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THE COMPLETION OF THE GIS (GEOGRAPHIC INFORMATION SYSTEM) ANALYSIS ACTIVITY IN MERU BETIRI NATIONAL PARK, EAST JAVA

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Bogor, 2010

INITIAL PHASE OF MEASURING CARBON SEQUESTRATION FOR REDD+ IN MERU BETIRI NATIONAL PARK, INDONESIA:
LANDCOVER CHANGE ANALYSIS USING REMOTE SENSING AND GIS

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SUMMARY

SPOT, ALOS and LANDSAT are satellites developed to perform observation on the earth surface in effort to monitor environment and to conduct inventory of natural resources. The images have been widely used by researchers in the world to observe phenomenon related to land cover changes. The images or data provide different spatial resolution, 20m in SPOT 4, 10 m in ALOS AVNIR-2, and 30 m in LANDSAT TM.

This report presents the analysis of processing image interpretation of SPOT 4, ALOS AVNIR-2 and LANDSAT TM. The project activity aimed to define land cover classes according to Directorate General of Forestry Planning classification and the changes over ten-year period using satellite images in each two-year interval period, starting from 1997 to 2010. The applied Methodology included image pre-processing, determination of training area, ground truth, and supervised classification.

The use of images resulted classification of variety of land cover classes in Meru Betiri National Park (MBNP) of East Java. The result of supervised classification was then compared with ground truth in the field. The applied supervised classification method classified land cover into 10 classes namely: primary dry land forest, secondary dry land forest, primary mangrove forest, bushes, swamp with bushes, urban area, plantation, bare land, cloud and no data. The results showed that there has been no continuous rapid deforestation, since the trend of the area in forest class from 1997 to 2010 has been relatively stable.

Keywords: Satellites images, deforestation, Meru Betiri National Park

RINGKASAN

SPOT, ALOS dan LANDSAT merupakan satelit yang dikembangkan untuk melakukan pengamatan di permukaan bumi dalam upaya untuk memantau lingkungan dan menginventarisasi sumber daya alam. Secara luas, citra-citra tersebut digunakan oleh banyak peneliti di seluruh dunia untuk mengamati fenomena yang berkaitan dengan perubahan tutupan lahan. Tiga data citra tersebut menyediakan perbedaan resolusi spasial, yaitu SPOT 4 20 m, ALOS AVNIR-2 10 m, dan LANDSAT TM 30 m.

Laporan ini menyajikan proses analisis dan interpretasi citra SPOT 4, ALOS AVNIR-2 dan LANDSAT TM. Proyek Penelitian ini bertujuan untuk menentukan kelas-kelas penutupan lahan menurut klasifikasi Kehutanan Biro Perencanaan dan perubahannya selama sepuluh tahun menggunakan citra satelit dengan periode dua tahun mulai dari 1997 sampai dengan tahun 2010. Metodologi yang diterapkan antara lain pra-pengolahan, penentuan daerah pelatihan dan survey lapangan, klasifikasi terbimbing.

Penggunaan citra-citra tersebut menghasilkan klasifikasi dari berbagai kelas penutupan lahan di Taman Nasional Meru Betiri di Jawa Timur. Hasil klasifikasi terbimbing kemudian dibandingkan dengan hasil survey lapangan. Hasil klasifikasi terbimbing menghasilkan 10 kelas tutupan lahan : hutan lahan kering primer, hutan lahan kering sekunder, hutan mangrove primer, semak-semak, rawa dengan semak-semak, daerah perkotaan, perkebunan, lahan kosong, awan dan tidak ada data. Penelitian ini menunjukkan bahwa deforestasi cepat yang terus menerus terjadi tidak selalu benar, karena trend daerah di kelas hutan 1997-2010 cenderung stabil.

Kata Kunci : Satelit data, deforestasi, Taman Nasional Meru Betiri.

I. INTRODUCTION

1.1. BACKGROUND

ITTO (International Tropical Timber Organization) program has been implemented due to concern of fast devastation of tropical rain forest. At the moment, the level of forest deforestation and degradation especially in tropical developing countries has been very high due to unsustainable management. In term of climate change, the high rate of deforestation has produced emission and significantly contributed to global warming due to high CO2 emission. By having the program of forest conservation, it is expected that countries of tropical timber producers would be able to manage their forest resources sustainably. Some forest areas have been determined as conservation areas meanwhile other areas are used for production of timber to support national development.

Data of the world forests 2007 issued by FAO mentioned that Indonesia's deforestation rate from 2000 to 2005 reached 1.8 million hectares per year. Deforestation rate in Indonesia was 2% per year. This condition, if there is no action performed, will result in the increase of levels of emissions of carbon dioxide (CO2). In a meeting of G20 countries in Pittsburgh, USA, Indonesia committed to reduce carbon emissions (CO2) emissions by 26% in 2020 and by 41% with international support. The amount of 14% is expected to come from the forests of Indonesia. Through this mitigation effort, Indonesia is highly eager to assist the world in avoiding disaster due to climate changes.

Meru Betiri National Park (TNMB) and its surroundings area have a total tropical forest area of 58,000 hectares. This area as conservation area has potential carbon stock and it is important to keep this area green as carbon sink to anticipate global warming. International Tropical Timber Organization (ITTO) has started a pilot activity on REDD+ in Meru Betiri National Park with objective to reduce emission from conservation area through community participation and development of measurable, reportable and verifiable (MRV) system in carbon accounting. Activities have been implemented by executing agency of Forestry Research and Development Agency (FORDA) of the Ministry of Forestry of the Republic of Indonesia, in cooperation with Meru Betiri National Park, NGO and Universities.

Act No. 41 / 1999 on Forestry, Act No.26 / 2007 on the spatial planning, PP (Government Regulation) No. 6/2007 and its revision in PP No. 2008 have provided framework and legal basis in mitigating climate change through reducing emissions and deforestation as well as forest degradation, including accommodating the provision of access and management of forest resources to communities around the forest.

The use of information data of remote sensing, especially satellite imagery nowadays is considered best because it has a high level and multi-temporal resolution. In each recording of the image, the aspect of a particular object that is wide enough (forest) can be identified without exploring the whole area surveyed. Thus, this method can save time and cost in implementation in comparison to terrestrial survey. In this study, the images of ALOS, SPOT and LANDSAT were used within 10 years interval.

1.2. OBJECTIVE

Investigation using GIS (Geographic Information System) in Meru Betiri National Park has objective to identify land use change by using remote sensing data in order to support the activities of reducing emissions from deforestation, forest degradation and increasing carbon stocks to conserve the national park.

1.3. TARGETS

The completion of GIS (Geographic Information System) analysis activity in Meru Betiri national park has the following targets.

a. To provide land cover map over ten-year period using satellite images with two-year interval starting from 1997 up to 2010 (1997, 2001, 2003, 2005, 2007 and 2009)
b. To define land cover type in MBNP
c. To identify the area of land cover changes

1.4. SCOPE

Scope of Project Implementation covered analysis using GIS (Geographic Information System) in Meru Betiri National Park, interpretation and image analysis to determine land cover changes of Meru Betiri National Park during the years 1997 to 2010 with a period of 2 years, preparing and presenting the results of analysis, preparing a report with the format of ITTO (International Tropical Timber Organization) and conducting an evaluation after the activities.

1.5. LITERATURE STUDY

Remote sensing as an observation technology has been used long to identify the environmental changes caused by the increasing energy demand and human activities around forests. Other studies on land cover changes have been made by using various types of satellite images. Among them are researches conducted by Hill and Sturm

(1991); Liew et al. (1998); Lohnertz (2006), Atkinson et al. (1997); Kanello Poulos et. al (1992), Cross et. al (1991), Du Jin Kang et al (2001), Dongmei (2002), Zhao Phing et al (2003). The methods used are classification, transformation and integration of GIS and classification.

Perumal and Baskaran (2010) examined the performance of supervised classification using LANDSAT and SPOT HRV satellites. The study showed that supervised classification was much better than the unsupervised one. In addition, the method of classification of maximum similarity can be used to determine land cover. Studies of land cover have been conducted i.e by Verhoeye (1999) and Millington et al. (2002). Collado et al. (2002) have observed the process of land degradation by using spectral analysis derived from a multi-temporal LANDSAT imagery. This degradation process is characterized by the process of change of a land into dry and barren land. According to Collado et al. (2002), unmixed spectrum shows vegetation while the mixed spectrum shows signs of degradation on the land. Millington et al., (2002) also conducted study of land cover by adding precision to the classification.

The study of land cover in Africa by using transformation has been carried out by Tucker (1985). From the results of transformation, a variety of vegetation densities are obtained and interpreted into land cover classes. In further development, the use of satellite images is integrated using GIS (Geographic Information System) to help correction in the classification.

From the results of studies by Ehlers (1991), Wang (1991) and Janssen (1990), the classification results obtained are more varied. Research by the International Mountain Society (2010) in Sagamartha National Park, Nepal by using ALOS AVNIR and LANDSAT found that there was a relationship between the role of forests in national parks and the problem of energy and human health. In addition, this study found that tourism activity occurred from 1992-2008 in the national parks affected forest conditions and land cover changes in the national park because of the increasing demand of forest wood as fuel. Millington et al., (2002) also investigated the changes of land in the surroundings forest areas by using LANDSAT imagery due to hydrocarbon exploration in forest areas that improve the agricultural colonization and development of road infrastructure in the area of forest. This study showed that the presence of regular patterns in the pixels provided an indication of the activities of land change in forest.

II. APPLIED METHODOLOGY

2.1 THE AREA OF STUDY

Meru Betiri national park that covers area of 58,000 hectare as conservation area is located in Regencies of Jember and Banyuwangi, East Java Province. It has a variety of flora, fauna and unique ecosystems that are potential to attract ecotourism. It can be reached from Jember and Banyuwangi. The distance from Jember is 64 kilometers or about 1.5 hours by car from Jember-Ambulu-Curahnongko-and Bandealit. From Banyuwangi, it takes about 4-4.5 hours by four wheel drive car from Banyuwangi-Genteng-Jajag-Pesanggaran-Sarongan-to Sukomade with distance of about 127 kilometers.

