Post-K&C – First Report

Development of Digital Services for Peatland Monitoring

Rahmat Arief¹, Orbita Roswintiarti¹, Dede Dirgahayu¹, Ita Carolita¹, M Taufik², Dirk Hoekman³

¹Indonesian National Institute for Aeronautics and Space (LAPAN), ²IPB University, ³Wageningen University

Post-KC Science Team meeting #1
Tokyo, Japan, January 20-24, 2020
Peatland in Indonesia: An Overview

**Forest Fires in 2015**

**INDONESIA**
- 7 Provinces
- 15 million ha
  - BRG Restoration MANDATE
  - 2 Million ha in 7 province

<table>
<thead>
<tr>
<th>Year</th>
<th>Affected Fire (HA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>1,757,433</td>
</tr>
<tr>
<td>2016</td>
<td>811,736</td>
</tr>
<tr>
<td>2017</td>
<td>124,983</td>
</tr>
</tbody>
</table>

**BRG Restoration TARGET (7 Province)**
- 2.5 million ha
- 104 PHU

**Non Concession Area:**
- 1.1 Million Ha
  - Funded by State Budget

**Concession Area:**
- 1.4 Million Ha
  - Concession responsibility under MoEF coordination

Source: BRG
Priority areas in 7 provinces

- Mapping of Peatland
- Mapping of Forest cover change
- Mapping of soil moisture
- Monitoring of hydrology
- Detection of Peat forest fire and burn scar
- Detection and reconstruction planning of drainage canals

<table>
<thead>
<tr>
<th>Province</th>
<th>Area [Ha]</th>
<th>PHU</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIAU</td>
<td>814.732</td>
<td>24</td>
</tr>
<tr>
<td>JAMBI</td>
<td>151.663</td>
<td>10</td>
</tr>
<tr>
<td>SOUTH SUMATERA</td>
<td>615.907</td>
<td>25</td>
</tr>
<tr>
<td>WEST KALIMANTAN</td>
<td>119.634</td>
<td>17</td>
</tr>
<tr>
<td>SOUTH KALIMANTAN</td>
<td>38.761</td>
<td>4</td>
</tr>
<tr>
<td>CENTRAL KALIMANTAN</td>
<td>713.076</td>
<td>19</td>
</tr>
<tr>
<td>PAPUA</td>
<td>38.753</td>
<td>12</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>2,492.527</strong></td>
<td><strong>107</strong></td>
</tr>
</tbody>
</table>
Project outline and objectives

The objectives of the proposed development are

(1) to demonstrate the innovative applications for peatlands monitoring and rehabilitation focused on 3 main thematic information products:
   a) Monitoring of forest fire
   b) Monitoring of soil moisture
   c) Detection of new drainage canals

(2) to demonstrate the satellite data digital services for multi sensor satellite data such as Landsat7/8, SPOT6/7, Sentinel-1, Sentinel-2, ALOS2 PALSAR2 ARD, and MODIS.
User Requirement : Role of Remote Sensing for supporting Peatlands monitoring (LAPAN – BRG Meeting)

- Hotspot from MODIS/ VIIRS from Terra/Aqua/SNPP/NOAA
- Rainfall rate from Himawari-8
- Landcover change (re-vegetation dan de-vegetation)
- Fire Danger Rating System (FDRS):
  - FFMC (Fine Fuel Moisture Code)
  - DC (Drought Code)
  - FWI (Fire Weather Index)
- Soil Moisture (Proxies indices with in situ measurement)
- Ground Water Level (Proxies indices with in situ measurement)
- Burn Area
- Drainage Canal network in Peatlands (Wageningen University)
(Goal 1a) Forest Fire Monitoring

Early Warning
- FDRS
- Rainfall

Emergency Response
- Hotspot/active fire
- Smoke

Affected Area
- Burnt area
Fire danger rating system (FDRS) using remote sensing data i.e. drought code (DC) and fine fuel moisture code (FFMC) as an early warning program for forest/land fire. Hotspot from MODIS/VIIRS (Purple dots)
FIRE WEATHER INDEX

