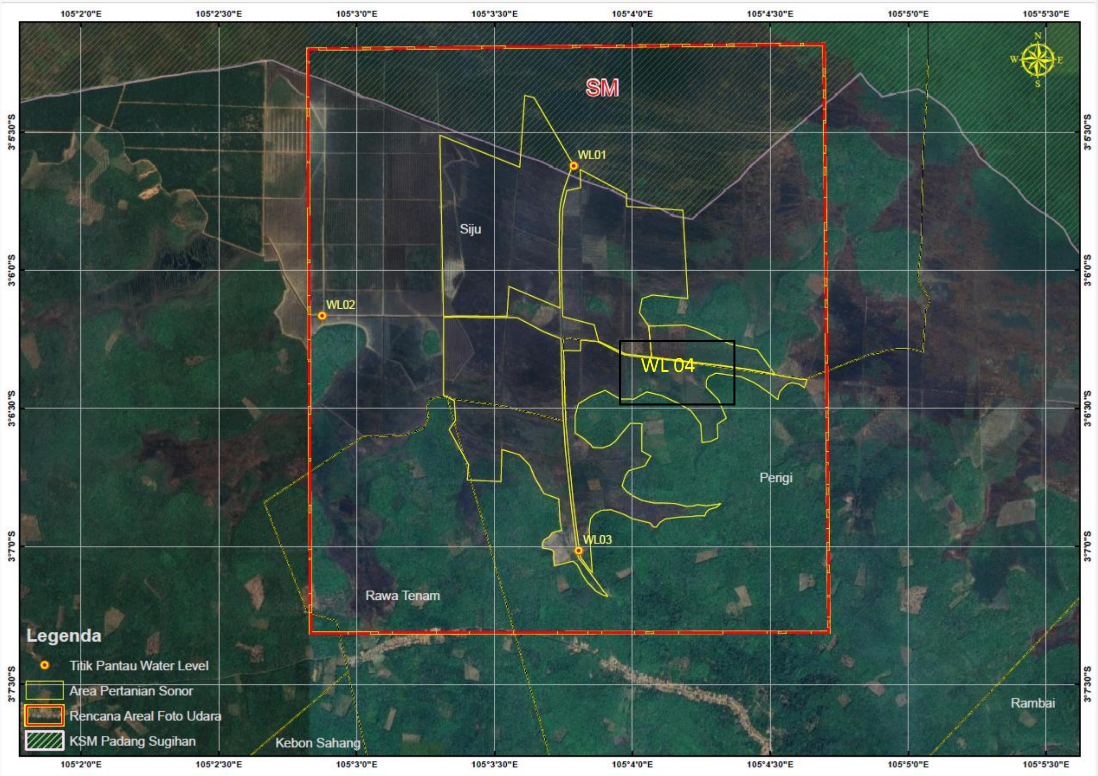


Figure 2.62. Research Location

C. Water Balance Analysis

1. Conducting water balance analysis based on input data (rainfall) and output data (evapotranspiration and runoff) that occur at the study location.
2. Monitoring and verifying spatial data using drone data during the rainy and dry seasons on the water balance conditions that occur.
3. Integrated analysis related to the impact of climate anomalies in 2019-2025 on the dynamics of hydro-climatological parameters that occur in the study area.
4. Analysis of the impact of water balance conditions in the canal blocking pilot project area.

2.2.5.3. Output

The output of this activity is an article entitled *Analysis of Water Balance and Design of Hydrological Systems in The Peatlands of Perigi Village* which will be published in a reputable international journal

2.3 Developing Model for Soil and Water Management in Lowland Agriculture under Various Soil and Hydro Climatic Condition

2.3.1. Introduction

Peatland areas are widely used for agriculture, plantation, and housing. Utilization in plantation and industrial forest crop (especially Akasia) and plantation (oil palm) are mostly cultivated on peatlands. Drainage (decrease in groundwater level) in peatlands can cause a decrease in the soil surface due to the acceleration of peat decomposition. This situation has the potential for large quantities of subsidence, which affect channel elevation, channel geometry, and channel configuration. Management of water by maintaining groundwater levels 30 to 50 cm is better for plantation and agroforestry crops, while at the same time reducing peat decomposition and mineralization levels, and preventing excessive CO2 emission. Further more effective water management (keeping the water level as high as possible) can reduce greenhouse gas emissions, land subsidence, and land fire risks.

Peatlands are very vulnerable and their existence must be maintained as stores of water and carbon stocks. However, due to inappropriate management, peatlands in Indonesia have experienced degradation, which has resulted in various environmental problems such as fire, flooding and subsidence. Excessive drainage can cause the peat to become dry and even vulnerable or flammable. In addition, the pyrite layers that are exposed can increase acidity, which will not only damage local lands but also associated bodies of water. To avoid degradation as mentioned above, it is necessary to regulate the water system in areas of development and conservation, in order to minimize the environmental impacts that will occur. Thus the research is very important to find out the optimum water management under various objective and different hydrodynamic conditions. To make it easier to operationalize water management at the field level, it is important to develop spatial information. Water management zones must be created based on consideration of the area of standing water, land use, soil type and drainaibility.

A water management zone is a plan for utilizing land units in tidal or non-tidal lowland areas. Each water management zone/area includes an area that is located under the control of a controlling water structure and is located in a tertiary unit, but it does not rule out the possibility that it can be planned in a secondary unit. Added by CTCN (2023) that the hydrological zoning (or simply zoning) is an approach to divide land into different zones based on their hydrological properties. Typically, each type of zone has different land use and development regulations linked to it. This land and water management method aims to protect local water sources from risks of over-abstraction, land salinization, groundwater pollution and waterlogging by managing land use activities based on the assigned hydrological zones. For example, zones with a high groundwater table, large amounts of surface water (e.g. rivers) or high erosion susceptibility will usually have more land-use restrictions in place. Such restrictions may limit irrigation to avoid nutrient loading and sediment runoff into watersheds, but can also limit other activities such as industrial discharge and water abstraction from surface or groundwater sources. Zoning also ensures that irrigation, urban development or other land-use activities take place in the ideal land areas in relation to local hydrology, as well as where environmental impacts can be mitigated.

Water management zones are closely related to land use planning for rice fields or plantations. In each water management zone there can only be one water management plan. The water management plan consists of instructions for the operation of the wetland in question. Thus, water management zones are created by combining land unit information with the selection of crop requirements in the area. The first stage in this research is to quantify several land characteristics, based on the potential and constraints above, it is important to prepare a water management plan based on information on the area, soil and hydrological characteristics, so that land use is appropriate to land capabilities and plant cultivation failures can be minimized. Therefore, spatial water dynamics information is very important. The research aims to build a water management zone based on a potential land use approach for rice and fruit crops which refers to several land characteristics such as hydro-topography; supply water and potential drainability, pirit depth; microclimate, and land use scenario. Through the water management zoning the recommendation for adapting the two scenarios water management (*surjan* and mounding) would be constructed. Therefore, farmers could cultivate various crops under shallow water conditions.

2.3.2. Research Methodology

Research was carried out in the field, laboratory and micro-scale adaptation. Field research begins with a preliminary survey to determine location points, mapping peat and puddles and taking initial soil samples. The second stage is the installation of hydrological monitoring tools for daily observation of groundwater and channel fluctuation data. The third stage is a soil survey carried out by means of random, controlled drilling in zoned areas of peat depth classes.

The tools used in this study were a set of Microsoft Word software, Microsoft Excel software and ArchGIS 2.18 software, as well as tools used in the field in the form of field knives, peat drills, plastic, stationery, and google maps.

Sampling of disturbed soil for laboratory analysis was carried out up to two layers, namely 0-30; 30-60. Soil sampling treatment was carried out in shallow, medium and deep peat conditions. Sampling was carried out in the rainy season (flooded) and dry. Sampling of intact soil was used for analysis of soil physical properties carried out only up to two layers. Soil sampling treatment was carried out at various levels of waterlogging, and then at various levels of peat depth.

For total microbial analysis (bacteria and fungi) it is important to assess the level of peat land degradation. Soil samples were taken at various levels of peat depth, namely shallow, medium and deep peat. In addition, the analysis of physical and chemical parameters of the soil for assessing peatland damage can be seen in Table 1. Observations were carried out in selected areas in the burned peat area zone with different peat depths (shallow; medium and deep). Meanwhile, soil chemical parameters are used to assess soil fertility status. namely the value of cation exchange capacity (CEC); base saturation (KB); organic C; total P, total K and pH levels and determining the water content and soil texture according to the technical instructions for soil fertility evaluation. The prepared soil samples were then analyzed in the Soil and Environmental Science Laboratory to determine the chemical properties of the soil. The analysis results obtained were then matched based on the criteria for assessing the chemical properties of the soil according to PPT (1995) which are presented in **Table 2.8.** Determination of the soil fertility status of the research location was carried out by analyzing data based on a combination of soil chemical properties and fertility status according to PPT (1995) which is presented in Table 3. Analysis of the physical properties of the soil includes soil water content; soil bulk density, total pore space and soil bulk density.

Table 2.8. Measurement of physical and chemical parameters of the soil in the field and laboratory to assess soil degradation.

No	Parameter	Metode	Equipment
1.	The depth of the pyrite layer is from Ground level	Measurement from the surface to the layer boundary	$H_2 0_2$; pH stick scale of 0,5 unit of meter
2.	Groundwater Depth (water table)	Measurement from the ground surface to groundwater	Meter stick
3.	Redox for peat soil	Electrical voltage	pH meter; elektrodaplatina
4.	pH ($H_2 0$) 1: 2,5	potensiometerik	pH meter
5.	Electrical Conductivity /DHL	Electrical resistance	EC meter
6.	Number of microbes	plating technique	petri dish; *colony counter*

2.3.2.1. Data Processing

a. Soil Fertility

Assessment of soil fertility status includes the results of soil chemical properties data that are matched with the Soil Fertility Status Criteria (PPT, 1995) in **Table 2.9**. Soil fertility levels are stated in low, medium and high classes.

Table 2. 9. Criteria for assessing soil chemical properties (PPT, 1995)

No	Soil Characteristics	VL	L	M	H	VH	
1	C-organik (%)	<1.00	1.00-2.00	2.01-3.00	3.01-5.00	>5.00	
2	N-Total (%)	<0.10	0.10-0.20	0.21-0.50	0.51-0.75	>0.75	
3	P_2O_5 HCL 25% (mg/100 g)	<10	10-20	21-40	41-60	>60	
4	K2O HCL 25% (mg/100 g)	<10	10-20	21-40	41-60	>60	
5	KTK (CEC)	<5	5-16	17-24	25-40	>40	
6	Base saturation(%)	<20	20-35	36-50	51-70	>70	
7	pH (H_2O)	<4.5	4.5-5.5	5.6-6.5	6.6-7.5	7.6-8.5	>8.5
		Stongly acid	Acid	slightly acidic soil	Netral	Slightly Alkaline	Alkaline

Description: VH= Very High; H=High; M=Medium; L= Low; VL= Very Low Source: (PPT, 1995).

b. Developing maps of peat depth and inundation height

This research method follows the Guidelines in the Indonesian National Standard (SNI 7925:2013), on Peatland Mapping at a scale of 1:50,000 based on Remote Sensing Imagery (National Standardization Agency, 2013). In accordance with the SNI above, the stages of this activity consist of: (1). Data collection (map of the mapping area, scale 1:25,000, Landsat remote sensing imagery, Indonesian Topographic map at a scale of 1:50,000, and geological map); (2). Compilation of secondary data; (3). Interpretation of remote sensing imagery; (4). Delineation of peatland typology; (5). Field survey; (6). Analysis of soil samples in the laboratory.

The peat depth map was made using a base map from the Peat Restoration Agency as an initial reference, which was then validated using the transect method with an observation distance of every 50m. Field survey - Soil identification was carried out through soil observations using transects through existing roads to determine variations in soil characteristics. The distance between observations ranges from 50-100 meters. Soil observations are carried out by drilling the soil. For mineral soil to a depth of 1.20 m, while peat soil to the mineral soil layer (substratum). The soil parameters observed include: depth/thickness, maturity/level of decomposition, color, consistency, pH, reaction to H2O2, groundwater level, and other symptoms. All of these parameters are recorded on the soil observation form. The classification of peat depth is carried out Shallow (50 - 100 cm); Medium (100 - 200 cm); Deep (200 - 300 cm); and Very deep (> 300 cm). The depth and duration of inundation are also recorded in each peat thickness zone.

c. Analysis of excess water in the root zone Critical value 40 cm

The method of analyzing the status of groundwater in peatlands for fire prevention is carried out using the Surplus Excess Water (SEW-40) concept. The calculation of SEW-40 is based on the value (Government Regulation Number 71 of 2014 in conjunction with PP No. 56/2016). If the groundwater level meet this level, it is said to be critical and a slight decrease is stated as a water deficit. The calculation of the SEW 40 cm value is stated in equation (1): The method of analyzing the status of groundwater in peatlands for fire prevention is carried out using the SEW-40 concept. The calculation of SEW-40 is based on the value (Government Regulation Number 71 of 2014 in conjunction with PP No. 56/2016). If the groundwater level touches this level, it is said to be critical and a slight decrease is stated as a water deficit. The calculation of the SEW 40 cm value is stated in equation :

$$SEW - 40 = \sum_{i=1}^{n} (40 - x_i)$$

where xi is the ground water level on day i, where i is the first day and n is the number of days during plant growth.

d. Land Drainage Capacity Study (Drainability)

Land drainage indicates the possibility of the groundwater level in the land being lowered to the average water level in rivers or channels, except during heavy rain. Based on its drainability, tidal swamp land is classified into 3 types of drainability, namely:

Class 1 - Good Drainage - excess water in the field will dry out due to gravity, even though there is high tide in the river or channel. Class 2 - Fairly Good - excess water in the field will dry out due to gravity by > 50% of the tidal cycle. Class 3 - Poor Drainage - excess water in the field will dry out due to gravity by < 50% of the tidal cycle. Class 4 - Very Poor

Drainage - gravity is not enough to drain excess water in the field, even though it is receding. In this case, mechanical pumping is needed which requires high costs.

The results of water level measurements for 24 hours within 3 consecutive days with natural field conditions (no pump operation) will calculate how much the water level in the land has decreased. Tabulated data from hourly measurements for 24 hours can be used to calculate how deep the water has dropped during one day. This condition occurs in the rainy and dry seasons.3.3.6. Evaluasi status kedalaman air tanah relative terhadap jarak saluran drainase

To see the effect of drainage due to the presence of channels, drilling was carried out from the nearest point of the channel to the middle of the channel every 20m. This data is needed to see the effectiveness of the channel when used as a water drain (water level reduction) and water filling (rewetting).

e. Peat Land Degradation Assessment.

After identifying the initial soil conditions, analyzing the basic properties of the soil, an evaluation is then carried out. This evaluation aims to determine whether a soil location is damaged based on the standard criteria for soil damage. The evaluation is carried out by first averaging the same parameter values in similar biomass production and then comparing the results of the analysis of the basic properties of the soil with the standard criteria for soil degradation in wet land (Table 4) based on PERMENLH No. 20 (2008).

The parameters of this study are observations of solum thickness, water content, bulk density, specific gravity, total porosity, pH, electrical conductivity, redox, shallow groundwater depth and number of microbes. The data obtained from the research results are listed in table form. Then the data is analyzed using descriptive statistics which are more related to quantitative interpretation.