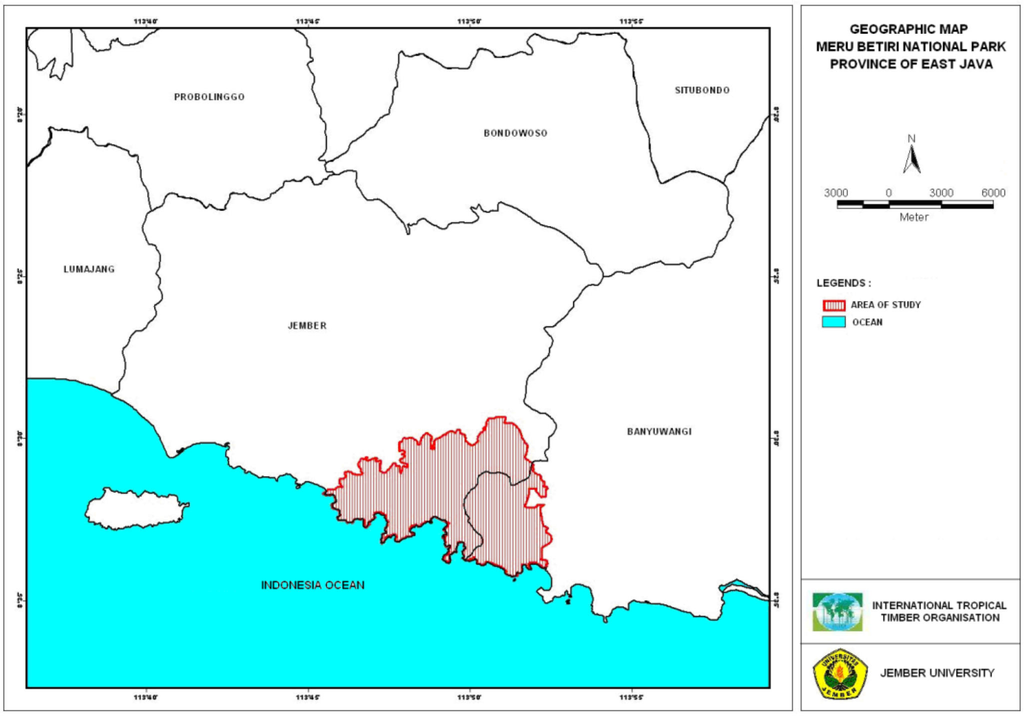


Figure1. Area of Study, Meru Betiri National Park.

Meru Betiri Area is situated 113º38’38” - 113º58’30” E and 8º20’48” - 8º33’48”S. The letter of decree No.277/Kpts-IV/1997 was issued by Forestry Ministry to decide that the area was 58.000 Hectares. Generally, the territory of the national park has tropical climate with various rainfall intensity from 2,544 to 3,478 mm per year.

2.2 DATA COLLECTION

Data used for the work of GIS (Geographic Information System) Analysis at Meru Betiri national park, East Java consisted of:

1. Multispectral images of SPOT 4 taken in 1997 and 2005, purchased from PT. Bhumi Prasaja in Bandung at Jurang Street 74, Bandung 40161, phone number:+(62)22-2038040.
2. Multispectral images of LANDSAT TM 7 obtained in 1999, 2001 and 2003. Images were downloaded from USGS's website since the purchase was not available and this was suggested by LAPAN (National Space and Aviation Bureau).
3. Multispectral images of ALOS AVNIR-2 acquired in 2007 and 2009 from LAPAN located in Jakarta at Pemuda Persil street 1, phone number:+(62)21-4892804email address: spacetech_lapan@yahoo.com.
4. Topography map of Indonesia issued in 2000 by BAKORSURTANAL (National Survey and Mapping Bureau).

2.3 RESEARCH EQUIPMENTS

The image processing used the Hardware i.e., Processor Pentium dual core, RAM 2 Giga Byte, Hard Disk 130 Giga byte and Monitor Color 14" Super Sync 4D, Keyboard and mouse. For software used, inlcude :

- ER Mapper Version 7.0 or Envi 3.1 as a processing and analysis tool in Remote Sensing field.
- ArcView version 3.2 to process Spatial Information Analysis Geographically.

2.4 ANALYSIS METHOD

There are three methods to process the image according to Projo Danoedoro (1996). The methods are:

1. Digital Transformation, which is digital processing to extract certain information and to reduce the annoying effect
2. Classification, which is processing images by classifying pixel value into land covers classes.
3. Integration of GIS (Geographic Information System) and Classification method, by integrating the result classification with other data using spatial information interpretation. This was to make interpretation of classification more reasonable, for

example: the remote sensing data coupled with the geomorphology map to inventory land cover and forest resources.

Based on the attained target, the interpreted land-cover classes would meet to the classification of Forestry Planning Bureau (2006). Therefore, it is important to select the combination of GIS and classification as the information of land cover classes obtained related to various aspects. This included not only land cover but also some characteristics of land use such as urban area, plantation and airport.

2.5 RESEARCH ACTIVITY

The activities were divided into two parts namely remote sensing processing analysis and Spatial Information Interpretation. For the image processing analysis, there were stages as a whole, using ER MAPPER as software. The following diagram in figure 2, shows the procedure for processing in remote sensing area.

1. Raw Image

This project used raw images of LANDSAT, SPOT 4 and ALOS AVNIR-2. Multi spectral images were taken in 1999, 2001 and 2003 derived from LANDSAT TM consisting of 7 bands having spatial resolution of 30 m. In addition, data of 1997 and 2005 were obtained from SPOT 4 censor in 3 bands and twenty-meter spatial resolution. In addition, multi spectral images of ALOS AVNIR-2 with 4 bands and resolution 10m for data acquisition in 2007 and 2009 were used.

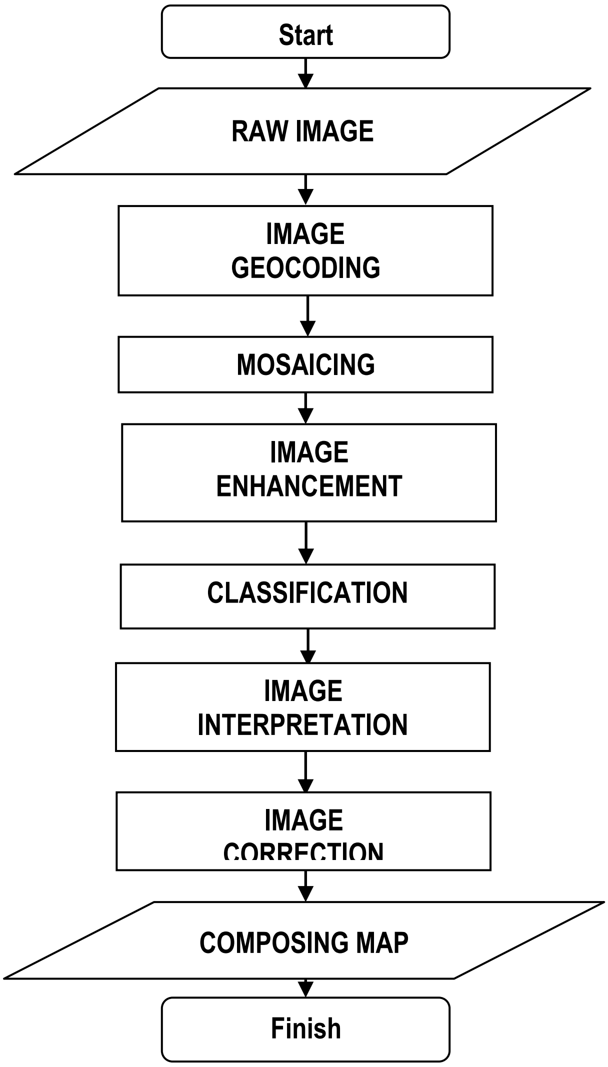


Figure 2. Flowchart of Remote Sensing Application for image classification

2. Image Geo-coding

The next step requires image geo-coding because the raw image data sometime contains distortion in geometric. Thus, it must be processed to remove the error of geometric. There are three processes applied:

1) Registration restoring or aligning the image position to enable them overlaid,
2) Rectification allowing them to be corresponded to real world map projections and coordinate systems,
3) Ortho-rectification considering account terrain and sensor calibration due to effect of vehicles.

In this study, the applied technique was rectification, because the error that derives the effect of velocity and height of vehicle happens rarely. It was calibrated using coordinate transformation of Universal Travers Mercator (UTM) in Zone 49 South and

Ellipsoid datum WGS 84. The transformation was conducted by adjusting to topography map of Indonesia with scale 1:25.000 issued by BAKOSURTANAL 2000, and GCP points measured by GPS (Global Positioning System).

3. Mosaicing

Normally, the study area is not formed in one image. It could be separated into two or more because of coverage and the track of satellite when orbiting the earth. Therefore, overlapping the images was performed to create a continuous representation of the area.

The composing of the image mosaic can be done easily because two images or more are referenced in the same geographic positions. It can be automatically displayed in the same processing algorithm.

4. Image Enhancement

The image Enhancement was undertaken to show image more contrast and more easily to be analyzed visually especially on the appearance of land cover. The Process used the ERMapper software. There are three ways to enhance the image; fusion enhancement, filter enhancement and contrast enhancement.

In fact, the Improving of the quality in the image satellite is intended to interpret and identify land cover classes easily by maximizing the contrast between light and dark portions in satellite image. Therefore, the possible way to carry out enhancement is contrast improvement, since fusion has to do with merging two images from different spatial resolution, while the filter enhancement is used to extract linear shape in the image. The contrast enhancement affects greatly on the image composite that contains multi spectral image of RGB (Red – Green – Blue) or IHS (Intensity Hue Saturation).

5. Classification

After correction and enhancement process, the classification process on image was done to identify types of land cover classes from satellite images. It statistically grouped the clusters pixel values into thematic categories or feature classes. There are two type of classifications; supervised and unsupervised classification.

The supervised is able to yield the realistic classes since it uses training area to define the number of classes. There are four algorithms in the supervised classification:

minimum distance to mean, box classification, maximum likelihood and K-nearest Neighbor Algorithm.

Classification was accomplished by maximum likelihood algorithm due to widely known and faster to process. This method was calculated based on:

1) The known area is considered as sample to find the different objects easily.
2) The area is identified through thematic maps which have already been plotted before.

The decision maker looking at maximum likelihood using the following equation:

$$D = \ln(a_c) - \left[0,5\ln\left(\left|Cov_c\right|\right) - \left[0,5\left(X - M_c\right)^T \left(Cov_c^{-1}\right)\left(X - M_c\right)\right]\right] \quad ...... \quad (1)$$

where, D = distance with probability; C= a certain class; X = classified pixel vector; M_c = mean vector of class sample; a_c = percentage of probability for any pixel to be a member of class c, which is default value is 1,0 from a priori information, Cov_c = covariant matrix of pixels on class sample c; $\left|Cov_c\right|$ = determinant Cov_c $\left(Cov_c^{-1}\right)$ = matrix invert of Cov_c .

Using the equation (1), a pixel is included into class C, if D value for c class is the lowest. Theoretically, the algorithm will work well, if the histogram shape in the involved bands in the process shows normal distribution, since it takes into consideration larger statistic variables than those of other methods.

6. Image Interpretation

The data interpretation is aimed at identifying land cover objects on an image visually to optimize the classification yield. The observation is based on texture, tone, brightness so that the image will appear 3-dimensional shape. Also, by studying the pattern arrangement, it can be useful to estimate specific land cover classes such as paddy field and plantation.

The Image Interpretation produces more reasonable analysis by observing characteristics of land cover related to aspects of interpretation. For example, urban area class will appear on flat landscape rather than on steep and hilly landscape. The feature of delta, coast and swamp as bare land class will appear nearby river and ocean.

