The effectiveness of canal blocking for hydrological restoration in tropical peatland

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Abstract. The Peatland Restoration Agency of the Republic of Indonesia (BRG-RI), an agency that is mandated to restore 2 million hectares of degraded peatland by 2020, has developed a 3-R approach towards tackling the problem based on the program of rewetting, revegetation, and revitalization of livelihood for the peatlands restoration in Indonesia. The Rewetting program that aims to rehabilitate hydrologically a peatland to a near natural state is carried out by canal blocking, canal backfilling, and construction of deep wells. To know the progress of the restoration activities by BRG, it is very important to understand the effectiveness of canal blocking on rewetting of the tropical peatland. The effectiveness of canal blocking was investigated through the monitoring of groundwater level (GWL) fluctuation around the canal block. This study was carried out at a canal block that is located at the peatland of Sungai Tohor Village, Kepulauan Meranti Regency, Riau Province. For monitoring of GWL fluctuation as the impact of canal blocking, five dipwells were set at the peatland that are perpendicular to the canal with the distance of 20 m, 70 m, 120 m, 170 m, and 220 m respectively. The results of this study show that the impact of canal blocking could raise the water table in the peatland at the radius of about 170 m from the canal. The radius impact of the re-wetting might be bigger or smaller, that strongly depends on the hydrotopography situation of the area.

1 Introduction

Peatlands are the most efficient terrestrial ecosystems in storing carbon in the world. While covering only 3% of the land area, they contain nearly 30% of all carbon on the land [1]. They are of crucial value for biodiversity conservation and climate regulation and provide

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important support for human welfare [2, 3]. Inappropriate management of peatlands is leading to large-scale degradation with significant environmental and social impacts [4]. The peatland degradation in Sumatera and Kalimantan shows that only about less than 4% of the peatland areas remain covered by pristine peat swamp forests (PSFs), while PSFs cover 37% with varying degree of degradation. Furthermore, over 20% is considered to be unmanaged degraded landscape, occupied by ferns, shrubs and secondary growth [5]. In order to restore their function, those peatlands need to be restored to their natural conditions [6].

The Peatland Restoration Agency of the Republic of Indonesia (BRG-RI), an agency that is mandated to restore 2 million hectares of degraded peatland by 2020, has developed a 3-R approach towards tackling the problem based on the program of re-wetting, re-vegetation, and revitalization of livelihood for the peatlands restoration in Indonesia [7]. The rewetting program that aims to rehabilitate a peatland hydrologically to a near natural state is carried out by canal blocking, canal backfilling, and construction of deep wells [8].

To observe the progress of the restoration activities by BRG, it is essential to understand the effectiveness of canal blocking on re-wetting of the tropical peatland. In this study, the effectiveness of canal blocking was investigated through the monitoring of groundwater level (GWL) fluctuation around the canal block. The study was carried out at a canal block that is located at the peatland of Sungai Tohor Village, Kepulauan Meranti Regency, Riau Province. For monitoring of GWL fluctuation as the impact of canal blocking, five dipwells were installed at the peatland that is perpendicular to the canal with the distance of 20 m, 70 m, 120 m, 170 m, and 220 m respectively.

2 Methodology

2.1 Study area

This study was carried out at a canal block that is located at a series of canal blocks of about 6 km canal at Sungai Tohor Village, Kepulauan Meranti Regency, Riau Province, Indonesia as shown in Fig. 1. Sungai Tohor village is one of the villages in Tebing Tinggi island that is mostly covered with peat soil. The village is included in the Pulau Tebing Tinggi Peatland Hydrological Unit (PHU) that is one of the most priority areas for peat restoration program by Indonesian government due to the previous peatland degradation [9, 10] Historically, the village experienced severe peat fires in the last few years. The recent peat fire occurred in 2014, after that the local community made some blocks at the canal to keep the peatland always wet to prevent the next fire. After the peat fire in 2014, there is no more fire at the Sungai Tohor village up to now. Based on the information from the local people, that the sago plantation that is located near the canal blocking become good growth. They said that it is because of the sufficient water supply stored at canal block.