The criteria and indicators of a good peat ecosystem include: the peat dome still functions as water absorption with an area of > 30%, is still covered by natural hard plants, the depth of the groundwater table in the dry season is below 40 cm, is hydrophilic with a pH ≥ 4, and a potential redox value < 200 (mV) (Anonymous, 2014)

.

Table 2. 9. Evaluation of Soil Degradation in Wetlands

No	Parameter	Critical Threshold	Metode	Equipment
1.	Peat subsidence over quartz sand	>35 cm/5 years for peat thickness ≥ 3 m	Direct measurement	Subsidence stakes
2.	The depth of the pyrite layer from the ground surface	< 25 cm with pH < 2.5	Direct measurement	H_2O_2; pH stick skala 0,5 In unit; meter
3.	Shallow groundwater depth	>25 m	Direct measurement	meter
4.	Redox for peat soil	> 200 mV	Electrical voltage	pH meter;el ektro-da platina
5.	pH (H_2O) 1:2,5	< 4,0 ; >7,0	potentiometer	pH meter
6.	lectrical Conductivity n/DHL	> 4,0mS/cm	Electrical resistance	EC meter
7.	Number of microbes	< 10^2 cfu/gtanah	*plating technique*	petri dish; *colony counter*

f. The effect of controlling the water level in the channel on the rise in ground water level in the farm unit.

To maintain the soil moisture of peat soil, water level control in the channel is needed. Therefore, a canal blocking has to be developed. The hydraulic structure of water gate building is made of reinforced cement concrete and to control the water level is equipped with a stop log gate model. Monthly gate operations will be recorded to find the right operation model during plant growth and land fire prevention efforts. Daily water level data will be used as an indicator of the model's success.

2.3.3. Result and Discussion

2.3.3.1. Climate and Hydrological Conditions

The research was conducted in Perigi Village, Ogan Komering Ilir Regency and not far from Palembang City. The description of the climate conditions in the land area with reference to the rainfall data of Palembang City can be seen in **Figure 2.63**. The total annual rainfall in 2023 was 2,233 mm. Usually, if the rainfall is below 2500 mm/year, fires often occur during the dry season. And it is proven that in 2023 there was a major fire in South Sumatra. Referring to the classification of rain based on the Oldeman Method, the occurrence of dry months where rainfall <100 mm occurs from June to October. If it is assumed that the land evaporation requirement is 4 mm/h, then in one month 120 mm of water is needed for evapotranspiration. A water deficit occurs when the precipitation value is lower than evapotranspiration. Therefore, the period of months where the rainfall is below 120 mm occurs, causing a decrease in the groundwater level which ultimately makes the peat soil flammable.

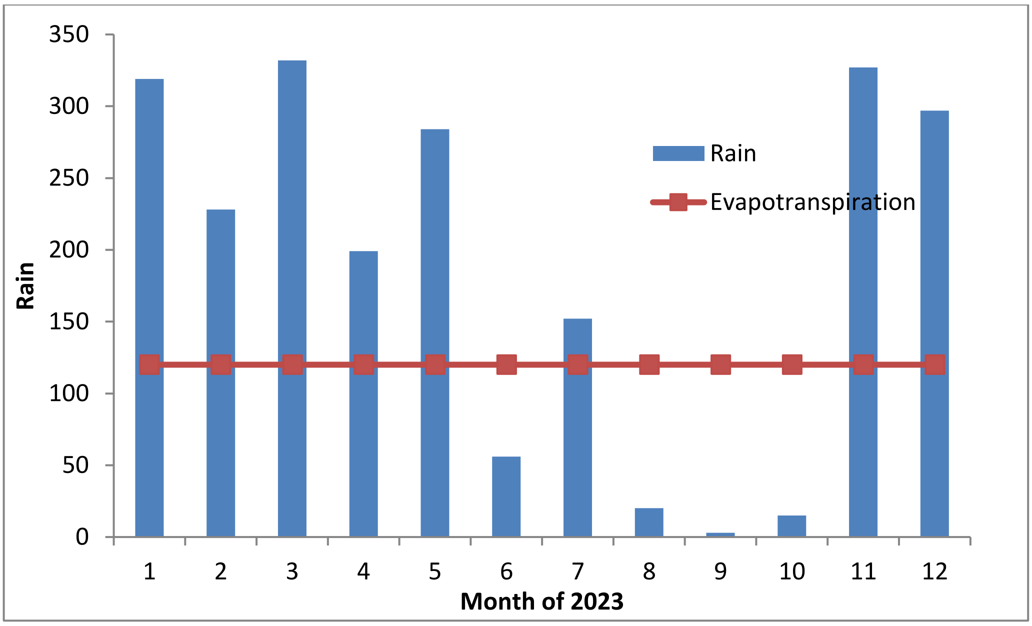


Figure 2.63. Distribution of monthly rainfall with plant evapotranspiration values

The dynamics of groundwater levels are influenced by space and time. Rainfall greatly affects the height of the water level on the land. The land in the study area is classified as swamp land.Lebak with peat soil. High rainfall in the rainy season causes water to inundate the land. Water level observation data **(Figure 2.64)** shows that the land was inundated during the period from January to June. A sharp decline occurred from June to July. The decline in water levels continued in August, the groundwater level was at -24. This was a 15 cm decrease in water levels. For the period from August to September, when there was almost no rain, the groundwater level dropped to -49 cm. This means that almost 22 cm of water is lost during one month if there is no rain. This condition clearly requires efforts to retain water in the channels so that the channels still have water and water loss in the land can be slowed down.

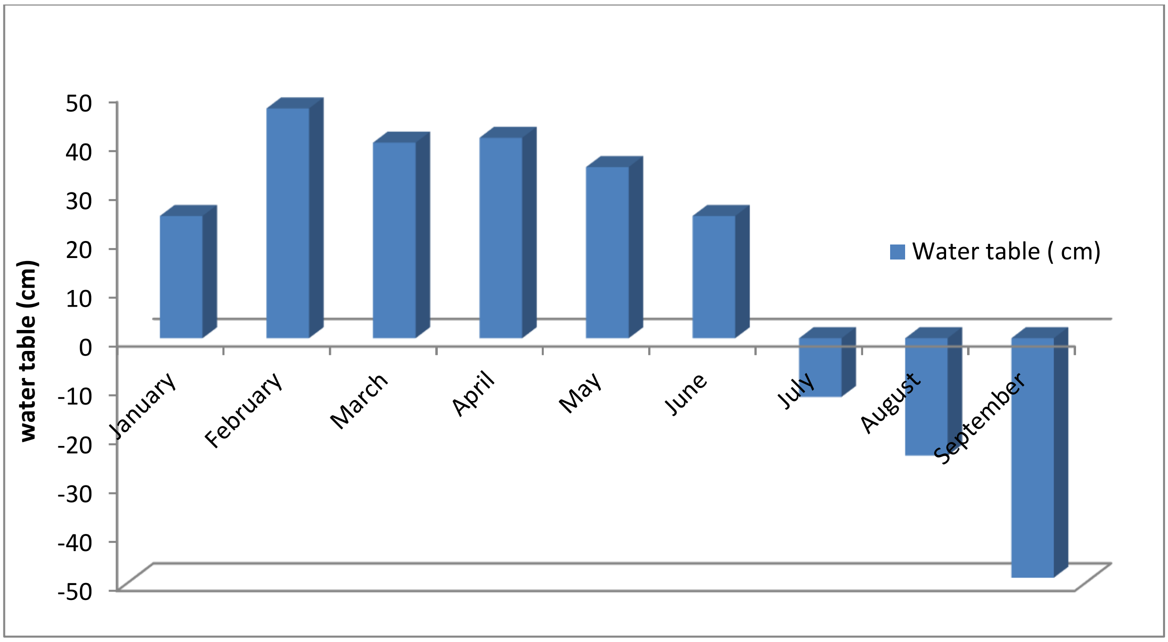


Figure 2.64. Groundwater dynamics in the peatlands of Perigi village

2.3.3.2. Land Drainable Capacity of the Area Study

Land drainable capacity is the ability of land to drain water without external assistance such as pumps, etc. In the case of the observation village of Perigi in April when the water was still high and in the condition of the existing network system where water drainage was still not optimal, the decrease in water level in the land when there was no rain was very slow, only 1 cm / day. This means that the drainability value is only 1 cm / day **(Table 2.9-2.10.)**. The slowness of water out causes the land to experience flooding for a long time until June. Therefore, the land has a very poor drainability class.

Entering the dry season where rain falls very rarely, the water in the channel gradually decreases and is followed by the groundwater level. Peak conditions of the dry season drainability class. The dry season occurs in September where the groundwater level drops to 57 cm, with an average of 49 cm at the water level. From this figure, the groundwater management value of -40 cm according to government regulation (PP) No. 57 of 2016 has been exceeded and this requires efforts to control the water level. The construction of canal barriers in this study is appropriate for peatland rewetting efforts.

Table 2.9. Observation of groundwater level data during the rainy season

Sampling Point	Water Table Depth (cm)

	April 28	April 29	dH
P1	47	46	1
P2	39	38	1
P3	40	38	2
P4	73	72	1
P5	44	43	1
P6	55	54	1
P7	20	19	1
P8	25	24	1
P9	28	27	1
P10	60	59	1
P11	60	59	1
P12	50	49	1
P13	28	27	1
P14	24	23	1
Avarege	42	41	1

Analysis of surplus excess water at -40 cm indicates that during the dry season, groundwater levels drop below -40 cm, meaning it has exceeded the critical threshold for groundwater depth concerning fire hazards. The average groundwater level reaches -49 cm, and even in October, it reaches -70 cm. This condition caused the land area (outside the experimental plot) to experience a fire **(Figure 2.67.).** Therefore, efforts are needed to control the water table in the channel to keep the groundwater at -40 cm below the soil surface. The construction of canal barriers in the demonstration area shows good results and is very important..

Table 2.10. Results of groundwater level observations during the dry season (September 2024)

Sampling Code	GPS Coordinates	Groundwater Level (cm)
T1	48 M 506375 E 9657123 N	-49

T2	48 M 506435 E 9657088 N	-45
T3	48 M 506433 E 9657109 N	-41
T4	48 M 506426 E 9657130 N	-47
T5	48 M 506421 E 9657150 N	-56
T6	48 M 506418 E 9657169 N	-63
P1	48 M 506326 E 9657080 N	-42
P2	48 M 506319 E 9657110 N	-46
P3	48 M 506324 E 9657133 N	-40
P4	48 M 506319 E 9657158 N	-49
P5	48 M 506316 E 9657182 N	-54
P6	48 M 506311 E 9657203 N	-57
Average		-49,08

Figure 2.67. . Fire in the peatland of Perigi occurred in October 2025 when the Groundwater level was -70 cm

2.3.3.3. Distribution of Peat Depth

The level of peat maturity in the peatland area is at the Hemic and Sapric levels. This means that it is good enough for agricultural and plantation businesses. Table 1 shows the level of peat maturity. In peat areas with medium and deep depths, it is dominated by Hemic and in shallow peat the level of maturity is quite mature, namely Sapric. There is a close relationship between topography and peat depth. Deep peat partly originates from low real topography (**Table 2.11**). Furthermore, spatially, the depth of peat can be seen in **Figure 2.68**.

Table 2.11. Peat depth in the Perigi OKI village area

Number	Sample Point	Coordinate Points		Depth Peat	Level Maturity
1	PRG T1 S1	3.095633	105.062322	221 cm	Hemic
2	PRG T1 S2	3.093424	105.054277	192 cm	Hemic
3	PRG T1 S3	3.092146	105.046203	cm	Hemic
4	PRG T1 S4	3.097363	105.067800	cm	Hemic
5	PRG T1 S5	3.101014	105.067008	200 cm	Hemic
6	PRG T1 S6	3.102682	105.056019	206 cm	Hemic
7	PRG T1 S7	3.102706	105.059048	194 cm	Hemic
8	PRG T1 S8	3.103750	105.061957	209 cm	Hemic
9	PRG 2 T1	3,103781	105.062354	195 cm	Hemic
10	PRG 2 T2	3,106599	105.055236	193 cm	Hemic
11	PRG 2 T3	3,105307	105.051569	128 cm	Hemic
12	PRG 2 T4	3,108002	105.056335	20 cm	Hemic
13	PRG 2 T5	3,107020	105.061992	186 cm	Hemic
14	PRG 2 T6	3,110325	105,062620	180 cm	Hemic
15	PRG 3 T1	3.106445	105.082049	70 cm	Sapric
16	PRG 3 T2	3.100413	105.079686	70 cm	Sapric
17	PRG 3 T3	3.091210	105.081913	50 cm	Sapric
18	PRG 3 T4	3.097108	105.073981	50 cm	Sapric
19	PRG 3 T5	3.097434	105.065831	70 cm	Sapric
20	PRG 3 T6	3.104987	105.068555	60 cm	Sapric
21	PRG 3 T7	3.104754	105.060968	40 cm	Sapric

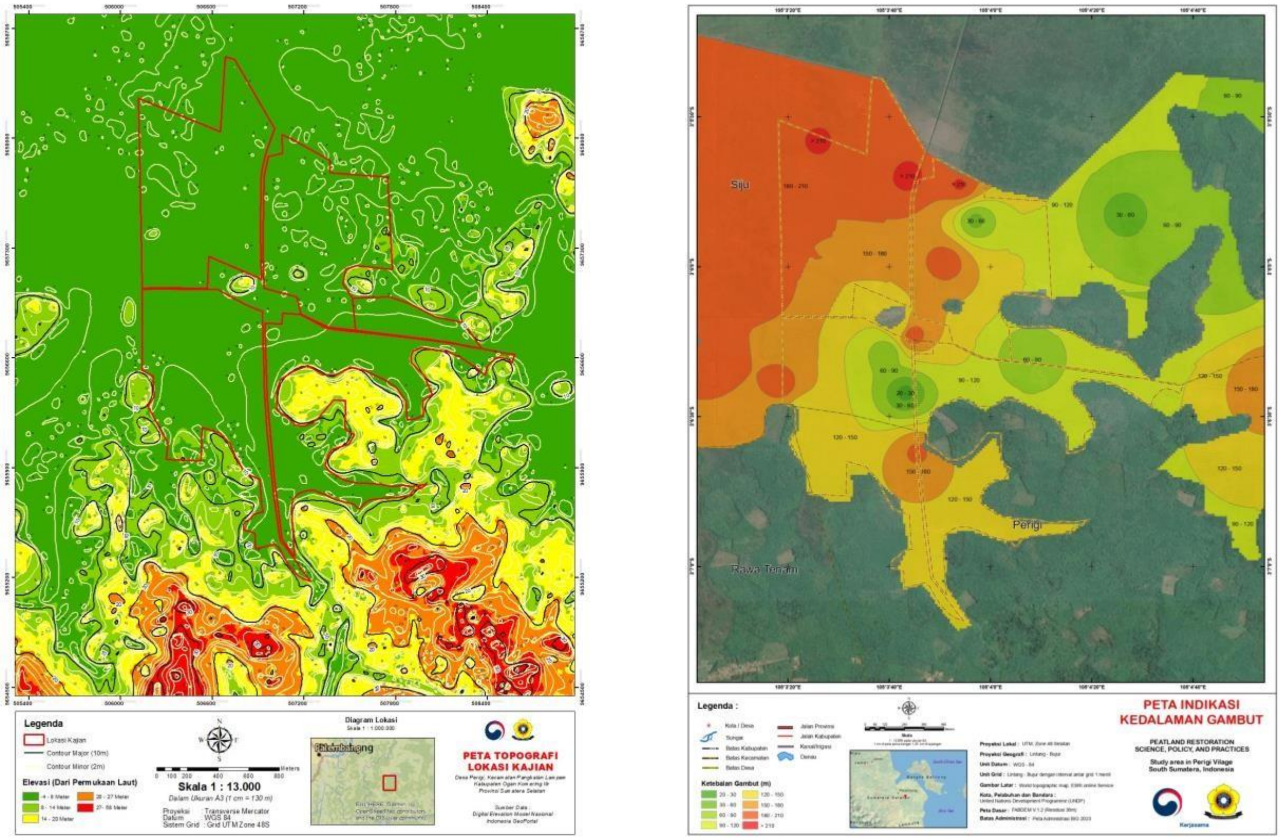


Figure 2.68. Topographic map and peat depth map of Perigi village, Ogan Komering Ilir

2.3.3.4. Groundwater Level Distribution Map for Dry Season Conditions (September 2024)

Areas during the rainy season experience inundation. The distribution of inundation can be seen in **Figure 2.69**. Water inundation originates from rainfall and surface flow from the upstream so that land with low topography receives excess water input, while the drainage capacity of the existing network system is hampered. Low drainage capacity causes land to be inundated. Entering the dry season starting from June, the water level began to decrease because rainfall began to decrease. The peak in September the water level dropped to 50-70 cm below the ground surface. The distribution of groundwater levels can be seen in Figure 5b. From random measurements, variations in groundwater levels were obtained from 40-70 cm and all land areas were no longer inundated. This condition proves that in the dry season there is potential for fires in peatlands because the groundwater level in some areas is below 40 cm from the ground surface.

