






Data Indo InaPeat: An Environmental Monitoring Platform on Peatlands Area and PHU (Peat Hydrological Units) using Earth Engine Apps

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Abstract: Peat is one of the wetland ecosystems in Indonesia which is often damaged due to unsustainable human intervention. This causes fires in peatlands, thereby eliminating ecological functions which are characterized by changes in land cover. The protection of peat ecosystems in Indonesia relies on hydrological aspects, namely the Peat Hydrological Unit (PHU) to maintain the Ground Water Levels (GWL) to minimize the potential for forest and peat land fires. This research aims to develop the DATAINDO InaPeat platform for monitoring PHU ecosystems in Jambi Province based on changes in land cover and hotspot distribution from 2002 to 2022. Data analysis was carried out by identifying the distribution of hotspots for each type of land cover. Hotspot and land cover data were obtained through the Moderate Resolution Imaging Spectroradiometer (MODIS) Fire Information for Resource Management System (FIRMS) and Landsat 9 OLI 2-TIRS2 imagery imported from the Google Earth Engine (GEE) dataset. The land cover classification was carried out using guided classification in 2021-2023. There are two types of classification used, namely classification to assess the condition of peatland damage (degraded and natural areas) and land cover (swamps, swamp forests, open land, plantations, mixed plantations, settlements, and water bodies). Based on the data analysis, the distribution of hotspots that dominated natural areas was 940 hotspots in 2002, 731 hotspots in 2007, and 651 hotspots in 2012, meanwhile, in degraded areas, 279 and 152 points in 2017 and 2022, respectively. This shows that hotspots caused damage to peatlands, thereby increasing the degraded area to 63.73% of the total PHU area of 874,951.7 ha. These were caused by the opening of oil palm plantations which can reduce GWL, thus potentially triggering forest and peatland fires. Data on hotspots and degraded areas that have been recorded are displayed on the Earth Engine Apps platform in the form of DATAINDO InaPeat. It is hoped that the use of this monitoring platform can become a tool for monitoring the physical condition of peat ecosystems and supporting the sustainable use of peatlands in Indonesia.

Keyword: FIRMS MODIS, Hotspot, KHG, Landsat 9 OLI/TIRS, Peatland

INTRODUCTION

Peatland is an area that consists of accumulated organic material deposits on the earth's surface over a long time due to incomplete decomposition under water-saturated conditions (Xu *et al.* 2018). These organic material deposits consist of dead plant microorganisms such as leaves, twigs, stems, and roots that have accumulated over thousands of years (Susandi

et al. 2015). High soil acidity is one of the factors that causes microbial activity in the decomposition process of organic material to be hampered so that it accumulates to form piles which eventually become peat (Andesmora 2021).

The area of peatlands in Indonesia ranges from 13 million ha to 26.5 million ha, making Indonesia rank fourth in the largest peatland category in the world after Canada, the Soviet Union, and America. The



distribution of peatlands in Indonesia is mostly in Sumatra, Kalimantan, and Papua (Muhanyah & Asyisyifa 2021). Peatlands in tropical regions, especially in Indonesia, have the most stored carbon compared to peat types in other climatic regions. Therefore, peatlands in Indonesia have a significant influence on climate change (Hergoualc'h *et al.* 2018).

