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DRIVERS OF RECURRENT PEATFIRE IN RIAU AND SOUTH SUMATERA, INDONESIA

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SUMMARY

Riau province once has been blessed with about 4 million Ha peat forest, making it one of the largest peatland countries in Indonesia. Responding to economic development, most of the peat forests have been largely drained and the province has been among the most prone to recurrent peat fire area. There has been much debates on the patterns and root of causes (drivers) of peat fire, causing effort to curb recurrent peat fire are daunting task and even becoming an inconclusive high tension of public debates. There has been much ambiguity on the drivers and the triggers. Poor availability of evidence of the peat fire patterns and their drivers making efforts to suppress the recurrent peatfire and its policy intervention has never been effective. Using different techniques of remote sensing, we present here a number of evidences that peatland in Riau becoming more vulnerable to recurrent peatfire due to expanding large scale peatland drainage, intensified peatland-human interaction and poor peatland governance. We found also a similar pattern in a near areas in province of South Sumatera, to make confident that recurrent peatfire is a merely consequence of a systemic impact following adoption of paradigm of development to put peatland as among central farming areas to provide a globally traded commodities like crude palm oil (CPO) and pulp and paper.

INTRODUCTION

Recent frequent & recurrent peatfires in Indonesia and its impacts throughout the region has caused an escalating political economy discourse as to clarify the drivers (Ref). Many claims on poor peatland governance such as encroachment by peasants as trigger for recurrent peatfire have resulted many suspects have been jailed and has somehow left many discourse on the biophysical factor that driving recurrent peatfire for example there is somehow a little confidence that disturbance on peatland in humid tropical forests makes them more vulnerable to fire. As commonly found that peatland disturbance has drying effect of the opened canopy and greater amounts of dead woody debris (Cochrane, 2001; Siegert *et al*., 2001). Drained peatland areas with degraded vegetation become extremely vulnerable to annual fires that further degrade these ecosystems (Hoscilo *et al*., 2011). Occasional but catastrophic fires on peatland can release immense quantities of carbon into the atmosphere from peat combustion (Page *et al*., 2002; Heil *et al*., 2006).

Indonesia has about 20 million Ha of peatland, making as a country with the greatest area for tropical peatland. Due to market pressure that heavily influences the development paradigm, in the last decades, about half of the peatland have been drained for cultivating export-oriented commodities like palm oil and pulp and paper, using species that are not adapted to water-logging. Within only less than two decades, Riau (which more than half of its areas ca. 4 million Ha once were peatforest) has experienced massive ecosystem change from previously being ‗frequently inundated and moist -ecosystem' into human-made ‗drained-ecosystem'. This is due to peatforest conversion and draining into plantations (palm oil, pulp-paper, whether at large scale owned by concessionaires or at smallholder scale). Furthermore, a large scale dried peat (biomass) material which has been left-behind could easily turn to be massive fire fuel during the dry seasons. This making Riau landscape has shifted into (peat) fire vulnerable ecosystem on the historical record. Its vulnerability has been increasing due to climate extremities and continuous extension of the drained areas.

Recurrent peatfire in across peatland in Indonesia has been worsening recently and with its regional haze impacts has a very sensitive political consequence domestically and internationally. Hence, many interpretation on as to why this severity is always increasing, making as a counter-productive in developing an effective policy intervention. The objective of this paper is to demonstrate using remote sensing data that onset and rapid increasing frequency of peatfire (and its recurrency) is due to conversion of peatforest and draining for establishing monoculture farming system. This is strongly linked and merely a consequence to the policy for regional development adopted by the peatland provinces.