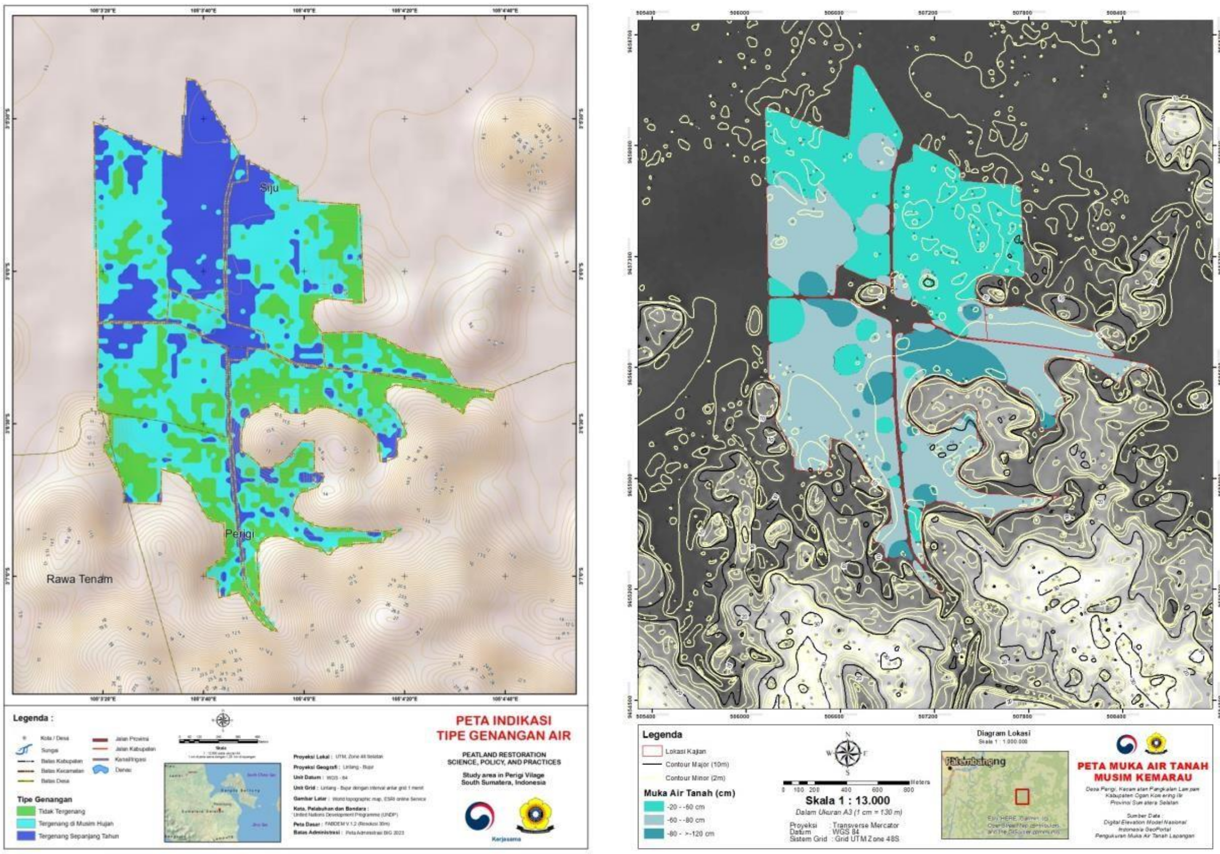


Figure 2.69. Map of water depth distribution in the Perigi peatlands in the rainy and dry seasons

2.3.3.5. Level of Diversity of Physical Properties of Soil in Drained Peat Lands

The land survey was conducted during the dry season, namely August-September. Observation of the groundwater level at various levels of peat depth did not show any significant difference where the groundwater level was in the range of 45-47 cm below the ground surface (**Figure 2.70**). However, shallow peat showed a relatively deeper groundwater level, and all values showed numbers that had exceeded the critical limit of the compliance figure of 40 cm. During that period there was no rainfall so there was a decrease in the groundwater level, and the water level control structure in the channel was not yet functioning (there was no canal bulkhead).

The impact of the decrease in groundwater level due to the land drainage process will also increase the decomposition process of organic materials which can gradually change the level of peat maturity which can then increase the value of the soil bulk density. Table 2. Shows the value of several parameters of soil physical properties. Soil sampling was carried out in a transect perpendicular to the channel. The value of soil bulk density ranges from 0.09-0.12 gr/cm3 very low, and the average value of procity is still very high, which is 86.76%. It does not show a high diversity rate between soil samples from the area near the channel to the middle of the channel.

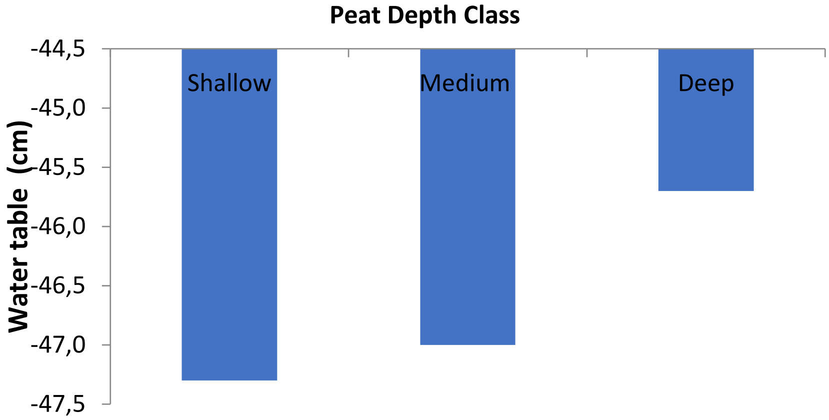


Figure 2.70. Depth of groundwater in various peat thickness classes

Furthermore, random soil sampling at a peat depth of between 1.5 - 2 m showed values that were not significantly different from the data in **Table 2.12**. where the average soil bulk density value was 0.13 gr/cm3and the soil porosity value is 95.12%. This is in line with the research results Sajarwan *et al.,* (2021) in Central Kalimantan peatlands showed that the porosity value of peat soil ranged from 85.5-86.5%, and the soil bulk density value was in the range 0.11 – 0.16 gr/cm3, the average porosity value in Norway is 88-89% (Kaczmarek *et al.,* 2023). Kamaliah *et al.,* (2022) added that the level of peat maturity also affects the soil bulk density value. In fibric maturity conditions, the soil bulk density value is in the range of 0.18-0.27 gr/cm3. This means that soil maturity will affect the density level of peat soil. Low soil bulk density values are followed by high porosity values. An increase in porosity values indicates that peat soil has a high-water storage capacity (Novrianti & Harisuseno, 2023). Research by Tetty *et al.,* (2023) on peatlands in Pontianak showed that porosity figures were in the range of 85.5-95.5%.

Table 2. 12. Soil bulk density and total pore space values on the peat land of Perigi village

Sample No.	Soil Bulk Weight (gr/cm3)	Total Pore Space (%)
P1	0.09	88.13
P2	0.17	78.18
P3	0.12	84.71
P4	0.12	85.57
P5	0.10	87.03
P6	0.12	85.34
T1	0.09	88.87
T2	0.08	90.13
T3	0.07	91.08
T4	0.11	86.13
T5	0.09	89.15
T6	0.11	86.79
Average	0.11	86.76

The low BD value of the soil is caused by the soil on peat land. formed from organic materials. Agus *et al.,*. (2005) stated that the low soil BD is caused by the presence of relatively high organic material content (average >3.0%). The condition of high organic material content causes the soil to become more porous, which causes the BD value to be lower. Table 8 shows the value of soil bulk density on land with medium peat depth (1.5-2.0 m) with a Hemic maturity level. The average soil bulk density is 0.11 gr/cm3and a maximum of 0.21 gr/cm3. The variation of BD value is related to the organic matter content and the length of time the land has been cultivated for agriculture. The largest number is obtained at a BD value of 0.21 gr/cm 3 The land was cleared 3 years ago and on land that has not been cultivated even though a channel has been built, the BD value is still at range of 0.11-0.12 gr/cm3. The land area that is cultivated for plant cultivation is a fruit plant cultivation model with a limited drainage pattern and plants are planted on raised land (mounding). In general, the opening of the area three years ago did not show any real changes in physical properties where the value of the soil bulk density and total pore space between the opened land (P) and that which has not been planted (K) did not show any real difference.

The porosity figures in the study area (**Table 2.13.**) are relatively high, ranging from 86-88%. From these results, it can be concluded that the soil in this study has the Porous porosity criteria (Arsyad, 1975; Afrianti *et al.,* 2023). This condition indicates that the land has a very large water storage capacity. Measuring soil porosity is an important aspect in the analysis of the physical properties of peat soil in oil palm plantations. Soil porosity is a very relevant indicator because it is related to the soil's ability to store water, gas exchange, and the development and health of the plant root system (Arsyad, 1975). High porosity in peat soil allows for a large enough pore space to store water, oxygen, and nutrients needed by oil palm plants. In addition, high porosity also contributes to good air circulation in the soil, helping gas exchange which is important for biological activity and the balance of soil microorganisms (Siti *et al*., 2021).

Table 2.13. Data on physical properties of soil, bulk density and total porosity values in peatlands cleared for agriculture

Code	Bobot Isi gr/cm3	Total Porosity (%)
P1	0,11	86,11
P2	0,11	86,13
P3	0,12	84,50
P4	0,12	85,11
P5	0,14	83,03
P6	0,14	82,51
P7	0,14	81,90
P8	0,15	81,46
P9	0,21	73,59
P10	0,12	85,22
P11	0,10	88,09

Average	0,10	87,05
Control 1	0,10	85,25
Control 2	0,12	83,84
Average	0,11	86,11

The physical characteristics of the soil that are very important in land drainage planning for agricultural cultivation on peatlands are permeability figures. The permeability values of peat soil in the study area range from 23.6-38.7 cm/hour with very fast criteria (**Table 2.14.**). This condition is in line with the results of the study by Tetty *et al.,* (2023) which showed that the assessment of peat soil permeability in Pontianak showed a figure of 20.5-30.5 cm/hour. This condition shows that the movement of water in peatlands is very fast, especially horizontal movement, so that the loss of water to the channel is very fast.

Table 2.14. Soil permeability values in the peatlands of Perigi village

Sample No	Permeability (cm/h)	Criterion
P1	31,57	Very fast
P2	37,47	Very fast
P3	38,76	Very fast
P4	34,91	Very fast
P5	32,60	Very fast
P6	27,21	Very fast
L1	22,59	Very fast
L2	37,47	Very fast
L3	27,21	Very fast
L4	33,62	Very fast
L5	32,34	Very fast
L6	38,76	Very fast
Average	32,88	Very fast

Changes in permeability occur when peat soil undergoes a decomposition process, and the level of maturity changes. Land cultivation and agricultural food business activities can accelerate the soil compaction process (increasing bulk density) which then has an impact on decreasing permeability. Research by Utari *et al.,* (2021) stated that on land cultivated with pineapple in Kuburaya Regency, Kalimantan, the permeability value was 11.3 cm/hour (rather fast) which should be in the range of 30-50 cm/hour on peat soil. The permeability of peat soil is also greatly influenced by the level of soil maturity. Research by Jakarius *et al.,* (2021) showed that peat soil with hemic maturity had a permeability value of 2.97×10-5 m/s-6.01×10-5 m/s, and for the level of fibric maturity, the permeability value was between 7.05×10-5 m/s - 8.31×10-5 m/s. Meanwhile, peat in the well study area has an average permeability value of 32.88 cm/hour or equivalent to 9.13 × 10-5 m/s. According to the criteria, the flow rate is classified as very fast so that the peat is still considered undegraded. The rate of fluid flow in the soil is also influenced by the level of maturity. Fibric peat soil has higher permeability than hemic peat soil because the porosity of fibric peat soil is higher than that of hemic peat soil. Therefore, the ability to pass fluid in fibric peat soil is higher than in hemic peat soil. High fluid flow in the soil can affect the water management system, especially in designing the distance between channels and channel dimensions.

Research by Mahardika et al., (2024) on permeability values using measurement methods directly on land cleared for oil palm plantations has a lower value with the measurement method in the laboratory, which is 106.7 cm hr^{-1} compared to land planted with rubber plants which is 19.56 cm hr^{-1} and secondary forests of 15.1 cm hr-1). The dynamics of permeability values are greatly influenced by the characteristics of other physical properties of the soil such as the value of soil bulk density and total porosity. The permeability value is also used as hydraulic function parameters in determining whether peatland has experienced degradation or not. Peat is categorized as experiencing severe land degradation if the soil hydraulic conductivity value is less than 0.01 cm/hour, and moderate category if the permeability value is between 1-100 cm/hour. Peat conditions that are still very good have a hydraulic conductivity value of >100 cm/ hour (soil permeability Lennartz, B. & Liu. H. 2019). Therefore, when viewed from the figures 32.88 cm/hour and soil bulk density 0.1 gr/cm3meet land criteria moderately degraded peat.

2.3.3.6. Study of Groundwater Status Relative to Drainage Channels

When the channel is used as a supply (inputting water), the ground water table will decrease the further away from the channel. Conversely, if the water in the channel is empty, the closer it is to the channel, the lower the groundwater level. **Figure 2.71**. shows the profile of the groundwater level relative to the drainage channel. The water level tends to decrease the further away from the channel. The groundwater level at the initial 10 m point is at a depth of 40-45 cm and then decreases further. In the 6th observation, namely at a distance of 120 m, the groundwater level is already at a position of 50-60 cm below the ground surface. This means that if the water level in the channel is at 40 cm below the ground surface (assuming a ground surface of 0 cm), then at a point 120 m from the channel the groundwater level has exceeded the critical limit of -60 cm. The compliance figure according to government regulations is -40 cm below the ground surface (PP 57. 2016). This indicates that in September the land area must be water-retained in the channel.This condition can be the basis that the spillway structure must be insHighed lower than 40 cm from the level of the embankment or bulkhead.

