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Canal Bulkhead Design Preventing Blockage of River Flow – A Case Study in the Bangah River, Sebangau National Park, Indonesia

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ABSTRACT

Vast tropical peat swamp forests in Sebangau, Central Kalimantan, Indonesia, make it difficult for officials to fight forest fires. Peat swamp forest fires are recurring events caused by anthropogenic activities around the forest. This research aimed to develop a new canal bulkhead design that prevents blockage of river flow. The approach employed involves enhancing current structures through engineering design in order to decrease the occurrence of structural breakdowns that impede the flow of rivers. The research yielded a new design for a canal bulkhead, featuring an enhanced one-meter-wide sluice gate in a "U" shape, as well as an upgraded boat ladder for passage. The novelty of the present study resides in the design of the canal bulkhead dwelling, which incorporates a ladder, enabling the inhabitants to utilize the canal without obstructing its flow. As a result, there is an enhancement in environmental safety as there are now efficient methods to promptly suppress wildfires.

Keywords: tropical peatland, hydrology, restoration techniques, peat swamp forest, watershed area.

INTRODUCTION

The canal blockage was a significant turning point in the history of peat swamp forest fires in Sebangau. Peat swamp forest fires in Sebangau are often associated with dry peat conditions related to climate variability (drought) and ecosystem degradation caused by anthropogenic activity (Ramdzan et al., 2023). Peat dryness is caused by water flowing through canals that penetrate peat domes. Peat swamp forest fires cause haze, making Indonesia the most significant contributor of greenhouse gases globally (Sosilawaty et al., 2022). Meanwhile, in almost all parts of Sebangau, several peat canals dry up and trigger severe fires that are difficult to extinguish. The total length of the canals is 673,486 km at nine locations in Sebangau National Park (SNP) (Kasih et al., 2016). The efforts to slow down the rate of water movement in canals by clogging canals are very effective in keeping peat swamps wet. Dry indicator in Sebangau area as early warning information with groundwater level (-0.40 m) (Silviana et al., 2020).

Peat swamp forest fires result in considerable financial losses. The 4,364 hectares of peat swamp forest fires caused economic losses of Rp 134 billion (Khalwani et al., 2017). These fires have not only impacted Indonesia but have become a global environmental threat (Edwards & Heiduk, 2015). After peat swamp forest fires in 2015, Indonesia

intensified the efforts to restore peatland ecosystems. One of the efforts is the blockage of canals to wet peat (Yuwati et al., 2021). However, some canal-using communities have long used the rivers, creeks, and canals that penetrate the Sebangau forest to make a living (Nurseptiani et al., 2021).

Ecologically, Sebangau is an ideal habitat for various types of wildlife, including endemic species of the island of Borneo that are protected by Government Regulation of the Republic of Indonesia No.7 of 1999, such as orangutans and Bornean gibbons, which are listed as endangered species by the International Union for Conservation of Nature (Mustari et al., 2010; Ramadhon & Fithria, 2021). Peat ecosystems have a vital hydrological role, because they naturally function as water reserves (reservoirs) with large capacities and where fish migrate to spawn and raise fish offspring (Thornton et al., 2018). Fish farming in peat swamp land is very prospective. Community empowerment can be done through toman fish farming (*Channa micropeltes*) and catfish introduction fish farming (*Clarias sp*) (Wildayana & Armanto, 2021). In addition, Sebangau is also a shelter for rare birds, seldom seen and used as a sacred symbol for the Dayak tribe, namely the Tingang bird (*Rhinoplax vigil*) (Ehlers Smith et al., 2013).

The destruction of the canal partition started a catastrophic peat swamp forest fire (Yulianti et al., 2020). On the basis of the data obtained from SNP, NGOs, and ground check results, 77.5% of canal barriers were damaged because they were considered to interfere with community activities in meeting their needs (Warren-Thomas et al., 2022). Therefore, the research aimed to develop a new canal bulkhead design that prevents blockage of river flow to minimize damage to canal blocks. The formulation and execution of such a design will simultaneously address two issues. Firstly, it will prevent the obstruction of water movement in the canal, facilitating the hydration of peat bogs and enabling swift fire suppression in case of ignition. Furthermore, the local community will persist in carrying out its own economic endeavors without any obstruction, while ensuring that no harm is inflicted upon the ecological environment (Zulkarnain et al., 2020).

METHODOLOGY

The study was conducted from 3 to 30 May 2023 in the Garung Village and on the Bangah River at SPTN II Resort Bangah SNP, which is

Figure 1. (a) Canal blockage in tropical peat swamp forest at the research location, (b) back view of the canal bulkhead, (c) front view of the canal bulkhead, (d) channel blockage damaged by channel users

located southwest of the Garung village (the closest village to the Bangah River) with a distance of about ± 35 km or about 2 hours away by boat.

