Study of potential applications of LAPAN-A3/IPB satellite's multispectral imager

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ABSTRACT

Since launched in 2015, LAPAN-A3/IPB satellite has been collecting many images of the surface of the earth. These images were taken by multispectral imager carried by the satellite. However, these data are not completely utilized yet. Therefore, this paper presents the potential applications of LAPAN-A3/IPB satellite multispectral imager. Literature study has been being done to find the research using the data form other satellites where their payload is similar to LAPAN-A3/IPB satellite. Because of the multispectral imager of LAPAN-A3/IPB has four bands (red, green, blue, and nir-infrared), most of the applications found are the application based on vegetation indices. It is found that LAPAN-A3/IPB satellite data is possible to support green open space mapping in the city, assessing soil saline degradation, measuring colored dissolved organic matter absorption, predicting land use land cover change and its effect on soil erosion, asses protective role of coastal woody vegetation against tsunami, asses resource development footprints using remote sensing, detect lahar path, and monitor urban growth.

Keywords: LAPAN-A3/IPB Satellite, Multispectral Imager, Vegetation Indices

1. INTRODUCTION

LAPAN/IPB A-3 Satellite was launched in 2015 from Satish Dawan Space center. Although it has been operating for 4 years, until today, the use of the images collected by multispectral imager of this satellite are not maximized yet. It is important to make the data collected to be maximized on its use. Based on this background, this paper presents its potential applications.

2. METHODOLOGY

The potential applications are given based on literature study about the research using data from other satellites where their data can be also taken by LAPAN-A3/IPB satellite. The multispectral imager of this satellite has 4 band with specification are listed in the Table 1[5]. They are quite similar with Landsat specification so that most of its potential application is based on the research using Landsat data. With satellite altitude of 510 kilometer and imager swath-width of 120 kilometer, in theory LAPAN-A3 multispectral imager will have 21 days temporal resolution[13].

Table 1. LAPAN-A3/IPB Satellite multispectral imager specification

Bands	Wavelength (micrometers)	Resolution (m)
Bands 1 – Near Infrared (NIR)	0.77 - 0.9	18
Band 2 – Red	0.63 – 0.7	18
Band 3 – Green	0.51 – 0.58	18
Band 4 - Blue	0.41 – 0.49	18

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Sixth International Symposium on LAPAN-IPB Satellite, edited by Yudi Setiawan, Lilik Budi Prasetyo, Yuji Murayama, Kasturi Devi Kanniah, Gay Jane Perez, Pham Tien Dat, Proc. of SPIE, Vol. 11372 113721Z · © 2019 SPIE · CCC code: 0277-786X/19/$21 · doi: 10.1117/12.2542769

Based on the specification listed on the Table 1 and the literature study, It is found that LAPAN-A3/IPB satellite data is possible to be used to support green open space mapping in the city, asses soil saline degradation, measure colored dissolved organic matter absorption, predict land use land cover change and its effect on soil erosion, asses protective role of coastal woody vegetation against tsunami, asses resource development footprints using remote sensing, detect lahar path, and monitor urban growth.

3. RESULTS AND DISCUSSION

Based on the literature study, the explanation about that potential application are given below.

3.1. Supporting green open space mapping in the city

Urban green spaces is the area in urban covered by mainly vegetation[23]. They give an significant contribution for sustainable development[15]. They are considered to be substantial importance for quality of life, since they have a significant impact on ecosystem functions, local microlimate, air quality, noise absorption, water resource protection and biodiversity protection[24]. Because of that, Fitriani et all[12] used remote sensing data to map green space map in Jakarta. They used NDVI (Normalized Difference Vegetation Index) from Landsat 8 and SPOT 6 data which have geometrically and radiometrically corrected. The NDVI is is given by

$$NDVI = \frac{NIR - RED}{NIR + RED} \tag{1}$$

where NIR and R are near-infrared reflectance and red reflectance.