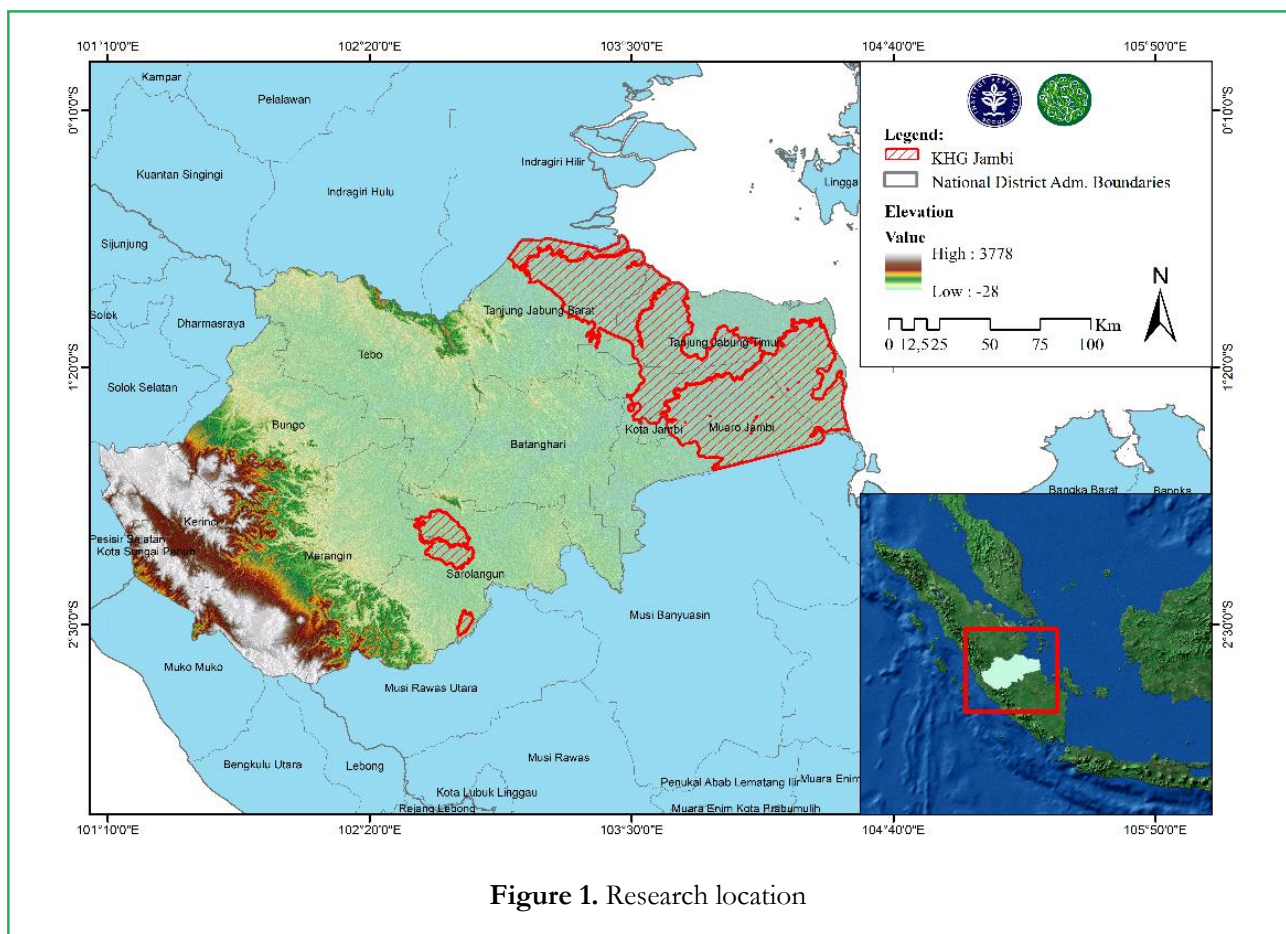
Peatlands have various important benefits in maintaining environmental balance (Antonius 2016). For Indonesia itself, peatlands have very important benefits because apart from being able to store carbon and preventing climate change, peatlands can also provide forest products in the form of wood and non-wood, habitat for endemic biodiversity, as well as storing and supplying water (Erlina 2017). The nature of the soil, which is similar to a sponge, makes peatlands have unique and vulnerable ecosystem characteristics. In rainy conditions, this soil can absorb water, becoming a water storage medium for downstream areas. However, in dry conditions, peatlands will dry out easily so that their water content is lost and can easily cause fires.

Utilization of peatlands, such as land conversion for agricultural areas, housing, and areas that are not environmentally friendly, can result in degradation. Changes in the use of peatlands for agricultural areas, especially for oil palm plantations, can cause changes in land use patterns which have a broad influence on

changes in environmental management and socio-economic life patterns of communities in the surrounding area (Sufardi *et al.* 2016). According to Muhayah & Asyisyifa (2021), more than half of Indonesia's total greenhouse gas (GHG) emissions come from activities such as changes in land use. Based on this situation, it can be concluded that plantation expansion on peatlands which causes land change from peat to non-peat has the potential to hurt global climate change because it can produce large amounts of GHG emissions (Sufardi *et al.* 2016).

The Peat Hydrological Unit (PHU) is the basis applied in peatland conservation efforts which aims to manage peat ecosystems in an integrated manner by paying attention to hydrological and ecological aspects (Yuliani & Rahman 2018). PHU is a holistic approach that combines various elements to maintain the sustainability of peat ecosystems, reduce GHG emissions, and support biodiversity conservation. This approach is important in facing complex environmental challenges and increasing climate change mitigation efforts in areas that have peat ecosystems.

Peat ecosystem monitoring technology, including remote sensing technology, has a crucial role in monitoring and preserving vulnerable and ecologically important peat ecosystems. One way to make monitoring an area easier is to utilize Remote Sensing



technology and Geographic Information Systems (GIS). Remote sensing can record earth surface data on a global scale without requiring direct physical contact with the object being observed (Nurazizah 2022). Advances in remote sensing platforms and sensor technology, as well as developments in science and technology in the field of Geographic Information Systems (GIS), have provided very important support in monitoring protected areas in various parts of the world, especially in Indonesia. Monitoring via remote sensing and GIS can provide important information to support efficient, transparent, and defensible decision-making in the management and governance of protected areas (Wang *et al.* 2020).