2.2 Experiment set up

Groundwater is a crucial parameter for the management of tropical peatland (Graham 2016). In order to understand the effectiveness of the canal blocking for re-wetting the peatland, six water loggers were set up to record groundwater level at canal block, and at five dipwells at the peatland, as shown in Fig. 2a. The dipwells are namely as SP-1, SP-2, SP-3, SP-4, SP-5 with the distance to the canal of 20 m, 70 m, 120 m, 170 m, and 220 m respectively (Fig. 2c). The canal has 4 m width and 3 m depth with 600 m interval between two canal blocks as shown in Fig. 2b. The dipwells are located in the peatlands area that is covered with secondary peat swamp forest, and the peat thickness is about 4 m to 5 m. The

canal block has a sluice gate that can be used to block the water flow to raise the water elevation to 0.6 m as shown in Fig. 3.
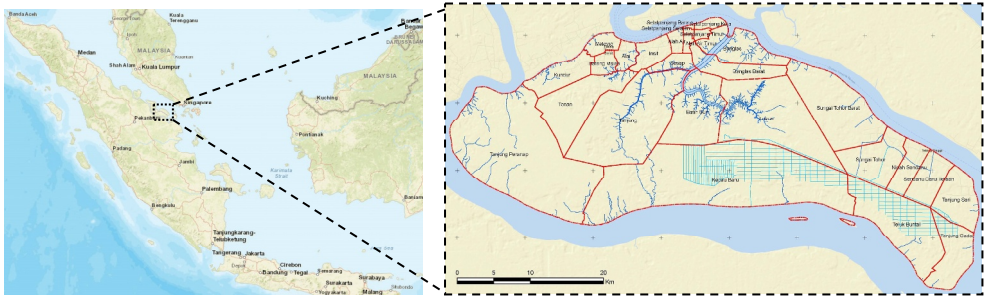

Fig. 1. Study area at Sungai Tohor village Kepulauan Meranti Regency, Riau Province, Indonesia.
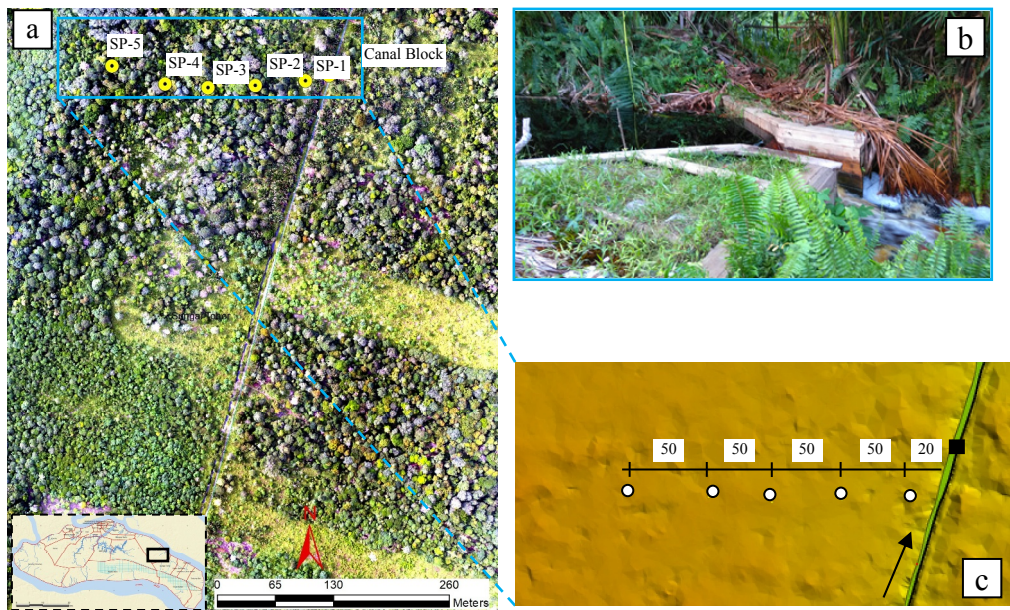

Fig. 2. Experiment Set up at Sungai Tohor village (a), the model of Canal Block (b), and the sketch of the dipwell at the secondary peat swamp forest in Kepulauan Meranti Regency, Riau Province, Indonesia.

2.3 Experiment simulation

The experiment simulation was carried out on July 2018, that is a dry season. Thus, to minimize the impact of rainfall on GWL fluctuation instead of canal blocking. However, the rainfall also takes into account in this analysis. Each of the dipwell and canal blocks was set up with water logger for recording water level fluctuation every 5 minutes. Initially, the water loggers were set to record water fluctuation for two days in the condition that the canal block remained open. After that, the sluice gate of the canal block was set to close for raising the water elevation at the canal for a few days until stable condition. To know the respond of GWL fluctuation at the peatland, the canal block was opened and closed alternately while the water loggers recorded those process.