7. Image Correction

The correction of image after interpretation is necessary to be undertaken by integrating image with other base maps, for example geomorphology map. The method was carried out using aid of Geographic Information system (GIS). GIS is a series of work both manual and digital supported by computer to make collection, saving, management as well as the presentation of data and information having geo-reference for specific goal. It is clear that data processed by GIS technique must refer to definite coordinate system.

The correction enables to reveal a number of land cover classes situated on irrational landscape. Besides, coupling geomorphology map will allow seeing clear borders of morphology, so that it can rectify the interpretation error. For example, bare land and urban area class are situated on flat land.

8. Map Composing

When map layout is printed on paper in certain size, composing map is necessary by GIS software assistance in order to get standard map. Therefore, it has important role to complete it adjust to what information intended on the map and the size.

The advantages of GIS in compiling map to get layout as desired are:

- *The Visualizing of the information* which is the presentation form of the information through visual. All information depicted on image can be seen, interpreted and in turn, analyzed.
- *The Organizing of the information* which is the arrangement of information based on the reasonable relation and spatial.
- *The Integrating of the Information* which is to compile data from the different source in scale, projection system as well as the way of storage.
- *The Analyzing of the Information* i.e. to analyze and to interpret data or information processed to a special requirement. The analysis process using GIS can be employed by combining all of parameters spatially, collecting and digitizing base map, Editing Data from image classification result in vector form, making spatial Data basis, spatial data integration, creating map's Index and legends.

III. PRESENTATION OF THE DATA

3.1. BANDS OF IMAGES

Data of LANDSAT TM (Thematic Mapper) contains 7-band spectrum i.e. 3 visible spectrums, one near-infrared, two middle infrared and one of thermal infrared as shown in table 1. The visible canal ranges 0.45-0.69 µm consisted of blue, green and red whereas middle infrared spectrum is divided into two spectrums which are middle infrared I and middle infrared II ranging 1,55-1.75 µm and 10.40-12.50 µm, respectively.

Table 1 Bands of LANDSAT TM

Band	Wave Range (µm)	Spatial Resolution (m)	Spectrum
1	0.45 – 0.52	30	Blue
2	0.52 – 0.60	30	Green
3	0.63 – 0.69	30	Red
4	0.76 – 0.90	30	Near Infrared
5	1.55 – 1.75	30	Middle Infrared I
6	2.08 – 2.35	120	Thermal Infrared
7	10.40 – 12.50	30	Middle Infrared II

The image of SPOT 4 is captured through censor of HRV (High Resolution Visible) with 3-band multi spectral mode and higher resolution than that of LANDSAT TM as indicated in table 2. In SPOT 4 image, visible spectrum is represented by 0.50-0.63 µm in range. The rest of canal is near infrared 0.79 – 0.89 µm in range.

Table 2 Bands of SPOT4

Band	Wave Range (µm)	Spatial Resolution (m)	Spectrum
1	0.50 – 0.59	20	Blue – Green
2	0.63 – 0.69	20	Red
3	0.79 – 0.89	20	Near Infrared

Data of ALOS AVNIR-2 image is past the censor with 4-band multi spectral which has higher resolution than those of other images as demonstrated in table 2.2. The visible spectrum on ALOS AVNIR-2 image ranges 0.42-0.69 µm. The other is near infrared canal having 0.79 – 0.89 µm in range.

Table 3 Bands of ALOS AVNIR-2

Band	Wave Range (µm)	Spatial Resolution (m)	Spectrum
1	0.42 – 0.50	10	Blue
2	0.52 – 0.60	10	Green
3	0.61 – 0.69	10	Red
4	0.76 – 0.90	10	Near Infrared

3.2. TOPOGRAPHY OF STUDY AREA

The type Land cover which is formed in the certain area is extremely influenced by the topography and morphology. Having the range of elevation from coastal line to 1.191 meter in height above sea level, Meru Betiri national park has types of morphology such as flat, undulating or sloping, hilly and mountainous. Based on it's morphology, the plain landscape in Meru Betiri area is classified into four flat plains namely flat plain, swamp plain, river-mouth plain and coastal plain.

The flat plain area is a part of land cover in which there are urban area, plantation and swamp classes. The plain morphology laid on the valley of hilly area has slope range between 0 and 2 %. Most of the area is occupied by the vegetation of the rain forest. In this type of land cover, the vegetation is also grown by palm trees, rubber trees, woody plant and bushes.

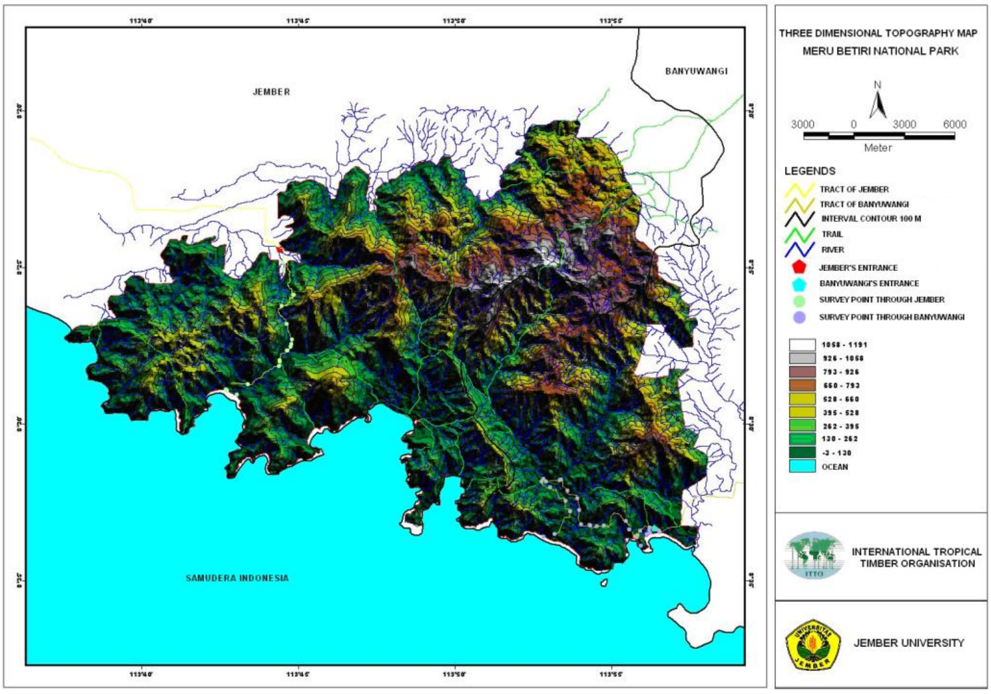


Figure 3. The 3-dimensional Map of Meru Betiri Area.

Swamp plain is the region having slope from 0 up to 2 per cent due to overflow from ocean or river. The flora found in this landscape include wild mango (*Mangifera sp*), sawo kecik (*Manilkara kauki*), rengas (*Gluta renghas*), pulai *(Alstonia scholaris)*, kepuh *(Sterculia foetida)* and Barringtonia spicota. This appearance can be found in Sukamade District.

The mouth-river plain is the area influenced by tidal wave and having slope of 0-2 %. The region is mostly set by mangrove trees situated in the eastern of Meru, Sukamade as well as Rajegwesi Gulf. Rajegwesi Gulf is located in the mouth-river of Lembu and Karang Tambak. The mouth-river plain is dominated by vegetation species such as pedada (*Sonneratia caseolaris*), tancang (*Bruguiera gymnorhiza*) and nipah (*Nypa fructicans*).

The coastal plain is a part of bare land class according to Forestry Planning Bureau Classes. It has slope from 0 to 2 per cent. The vegetation formation in this area is mostly vegetation of Baringtonia formation.

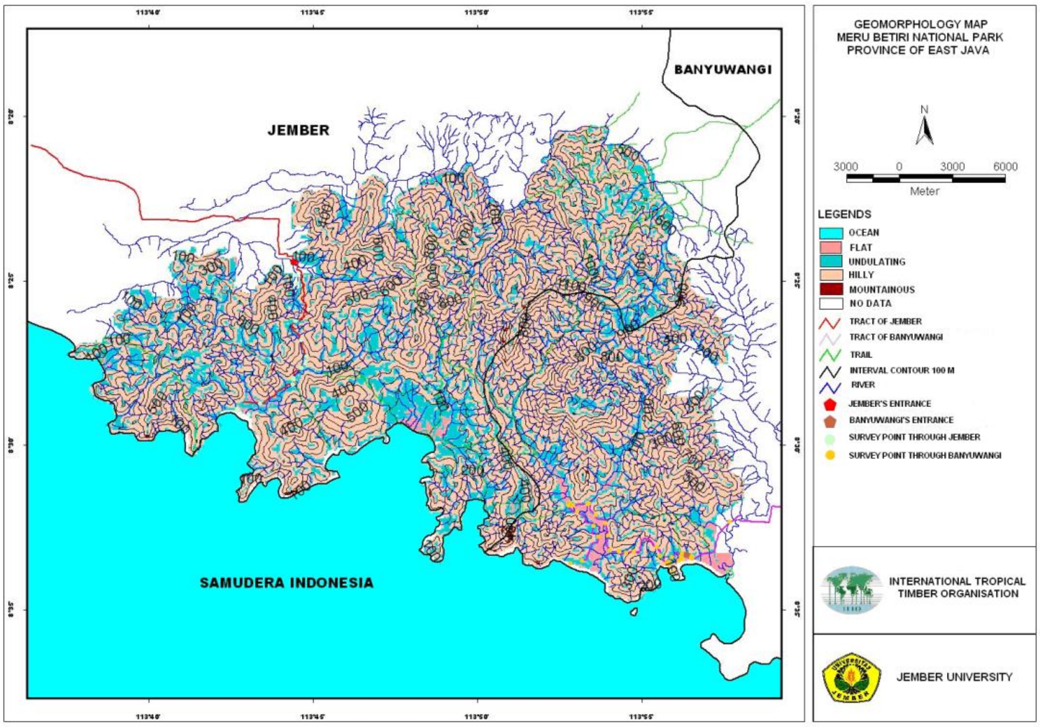


Figure 4.Geomorphology Classes in Meru Betiri National Park.

The hilly area is a part of south mountain ranges that consist of hill, hilly, hillside, mountainous and river valley characterized by slope of land ranges between 14 and 80 percent. The area of the river valley such as in Sukamade, Sanen and Bandealit is mostly grown by vegetation such as grass and several types of shrubs plant. On the hill side, it is dominated by big trees known as the primary forest. There are also secondary forest that has experienced logging.

IV. ANALYSIS, INTERPRETATION AND RESULTS

4.1 IMAGE ANALYSIS

Image analysis was carried out to gain land cover classes on the study area over three different images i.e. LANDSAT ETM7, SPOT 4, and ALOS AVNIR-2 image. Pre processing was done by the following order.

