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Water Table Dynamic and Peat Motion in Forest and Burnt Area in Central Kalimantan Province, Indonesia

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Abstract. Water table dynamic (WTD) and peat motion are useful data to assess the condition of peatland ecosystems. Decomposition of peat is affected by WTD, with lower groundwater levels resulting in larger peat subsidence and CO_2 emissions. In this study, we used low-cost time-lapse cameras based on Raspberry Pi computers to periodically monitor peat motion and water table depth. The camera will take pictures every 2 hours at the same time as the WTD data taken by water level logger. The aim of this research is to determine the magnitude of peat surface movement under forest cover and ex-burnt conditions. The research locations where time-lapse cameras were installed were six locations: UPR Hampangen Natural Laboratory, KHDTK Tumbang Nusa, Repeat, the southern burnt area, and Sebangau National Park. Data collection for WTD and peat movement was carried out from December 2022 to June 2023. The research results show that the WTD value is inversely proportional to the value of peat subsidence. In the Sebangau National Park location, which has a low mean WTD value (-0,31 m), there was a large decrease in the peat surface of -1.36 cm. The UPR Hampangen Natural Laboratory location has a high mean WTD (0,12 m), there was the smallest peat reduction of -0.12 cm.

1. INTRODUCTION

Indonesia has 865 Peat Hydrological Units with a total area of 24,667,804 hectares. The distribution of peatlands in Indonesia is found on the islands of Sumatra, Kalimantan, Sulawesi and Papua. Central Kalimantan Province has the largest KHG area on Kalimantan Island with a percentage of 55.62% of the total Peat Hydrological Units area in Indonesia. Peatlands have the function of controlling global climate, hydrological functions (flood control and water supply), storing carbon, maintaining diversity of flora and fauna, educational and research functions.

Water is a key parameter in peatland management which is expressed in terms of the Water Table Dynamic (WTD) of the peatland. WTD and vertical peat motion are very important data for the sustainability of peatland ecosystems. A decrease in soil WTD causes decomposition of peat soil which results in subsidence and carbon dioxide [1]. The decrease in WTD causes peatlands, which were originally sources of carbon reserves, to become sources of carbon emissions [2]. In the dry season, low groundwater levels cause the surface of peatlands, which consist of organic material, to become dry and flammable [3].

Land cover conditions will produce different WTD and vertical movement of peat. The conversion of peat land to plantations or agriculture usually results in a decrease in WTD due to the creation of drainage canal. Fires in peatlands also affect the WTD of peat and the vertical movement of peat. Monitoring WTD in peatlands is absolutely necessary to restore damaged peatlands and for sustainable management and Peatland restoration always begins with WTD restoration in the peat [1].

In this study, we used low-cost time-lapse cameras based on Raspberry Pi computers to periodically monitor peat motion and water table depth. The aim of this research is to determine the magnitude of peat surface movement under forest cover and ex-burnt conditions.

2. RESEARCH METHODS

2.1. Study sites

The research locations where time-lapse cameras were installed were six locations and is divided into 2 types of land cover, namely forest and burnt areas. The forest location consists of 3 locations, namely KHDTK Tumbang Nusa, UPR Hampangen Natural Laboratory, and Sebangau National Park Forest. The burnt areas consist of 3 locations, namely, Repeat, the southern burnt area and the burnt area of Sebangau National Park. A map of the site research location can be seen in Figure 1. Data collection for WTD and peat movement was carried out from December 2022 to June 2023.