Fig. 3. The canal block was just closed (left) and after the stable condition (right).

2.4 Rainfall data

The rainfall data were recorded using real-time telemetry technology, namely SESAME (Sensory Data Transmission Service Assisted by Midori Engineering) at Sungai Tohor village, as presented in Fig. 4. The data were recorded every 10 minutes by the SESAME system are rainfall, air temperature, and water depth.

Fig. 4. The SESAME System for recording air temperature and rainfall data at Sungai Tohor Village.

3 Results and discussion

3.1 The result of recorded data

The recorded data of the water level fluctuation from the simulation together with the rainfall data are presented in Fig. 5. The figure shows the respond of the water table fluctuation at the five dipwells because of the water level change at the canal due to the canal block was opened and closed alternately. Firstly, the canal block was open for 15 hours. During this time, there was no water table change at all of the dipwells. It means that the water flow at the canal and groundwater flow at the peatland were in stable condition. When the canal block was closed for two days, the water level at canal continued to increase up to 0.5 m from its original elevation. This condition caused increasing the water table at the dipwells of SP-01 and SP-02 about 0.41 and 0.2 m respectively. There was no impact on the other three dipwells SP-03, SP-04 and SP-05 with the distance to the canal about 120 m, 170 m, and 220 m respectively.

From hour-73, the water level at the canal had fluctuated dynamically for about six days. This is because of the local people activities that they need to open the canal block for their sago trunk transportation. The SP-03 dipwell started to be impacted by canal blocking at hour-96 (after four days). The water table at SP-03 continued to increase up to 0.13 m from its original elevation. The canal block was closed from hour-215 for about seven days that caused the water level increase up to 0.69 m. This condition caused increasing the water table at the dipwells of SP-01, SP-02, SP-03 and SP-04 about 0.63, 0.29, 0.13 and 0.04 m respectively. There was three days rainfall recorded during the simulation that was occurred on July 25th, 28th, and August 1st. They have a small impact on increasing water elevation at the canal, SP-01, and SP-02 dipwells, but has a significant effect at the SP-03 and SP-04 dipwells.
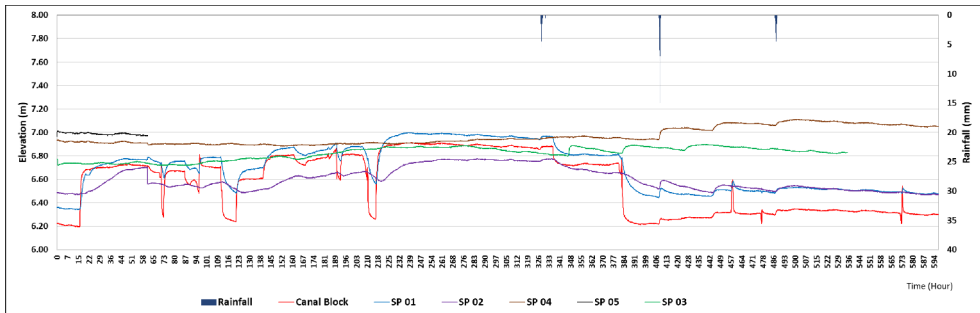

Fig. 5. Water level fluctuation at five dipwells every 5 minutes as respond of the water level fluctuation at canal because of canal blocking.