4.1.1 Image Geo-coding

There are several series stages which are explained in the following procedure to make geometric correction.

a. To define Ground Control Point (GCP)

The points which are chosen the object on the satellite image should be adjusted to them on the same object on the reference map in terms of position. The reference Map used is the border map obtained from The Meru Betiri National Park located in Jember. The points as control point must be identified easily on the image. For example, the control points situated nearby river meander, a lake, the edge line of island and bare land are clear on the image and the reference map.

b. To determine coordinate reference system, datum and the kind of transformation.

The reference system applied was coordinate system of SUTM 48 (South Universal Transversal Mercator Zone 48) using Datum WGS'84 (World Geodetic System 1984). The Method used in transformation cubic polynomial by taking into account topography relief in study area of The Meru Betiri National Park.

c. To specify rectification process.

The border map of Meru Betiri region from the topography map was selected as a base map as it has been corrected.

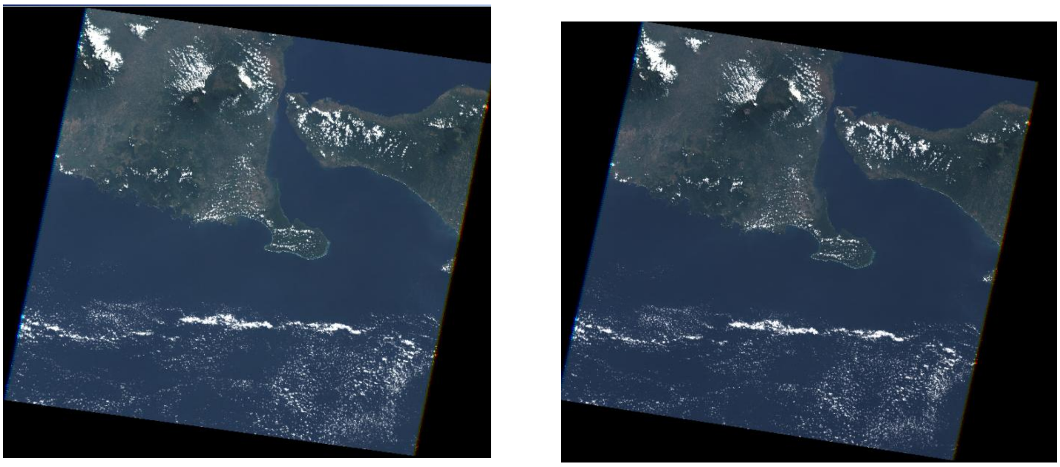


Figure 5. The raw image of LANDSAT TM before Geometric correction (Left side) and after the correction (right side).

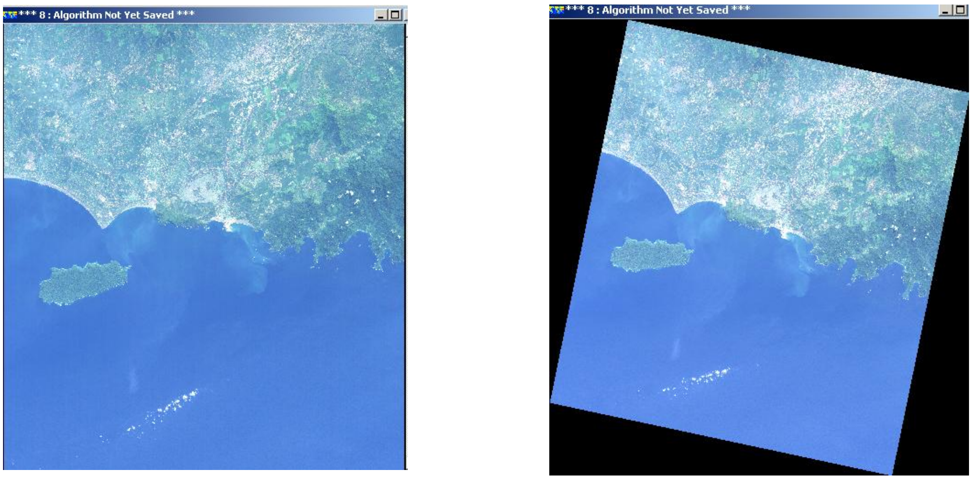


Figure 6. The raw image of ALOS AVNIR-2 (left side) and after geometric correction (right side).

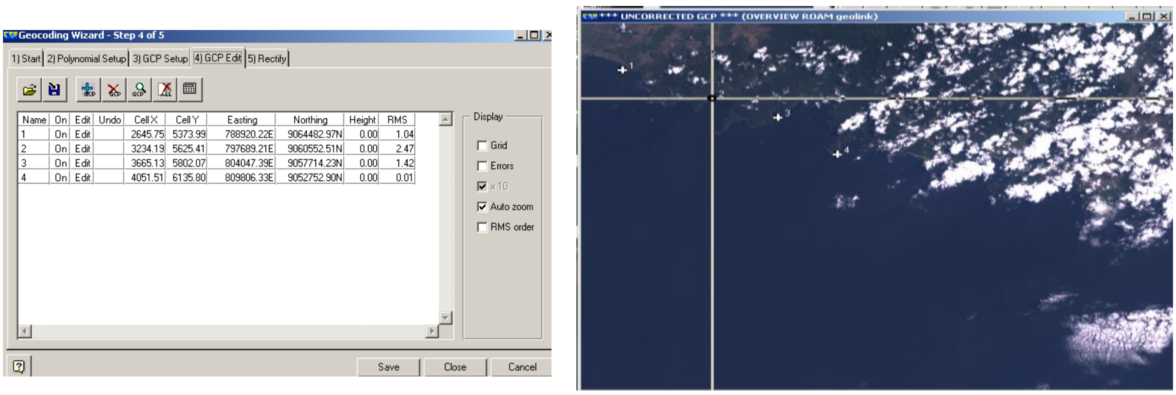


Figure 7. The selection of GCP points in rectification.

4.1.2 Image Mosaicing

The regioning of images of the area study can be carried out before as seen in the figure 8 or after mosaicing. However, geometric correction must be applied on image at first. To dissect the image, the polygon that represents the outside border of the Meru Betiri region was superimposed on the scene as illustrated in the figure 9.

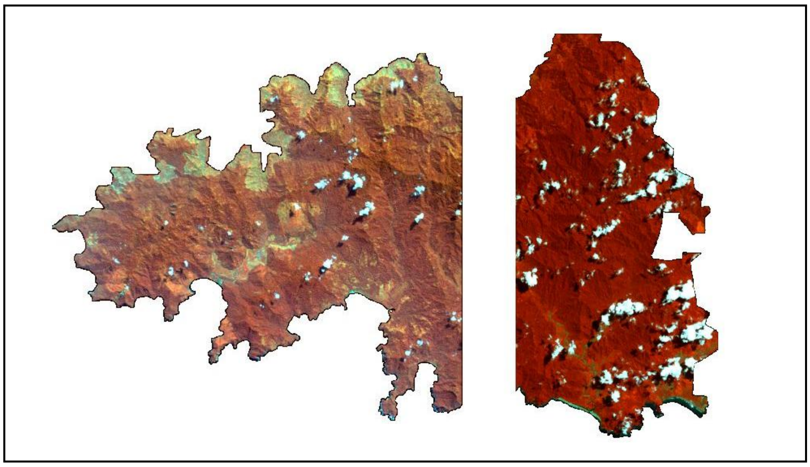


Figure 8. Regioning on ALOS AVNIR-2 before mosaicing.

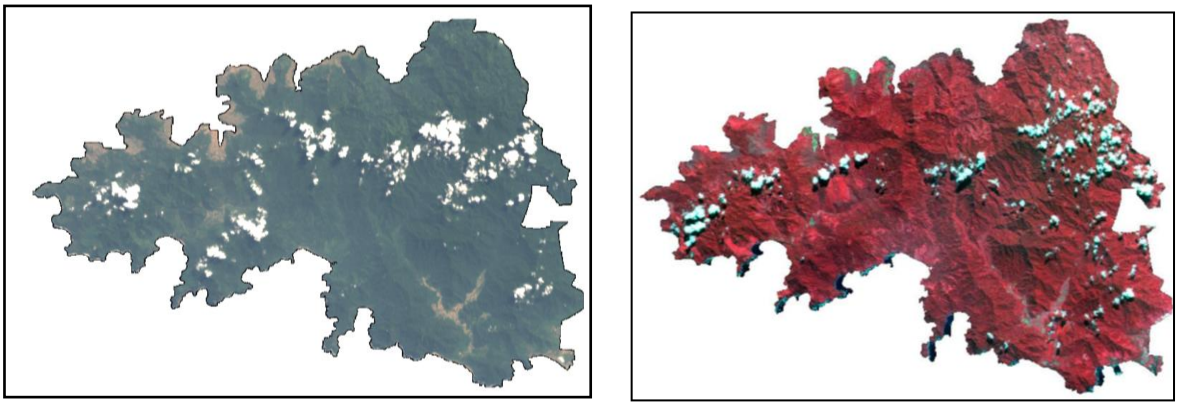


Figure 9. Regioning on LANDSAT TM (leftside), SPOT (rightside).

The Mosaic processing creates the representation of the image to be a continuous image by overlapping two or more images as the image coverage is needed. However, for scene which portraying all of the area study for example LANDSAT TM and SPOT 4, the mosaicing is not required.

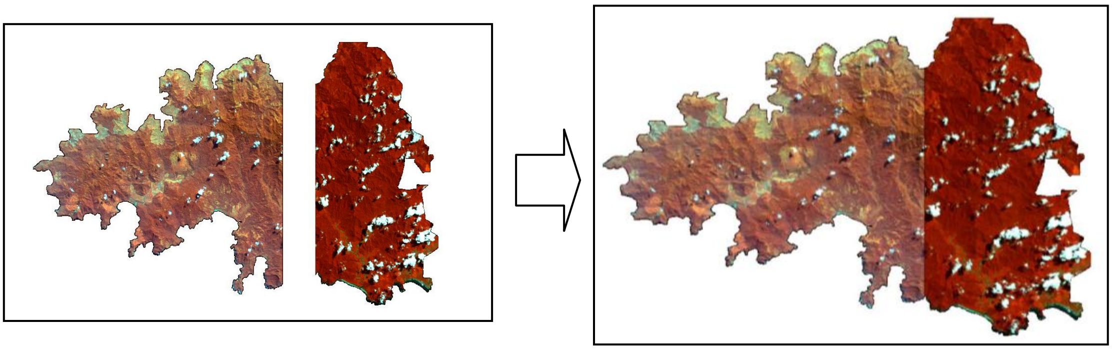


Figure 10. The image on the right side is the Mosaic Image.

For data of ALOS AVNIR-2, the area coverage is divided into two parts on different scene, therefore it is necessary to overlay two parts data to get one complete study area as shown in the figure 10.