MATERIALS AND METHODS

We used spatial plan map to delineate the peatland designated for non-conservation areas in order to demonstrate that these areas are then been drained (canal infrastructure were built) making them vulnerable to the recurrent peatfire as they are subjected into disturbances (forest conversion, peatland draining and its corresponding intensive management). Using a historical analysis of Landsat imageries, we did manual peatforest classification (2000, 2005 and 2010) superimposed corresponding annual hotspot to ascertain that non-disturbed peatforest are not vulnerable to peatfire. Manual canal mapping was done using available optical and when the cloud-smog were too bad, we used different SAR imageries. Hotspot datasets from MODIS sensor for the year of 2014 and 2015 within both study areas (province of Riau and South Sumatera) were collected from NASA data server[10]. Regardless the confidence level, all hotspot were taken into account as suggested by Zubaidah., *et al.* (2014). From canal location, a buffer zones were established, ranging from zone of “within canal[11]” to 10 km with interval of 1 km. Buffer zone of “within canal” refers to areas surrounded by canal (land-locked) with distance less than 1 km. From each buffer zone, the quantities of hotspot were summed, and the proportions of the quantity relatively to the total hotspot within study area were calculated. Nonetheless, due to uncomplete canal network map in the northern part of Riau province, this area was excluded from the hotspot computation. In addition, the calculation of quantity and proportion for hotspot with confidence level above 70 % were also performed. Due to similar results, the graphics are unseen in this paper. The computation of hotspot in buffer zone is aimed to proof that hotspot were caused by canalization (peatland drainage) and the draining impact has extended beyond to the canal.

RESULTS AND DISCUSSION

Figure 1 shows rapid increase in palm oil plantation in Riau. FAO report also showed that global demand for CPO is double in 2050, making further pressure to the remaining forest and peatland in the tropics, as we saw in Riau province as among the fastest expansion areas for palm oil plantation, including on the peatland. A similar trend is also found in global demand in pulp-paper products which also trigger new expansion on pulp-paper plantation in the drained peatland.

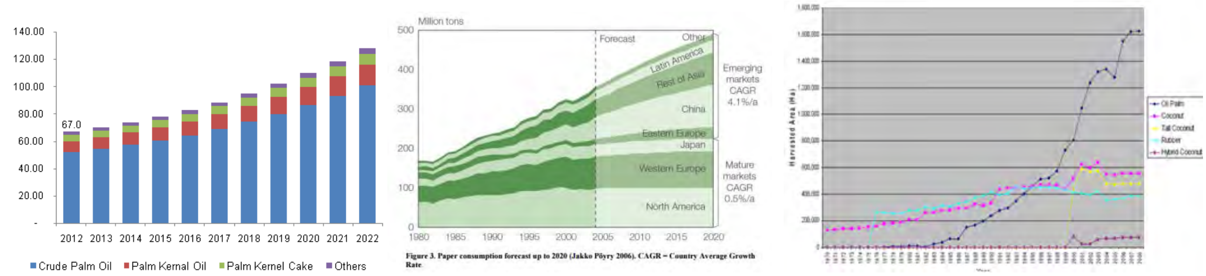

Figure 1: Increase on global demand of CPO, FAO 2011 (*above-left*), pulp-paper Jaacko Poyry 2013 (*above-centre*) and its impact on a drastic increase of palm oil plantation area in Riau which also include on peatland-Ministry of Agriculture GOI 2009 (*above-right*)

In 2013, a total 15 m Ha palm oil plantation produce 65 m ton palm mesocarp + kernel oils, whilst global demand in 2018 will be increasing at 77 m ton (FAO) and further increase at 93-156 m t by 2050 (Corley, 2009). Continuous pressure to increase productivity and additional land conversion to satisfy increasing global demand, where Riau among the place where this further expansion is very possible. We saw this global market demand has coincidence and thus we believed that it has triggered these large scale peatland draining, as shown by Figure 2. These peatland draining has been justified by the government spatial plan to further drain peatland, in order to response global demand of CPO-pulp paper and its related new investments. These well-ordered extensive and intensive canal infrastructure typically developed by large concessionaires (pulp and palm oil plantations) have concentrated in the non-conservation peatland areas as previously designated by the government (as shown by outside of the red-polygon (non-conservation areas), indicating compliance of the those expanding peatland drainage to the existing spatial planning. This clearly shows that the peatland drainage have been mostly expanding due to commercial farming by large concessionaires on non-conservation areas designated by the government.