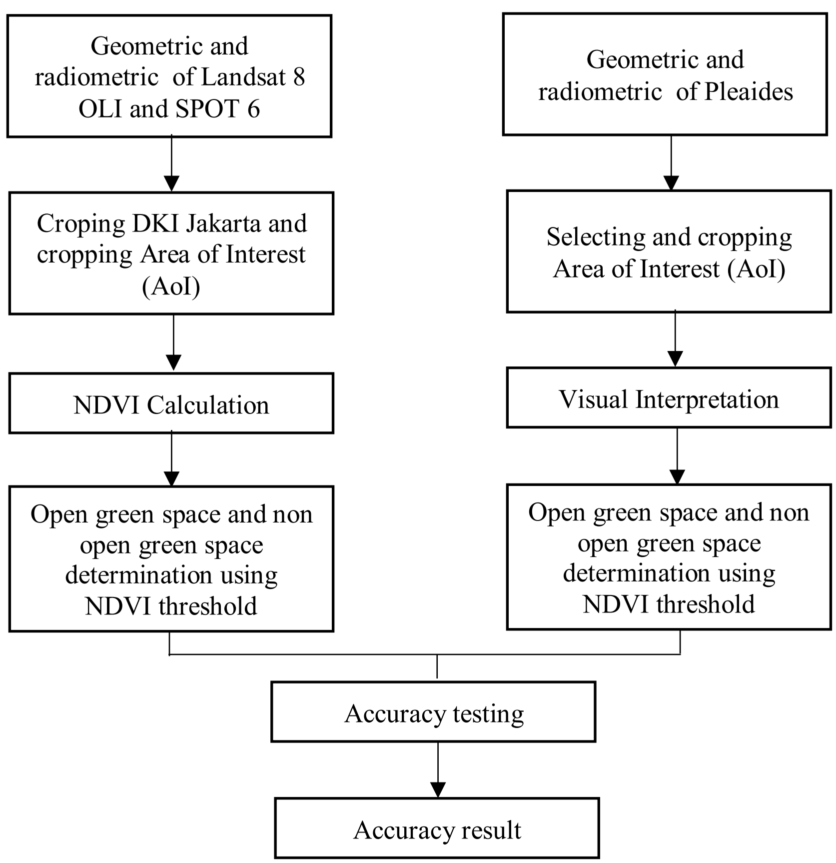

Figure 1. Research flow chart done by Fitriani.

By NDVI threshold, they separated open green space and non open green space. To measure the accuracy of Landsat 8 and SPOT 6, the results were compared to higher resolution camera from Pleiades data. The green open space classification from Pleiades is classified by visually interpreting the traing sample with the RGB composition. The flowchart of their research is given by Figure 1. From their research, it was concluded that Landsat 8 and SPOT 6 images can be used to identify the green open space.

3.2 Assessing soil saline degradation

Soil Salinization is the process of enrichment of soil with soluble salts that result in the information of salt affected soil[7]. It triggers the process of soil erosion and sometime becomes geo-hazard by making the ground condition unsuitable for construction due to subsidence, corrosion and low bearing capacity of saline soil[20]. Land degradation implies temporary or permanent recession form higher to lower status of productivity, such as reduction in fertility, erosion, salinity and excessive flooding[1,2].

Mohamed A.E et all used remote sensing method to make quantitative assessment about soil degradation[1]. That research was done on Siwa oasis, western desert, Egypt. To see the degradation, they used Landsat images on different years, 1987, 2002, 2007 and 2017[1]. To se the spatio-temporal change of vegetated area, they used index proposed by Huete called Soil Adjusted Vegetation Index (SAVI) given by

$$SAVI = \frac{NIR - R}{(NIR + R + L)}(1 + L) \tag{2}$$

where L is soil brightness correction factor which ranges between 0 and 1 based on the density of vegetation cover. In their research, Mohamed A.E et all used 0,5 for L. It was found that agriculture area was increased. They also estimated the water bodies area using indices proposed by Mcfeeters [20]

$$NDWI = \frac{G - NIR}{G + NIR} \tag{3}$$

where G id green reflectance. It was found that the water body was increased so that it could be concluded that the drainage it that area was poor. To observe the salinity of the soil, Mohamed A.E et all used salinity index given by[11]

$$SI = \sqrt{G^2 + R^2 + NIR^2} \tag{4}$$

Form this indices, it was found that there was an increase on soil affected by salt. It was the implication if the increase of agricultural areas and conventional irrigation system causing poor the drainage.

