Peat Ecosystem Restoration Through Canal Block Construction and Integrated Farming in Upt Singkuang Village, Mandailing Natal District, North Sumatera Province

Poppy Wiharja[1], Bambang Supriyono[2], Abdullah Said[3], Hermawan[4]

[1]Doctorate Program of Administrative Science, Faculty of Administrative Science, Universitas Brawijaya, MT Haryono 163 Lowokwaru Malang, Indonesia
[2,3,4]Faculty of Administrative Science, Universitas Brawijaya, MT Haryono 163 Lowokwaru Malang, Indonesia

ABSTRACT
Peatland is one type of marginal land the community chooses to develop agricultural land and plantations. Sporadic use of peatlands causes extensive damage to peat ecosystems in Indonesia. Restoration of damaged peat ecosystems can be done using natural succession, rehabilitation, restoration, and other methods by scientific and technological developments. This research was conducted using qualitative methods and a literature study. This research aims to comprehensively and discursively understand the literature on a phenomenon related to how TKPPEG "Harapan Kita" restores peat ecosystems through rewetting through the construction of canal blocks and the development of Peatland Stewardship Village (DMPG) through an integrated agricultural system approach. From this literature study, it is known that there is a strong correlation between the existence of canal blocks and the increase in groundwater levels, which has an impact on agricultural land productivity. The integrated agricultural system being developed combines the Waringin variant of sheep farming, seasonal crop farming in the form of pineapple (Ananas et al..) and cassava (Manihot esculenta) cultivation, and annual crops in the form of areca palm trees (Areca catechu) and rambutan trees (Nephelium lappaceum L). This agricultural system can increase land productivity and environmental conservation in an integrated manner.

Keywords: Peatland, Canal Blocking, Integrated Agricultural System

INTRODUCTION

Indonesia harbors peatland ecosystems distributed across Sumatra, Kalimantan, Papua, and Sulawesi to a lesser extent (Wahyunto et al., 2013). Recent research by Xu J et al. (2018) indicates that globally, peatland covers 4.23 million km2, equivalent to 2.84% of the world's land area. According to Ministerial Decree Number: SK.129/MENLHK/SETJEN/PKL.0/2/2017 on the Establishment of National Peatland Hydrological Units, Indonesia comprises 865 Peatland Hydrological Units (KHG) covering a total area of 24,667,804 hectares spread across Sumatra (9.6 million hectares), Kalimantan (8.4 million hectares), Sulawesi (63.2 thousand hectares), and Papua (6.59 million hectares).

The limitation of productive land has directed agricultural and plantation expansion towards marginal lands. Peatlands are among these marginal lands chosen by communities and entrepreneurs for agricultural and plantation development. The sporadic utilization of peatlands in Indonesia has led to significant potential damage to peat ecosystems. This damage has contributed notably to the deforestation rate in Indonesia over the past decade, and according to the monitoring results of the Ministry of Environment and Forestry (2023), Indonesia's net deforestation in 2021-2022 amounted to 104 thousand hectares, while it was 113.5 thousand hectares in 2020-2021. Data from the Ministry of Environment and Forestry (2017) indicates that peatland ecosystem damage in Indonesia has reached 23.95 million hectares. Damaged peatland ecosystems exhibit characteristics such as artificial drainage, exposed pyrite and quartz sediments beneath the peat layer, reduced land cover due to forest and land fires, and groundwater table decline in peatlands.

The characteristic of peat soil, which does not revert when damaged, poses a significant constraint in restoring peatlands to their functional state. According to Wahyunto et al. (2013), several indicators of peatland degradation include (1) forest and land fires, (2) land use change, (3) land drainage through canals, and (4) natural resource mining. The composition of peat soil, comprising water and organic materials, necessitates drainage or channels for agricultural and plantation utilization (Ritzema, 2007). Dry peatlands, resulting from uncontrolled drainage channels, present a potential source of greenhouse gas (GHG) emissions (Wilson et al., 2016). Research by Evans et al. (2015) indicates that lowering the groundwater table in peatlands due to drainage increases CO2 and methane (CH4) emissions. This drying potential also heightens vulnerability to forest and land fires, contributing to substantial GHG emissions (Kettridge et al., 2015).

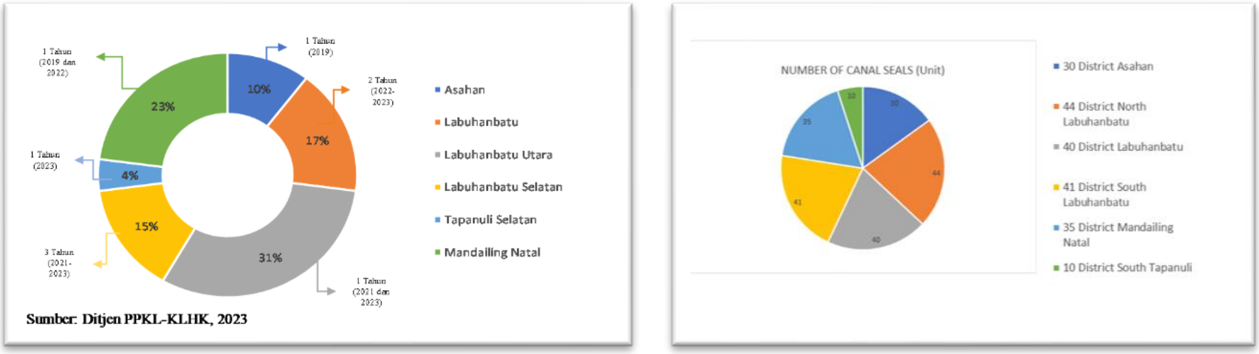
Presidential Regulation of the Republic of Indonesia Number 57 Year 2016, in conjunction with the Amendment to Government Regulation Number 71 Year 2014 concerning Peat Ecosystem Protection and Management, Article 30, stipulates that damaged peatland ecosystems can be restored through natural succession, rehabilitation, restoration, and other methods aligned with advances in science and technology. Restoration efforts encompass techniques such as water management on peatlands, construction activities for rewetting infrastructure, and the implementation of local wisdom-based cultivation. According to the Ministry of Environment and Forestry (2017), technical guidelines for restoring peatland ecosystem functions specify that local communities conduct restoration outside concession areas or management units. Community-led ecosystem restoration aims to maintain high groundwater levels in peatlands through infrastructure development for rewetting, including canal blocking and canal blocking infill. Furthermore, rehabilitation activities include the development of Peat Care Self-Reliant Villages through natural succession, agroforestry, and paludiculture systems.