On the other hand, the condition of water in the channel is decreasing (drainage flow pattern) occurs when the dry season conditions and no rain (supplementation) then the groundwater level becomes deeper when close to the drainage channel. This is caused by the movement of groundwater getting higher, so that there is a reduction in the water content of the peat soil due to drying, which causes the retention capacity of the groundwater to decrease, the creation of drainage channels greatly affects the decrease in the water level of the peat soil (Azri 1999). In line with the research of Putra and Lasmana (2019) that the rapid decrease in the groundwater level in the dry season causes the land surface to become dry and the land is easily burned. During this period the groundwater level tends to decrease until the land drainage limit reaches -1.5 m (base of the channel).

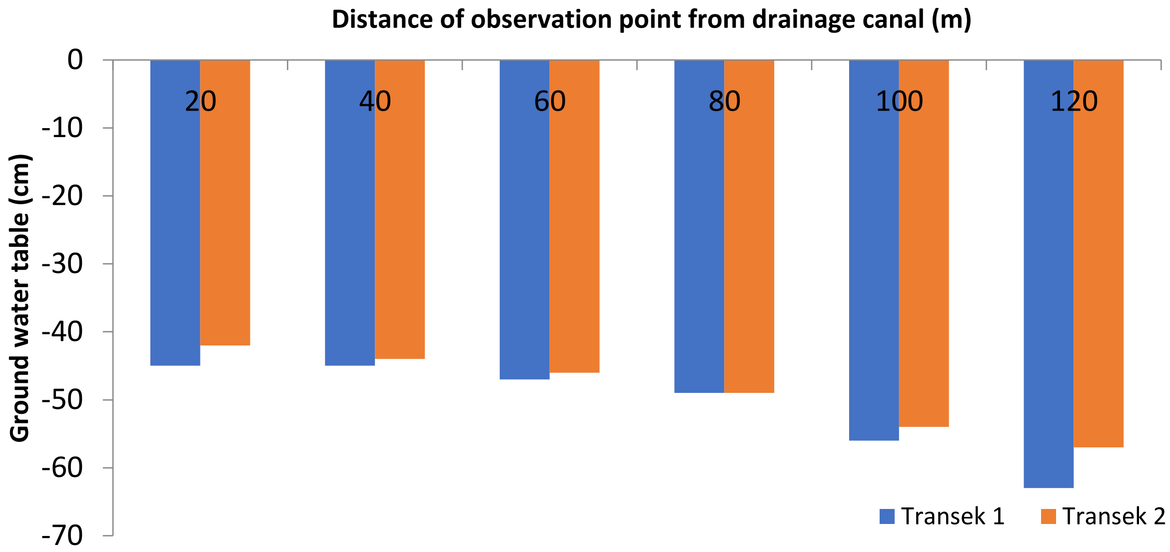


Figure 2.71. Changes in groundwater depth relative to the drainage canal

The peat water content at the research location (natural forest peat) is 500-600% (**Table 2.14.**). This is very much in accordance with the original nature of peat soil which has porous properties so that it can store large amounts of water. The relationship between the depth of the groundwater table and the groundwater content shows a positive relationship where the increase in the groundwater table will be followed by an increase in the groundwater content. However, diversity occurs because the movement of groundwater to the surface is also greatly influenced by the maturity of the peat, the content of organic matter and other physical parameters of the soil. However, in general, observations made in the dry season in September 2024 showed that the water content on the surface (root zone 0-20) showed high numbers and was relatively safe from the danger of fire.

This is because the upper biomass is still maintained so that the surface soil moisture is still good. The relationship between Groundwater Level and Soil Moisture shows a positive effect where the increase in the groundwater table will be followed by an increase in the groundwater content. According to Situmorang (2015) a decrease in the depth of the peat groundwater table from 40-50 cm, 60-70 cm, 80-90 cm can reduce the field water content of peat soil. A decrease in the depth of the groundwater level that is too deep will affect the distribution of soil moisture throughout the peat soil profile and result in the release of a certain volume of groundwater from the layers above (Winarna, 2015).

Table 2.14. Dynamics of groundwater level and water content in the plant root zone (20 cm)

Sample No.	Groundwater Table (cm)	Water Content (%)
P1	-42	519.64
P2	-46	497.20
P3	-40	603.17
P4	-49	553.93
P5	-54	668.66
P6	-57	558.91
T1	-49	455.84
T2	-45	593.68
T3	-41	683.14
T4	-47	601.38
T5	-56	482.75
T6	-63	575.02
Average	- 49.08	566.11

In line with the research results of Nusantara *et al.,* (2023) that the water content of peat soil can be influenced by the depth of the groundwater table. The field water content value reached the highest figure, namely 801.82% with a groundwater table depth of 15 cm, while the field water content was the lowest, namely 437.43% with a groundwater table depth of 49 cm. This shows that the pattern of the relationship between groundwater table depth and field water content is opposite because the shallower the groundwater table depth, the higher the field water content and vice versa.

This is in accordance with Simatupang's *et al.,* (2018), stating that water content can be influenced by the depth of the groundwater table, the shallower the groundwater table, the higher the water content. Situmorang*et al.,* (2015), also added that the depth of the peat groundwater table can significantly reduce the water content of the peat soil. Peat fires can still occur at a water content of 119% which is the critical water content for peat fires (Syaufina*et al.,* 2004; Nurkholis, 2018). Critical fire values peat land on groundwater levels is 110-120% dry basis (Glenn etal., 2015). Added by Rauf (2016), that critical water content in peat soil materials in general ranging from 272-275%. Peat with a water content less than this critical water content is said to be peat that is approaching irreversible drying properties.

2.3.2.8. Water Level Dynamics, Water Level Control by Building Canal Blocks

The land has been inundated since December. A survey of water level dynamics in the canal conducted in May showed that the water in the canal was still full. The water depth varied from 150 to 250 cm (**Figure 2.72**). The full water level in the canal resulted in poor drainage conditions in the land and the land was inundated. During this period, planting could only be done on elevated land. The water level on the land is high because the water level in the channel is also high, so the drainage process is hampered (**Figure 2.73**).

Figure 2.72. Land conditions in December (a) and May 2024 (b) are still flooded

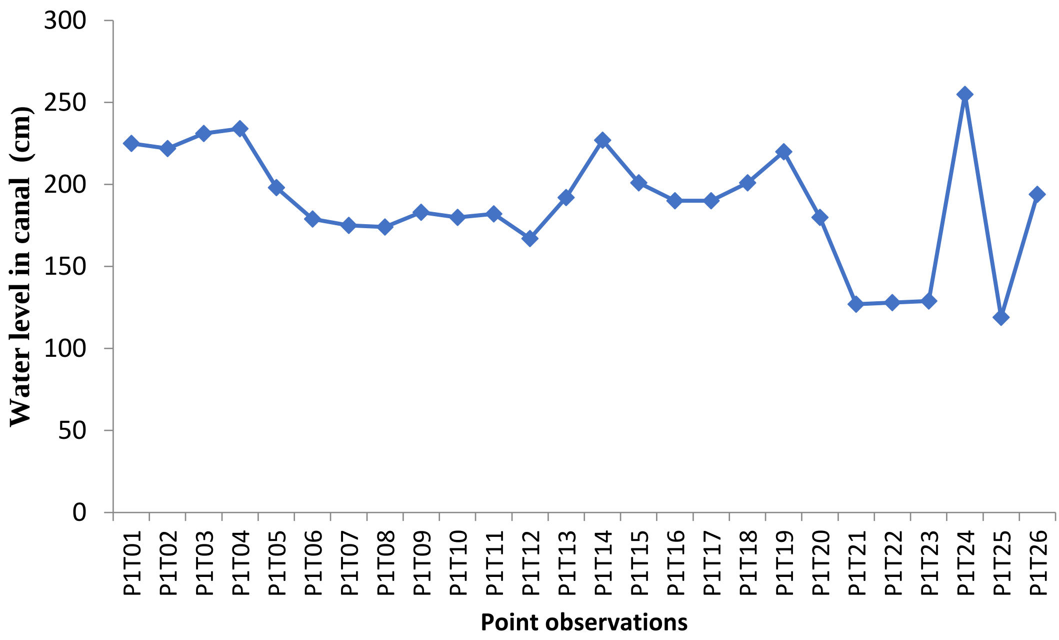


Figure 2.73. Water level conditions in the channel on May 18, 2024

The decline in groundwater levels during the dry season in the Perigi peatland area is relatively fast. In conditions where there is no rain, the decline in groundwater levels can reach 20-25 cm/month. This condition requires efforts to control the water level in the channel by building a canal bulkhead. In this study, a canal blocking has been built in the channel (**Figure 2.74**). The type of building is permanent with a reinforced concrete model. To prevent the building from subsidence, the foundation is made by planting *gelam* wood and filling mineral soil to a depth of 2m.

The canal blocking operation was carried out with water retention efforts. So that the water flow through the channel could be stopped. However, there was a loss from below the channel. The effect of the canal blocking barrier was very obvious when the empty channel (0) cm occurred when the blocking construction had an impact on the sharp decrease in the groundwater level reaching - 70 cm (**Figure 2.41**), and after the canal blocking was completed and functioned to hold water, the water in the channel rose again. The water level in the channel rose to above 100 cm and was followed by a rise in groundwater to a groundwater depth of -20 cm below the ground surface on October 3.

Figure 2.74. Canal blocking model for controlling water levels in the peatlands of Perigi village

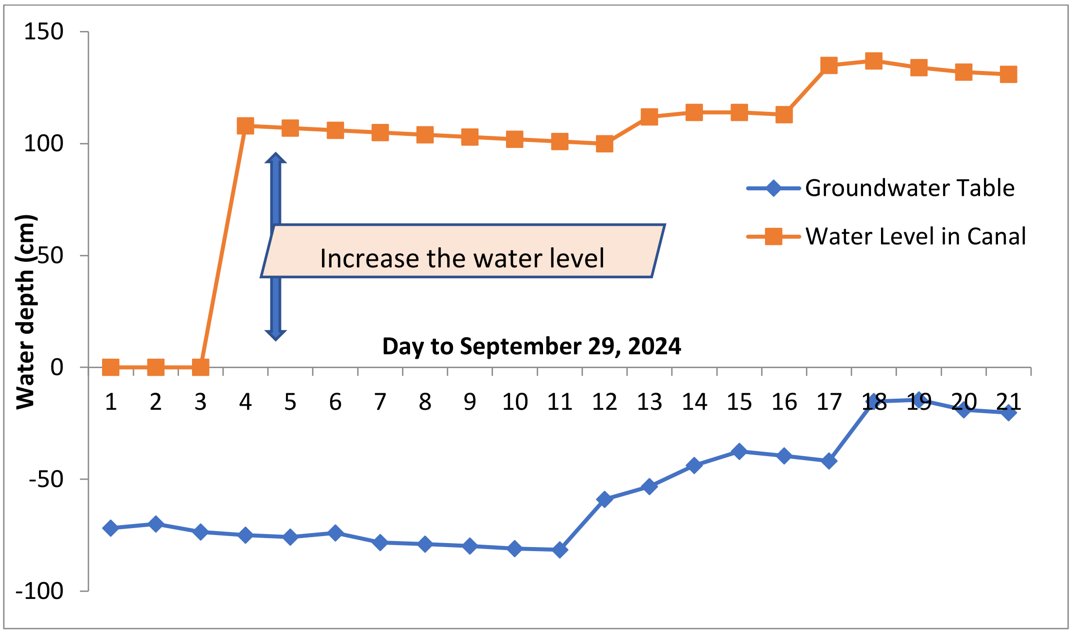


Figure 2.75. Impact of canal blocking operations on rising groundwater levels

2.3.3.7. Evaluation of Soil Fertility Status

To assess the soil fertility status, laboratory analysis was carried out on some parameters of soil chemical characteristics: pH, Nitrogen content, Phosphorus Potassium and Cation Exchange Capacity value. The following is an explanation of the soil fertility status from the parameters analyzed.

The treatments in this study were based on the height of the water puddle, namely: T1; T2; T3 and T4 are land with standing water of 20 cm; 40 cm, 60 cm and puddles > 80 cm. To see nutrient dynamics, sampling was carried out when the land was flooded and not flooded. Below are presented the results of soil chemical analysis in the laboratory.

1. Soil reaction (pH)

Soil acidity is an important soil chemical parameter to know. pH is a parameter that measures the concentration of hydrogen ions (H^+) in a solution, and is expressed on a scale of 1 to 14. This scale classifies pH into three main categories: acidic, basic, and neutral. Acidic pH is located on a scale below 7, while neutral pH is on a scale of 7, and basic pH is above 7. In the context of soil, acidic pH indicates a higher concentration of hydrogen ions (H^+) compared to hydroxide ions (OH^-), while basic pH indicates a higher concentration of hydroxide ions (OH^-) compared to hydrogen ions (H^+) (Kusuma *et al.,* 2014). Laboratory analysis shows that the pH content of soil in peatlands can be seen in (**Figure 2.76**)

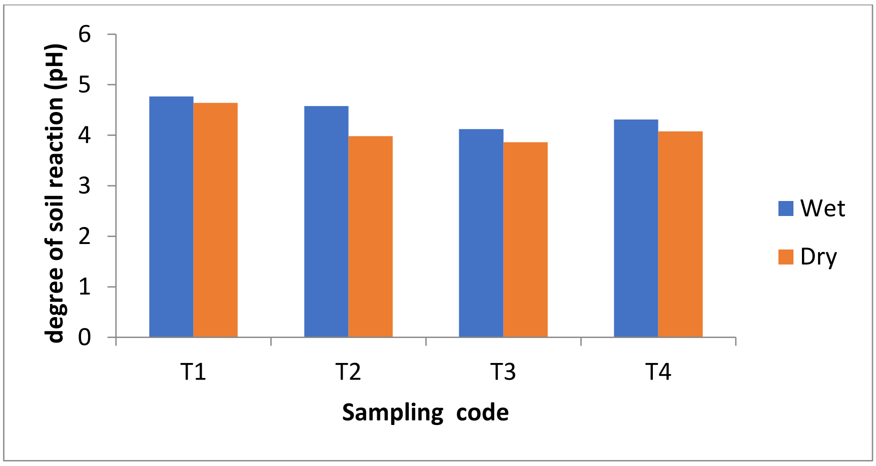


Figure 2.76. Results of Soil pH (H2O) Analysis

Based on the results of laboratory analysis (**Figure 2.76**), the pH value of the soil in the area classified as acidic. The soil pH in peatlands showed the highest value at T1 L1, which was 4.77, and the lowest value at T1 L3, which was 4.31. That the soil pH in this area meets the acid criteria. It is known that soil pH is an important indicator in assessing soil quality, and can affect nutrient availability. Acidic soil pH conditions can be influenced by several factors, one of which is high water content. Soil flooding has a significant impact on soil pH; during flooding, soil pH tends to decrease. This is due to the decomposition process of organic matter by microorganisms, which produces carbon dioxide (CO_2) which reacts with water to form carbonic acid (Imanudin *et al.,* 2018). Excess water causes leaching of important minerals, especially base cations (K, Na, Ca, Mg), from the soil. This process results in the soil absorption complex being dominated by H^+ and Al^{3+} ions. In line with this, Syofiani *et al.,* (2020) stated that high water content causes leaching of base cations from deeper soil layers, thereby decreasing soil pH and increasing soil acidity.

