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Performance of the Existing Canal Blocking in the Peatland Conservation and Restoration Management

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Abstract: This research intends to investigate the real understanding of the performance of canal blocking based on the most effective and efficient five types of canal blocking in the peatland restoration and conservation management. The protection and management of peatland ecosystems are systematic and integrated efforts for conserving and preventing the peatland ecosystem function damage, including the design, usage, and controlling as one whole unit that interplay in the form of balance, stability, and productivity. The methodology based on the restoration management in conserving the peatlands must be comprehensively conducted; it means that the handing pattern must refer to the peatlands hydrology unity (KHG) that includes protected area (upstream part), limited cultivation buffer area, and cultivation area (downstream part), considering the legal aspect in area, social aspect, and technical aspect to obtain an optimal system of canal blocking installing, to make a model of handling pattern that refers to the peatlands hydrology unity that is to identify the problem of peatland restoration and conservation management based on the zone parameters of peatland scientific hydrology management, aspect that affects the blocking type model, and the type of blocking construction. Based on the canal blocking five types' classification, they have each role and function, which will be effective and efficient if used due to the selected parameters of canal blocking in managing the conservation and restoration of peatlands that refers to the comprehensive peatlands' hydrology unity.

Keywords: canal blocking, restoration management, conservation, peatlands.

既有渠道堵塞在泥炭地保护与恢复管理中的表现

摘要：本研究旨在基于泥炭地恢复和保护管理中最有效和最高效的五种渠道阻塞，调查对渠道阻塞性能的真正理解。泥炭地生态系统的保护和管理是保护和防止泥炭地生态系统功能受损的系统性综合工作，包括设计、利用和控制作为一个整体，以平衡、稳定和生产力的形式相互作用。必须全面实施基于恢复管理的泥炭地保护方法；这意味着处理模式必须参考包括保护区（上游部分）、有限种植缓冲区和种植区（下游部分）的泥炭地水文统一体（KHG），同时考虑区域、社会和技术方面的法律方面 一方面获得最佳的渠道阻断安装系统，建立参考泥炭地水文统一的处理模式模型，即根据泥炭地科学水文管理的区域参数确定泥炭

地恢复和保护管理的问题，方面 影响阻塞类型模型和阻塞构造的类型。基于渠道阻塞的五种类型分类，它们具有各自的作用和功能，由于选择的渠道阻塞参数在泥炭地保护和恢复管理中的使用将是有效和高效的，这是指综合泥炭地水文统一体.

关键词：运河阻塞、恢复管理、保护、泥炭地。

1. Introduction

The area of tropic peatlands in the entire world is about 40 million ha, and half of them is in Indonesia: the Sumatera, Borneo, Papua, and Sulawesi. Peatlands have an immense ability to save water (90% of volume), so the peatlands can be hoped to be used as hydrology buffer [1] for the environment area. In 1993-1997, the condition of forest and peatlands in Indonesia, mainly in Kalimantan, continuously experiences the degradation due to the massive land clearing (PLG) without considering the aspect of the peatland hydrology area (KHG) so it causes a drought problem [2] in the peatlands that is implied the big fire every year that causes the thick smog months; therefore, it impacts economics, society, and health. Although the canal development has been carried out for managing water resource systems, forest and peatland fire is still a problem [3].

Based on the hydrological management of natural star in the Ex-PLG zone, it is classified into three zones: 1) Protected zone on peatlands in the high vital areas; 2) Limited cultivation buffer zone by means of cultivation with limited drainage, which is aimed to decrease the negative impact on the hydrologic function of peatlands [4] and has the ability to maintain the cultivation in hydrology unity as maximal as possible [5] in the dry season; 3) Cultivation zone which the cultivation development in the hydrology unity with the thickness of thin peatland and/or stacked up mineral material (Fig. 1).

Canal blocking is one of the water structures [6], [7] that is hoped to be able to maintain the groundwater level [8] in the peatlands for preventing the forest fire and improving the water quality [9]. The work principal of the canal blocking is to hold the flow from upstream [10], [11] by the canal blocking so the water level is rising and the condition of the water system is safeguarded so it can wet the soil and the water need is safeguarded [12]. By conducting the blocking to the channel as the primary channel, so the canal can hold the water drain speed from forest and peatland, maintaining the water capacity in the peatland forest and increasing the water level in the forest [13] and peatland, so the peatlands surrounding it become wet again and can prevent the forest and peatland fire. This research intends to provide a deep understanding of the performance of canal blocking based on the five-type classification of the most effective and efficient canal blocking on the restoration management in conserving the peatlands that is comprehensively carried out.