Rewetting prevents peatland droughts, reducing GHG emissions and preserving carbon storage functions. Tata and Susmianto (2016) state that rewetting efforts involve infrastructure development, such as canal blocking. Barakah and Sidiq (2009) state that canal blocking in peatlands aims to (1) improve water management by maintaining high groundwater levels, (2) prevent forest and land fires during the dry season, and (3) enhance plant productivity to improve the socio-economic status of communities. The development of Peat Care Self-Reliant Villages adheres to sociological and anthropological principles, empowering local communities to participate, negotiate, influence, and responsibly manage community institutions for their livelihood improvement.

Based on data from the Ministry of Environment and Forestry (2023), North Sumatra province has seen the most canal-blocking and Peat Care Self-Reliant Village developments from 2018 to 2023. In North

International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Sumatra, 200 canal block units and 40 Peat Care Self-Reliant Villages (DMPG) have been established. Mandailing Natal District is recognized as successful in canal blocking and DMPG development. Graph 1 illustrates the distribution of canal blocking and DMPG development across North Sumatra province from 2018 to 2023.



Graph 1. Distribution of Canal Block Construction and Peat Care Self-Reliant Village (DMPG) Development in North Sumatra Province (Source: Directorate General of PPKL-Ministry of Environment and Forestry, 2023)

Based on Graph 1 above, UPT Singkuang Village successfully constructed a canal block and developed the Peat Care Self-Reliant Village model in Mandailing Natal District, North Sumatra Province. UPT Singkuang encompasses 70% of its administrative area in peatlands. Forest and land fires are the primary challenges the Village Government and the District Government of Mandailing Natal must address. According to SiPONGI-KLHK data (2023), from 2018 to 2021, approximately 266 hotspots were reported with a confidence level of > 80%. Hotspots are detected instances of forest or land fires within specific pixel dimensions that are likely to have burned during satellite passes (Giglio, 2015). The satellites known for hotspot detection by SiPONGI-KLHK include NOAA, Terra/Aqua MODIS as described by Giglio (2015) within MODIS, categorized into three confidence levels:

Table 1. MODIS Satellite Confidence Levels

Level of confidence (C)	Class	Action
O%≤ C < 30%	Low	Needs attention
30% ≤ C < 80%	Normal	Alert
80% ≤ C ≤ 100%	High	Immediate intervention

UPT Singkuang Village, predominantly settled by transmigration communities in the 1990s, favors agricultural and plantation activities as its primary livelihood, leading to extensive canal construction to enhance land productivity. Limited understanding and capacity among the community regarding sustainable peatland ecosystem protection and management have resulted in an increasing number of canals directly draining into nearby rivers around agricultural and plantation areas.
This study is based on field observations, Focus Group Discussions (FGD), and literature reviews of the peatland ecosystem restoration activities conducted by the Peatland Ecosystem Protection and Management Team (TKPPEG) in UPT Singkuang Village, known as TKPPEG "Harapan Kita." The research aims to present the concept, process, and practices of peatland ecosystem restoration through

canal block construction and the establishment of the Peat Care Self-Reliant Village, implemented in UPT Singkuang Village. This case study can serve as a learning example and reference for decision-makers in formulating strategic policies for sustainable peatland ecosystem management.

METHODOLOGY

This research employs a qualitative descriptive method and literature review. The qualitative descriptive method aims to comprehensively understand a phenomenon by describing observed occurrences and conducting a literature review. The qualitative approach involves describing recognized phenomena. Descriptive qualitative research produces descriptive data in written or oral form obtained from informants (Nugrahani, 2014).

The research location focuses on Canal Block Construction and Peat Care Self-Reliant Village (DMPG) development activities in UPT Singkuang Village, Muara Batang Gadis District, Mandailing Natal Regency, North Sumatra Province. The selection of this location was purposive due to the assumption that UPT Singkuang Village has successfully constructed canal blocks and DMPG, thereby significantly impacting environmental improvement, community perception, and economic enhancement. Figure 1 depicts the location of canal block construction and DMPG development in UPT Singkuang Village.