The type of data required in this study is vector data (*.shp*) distribution of channel bulkheads, dimensional data of constructed channel bulkheads, and in-depth interviews with channel users.

The Garung Village cannot be separated from the Bangah River and SNP, so most people still depend on nature to fulfill their daily lives (Tito Surogo, 2020). Figure 1 depicts channel blockages in tropical peat swamp forests at the research location.

The first research method investigated the number of broken canal bulkheads. In addition, in-depth interviews with channel users were conducted to explore the information related to canal blockages that do not interfere with what kind of livelihood activities according to people's views.

Through this, damage to canal bulkheads and alternative forms of canal bulkheads can be known. Secondly, the dimensions of the canal bulkhead, which include the height, width, and material of the canal bulkhead, were investigated. Furthermore, the width of the boat used by canal users wasalso measured. Thirdly, the damaged canal bulkhead was analyzed for design to make it easy for local people to use and provide water to wet the structure's peat swamps.

The implementation of 3D modeling was utilized to enhance the visual impact, enabling the local population to comprehend the operational principles of the proposed construction and utilize it in a responsible manner.

RESULTS AND DISCUSSION

During the field examinations conducted by the researchers, it was discovered that out of the 216 canal dividers in the research location, 155 were determined to be damaged. Figure 2 depicts the geographical positioning of the Bangah River and the Garung hamlet with respect to Sebangau National Park.

On the basis of the data, 216 canal partitions have been built at the research site, and 77.5% of the data was damaged during field checks. Figure 3 is a comparison of built and vandalized canal bulkheads.

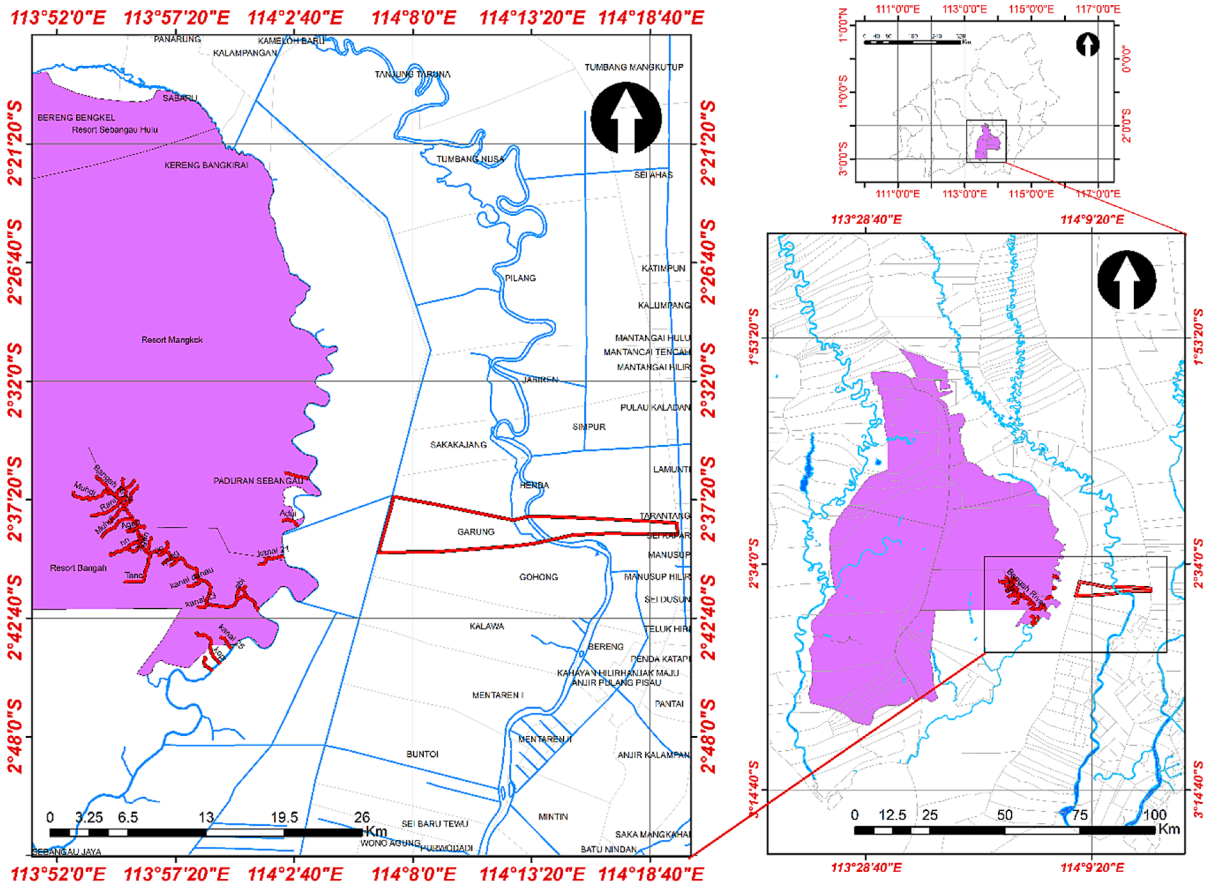


Figure 2. Geographical representation of the Bangah River and Garung village position in relation to Sebangau National Park