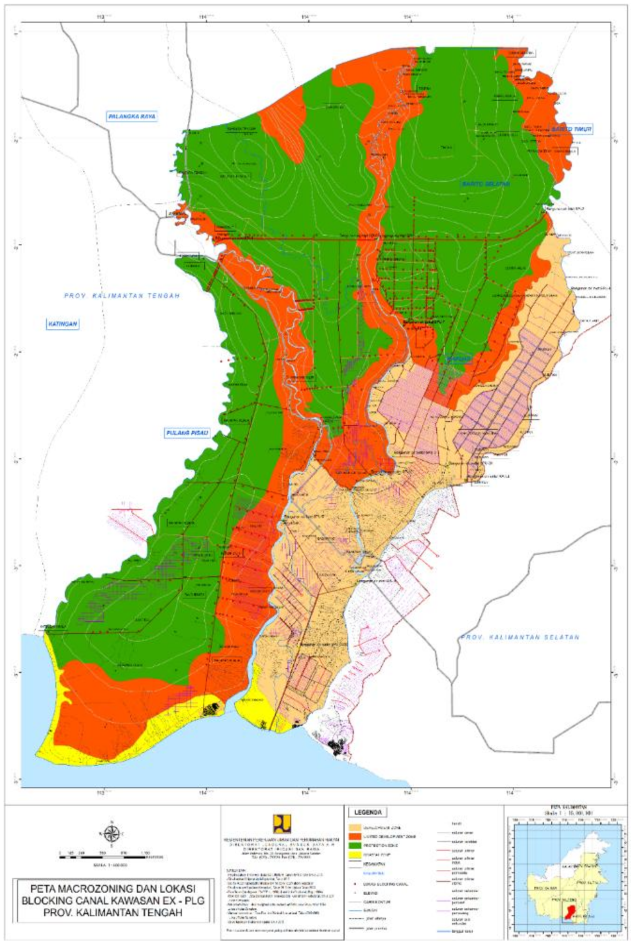

Fig. 1 Map of the area macro-zoning ex. peatland area development project (PLG) (Ministry of General Work and Public Housing, 2007)

2. Materials and Method

2.1. Literature Review

The management of peatlands and rehabilitation of the past development in the Ex-PLG area in Borneo did not consider the natural characteristics of peatlands susceptible to drainage and cleaning. Peatlands is a dynamic system and the drainage oxidizes peatlands and land subsidence through the process of compaction and the loss of peatlands as the reason for oxidation. The process causes the topography change in peatlands, which influences the hydrology and drainage and causes the potency of flood problem. The master plan for rehabilitation and revitalization in the Ex-PLG area needs the integrated approach, gradually in management. Rehabilitation of the peatlands also includes the fire control, rehabilitation of hydrology, robotization, and development of society that increases the consciousness and supports the proposed intervention and producing the long-term benefit for society. The accurate management and rehabilitation on the management hydrology of peatlands needs to be stopped the drain in all thick peatlands (> 3 m), to stop the building of channel and drain in further, and to minimize the drainage of side by side of shallow peatlands (1–3 m) through the intervention of water management for controlling the drainage.

The challenge in hydrology rehabilitation shows that the drainage and development is very affecting the hydrology of peatlands, drying and losing the micro-topography (‘hummock-hollow’) in the upper layer that is an important element in the natural peatland forest, and therefore it decreases the capacity of water saving in the peatland surface. This is because the rainfall in the peatland surface decreases; the water surface in the whole peatlands decreases uniformly until a distance of a few kilometers from the channel. Near the channel, the ground water surface is decreasing again through the increasing of groundwater flow. However, most of the Ex-PLG area that is influenced seems only limited because the hydraulic conductivity of peatlands is low.