2. C-Organic

Organic carbon (C-organic) content is a key indicator of the amount of organic matter present in the soil. Low C-organic levels generally indicate low organic matter content. Soil organic matter is formed through the process of decomposition and formation of matter by soil microorganisms. In the context of soil chemistry, organic matter can be grouped into compounds such as carbohydrates, proteins, lignin, and small amounts of other compounds such as oils and waxes. The process of decomposition of organic matter is influenced by various factors, including the type of organic matter itself and the activity of microorganisms that are involved. The type of organic matter affects the rate of weathering; generally, materials with high lignin content are more difficult to decompose. The results of laboratory analysis of soil C organic content can be seen in **(Figure 2.77)**.

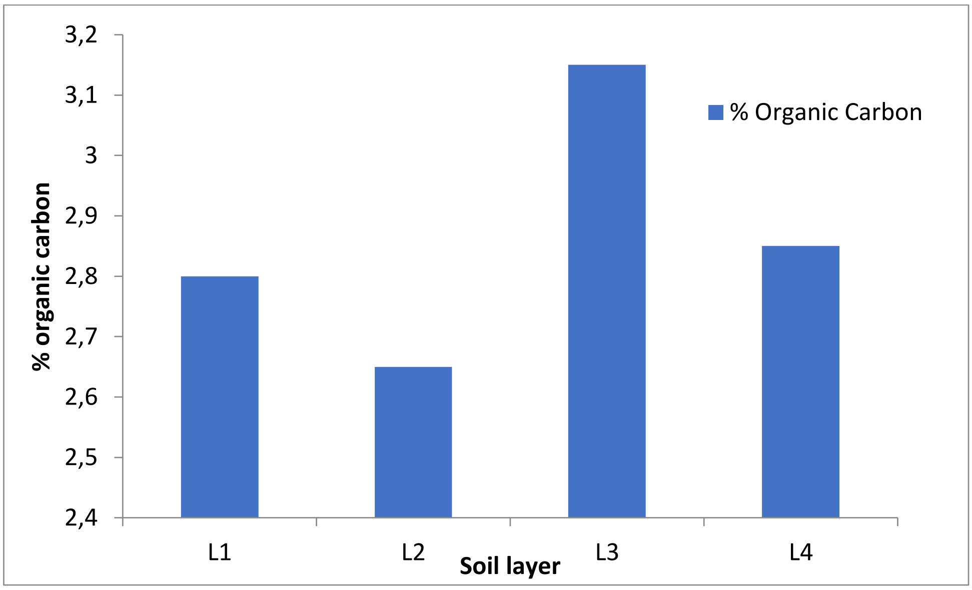


Figure 2.77. Results of Organic C Analysis

Based on the data presented in **Figure 2.77**, the C-Organic content in the research peatland is included in the moderate category. The highest C-Organic content was found in T1 L3 with a value of 3.16%, while the lowest content was found in T1 L2 with a value of 2.65%. C-Organic plays a crucial role in supporting sustainable agriculture, functioning as the main indicator of soil fertility, maintaining nutrient availability, improving soil physical properties, and supporting the survival of soil microorganisms.

The low C-Organic value at the research location can be attributed to the source of its constituent materials, namely plants, which mostly consist of organic matter. Therefore, the higher the C-Organic content in the soil, the higher the organic matter content. Pinatih *et al.,*. (2015) explained that the addition of organic matter such as manure can increase the C-Organic content or organic matter in the soil. Carbon is the main component in organic matter, so increasing organic matter will increase the organic carbon content. High C-Organic content has the potential to improve soil properties physically, chemically, and biologically, as well as increase the metabolic activity of soil microorganisms.

3. N-Total

Soil fertility is a crucial factor in decision-making regarding agricultural land management. Soil chemical content, including nitrogen, plays a significant role in supporting soil fertility. Nitrogen is an essential element that contributes to soil fertility quality and plant health, so measuring Nitrogen content in the soil is essential (Kamsurya and Botanri, 2022). The results of laboratory analysis show the nitrogen levels in the soil, which can be found in (**Figure 2.78**.) Total nitrogen availability in dry land conditions is higher than in flooded land conditions**.**

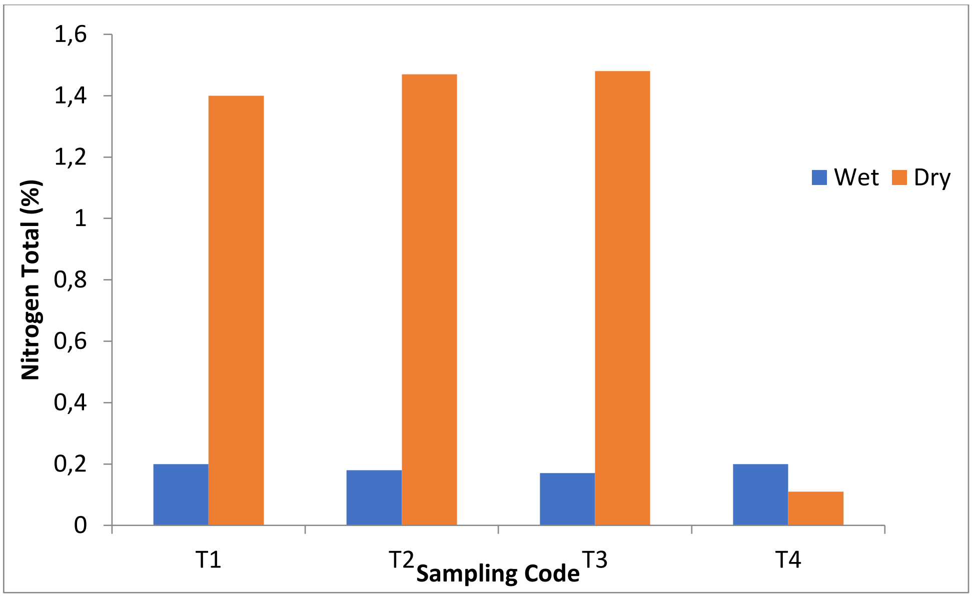


Figure 2.78. Results of Total N Analysis on Peat Land under different water regimes

Based on the results of laboratory analysis, the total nitrogen (N-total) content in peatlands is shown in (**Figure 2.78**) The data shows that the highest N-total value is found in land T1 L1 with a content of 0.20%, while the lowest value is found in land T1 L3 with a content of 0.17%. The results of the analysis show that the N-total content in peatlands is included in the low category. The low N-total content is thought to be caused by the low content of organic matter, which is the main source of nitrogen. C-Organic is one source of nitrogen for the soil. Mansyur *et al.,* (2021) explained that organic matter functions as a source of nutrients, including nitrogen, phosphorus, and potassium. Hidayanto (2019) explained that during the decomposition process of organic matter, organic nitrogen undergoes mineralization, while mineral nitrogen undergoes immobilization. Nitrogen levels in soil are influenced by environmental factors such as climate and type of vegetation. Vegetation that grows on the ground and the speed of its decomposition affect changes in nitrogen content in the soil (Rahmi and Biantari, 2014).

4. Phosphorus-Available

Phosphorus plays a crucial role in the formation of ATP and proteins, cell metabolism, and stimulation of plant root growth. Phosphorus (P) deficiency in the soil can occur due to the process of washing, erosion, and absorption by plants. explains that tidal swamp land, although it has great potential for the development of food crop agriculture, often face various obstacles such as low soil pH, high iron content (Fe^{2+}), low phosphorus (P) levels, relatively shallow pyrite layers (FeS_2), high salinity levels, and excess water volume. The results of laboratory analysis of phosphorus content in peatlands can be seen in (**Figure 2.79**). The availability of Phosphor is also higher when the soil in dry rather than in wet condition.

Based on the data presented in **Figure 2.79**, the levels of available phosphorus (available-P) in peatlands showed the highest value in T1 L1 with 14.70 ppm and the lowest value in T1 L2 with 10.95 ppm. The results of this analysis indicate that the levels of available-P in peatlands are relatively low. The decrease in available-P levels can be caused by the decomposition process of organic matter which produces organic acids, which in turn lowers soil pH. A decrease in soil pH causes an increase in the concentration of elements such as aluminum (Al), iron (Fe), and manganese (Mn), which can bind phosphorus and make it unavailable to plants. This statement is consistent with the research of Damanik *et al.,* (2012), which states that organic matter affects the availability of phosphate through weathering which produces organic acids and carbon dioxide (CO_2). These acids produce organic anions that can bind to metals such as Al and Fe.

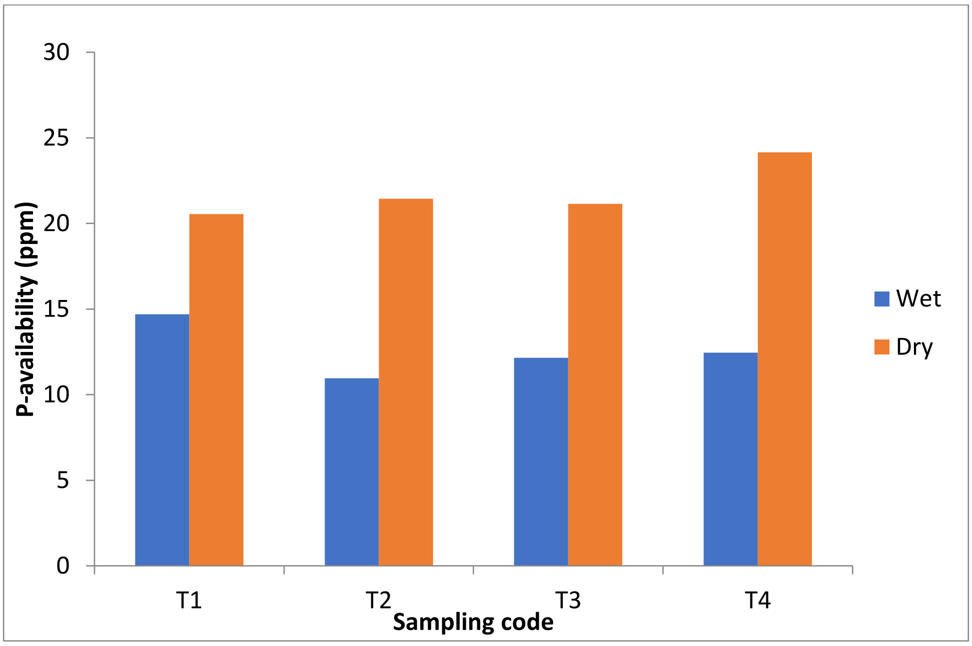


Figure 2.79. Results of P-available Laboratory Analysis under different water regimes

5. K-Available

Potassium is an essential element needed by plants as one of the supporters of plant growth and development. Potassium functions to help root development, stimulate seed filling, protein addition and others. The amount of potassium absorbed by plants is only small, in addition to the low potassium content in the soil, other factors also affect the availability of potassium in the soil such as the uptake of K by plants, harvesting, soil erosion, and K leaching by water. The results of the soil K-Available analysis can be seen in (**Figure 2.80**) below.

Based on the analysis results, the levels of available potassium (K-available) in peatlands, as presented in (**Figure 2.80**) shows the highest value in land T1 L2 and T1 L3, each with a value of 0.38 me 100 g^{-1}, and the lowest value in land T1 L1 and T1 L4, each with a value of 0, 32 me 100 g^{-1}. The results of this analysis show that the available K levels are classified as medium. The available potassium content can be maintained properly if leaching does not occur, so that potassium remains in the soil and is not lost. The availability of potassium in the soil is influenced by pH and base saturation. At low pH and low base saturation, potassium is more easily leached. Conversely, at neutral pH and high base saturation, potassium can be bound by calcium (Ca). Higher cation exchange capacity increases the soil's ability to retain potassium, so that the soil solution releases potassium more slowly and reduces the potential for leaching (Kautsa *et al.,* 2020).

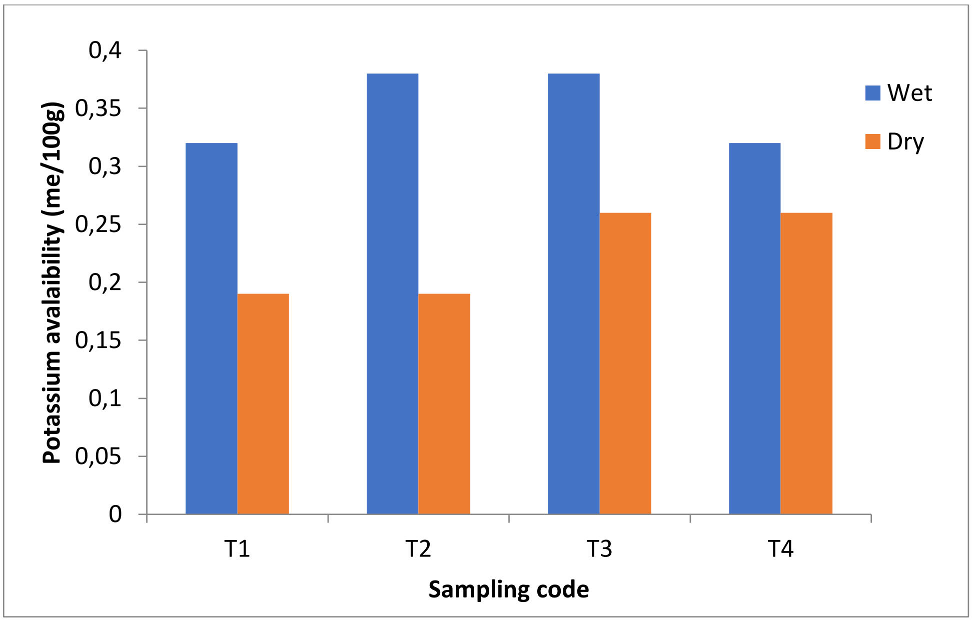


Figure 2.80. Results of K-Available Laboratory Analysis

Adequate potassium availability contributes significantly to plant resilience. Potassium plays a key role in strengthening plant structure, preventing leaf, fruit, and flower shedding, and increasing turgor pressure that supports resistance to drought and disease. In addition, potassium functions to improve photosynthesis and water use efficiency. By strengthening stems and roots, potassium also expands the plant's root system and increases resistance to pests and diseases.

6. Exchangeable cations/Cation Exchange Capacity (CEC)

Cation Exchange Capacity (CEC) refers to the total number of cations that can exchanged on the negatively charged soil colloid surface. CEC is measured in milliequivalents of cations per 100 grams of soil (me 100 g^{-1} of soil). CEC is an important attribute in assessing soil fertility and classifying soil types, because it reflects the ability of the soil to provide important cations such as calcium (Ca), magnesium (Mg), and potassium (K). In addition, CEC is used as the main indicator to determine the class of soil fertility. The results of the CEC analysis on peatlands can be seen in (**Figure 2.81**). The analysis results show that the CEC value tends to decrease with lower soil moisture. The CEC value in flooded soil condition is greater than dry soil.