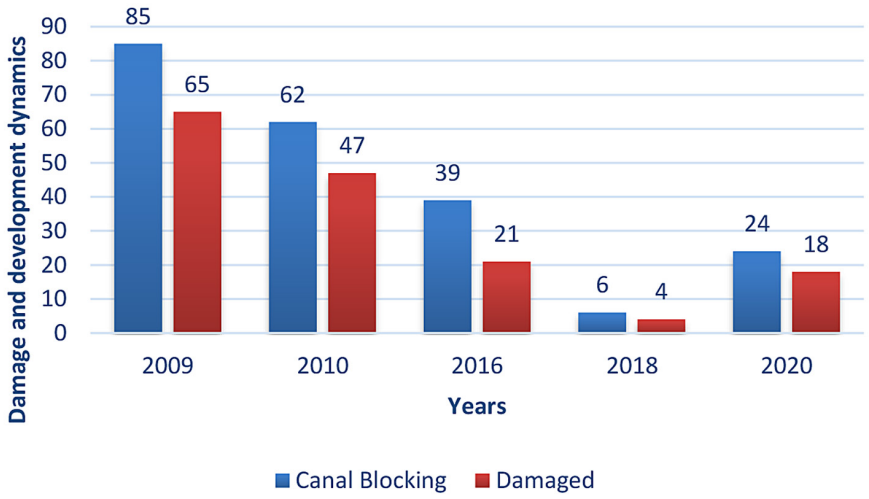


Figure 3. Comparison of built and vandalized canal bulkheads

The canal user community does not like constructing canal barriers because it blocks the access to boat transportation into peat swamp forests or when taking fish (Suwito et al., 2022). The incident of destruction of the canal partition was exacerbated due to the effects of forest fires in the Sebangau peat-swamp, which caused an increase in the acidity of the Sebangau River, which had a negative impact on the number of fish populations (Minggawati et al., 2020). The destruction was also triggered by low fish catches, which encouraged the destruction of canal barriers (Medrilzam et al., 2014).

The canal blockage project in the Sebangau area must support local communities because of the interdependence in utilizing water resources (Thornton et al., 2020). Some community groups participated in building the canal bulkhead, and some resisted (Purwawangsa, 2018). Community empowerment has emerged as a viable strategy to resolve the social conflicts in the Sebangau region. Fish farming with a cage system between canal dividers is a short-term advantage (Triana, 2014). It is necessary to have a common perception of canal blockages that provide long-term benefits to avoid conflict and destruction (Meilani et al., 2021).

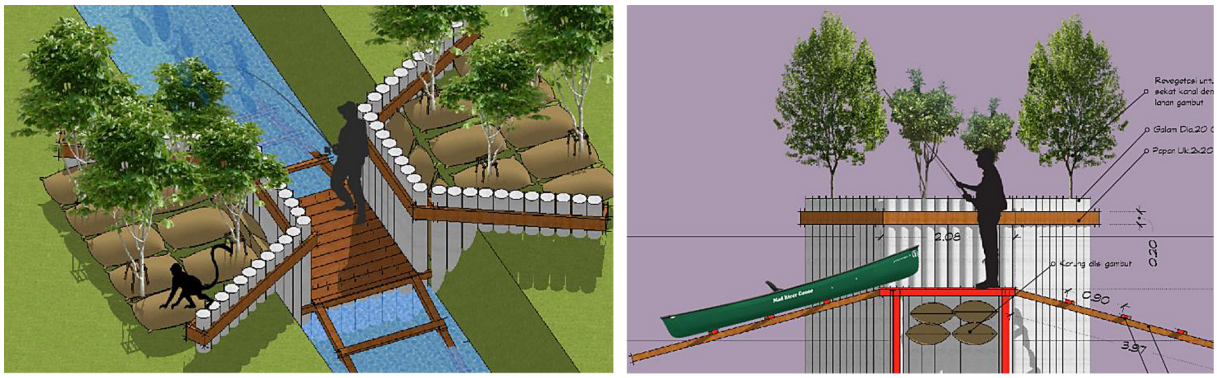
The analysis results show that the canal bulkhead was damaged because the design of the canal bulkhead structure was not easy for the public to use (Agung et al., 2022; Ritzema et al., 2014). The distance of the canal bulkhead is relatively close, so maneuvering the boat when turning in the direction is very difficult. If allowed to continue using the old design, the damage to the canal partition will undoubtedly increase, which will affect the wetting of peat swamps in a non-optimal way.