The groundwater surface that is getting lower is caused by the drainage, which causes the peatland subsidence through the decomposition, decay, and shrinkage of peatlands. The decay of peatlands produces the gas emission of CO_2 that is missed out of the atmosphere, which affects the global climate. Therefore, it is needed to increase the water surface to decrease the emission of CO_2, which can be reached by curbing the channel by an embankment. However, the hydrology analysis said that channel embankment in the Ex-PLG area will generally be limitedly impacted by the water depth in the short period. This is due to the form of peatland landscape that has drastically changed since the drainage is begun; now, there are climbs relatively steep and far from the channel, so most of the embankment can again water the narrow area in the surrounded channel. Further, the level of groundwater flow limited in the Ex-PLG peatlands indicates that the groundwater level will only be affected in the distance that is relatively near the channel when closed.

The limited effect from the channel closure in the effort of increasing the water surface in the large area shows that the effect of CO_2 emission will also be limited in the short period. However, the channel embankment is needed to rehabilitate the peatlands in a long period because it creates a base level, at which outside, the decay of peatlands cannot happen. For a strong and effective channel embankment, a regular maintenance is needed. The channel closure can also immediately create a wet area in the surrounded channel that can help decrease the vulnerability to the fire in this area. However, in the dry year, when the vulnerability to the fire is the highest, the channel embankment in most of the area will not be able to maintain so the channel edge remains wet. Therefore, the prevention and management of fire is needed where the tabat is built for curbing the channel. The tabat must be built to increase the water level as high as possible. The best is to build a high enough tabat peak so it remains over the water level when the water level is in the maximal depth and to build the tabat where there is large low minimal land on one side, so if there is the water flow, the water is not forced through the tabat, but it is spread in all the area.

The difference in water level between the tabats has to be less than 0.5 m for minimizing the water pressure in the building structure. The different peatlands have different hydrological characteristics too. In some areas, the humification process of peatland precipitate that is less besides the peatlands itself is thicker so there may be a bigger groundwater flow; in the area like this, the channel closure will have the more directly impact by the larger range in the water depth.

In the rehabilitation and revitalization of Ex-PLG area in the thick peatlands, the further development must be prevented, it must conduct the available channel and drain closure, and the groundwater level is increased if it is possible. However, the hydrology analysis shows the following:

1. As the reason for mini-dome topography, the channel edge is generally about 1 m or more under the general peatland dome level.
2. The lateral groundwater flow (horizontal hydraulic conductivity) is relatively limited, and it is unlikely that the channel closure can again water the large peatland area in a short time, but it is needed to avoid in further damage that will make the rehabilitation becomes more difficulty if it is just implemented later.

In the short period, the channel closure can often water again the area with the area is only about 300-500 m in the surrounded channel, but it is still valuable for the ecology restoration and preventing the fire. In the shallow peatlands (1-3 m), the drainage must be limited, but if it is happened, it must be built the structure of water controlling for ensuring the amount of water losses during the dry season can be decreased while in the rainy season the surplus water can flow.

The Ex-PLG area, where the low land is influenced by the tides of river making it, becomes a dynamic system, where most land use potency is determined by the hydrology and management of water and land resources in the area. The master plan uses the hydrology simulation and subsidence of peatlands for investigating the result potency of several development scenarios in the future. The few scenarios emphasize the demand for a balanced development strategy based on the spatial zone, where the sustainable long-term management and a fair usage of peatland resources and increasing in the water and land management in the whole area for stimulating the revitalization and development of agriculture are possible.

2.2. Research Methodology

The location as the research object is the Peatlands Hydrology Unity in the Block C Ex-PLG area located between two big rivers, Kahayan River and Sebangau River, Pulang Pisau Regency, Central Borneo, Indonesia. The peatland hydrology unity in the Block C area is interesting enough because there is much area usage by the government through the cultivation program of agriculture areas, management of protected forests, by the public through the corporate plantations, and local society through the plantation society.

The methodology research is as follows:

1. To collect the primary data related to the parameters in the earlier applied study of canal blocking modeling as the main data;
2. To collect the secondary data as the literature study that has ever carried out for deepening this research;
3. The primary and secondary data will be analyzed for obtaining the model system of canal blocking type and the placement;
4. The result of evaluation is the base in making a conclusion about the relationship of an accurate and suitable model and the hydrology unity condition.

The main steps of the research are summarized in Fig. 2.