3.3 Measuring colored dissolved organic matter absorption

Colored dissolved organic matter (CDOM) is photoactive fraction of organic carbon where usually expressed as the absorption coefficient of water sample filtered through 0.2 μm filter[27,19]. The monitoring of CDOM is important for studies associated with the carbon cycle, global warming, and climate change[27]. Because of that, Fernando Watanabe et all uses Landsat satellite to measure the absorption of CDOM coefficient[27]. They did the case study in Itumbiara Hydroelectric Reservoir (IHR). To do that, they evaluated some retrieval algorithm for aquatic CDOM proposed for different types of waters first. Then, they calibrate theses algorithm using field data. After that, they adjust new algorithm based on Landsat 5 TM bands.

From their research, Landsat 5 TM can be used for predicting a_{CDOM} although it has a poorer radiometric resolution and signal-noise ratio than Landsat 8 OLI. After evaluating some retrieval algorithm for aquatic CDOM and calibrating theses algorithm using field data, it was concluded that the best formula for measuring a_{CDOM} using Landsat 5 TM are

$$a_{CDOM}(412) = 10^{3.493 - 8.1296 p_{12} + 3.9929 {p_{12}}^2} \tag{5}$$

$$a_{CDOM}(443) = 10^{5.3311 - 12.579 p_{12} + 6.3982 {p_{12}}^2} \tag{6}$$

where 412 and 443 are the wavelength absorbed in (μm) and p_{12} is the blue green ratio.

3.4 Predicting land use land cover change and its effect on soil errosion

Soil erosion refers to the wearing away of field topsoil by natural physical force of water and wind. It is an important social and economic problem and essential factor assessing ecosystem health and function[8]. Because of that, assessing soil erosion becomes very important in the last few years. Studying about it connection to land use land cover change is also become a serious interest[16]. This because the change in land use pattern due to agricultural intensive practice and deforestation causes land fertile degradation process[16].

One example of study about soil erossion is study done by Aafaf El Jazouli et all. They used remote sensing data to predict the land use land cover change effect on soil erosion on the high basin of the Oum Er Rbia river, Morocco. To do that, they used Landsat ETM and Landsat 8 OLI images taken on 2003, 2013 and 2017. To forecast and predict the land use land cover and it change, they use Autamata Markov (CA Markov) model. The flowchart of their research is given on the figure below.

