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PEAT FIRE SUSCEPTIBILITY IN SARAWAK, MALAYSIA IN THE CONTEXT OF CLIMATE CHANGE

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SUMMARY

Fire has the potential to disturb the carbon stored in peats, which globally account near to the total amount of carbon in the atmosphere. Therefore, peat fire risk management is important for carbon emission reduction, particularly in the context of global climate change. Though peat in tropics is naturally fire resistant as they maintain high moisture, it has been reported that human activities including plantation development, agriculture, and logging, have made tropical peatlands more vulnerable to burning. Peat ignition probabilities may increase in a warm climate and therefore, fire susceptibility of peatlands may increase due to global warming. The objective of the present study is to assess the changes in fire susceptibility of the peatlands of Sarawak, Malaysia due to the changes in climate. The peat fire index (PFI) proposed by Takahashi using a one-dimensional water balance equation with rainfall and evapotranspiration as the components. Monthly total rainfall and temperature data at six locations for the time period 1981-2014 were employed to calculate the historical PFI. An ensemble of six global circulation model (GCM) simulations of Coupled Model Intercomparison Project phase 5 (CMIP5) namely, BCCCSM1-1, CanESM2, MIROC5, MIROC-ESM, MIROC-ESM-CHEM and NorESM1-M under two Representative Concentration Pathways (RCP) scenarios, namely, RCP4.5 and RCP8.5 were used for climate downscale at the points of interests using support vector machine (SVM). Projected climate was then used to assess the future changes in PFI compared to historical period in the study area. The results show high uncertainty in the projection of peat fire susceptibility in the region due to climate change. It is expected that projected PFI in the region can be used to assess the peat fire risk as well as in operational fire management and development of early warning system.

***Keywords**: Tropical peatlands, peat fire index, climate change, risk assessment, uncertainty.*

INTRODUCTION

Peatland fire is an annual phenomenon in Borneo island (Yong and Peh 2014; Yulianti Nina, Barbara Betrixia *et al.,* 2014). In the last three decades, the region has suffered from large events of peat fire in 1982/83, 1990, 1991, 1994, 1997/98, 2005/2006, 2009, and 2012-2015. Peat fire is considered as one of the major causes of the deforestation of tropical peat swamp in Malaysia and Indonesia (Razali, Nuruddin *et al.,* 2010). The peat fires cause severe damage to soil and consequently, the whole agro-ecosystem (Yulianti Nina, Barbara Betrixia *et al.,* 2014). (Miettinen, Shi *et al*. (2010) used land-cover maps and active fire detection based on satellite imagery to evaluate the rates and spatial distribution of peat land deforestation in Southeast Asia for the time period 1990-2010, and reported that the deforestation in the region is strongly associated with fire activity. Therefore, actions toward combating the peat fires are very important for long-term conservation of peat swamps, protect peat agro-ecology and biodiversity, and the livelihood of the people (Yong and Peh 2014). Development of peat fire index (PFI) for assessment of vulnerability of peat land to fire is considered as one of the options to mitigate peat fire. Mitigation measures based on vulnerable zones identified using PFI can minimize the losses of peat layers, reduce emission, and prevent the high cost of peat land fire suppression. Furthermore, the index can be used to assess the possible changes in peat land fire vulnerability due to climate change. (McLaughlin and Webster 2014) reported that future dry conditions due to climate change may potentially increase peat land susceptibility to fire. Therefore, knowledge of these changes should be useful for climate change vulnerability and adaptation assessments for peat swamps

Number of studies has been carried out to assess the peat fire vulnerability using peat fire index.. (Yulianti Nina, Barbara Betrixia *et al*., 2014) developed a Geographic Information System (GIS) data base of Peat land Fire Risk Index (PFRI) for Central Kalimantan of Indonesia that can be used as fire early warning system. Khomarudin *et al*. (Khomarudin, Vetrita *et al.,* 2013) conducted a study to characterize peat fire hotspots from Terra/Aqua MODIS data, field survey, haze detection, and the burnt area mapping. They reported that the fires spot can be analyzed by the hotspot characteristics and the haze detection. Seitawan *et al.* (Setiawan, Mahmud *et al.,* 2004) identified the peat swamp forest fire hazard areas by integrating GIS-grid-based and multi-criteria analysis.

They concluded that proposed method can provide valuable information about the locations most likely to be affected by fire. However, all the methods mentioned above are mostly based on satellite remote sensing data, which is often very time consuming and need to high computational skill to identify peat fire risk zones.

The objective of the present study is to assess fire susceptibility of the peatlands of Sarawak, Malaysia using climatic parameter. The PFI) proposed by Takahashi is used. The study can provide a too quick assessment of peat fire vulnerability which in turn may help in adopting necessary mitigation measures.

DATA AND METHODS

Rainfall data from 24 locations in Sarawak were used in the present study for computation of peat fire index (Figure 1). Daily rainfall data of the stations were obtained from Drainage and Irrigation Department (DID) of Malaysia. The daily data was converted to monthly total. The temperature data for four locations available in open source database are collected from the website. Time periods of data used for the study are different for different locations. PFI is estimated using whole data available at a location. As the spatial variation of temperature in Sarawak is not very high, temperature data from the nearby location is used.

The peat fire index (PFI) proposed by Takahashi is used in the present study. Takahashi method uses a one-dimensional water balance equation with rainfall and evapotranspiration as the components using the following equation (Hayasaka, Noguchi *et al*. 2014):

$$I_{pf} = \int_{June}^{Nov} G_w dt = c \int_{June}^{Nov} (P_r - E_t)\ dt \qquad \text{Equation 1}$$

Where, P_r is precipitation and E_t is evapotranspiration estimated from mean temperature.