[10]https://earthdata.nasa.gov

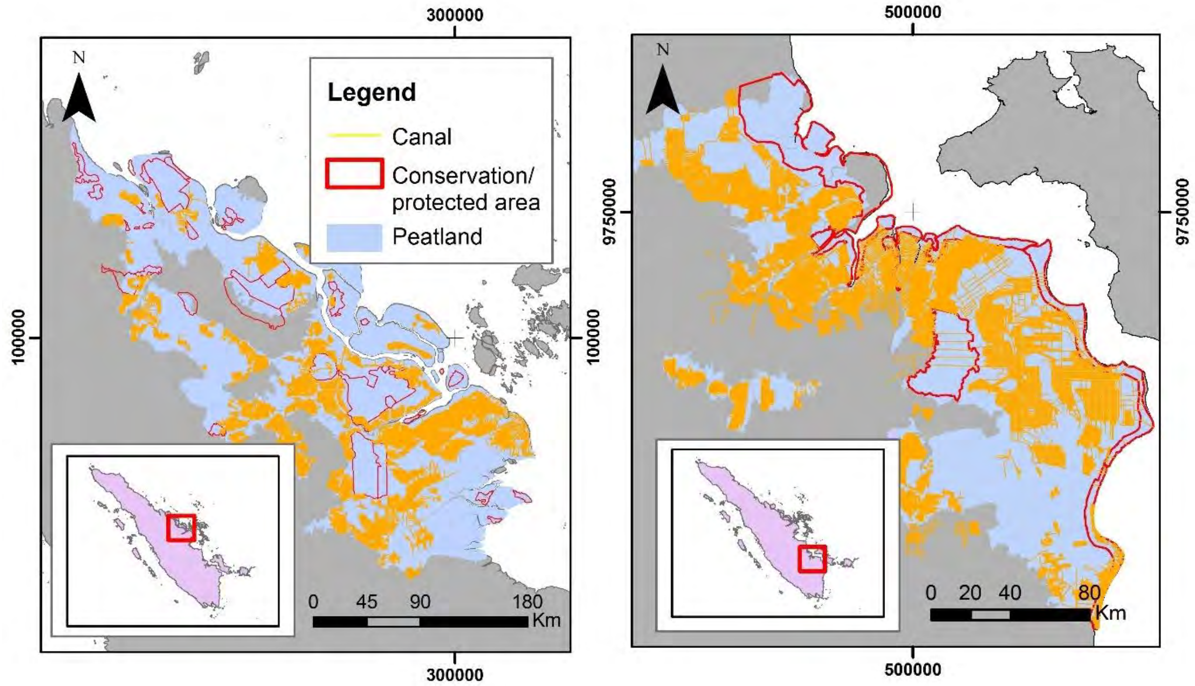

Figure 2: **S**patial plan and peatland drainage areas of Riau and South Sumatera Provinces. See the canal infrastructure (yellow) did not encroach the designated conservation-protected areas (red line polygons)

Such global market has put a pressure on the development of many frontiers areas in Indonesia ie. peatland areas that previously relatively untouched. Global demand on CPO and pulp-paper has made those peatland as a new area for large scale farming on drained peatland since the plant species being cultivated are not tolerant to water-logging condition. This developmental scenario on peatland has been justified by current legislation designated by both at central and at local (provincial and district) levels to support new livelihood and new economic era. As spin off impacts, this intensive farming on drained peatland has also attracts further new large scale migrants and investments, making peatland ecosystem previously were relatively unoccupied by settlement, now becoming among centre for agro-politan areas including pressure from human populations who seek for new livelihood. Under poor land governance and government policies which prefers providing licences for large scale companies and do not offer equitable opportunity of peatland access for smallholders and the locals, we see a dramatic sporadic peatforest encroachment.