3.2 Daily water level fluctuation

Fig. 6 presents daily water table fluctuation at five dipwells as respond of the water level fluctuation at the canal because of canal blocking. It shows clearly that water table fluctuation at dipwells of SP-01 and SP-02 follow the water level fluctuation at the canal. It means that those locations were significantly impacted by canal blocking. However, the canal blocking has a small impact at dipwells of SP-03 and SP-04. The dipwells of SP-03 and SP-04 were more affected by rainfall than that of canal blocking.
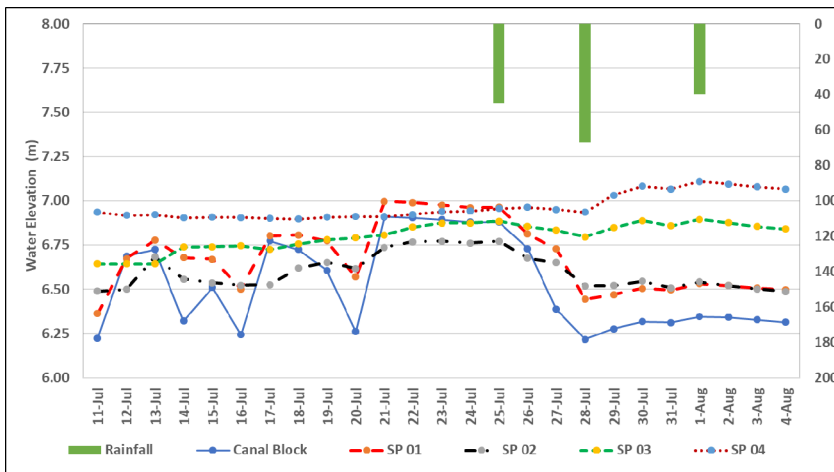

Fig. 6. Daily water level fluctuation at five dipwells as respond of the water level fluctuation at canal because of blocking canal.

The phenomena of those water level fluctuations because of canal blocking can be understood through the hydro-topography situation of the research area. The ground surface around the canal tends to be lower, and it is higher gradually from canal block toward SP-05 as shown in Fig. 7. On July 11th, the water table at the original elevation was a sloping ground surface, that followed the elevation of the ground surface. When the canal block was closed on July 13th, the water level at canal became 0.5 m higher than its original elevation then infiltrated to the peatland. It caused water table at dipwells of SP-01 and SP-02 became 0.4 m and 0.2 m higher than their original elevation respectively. It means that those locations were impacted by canal blocking. Water level fluctuation at the canal from July 17th to July 25th have an impact on the water table fluctuation at dipwells of SP-01, SP-02, and SP-03. It means that the canal blocking was able to wet the peatland to a radius of about 170 m towards the perpendicular canal.

Water infiltration from the canal to the peatland due to canal blocking was not able to increase the water table more than the radius of 170 m because its original water table has the same elevation as the elevation of water in the canal after blocking. In this case, a canal block was able to wet the peatland to a radius of 240 m on both sides of the land from the canal. In other cases, the radius might be bigger or smaller, that strongly depend on the hydro-topography situation of the area as well as the influence of peat characteristics, land cover and flow discharge in the canal. Those matters are going to be studied in further researches.
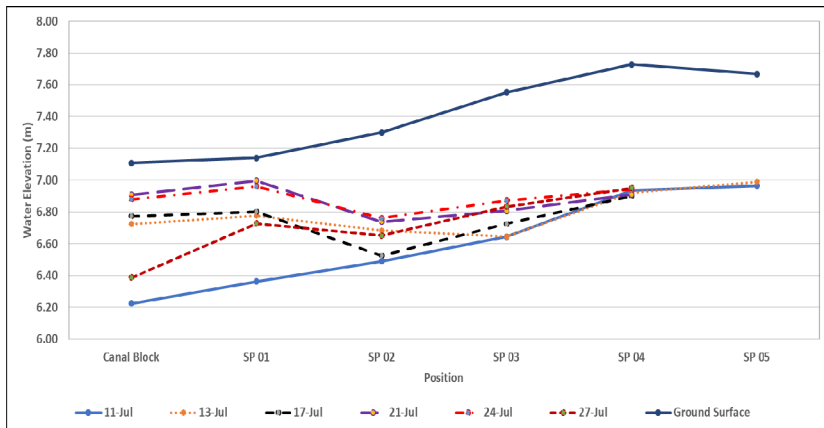

Fig. 7. Cross section of water table fluctuation along five dipwells as respond of the water level fluctuation at canal because of blocking canal.

4 Conclusions

This study investigated the effectiveness of canal blocking on rewetting of the tropical peatland by monitoring of groundwater level (GWL) fluctuation around the canal block. The monitoring was carried out during three weeks in the dry season of the five dipwells with the distance to the canal of 20 m, 70 m, 120 m, 170 m, and 220 m respectively. The results of this study show that the impact of canal blocking could raise the water table in the peatland at the radius of about 170 m (or 240 m on both sides) from the canal. The radius impact of the re-wetting might be bigger or smaller, that strongly depends on the hydro-topography situation of the area as well as the influence of peat characteristics, land cover and flow discharge in the canal. Those matters are going to be studied in further researches.

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