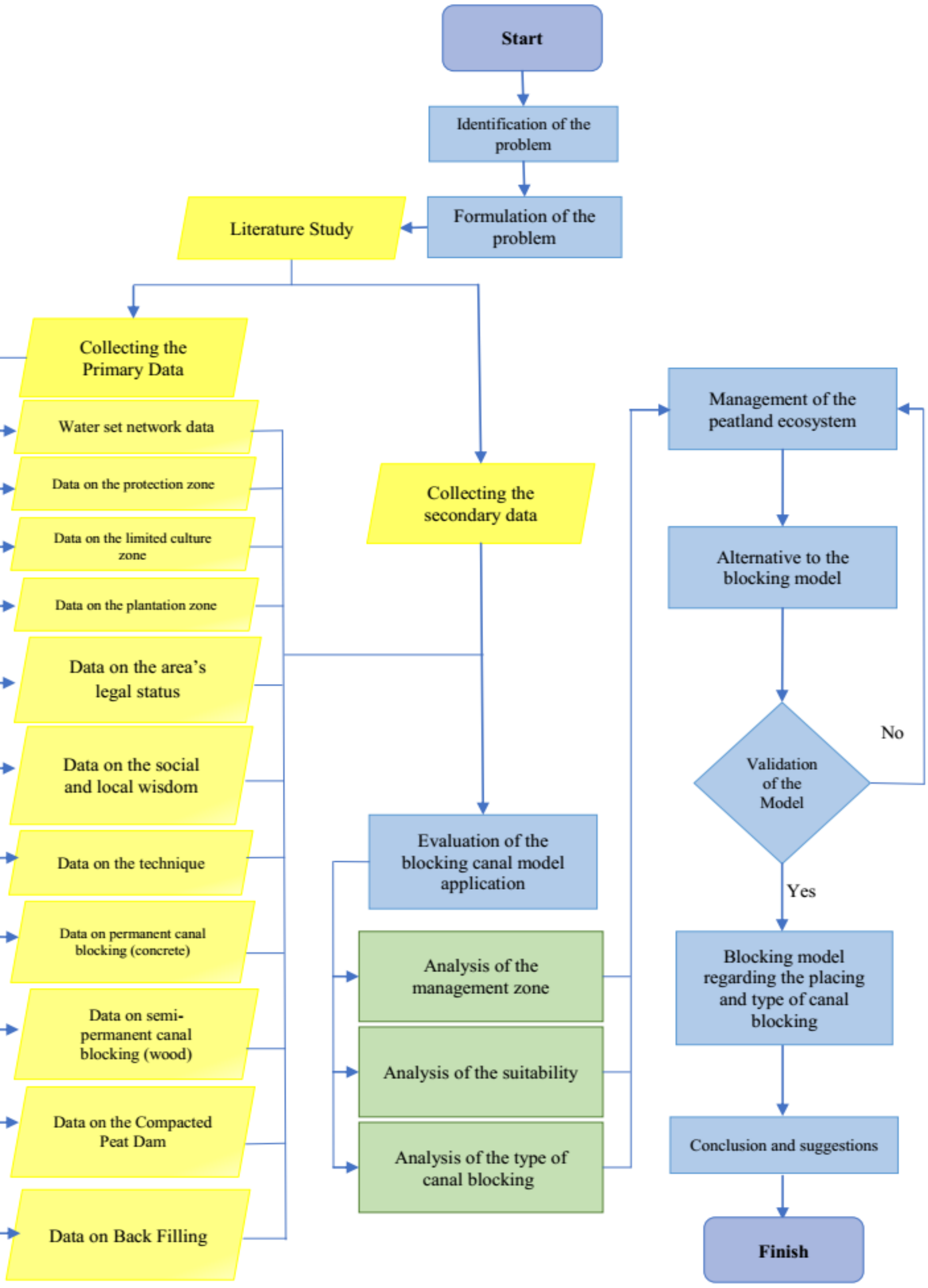

Fig. 2 Flowchart of the research

3. Results and Discussion

Implementing the peatland conservation and restoration management refers to the comprehensive peatland hydrology unity by attending the parameters as follows:

a. Scientific hydrology management zone of peatlands as a protected zone, limited cultivation zone, and cultivation zone.

b. Determination of blocking type model as social and local wisdom, legality of area status, and technique

c. The type of blocking construction as permanent canal blocking (concrete), semi-permanent canal blocking (wood), compacted peat dam), and back filling.

Making a model of handling pattern refers to the peatlands hydrology unity that is to identify the problem of the peatland restoration and conservation management based on the zone parameters of peatland scientific hydrology management, aspect that affects the blocking type model, and the type of blocking construction. The determination of restoration management parameters in conserving the peatlands can be seen in the figure below.

