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Characterization of mangrove forest types based on ALOS-PALSAR in overall Indonesian archipelago

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Abstract. Indonesia has largest mangrove forest in the world, total area around 3.5 million ha or 17% - 23% from mangrove forest in the world. Mangrove forest provides products and services, such as carbon balance of the coastal zone. Mapping and monitoring biomass of mangrove is very important but field survey of mangrove biomass and productivity in overall Indonesia is very difficult. Global-scale mosaics with HH and HV backscatter of Advanced Land Observing Satellite (ALOS) Phased Array L-band Synthetic Aperture Radar (PALSAR) which is 50-m spatial resolution has been generated. This image available for identification and monitoring mangrove forest. The Objective of this research to investigate characterization of mangrove forest types based on ALOS-PALSAR in overall Indonesian archipelago. Methodology consists of collecting ALOS-PALSAR image for overall Indonesian archipelago, preprocessing and mosaicking, collecting region of interest of mangrove forest, plotting, ground survey, characterization and classification. The result of this research has showed characterization of mangrove forest types based on ALOS-PALSAR. Indonesian mangrove forest types has HH value around -10 dB until -7 dB and HV value around -17 dB until -13 dB. Higher of HH and HV backscatters value indicated higher of level biomass. Based on scatter plot of HH and HV, Indonesian mangrove forest can be classified in three level biomass. Generally level biomass of mangrove forest in Indonesia archipelago is moderate.

1. Introduction

The term ‘mangrove’ is used to define both the plants that occur in tidal forests, and to describe the community itself [1],[2],[3]. According to Kuenzer et al., [4] mangrove ecosystems provide important products and services that can be divided into four categories ; regulating (e.g., shoreline protection), providing (e.g., fisheries, aquaculture, construction material, fuel, tannins, honey, traditional medicine, paper, and textiles), cultural (e.g. tourism and recreation, spiritual; and supporting (e.g., nursery habitats, nutrient cycling). Indonesia has largest mangrove area around 3.5 million ha or around 17% - 23% from large in the world [5]. In recent years global mangrove loss of more than 50%. Industrial lumber and wood chip operations, increasing human populations, industrialization, and agriculture have caused dramatic forest loss as well. In addition to the natural progression and succession stages

of the ecosystem, a significant amount of the loss is triggered by natural forces, such as tsunamis, cyclones, and the threat of global warming. The related reduction in mangrove-related services and product delivery imposes serious limitations on the local residents [4].

Mapping and monitoring biomass of mangrove forest is very important but field survey of mangrove biomass and productivity in overall Indonesia is very difficult due to muddy soil condition, heavy weight of the wood [6] and very large area. According to Kuenzer et al. [4] remote sensing has been widely proven to be essential in monitoring and mapping highly threatened mangrove ecosystems. Many research studies on this subject have been carried out around the globe. Tropical and subtropical coastal mangroves are among the most threatened and vulnerable ecosystems worldwide. According to Lucas et al., [7] the launch of the Japanese Space Exploration Agency's (JAXA) Advanced Land Observing Satellite (ALOS) Phased Arrayed L-band SAR (PALSAR) in 2006 therefore represented a milestone in the global observation, characterization, mapping and monitoring or mangroves largely, because these provide more information on the three- dimensional structure and biomass of woody vegetation and the presence and extent of (primarily tidal) inundation. As data can be day or night regardless of weather conditions, mangroves can be observed more frequently, even in regions with prevalent cloud cover. L-band microwaves (wavelength approximating 25 cm) emitted by the ALOS-PALSAR penetrate through the foliage and interact primarily with the woody components of vegetation. Horizontally transmitted waves are either depolarized through volume scattering by branches in the canopy, with a proportion of vertically polarized microwaves returning to the sensor, or penetrate through the canopy and interact with the trunks, returning primarily through double bounce scattering as a horizontally polarized wave.

The Objective of this research to investigate characterization of mangrove forest types based on ALOS-PALSAR in overall Indonesia archipelago. Methodology consists of collecting ALOS-PALSAR image for overall Indonesia archipelago, preprocessing and mosaicking, collecting region of interest of mangrove forest, ground survey, plotting, characterization and classifications.