Remote sensing monitoring applications are considered to contribute greatly to inventory and monitoring efforts (Wang *et al.* 2020). The development of a sophisticated and continuous monitoring platform using Earth Engine Apps is critical to identifying, preventing, and addressing adverse changes. Therefore, the DATAINDO InaPeat platform is present as an important step in the process of monitoring sensitive areas such as KHG. This platform can display the results of hotspot point detection based on conditions and land cover so that it can help collect data, analyze, and make better decisions to support global efforts to overcome climate change and preserve biodiversity in peat ecosystems.

METHODOLOGY

Research area

Province of Jambi is geographically located between 0.45° North Latitude, 2.45° South Latitude, and between 101.10°–104.55° East Longitude. Administratively, the monitoring study location is in the PHU of Jambi Province which is divided in 12 areas, namely Batang Merangin-Batang Tembesi, Batang Tembei-Merak River, Air Hitam Laut River-Buntu Kecil River, Batang River-Tungkal River, Batanghari River-Air Hitam Laut River, Batanghari River-Kampeh River, Batanghari River-Mandahara River, Baung River-Betara River, Betara River-Mendahara River, Lalan River-Merang River, Mendahara River-Batanghari River, Mesao River-Aek Rawas, and Pengabuan River-Baung River. The area that will be monitored consists of 874,951.7 ha, including degraded and natural areas.

Data Source and Data Process

Information regarding hotspot sources analysis was recorded day and night using Terra and Aqua sensors that connected to Moderate Resolution Imaging Spectroradiometer (MODIS) satellite. This satellite provides Fire Information for Resource Management System (FIRMS), which refers to a system