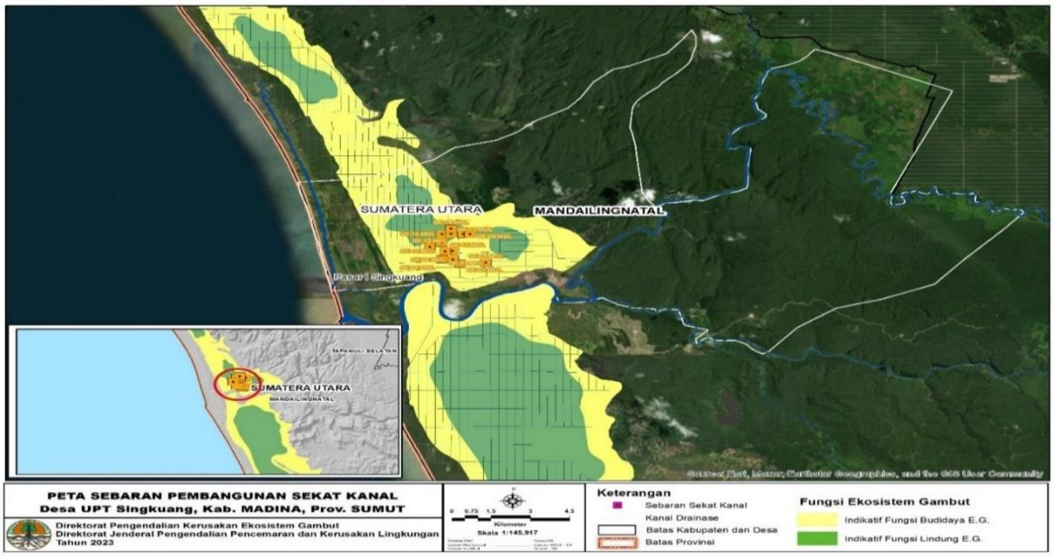


Figure 1. Location of Canal Block Construction and DMPG Development in UPT Singkuang Village

Primary data for this research were gathered directly from informant interviews and literature sources. Secondary data included documents related to canal block construction (preliminary survey reports, location measurement survey reports, Detailed Engineering Design (DED) and Cost Estimate (RAB), and final reports on canal block construction) and DMPG (IMAS and RKM documents, and implementation report of RKM). Data collection techniques utilized in this study include (1) interviews, (2) observations, (3) Focus Group Discussions (FGD), and (4) a literature review. Respondents included the Village Head, community leaders, and participants in canal block construction. Observations were conducted to collect data on canal block construction activities and DMPG development outcomes. Focus Group Discussions involved focused and directed group discussions to quickly gather information, explore understanding of beliefs, attitudes, and behaviors within specific groups, and generate ideas.

RESULTS AND DISCUSSION

The peatland ecosystem restoration undertaken by TKPPEG "Harapan Kita" in UPT Singkuang Village through canal block construction and Peat Care Self-Reliant Village (DMPG) development began in 2023. Canal block construction is a critical initiative in peatland ecosystem restoration to facilitate the rewetting of peatlands in UPT Singkuang Village. The objective is maintaining groundwater levels in peatlands approximately 0.4 meters below the ground surface to minimize forest and land fires. TKPPEG "Harapan Kita" has constructed 15 canal block units.

The development of Peat Care Self-Reliant Village aims to improve water management, rehabilitation, and enhance community livelihoods (social, cultural, and economic aspects), or in other words, "Rewetting, Revegetation, and Revitalization of local community livelihoods (3R)" (KLHK, 2023). Increasing the role of communities engaged in Peatland Ecosystem Protection and Management independently is critical to the success of DMPG development. TKPPEG's "Harapan Kita" approach to developing DMPG involves an Integrated Farming System. This farming system integrates Waringin variant sheep farming, composting using sheep dung, seasonal crop cultivation such as pineapple (Ananas comosus) and cassava (Manihot esculenta), and perennial crops including areca nut palm (Areca catechu) and rambutan trees (Nephelium lappaceum L). This integrated farming system enhances land productivity and environmental conservation holistically.

A. Construction of Canal Blocks

According to the Ministry of Environment and Forestry (2018), the infrastructure development for rewetting peatlands includes (1) construction of canal blocks and canal blocking, (2) water reservoirs, and (3) water pumping. The construction of canal blocks for restoring the hydrological function of peatland ecosystems involves planning and construction studies of canal blocks.

1. Planning Study

The planning study, often called Survey, Investigation, and Design (SID), aims to develop plans and analyze appropriate water management within a Peat Hydrological Unit (KHG) of a peatland ecosystem. There are five activities conducted by TKPPEG "Harapan Kita" to produce the planning study, including preliminary surveys, field surveys, data analysis, planning system, and design development. Figure 2 illustrates the workflow of planning study activities for canal block construction.