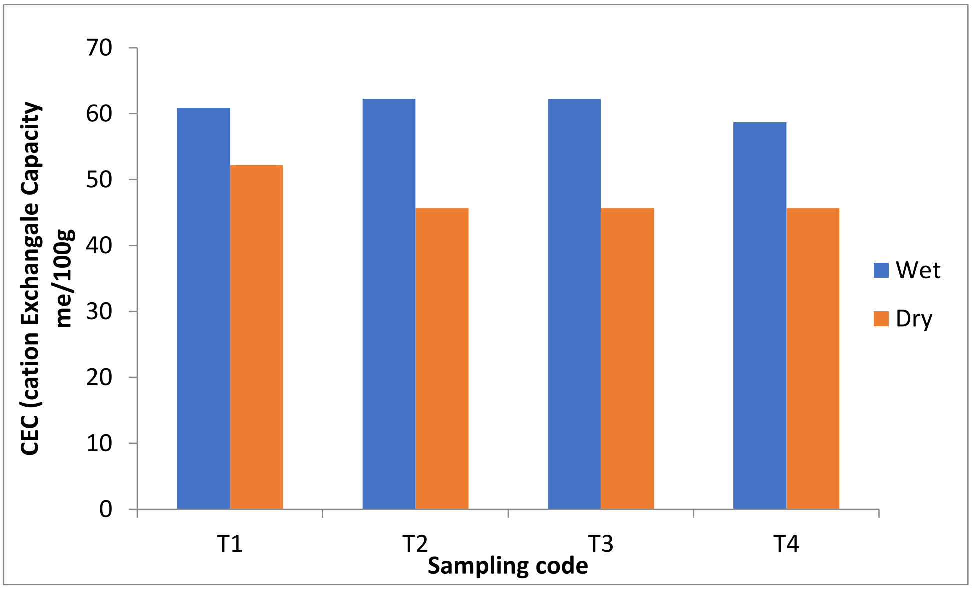


Figure 2.81. Results of Soil CEC Analysis on Peat Land of Perigi

Based on the results of the analysis of cation exchange capacity (CEC) in peat soil, the value The highest value was found in T1 L2 and T1 L3 lands, each with a value of 65.25 me 100 g^{-1}, while the lowest value was found in T1 L4 land with 58.73 me 100 g^{-1}. This CEC value is classified as very high. A high CEC indicates the ability of the soil to retain and exchange greater cations. Soil CEC is influenced by the clay and organic matter content in the soil. The higher the clay content or the finer the soil texture, the higher the CEC tends to be. Likewise, a high organic matter content will increase soil CEC (Putri *et al.,* 2017).

Soils with high cation exchange capacity (CEC) show slow changes in soil pH and can affect the timing and amount of nitrogen and potassium fertilizer applications. In soils with low CEC, for example less than 5 cmol (+) kg^{-1}, the risk of cation leaching is greater. The addition of ammonium and potassium to soils with low CEC can result in cation leaching below the root zone, especially in sandy soils with low subsoil CEC. Conversely, soils with higher CEC, for example more than 10 cmol (+) kg^{-1}, experienced relatively low cation leaching. The on-going decomposition process of organic matter produces humic compounds, which can significantly increase the cation exchange capacity (CEC) of the soil.

2.3.3.8. Plant Adaptation Model in Peatlands

One of the causes of forest and land fires is the traditional farming pattern of Sonor. Sonor farming activities are a community farming pattern in OKI Regency by clearing land for rice fields and gardens by burning. This pattern of farming with sonor has long been carried out by people living in swampy areas, both swamps with alluvial and peat soils in Ogan Komering Ilir Regency. This condition also occurs in Perigi village. **Figure 2.82** shows farmers starting to clear land by burning.

Figure 2.82. Land burned to grow rice (August 2024).

Farmers have a reason why they burn as an effort to prepare land for rice planting. Burning is certainly economically cheap, and also the result of burning leaves ash that can fertilize the soil. The ash produced can increase the pH of the soil, function as an ameliorant and also contribute some nutrients. **Figure 2. 83.** proves that the rice seedlings in the burned peatland are very good, the rice plants are thriving. This condition makes rice plantations thrive. From the above conditions, it is felt that it is necessary to cultivate rice plants that are more environmentally friendly

Figure 2.13. Plant growth with a direct seed sowing pattern in September 2024.

Plant adaptation from the direct seed sowing pattern is similar to in sonor activities, tried with a transplant planting pattern. The rice plants from the seedlings are uprooted and transplanted into pots (**Figure 2.84**). This activity is a micro-scale experiment of a rice cultivation system with a transplant planting pattern. Environmental treatment is to condition the groundwater level at a depth of -20 cm from the ground surface. It is believed that at a groundwater level of -20 cm, the surface of peat soil will always be wet so that plants can grow well and the land is avoided from the danger of land fires.

Figure 2.84. Rice growth in peat soil with transplant planting model

Furthermore, a trial planting was carried out at the field level. Land clearing is carried out by first killing the grass using herbicides, then the land area is cleaned manually (**Figure 2.85)**. Plant residues are piled on the edges which will then be developed into land dividers (galengan). In the field, planting is carried out by transplanting (**Figure 2.86**) and Tugal planting (**Figure 2.87)**

Figure 2.86. Land preparation for rice plants with a no-burn system

Figure 2.86. Rice planting model in the field with a moving planting system

Figure 2.87. Rice cultivation on peatland with a tugal system conditions October 5, 2024

The development of the plant is quite good, where when the last observation was made on November 15, 2025, the rice plants began to emerge panicles and the grain filling stage (**Figure 2.88**). Field observations on November 11-15, the plant has come out, panicles, this stage indicates that the generative phase has started since the beginning of November and it is estimated that at the end of November it can be harvested. The obstacle in the field is the rapid growth of weeds. Because at the beginning of growth, the land condition is not in a flooded state, the groundwater level is 20-30 cm below the ground level. In the condition that the soil is not in a flooded state, the growth of weeds (grass) is very fast. The weed problem is the main problem of rice cultivation in swampland. Added by (Ramadhan et al., 2023) Rice yield loss due to weeds worldwide is estimated to reach 10% to 15%, even yield loss can reach 86% if weed control is not carried out. Weed control efforts can be carried out by inundation to a depth of 10 cm for 2 weeks to kill or suppress weed germination (Johnson, 2024)

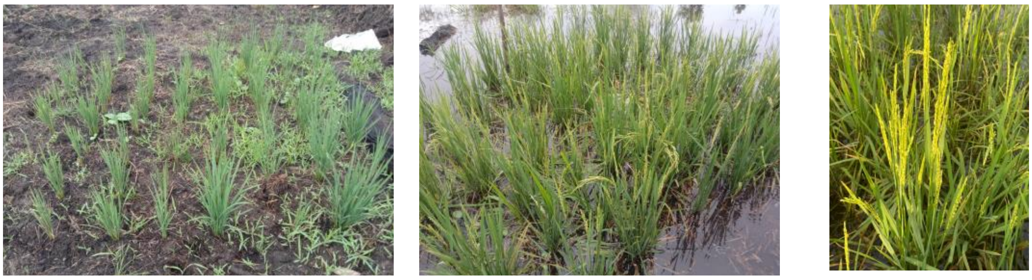


Figure 2.88. Rice growth conditions in the field with the transplant model without burning

The results of plant growth analysis and calculation of rice tubers in the field can be seen in **Table 2.15**. Rice production is quite good where the calculation of tubers shows a production of around 4.3 tons/ha. The same production was obtained from research (Partohardjono and Syam, 1992) that rice cultivation on peatland is able to produce between 3.5 to 4.0 tons/ha. The same thing is also shown from the results of the research of Jaelani et al (2016) the application of biochar as much as 7 tons/ha and coupled with a dose of manure of 5 tons/ha in Riau peatland shows a rice yield of 3.5 tons/ha. This condition fosters a sense of optimism where peat swamps, if intensively pursued, can be used for rice cultivation.

Table 2.15. Analysis of rice adaptation production in the field with the transplant planting method

	Growth Observation Parameters	Intermediate Values	Average (cm)
1	Plant height	102-106	104
2	Total number of saplings	12-16	14
3	Number of productive saplings	7-11	9
4	Total details in 1 panicle	185-187	186
5	Number of grains	112-116	114
6	Number of clumps per hectare (clump)	160.000	
7	Prediction of Dry Grain harvested in kg/ha	4.268	

	(The assumption of weight per 1000 grains is 26 grams).	
8	Total production in tons/ha	4,3

2.3.3.9. Model of Rice Plants in Place (Tugal) on Peatland without Burning (Micro Scale Tested)

The trial of planting rice without burning was also carried out with the tugal planting system. Farmers' activities begin by preparing the land by spraying with herbicides, which then the land is cleared manually. Preparations begin in early September and planting begins at the end of September.Rice planting is carried out with a tugal model, where rice seeds are directly inserted into the planting hole. The development of rice from September, October and the first week of November 2024 can be seen in **Figure 2.89**. In general, rice growth is quite good, but in dry soil, rice plants are attacked by pests from the soil, which causes the roots of rice to fall off. In addition, the main problem is weeds that are very fast, because the growth of rice saplings is slow so that the space between rice clumps is overgrown with weeds.

Figure 2.89. Rice development in peatland with tugal planting system until November 11, 2024.

The trial of planting rice without burning was also carried out with the tugal planting system. Farmers' activities begin by preparing the land by spraying with herbicides, which then the land is cleared manually. Preparations begin in early September and planting begins at the end of September.Rice planting is carried out with a tugal model, where rice seeds are directly inserted into the planting hole. The development of rice from September, October and the first week of November 2024 can be seen in Figure 3.24. In general, rice growth is quite good, but in dry soil, rice plants are attacked by pests from the soil, which causes the roots of rice to fall off. In addition, the main problem is weeds that are very fast, because the growth of rice saplings is slow so that the space between rice clumps is overgrown with weeds.

2.3.3.9. Rice Cultivation By Transplanting Using Pots Under Maintenance Shallow Water Tables.

Micro-scale experiments were carried out on peat soils using pots. The purpose of this study is to prove the maximum production of rice plants if the conditions of agricultural inputs are given to the maximum. With the hope of fostering optimism from the government and farmers that peatlands with hemic maturity have potential for the development of rice cultivation. Improving soil fertility begins with the provision of amelioration materials, namely husk charcoal biochar with a dose equivalent to 10 tons/ha; and the application of liquid fertilizer 15 ml/pot. The application of liquid fertilizer is carried out at the beginning, middle and before flowering rice (primordial). NPK fertilizer with a dose of 150 kg/ha is given twice, namely 2-week-old rice plants and 8-week-old rice plants.

For plant water needs from capillary supply from shallow groundwater where the depth of groundwater in the pot is conditioned at a depth of 20 cm. To maintain a constant water level, the plant is given water every 3 days and excess water will be wasted through a hole made 20 cm deep from the surface of the potting soil. Example of plant development during growth from the beginning of planting on August 15, 2024 to November 15, 2024. can be seen in **Figure 2.90.**

Figure 2.91. Rice development in pot-scale peatlands from August to November.

The analysis of the planting description data can be seen in Table 3.9 Rice growth is very good where the average plant height is above 100 cm. The highest height is reached at 107 cm. This figure has exceeded the Ciherang rice variety as a result of Akbari at al (2022) research which reached a maximum height of 95 cm. Meanwhile, according to Abdillah et al.

(2020), the height of rice plants planted on peat soil given 60 t.ha-1 coal ash is 142.5 cm. Table 2 shows the results of the analysis of the growth and production of rice plants on a pot scale converted to hectares. From the calculation of pots, it was obtained that the production converted to a unit of hectares was 5.3 tons/ha.

Table 2.16. Results of plant development measurements and production estimates

	Growth observation parameters	Intermediate Values	Average (cm)
1	Plant height	103-107	105
2	Total number of saplings	12-16	14
3	Number of productive saplings	10-13	11
4	Total details in 1 panicle	200-233	216
5	Number of grains	114-117	116
6	Number of clumps per hectare (clump)	160.000	
7	Prediction of Dry Grain harvested in kg/ha	5.308	
	(The assumption of weight per 1000 grains is 26 grams).		
8	Total production in tons/ha	5,3	

2.3.3.10. Adaptation of Mounding Technology for Coffee Plants

The model of plant adaptation by not changing the condition of the groundwater level is the Mounding technique. The height of the *mounding* should be above the tide level. So far, the maximum water level is at 60-70 cm. From the water level, a safety factor of 30 cm can be added. So that the height of the mounding is 100 cm from the bottom soil surface. In Figure 3.25. It shows that farmers are making mounding for coffee plant cultivation. In the implementation of making ordinary landfills, petanio does it in stages. Liberica coffee plants are coffee plants for wetlands that have been successfully developed in Riau Province.

The model of plant adaptation by not changing the condition of the groundwater level is the Mounding technique. The height of the moundin must be above the tide level. So far, the maximum water level is at 60-70 cm. From the water level, a safety factor of 30 cm can be added. So that the height of the mounding is 100 cm from the bottom soil surface. Figure 8 shows farmers making mounding for coffee cultivation. Liberica type coffee plants are coffee plants for wetlands that have been successfully developed in Riau province.The introduction of coffee plants is intended so that farmers are more interested in using land. Coffee is an industrial crop that has a clear market and relatively stable prices. Reported by

Media Indonesia (2018), liberica coffee cultivation has been successfully cultivated in Keduburapat Village, Rangsang Pesisir District, Meranti Islands Regency, Riau.For a planting area of 1 hectare, it can produce 1-5 tons of coffee. And in one coffee tree can reach 20 kg. From these conditions, it is very important to test liberica coffee on a large scale.

Figure 2.92. Mounding technology for coffee cultivation on peatlands.

The problem of soil salinity and low nutrients in peat soil requires coffee plants to be given amelioration and fertilization materials. According to research by Riyani et al (2020), the administration of dolomit 10-15 grams/tree is effective in increasing soil pH. Kartika et al (2022) added that the application of 10 g of mycorrhizal biofertilizer per plant and 50% inorganic fertilizer is the best combination in increasing the growth of Liberica coffee in peatlands. The recommended 100% dose value is 20 g of Urea/plant, 25 g of SP36/plant, 15 g of KCl/plant, and 10 g of Kisserite/plant. It can be reduced to 50 when combined with the use of bemicrobial liquid fertilizer. Fertilizer application is given *2 times a year*, at the beginning and end of the rainy season.

2.3.3.11. Evaluation of Soil Microbial Status

Soil fertility indicators are highly dependent on the existing microbial population. Microbial population data is also used to assess the extent of peatsoil damage. The soil contains an assortment of microbes including various species of bacteria, gangways, fungi and others. Bacteria and fungi play a very active role in breaking down organic matter so that they are widely found in peat soils, because peat soils are formed from the decomposition of organic materials in anaerobic conditions. Microbial activity is necessary to maintain the availability of an important nutrient for plants, namely nitrogen. Therefore, the total microbes in the soil are an indicator of whether peatland has been degraded or not. Peatsoil bacteria have many benefits besides producing a lot of protease enzymes (as antimicrobials) and also degrading as cellulose (fertilizing the soil) besides that it can also fertilize plants.

Soil sampling was carried out by treatment at various levels of peat thickness, namely shallow, medium and deep peat. Soil samples were taken at depths of 0-30 and 30-60 cm. **Table 2.17** shows that the total number of bacteria is greater than the function both based on soil depth and based on peat layer thickness. When we compare the critical limit of degraded peatland with a bacterial population value of <102 Cfu, the land is still very fertile where the average has 1.1-5.3 bacterial colonies. 104 Cfu/g. Likewise, the population function of the laboratory analysis showed a fairly high value of 3.2-7. 103 Cfu/g, still quite far when compared to the critical value of degraded land. Therefore, it can be concluded that peatlands in the well area are not classified as degraded peat when viewed from the total microbial indicators.