Hayasaka *et al*. (Hayasaka, Noguchi *et al.* 2014) derived Takahashi's PFI from monthly rainfall data and established the linear relationship to the annual lowest groundwater level and hotspots observed by MODIS and reported that it can be used for the early warning of peat fire in tropical peat lands.

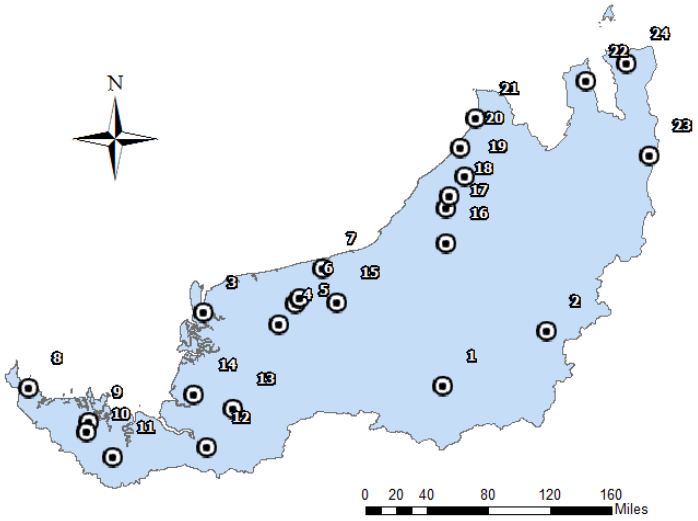

Figure 1: Location of rain gauge stations used for computation of Peat Fire Index (PFI)

RESULTS

The time series of PFI at four locations are shown in Figure 2. Negative values of PFI indicate the possible occurrence of peat fire in that year. Therefore, the number of years with negative PFI to total number of years used for the study indicates the frequency of possibility of peat fire.

The graphs in Figure 2 shows number of negative PFI years vary widely from one station to another. However, negative PFI in years 1982 and 1997 is found common in most of the stations. Hot weather and low rainfall due to El-nino caused peat fire in those years. Literature reviews suggested that peat fire burned the rainforests in the summer of 1997. Prolonged air pollution in the region due to peat fire affected the health of tens of millions of people. It also severely affected the peat ecosystem in the region (Brauer and Hisham-Hashim 1998). The PFI used in the present study is able to detect those years efficiently. This indicates the potential of Takahashi's PFI index to detect peat fire vulnerable zones.

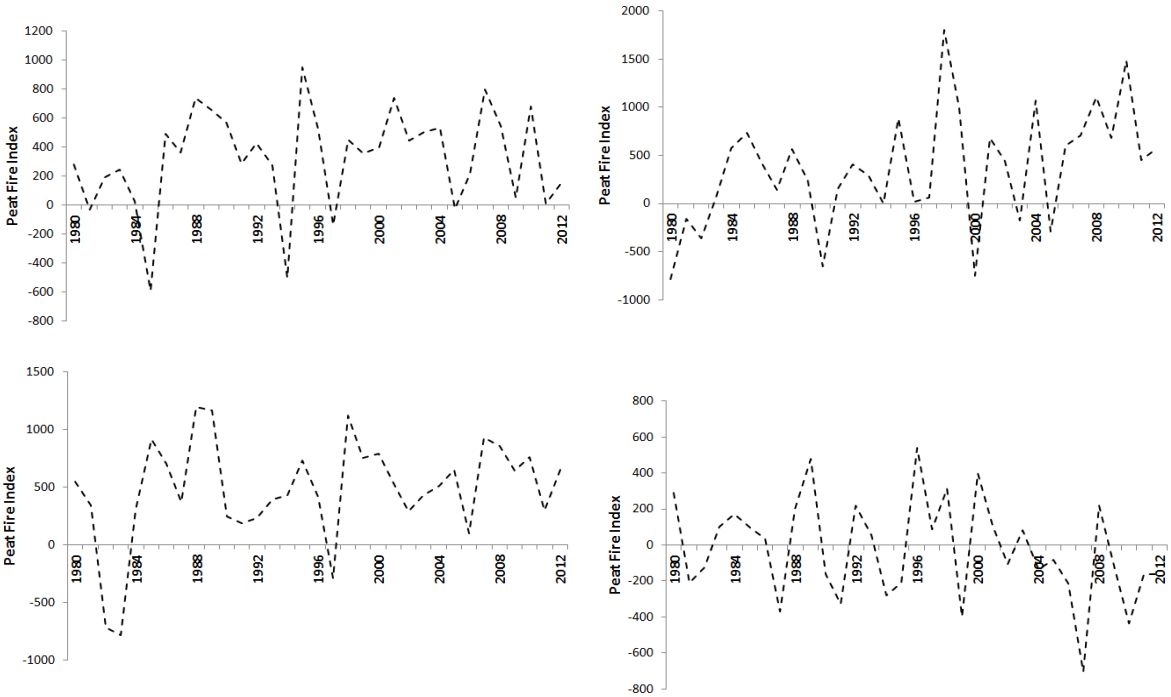

Figure 2: Time series of PFI at four locations in the study area

Analysis of frequency of occurrence of peat fire through fitting of frequency distribution curves to PFI reveals that return period of peat fire events in the study area varies from 5 to 15 years. Spatial analysis of return period of peat fire shows no particular pattern in peat fire vulnerability zones.

CONCLUSION

A PFI index that uses climatic parameters namely, rainfall and evapotranspiration for the estimation of peat fire vulnerability at a point are used in this study. The study reveals that PFI used in the present study is able to identify the historical peat fire years effectively, which means that it can be used for assessment of peat fire vulnerability in Sarawak. The study can be extended further in future for assessment of the impacts of climate change on peat fire vulnerability in the study area.

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