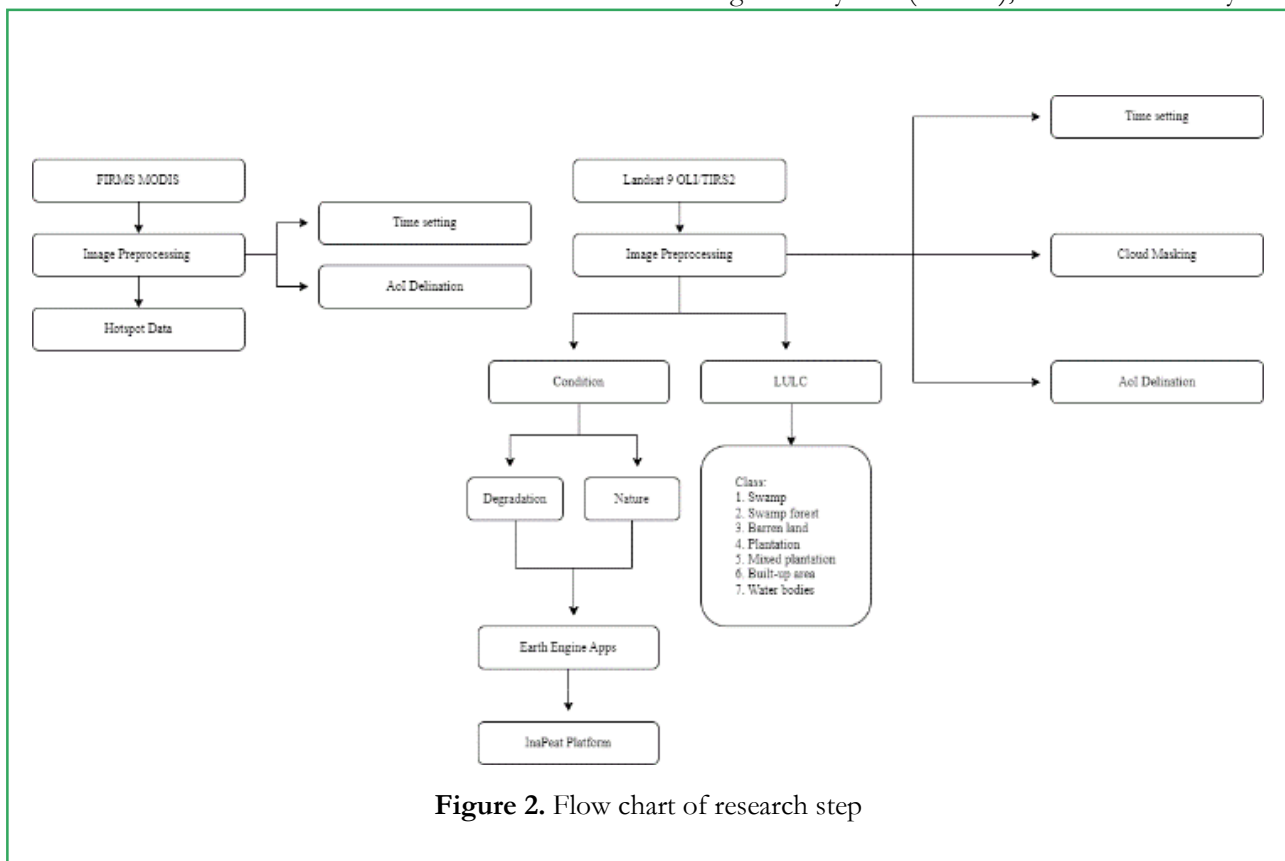
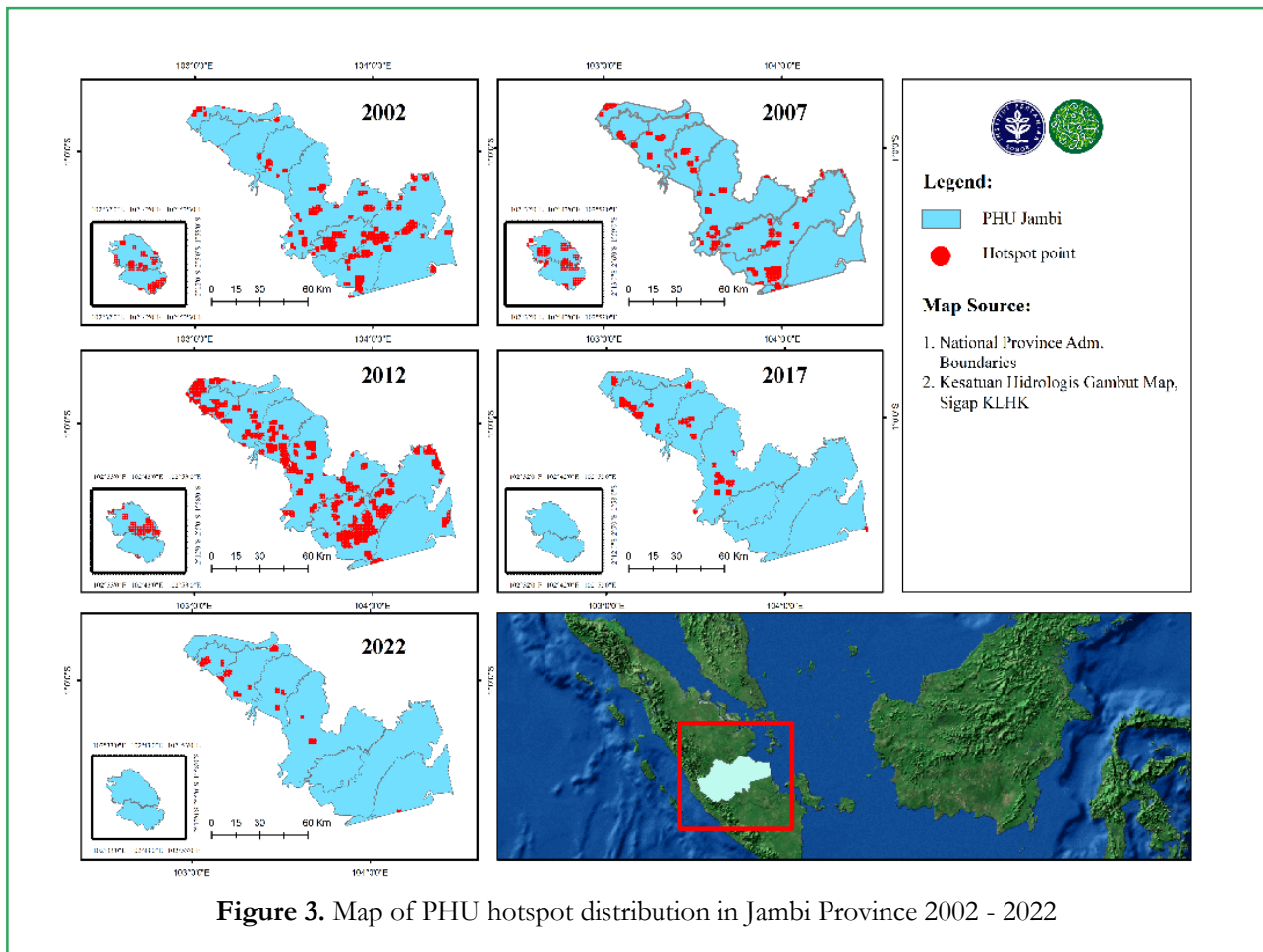


Figure 2. Flow chart of research step



developed by NASA (National Aeronautics and Space Administration) for monitoring and mapping forest fires globally. This system provides real-time information regarding the location, intensity of hotspot distribution, and estimated area of forest fires throughout the world (Muin & Rakuasa 2023).