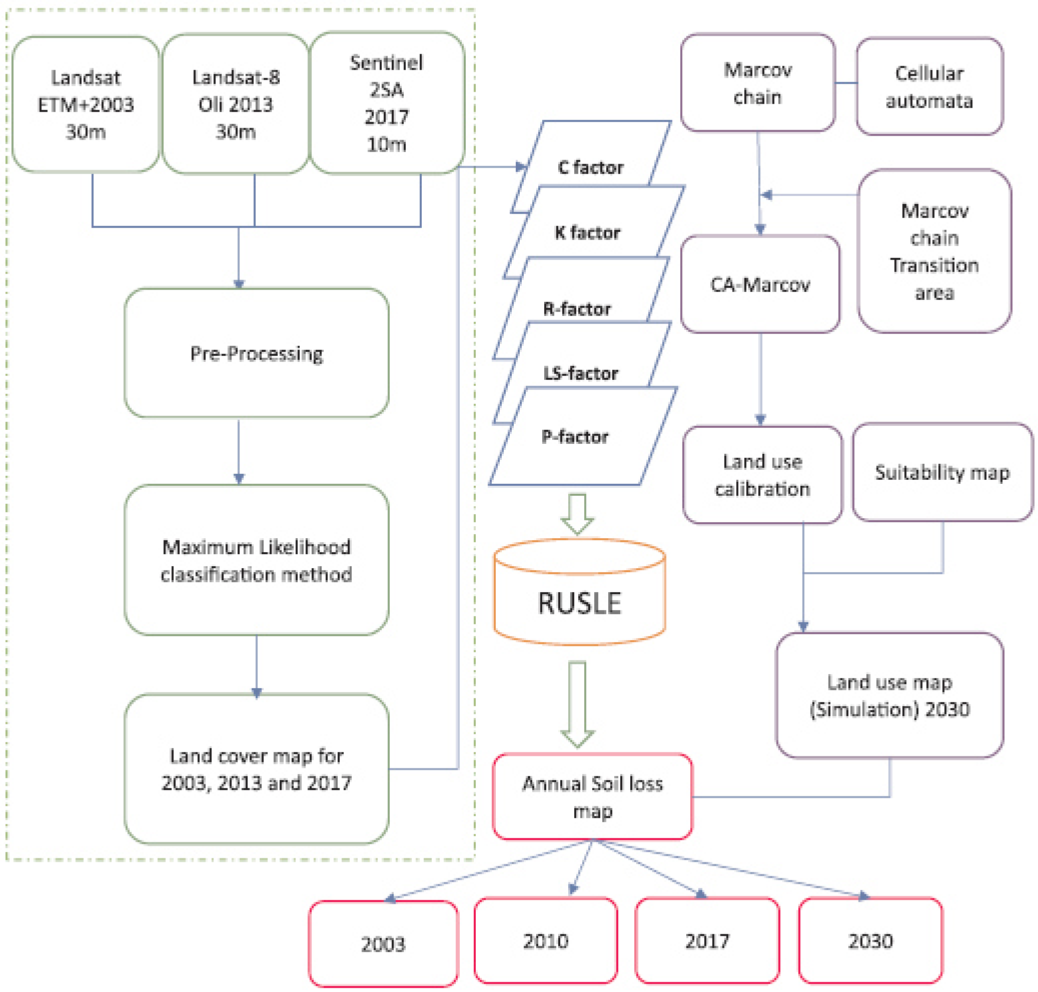

Figure 2. Research flowchart[16]

3.5 Assessing protective role of coastal woody vegetation against tsunami

The Indonesian region and surrounding area have very complicated plate-convergences consisting of subduction, collision, back-arc thrusting and back-arc resulting this region to be the most tectonically active area in the world[14]. As a result, many earthquakes generated large tsunami that killed thousands of people[14].

Coastal ecosystems may indeed act as a buffer against tsunami through a reduction of water flow speed and inundation depth, debris blockage, their life saving role for people washed away by waves, and formation of sand dunes resulting form sand accumulation in front of the forest[10]. Many publications and reports confirming the positive role of coastal vegetation in tsunami attenuation, and based predominantly on qualitative evaluation of the pre and post tsunami situation in the affected areas, reached the public after 2004 Indian Ocean Tsunami[10].

M.F. Olwig[21] used remote sensing to asses the protective role of coastal woody vegetation against tsunami, especially mangrove. Mangrove forest are tropical tress growing in coastlines, mudflats, and river banks in many part of the earth[25] and gives numerous benefit and services to society. Indonesia has the world's largest proportion of mangrove surface area, though currently less that half its original extent[22].