Both small-scale and large-scale peatland drainage infrastructure have severely impacted on peatland water status, as shown in Figure 3 which is respectively borrowed from Sumawinata *et al.* (2012) and Hooijer *et al*. (2011) papers who worked in closely with pulp plantation companies in Indonesia. It is very obvious that the so called ecohydrology, a sophisticated technology adopted by the companies to maintain water level in across drained peatland landscape have failed to achieve the target water level ie. it drops mostly below 1 m during peak of dry seasons, making them very vulnerable to recurrent peatfire, worsening during the El Nino years. This vulnerability of water level drop on peatland against recurrent peatfire have been clearly demonstrated by few monitoring data shown by Osaki *et al*. (2011) and Saharjo *et al*. (2012) in Figure 3b.

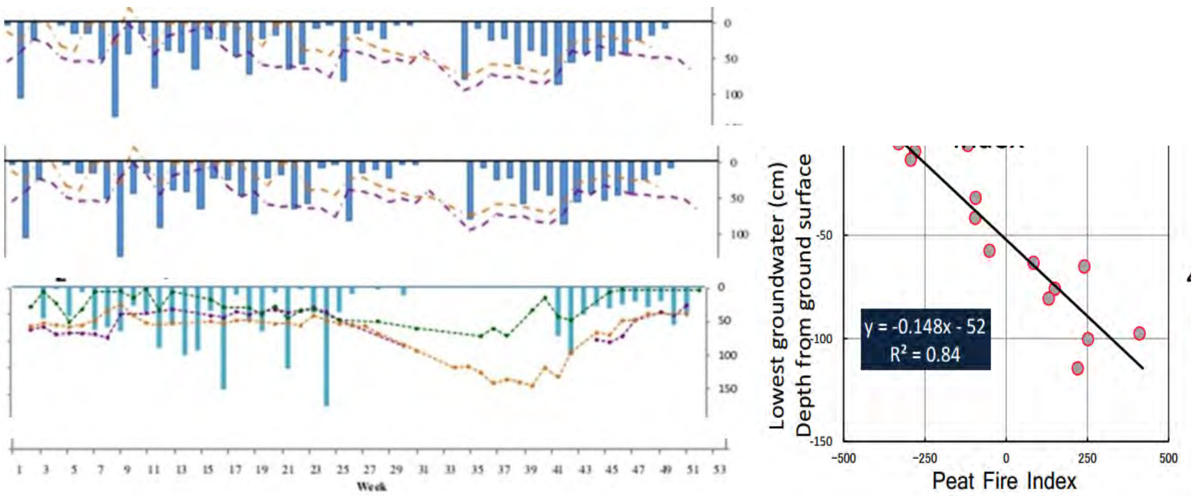

Figure 3: Left-Dropped water level (*dashed lines*) on drained peatland during peak of dry season in a pulp-paper plantations in three provinces in Sumatera in a year monitoring, see the water level in cm below peatsurface that could drop below 150 cm during the peak of dry seasons even under on so called ecohydrological technology management (after Sumawinata *et al*. 2013) and right- increased peatfire index under low water level (drought condition-after Takahashi 2012)

Peatfire occurs under dry atmospheric condition worsen during extreme weather events, such as ENSO (El Niño–Southern Oscillation) events and prolonged droughts, make areas more prone to fires. This background will be triggered by large-scale developments, such as oil palm and timber plantations, also make the landscape more prone to fire by degrading the land through logging and drainage and left dead aboveground biomass prone to fire. When peatlands are excessively drained, as happens in plantation developments, upper layers dry up and become prone to fire. The repeatedly burned vegetation is more prone to fire as the peat becoming hydrophobic hence vulnerable to fire.