The method used in hotspot analysis for fire detection is through remote sensing, MODIS Fire Information for Resource Management System (FIRMS) hotspot data is taken via Google Earth Engine software with a script that has been built. Google Earth Engine is a cloud-based platform that is used to process geospatial data without requiring large amounts of storage and has fairly good spatial resolution (Gorelick *et al.* 2017). According to Pratamasari *et al.* (2020), MODIS imagery is the most suitable image for identifying forest fires because of its daily temporal resolution. Next, the FIRMS hotspot data is downloaded in raster form in .tiff format. Then the downloaded data is processed using ArcGIS software to convert raster data into vector data in shapefile (shp) format. Through ArcGIS, nearest neighbor analysis (NNA) values can be calculated and used to see the spatial pattern of hot spots in a location.

The Landsat data used was taken from 2021 - 2023 in the PHU of Jambi Province. The Landsat-9 data analysis process is carried out via the Google Earth Engine platform first before the data is entered into ArcGIS. The Landsat data used is Landsat 9 OLI/TIRS, indicating an earth observation satellite with a similar function as Landsat 8, including identical copies of long-range sensors: Operational Land Imagery (OLI), OLI-2; Thermal Infrared Sensor (TIRS), TIRS-2. This satellite can produce satellite images in the same area every 16 days and take images of all parts of the earth at the same time.

Data Analysis

Hotspot Analysis

Hotspot analysis was carried out using FIRMS MODIS. The spatial analysis of this research was carried out by mapping the number of hotspots that appear every five years, from January to December, from 2002 until 2022 by using the Google Earth Engine platform.

Land Cover Analysis

PHU Jambi has environmental conditions consisting of peat soil with a composition of organic material. The training area is carried out via Google Earth Engine which then produces an interpretation of Landsat 9 imagery with the best band combination. Observations of land cover in the PHU area of Jambi Province identified 7 classes, namely swamp forest, swamp, open land, plantations, settlements, water bodies, and mixed plantations.

Development of the DATAINDO InaPeat Platform

The DATAINDO InaPeat platform was running by using Google Earth Engine (GEE) to process and analyze available data sets in monitoring sensitive areas, such as PHU (Rizaldi *et al.* 2023). The platform was created by inputting hotspot, creating a script, and uploading the new platform registration data every year (national registry).

