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FOREST AREAS WITH A HIGH POTENTIAL RISK OF FIRE MAPPING ON PEATLANDS USING INTERFEROMETRIC SYNTHETIC APERTURE RADAR

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ABSTRACT

Forest fires, especially on peatlands, constitute a significant problem that is often faced in Indonesia. Forest fires that occur on peatlands are caused because the peatlands have been degraded due to deforestation, with the aim of utilizing peatlands for forestry and agricultural cultivation activities. Efforts to mitigate forest fires on peatlands need to be made. The first thing to do is to map peatlands that have a high risk of burning. In order to cover a large area, remote sensing technology is needed. Peatlands that have subsided are identical to peatlands that are dry, so they burn easily. SAR interferometry has the ability to detect the subsidence of peatlands. Combined with the Wosten model, areas with a high potential risk of forest fire on peatland can be mapped, and this has been demonstrated in this research.

Index Terms— Forest Fire, Peatland, InSAR

1. INTRODUCTION

The total area of peatlands is 3% of the total land area on earth, covering a large part of Russia, North America, and Europe has cold temperature -high rainfall, and mostly tropical area as well, especially Southeast Asia area. Nevertheless, some of East Asia areas. In addition, Africa and Latin American countries have precipitation-high temperature conditions as well [1]

Indonesia, as a part of Southeast Asia, has an extensive peatland domain, approximately 47% of the global tropical peatland area or 14.910.000 Ha. The total area of tropical peatland area is 10-16% of the global peatland area [1].

It is common knowledge that the forests in Indonesia suffered from deforestation, especially the forests in Kalimantan in the 1980-the 1990s, and continues to this day. The clearing of oil palm plantations also results in the clearing of peat forests. Furthermore, from 1996 to 1998, 1 million were cleared for agricultural land on these peatlands. Then, irrigation canals are made to provide irrigation for the agricultural land. This causes a process of drying, oxidation, and collapse that increases peatland proneness to fire. Furthermore, this agricultural land clearing activity causes peatland degradation to extend to other areas. [2]

One of the methods and techniques used for subsidence mapping is the microwave remote sensing Synthetic Aperture Radar (SAR) by using the SAR interferometry (InSAR) approach. In the case of peatlands, several parameters that must be considered are the condition of the depth of the groundwater table and carbon emissions. Then the depth of the groundwater table is multiplied by 0.04, where the depth of the groundwater table is in cm, while the subsidence is in cm/year [3].

Forest fires usually occur in the peatland areas when the water table depth is more than 40 cm. The standing order of the Indonesian gov states that peatlands with a groundwater level of > 40cm are classified as degraded areas. Thus, this is what causes that dry peatlands will easily burn, spread quickly, and be difficult to extinguish.

Based on the above concepts and understanding, this research has utilized land subsidence data generated from the InSAR analysis to be used as a basis for mapping forests that have a high risk of burning. Mapping of Areas with a Potential High Risk of Forest Fire on Peatlands, which can cover a large area, is needed to support forest fire disaster mitigation.

2. MATERIAL AND METHOD

This research has used synthetic aperture radar data from L-Band Frequency ALOS-2 PALSAR-2, collected on Feb. 25th, 2016, and Feb. 2rd 2018, provided by Japan Aerospace Exploration Agency (JAXA), Japan. The data specification can be seen in Table 1.

Table 1. The data Specifications.

No	Item	Specifications
1	Type of Sensor	ALOS-2 PALSAR 2
2	Data Format	SLC
3	Frequency	L-Band
4	Wavelength	0.24 M
5	Polarization	Dual Pol. VV and HH
6	Acquisition Date	Feb. 25th 2016 and Feb. 2rd 2018
7	Acquisition Mode	Ascending
8	Acquisition Heading	−126.2211
9	Incident Angle	36.295 degree

The research method is based on SAR interferometry analysis using two images of SAR. Thus, We employed Wosten model to obtain the WT depth distribution map. Based on the WT depth condition, depths of more than 40 cm are classified as the high potential risk of forest fire area [3]. These results are then verified with previous forest fire data as validation.