Drought and smoke Potential
Estimation of Burnt Area

ALOS2-PALSAR2
JJFAST Scansar 50m
RGB Composite – Temporal
R: 20190628
G/B : 20190728
Pre-Processing:
- Calibration
- Speckle Filtering
  (Frost 5x5)
Blue Line : Peatlands
ALOS2-PALSAR2
JJFAST Scansar 50m
RGB Composite – Temporal
R: 20190628
G/B : 20190823

Location : Jambi Province
Tile S03E113
ALOS2-PALSAR2
JJFAST Scansar 50m
RGB Composite – Temporal
R: 20190628
G/B : 20191004
ALOS2-PALSAR2
JJFAST Scansar 50m
RGB Composite – Temporal
R: 20190628
G/B : 20191018

Location : Jambi Province Tile S03E113
ALOS2-PALSAR2
JJFAST Scansar 50m
RGB Composite – Temporal
Pre : 20190628
Post : 20191018

Change Detection using threshold
and Segmentation

Location : Jambi Province
Tile S03E113
ALOS2-PALSAR2
JJFAST Scansar 50m
RGB Composite – Temporal
Period: 20190628 - 20191018

Green polygon:
Change Detection of using threshold and Segmentation

Red dots:
hotspot (MODIS/VIIRS) from 20190628-20191018

How to distinguish burn area and change?

Location: Jambi Province Tile S03E113
Green polygon: Change Detection of JJFAST using threshold and smoothing.

Pink dots: hotspot (MODIS/VIIRS) from 20190628-20191018.

Train data: Burn and noburn (total 1334 samples), Number of trees: 500.

Random Forest classification of JJFAST
Input: Pre HH, Pre HV, Post HH, Post HV, NDiff HH, Ndiff HV

Probability:
- 0 - 0.168627451
- 0.168627451 - 0.356862745
- 0.356862745 - 0.631372549
- 0.631372549 - 1

Random Forest classification of Sentinel 1
Input: Pre VV, Pre VH, Post VV, Post VH, NDiffVV, NDiffVH

Probability:
- 0 - 0.419607843
- 0.419607843 - 1

Confusion Matrix

<table>
<thead>
<tr>
<th></th>
<th>BURN</th>
<th>NOBURN</th>
</tr>
</thead>
<tbody>
<tr>
<td>JJFAST</td>
<td>0.252</td>
<td>0.1696</td>
</tr>
<tr>
<td>Sentinel-1</td>
<td>0.35</td>
<td>0.292</td>
</tr>
</tbody>
</table>
Combination Difference NBR (L8) and Sentinel-1
Next Steps
- Still need to be validated
(Goal 1b) Soil moisture Estimation in Peatland

- Observation data of soil moisture and ground water level from 42 BRG sesame stations are used to build a model of spatial peat soil moisture estimation.
- The soil moisture estimation model is built from the relationship between observation soil moisture and the Normalize Difference Polarization Index (NDPI) parameter from backscatter VV/VH of Sentinel-1.
- The combined conditions of wetness and roughness of plant canopies on peatlands affect the humility of the underlying land (dielectric changes in objects). Therefore the use of the NDPI Index is used directly to estimate soil moisture.
GWL and soil moisture time series at the same observation station of Jambi Province visited on 26-28 August 2019.

- GWL variations are below -0.1 m even in the rainy season, except BRG.6 and BRG_150607_01 Station.
- BRG.6 Station was flooded during the period 18-27 December 2018 with a maximum TMA reaching 0.25m.
- In the dry month period (July-August), the TMA value at the five stations experienced a massive decline and reached its lowest point each year at the end of August.

- Sesame tool measures SM at depths of 0-10 cm. The five stations show similar patterns of SM variation.
- In general, the upper layers of peat are in wet conditions during the rainy season, and the humidity decreases during the dry season period.
- The soil moisture value has a correlation with the dynamics of the ground water level. High ground water level tends to produce high soil moisture value.