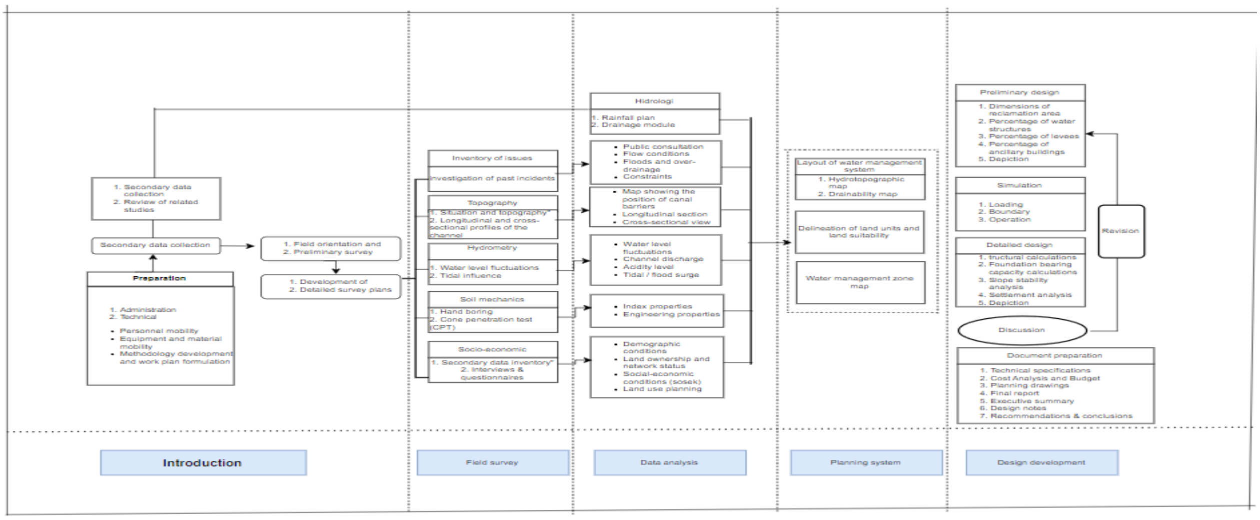


Figure 2. Workflow of Planning Study Activities for Canal Block Construction (Source: Directorate General of PPKL-KLHK, 2020)

1.1. Collection of Secondary Data and Analysis of Related Studies

Secondary data analysis marks the beginning of the Survey, Investigation, and Design (SID) activities to identify the initial conditions based on officially established spatial data. Geographic Information System (GIS) analysis is crucial for formulating survey plans. The secondary data considered in this activity include maps of peat ecosystem functions at scales of 1:250,000 and 1:50,000 based on an inventory of peat ecosystem characteristics in the village, maps prioritizing peat ecosystem degradation, satellite image maps, maps of forest and land fire incidents, irrigation plans at the district and provincial levels in Mandailing Natal, maps of forest area functions, river and canal flow maps, working area maps of HGU/HTI concessions, DEMNAS elevation maps at a scale of 1:10,000, and water balance analysis results and water flow predictions.

The outcome of this activity is an estimated location plan for surveying the construction of canal blocks based on spatial data analysis. According to KLHK (2017), activities to restore hydrological functions must prioritize the dome peak of the peat as a water storage area. Plans to close existing canals by constructing canal blocks must consider adequate blocks to rewet the peatland within a KHG. Canal blocks should provide sufficient space for the growth medium of endemic/native peatland vegetation to reinforce block construction and prevent erosion of canal walls. Figure 3 illustrates the initial location placement analysis for surveying the construction of canal blocks based on secondary data.

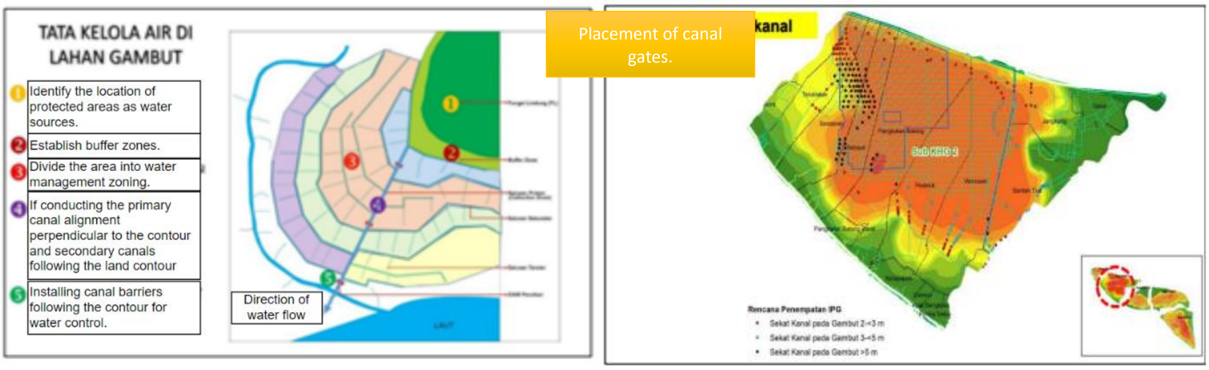


Figure 3. Illustration of the initial location placement analysis for surveying canal block construction based on secondary data (Source: Directorate General of PPKL-KLHK, 2020)

1.2. Field Orientation and Preliminary Survey

The field orientation and preliminary survey activities aim to directly observe the peatland ecosystem issues in UPT Singkuang village and assess the area's general physical, socio-economic, and biological conditions. These activities also serve as a field check to verify the suitability of the secondary data analysis previously conducted for the planned type of construction. The preliminary study will include developing a master plan and providing recommendations for subsequent detailed design studies.

Field orientation and preliminary survey activities involve socialization and active engagement of the community regarding the planned construction of canal blocks in UPT Singkuang village. Socialization efforts aim to increase the community's knowledge, curiosity, and capacity to manage the peatland ecosystem. This initiative emphasizes the support from provincial, district, village governments, and community groups towards improving the hydrological function of the peatland ecosystem through canal block construction. According to KLHK (2020), the active involvement of stakeholders and community groups in decision-making is crucial to supporting the success of canal block construction. Figure 4 illustrates the process of field orientation and preliminary survey involving stakeholders in the region. The figure depicts the preliminary survey process in UPT Singkuang village.