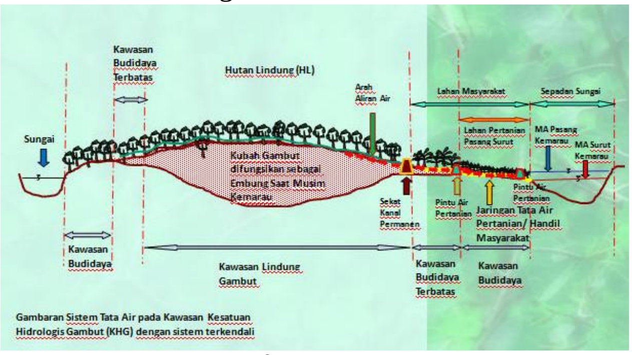

Fig. 3 General illustration of mapping in the ex PLG area based on the survey and investigation in field as the problem formulation

In the problem identification, there are three critical items to be determined:

1. To determine the three main management types based on the natural hydrology star unit that consists of:

a. Protected zone in the peatlands and highly vital variety area

b. Limited cultivation buffer zone, cultivation by limited drainage that intends to decrease the negative impact on the hydrology function of peatlands and to be able to maintain the water level elevation as maximal as possible in the dry season.

c. Cultivation zone, in the hydrology unity with the thin peatland thickness and/or stacked up mineral area.

2. To determine the influencer on the blocking type model that is used as follows:

a. Legality of area in the region
b. Social
c. Technique

3. To determine the type of blocking construction based on Points (1) and (2):

a. Back filling
b. Compacted peat dam
c. Semi-permanent canal blocking of local wood (type of 'Tumih" tree)
d. Semi-permanent canal blocking of local wood (type of coconut tree)
e. Permanent canal blocking (reinforced concrete)

4. Conclusion

Based on the classification of five types of canal blocking, it can be concluded as follows:

1. Back filing canal blocking will be effective and efficient if used for the conditions as follows:

a. In the protected area with the thickness of peatlands > 5 m

b. The channel is not used by society as the navigation channel

c. The area condition is heavy enough for fire damage, and the channel potency is used as the wood logging

d. The resilience of construction is long lasting if it is combined with the semi-permanent blocking in the downstream, it is constructed in a channel < 25 m

e. It is used as the channel closure blocking with a length of 100-300 m

f. From the implementation method, this type is easier to be implemented using a heavy tool. Fig. 4 presents the canal-blocking structure of back filling, and Fig. 5 presents the canal-blocking design of back filling.

Fig. 4 Canal-blocking structure of back filling

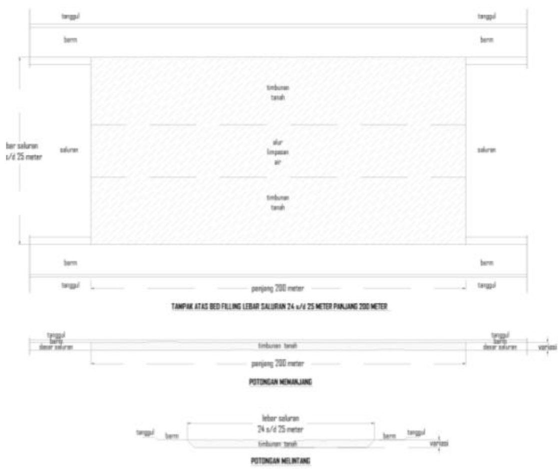

Fig. 5 Canal-blocking design of back filling

2. Compacted peat dam will be effective and efficient if used for the conditions as follows:

a. In the protected area

b. The channel is still utilized as a navigation channel by a part of society

c. The area is still less managed by society as plantation.

d. The construction resilience is long lasting if it is combined with the semi-permanent blocking in the downstream that is constructed in the channel < 25 m with the length until 50 m.

e. It functions as the controlled blocking with the thickness of the peatland of 3-5 m.

f. It is used on the flow current in the slow channel, the local material in the surrounded area is very minimal, and the location point of activity is limited.

g. From the implementation method, it is easier to be implemented using a heavy tool. Fig. 6 presents the canal-blocking structure of the compacted peat dam, and Fig. 7 presents the canal-blocking design of the compacted peat dam.