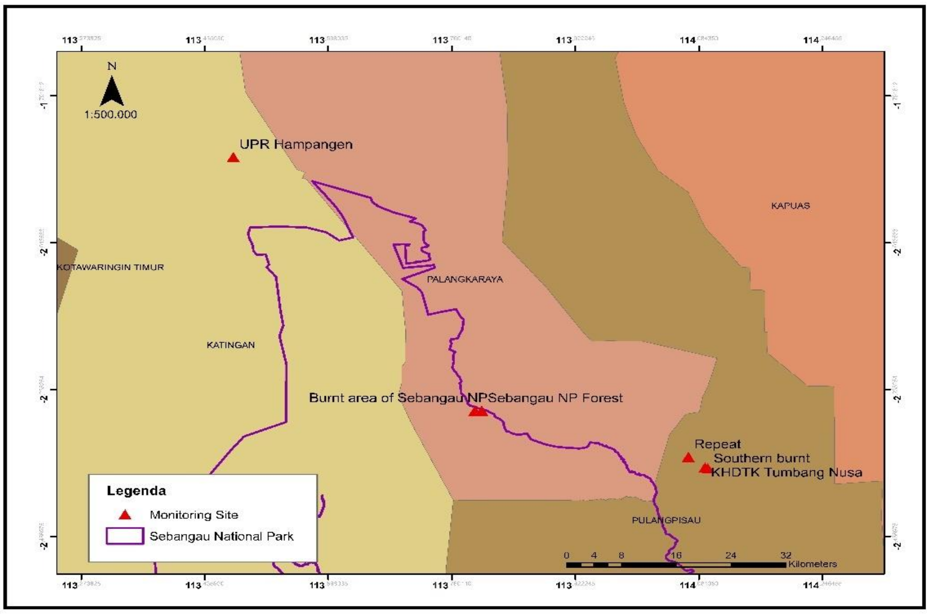

Figure 1. Site Locations

2.2. Water Table Dynamic (WTD) Measurement

WTD measurements use a water level logger inserted into the dipwell. Measurements were carried out every 2 hours. The data will be stored on a memory card and sent to the user every 2 hours using an internet signal.

2.3. Peat camera design and operation

This camera was equipped with a small computer (Raspberry Pi) and a ruler measuring peat movement was equipped with a barcode. A time-lapse camera device consists of several components including camera, cable, pressure transducer, dipwell, solar panel, soil temperature sensor, antenna, ground anchor, metal stool, time-lapse camera box, etc. Ground anchors are inserted into the soil layer. Ground anchors are useful for supporting the metal bench on which the time-lapse camera box is placed. Right in front of the time-lapse camera there is a ruler attached to a subsidence iron pole with a height of 2 m. The subsidence iron pole is inserted until it reaches the mineral soil and is used as a fixed reference and the camera box will move up and down following the movement of the peat. The camera will capture an image of the ruler in front of it. The camera will take pictures every 2 hours at the same time as the WTD data taken by water level logger.

Above the camera box is placed a solar panel as a power source. The signal amplifier is placed at the top of the iron pole. There is a soil temperature sensor inserted into the soil to a depth of 10 cm. The height of the camera box pole is set based on the history of flooding. If the research location is prone to being flooded. The camera box pole will be set higher so that the camera box does not get flooded.

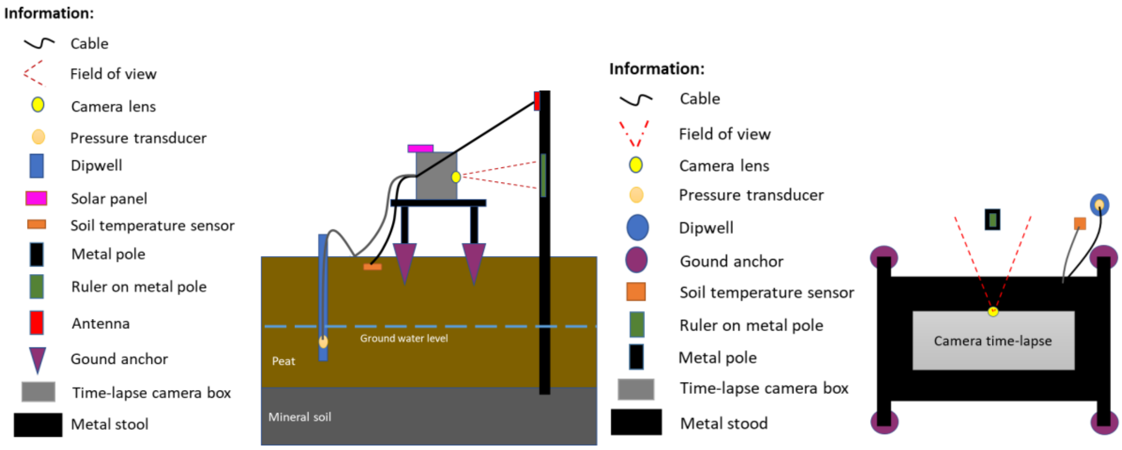

Figure 2. Schematic of peat cameras design (adapted from Evans et al, 2021)

2.4. Data analysis

The images captured by the time-lapse camera are then processed using a special program written in Python via a graphical user interface (GUI). Peat heights are automatically extracted into a spreadsheet with detailed image information (date, time, image number, warning). The script requires initial images for calibration and initial visual assessment. The initial reading for calibration is done manually, and the script compares the image to the initial image within the Area of Interest (AOI). Image analysis/feature matching was carried out using the ORB (Oriented FAST and Rotated BRIEF) method [4].