In this research, a pair of ALOS-2 PALSAR-2 data images with horizontal-horizontal polarization (HH) were used.

3. RESULT AND DISCUSSION

Based on the data analysis that has been carried out, the results of the reflectivity map are obtained, as shown in Figure 1. Based on Fig. 1. It can be seen that in this area, several large rivers flow, with a reflectivity that is close to zero with a dark color. Also obtained a bright reflectivity close to one which is an open area.

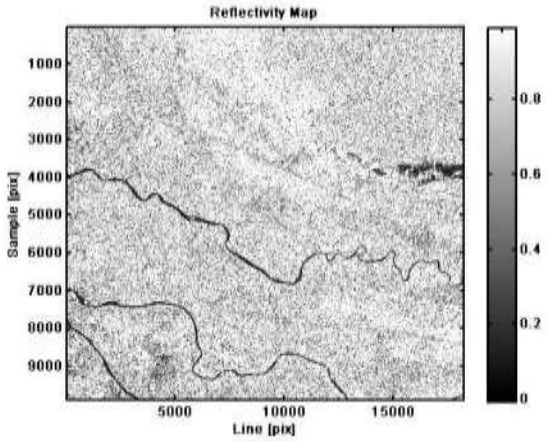

Fig.1. Reflectivity Map of this research area

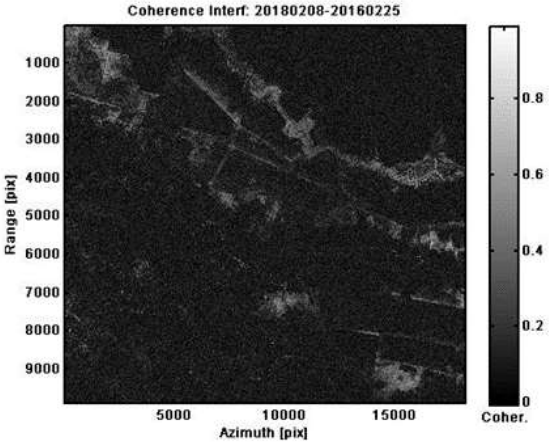

Fig.2. Coherence map of the research area

From the results of the InSAR analysis, it appears that only a small part of the area results in incoherence. This is due to areas with high temporal dynamics, especially those covered with dense vegetation, usually no coherence due to the influence of the plant canopy, as shown in Fig. 2. With regard to mapping flammable areas or with a high risk of burning potential in peatlands, this is actually beneficial, as fires on peatlands usually occur in open areas.

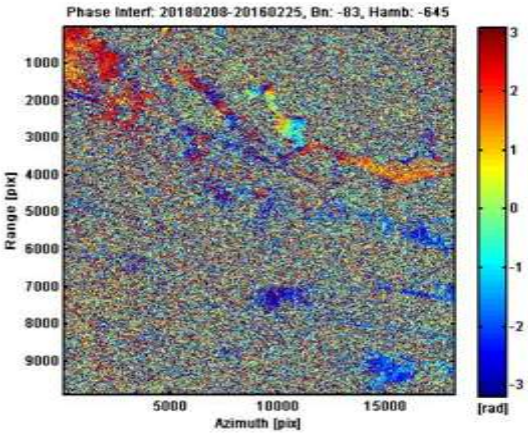

Fig.3. Phase Interferogram of the research area

From the interferogram data, which is another result of the InSAR analysis, it can be seen (Fig. 3) that several areas have a phase difference between -3 to 3 radians. The unwrapping process then carries out this interferogram data so that land deformation that occurs in peatlands can be observed. Land deformation (subsidence) and uplift deformation will be observed more clearly, after the unwrapping process.