4.1.3 Color Composite

RGB (Red-Green-Blue) color composite format is one of types to display image on the screen. The image composite is viewed by combining 3-band in the canal of red, green, blue to make clear the object on the classified image. The 3-colour combination will produce other colors such as cyan, magenta, yellow and white. On the other hand, the absence of combination from these tree colors will lead to black color.

Near infrared (band 3) was picked out in red channel composite color. In this way, it can strengthen and show the appearance of the vegetation more sharply so that it brings to the objective of this project. For images of the ALOS AVNIR-2 and SPOT 4, channel of band 1 (red) will have the higher value than that of band 2 in green channel and band 1 in blue channel, whereas water will look blue to cyan because contribution from blue (band 1) and green (band 2). For Images of LANDSAT TM, the near infrared was placed in green, so that the vegetation will appear in green.

4.1.4 Image Enhancement

The image visualization can be seen apparently by image enhancement so that the image interpretation is able to be done to assist digitally and make information better quantitatively. In image Enhancement, changing the histogram of the brightness value in the image numerically leads to stretch the matrix values.

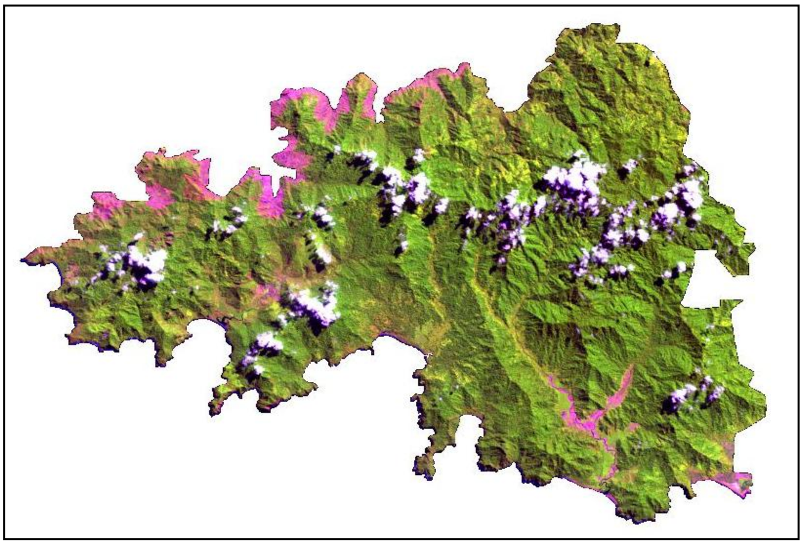


Figure 11. Image after stretching contrast in LANDSAT TM.

In this case, the minimum of original pixel value was set into zero and the maximum of it was stretched into 255 as a new value so that the brightness in LANDSAT, SPOT 4 and ALOS AVNIR-2. After modifying the maximum, the appearance of morphology form 3-dimensional image form as shown in the figure 11-13.

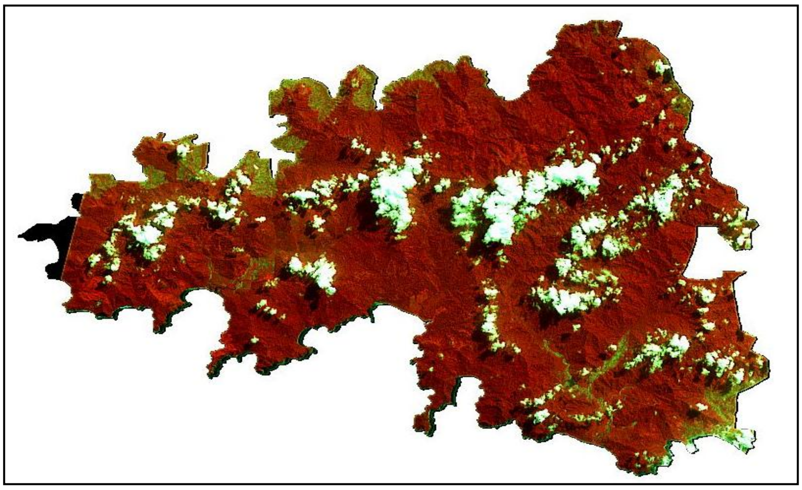


Figure 12. Image after stretching contrast in SPOT 4.

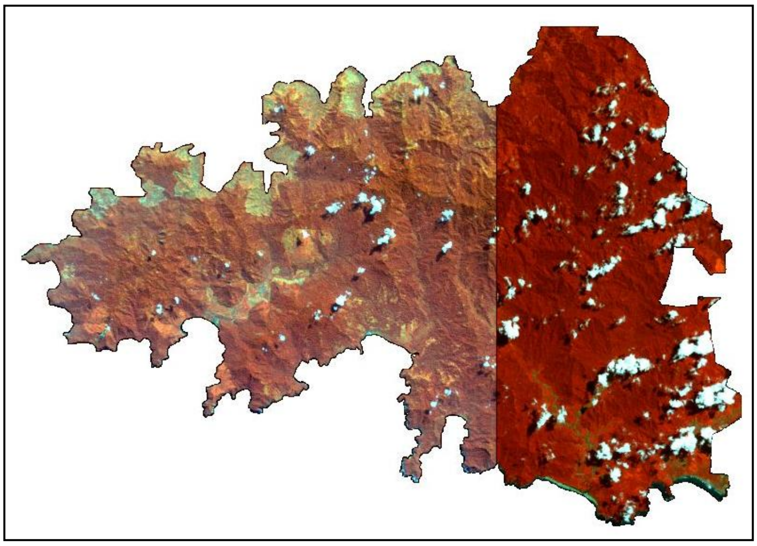


Figure 13. Image after stretching contrast in ALOS AVNIR-2.

4.2 DATA INTERPRETATION

Before classification process, thematic information that wanted to be attained must be divided into certain classes. The determination in land cover classes is the most important stage of the success in classification process of it. The image interpretation can be defined as visual activity to study the image representing the illustration of the real landscape captured in the satellite image for the interest in identifying object and assess its meaning (Howard, 1990).

The image interpretation is an activity based on the detection and identification of the object on earth in satellite image. The Interpretation technique was made so that the interpreter can do the task of image interpretation easily by obtaining the result of the interpretation in better result and accuracy level. The interpretation uses Tone and color as major recognition element or primary upon an object in this study. The main function is to identify object border on the satellite image.

By the color composite in LANDSAT, SPOT 4 and ALOS AVNIR 2 in RGB mode, it can differ easily between the vegetation object and the non-vegetation object. The vegetation can be represented in green color whereas dry land is appeared in red color. Also in the color composite, it can be found other benefit which is easy to differentiate the object with high water content and moisture. This object will be represented by the contrast darker tone. For example, the object containing water will seem blue, black rectangular shape pattern. This composite helps to differ between the swamp forest and dry land forest, wet land agriculture and dry land agriculture. For identifying other objects in the image, LANDSAT image is used as reference to interpret different objects, because the advantage of it which has more various bands and been studied widely.

The Accomplishment of Classification was approached by interpretation process according to Forestry Planning Bureau (2006) with the following land cover classes.

1. Primary dry land forest comprises all appearances of forests in the flat plain, hilly and mountainous area which have not undergone the characteristics of logging, including low trees grown on massive rocks.
2. Secondary dry land forest is all of forests of the flat plain, hilly and mountainous area which have presented the characteristics of logging (open-up space in the wild and logging trail).
3. Bare Land is of the region without vegetation, and is uncovered by water inundation as well as building. The mining area is included in this class.
4. Urban Area is an area in the image which is shaded by construction and houses. The industry zone is included in this class.
5. Bushes are illustrated by ex dry-land forest area grown mostly by low vegetation and no appearance any longer characterized by open-up space in the wild and logging trail.
6. Swamp with Bushes is area planted by bushes from ex-forest in wetland area.
7. Plantation is indicated by all plantation area, either having been planted or still in bare land. The Identification can be obtained on plantation distribution map (main plantation). The location of private plantation may not be classified in the map, so that it requires other further information.
8. Primary mangrove forest includes mangrove forest, *nipah* and *nibung* are located in surrounding coast without carrying out logging.
9. Cloud is all demonstrations of cloud shading in the study area. If there is thin cloud which still shows appearance under its character and can be estimated, the interpretation keeps being done. The smallest polygon traced for cloud was 2 x 2 cm per square.
10. No data is the appearance in black from the shadow of cloud, or not covered by the image.

The image classification result is depicted in the figure 14-20.

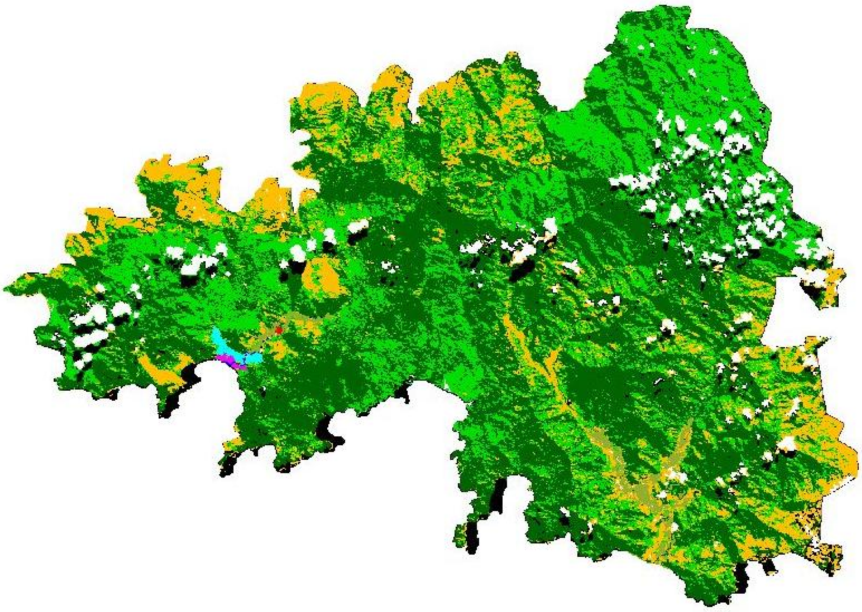


Figure 14. SPOT image acquired 1997 after Classification.

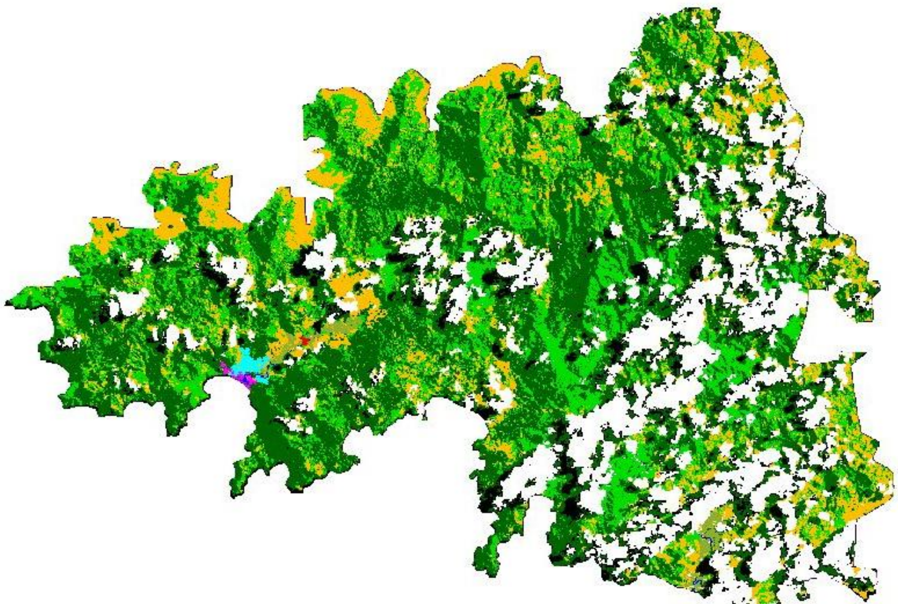


Figure 15. LANDSAT image of 1999 after Classification.