Key points are characterized by their coordinates, orientation and scale. Since the script has a GUI (Figure 3), which includes: variable selection, reference image selection, drawing areas of interest, drawing calibration segments, reading initial heights, checking data quality, and calculating peat movement.

Figure 3. UI screen display Python script for automating image reading

3. RESULTS AND DISCUSSION

3.1. KHDTK Tumbang Nusa

KHDTK Tumbang Nusa has secondary forest cover and was burned in 1997. The depth of the peat at this location is 255 cm and is categorized as deep peat. Data on vertical movement of the peat surface and WTD movement at KHDTK Tumbang Nusa as in Figure 4. The location of KHDTK Tumbang Nusa was never flooded during the observation period. This is indicated by the WTD value always being below 0 m. At the Tumbang Nusa KHDTK location which is never flooded, the fluctuating movement of the peat surface tends to follow the movement of the WTD.

The total value of the decrease in vertical movement of peat during the observation period was -1.33 cm. The R2 value for the Tumbang Nusa KHDTK location is 0.82. This value shows that the relationship between daily WTD and daily peat movement is strong.

3.2. UPR Hampangen Natural Laboratory

UPR Hampangan Natural Laboratory has secondary forest cover and was burnt in 1997. The depth of the peat is 86 cm and is categorized as shallow peat. The depth of the peat at this location is the shallowest compared to other locations. Data on vertical movement of the peat surface and WTD movement at UPR Hampangen Natural Laboratory as in Figure 4. This location was always flooded with water almost the entire time of observation. From Figure 4, it can be seen that although the WTD continues to increase, the increase in peat movement occurs very slowly if the WTD is more than 0 m (flooded). Flooded conditions cause the soil to become completely saturated and the soil pores to be completely filled with water so that the peat's ability to expand is limited.

The total value of the decrease in vertical movement of peat during the observation period was –0.12 cm. This value is the smallest value of peat surface reduction compared to other locations. From Figure 5 it can be seen that the R2 value for the UPR Hampangen Natural Laboratory location is 0.04. This condition explains that only 4% of the daily peat movement variables can be explained by the daily WTD variable. This value shows that the relationship between daily WTD and daily peat movement is weak. The low value of peat surface subsidence at this location is due to the high WTD value [5].

3.3. Sebangau National Park Forest

This location is secondary forest. The camera was installed at a distance of 5 m from the edge of the canal. The width of the canal is 3 m and a canal block has been built. The depth of the peat at this location is the deepest compared to other observation locations. The depth of the peat is 600 cm and is categorized as very deep peat. This location experiences dry and waterlogged periods. Data on the vertical movement of the peat surface and the movement of the WTD are as shown in Figure 4. The movement of the peat rises slowly when the location is flooded with water. This can be seen in March 2023, when the WTD reaches more than 0 m, the increase in peat movement is slow and not as fluctuating as following the WTD during dry conditions.

The total value of the decrease in vertical movement of peat during the observation period was –1.36 cm. From Figure 5 it can be seen that the R2 value for the Sebangau National Park Forest location is 0.39. This value shows that the relationship between daily WTD and daily peat movement is weak.

3.4. Burnt Area of Repeat

Repeat is an area burned in 2015. This location then became a rehabilitation project which included planting activities. The depth of the peat in Repeat is in the deep peat category. The depth of the peat is 277 cm. the camera was installed at a distance of 1.5 m from the edge of the canal. The canal is 2 m wide.

Repeat experienced dry and waterlogged periods. Data on the vertical movement of the peat surface and WTD movement can be seen in Figure 4. The total value of the decrease in vertical movement of peat during the observation period was -1.21 cm. From Figure 5 it can be seen that the R2 value for the Repeat location is 0.27. This value shows that the relationship between daily WTD and daily peat movement is weak.

3.5. Southern Burnt

The Southern Burnt is an area burned in 2015. The depth of the peat at the southern burnt location is categorized as deep peat. the depth of the peat is 300 cm. Data on vertical movement of the peat surface and WTD movement are as in Figure 4. The observation location is never flooded (WTD < 0 m). Figure 4 for the southern burned location shows that the southern burned location which has never been flooded tends to have a peat movement pattern that follows the TWD movement.

The total value of the decrease in vertical movement of peat during the observation period was -0.96 cm. The R2 value for the southern burnt location is 0.55 which indicates a strong relationship.