Table 2.17. Results of total analysis of peatsoil microbes in the Well area.

No	Sample	Bacteria	Fungi
1	L 0-30	2,1.104 Cfu/g	7.103 Cfu/g
2	L 30-60	1,1.104 Cfu/g	4,3.103 Cfu/g
3	S 0-30	5,3.104 Cfu/g	5,9.103 Cfu/g
4	S 30-60	1,8.104 Cfu/g	3,9.103 Cfu/g
5	P 0-30	1.105 Cfu/g	6,1.103 Cfu/g
6	P 30-60	2,4.104 Cfu/g	3,2.103 Cfu/g

Figure 2.26 shows that the total bacterial population is higher than fungi based on both peat thickness and peat depth. The deeper the thickness of the peat, the smaller the bacterial population, the shallower the colony. This condition is also followed by the topsoil layer higher than the bottom layer. So that the total decrease in microbes is in line with the decrease in depth. This condition is also followed by fungal populations. The population of peat-covered bacteria showed a smaller number when compared to the results of research on dry land planted with oil palm plants. The population of bacteria on the soil surface of oil palm plantations at the age of 3 years is 1.16 x 105 Cfu (Irfan, 2014). In line with Palupi et al (2023) that the total micro in the area is more found at a depth of 0-25 cm.

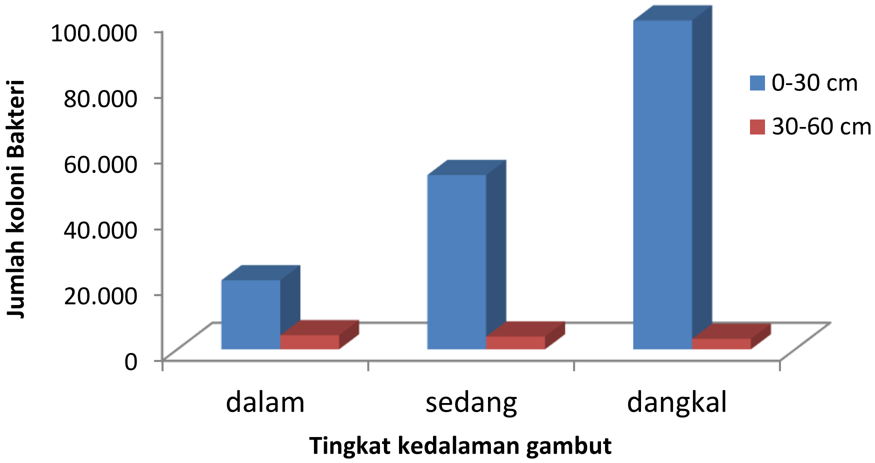


Figure 2.93. Total bacterial colonies on well peat soils

Figure 2.94 shows that the fungal population is also affected by the thickness of the peat and the depth. The mushroom population is getting higher along with the thickening of peat. On the contrary, the decrease in the number of fungal colonies occurs with the depth of the soil layer. The highest value of functional colonies is peat in the first layer, which is 7.103Cfu/g. However, when compared to cultivated land in dryland agriculture, it is still smaller. Research by Fitria et al (2014) showed that the total fungal population ranged from 0.4x105 -1.0x105 Cfu/g of soil with the highest population found in corn fields.

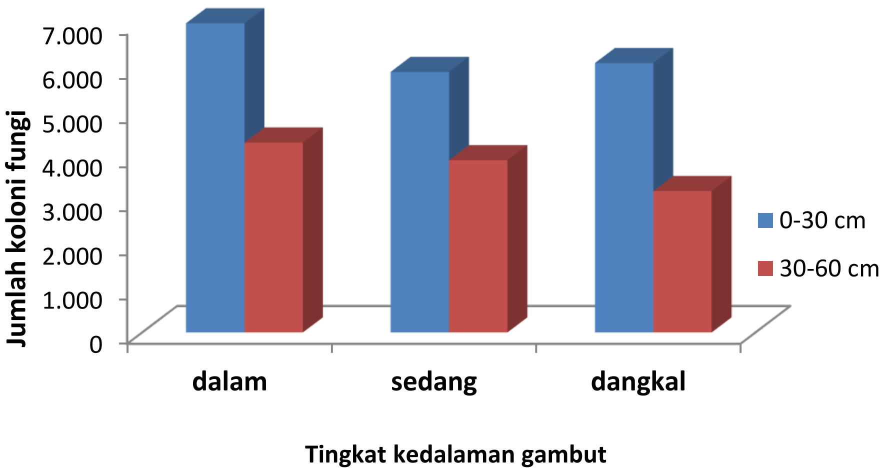


Figure 2.294. Fungi populations in peatlands at various depths and thicknesses of peat wells, South Sumatra

2.3.3.12. Evaluation of The Effectiveness of The Hydroulic Structure to Control The Water Table

The key to the success of agricultural cultivation in peat wetlands is how farmers can control the groundwater level to be suitable for plant growth. In addition to plants, water management in peatlands is also to prevent fires. For this reason, drainage channels must be equipped with control buildings. The results of the water building study made are using a reinforced concrete structure with a congcrate model bottom foundation. The strcuture in the bottom was construct by gelam wood up to 2m more, and then it is filled with mineral soil. (**Figure 2.95**) is the process of building construction.

Figure 2.95. Construction of canal blocking building in peatland areas.

To regulate the water level, the building is equipped with a gate under stooplog model. The gate made is a model of a wheelbarrow installed on the discharge threshold -40 cm from the embankment. The purpose of this threshold (*over flow*) is so that groundwater in the canal is maintained at least at an altitude of -40 cm from the canal embankment and groundwater in the land can be maintained at the level of -40 cm below soil surface. Gate operation is only open and close. The gate are opened during the rainy season and must be closed ahead of the dry season or the month starting in June. An overview of the sluice gate operation can be seen in **Figure 2.96.**

(a) (b)

Figure 2.96. Gate operation model in the channel during the dry season closed (a) and opened in the rainy season (b).

2.3.4. Conclusion

1. The results of laboratory analysis of several physical, chemical and biological soil parameters show that the analysis results are still above the quality standard criteria. Only the soil permeability value had a significant decrease. However, in general land has not been classified as degraded peat soil.
2. Water dynamics studies show that the land has been inundated for a long period, and the drainage system is in poor condition. The duration of inundation is more than 6 months, namely from November-December, January, February, March, April, May, June. Therefore, food crop cultivation can only be carried out during this period using a rice-palawija planting pattern. Soil water dynamics show -15 to 20 cm so it is suitable.
3. for the rice planting period. Rice planted in the field on August 15 showed good growth and in November the plants entered the generative phase. Trials in pots showed good results and rice could grow well at a groundwater depth of -20 cm
4. Analysis of soil chemical properties and soil nutrient dynamics shows that there is a decrease in soil pH values when the soil dries out, meaning that the pH during the rainy season is higher in dry conditions. This is inversely proportional to Nitrogen nutrients where the dry season has higher levels than the rainy season. The same is true for the Phosphorus content. Only the CEC (cation exchange capacity) and K-dd values in the rainy season have higher values compared to the dry season.
5. The canal blocking model in the study area is very appropriate to be built using a permanent construction model with a reinforced concrete structure. This model will have a long operating life and avoid the danger of fire. The application of a sliding type gate is effective and can be used to close in the dry season to keep out water. Retaining water for 3 days can raise the water level by up to 20 cm; and the door operation enters the rainy season (November) then the door is opened. The results of

the study show that there are only two operations system, namely closed in the dry season and open in the rainy season. The overflow water was set at a depth of 30 cm from the average ground level.

6. Dry season conditions without controlling the water level in the channel mean that the ground water level drops in October to 70 cm; This condition caused land fires to occur in October. The burned land is currently planted with sonor rice. So land fires also have an intentional element in preparing the land for sonor rice system
7. To adapt the cultivation of perennial crops in peat swamp land, it is carried out using a mounding model. A technological adaptation pattern that does not change major environmental conditions, namely the mounding technique, is the appropriate model. The land is raised to a minimum of 30 cm above the peak level of standing water. The work is carried out in stages. This mounding model is also very good for slowly improving the physical and chemical properties of the soil
8. The model for adapting rice plants under shallow groundwater levels (-20 cm) on peat soil has been successfully tried on a pot scale. Maximum plant height is 105-107 cm; number of offspring 14-16; the number of productive tillers is 11-13 and the predicted dry grain harvest will reach 5.3 tons/ha
9. Analysis of soil microbes shows that bacterial and fungal populations are still above the threshold for degraded peatlands. The number of bacterial and fungal colonies tends to decrease as the peat soil becomes deeper. Bacterial and fungal populations are higher on land with moist soil conditions compared to flooded conditions.
10. Evaluation of physical, chemical and biological soil parameters shows that all parameters are relatively below critical figures for land degradation criteria. That only the permeability value is lower than the threshold number. However, in general, peatlands in Perigi are not yet

2.3.5. Research Plan on 2025

2.3.5.1. Introduction

This research is based on the current agricultural activities that are directed at sub-optimal lands as a strategy to meet the increasing food needs. Van Dijk et al. (2021) have projected that there will be an increase in global food needs in the range of 35-56% in 2010-2050. In another study, Falco et al. (2022) also confirmed that there will be an increase in food demand of 50-60% in 2019-2050. Therefore, several alternatives should be sought to optimize unproductive land. One of the lands that needs to be optimized for agricultural activities is burnt peatlands. As a country that has 36% of the world's tropical peat and is the largest in the world (Dargie et al., 2017), Indonesia needs to start optimizing this land seriously, especially for sustainable agricultural activities. The most important peatland to be optimized is burnt peat. In 2015, peatland fires occurred in Indonesia and became the center of world attention. Kiely et al. (2019) reported that the fires that occurred in Indonesia in 2015, in addition to producing carbon dioxide and other gases, also produced small air particles (particulate matter (PM)). These air particles have a very negative impact on health. This is also in line with Wooster et al. (2018) who reported that there was an accumulation of PM2.5 due to the 2015 peat fires which caused people to be exposed to air pollution for a long period of time. Meanwhile, when associated with biodiversity, peat fires cause significant loss of biodiversity. Harisson et al. (2016) stated that in addition to environmental health problems, several living things are threatened with extinction due to peat fires.

Regarding land suitability, the physical, chemical, and biological properties of the soil need to be the main focus due to peat fires. These three soil properties play an important role in cultivation activities. Good physical, chemical, and biological properties of the soil will support plant growth as well as optimal yields. However, peat fires will change the physical, chemical, and biological properties of peat soil. Ash from burned peat plays an important role in changing the properties of peat soil. Arisanty reported that burned peat was indicated to have higher pH, P_2O_5, and K_2O. However, Sulaeman et al. (2019) reported that burned peat has been shown to have a negative impact, especially related to decreased nitrogen, cation exchange capacity, and organic matter content. Fullazaki et al. (2022) stated that peat fires have reduced permeability and soil microbial populations. This condition is exacerbated by the decreased ability of the soil to hold water when the peat has burned (Agus et al., 2019). Thus, holistic efforts are needed to restore burned peat to make it more productive.

Efforts to plant food crops on burnt peatlands are a strategy that needs to be continuously tested. Selection of adaptive plant types with the selection of appropriate treatments is part of the strategy in optimizing degraded land conditions. In this case, we categorize burnt peatlands as degraded land. This is inseparable from the nature of the soil with decreased quality due to burning. Through good water management, it is expected to support the growth of food crops. Hairani and Noor (2020) stated that good water management is very important in determining the success of food crop cultivation on peatlands. Nursyamsi et al. (2016) stated that to achieve sustainable agriculture, water management, ameliorants, and fertilization are efforts that need to be considered. The balance of water balance needed by plants while preventing peat from losing excessive water is the main strategy in sustainable water management on peatlands. The development of plant adaptation strategies as well as water management and cultivation models need to be continuously developed to achieve successful cultivation on burnt peatlands. This study aims to evaluate soil health and growth-yield of rice planted at different times after peat burns, planting models, and fertilization.

2.3.5.2. Research Methodology

This research is the Second Year Research (2025) which is part of the research to continue the field adaptation test of plants and see the effect of water level control operations (block gates) on soil macro nutrient dynamics and groundwater level dynamics. Physical, chemical, and biological parameters of the soil in several land use models (land management systems) will also be studied to see the extent to which they affect the soil health status. The research was conducted in the peatland area of Perigi Village, Pangkalan Lampam District, Ogan Komering Regency, South Sumatra.

The study used soil and hydrology survey methods at a detailed level and field experiments following the rules of Randomized Block Design. Rice plants were selected to test their adaptation levels through several treatments, namely:

• P0 (burned land <1 year (repeated fires) sonor model of scattered planting, not fertilized and no water level control

• P1 (burned land <1 year (repeated fires) sonor model of scattered planting, fertilized and no water management;

• P2 (burned land> 2 years of scattered planting, fertilized and no water management;

• P3 (burned land> 2 years of scattered planting, fertilized and water management;

• P4 (burned land> 2 years of scattered planting, without fertilization and no water management

All treatments were repeated 3 times and each experimental plot was 0.25 ha in size.

The data collected consisted of soil characteristics (physical, chemical, and biological properties of the soil), hydrology, and rice growth-yield. The parameters of the physical properties of the soil were permeability value, bulk density, total pore space, water content, pyrite depth, soil color, and peat maturity level. The chemical parameters of the soil included Nitrogen, Phosphorus, Potassium, Ca, Mg, pH, Al-dd, and CEC content; for the biological parameters of the soil were the number of bacterial and fungal colonies. The height of the puddle or depth of the groundwater would also be recorded every 3 days in each treatment. Soil sampling for soil fertility analysis was at a depth of 0-30 cm; and 30-60 cm.

To see the effect of canal blocking operation, hydrological observation was conducted. Hydrological parameters measured in the field were water level observation in the channel; groundwater level in the experimental land, gate opening and closing operation, and rainfall. In addition, groundwater quality will be analyzed in each treatment, samples will be taken in wet conditions (rainy season) and dry season. To save cost, water sampling was conducted using the transect method **(Figure 2.97**) from land planted with sonor rice (no water gate); and land planted without burning (there is a water gate). So there are 2 transects.

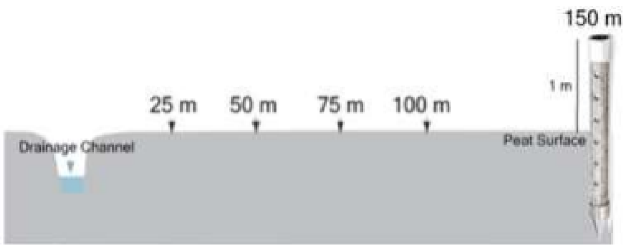


Figure 2.97. Observation of groundwater levels and groundwater sampling using the transect method.

After the data on physical, chemical, biological and hydrological properties of the soil have been collected, data processing is carried out and the data will be approached with the weighted value of each parameter. The Cornell method is used in weighting. This method uses a value or weight score of 0 with very low criteria and 100 with very high criteria for each parameter. Soil indicators consist of Bulk density, Porosity; Permeability; active pH, P-available, N-total, K-available, Ca-available, Mg-available, Na-available, total microbes and respiration.