2. Methodology

Indonesia also called "Nusantara" is a country in Southeast Asia that is located on 6° N – 11° S and 95° E - 141° E, between the Asian and Australian continents and between the Pacific and Indian Oceans. Indonesia Consisting of 17,508 islands that is largest archipelagic country in the world. Indoensia have large area around 1.904.569 km^2 which population around 237,6 million people in 2012, total province is 33 provinces. (www.indonesia.go.id). For this study that can see in the figure 1, we focus on 20 sites mangroves forest in Indonesia that is (a) Langsa, Aceh, (b) Bengkalis, Riau,

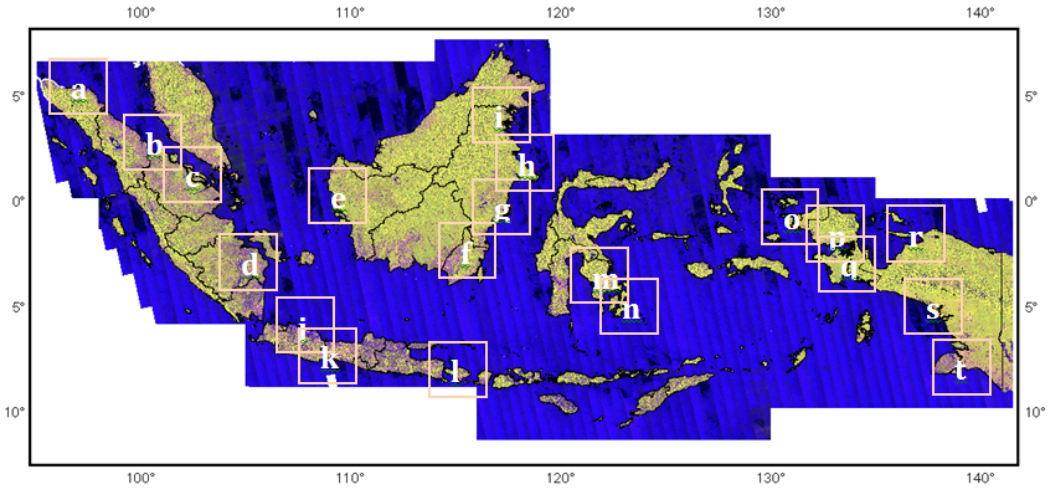


Figure 1. Study area dispersion of 20 sites (a - t).

(c) Indragiri Hilir, Riau, (d) Banyuasin, South Sumatera, (e) Pontianak, West Kalimantan, (f) Kotabaru, South Kalimantan, (g) Kutai Kartanegara, East Kalimantan, (h) Berau, East Kalimantan, (i) Nunukan, East Kalimatan, (j) Subang, West Java, (k) Cilacap, Central Java, (l) Badung, Bali (m) Bombana, Southeast Sulawesi (n) Muna, Southeast Sulawesi, (o) Sorong, West Papua, (p) Teluk Bintuni, Papua, (q) Teluk Bintuni, Papua, (r) Waropen, Papua, (s) Asmat, Papua, (t) Merauke Papua. We choose their location because their site has large area of mangrove forest that can describes mangrove forest types in overall Indonesia.

Generally mangrove can be found throughout in the Indonesian archipelago. Largest mangrove found in Papua around 1.3 million ha (38%), Kalimantan around 978 thousand ha (28%) and Sumatera 673 thousand ha (19%) [5]. In Indonesia archipelago mangroves grow and thrive well on the beach that has a large river and protected [5]. According to Rusila et al., [5] in Indonesia mangrove can be categorized in fourth zone; first open zone, which is mangrove zone front of in the sea and very effected by water from the sea. Majority of mangrove type is *Sonneratia alba*. Second middle zone, which is mangrove zone behind open zone. Majority of mangrove type is *Rhizophora*. Third payau zone, which is mangrove zones along the river. Majority of mangrove type is *Nypa* or *Sonneratia*. Fourth land zone, which is mangrove zone behind middle zone and payau zone, in this zone mangrove is very little affected by water from the sea. This zone has variety species than the other zones.

For this study, methodology consists of collecting ALOS-PALSAR image for overall Indonesia archipelago, preprocessing and mosaicking, collecting region of interest of mangrove forest, ground survey, plotting, characterization and classifications. The Methodology can see in the figure 2.