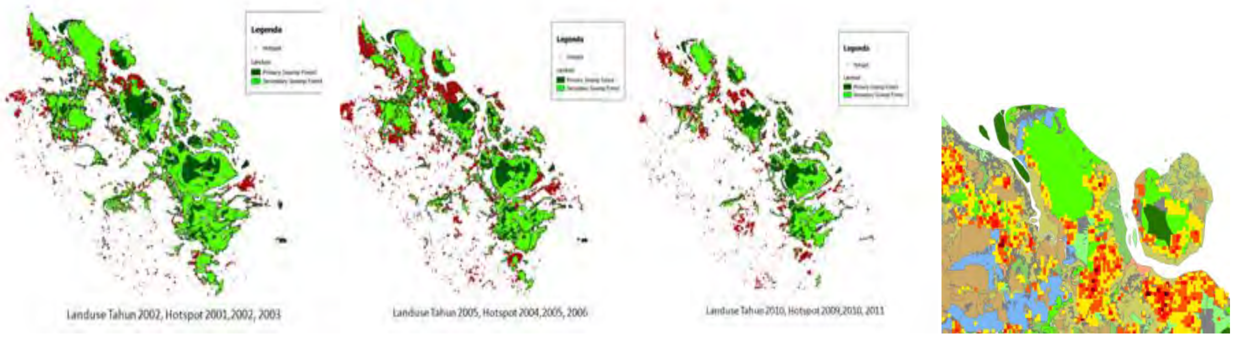

Figure 4: No 1 - 4 (from left-to-right) Historical hotspot patterns in Riau province :2001-2003 (1), 2004-2006(2) and 2011 (3) super-imposed on 2010 land cover indicating that hotspot were mostly on peatland especially associated with peatforest conversion. Negligible hotspot was detected in less-disturbed undrained peatforest. Hotspot were detected by MODIS and land cover were generated from Landsat (dark green is primary forest and light green is secondary or plantation forest or plantation forest). No (4) shows that the peatfire from the surrounding drained peatland have been encroaching its core undrained peatforests.

It is very clear from Riau analysis 2000 to 2010 (Figure 4) that hotspot have been obviously absence in the less-disturbed (non-drained) peatforest, confirming that peatfire is not natural peatforest phenomena. However following draining of the surrounding forest, fire could start to invade the edge of undrained secondary forest.

We have calculated how close interaction between peatland drainage and occurrence of the hotspots including the corresponding footprints areas beyond the drained peatland. It is clearly shown that the hotspot were mostly concentrated on the drained peatland areas, but the impact of draining on the hotspot could be as far as 5 km beyond the outer of canal infrastructure (Figure 5), possibly caused by an evidence of high hydraulic conductivity of very porous material such as these peatland which has ability to suck the water from the areas of undrained peatalnd. It was previously reported that the lateral ground water movement across the peatland (not in the canal) per day could reach as far as 125 m (*Hooijer pers commun*, 2014), questioning the effectiveness issue of canal blocking system as the way to retain the water within the drained peatland areas. That reported value of hydraulic conductance is rather greater than have been previously reported since the plantations are usually located on the peatdome (not shallow peatland).

Our manual canal digitations would have possibly missed the small canals developed by smallholders (who plant rubbers for the last few decades and the closed canopy have prevented us to digitize the canals). If so, our calculation result could be interpreted as impacts of large scale peatland drainage.