After soil analysis is carried out, the soil health assessment is calculated using the Cornell Soil Health method. In soil health assessment, the score function is a curve that has a specific value between 0-100 for each indicator. The sum of all scores from the soil indicators analyzed divided by the number of indicators is the value of soil health.

$$SH = \Sigma Si/N$$

Description: SH = Soil Health, Si = Soil Indicator, N = Number of indicators

In addition to observing soil characteristics, there are also observations of plant growth. The growth data taken are plant height, number of shoots and plant production. The data obtained were then analyzed statistically using analysis of diversity (ANOVA) to determine the effect of treatment on the parameters tested and continued with the smallest significant difference test (LSD 5%) to determine the difference in effect between the treatments tested.

The Studio's work also includes computer simulation activities of the DRAINMOD model to see the effect of gate operations on groundwater dynamics in wet and dry year conditions; and in several land use plan scenarios. The model is accepted if the simulation data shows the same results as the observation results. Adaptation of the DRAINMOD modeling will be used as the basis for compiling a water management operation plan at the field level in the case of rice and secondary crops cultivation on peat soils with variations in tropical climate conditions (Elnina and Lanina).

The results of field adaptation related to this land and water management model will be Upaschalling using GIS technology with the intention of facilitating dissemination (distribution technology) and ease of access if the government will make agricultural policies on peatlands. The zone approach model (biophysical components of the environment that are almost the same as the study area) in a Peat Hydrological Unit. The management zone level will be the basis for compiling future programs.

III. SCIENTIFIC PAPERS PRODUCED BASED ON RESEARCH ACTIVITIES AND FINDINGS

The Unsri Team together with the CIFOR Team and the NIFoS Team have carried out various scientific activities during 2024. These activities have resulted in several publications which have been and will be published in various reputable international journals, and also draft publication.

Table 3.1. List of Research Outputs

No.	Category	Total numbers	Title of Article
1.	International Journal	1	Muhammad Irfan, Erry Koriyanti, Khairul Saleh, Hadi, Sri Safrina, Awaluddin, Albertus Sulaiman, Hamdi Akhsan, Suhadi, Rujito Agus Suwignyo, Eunho Choi, and Iskhaq Iskandar. 2024. *Dynamics of Peatland Fires in South Sumatra in 2019: Role of Groundwater Levels*. ***Land,*** **2024**, *13*(3), 373; **https://doi.org/10.3390/land13030373**
2.	International Seminar/Conference	7	Imanudin, M.S., Bakri, Muh Bambang Prayitno., Assad Sazili., Eunho Choi. 2024, Variability Of Hydro-Physical Properties In Drained Peat Soil (A Case Study Of Perigi Village Ogan Komering Ilir South Sumatra Indonesia). The First International Conference On Agricultural Science, Technology, Economics And Sustainability. Faculty of Agriculture Jambi University. October 30-31 2024.
			Unlocking the potential of paludiculture for sustainability in peatland: a case of Perigi village, South Sumatra, Indonesia. International Workshop Program the Peatland Restoration for Sustainable Development, Jeju island 2024.
			Sustainable peat ecosystem management policy in Indonesia. International Workshop Program the Peatland Restoration for Sustainable Development, Jeju island 2024.

			Adaptive technology for soil and water of peatland management under tropical hidro-climatic condition. Jeju island 2024
			Community-based for sustainability of mangrove restoration: a case study of action research at Sungsang village, South Sumatra. Jeju island 2024.
			Muhammad Irfan, Sri Safrina, Awaluddin, Albertus Sulaiman, Mokhamad Yusup Nur Khakim, Frinsyah Virgo, Sutopo, Azhar Kholiq Affandi, Dedi Setiabudidaya, and Iskhaq Iskandar. 2024. *The Impact of Positive IOD and La Niña on Rainfall, Groundwater Level, and Soil Moisture in Peatlands in South Sumatra*. **It has been published** in EUDL International Proceeding of The 3rd Sriwijaya International Conference on Bacis and Applied Sciences. **https://eudl.eu/doi/10.4108/eai.3-11-2023.2347941**
			Muhammad Irfan, Muhammad Yusup Nur Khakim, Wijaya Mardiansyah, Netty Kurniawati, Sri Safrina, Awaludin, Eunho Choi. 2024. *The Impact of Positive IOD and El Niño on Rainfall, Groundwater Level, and Soil Moisture in Peatlands in OKI Regency*. The 5th international conference on applied sciences, mathematics, and informatics. 14 - 15th October 2024. Universitas Lampung. **It has been accepted**
3.	Books	1	Growth analysis on a peatland restoration species, Tamanu, under different ground water levels 1

V. CLOSING REMARK

This report was prepared as a form of accountability for the implementation of Unsri's collaboration with NiFos through an MoU signed by Prof. Dr. Ir. Annis Saggaff, MSCE as Chancellor of Sriwijaya University (Unsri), Indonesia with Dr. Jae Soo Bae as President of the National Institute of Forest Science (NiFos), South Korea. The MoU signed in 2023 was followed up by a Cooperative Research Agreement between Sriwijaya University and the National Institute of Forest Science (NiFos). This research collaboration agreement takes topics related to peatlands in a broad sense, including aspects related to forestry and environmental preservation. Peatlands, which are a very important ecosystem that stores about 30% of the world's carbon reserves, are currently experiencing a lot of damage due to human activities such as deforestation, conversion to agricultural land, drought and fires, and climate change.

As of December 2024, many results have been achieved as a result of the implementation of collaborative research which was signed in February 2024. Some of these results, especially in the form of scientific publications in international journals, are important outputs of research. So far 4 publications have been produced in international journals. Apart from being published in journals, research results are also published in national and international seminars.

Sriwijaya University also has a peatland area of around 12 hectares which so far has not been utilized optimally. To support this collaboration with NiFos, starting in the middle of the year, Unsri prepared the peatland to be used as an integrated peatland research area starting from vegetation analysis, testing various types of forest plants (enrichment of plants in peatlands), soil properties, identification of flora and fauna, carbon analysis and other research topics that are possible after discussion and become a common interest. Currently, around 5,200 m2 of land is being prepared. It is hoped that this area can become an arena for long-term collaborative research between UNSRI and NiFos.

Unsri welcomes and is grateful for NiFos' trust in carrying out the collaboration. It is hoped that this collaboration will last longer and produce research on peat in a broader meaning, more comprehensive sense and can become an international reference regarding the management of peat areas.

Hopefully this report can provide a complete picture of what has been agreed and has been done, as well as what will be done in the future, especially in 2025.

Acknowledgement

We would like to express our gratitute to Dr. Eunho Choi (Head of Project of NIFoS) for providing the opportunity to carry out this activity. Through this activity, the Unsri Team has had many opportunities to discuss with the Korean National Institute of Forest Science (NIFoS) Team. We have got many priceless experiences. Hopefully this activity will provide many benefits not only for the surrounding community but also for the development of science.

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Apendix 1. Activities between UNSRI and NIFoS

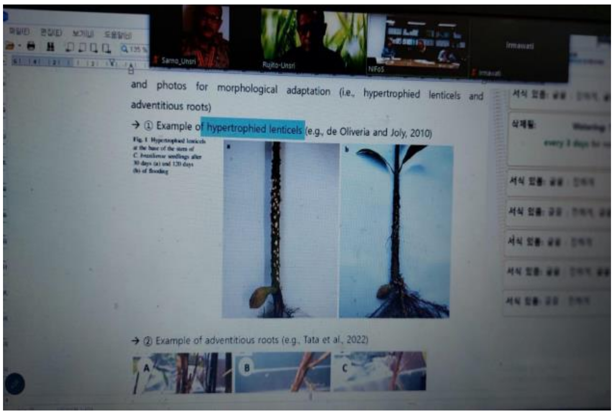
1. Internal Meeting between UNSRI and NIFoS

The collaboration between Unsri and NIFoS was made possible due to the good cooperation from many parties. This collaboration is also running smoothly due to regular meetings held to ensure that the research collaboration activities are carried out as planned. During the year 2024, several meetings were held both online and offline as seen on **Table 2.1.**

Table Apendix 1. Meeting Schedule and Agenda

No.	Meeting Date	Meeting Agenda
1	April 3th, 2024	Vegetation Research Guideline
2	May 10th-13rd, 2024	Offline Meeting
3	June 3th, 2024	Vegetation Research on 2024
4	June 24th, 2024	Follow Up Research 2024 and Research Plan 2025
5	August 6th, 2024	Vegetation Research 1. To finalize the 2024 experimental Design 2. To discuss the 2025 species and study site
6	September 5th, 2024	Midterm Internal Meeting
7	October 12th, 2024	Research Progress 2024 and Research Design for 2025

In various meetings that were held, we agreed on various matters, including the research design, research timeline, research outputs, and research outcomes. In the meetings, we also reported on the progress of the research, as well as the obstacles and challenges in the research, and together we found solutions. In vegetation teams, we got agreement about evaluation of the growth of tree seedling under different flooding levels and duration in peat soil. In the climate change team, we also got agreement about the way to investigate climate change anomalies on hydro-climatological parameters, and the last one, we also reached agreement about the method in developing water management in the peatland area. Figure 2.1. describe about the meeting activities.

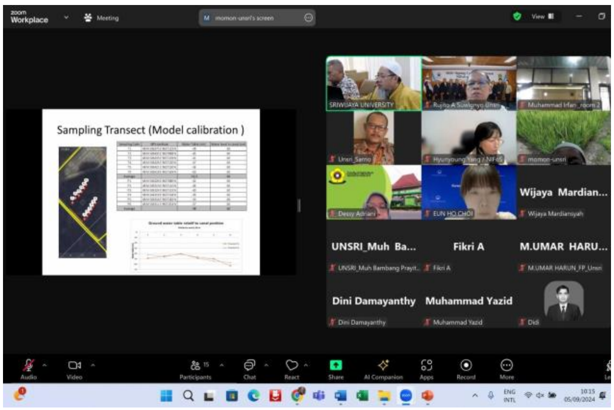


April 3th, 2024

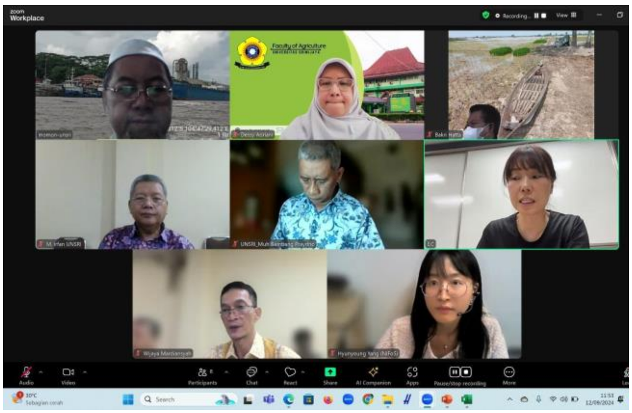
May 10th, 2024

May 10th, 2024

May 11th, 2024



September 5$_{th}$, 2024



October 12th, 2024

Figure Apendix 1. Some of Meeting Documentations

2. Guest Lecturer Program

Collaboration with NIFoS is not only related to the research sector but also to the education and teaching sector through the Guest Lecturer Program with the topic: "Sharing research Experience for Sustainable Forest" at Mei 13th 2024 at Faculty of Agriculture Universitas Sriwijaya (**Figure 2.2**). The public lecture on Sharing Research Experience for Sustainable Forest has many benefits, especially for students, researchers, and policymakers involved in the fields of forestry and the environment.

Figure Apendix 2. Leaflet of Guest Lecture

From this program, we gave some of the benefits:

1. Improving Understanding of Forest Sustainability. Delving into the concepts and practices of forest sustainability is very important, especially in the current era where climate change and forest exploitation are global concerns.
2. Learning from Real Experiences. Students and participants can learn techniques and strategies based on previous research that has proven effective in maintaining and restoring forest ecosystems.

3. Encouraging Innovation in Forestry Research. Through the shared experiences, participants can be inspired to develop new ideas in research, both from technical and social aspects.

Figure Apendix 3. Guest Lecturer Documentation

4. Implementation of Sustainable Practices in Indonesia. Discussing research findings relevant to the forest conditions in Indonesia helps provide guidance for policies and practices that support forest sustainability.
5. Strengthening Cooperation Among Researchers and Institutions. This forum opens opportunities for researchers from various institutions to collaborate, share data, and combine resources in an effort to effectively enhance forest conservation.
6. Sharpening Students' Analysis and Research Skills. Listening to researchers' experiences helps students develop relevant analysis skills and research techniques, especially in the context of environment and conservation.

7. Increasing Public Awareness about the Environment. Events like this also raise awareness about the importance of preserving forests and the environment, both for participants and the wider community if this information is disseminated.

Guest lectures like this not only enrich academic knowledge but also encourage real actions for the preservation of forests in Indonesia.

3.Dissemination at the international level by attending meetings and presenting the results of research activities

Conference Title: The Third International Workshop on the Peatland Restoration for Sustainable Development 2024

Overview:

- Date: 4 June 2024 (Tuesday), 10:00-16:00 KST (GMT+9)
- Venue: B1 Rose Room, Seogwipo Kal Hotel, Jeju Island, Republic of Korea
- Participants: Hybrid (NIFoS, UNSRI, KU etc.)

Objectives :

- Enhancement of a community-led management system for the sustainable restoration and development of peatland restoration model
- To foster synergy for the joint international research project in the forest sector via mutual cooperation and partnership between research institutes
- To inspect and share the progress of the joint international research project for peatlands restoration

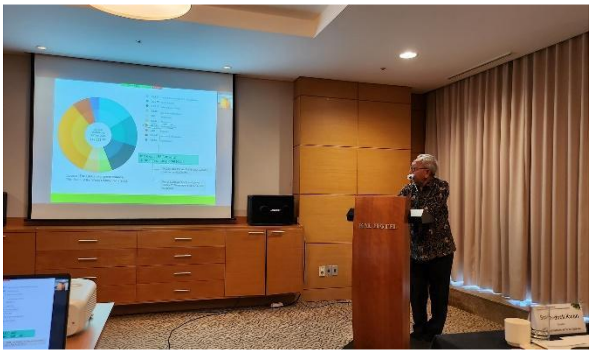


Figure Apendix 4. Presentation in International Workshop, NIFoS, Jeju Island, Korea

Table Apendix 2 . International Workshop Program the Peatland Restoration for Sustainable Development 2024

Contents	Speaker
[presentation 1] Unlocking the potential of paludiculture for sustainability in peatland: a case of Perigi village, South Sumatra, Indonesia	Dessy Adriani Associate Professor, Sriwijaya University
[presentation 2] Sustainable peat ecosystem management policy in Indonesia	Muh Bambang Prayitno Professor, Sriwijaya University
[presentation 3] The dynamics of rainfall, groundwater level, and hotspot under the influence of IOD+ 2019 in OKI peatland	Muhammad Irfan Professor, Sriwijaya University
[presentation 4] Adaptive technology for soil and water of peatland management under tropical hidro-climatic condition	Momon Sodik Imanudin Professor, Sriwijaya University
[presentation 5] Community-based for sustainability of mangrove restoration: a case study of action research at Sungsang village, South Sumatra	Erizal Sodikin Associate Professor, Sriwijaya University

4. Monitoring and Evaluation On November 2024

In November 2024, the NIFoS Research Team visited Palembang to discuss several matters, namely:

1. Plan for the Concept Note (with budget) for the 2025 international symposium
2. Final report 1st draft by 31st December. Final official submission in Feb. 2025.

3. Plan for the preparation of a book on peatland. Garis besar buku hingga 31 Desember. Persiapan draf pertama hingga Maret 2025.
4. Research Plan on 2025 Discussion

Figure Apendix 5. Monitoring and Evaluation On November 2024