3.6. The Burnt area of Sebangau National Park

The burnt area in Sebangau National Park was burned in 2019. This location is overgrown with bushes. The camera was installed at a distance of 5 m from the edge of the canal. The width of the canal is 1.5 meters. The depth of the peat at this location is 295 cm and is in the deep peat category. Data on vertical movement of the peat surface and WTD movement as in Figure 5.

The Burnt area of Sebangau National Park experiences flooded and dry conditions. When the WTD has a value of more than 0 m (flooded), in early February 2023 it can be seen that the vertical movement of peat upwards begins to slow down even though the WTD continues to increase. The total value of the decrease in vertical movement of peat during the observation period was -1.04 cm. The R2 value for the Burnt area of Sebangau National Park is 0.03 which indicates a weak relationship.

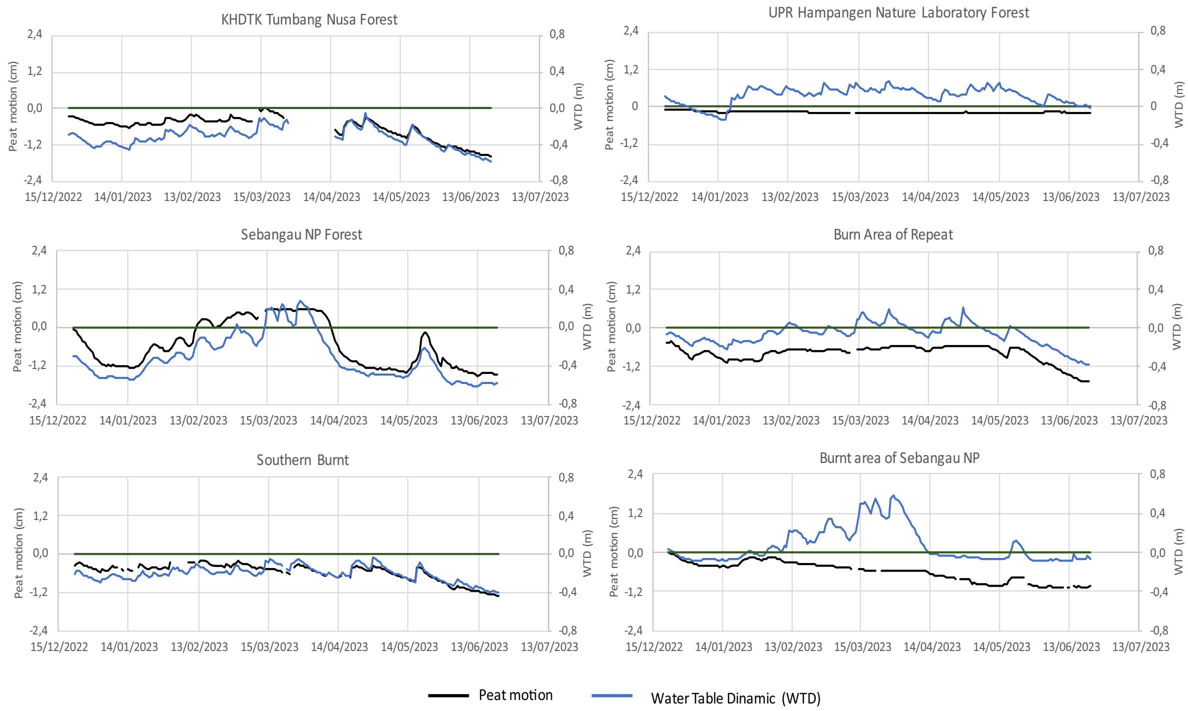

Figure 4. Relationship between peat motion and WTD at all research locations

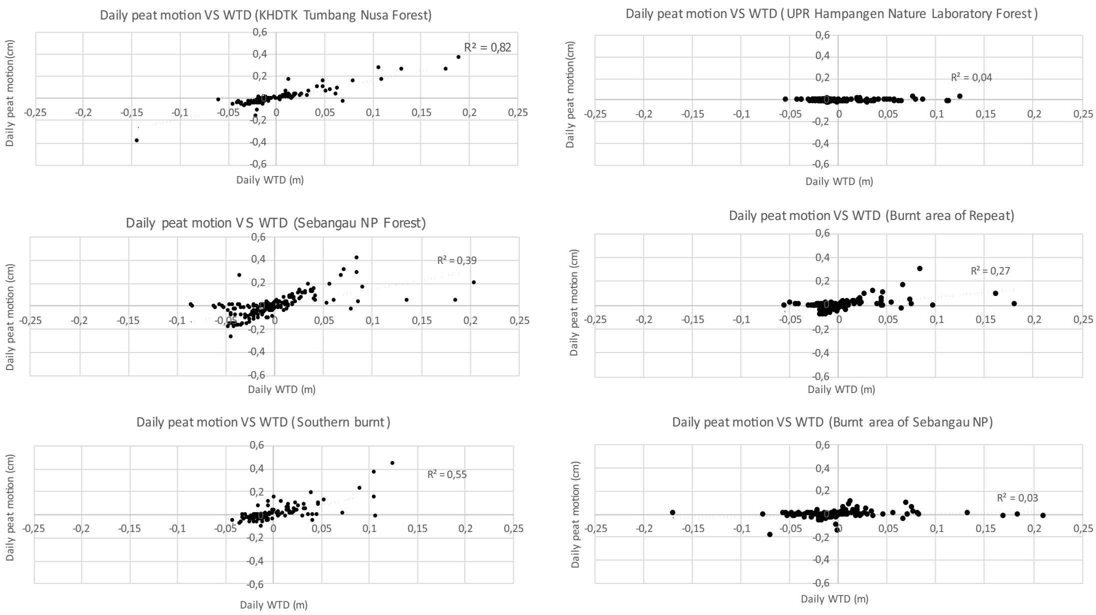

Figure 5. Relationship between daily WTD and daily peat motion at all research locations

The net peat motion, mean water level and R2 values for six months at the six locations can be seen in Table 1. The data shows that the highest peat motion reduction value at the Sebangau National Park location was -1.36 cm and the lowest mean WTD value of -0.31 m. The UPR Hampangen Natural Laboratory location has the lowest net peat motion value of -0.12 cm and the highest mean WTD value of 0.12 m.

Table 1. Net peat motion values, mean WTD and R^2 at all research locations

Location	Net Peat Motion (cm)	Mean WTD (m)	R^2
KHDTK Tumbang Nusa	-1.33	-0.31	0.82
UPR Hampangen Natural Laboratory	-0.12	0.12	0.04
Sebangau National Park Forest	-1.36	-0.31	0.39
Burnt Area of Repeat	-1.21	-0.06	0.27
Southern Burn	-0.96	-0.21	0.55
The Burnt Area of Sebangau National Park	-1.04	0.07	0.03

4. CONCLUSION

