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DEGRADED PEATLANDS, GROUND WATER LEVEL AND SEVERE PEAT FIRE OCCURRENCES

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SUMMARY

Tropical peat fires occur nearly every year, but burning conditions are aggravated during droughts in Indonesia. Severe dry conditions in degraded peatlands may increase peat susceptibility to fire, creating suitable conditions for peat fires to be ignited. Ground water level (GWL) has been used as a key indicator for determining fire activity in peatlands. We studied the fire situation on 2011-2012 in a portion of the ex-Mega Rice Project (MRP) area, Central Kalimantan to get better understanding of this critical issue. Further analyses using TRMM data and the changing GWL from 460 dipwells set up at Block A and E of MRP area showed a time-lag between the lowest precipitation and the lowest GWL at this area, pointing out the high risk of future fires in the area due to the loss of the peat‘s future ability for absorbing and storing water. Terra/Aqua MODIS hotspot data, combined with Landsat imagery showed that most of fires occur in areas with GWL less than -20 cm, indicating that fire is coincident with lower GWL. This result also strongly illustrates the importance of maintaining high GWL, of more than 5 cm, to reduce fire risk and prevent degraded peatlands from experiencing surface peat fires and further devastating deep peat fires.

***Keywords**: peat fires, degraded peatland, ground water level, precipitation*

INTRODUCTION

Indonesia holds the largest tropical peatland areas, comprising approximately 50% of world‘s total tropical peatlands. Of the total of 14,905,574 ha of Indonesian peatland area, 32% is in Kalimantan and peatland in Central Kalimantan accounts for 56% (Ritung *et. al.,* 2011). An ambitious Mega Rice Project (MRP) in Central Kalimantan was initiated by Indonesian Government, in 1996, to convert 1.4 million hectares of peatland there to fields for cultivating rice and promoting transmigration. Over 4,000 km of channels were dug to open up the area, but with inadequate consideration of topography and peatland hydrology (Siegert, *et. al*., 2001), this project just exacerbated the problem when the over drained peatland became more vulnerable to fire. Fires commonly occur in this area annually during the dry season (July-September), but burning conditions are aggravated during pronounced *El Niño* years when the peatlands there are subjected to extremely severe dry conditions.

Ground water level (GWL) has been used as a key indicator for predicting fire occurrences in Central Kalimantan‘s degraded peatland (Putra et. al 2008, Usup *et. al*. 2004, Wosten et. al. 2008). Putra *et al.* (2008) revealed that more than 99% of fires in the Ex-MRP area occurred when the GWL was below the soil surface. Furthermore, recurrent fires in the Ex-MRP area may result to the decreasing of peatland capacity for retaining and absorbing water from precipitation, lowering ground water levels further and making the area more susceptible to fire, particularly in the dry season. To get a better understanding of this critical issue, we studied the recent fire situation in a portion of the ex-Mega Rice Project (MRP) area by linking the situation with GWL and precipitation.

METHODS

In this study, we are using monthly GWL data from 460 dipwells in upper part of Block A and the bottom part of Block E of the Ex-MRP area (Figure 1). These dipwells were established in 2010 within the Kalimantan Forest and Climate REDD+ demonstration project (KFCP). The GWL were monitored monthly during the period of January 2010-January 2013 using the blow-straw method (Ichsan *et al.,* 2014). In this study, we examine the relationship between ground water level, rate of precipitation and fire occurrences during 2011- 2012. IDW (Inverse Distance Weighting) multivariate interpolation technique is used to figure the ground water level surrounding each dipwell point. We used monthly TRMM (Tropical Rainfall Measuring Mission) data from NASA and JAXA to illustrate precipitation patterns in the study area. Monthly TRMM precipitation data is derived from GES-DISC NOAA (http://mirador.gsfc.nasa.gov/). Terra/Aqua MODIS active fire data from NASA-EOSDIS (https://earthdata.nasa.gov/) is used to explain fire occurrences and tendency in the area.

