Application ALOS Palsar Mosaic 25 m and legacy data for determine tidal swampland and back swampland

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Abstract. An up to date swampland spatial data in tropic area such as Indonesia based on remote sensing data is important needed for estimating the recent change, especially for agriculture activities. The big problem to acquire remote sensing data in tropic area is cloud cover in almost entire areas. In this study, a base map of swampland map in South Kalimantan was developed using ALOS Palsar 25 m Mosaic data obtained in 2010 and legacy data. That remote sensing data are adequate to represent the area because was produced by active remote sensing that able to through cloud cover in tropic area. For this purpose, the datasets was segmented by region growing algorithm and then random forest classification method were developed using training data to determine swampland and no swampland area. Afterward the legacy data from prior research that is mathematic equation calculated and applied to determine tidal swampland and back swampland. The visual comparison result showed there are 3 types backscatter combination HH and HV, 30:70; 40:60; and 50:50 that the best combination is 50:50 with overall accuracy 85.25%. Using that combination the area of swampland that suitable for agriculture activities in South Kalimantan is 669,185.37 ha that tidal swampland around 45% and back swampland around 55%.

Keywords: ALOS, cloud cover, random forest, region growing algorithm, tropic

1. Introduction
Information on soil legacy data used for mapping can be divided into 3 types. First, based on profile or boring data at point of coordinates; second, based on area at polygons; and third, expert knowledge that reflect a map concept or a number of rules that can be used to map. The three types of legacy data have begun to be widely used as data sources for updating conventional land maps in some countries, especially in temperate regions, but have not been widely used to update swampland maps [1].

In Indonesia the classification of swampland for agricultural activities in wetlands is more advanced than others countries that were indicated by a very detailed concept of classification of swampland. Agriculture Ministry of Indonesia developed specific classification of swampland base on 2 mains idea: 1) the source of water energy that is affected inundation to the land; and 2) hydro fluctuation base on the maximum ability of paddy plant to growth in height and periods of inundation water. Hydro fluctuation means the seasonal pattern of water level: duration and amount of time. The duration of time water standing in wetland is called flood duration and the amount of times water flooded the wetland is called flood frequency [2].

There are two sources of water energy which generated 2 types of swamplands. First, tidal swampland that water inundation was affected by tide movement of ocean. Second, back-swampland that water inundation was affected by amount of water from river or precipitation in upstream area. Afterward, both of them were classified by hydro fluctuation using threshold 50 cm water level scale and periods. This scale based on assumption that paddy unable to survive if its stem and root were waterlogged by water more than 50 cm for 3 month. The tidal swamplands also were classified based on flood frequency (daily tide) and on the other hand back-swamplands were classified based on flood duration (quarterly or 3 month) [2].
That concept is easily explained theoretically, but it is difficult to describe correctly on the map or spatial information data. Even in reality determining tidal swamps and back swamps is also difficult due to several constraints such as: 1) the boundary between tidal swamps and back swamps differs every time depending on the season i.e. the rainy season and the dry season so there are no firm boundaries; 2) the boundaries between types on tidal swamps and also back swamps are not firm depending on the season; 3) On the reality the boundary is not clear but changed gradually, so the boundaries lines that depicted on the map is obtained arbitrarily based on the concept who understood by the maker.

Swamplands are a function of climate and landform that able to preserve saturated soils or inundated waters condition with specific floras and soils. The simple approach to observe swamplands using remote sensing and digital mapping technique is detecting the presence of water, form of landscape, and type of vegetation that reflect specific characteristic of electromagnetic wave that able received by sensor [3].

Remote sensing techniques have been used to study swamplands more than four decades. In the early periods visible and infrared wavelength of aerial photography was applied for mapping in local area [4,5]. Afterward a variety of combined aircraft and satellite remote sensing were applied to provide information such as location, status, and extent of wetland used visible and infrared wavelength image that consists high resolution (1-4 m) and medium resolution (10-30 m) to service the data [6]. In many countries aerial photography, Landsat TM, and SPOT images were commonly applied to observe and to study wetland [7].

Recently the studies of wetlands have been applied remote sensing data at spatial ranging 1 km—300 m in particularly continental and whole globally continental. However, to obtain good spatial distribution of wetlands accurately from single data satellite is difficult. Some researchers attempt to increase the accuracy with multiple source of data such as satellite and ancillary data, including Digital Elevation Models (DEM), soil maps, and existing wetland map [7]. Indeed, to define wetlands area is more complicated than uplands area because in shrub-scrub wetlands and forested wetlands the inundation of water are covered by canopy of plant that unable to penetrate with passive sensor. The other problem is many presences of clouds cover especially in rainy seasons in tropic area.