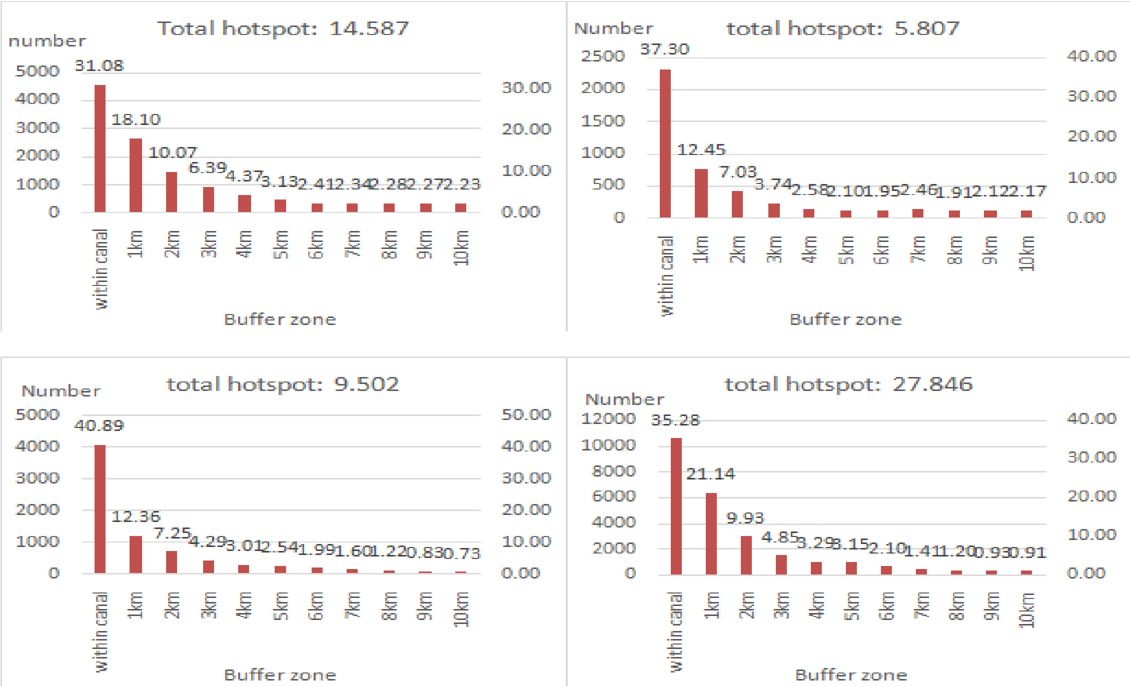

Figure 5: Hotspot occurrence in various distances from canal in Riau (above) and South Sumatera (below) provinces (2014-left and 2015-right) indicating that most of the hotspots were within the canals and the footprint of the hotspots has extended beyond few km away from the outermost canals.

Palm oil expansion expansion on drained peatland in Sumatera has followed its benchmark in Sarawak, Malaysia but why such massive and recurrent peatfire have not occurring in the similar drained tropical peatland areas like in Sarawak? It was reported that from the climatic condition, Sarawak has rarely exposed to the pronounced dry months, in contrast to eastern coasts of Sumatera peatland (Vernimmen *et al*., 2012).

By pointing out that it is peatland drainage that mostly drives the recurrent peatfire, we also acknowledge social driver that frequently triggers peatfire ie. due to contesting peatland access. Most of peatland in Riau and South Sumatera has been designated for large scale concessionaire and the remaining areas are strictly prohibited for use ie. deep peatland (moratorium under the Presidential Instruction 10/2011), leaving a limited action space for the locals (Riau Forest Watch, 2014). This has triggered a tenurial conflicts recorded in Riau which the trend has rapidly increased from 79,100 Ha in 2012 to 171,645 Ha in 2013 (Scale Up, 2014) which ignites peatfire under poor peatland governance.

CONCLUSION

It is clearly demonstrated that extensive and intensive peatland drainage has respond global demand increase for CPO and pulp paper products that attract large scale investments and been justified by the provincial spatial plan. Peatland drainage has been the most dominant driver for recurrent peatfire at least in two provinces Riau and South Sumatera, and the impact of the peatfire has extended up to few km away from the outmost canals. This understanding should provide a strong basis for effective policy for improving peatland management in Indonesia.

Based on sustainable peatland management principles peatland should be minimum disturbed, always kept moist and never been opened, we could propose policy intervention to minimize peatfire such as improving spatial planning to protect peatforest from conversion thus any developments involving large-scale land-use change take place only on land that is already degraded/deforested non peatland. Peatland drainage should be highly regulated and be transparence for spatial planning and independent monitoring for restoration of peatland hydrology beyond frequently claimed ecohydrological engineering so peat will be moist throughout the year (wet peat does not burn).

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