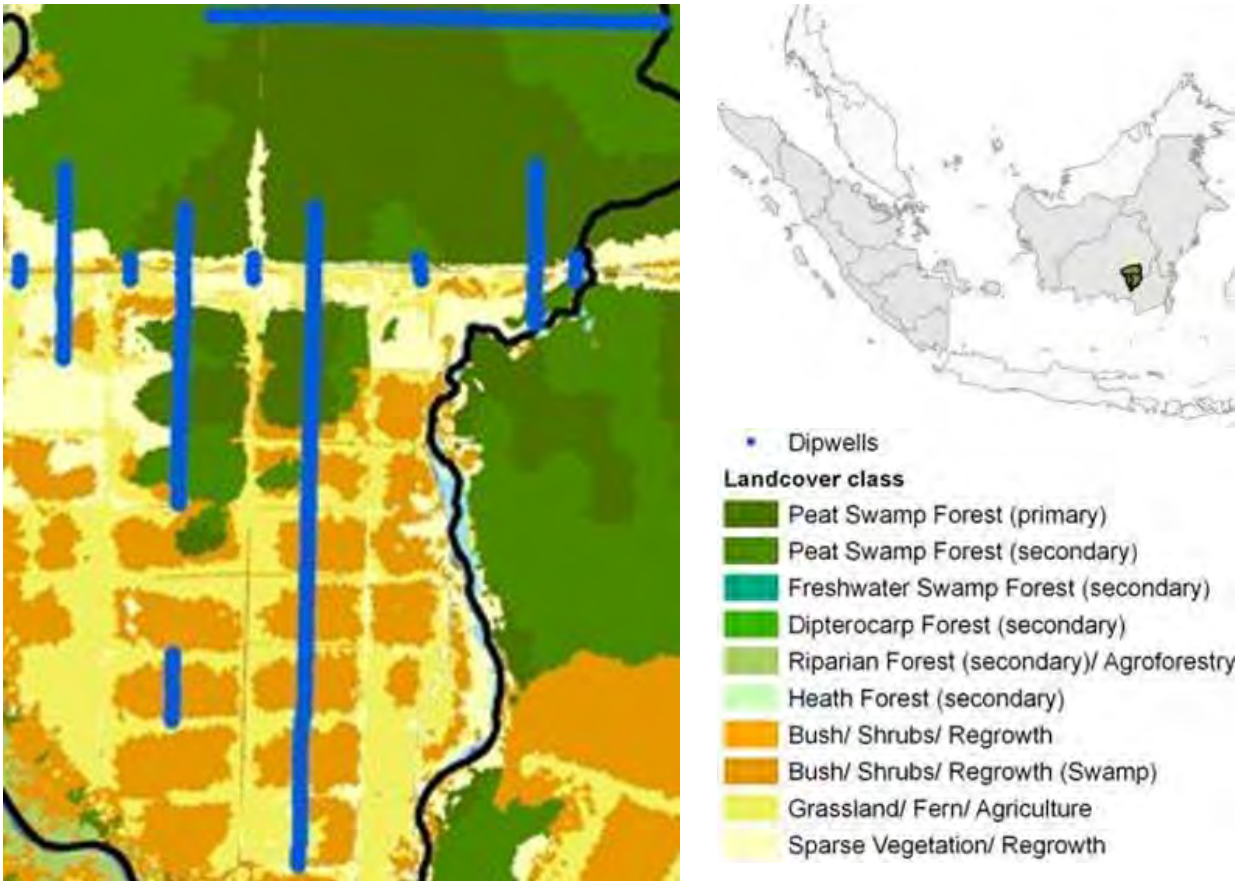
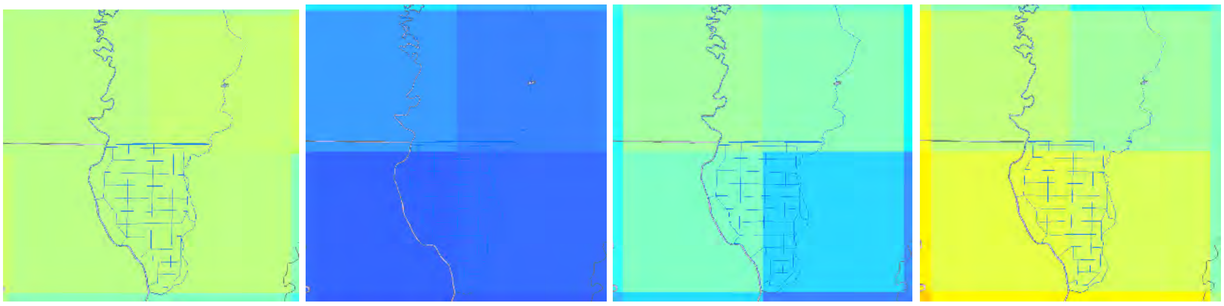