Some researches applied active remote sensing or combine passive and active remote sensing to overcome these obstacles. The earlier studies combined passive and active remote sensing then applied multi-temporal active remote sensing such as L-band ALOS/PALSAR and C-band RADARSAT-2 data [8]. Presently there was more advantage when JAXA provided free four years New Global 25 m-resolution PALSAR mosaic in 2014. This research tried to combine those image and legacy data to generate and determine tidal swampland and back swampland.

2. Materials and Methods

In this study, South Kalimantan Provinces within the part of Borneo Island, Indonesia was chosen as location. The province was approximately 37,530.52 km² in area that located from 114° 19’ 13” - 116° 33’ 28” E and 1° 21’ 49” – 4° 10’ 14” S. South Kalimantan has tropic climate, with annual precipitation in 2013 was 3006.1 mm, average relative humidity 84.3 %, and average temperature 26.7 °C. Total of 40.22 % area in South Kalimantan is less than 25 m above sea level and 43.3 % total area is level slope class. Alluvium is main mineral soils with an area 1,186,913 ha or 31.8 % of total terrestrial area. Mostly that’s areas are mineral soils swampland and peat soils swampland which has high-level of acidity.
2.1. Materials
Since 2015 JAXA EORC has produced the higher resolution 4 year-25 m spacing global PALSAR mosaic than its predecessor PALSAR 50 m Orthorectified Mosaic Product. This image series were collected by Advanced Land Observing Satellite (ALOS)/ Phased array Type L-band SAR (PALSAR) from 2007 to 2010 using the accurate SAR processing and then provide HH and HV mosaic data. The image 25 m data are available and free of charge for everyone who want to download in JAXA official website after registering for the ordered. This research uses 2010 series as the latest of data image when research was conduct at 2014—2015. JAXA also provided using Land Use Land Cover (LULC) software to process the images.

2.2. Methods
This research attempts to combine legacy data from previous research of swampland in South Kalimantan by Anwar [9] (2011). The research described the dynamic of water level height in five secondary channels along the Barito River that was affected by tidal movement from estuary. This research calculated and modified his research that was resulted the equation

\[ y = -0.5216x + 99.841 \]  

(Equation 1)

that,

- \( y \) = \( \Delta \) inundation water
- \( x \) = distance of river location from estuary

Based on above equation this research obtained that the effect of tidal movement in rainy seasons will be zero at 191.41 km from estuary. This research also defined the threshold of water level height for agriculture purpose is 50 cm based on the classification framework of tidal and back swampland that mentioned previously. This research concluded the furthest distance of tidal effect to the water height level by the threshold is 70 km from estuary. This research delineated the boarder of tidal swampland and back swampland manually followed the stream of rivers or channels.

ALOS PALSAR 25 m global mosaic data are processed following this sequence: 1) mosaicked HH and HV polarization scene using ENVI 4.8; 2) resized mosaics of dataset to study area using ENVI 4.8; 3) collected training data were derived from Google Earth; 4) segmented HH and HV dataset using various weights combinations of HH and HV image by region growing algorithm using LULC; 5) created truth image using training data (307 point) at segmentation map (polygon) became polygon training data using LULC; 6) classified segmentation image using truth image (deriving from 50% training data) by a random tree algorithm using LULC; 7) evaluated result of 3 combinations of HH and HV by visual assessment; 8) evaluated accuracy of map using 50% of training data; 9) re-
evaluated accuracy of map using 500 random sampling points; 10) refined map using DEM SRTM 30 (more than 10 m asl).

At the step fourth, we used region growing for image segmentation. This algorithm classified the similarity of the image into regions that able to separate correctly the regions with same properties and to define clearly the edges of borders. This algorithm clustered pixels starting at a limited number of single seed point and then the region’s growth to adjacent points depending homogeneous criteria such us texture, pixel intensity, or colour [10]. Subsequently at the step fifth, we used random tree or random forest. This algorithm constructs a decision tree in numerous trees and collects the class ‘votes’ at the leaves of each many trees. This algorithm selecting the majority votes of class as the best [11,12]. Previous studies report random tree algorithm could increase the performance of Decision Tree [13].

3. Result & Discussion

3.1. Classification of ALOS PALSAR Mosaic

ALOS PALSAR Mosaic 25 images were created by JAXA used L band active remote sensing that able to penetrate cloud cover in atmosphere above South Kalimantan Province. The L band (15—30 cm) also can penetrate the earth surface is deeper than C band (3.75—7.5 cm) because wavelength of L band is longer than C band. This advantage encourages some researchers to applied it for analysis earth surface that covered by vegetation. Some researchers also reported it has good result for analysis and separate wet vegetation and dry vegetation using special software (LULC) that they launched for processing this image.