To do that, the first thing that they did is to determine whether substantial mangrove forest exist. They identified the mangrove forest using Landsat ETM images. Areas covered by mangroves were identified using information about wetness form the near infrared (NIR) bands as well as the the texture that is characteristic of mangrove[21].The vegetation is divided into three categories:

1. Dense woody vegetation included all the mangrove and shelterbelt areas
2. Open woody vegetation included all other woody vegetation such as degraded mangrove
3. No woody vegetation

Once the presence of mangrove was established, they tried to find the report about substantial damages[21]. Then, they identified and digitized post-tsunami damages. The damages was dividing into four categories:

1. Severely damages (all or most the physical infrastructure had been destroyed, removed or damaged)
2. Partially damaged (some damage but most of the physical infrastructure were intact)
3. Undamaged (no damage visible on the ground or on satellite images
4. Area inundated by water but otherwise undamaged.

By comparing the images on pre and post tsunami, it was found that the presence of woody vegetation was able to protect the region behind them. It also showed that remote sensing images is effective and efficient to assess the different in impact of the tsunami.

3.6 Assessing resource development footprints using remote sensing

Mine environment problem caused by the exploitation of mineral resources has become a key factor which affects normal production of mine and safety of ecological environment for human settlement[17]. Because of that, mining area needs to be monitored. Remote sensing data can provide information on changes to surface water and land cover over time, which is essential for environmental monitoring in mining areas[9]. It is also ideal for environmental impact assessment due to their broad spectral range, affordable cost, and rapid coverage of large areas[9].

Alex M. Lechner et all used remote sensing data to assess change in mining land cover. The pre-existing land uses, such as agriculture and human settlement creating spatial constraint that drive the trade off between the development and operation of a mine and other alternative land uses. Disruptions to both physical and sociological environment can invoke powerful responses from people affected by the change. So that, spatial analysis using historical data remote sensing can be used to go back in time to assess the change in mining land cover to better understanding the cause of present complexity. They used Landsat images 2002, 2005 2008 2010 2011 2013 2015 and 2017.

To classify the mining land cover, all Landsat images are classified using a maximum likehood classifier in ArcGIS. The region was classified to be relevant mining and non-mining land cover in and around a mine site. It can be used to guide the development of an actual land cover scheme based on what is achievable within the limitations of Landsat satellites's spectral and spatial characteristics. The classification is shown in Figure 3[6]. More detail about that classification is given on Alex M. Lechner et[6].