This research suggests that locations that tend to always be dry and have a low average WTD value (WTD < 0 m) will generally have a high R^2 value. The KHDTK Tumbang Nusa and Southern Burnt locations, which were always dry during the observation period, had R^2 values that were greater than other locations. The R^2 values at these two locations indicate that the relationship between daily WTD and daily peat motion has a strong relationship.

Locations that tend to flood during the observation period and have a high average WTD (WTD > 0) will have a low R^2 value. This is shown by the UPR Hampangen Natural Laboratory and The Burnt area of Sebangau National Park locations which have an average WTD of more than 0 m which have lower R^2 values than other locations. The R^2 values at the two locations that tend to be flooded have low R^2 values. This shows that daily WTD and daily peat motion have a weak relationship.

The lowest average WTD value occurred in the Sebangau NP and KHDTK Tumbang Nusa Forest locations. The low average value of WTD resulted in a large decrease in the peat surface occurring in these 2 locations. A decrease in low WTD values will generally also be followed by a decrease in the peat surface. Drastic reduction in soil WTD will be followed by peat oxidation and peat

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shrinkage/subsidence. This is because if the WTD is low (WTD <0), sufficient oxygen will be available for microorganisms to quickly decompose dead plants.

REFERENCES

[1] Ritzema H, Limin S, Kusin K, Jauhiainen J and Wösten H 2014 *Catena* **114** 11–20
[2] Sundari S, Hirano T, Yamada H, Kusin K and Limin S 2012 *J. Agric. Meteorol.* **68** 121–34
[3] Wösten J H M, Clymans E, Page S E, Rieley J O and Limin S H 2008 *Catena* **73** 212–24
[4] Rublee E, Rabaud V, Konolige K and Bradski G 2011 ORB: An efficient alternative to SIFT or SURF *2011 International Conference on Computer Vision* (IEEE Xplore) pp 2564–71
[5] Evans C D, Callaghan N, Jaya A, Grinham A, Sjogersten S, Page S E, Harrison M E, Kusin K, Kho L K, Ledger M, Evers S, Mitchell Z, Williamson J, Radbourne A D and Jovani-Sancho A J 2021 *Front. Environ. Sci.* **9** 630572