Figure 1: Location of dipwells at the Ex-MRP area, Central Kalimantan (Ichsan *et al.,* 2014)

RESULTS AND DISCUSSION

The Tropical Rainfall Measuring Mission (TRMM) is a joint mission between NASA and the Japan Aerospace Exploration (JAXA) Agency to study rainfall for weather and climate research. The TRMM dataset became the space standard for measuring precipitation, and led to research that improved our understanding of tropical cyclone structure and evolution, convective system properties, lightning-storm relationships, climate and weather modeling, and human impacts on rainfall (Braun, 2016). Northern part of Block A and southern part of Block E of Ex-MRP area covers four TRMM pixels, thus we have four different precipitation regions for the study area (Figures 2 and 4).

All of the regions experienced similar precipitation patterns in 2011 and 2012 (Figure 4), with peak dry season between July and September, and the lowest precipitation in August. Previous studies (Aldrian and Susanto 2003, Putra *et al.,* 2008, Usup *et al.,* 2004) have defined dry and wet seasons in Central Kalimantan by using the monthly rainfall variation. Figure 4 clearly shows a U-shaped monthly precipitation pattern with a trough reaching minimum in August. Similar findings were found by Putra and Hayasaka (2010), revealing that the dry periods in the Ex-MRP area remains the same in June – October each year, with the peak in August. Low precipitation dries the degraded peatland in the MRP area, increasing its susceptibility to fire, and creating suitable conditions for peat fires to be ignited. Figure 5 illustrates that peat fires are found mainly during the dry periods between July – October.



July 2012 August 2012 September 2012 October 2012

Figure 2: Monthly precipitation surrounding area, July – October 2012. The graduated color indicates precipitation rates; dark blue for lowest precipitation (0-10 mm), yellow for moderate rain (30-40 mm); light blue and green indicates precipitation rate between lowest and moderate.

Peatland areas at the northern part of Block A experienced severe dry conditions during the dry periods of July – October, as shown by the red and orange colors in Figure. 3. These areas have suffered from almost yearly peat fire occurrences since 2001, except 2008 (Figure. 4).

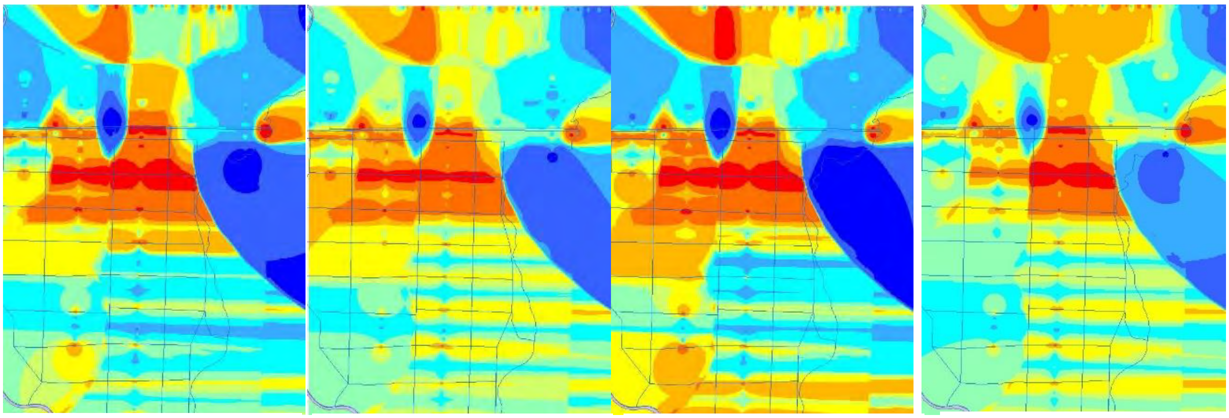


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Figure 3: Change of ground water level from July – October 2012. Red color indicates deep GWL (more than 30 cm below peat surface); dark blue color for positive GWL; light blue, yellow and orange indicates GWL between 0 (peat surface) and -30 cm (30 cm below peat surface).