![Graph](image)
Rainfall time series at the same observation station of Jambi Province visited on 26-28 August 2019.

- The study locations has two peaks in the rainy season, February-April and October-December.
- During the month the rainfall was very high to reach 100mm / day as happened at BRG station.3 (120mm, 11 November 2018), and Jambi.1 (130 mm, 12 November 2018; 104 mm, 19 & 26 April 2019).
- The lowest rainfall occurs around July-August
Hydrometeorological data correlation

- In general there is a positive and linear correlation between soil moisture and groundwater level with a correlation coefficient > 0.7.
- With this fact, soil moisture parameters can be used to estimate water levels.

Correlation between soil moisture (% in y axis) and groundwater level (m in x axis) for stations BRG.3, BRG.6 and BRG_150706_01 (near the burnt location)
Correlation between soil moisture (SM in %) with NDPI SAR parameters from Sentinel-1 images

- The increase SM causes a significant increase in NDPI.
- NDPI threshold value of around 0.4 indicates a slightly dry SM condition (<30%)
- NDPI threshold values around 0.575 indicate high SM (>100%)
The soil moisture condition in the Peatlands of Jambi region is mostly in the wet category (>91%).

Sungai Buluh has soil moisture values ranging from 121-130%.

Low soil moisture (<40%) with red magenta is detected in some areas.
Peat Fire Vulnerability Mapping

the vulnerability of Jambi peatland fires from on (a) ten days 1, (b) ten days 2, and (c) ten days 3 in August 2019 periods did not change much. Several spots in the same area were identified as dangers to forest fires, namely in the Districts of East and West Tanjung Jabung.

### Index mKBDI

<table>
<thead>
<tr>
<th>Index mKBDI</th>
<th>Ground water level (cm)</th>
<th>Soil Moisture(%)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 100</td>
<td>&lt; 40</td>
<td>&gt; 60</td>
<td>Safe</td>
</tr>
<tr>
<td>100 – 200</td>
<td>40 – 60</td>
<td>50-60</td>
<td>Alert</td>
</tr>
<tr>
<td>200 – 250</td>
<td>60 – 70</td>
<td>40-49</td>
<td>Danger</td>
</tr>
<tr>
<td>250 – 300</td>
<td>&gt; 70</td>
<td>&lt; 40</td>
<td>Very danger</td>
</tr>
</tbody>
</table>
Peat Fire Vulnerability Mapping

Rentan Kebakaran Gambut
21-31 Agustus 2019
- Ekstrim bahaya
- Bahaya
- Waspada
- Aman
(Goal 2) Platform digital services for multi sensor satellite (optical and SAR)

- Acquisition to Product:
  - Data Access ➔ Reflectance/Backscatter ➔ Information extraction ➔ Access ➔ Information Product

- Production of Analysis Ready Data
- Based on Satellite Data Cube Design
- Providing information products via webservices

- Landsat-8, SPOT6/7, Pleiades, TerraSAR-X, Sentinel-1/2, ALOS2-PALSAR2 Mosaic JJFAST (planned)
Describe planned output of your project.

- **Project deliverables**
  - Distribution of Burnt Areas for the Period of January - November 2019

- **Non-peer-reviewed publications (conference papers, reports etc.)**
  - The 4th International Seminar on Sensors, Instrumentation, Measurement and Metrology (ISSIMM 2019), Detecting the Burned Area in Southern Kalimantan by Using the Sentinel-1 Polarimetric SAR and Landsat-8 OLI Optic
Summary and Future Plan

- Need to validate the burn area
- Estimation of burnt area (January - November 2019) 884,414 ha. But recapitulation of burn area in Jan-Dec 2019 displayed on the SIPONGI website, total 1,592,010 ha ➔ Sinergy with Ministry of Forestry and Environment to compare the method how to calculate the burn area
- Integration with classification for burn area using JJFAST
- Soil moisture map based on ALOS2 PALSAR2
THANK YOU

Rahmat Arief
rahmat.arief@lapan.go.id