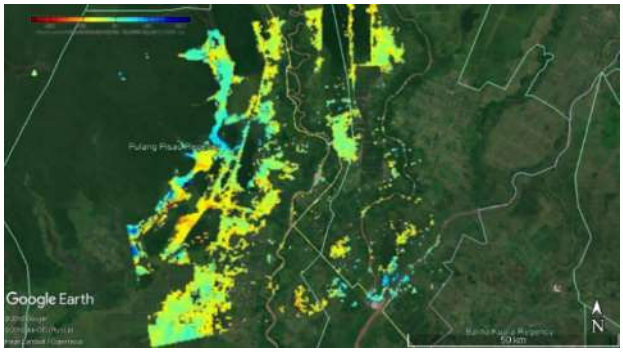

Fig.4. Land deformation Map of the research area

After the unwrapping process, the peatland deformation has been seen as shown in Fig. 4, where areas that have decreased (subsidence) are shown in yellow to red, and areas that have increased levels (uplift) are shown in blue. Some areas have seen subsidence.

From the results of the land deformation map generated from the InSAR analysis process, a mapping of areas with a high risk of potential fire was carried out based on the Wosten model, which links land subsidence in peatlands and groundwater levels; the results are as shown in Fig. 5.

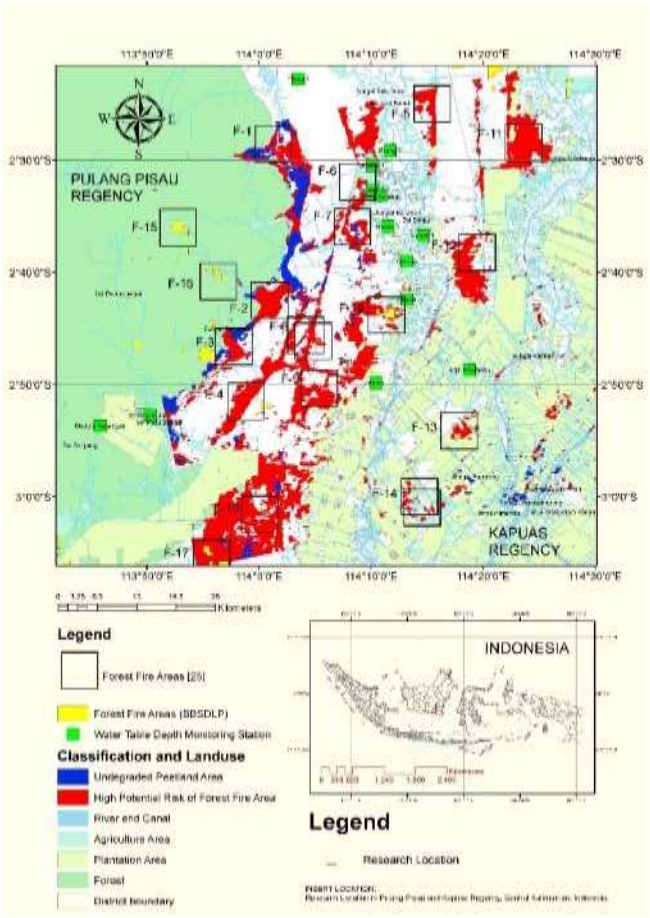

Fig.5. High Potential Risk of Forest Fire Area

From Fig. 5, it can be seen that areas with high forest fire potential have been mapped in red based on the classification results.

After overlaying with previous forest fire data, it has been seen that the areas in red have previously been burned and based on facts on the ground, and the burned peatland areas are in the same area, or in other words, burnt repeatedly.

After conducting a comparative analysis with groundwater level data that is monitored online in the field, it shows that the water level in the dry season tends to fall below 40 cm. From Wosten's concept, this area is an area that has a high risk of burning.

Based on the results of the above analyzes, synthetic aperture radar interferometry, so the mapping of peatlands that have a high risk of burning has been successful and can be well mapped.

4. CONCLUSION

Based on the research that has been done, mapping of forests that have a high risk of burning can be done using the basis of InSAR analysis of the ALOS-2 PALSAR-2 frequency L-Band data. From the results of the overlay with previous forest fire incidents, it is evident that areas that experience subsidence on peatlands have a high risk of burning.
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