![Swampland and non-swampland map from ALOS PALSAR 25 m.](image)

**Figure 2.** Swampland and non-swampland map from ALOS PALSAR 25 m.

In this study ALOS PALSAR Mosaic 25 m was applied not only to separate swampland and non-swampland, but also attempted to separate land use in swampland area such as urban, mining, water, dry vegetation, wet vegetation, and swampland. The previous research from JAXA also reported Random Forest is the best method for classifying ALOS PALSAR data than Support Vector Machine, Multi-Layer Perceptron, Bayes, and Boost [13]. This study emphasized to separate wet vegetation area
that unable for food agriculture activities and swampland area that able for food agriculture activities. Wet vegetation areas such as mangrove, orchard, plantation, or vegetation in the river embankment are not for food agriculture activities. Mining area also separated because since 10 years ago mining activities expanded in upland and swampland area in this province.

The weighted combination of HH (horizontal transmit and horizontal receive) and HV (horizontal transmit and vertical receive) polarization image also determine the quality of model segmentation and classification image. This study tried many types of weighted combination of HH and HV image that ALOS PALSAR produce to get the best segmentation and classification. There are 9 weighted combinations of HH and HV such as 10:90; 20:80; 30:70; 40:60; 50:50; 60:40; 70:30; 80:20; and 90:10. The unit of number is percentage and the sum of ratio is 100. There are 3 types of weighted combination that showed good result and almost similar such as 30:70; 40:60; and 50:50. However, visual comparison showed the best weighted combination HH:HV is 50:50 and the overall accuracy is 85.25%. Using that combination the area of swampland that suitable for food agriculture activities is 669,185.37 ha or around 66.93% of the total alluvium area.

This research also attempts to simplify the map only swampland and non-swampland map and the result showed overall accuracy is 85.20% as shown in table 1. The accuracy of swampland for user accuracy and producer accuracy were 90.94% and 83.67% respectively. The agreement of this result is into moderate agreement with Kappa coefficient 0.69 that describe ALOS PALSAR 25 m is adequate for map swampland. This result provide big prospect because JAXA continue to release data for public free of charge.

| Image             | Swampland | Non-swampland | Total  | User Accuracy |
|-------------------|-----------|---------------|--------|---------------|
| Swampland         | 251       | 49            | 300    | 83.67%        |
| Non Swampland     | 25        | 175           | 200    | 87.50%        |
| Total             | 276       | 224           | 500    |               |
| Producer accuracy | 90.94%    | 78.13%        |        | 85.2%         |

Kappa coefficient= 0.69

3.2. Applied of legacy data concept

Subsequently this research combined legacy data from previous research of swampland in South Kalimantan by Anwar [9] and the result as we discussed before. Anwar monitored and explained the dynamic of water level height in five secondary channels along the Barito River that was affected by tidal movement from estuary. This research calculated and modified his research that was resulted the equation 1. Anwar states that the tidal movement of water in main rivers will push water to the upstream through secondary channel that connected. The effect of tidal energy will decrease with the increase of distance.

The result of the calculation obtained that effect of tidal movement in rainy seasons will be zero at 191.41 km from estuary. This research also defined the threshold of water level height for agriculture purpose is 50 cm. The threshold based on the classification of tidal and back swampland that mentioned previously. This research obtained the furthest distance of tidal effect to the water height level by the value of the threshold is 70 km from estuary. Previously the concept of Anwar had not depicted at spatial data until this research delineated the boarder of tidal swampland and back swampland.

This research delineated the area below 70 km from estuary manually by following stream of river branch or secondary channel because water movement primary trough those tracks. This method obtained area of tidal swampland is 302,037.72 ha (45%) and area of back swampland is 367,147.64 ha (55%) that described in figure 3. This result, especially for tidal swamplands, is almost similar with tidal swampland extend that produced by ISARI in 2014. However, ISARI produced almost twofold value for back-swampland than this research. It could be understood because ISARI had not applied DEM SRTM for masking the area above 10 m. It created the result is significantly different because back-swampland area was located adjacent with upland area.
Figure 3. Swampland for food agriculture in South Kalimantan: tidal (45%) and back-swampland (55%).

4. Conclusion
Combination of L band in ALOS PALSAR mosaic 25 m and a number soil rule model concept are important to update wetland map rapidly. The best weighted combination for image segmentation using region growth segmentation for wetland map is 50:50 and random forest algorithm is adequate to classified land use in wet soil and dry soil that useful for classified wetland. This method has advantage to monitor the extent of tidal swampland and back-swampland because ALOS PALSAR continue to release free of charge active remote sensing data.

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