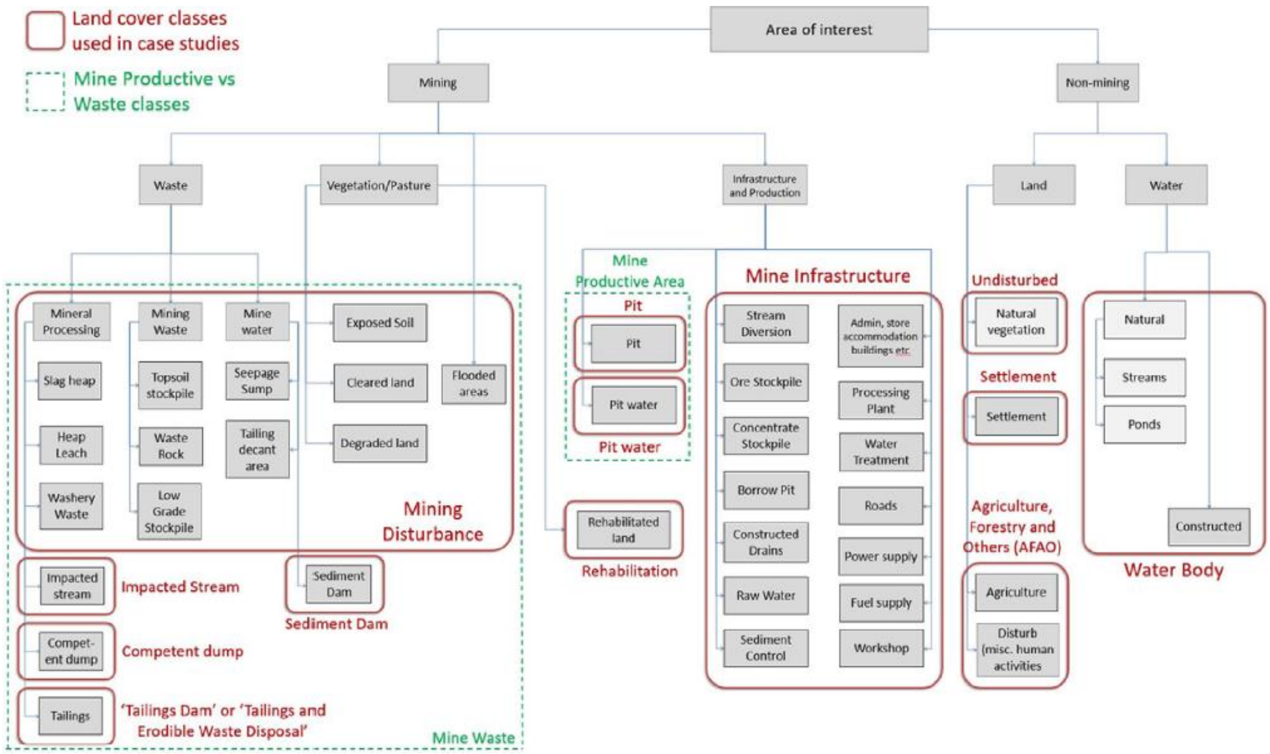

Figure 3. Gold mining idealized land classification[6].

From the observation using Landsat images, they observed that the amount of undisturbed land decrease as the land disturbed by mining increasing. Then, they analyze the spatial and temporal relationship between key type of land cover: mine pits, waste, disturbed land, and mine infrastructure to characterize the socio-environmental footprint of the project over time. Finally, they relate their site-based knowledge of local effect to remote sensing historical mapping to describe how temporal change in mining operation affect community land cover. This spatial temporal data is very important for more holistic study. This data is needed for transdisiplinary study called spatially integrated social sciences.

3.7 Detecting lahar path

Remote sensing approach can be used to map the source and extent of vulcano debris[6]. Karen E Joy et all used remote sensing data to detect lahar path of Mt Ruapehu[6]. The vulcanic activity during 1995-1996 emptied crate lake and deposited 8 m thick blanket of tephra creating the potential of for an overfilled lake to develop behind an unstable natural dam. In 18 March 2007, the refilling crate breach this barrier during rainstorm. This research is to map the lahar deposite and it path to provide the basis of hazard zonation and validation of pre-existing map.

To study that, they used ASTER imager with 15 m ground resolution element acquired before (9 February 2002) and after (25 March 2007). NDVI was calculated on after images ti restrict the area of analysis to unvegetated surface.

To measured the accuracy, the images were compared to manually digitized from 18 to 21 cm spatial resolution aerial photography. In their paper, it was concluded that optical data were proved to be fast, accurate, and the most cost effective method for lahar path deposite.

3.8 Monitoring urban growth

Over the last few decades, urbanization has been occuring impacting the ecosystem[4]. In comparison with traditional methods, satellite remote sensing method is considered to be an effective although costly way of illustrating the relationship between the environment around the urban area and its population[4].

Mansour Al Moudi et all used Landsat data to monitor urban growth in Jeddah. They used The eight images were used to identify urban growth development as well as land use and land cover classification in Jeddah City. In his research, they used Principle Component Analysis (PCA) and NDVI to appraise a detail training site. The results of our analysis show that urbanization in the study area increased by 109.76 km2 for the period 1973–2014.

4. CONCLUSIONS

Based on the explanation above, because all satellite data used are the bands that LAPAN-A3/IPB has, so it is possible to use LAPAN-A3/IPB multispectral data to do the similar research. In addition, to apply the multispectral data, others supporting data are also needed.

ACKNOWLEDGEMENT

This research was supported by Satellite Technology center of National Institute of Aeronoutics and Space (LAPAN). We are thanks to head of Satellite Technology Center and all crews of LAPAN satellite operator.

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