Figure 4. Process of field orientation and a preliminary survey involving stakeholders

These activities yield insights into the social and economic conditions of the village community and secure sustainable support from stakeholders, including the North Sumatra provincial government, Mandailing Natal district government, and UPT Singkuang village government. The field orientation and preliminary survey serve as a crucial reference for subsequent field surveys and investigations.

1.3. Field Survey and Investigation

The determination of appropriate locations and quantities of canal blocks is influenced by several factors: the topographic conditions of peatland, water surface slope (commonly referred to as water thread), groundwater level fluctuations, water flow velocity and discharge, peatland ecosystem characteristics, and community consensus. Determining canal block locations must start from the highest elevation downwards, following the principle of water movement. The geographical location of UPT Singkuang village, situated near rivers and the sea, necessitates consideration of tidal influences in site selection.
Topographic surveys aim to comprehensively view the land surface shape (longitudinal and transverse profiles) under various situations and elevations mapped with specific contour scales and intervals. These surveys also measure the water surface slope to determine criteria for water threads in channels. The approach employs flat property measurement techniques using trigonometric/tachymetric methods, where measurement routes are tied to controlled frameworks (surveying polygons). Figure 5 illustrates topographic measurements using flat property measurements for determining canal block locations in UPT Singkuang village.

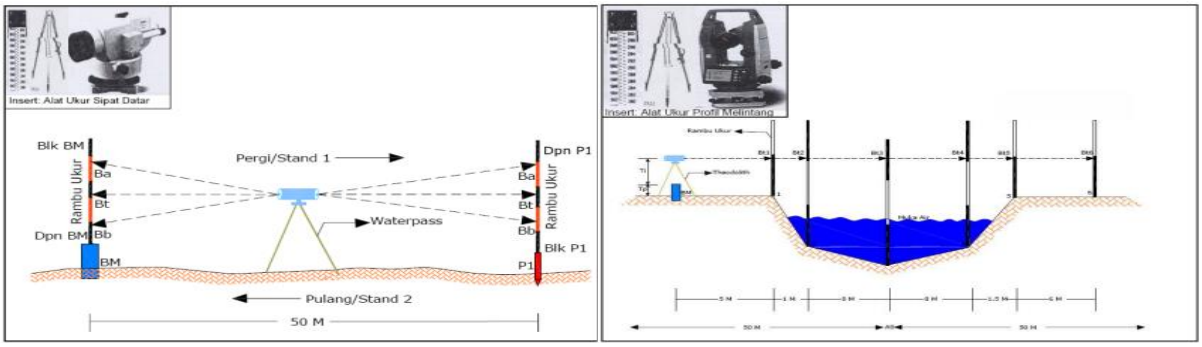


Figure 5. (a) Flat property measurement and (b) longitudinal and transverse section measurement

Criteria for land elevation measurements along the canal include intervals of 0.5m to 1m. Meanwhile, the criteria for calculating water elevation (water thread) between measurement points exceed 20 cm. The results depict longitudinal and transverse cross-sections of each canal. Water discharge is measured through estimated water flow velocities in canals ranging from 2-5 m/s, with canal water levels during the dry season (TMA > 60 cm) and rainy season (60 cm < TMA > 40 cm). The peat dome, at the highest elevation, plays a crucial role in the effort to restore the hydrological function of the peatland ecosystem in UPT Singkuang village. Figure 6 illustrates the location selection process for canal block construction based on the field's topographic data and water slope.

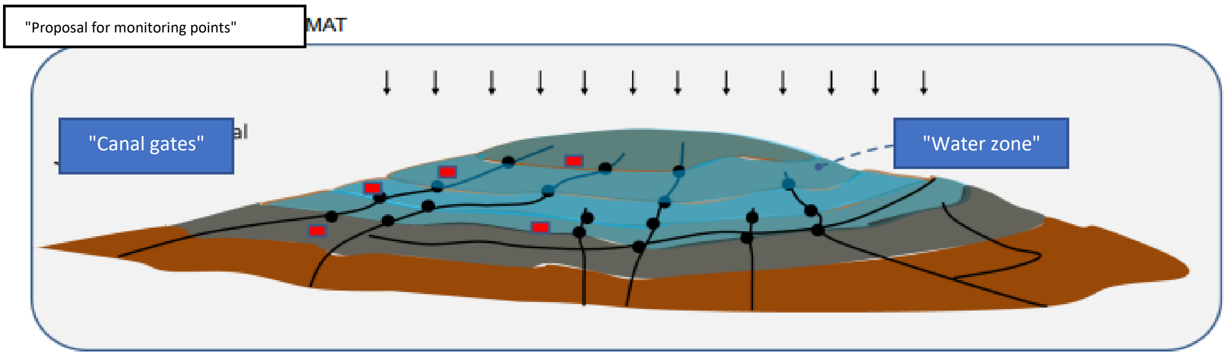


Figure 6. Illustration of the approach to determining canal block construction Locations

1.4. Recommendations and Planning System

The canal conditions in UPT Singkuang village are predominantly influenced by oil palm plantations on peatlands, characterized by relatively swift water flow. Consequently, many canal blocks are required, spaced between 200 to 300 meters. The recommended number of canal blocks for construction aligns with topographic measurements and water slope (hydraulic gradient) of 25-35 cm. According to Triadi I.B (2020), under the Best Practice RSPO of 2013, guidelines applicable to swampy areas generally recommend implementing tiered canal blocks at each water level drop (hydraulic gradient) exceeding 20 cm. Single-tier canal block construction is discouraged as it proves less effective in water retention and is prone to damage from water pressure. Figure 7 illustrates the approach to selecting recommended locations for canal block construction undertaken in the development of canal blocks in UPT Singkuang village.