Fig. 6 Canal-blocking structure of compacted peat dam

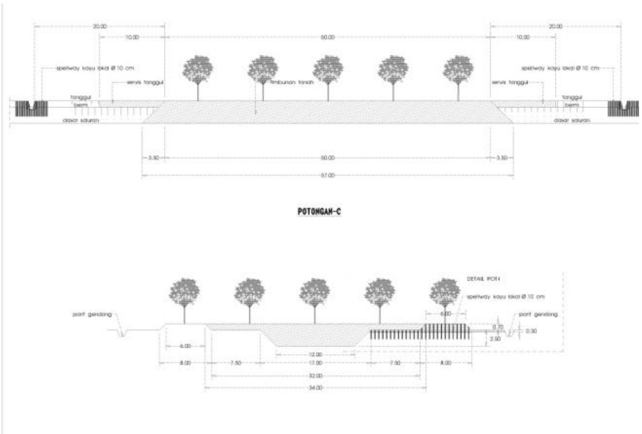

Fig. 7 Canal-blocking design of compacted peat dam

3. Semi-permanent canal blocking using the local wood of Tumih tree type (*Combretocarpus rotundatus (Miq.) Danser*) will be effective and efficient if used for the conditions as follows:

a. In the adaptive cultivation area

b. The channel is still utilized as a navigation channel by a part of society.

c. The area is less managed by society as a plantation.

d. The construction resilience is long lasting if it is combined with the semi-permanent blocking in the downstream that is constructed in the channel < 20 m (the condition of area location is limited) with a diameter of 0.1-0.15 m.

e. It functions as the water pressure reduction blocking, it is located in the adaptive area where in the downstream uses the concrete blocking.

f. It is used on the flow current in a pretty heavy channel, and the local material in the surrounded area is very minimal.

g. From the implementation method, it is easier to be implemented using a heavy tool. Fig. 8 presents the canal-blocking structure of semi-permanent using the local wood of Tumih tree type, and Fig. 9 presents the canal-blocking design of semi-permanent using the local wood of the Tumih tree type.


Fig. 8 Canal-blocking structure of semi-permanent using the local wood of Tumih tree type

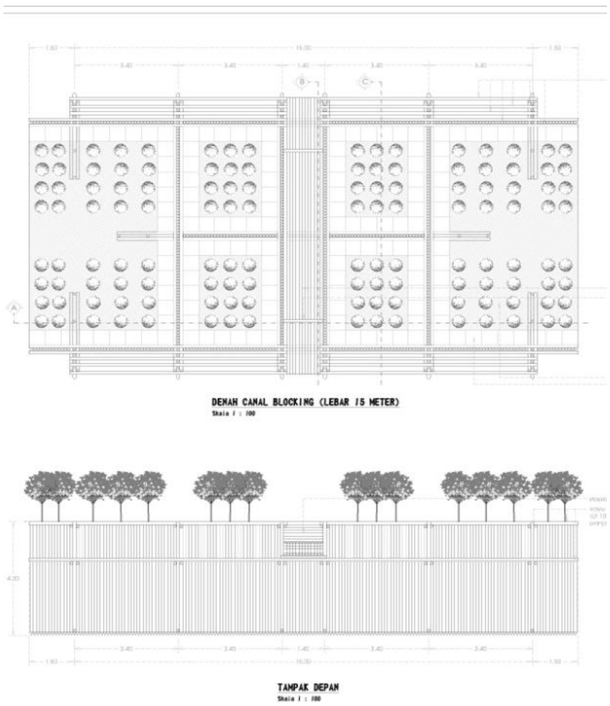

Fig. 9 Canal-blocking structure of semi-permanent using the local wood of Tumih tree type

4. Semi-permanent canal blocking using the local wood of the coconut tree (*Cocos nucifera*) will be effective and efficient if used for the conditions as follows:

a. In the adaptive cultivation/protected area

b. The channel is still utilized as a navigation channel by a part of society.

c. The area is less managed by society as a plantation.

d. The construction resilience is long lasting if it is combined with the semi-permanent blocking in the downstream that is constructed in a channel > 10 m with the diameter of wood between 0.2 and 0.25 m and a length of 4-6 m.

e. It functions as the lock blocking and is located in the downstream of the protected area, where in the upstream, the back-filling blocking is used.

f. It is used on the flow current in a pretty heavy channel, and the local material in the surrounded area is very minimal.

g. From the implementation method, it is easier to be implemented using a heavy tool. Fig. 10 and 11 present the canal-blocking structure of semi-permanent using the local wood of the coconut tree with the width of the channel cross section of 25 and 50 m, respectively; Fig. 12 and 13 present the canal-blocking design of semi-permanent using the local wood of the coconut tree with the width of the channel cross section of 25 and 50 m, respectively.