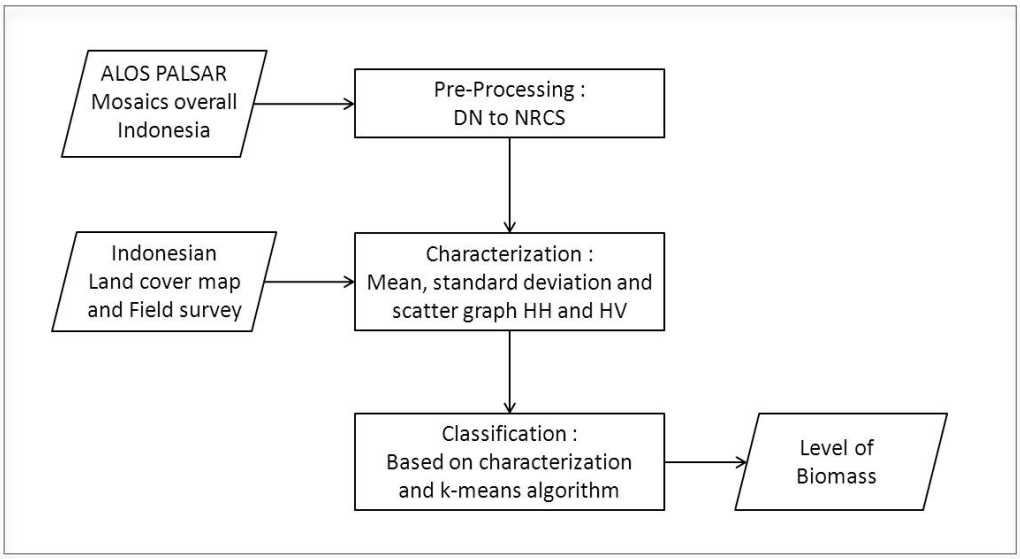


Figure 2. Methodology for characterization of mangrove forest on ALOS PALSAR.

The methodology in figure 2 can be described as follows :

2.1 Data collection

We used dual polarization ALOS PALSAR L-band HH and HV spatial resolution 50 m orthorectified mosaic product in 2008 from Kyoto and Carbon Initiative. We collected scene of Sumatra, Kalimantan, Sulawesi, Java and New Guinea to cover overall Indonesia archipelago. All data were acquired in fine beam dual mode at a viewing angle of 34.4 and delivered in single-look complex (SLC) as the normalized backscattering coefficient in slant-range geometry by JAXA. Secondary data

we used land cover map from Indonesian ministry of forestry and Indonesian base map from Badan Informasi Geospasial (BIG).

2.2 Pre-processing

We collected ALOS PALSAR from http://www.eorc.jaxa.jp/ALOS/en/kc_mosaic/kc_map_50.htm, totally 28 images to cover overall Indonesia archipelago. All images are projected into geographical latitude and longitude coordinates. The digital number (DN) value of HH (DN_{HH}) and HV (DN_{HV}) backscatter intensities were converted to a normalized radar cross section (NRCS), (i.e., $\sigma°_{HH}$ and $\sigma°_{HV}$) by the following equations [8] :

$$\sigma°_{HH} = 10 \times \log_{10}(DN^2_{HH}) - 83.2 \quad (1)$$

$$\sigma°_{HV} = 10 \times \log_{10}(DN^2_{Hv}) - 80.2 \quad (2)$$

The 28 image were mosaicked into one continues image to cover overall Indonesia archipelago using the image analysis software. For visualization we used image composite with R=HH, G=HV and B=HH/HV.

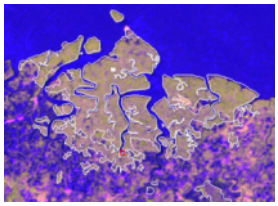
2.3 Charactization and classification

We collected Region of Interest (ROI) of mangrove forest by land cover map from Indonesian ministry of forestry and Indonesian base map from Badan Informasi Geospasial (BIG). We collected 20 ROI of mangrove forest dispersion on overall Indonesia archipelago. And then calculate mean and standardeviation. After we known characterization of mangrove forest, we classify mangrove forest using k-means algorithm.

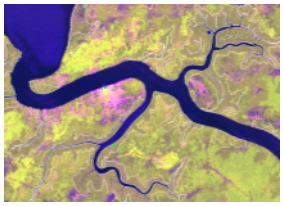
3. Results and discussion

Mangrove is plants that occur in tidal forests, and to describe the community itself. Mangrove can be found throughout in the Indonesian archipelago. We pre-processed 28 image ALOS-PALSAR include converted DN to NRCS, Mosaicked and then created image composite with R=HH, G=HV and B=HH/HV. The image cover overall Indonesia archipelago. Based on ALOS-PALSAR composite we can identify mangrove forest. In the figure 3 we show dispersion of mangrove forest from ROI in Indonesia archipelago.