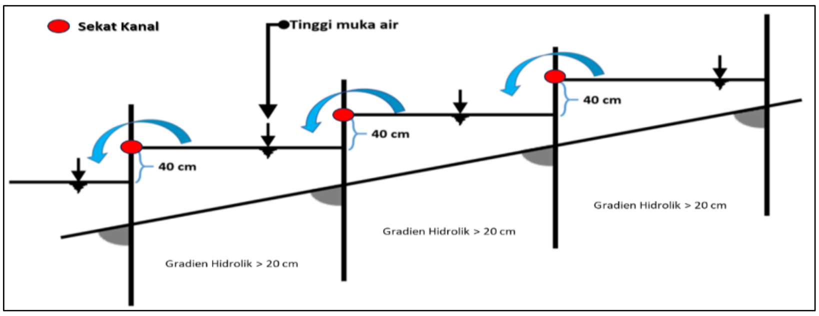


Figure 7. Approach to selecting recommended locations for canal block construction

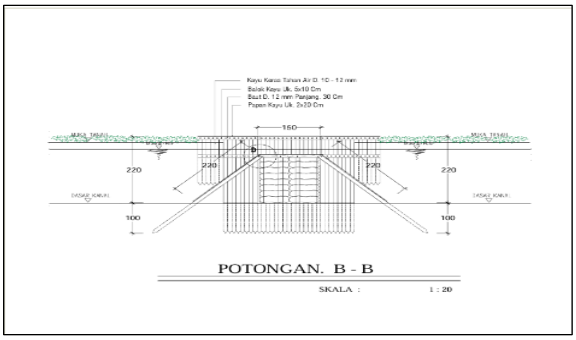
Based on field survey and investigation results through topographic and water slope approaches, water fluctuation, peatland ecosystem characteristics, and community consent, it is recommended that 15 units of canal blocks in UPT Singkuang village be constructed. These canal blocks are predicted to meet the planned water level maintained on peatlands. Referring to Republic of Indonesia Government Regulation

Number 71, 2014, and its amendment in Republic of Indonesia Government Regulation Number 57, 2016, concerning the Protection and Management of Peat Ecosystems, the groundwater level in cultivation areas is set to be equal to or less than 40 cm below the peat surface.

TKPPEG Harapan Kita advocates the concept of collaborative water management in peatland management in UPT Singkuang village. The "Shared Water Governance" concept is better suited for managing water in peatlands that are landscape or Peatland Hydrological Units. The fact that water flows from higher to lower elevations necessitates agreements on Water Sharing that benefit all parties involved. Implementing "Shared Water Governance" involves regulating water flow by opening and closing water gates at outlets, retaining as much water as possible upstream, and managing water governance in each watering zone through a canal block construction.

1.5. Preparation of Detailed Engineering Design

In Indonesia, there are four types of barriers applicable to peatlands: plank dams, slice dams, composite dams, and plastic dams (Barkah & Sidiq, 2009; Dohong et al., 2017). The construction of canal barriers in UPT Singkuang village utilizes a composite dam structure. These canal barriers consist of two or multi-layered structures made from wooden planks or logs. The layers of the canal barrier are filled with minerals



oil material wrapped in sacks and protected by a geomembrane. The mineral soil fill reinforces the canal barrier structure, making it stronger and more resistant to water pressure (KLHK, 2022). Figure 8 illustrates the Detailed Engineering Design of the two-layer wooden canal barrier (semi-permanent) constructed in the village.

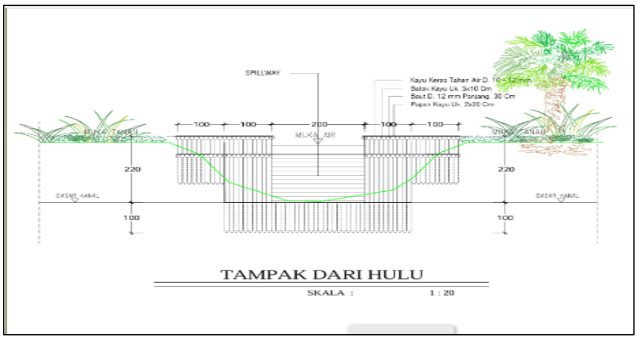


Figure 8. Detailed Engineering Design of the two-layer wooden canal barrier with spillway

2. Canal Barrier Construction

The construction of canal barriers in UPT Singkuang village, Muara Batang Gadis sub-district, Mandailing Natal Regency, North Sumatra Province, amounts to 15 units. The duration required to complete the construction activities for canal barriers to restore the peatland ecosystem's hydrological functions is 45 days. Table 2 details the construction activities for the canal barriers in UPT Singkuang village.