RESULTS AND DISCUSSION

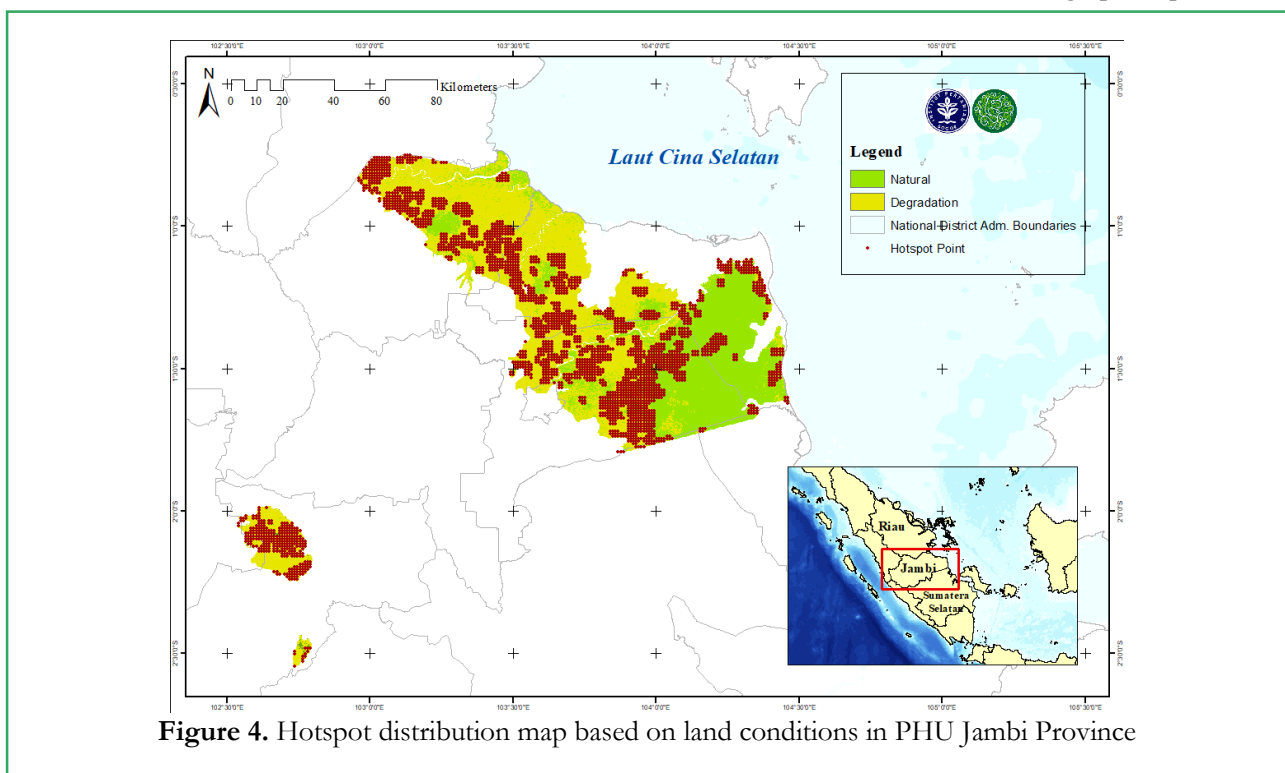
PHU condition

Jambi Province is one of the provinces that has peatlands on the island of Sumatra. According to Zainuddin *et al.* (2019), the peatland area in Jambi

Province reached 736,227.2 ha, or around 14% of the province's area, while the PHU area reached 874,951.7 ha. Most of the land used in this province is agricultural land, which are rice fields and non-rice fields. In addition to the commodity, Oil palm is the most widely developed plantation in Jambi Province (Wibowo 2010). The land area used for oil palm plantations reached 1,074,600 hectares (BPS 2020) and almost half of this area is peatlands. Around 70% of the 751,000 hectares of peat land in Jambi are in oil palm cultivation and industrial forest plantation concessions. The use of peatlands for plantations is affected by the level of degraded areas in the Jambi PHU. Wetlands that should store millions of tons of carbon are destroyed by thousands of canals deliberately built by companies to make peatlands dry and land subsidence (Ratnaningsih & Prastyaningsih 2017). This condition makes peat soil highly susceptible to fire.

Spatiotemporal Hotspots 2002-2022

The results of the analysis of the number of hotspot distributions obtained from FIRMS MODIS images identified in the PHU of Jambi Province show that hotspots were distributed in 2002 at 940 points, in 2007 at 731 points, in 2012 at 1,651 points, in 2017 at 279 points, and 2022 at 152 points. Based on Figure 3, it can be seen that the value of information is clustered in 2012. The number of hotspot points based on area conditions forms a distinctive graphic pattern in