Generally visual interpretation of mangrove forest based on ALOS-PALSAR mosaic very easy. In figure 3, we show also polygon of mangrove forest (white line) from land cover map derived from Indonesia ministry of forestry. Based on ALOS-PALSAR mosaic and land cover map as secondary data we can classify mangrove forest and non-mangrove forest.



a.Langsa, Aceh



b.Bengkalis Riau

c.Indragiri, Riau

d.Banyuasin, South Sumatera

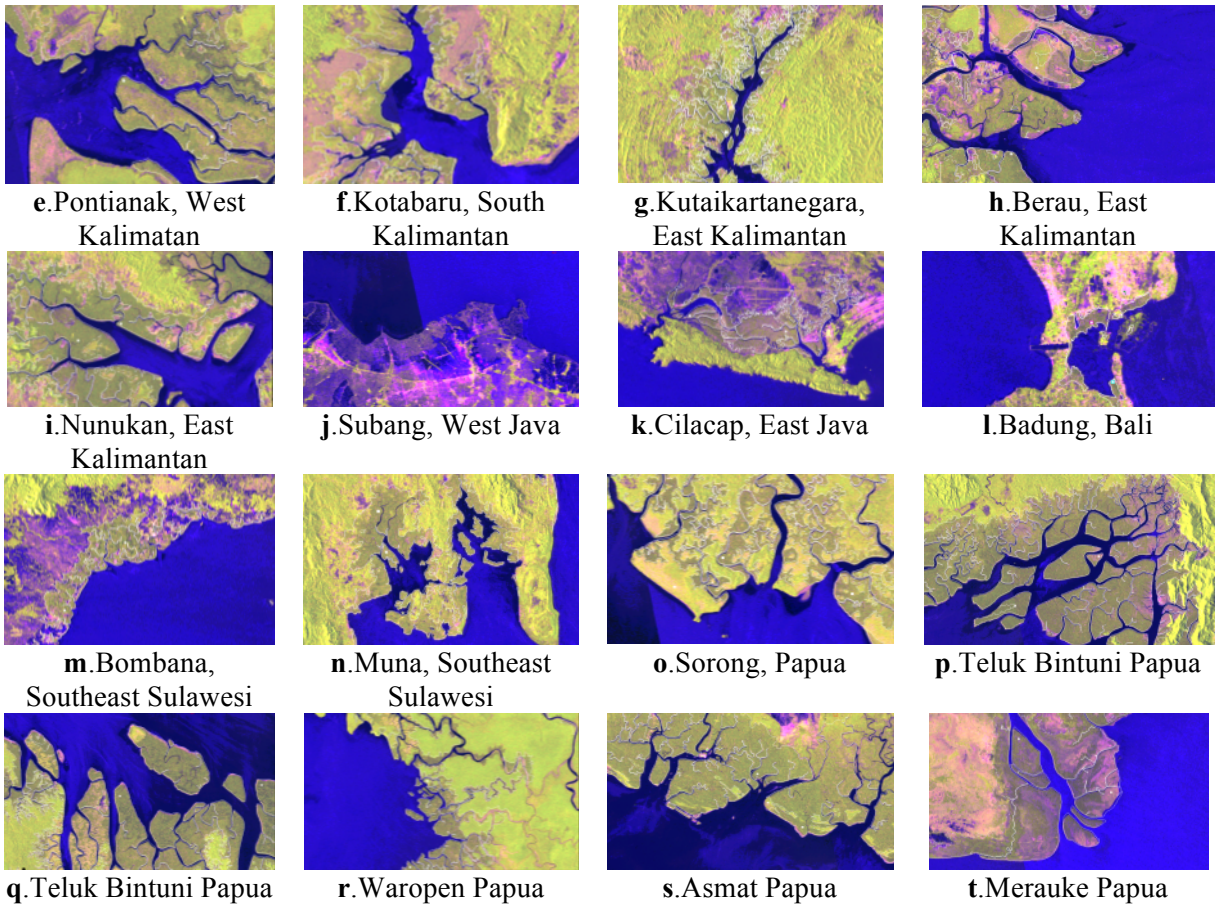
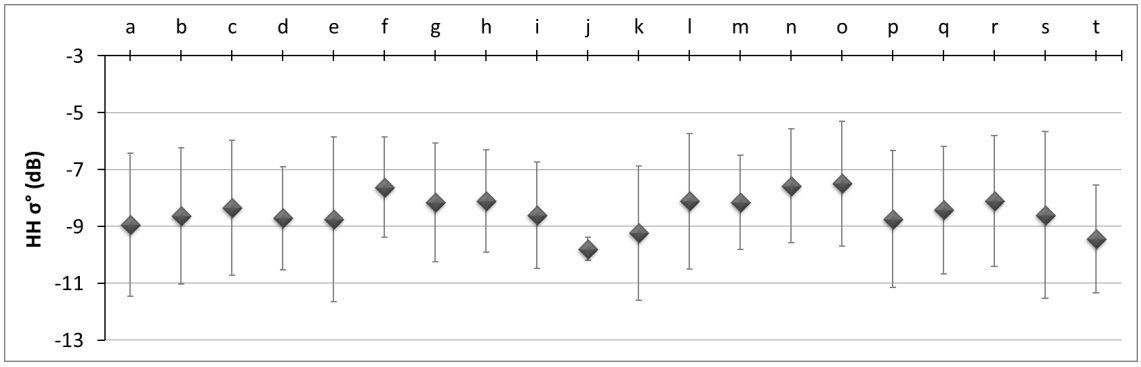
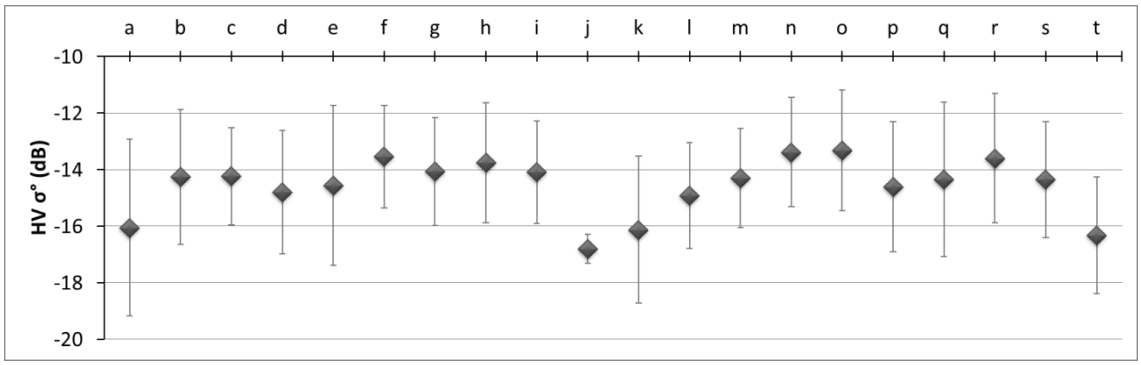