Table 2. Detailed activities for the construction of canal barriers in UPT Singkuang village

NO	Dimensions of canal gates (Width)	Number of units
1	3	2
2	4	11
3	5	2
	Aggregate	**15**
4	Monitoring well construction	15
5	Development of Fire Danger Rating System	2

Implementing canal barrier construction actively involves community groups or the existing TKPPEG "Harapan Kita." The construction activities for restoring the peatland ecosystem are based on maintaining the groundwater level in peatlands no more than 0.4 meters below the peat surface. The process of constructing semi-permanent canal barriers with spillway systems is detailed below.

2.1. Provision of Materials

The canal barriers consist of two or multi-layered barriers made from wooden planks or logs. The required materials include vertical hardwood posts with a minimum diameter of 10 cm, mineral soil wrapped in plastic sacks (43 cm x 54 cm), wooden beams for the barrier layers, double-ring bolts (½" 10"), 500-micron geomembrane, and pipes coated with a jarring parent for TMAT well installation. Figure 9 depicts the materials required for the construction of canal barriers.

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

Figure 9. Materials for the 2-layer and multi-layer canal barriers with spillway

(a) wooden posts and beams
(b) geomembrane
(c) nails and bolts
(d) soil sacks

2.2. Preparation Work

Preparation involves mobilizing materials and equipment, erecting boundary poles and markers for the canal barriers, providing safety equipment (K3), clearing the field and stripping peat layers, and measuring and installing bow planks using water passes and nylon strings. A crucial aspect of preparation work is clearing the area to remove debris and wild vegetation from the old channels, ensuring they are free of obstructions. The installation of bow planks serves as initial reference points for all subsequent measurements in the wooden materials used. Figure 10 depicts the preparation process for constructing canal barriers in UPT Singkuang village.

Figure 10. Land clearance and bow plank installation

2.3. Construction Work

Construction work includes driving dolmen wooden posts, fabricating ring nails and bolts, excavating peat soil on the wing area, installing 500-micron geomembrane, constructing spillways and lining the sides of the canal barriers, filling mineral soil into plastic sacks, and inserting them into the wing areas of the canal barriers. The mineral soil material wrapped in plastic sacks supports the barrier structure, enhancing its strength and resistance to water pressure. Therefore, geomembrane is essential to line the soil, making it impermeable and resistant to degradation. Dolken wooden posts must be driven down to the mineral soil layer to ensure the construction can withstand the dynamic movements of the peatland caused by water flow. Figure 11 illustrates the construction process for building canal barriers in UPT Singkuang village.

Figure 11. Construction work process of canal barriers

2.4. Monitoring Activities

Other tasks include final cleaning, installation of boundary posts and plates for the canal barriers, and installation of the Fire Danger Rating System (FDRS) based on TMAT. The addition of FDRS aims to monitor fire risk information in areas where canal barriers have been constructed. Based on my experience in canal barrier construction, the final tasks involved leveling the spread of mineral soil in every gap of the plastic bags, aiming to compact the soil structure on each wing of the canal barriers. This also serves as an effort for revegetation to facilitate the growth of pioneer plants.

(a) (b) (c)

Figure 12. Final construction work of canal barriers.

(a) Completed canal barriers; (b) Canal barrier markers; (c) Fire Danger Rating System (FDRS)

Based on post-construction observations, the constructed canal barriers significantly raise the water level in the channels compared to before the barriers were built. This is followed by an increase in groundwater levels in peatlands. Research by Daryono (2009) suggests that canal blocking can impede water flow in drainage channels, leading to the rewetting of peatland areas adjacent to the drainage channels. Research by Khotimah G. H. et al. (2020) indicates that constructing canal barriers positively impacts maintaining groundwater levels and preserving peatlands under consistently wet or moist conditions up to a perpendicular distance of 201 meters from the canal.

Integrated Agricultural System

Indonesia is an agrarian country, as indicated by the agricultural sector's significant role in the national economic growth. The agricultural sector remains a cornerstone and the economic base for Indonesian society, especially in rural areas. Agricultural activities commonly developed by rural communities include food crops, horticulture, plantations, livestock, fisheries, forestry, and agricultural services. According to the BPS data (2023), almost 90 percent of the population in Muara Batang Gadis subdistrict, Mandailing Natal Regency, are engaged in the agricultural sector, encompassing agricultural cultivation, forestry, livestock, and fisheries. UPT Singkuang Village is part of the administrative area of Muara Batang Gadis subdistrict, Mandailing Natal Regency. A significant portion of UPT Singkuang Village is located within a peatland ecosystem. The potential for agricultural development on peatland is substantial. However, its management must be careful and sustainable due to the marginal and fragile nature of peatland ecosystems, which are easily damaged.

TKPPEG "Harapan Kita" has established the Peatland-Aware Independent Village Program (DMPG) using an Integrated Agricultural System approach. According to Haryana D et al. (2018), the Integrated Agricultural System is a farming system that combines agricultural, livestock, fishery, and forestry activities within a single land area. This system serves as a solution for increasing land productivity, promoting environmental conservation, and fostering comprehensive village development. The integrated agricultural activities carried out by TKPPEG "Harapan Kita" include goat farming, seasonal crop cultivation, and perennial crop cultivation. The development of integrated agricultural activities considers local species and community needs.

1. Goat/Sheep Farming

Goat farming in UPT Singkuang Village is a prominent agricultural activity that increases the villagers' income, aside from their primary occupation in oil palm plantations. The types of goats commonly raised by the villagers are Javanese or Kacang goats, Etawa goats, and Waringin sheep. TKPPEG "Harapan Kita" has developed Waringin sheep as a livestock commodity on peatland. Waringin sheep are well-suited to the tropical climate of Indonesia. These sheep are disease-resistant and consume all grasses and concentrates as feed sources.