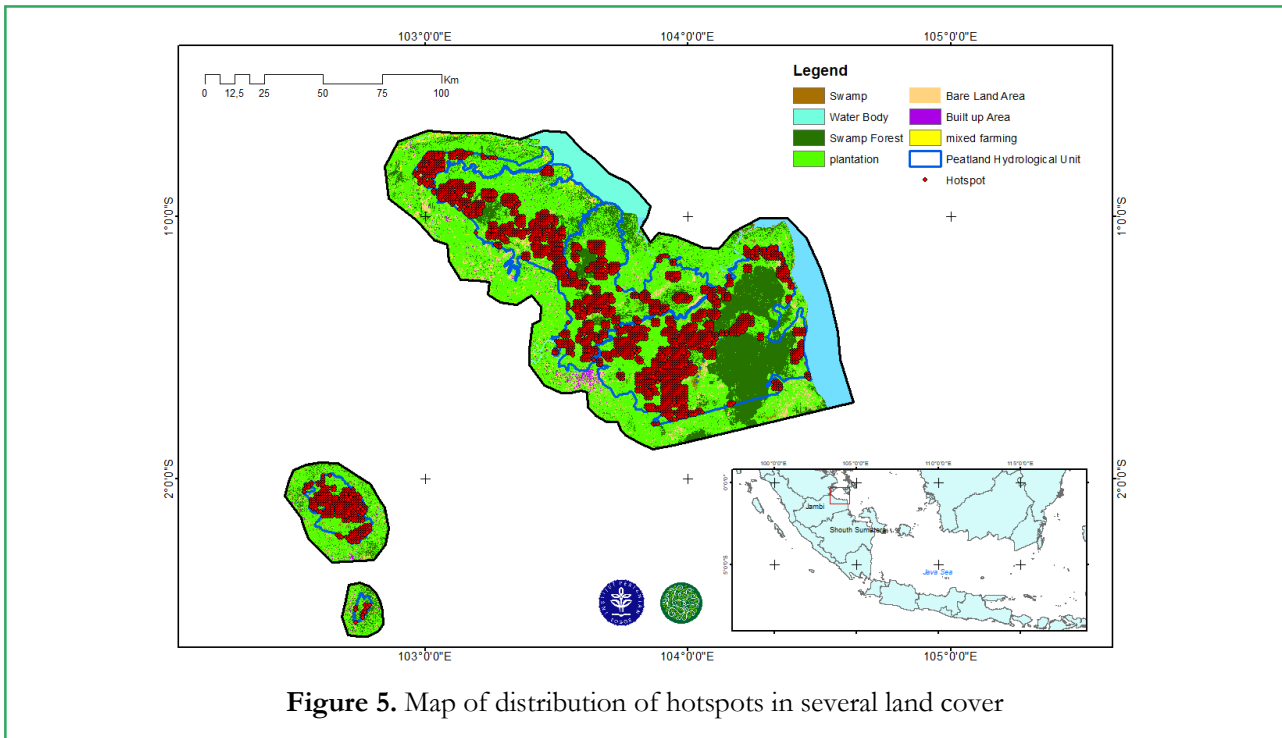


Figure 5. Map of distribution of hotspots in several land cover

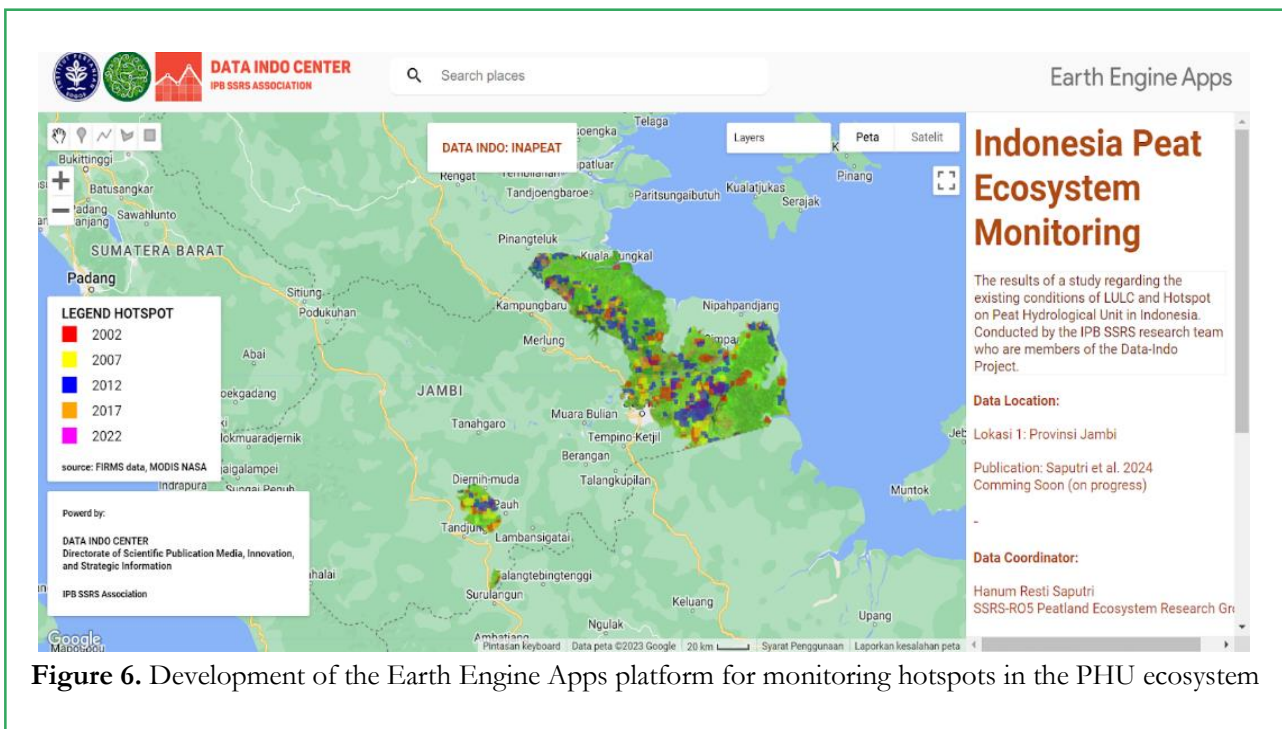


Figure 6. Development of the Earth Engine Apps platform for monitoring hotspots in the PHU ecosystem

(Figures 4 and 5), there was a decrease in the number of hotspots from 2002 to 2007. In addition, there was a significant increase in 2012 and there was a decline again in the number of hotspots in 2017 and 2022. Furthermore, the distribution of hotspots in 2002, 2007, and 2012 was concentrated in natural areas, while in 2017 and 2022 the distribution of hotspots was dominated in degraded areas. However, overall the hotspots from 2002 to 2022 dominate the degraded

areas. This proves that hotspots cause damage to peatlands, thereby increasing the degraded area to 63.73% of the total PHU area of 874,951.7 ha. The degraded area is dominated by plantation-class land cover, this condition can be seen in (Figure 5). The condition of land cover in PHU Jambi influences the level of hotspot density. According to *Asyrowi et al. (2021)*, the number of hotspots appearing is influenced by regional function, land cover, land use, and soil type.