Figure 3. Composite of ALOS-PALSAR, R=HH, G=HV, B=HH/HV.

We collected ROI to know characterization of mangrove forest based ALOS-PALSAR. ROI spread overall Indonesia archipelago from (**a**) Langsa Aceh until (**t**) Merauke Papua. And then calculate mean and standard deviation from each ROI. Mean and standard deviation value for each ROI can see in the figure 4.



(a)



(b)

Figure 4. Mean and standard deviation of backscatter coefficients
(a).HH and (b). HV.

In figure 4, we had seen characterization backscatter coefficient of mangrove forest. Characterization of mangrove forest for mean of HH value around -10 dB until -7 dB and mean of HV value around -17 dB until -13 dB. According scatter graph in figure 5, mangrove forest in Indonesia archipelago that can be classified on three classes. According to Takeuchi et al., [6] the higher of HH and HV value has the higher of tree and this condition can be indicated higher of biomass.

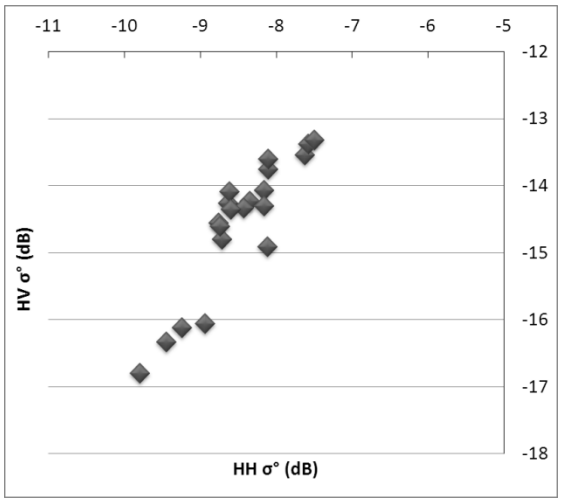


Figure 5. Scatter graph HH and HV.