The sheep are intensively reared in pens, becoming accustomed to the provided feed and concentrates. They are fed three times a day: first in the morning (around 07:00-09:00), second at noon (around 11:00-13:00), and third in the evening (around 17:00-19:00). Observations show that peak feeding activity occurs in the morning and evening. According to Setianah et al. (2004), goats consume more feed in the morning and evening as the daytime temperatures reach 27-34°C, causing the goats to rest more despite some feeding with lower frequency. This aligns with Wodzicka-Tomaszewska et al. (1991), who stated that goats graze less during the hot daytime, with shorter rumination times and relatively more extended rest periods. Below is an image of the sheep reared by TKPPEG "Harapan Kita."

Figure 13. Sheep reared by TKPPEG "Harapan Kita"

The sheep are reared from around six months old, requiring considerable time for their breeding process. In 2023, 15 sheep were reared and sourced with the Ministry of Environment and Forestry's assistance. The sheep begin producing offspring at 12-15 months old. A challenge in sheep farming is bloating. According to Njiati et al. (2005), bloating in goats is caused by poor-quality feed, such as wet or moldy feed, excessively young leaves, overeating, imbalanced drinking, or getting wet in the rain. This disease can be fatal for the goats.

2. Seasonal and Perennial Crop Cultivation

The combination of seasonal and perennial crops carried out by TKPPEG "Harapan Kita" in UPT Singkuang Village adopts the concept of agroforestry. Agroforestry is a land-use system that combines agricultural and forestry aspects on the same land. The agroforestry land managed by the group covers 4 hectares. Seasonal crops planted include pineapple (Ananas et al..) and cassava (Manihot esculenta). These crops grow well on shallow to deep peatlands with good drainage and are relatively tolerant of low pH.

They are cultivated intensively or non-intensively. The recommended fertilization per hectare is 45-80 kg N, 45-80 kg P2O5, and 80-120 kg K2O. On deep peat, additional micro-fertilizers are needed (Nijiyati et al., 2005). Perennial crops planted include areca nut trees (Areca catechu) and rambutan trees (Nephelium lappaceum L). Rambutan trees grow well on shallow to medium peatlands with good drainage, without requiring lime or fertilizers, and can be propagated through grafting or budding. Areca nut trees grow well along rivers and on shallow to deep peat swamps, requiring minimal intensive care.

Figure 14. Agroforestry Crops by TKPPEG "Harapan Kita”

3. Manure Fertilizer

The manure fertilizer produced by TKPPEG "Harapan Kita" in UPT Singkuang Village is derived from sheep dung. Sheep dung is used as manure because it has a relatively balanced nutrient content compared to other natural fertilizers. It is also mixed with urine, which also contains nutrients. According to Setianah et al. (2004), applying goat manure as compost increases the production and growth of seasonal crops. The optimal dosage of sheep manure for plant growth is approximately 12-15 tons per hectare.

Conclusion

The Presidential Regulation of the Republic of Indonesia No. 57 of 2016, which amends Government Regulation No. 71 of 2014 on the Protection and Management of Peatland Ecosystems, states in Article 30 that the restoration of damaged peatland ecosystems can be achieved through natural succession, rehabilitation, restoration, and other methods in line with scientific and technological advancements. The community conducts restoration activities outside concession areas or management units. The basic principles in peatland ecosystem restoration activities on community land are "Rewetting, Revegetation, and Revitalization of local community livelihood (3R)." UPT Singkuang Village is one of the villages that has implemented peatland ecosystem restoration through rewetting efforts by constructing canal blocks, economic revitalization of the community, and revegetation through the development of Peatland-Aware Independent Villages using an integrated agricultural system approach.

For rewetting efforts through the construction of canal blocks, UPT Singkuang Village opted for wooden (semi-permanent) canal blocks with two or multiple layers. This choice aligns with the bio-physical conditions, canal dimensions, peat topography, material availability, and material transportation accessibility to the site. Canal block construction is cost-effective and technically feasible; however, this type of construction is prone to damage, requiring annual maintenance. Topographical conditions and canal slope determine the distance between canal blocks. In UPT Singkuang Village, a hydraulic gradient of 25-35 cm is needed between canal blocks. Spillways constructed on canal blocks have an average elevation of 40-45 cm below the canal surface.

The rewetting of the peatland ecology facilitated TKPPEG "Harapan Kita" to develop the peatland into agricultural land. They established the Peatland-Aware Independent Village Program (DMPG) using an integrated agricultural system approach. This integrated agriculture combines farming, livestock, and forestry activities within a single land area, transforming idle peatland into productive land. Livestock activities include raising Waringin sheep, which are disease-resistant and consume all grass and concentrates as feed sources. Sheep dung is used as manure due to its relatively balanced nutrient content compared to other natural fertilizers, and the dung mixed with urine also contains nutrients. Agricultural activities include cultivating pineapple (Ananas et al..) and cassava (Manihot esculenta). These crops grow well on shallow to deep peatlands with good drainage and are relatively tolerant of low pH. Forestry activities involve planting areca nut trees (Areca catechu) and rambutan trees (Nephelium lappaceum L). Areca nut trees are a forestry plant that prevents erosion and flooding in peatlands. Rambutan trees grow well on shallow to medium peatlands with good drainage without lime and fertilizers.

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