The best canal divider is to maximize water level rise and not be damaged by canal users (Urzainki et al., 2020). The current design of the canal bulkhead uses a wooden building structure that is less resistant to water, so that it is easily weathered and collapsed. The proposed new design provides for planting trees on the bulkhead body of the canal, which will strengthen its material structure and give a longer service life (Kinasih et al., 2020). Tree planting in the canal bulkhead can increase community income by conducting peat swamp tree nurseries and agroforestry development, including planting mixed trees of belangeran (*Shorea belangeran*), jelutung (*Dyera spp*.), and gemor (*Nothapoebe coriacea*) (Akbar et al., 2021).

From the analysis of the new canal bulkhead design development, the "U" shaped canal bulkhead with a width of one meter and the addition of stairs at the front and back are the latest solutions to reduce structural failures in wetting peat swamps. Therefore, researchers made a 3D design visualization as follows. Figure 4 is a conceptual design that reflects a collaborative approach to developing the most suitable channel-blocking strategy.

This addition makes it easier for canal users to stand at the sluice gates while pulling the boat from the ladder. According to canal users, the ideal canal bulkhead point is 300 meters from the mouth of the canal for the first canal bulkhead and every 200 meters for the next canal bulkhead. Figure 5 is the most optimal distance between canal bulkheads.

People use the canal to find transportation routes for fish and boats. It can be seen that each distance of the 200-meter canal divider functions as a fish enlargement pond or, in the Dayak



(a) (b)

Figure 4. A conceptual design reflects the collaborative approach to developing the most suitable channel-blocking strategy; (a) the perspective of the canal bulkhead in the bird's eye view, (b) the longitudinal cut of the canal bulkhead

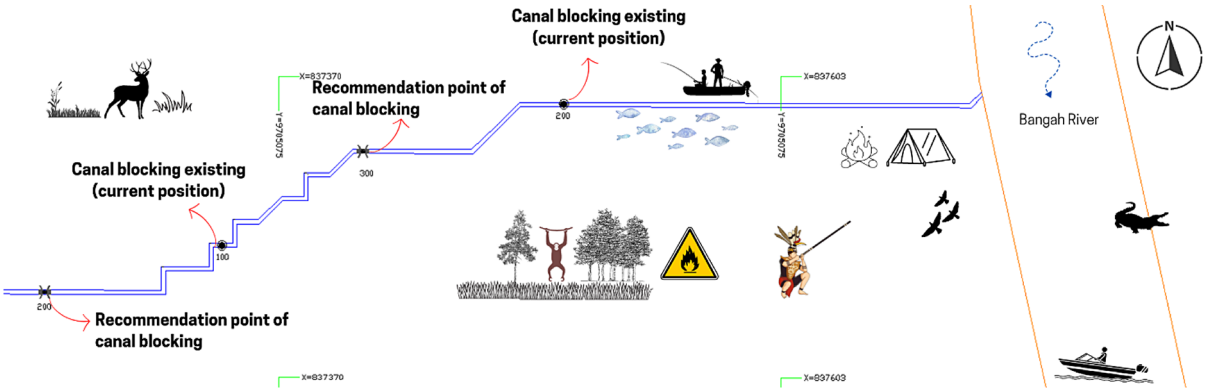


Figure 5. The most optimal distance between canal bulkheads

language, called Beje. The canal users in Sebangau can build a "Beje" pond for fishing and agrosilvo fishery cultivation system between the canal dividers (Aguswan et al., 2022). The agrosilvo fishery system has maximum comprehensive benefits and can be a reference for the rational use of peat swamp land (Hsiung & Xue, 1993). To achieve sustainable management of canal blocks, it is necessary to take a food commodity-based water conservation approach with sustainable fish farming (Sutrisno et al., 2023).

CONCLUSIONS

To prevent the human-caused damage to canal blockages, involving local communities that depend on canals is essential. Their involvement and agreement on the placement and design of canal bulkheads at the site level was crucial. Therefore, a channel bulkhead design recommendation was proposed, recommending that people can use channels in Sebangau National Park up to 300 meters from the mouth of the channel, with a distance between each dividing channel of 200 meters.

Regarding the specifications of the canal bulkhead, the sluice gate on the canal bulkhead must adopt a U-shaped configuration with a one-meter width, reflecting the boat body's width and making it easier for canal users to pull the boat.

The addition of a ladder is used as a tool so that the boat can pass through it without causing damage to the canal bulkhead. Furthermore, this study shows that the optimal distance for boats to enter the canal ranges from 200 meters for fishing areas or fish farming cage systems.

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