Fig. 10 Canal-blocking structure of semi-permanent using the local wood of the coconut tree with the width of the channel cross section of 25 m

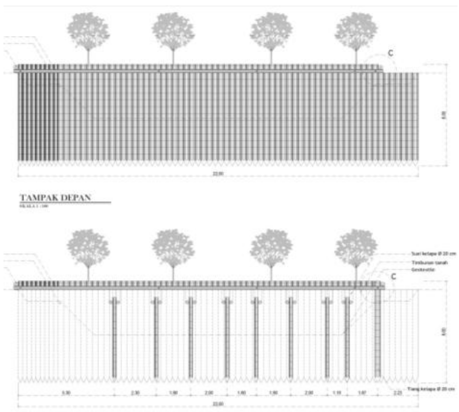

Fig. 11 Canal-blocking design of semi-permanent using the local wood of the coconut tree with the width of the channel cross section of 25 m

Fig. 12 Canal-blocking structure of semi-permanent using the local wood of the coconut tree with the width of the channel cross section of 50 m

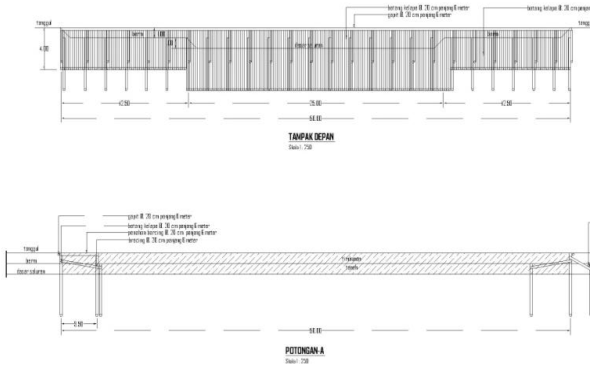

Fig. 13 Canal-blocking design of semi-permanent using the local wood of the coconut tree with the width of the channel cross section of 50 m

5. Permanent canal blocking of reinforced concrete will be effective and efficient if used for the conditions as follows:

a. In the adaptive cultivation/protected area

b. The channel is still utilized as a navigation channel by society.

c. The area is much managed by society as a plantation.

d. The construction resilience is long lasting and safe from the damage or weathering.

e. It functions as the regulator blocking the navigation channel tide height as a natural dam.

f. From the implementation method, it is easier to be implemented mainly the material mobilization and construction process. Fig. 14 presents the permanent canal-blocking structure of reinforced concrete, and Fig. 15 presents the permanent canal-blocking design of reinforced concrete.

Fig. 14 Permanent canal-blocking structure of reinforced concrete

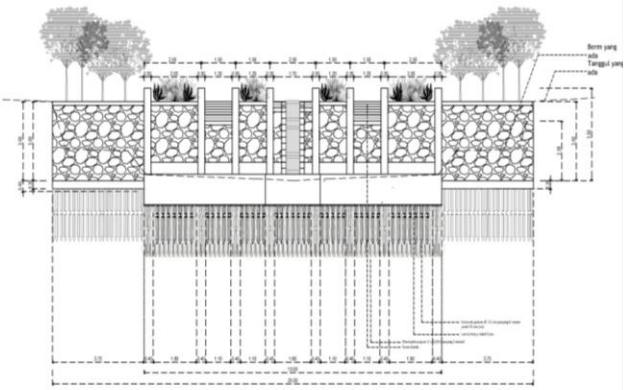

Fig. 15 Permanent canal-blocking design of reinforced concrete

Peatlands is a dynamic system and the drainage oxidizes peatlands and land subsidence through the process of compaction and the loss of peatlands as the reason for oxidation. The process causes the topography change in peatlands, influencing the hydrology and drainage and causing the potency of flood problem. The accurate management and rehabilitation on the management hydrology of peatlands needs to be stopped the drain in all thick peatlands (> 3 m), to stop the building of channel and drain in further, and to minimize the drainage of side by side of shallow peatlands (1–3 m) through the intervention of water management for controlling the drainage.

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