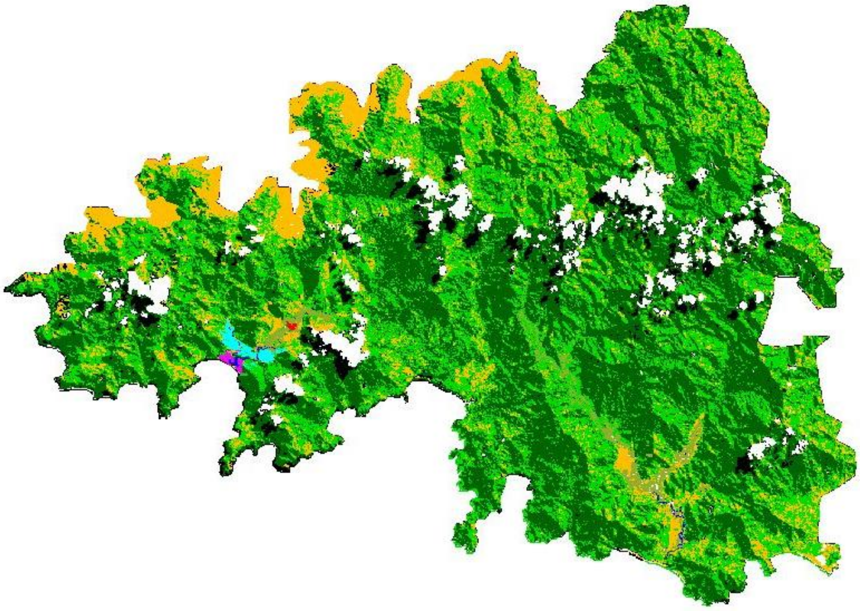


Figure 16. The Classification of LANDSAT image taken 2001.

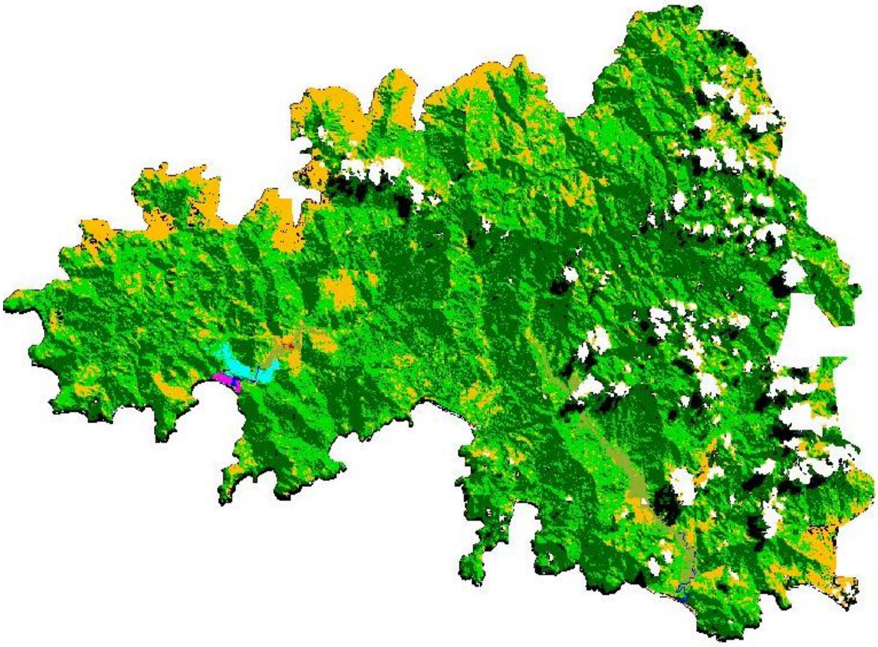


Figure 17. LANDSAT Acquisition in 2003 after Classification.

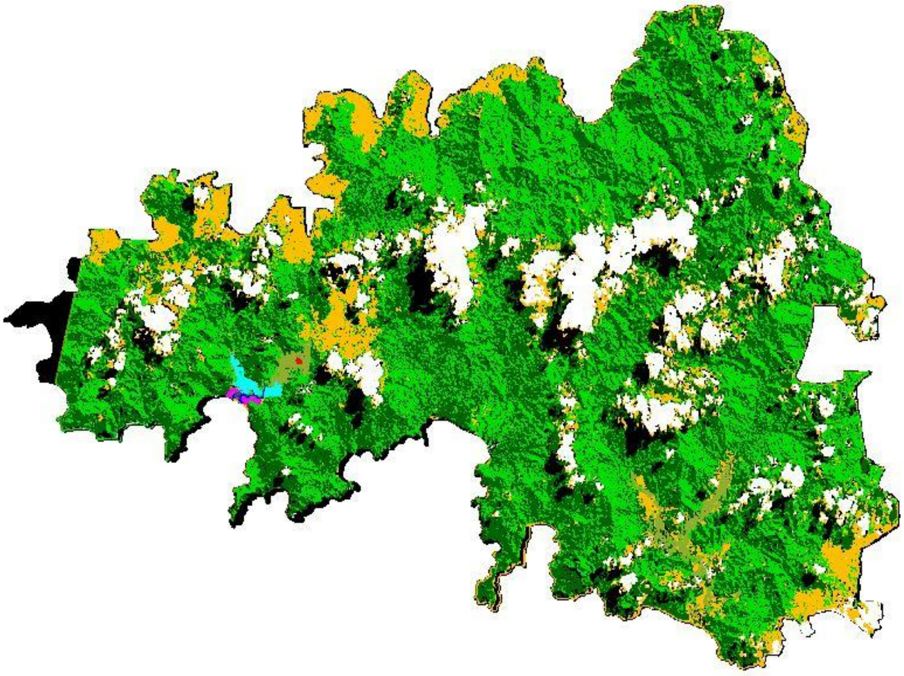


Figure 18. SPOT 4 of 2005 after Classification.

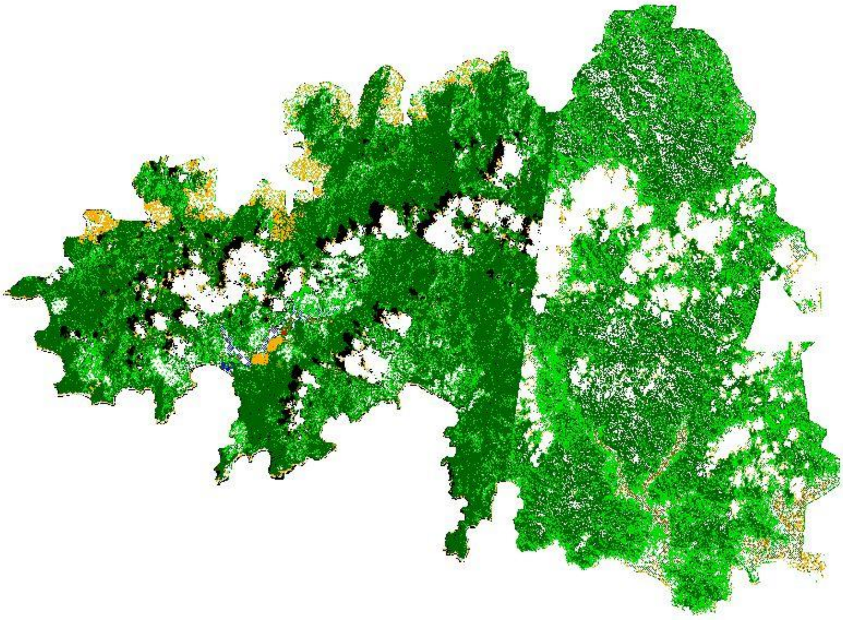


Figure 19. The Classification of ALOS AVNIR 2 taken in 2007.

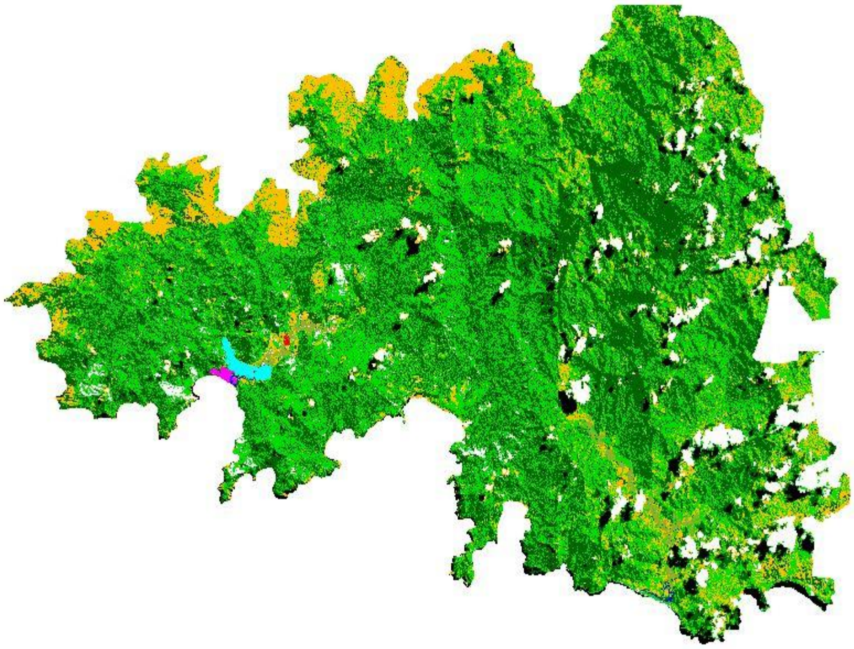


Figure 20. The Classification of ALOS AVNIR 2 taken in 2009.

In the post classification stage, the result of classification was restored on minor error or blunder to get the smooth result, for example in bare land class, some sites have the same color as that of cloud shadow so that it will be classified in the same class. By assistance of ground truth survey and visual interpretation, analyzing and identifying the land cover was carried out due to the above phenomenon. The result of investigation was superimposed over the image to verify of the classification result. In the next step, it is used to correct manually and visually.