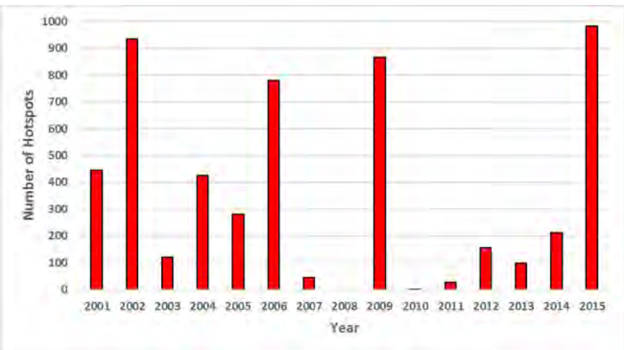

Figure 4: Number of hotspots detected by Terra/Aqua MODIS Satellite in study area, 2001 - 2015

In its natural condition, peat swamp forest is always inundated with water. The peat acts as a natural sponge, retaining moisture at times of low rainfall but, because it is normally waterlogged already, with a very limited capacity to absorb additional heavy rainfall during periods such as a tropical monsoon (UNDP, 2006). GWL in the study area now remains in deficit for the whole of the year (Figure 5) which can be considered unnatural for the system and can explains the severe dry condition of peat in the area.

There was a month time-lag between the lowest precipitation and the lowest GWL both in 2011 and 2012 (Figure 5). Lowest precipitation is found in August, while the lowest GWL occurred in September. GWL starts to increase in October after having continuous high precipitation that starts in September. This time-lag may indicate that peat capacity in absorbing and retaining water from rain water droplets has been substantially decreased, suggesting that ground water levels in the area will recover only after having plenty water supplies from continuous precipitation.

Figure 6 shows that the peat fire occurrences in the study area coincide with the precipitation curve. Fires occur following precipitation patterns with little or no rainfall during the dry period. A large number of peat fires tends to start three months after the start of the decreased of precipitation. In 2011, precipitation decreased gradually from May and reached the lowest point in August, creating the necessary dry conditions for fires to ignite. Equally, a large number of fires began to occur in July and became numerous during August and September. The end of the fire season occurred during October in 2011 and 2012, after having peak fire periods in September. A large numbers of fires started during August 2012, three months after the commencement of decreasing precipitation patterns during June 2012. These peat fire occurrence tendencies may indicate that peat in the study area is still quite dry into the beginning of the wet period, after suffering from severe dry conditions for prolonged dry periods, thus maintaining conditions where ignition may easily occur.

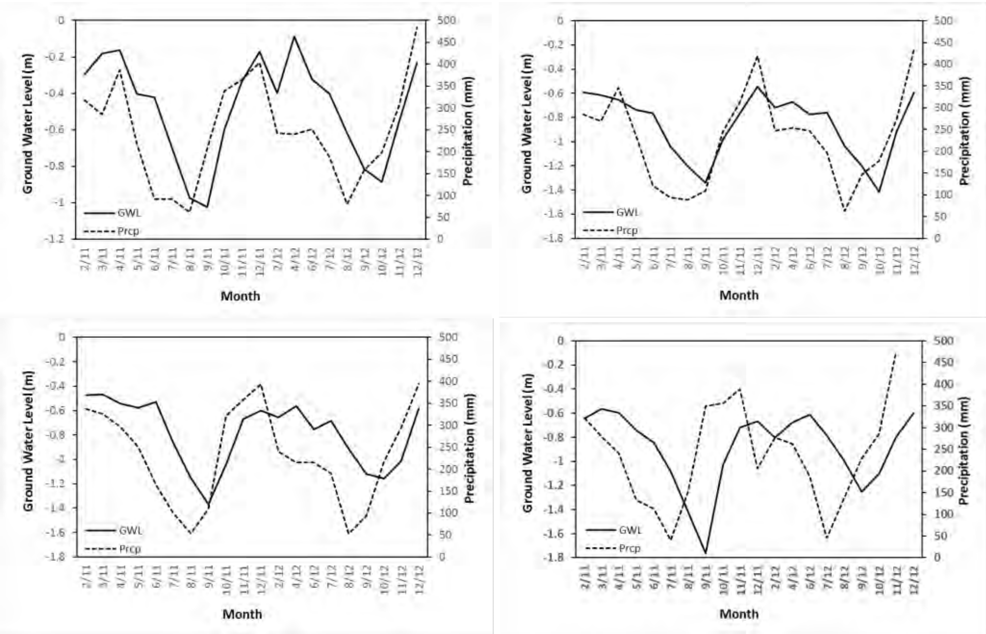

Figure 5: Ground water level and precipitation patterns at four TRMM pixels in the study area, 2011 - 2012