Based on characterization, we classify of mangrove forest on three levels of biomass that are low biomass, moderate biomass and height biomass. According Rusila et al.,[5] type of mangrove majority In Indonesia in open zone and payau is *Sonneratia alba and Nypa* (low biomass), middle zone is *Rhizophora* (moderate biomass), and land zone tree mangrove (highest biomass) and According Kusmana et al.,[9] Indonesia has three species majority of mangrove that are *Rhizophora, Bruguiera,* and *Ceriops.* Classification of mangrove forest based on characterization of ALOS PALSAR on three level biomass can see in the figure 6.

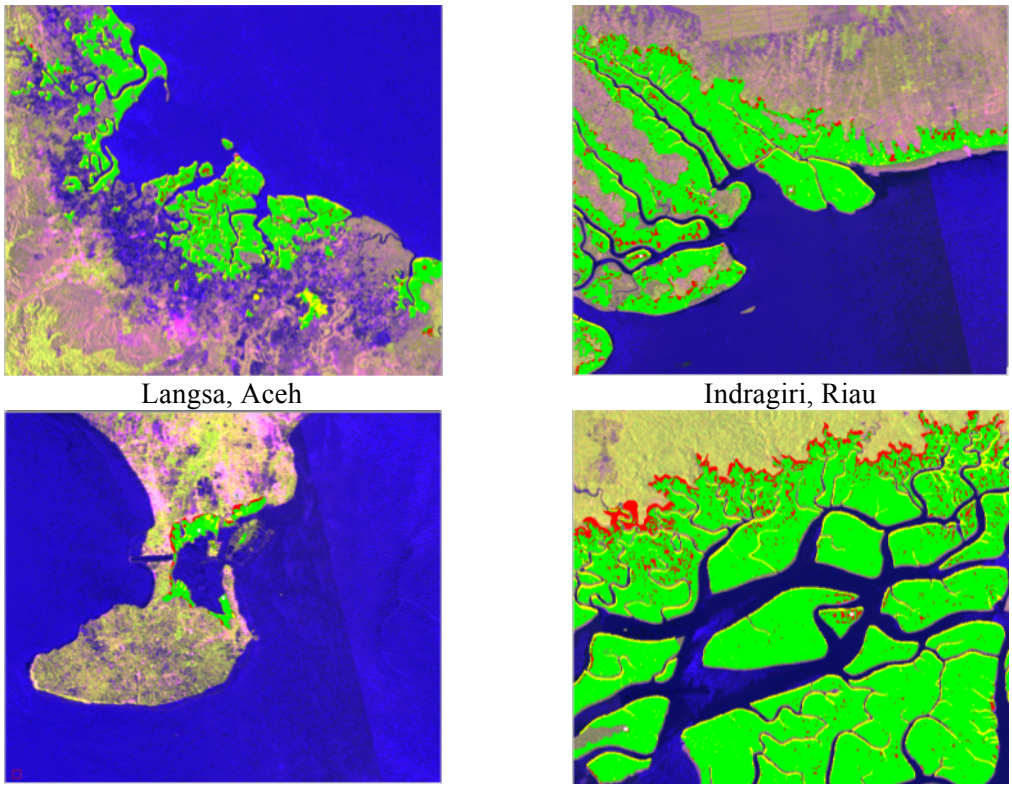


Figure 6. Spatial distribution of level biomass mangrove forest
Yellow=low biomass, green, moderate biomass, red=highest biomass.

4. Conclusion

We have showed characterization of mangrove forest types based on ALOS-PALSAR in overall Indonesia archipelago. Based on characterization Indonesia mangrove forest types has HH value around -10 dB until -7 dB and HV value around -17 dB until -13 dB. That can be classified into three level biomass of mangrove forest. Generally level biomass of mangrove forest in Indonesia archipelago is moderate. For future works we will validate image that has been classified and then if result of validation have accuracy assessment value very small we will try to classify using another parameter such as topography, geomorphology and tidal effect.

Acknowledgement

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