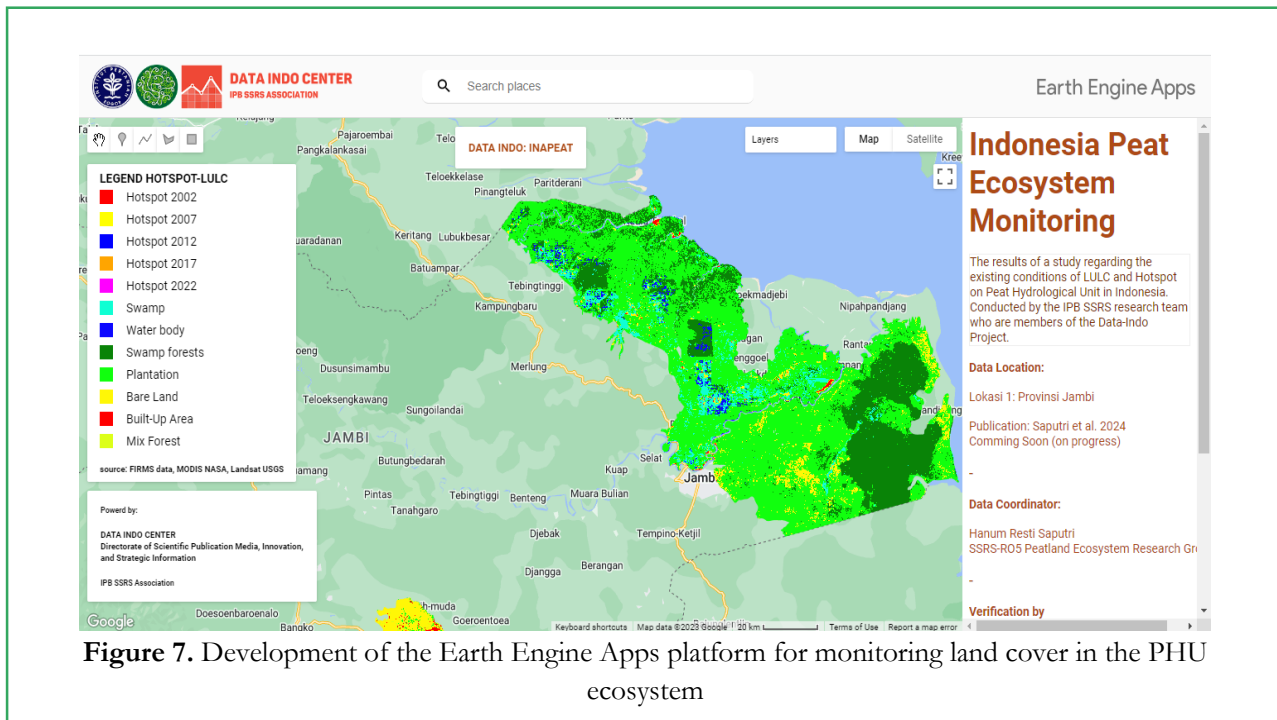


Figure 7. Development of the Earth Engine Apps platform for monitoring land cover in the PHU ecosystem

DATAINDO InaPeat Platform: Cloud Computing-Based Media Monitoring Solution

Very rapid technological developments such as internet-based data processing (cloud computing) allow us to carry out monitoring actions using web-based GIS or webGI in the PHU area. The existence of webGIS can be used for the integration of datasets and provides information to the public. The development of the DATAINDO InaPeat platform is monitoring medium, especially hotspots, and their relationship to the condition and cover of PHU land in Jambi Province. This monitoring activity aims to prevent and overcome fires in areas that are prone to burning early. Apart from being able to monitor the PHU area in real-time, this platform does not require special skills to operate and has large costs to purchase licenses for GIS applications. Evaluation of spatial-based information media and websites is very important for monitoring sensitive areas and state assets such as peat. The creation of the DATAINDO Inapeat platform is a solution for Cloud Computing-based monitoring media whose process takes place online involving various algorithms in the form of scripts. This platform can be accessed by the public via the Earth Engine Apps website (<https://ee-dataindossrs.projects.earthengine.app/view/inapeat>).

In conclusion, data visualization in the PHU monitoring platform can be seen in (Figure 6) (for hotspot data) and (Figure 7) (for land cover data).

CONCLUSIONS

Geospatial analysis can be an option to detect changes in regional characteristics such as conditions and land cover in PHU areas such as Jambi Province. The existence of a webGIS platform such as DATAINDO InaPeat can be used to monitor areas because the data is real-time, cheaper, and easier to use. In conclusion, DATAINDO InaPeat, a data visualization system for peatland ecosystem conditions, is expected to be used as a consideration for policy-making regarding peat management in various regions. In addition, it can be used as a reference for further research. The distribution of hotspot data in PHU of Jambi Province 2002-2022 produces a spatial pattern that is concentrated in degraded areas of 557,609.02 ha (63.7%) of the total PHU area of 874,951.7 ha. The highest number of hotspots over 5 years occurred in 2012 with 1,651 points.

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