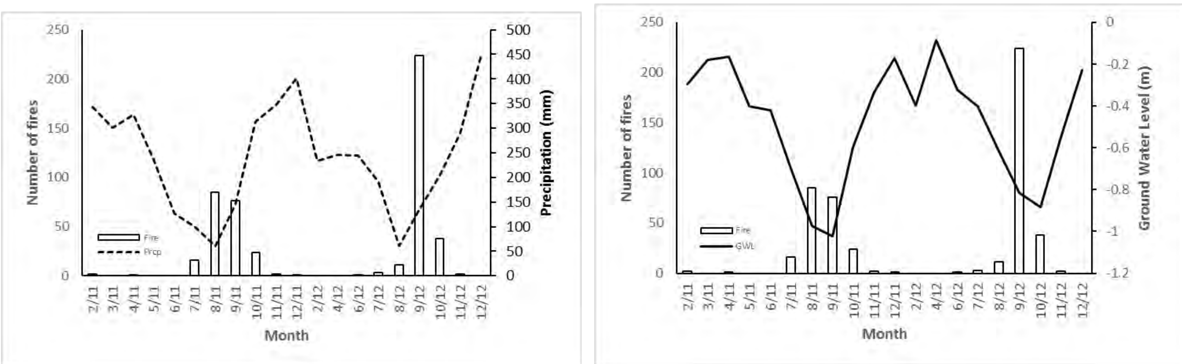

Figure 6: Relationships between number of fire occurrences and precipitation (left), and with GWL at study area (right), 2011 – 2012.

Figures 6 (right) and 7 illustrate the relationships between fire occurrences and GWL, suggesting that the low GWL accelerated conditions where fires ignite with ease. In 2011, a large number of fires started occurring in July when the mean GWL dropped to – 69.9 cm, while in August 2012 fires began with a mean GWL of -61.7 cm (Figure 5). Numbers of fires in 2011 greatly expanded to more than 80 in August and September when the area was subjected the lowest GWL of -1 m. The same phenomenon was observed in 2012 when fires spread quickly after the GWL reached its minimum at -80 cm.

Usup *et al.* (2004), Wosten *et al.* (2008) and Putra *et al.* (2011) suggested critical ground water level of 40 cm below peat surface to prevent fire. However, our findings suggest that shallower GWL below peat surface should be maintained to prevent peat fire occurrences in dry-degraded peatlands. Figure 6 (right) shows that fires are also found during GWL conditions between 15 and 30 cm below the peat surface, such as in February 2011 (-30 cm), March 2011 (-16 cm) and December 2011 (-17 cm).

Most of the fires occurred with shallow GWL conditions of 25 – 30 cm below the peat surface (Figure 7), but fire occurrences with GWL of less than 5 cm below peat surface may strongly suggests that degraded peatlands are very vulnerable to fires even under relatively moist conditions, and therefore degraded peatlands should be maintained in wet conditions with critical GWL of less than 5 cm below peat surface, to prevent the area from experiencing surface peat fires. Dry conditions of degraded peatland create suitable condition for the fire to burn downward into deeper peat layers and ignite deep peat fires, resulting to devastating peat fires in the area.

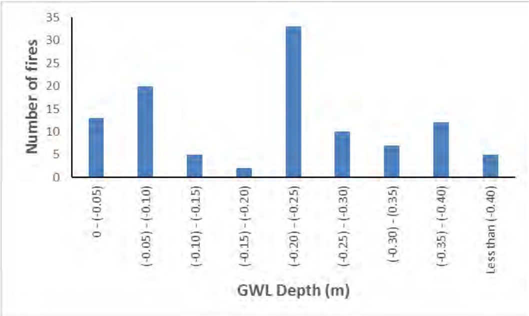

Figure 7: Number of selected peat fires on each GWL depth, September 2012

CONCLUSION

This study reveals that the peatlands in the northern part of Block A and southern part of Block E of Ex-MRP have been changed to degraded peatlands that are very vulnerable to fire. A time lag between lowest precipitation and lowest GWL strongly indicates that peatlands here have lost the capacity to effectively absorb and retain water from rain water droplets, keeping them in drier conditions than natural for most of the year, and therefore maintaining conditions where ignitions may easily occur. Numerous fires found starting during shallow GWL conditions strongly illustrate the importance of maintaining high GWL, of less than 5 cm below the surface, to reduce fire risk and prevent degraded peatlands from experiencing surface peat fires from human impact that may escalated to devastating deep peat fires.

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