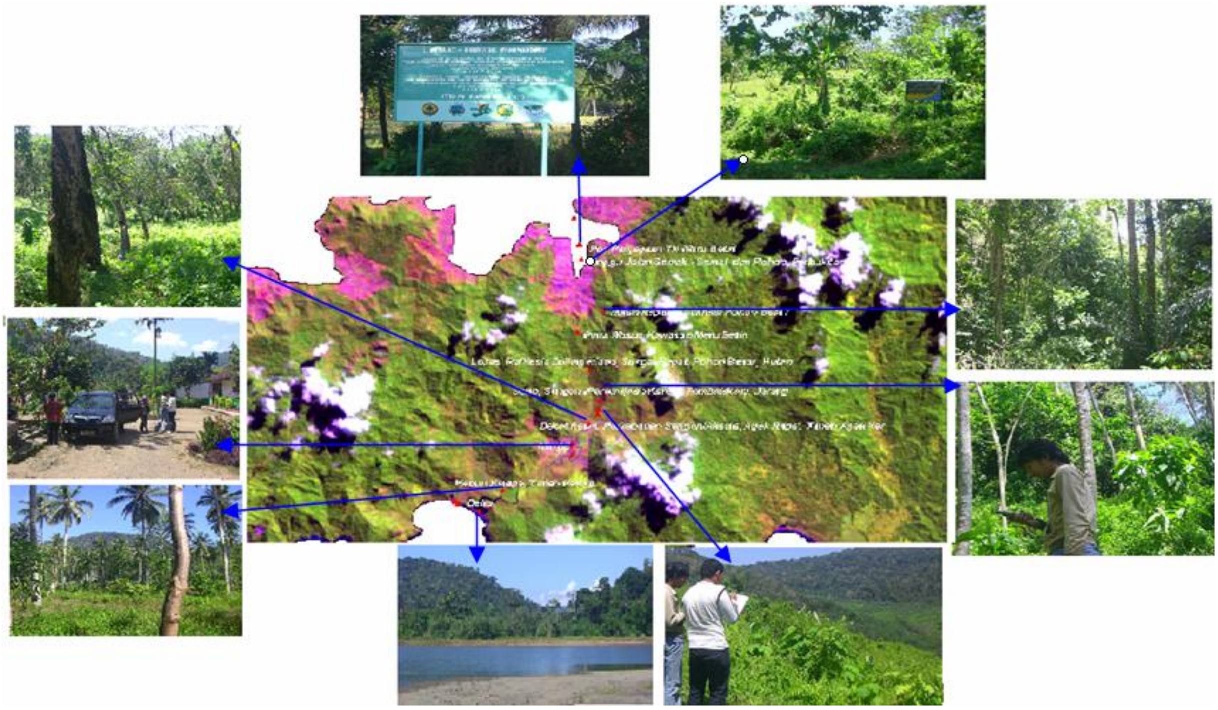


Figure 21. Identification of Training Area and Ground Truth on site.

The analysis of land cover classes employed GIS software i.e. Arcview 3x. This can be done by converting the classification result using RtoV (Raster to Vector) for simple editing, changing the thematic class, setting up layout and calculating area of every class in land cover classification.

Geometric map accuracy through image interpretation is determined by two factors i.e.: image geometric and delineation validity among the classified object. The geometric accuracy is set by geometric correction over the image and whereas the accuracy on delineation is specified by interpreter, if two elements have been done in cartographic principle, the most important thing must be taken into consideration is polygon area size to be delineated.

The area depends on the objective of map scaling to be planned. This process is known as map generalization. The rule to specify the smallest polygon is 0,5 x 0,5 x mapping scale. The following generalization over every map scale was set in this study.

a. Map Scale 1 : 50.000 with the smallest polygon area 1,25 hectare

b. Map Scale 1 : 100.000 with the smallest polygon area 2,5 hectare

c. Map Scale 1 : 250.000 with the smallest polygon area 6,25 hectare.

If the layout result uses different paper size, the map scale will adjust to it. For the lay out of the land cover classification produced can be seen in annex of this report.

4.3 RESULTS

The Table 4 shows the information about the area of classification from 1997 to 2009 in Meru Betiri national park using three types of satellites i.e. LANDSAT, SPOT and ALOS. The classification has identified 10 land cover classes which refer to land cover classes based on The Forestry Planning Bureau 2006.

Table 4. The Area of Land Cover in Meru Betiri national park from 1997 to 2009

No.	KLASIFIKASI	Spot 1997 (m2)	Landsat 1999 (m2)	Landsat 2001 (m2)	Landsat 2003 (m2)	Spot 2005 (m2)	Alos 2007 (m2)	Alos 2009 (m2)
1	Primary dry land Forest	256,948,139.98	206,435,673.50	235,033,358.62	229,224,034.69	199,543,900.72	222,466,601.85	217,449,660.65
2	Secondary dry land Forest	160,424,141.75	114,056,894.34	179,528,840.82	178,406,743.82	169,158,939.11	193,163,433.27	210,310,382.97
3	Primary Mangroove Forest	332,794.65	386,388.86	379,933.40	383,251.32	329,624.16	321,196.15	316,178.10
4	Bushes	74,670,403.97	69,740,440.72	70,886,936.95	76,539,693.00	63,115,175.32	64,156,582.13	63,629,685.28
5	Swamp with Bushes	5,669,369.59	3,120,364.12	6,541,412.30	5,698,945.35	6,442,687.71	5,155,500.15	5,464,969.17
6	Plantation	1,090,803.61	1,083,428.97	1,193,633.38	1,187,246.82	1,140,944.42	1,143,695.20	1,148,611.91
7	Urban Area	80,470.68	99,644.46	89,433.86	89,709.79	96,070.19	92,187.94	90,217.56
8	Bare Land	144,040.82	155,639.37	157,717.48	167,559.82	171,033.28	189,275.76	142,718.99
9	Cloud	25,435,415.00	112,925,796.52	28,511,673.14	28,570,567.31	54,872,108.85	42,009,813.27	29,725,522.51
10	No data	23,313,092.68	40,104,727.65	25,785,895.58	27,841,620.02	53,238,276.10	19,411,465.64	19,831,653.58
	Jumlah (m2)	**548,108,672.74**	**548,108,998.49**	**548,108,835.53**	**548,109,371.95**	**548,108,759.86**	**548,109,751.35**	**548,109,600.73**

According to Table 4, the primary dry land forest decreased slightly between 1997 and 1999, after that it indicated a stabile trend until 2009. At the same time as the condition of primary dry land forest which tended to be stable, the secondary dry land forest seemed to be stable over ten-year period. In addition, the site which is without vegetation or bare land area was also stable.5 .

Table 5. The Percentage of Land Cover Classification from 1997 to 2009

No.	KLASIFIKASI	Spot 1997	Landsat 1999	Landsat 2001	Landsat 2003	Spot 2005	Alos 2007	Alos 2009
1	Primary Dry Land Forest	46.88	37.66	42.88	41.82	36.41	40.59	39.67
2	Secondary Dry Land Forest	29.27	20.81	32.75	32.55	30.86	35.24	38.37
3	Primary Mangrove Forest	0.06	0.07	0.07	0.07	0.06	0.06	0.06
4	Bushes	13.62	12.72	12.93	13.96	11.52	11.71	11.61
5	Swamp with Bushes	1.03	0.57	1.19	1.04	1.18	0.94	1.00
6	Plantation	0.20	0.20	0.22	0.22	0.21	0.21	0.21
7	Urban Area	0.01	0.02	0.02	0.02	0.02	0.02	0.02
8	Bare Land	0.03	0.03	0.03	0.03	0.03	0.03	0.03
9	Cloud	4.64	20.60	5.20	5.21	10.01	7.66	5.42
10	No Data	4.25	7.32	4.70	5.08	9.71	3.54	3.62
	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

For the percentage, the changes of land cover classification in the Meru Betiri Region are described on the table 5 for the 10-year period. The classification observed by two-year period of satellite image referred to Forestry Planning Bureau (2006).

According to Table 5, the percentage of forest area was dominated by primary dry land forest class, whereas bushes class was accounted for less than two percent of land cover classification over ten-year period. Moreover, no data due to cloud and shadow of cloud represent the biggest percentage over LANDSAT in 1999.

V. CONCLUSION

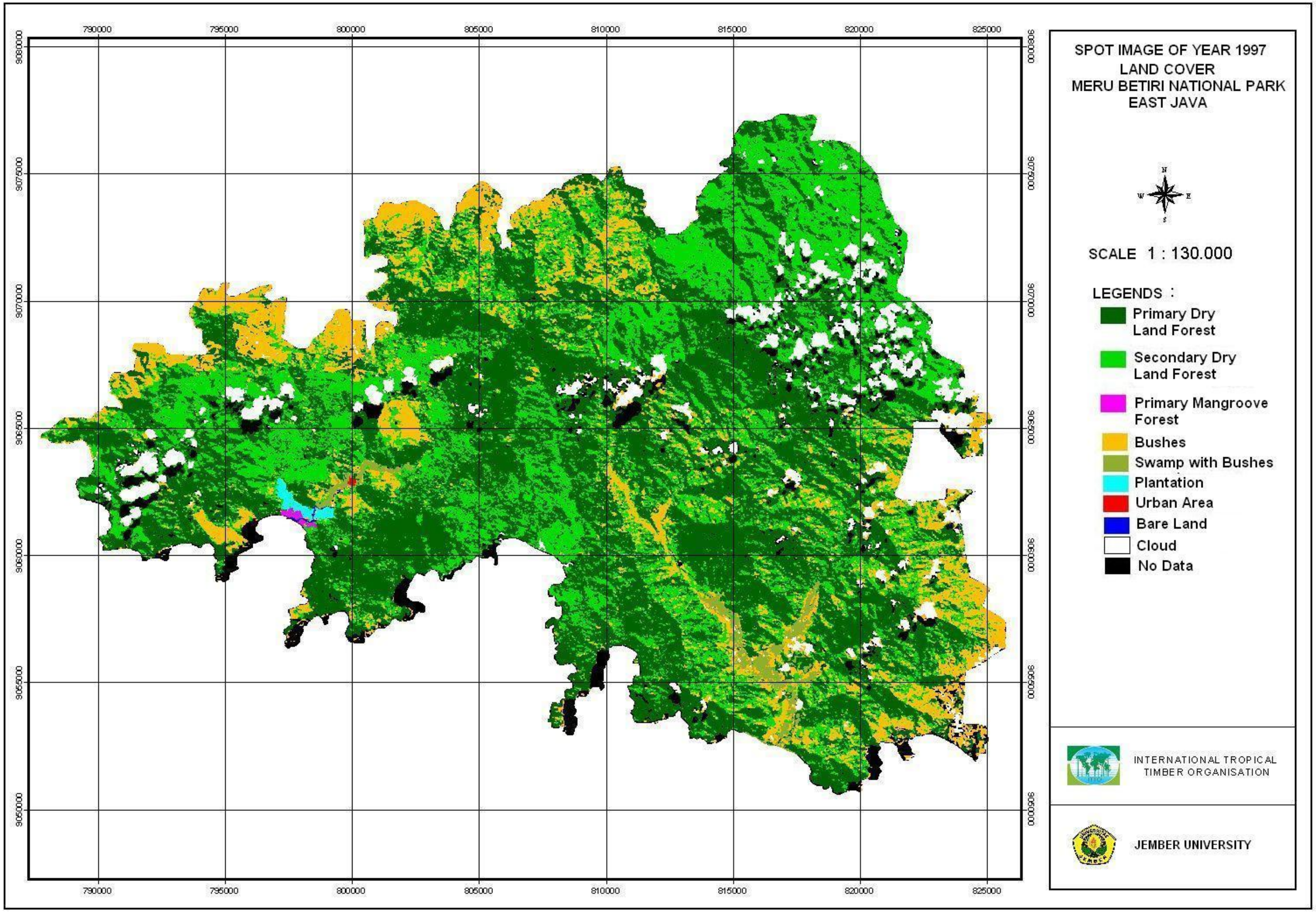
Land cover condition over ten-year period studied based on the satellite images analysis obtained by three types of satellites (LANDSAT TM, SPOT 4 and ALOS AVNIR-2) from 1997 up to 2010 is as follows:

1. The classification of the satellite images observed in Meru Betiri national park has defined the 10 classes of land cover according to Forestry Planning Bureau, namely primary dryland forest, secondary dryland forest,primary mangrove forest, bushes, swamp with bushes, plantation, urban area, bareland, coud and no data
2. The area in Forest Class tended to be stable except in year 1999; it might be due to higher cloud cover compared with other years.
3. Forest land cover from 1997-2010 in Meru Betiri national park area was dominant, meaning that the deforestation rate was quite low.
4. The findings of the interpretation result using multi temporal images over the land cover classes could be used as a basis to calculate the carbon stock in the National Park.

RECOMMENDATION

1. For better interpretation of analysis of land cover using GIS, independent data like detail mapping in certain area should be conducted in the future to have an accurate classification.
2. Classification of land cover based on remote sensing analysis can be used as the basis for stratification to estimate carbon stock through ground measurement.
3. The practical implications resulted from the image satellite include: to identify forest degradation due to illegal logging both in secondary and primary forest, to define zonation such as for rehabilitation and buffer zone, so that the local community can utilize forest resources without performing illegal logging.

Annex -1


SPOT IMAGE OF YEAR 1997
LAND COVER
MERU BETIRI NATIONAL PARK
EAST JAVA
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S
SCALE 1 : 130.000
LEGENDS :
Primary Dry Land Forest
Secondary Dry Land Forest
Primary Mangroove Forest
Bushes
Swamp with Bushes
Plantation
Urban Area
Bare Land
Cloud
No Data
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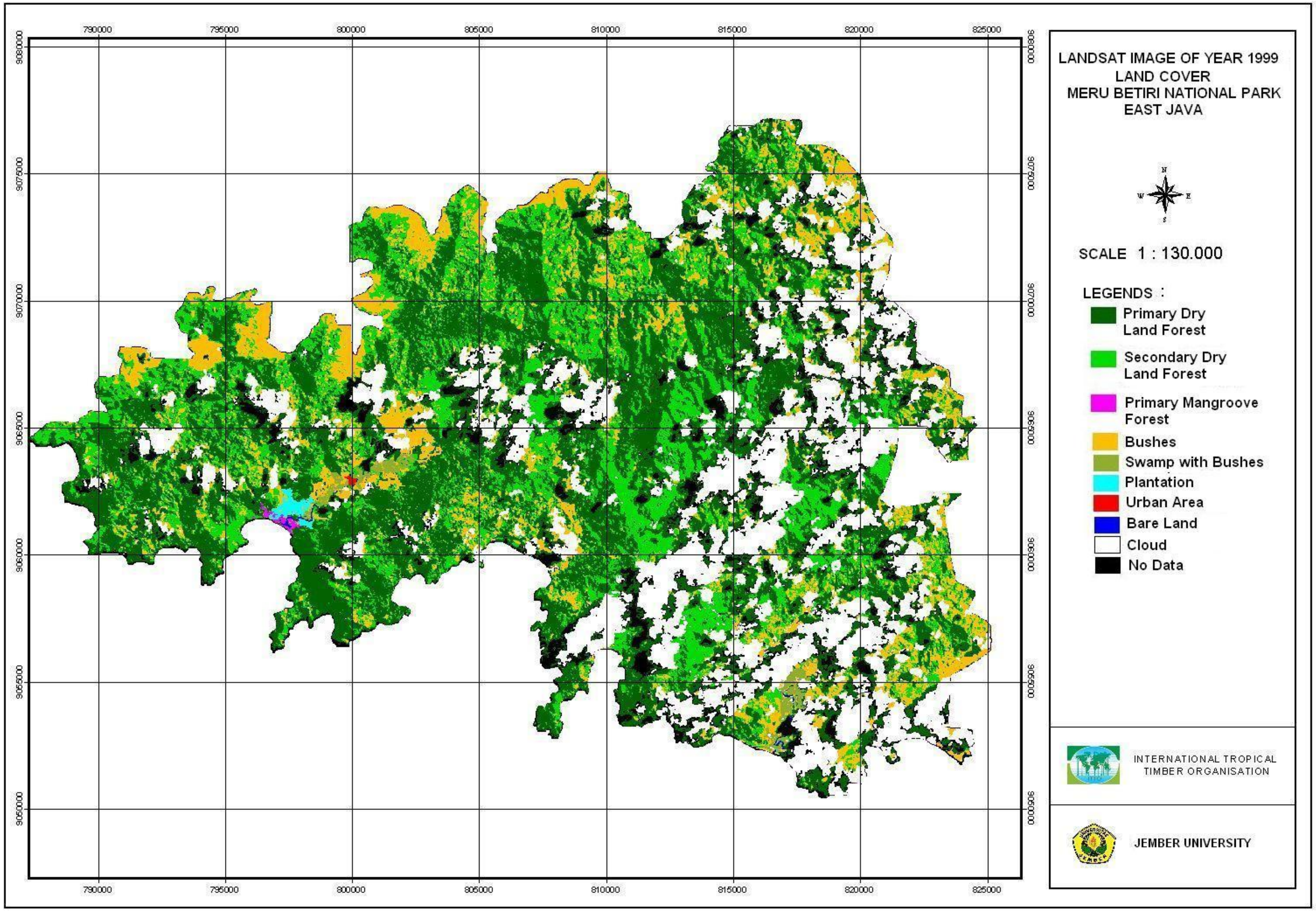
Annex -2


LANDSAT IMAGE OF YEAR 1999
LAND COVER
MERU BETIRI NATIONAL PARK
EAST JAVA
SCALE 1 : 130.000
LEGENDS :
Primary Dry Land Forest
Secondary Dry Land Forest
Primary Mangroove Forest
Bushes
Swamp with Bushes
Plantation
Urban Area
Bare Land
Cloud
No Data
INTERNATIONAL TROPICAL TIMBER ORGANISATION
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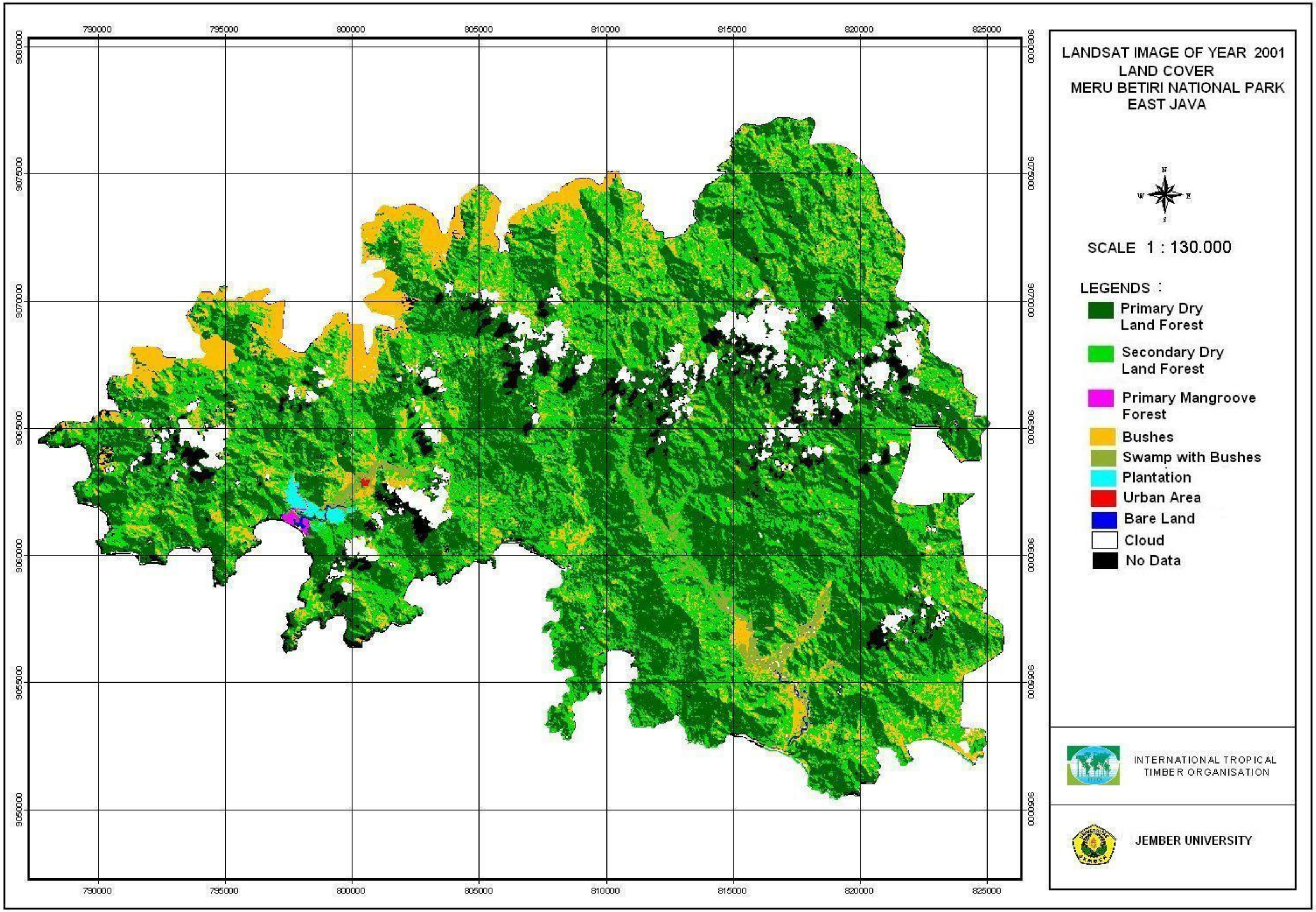
Annex


LANDSAT IMAGE OF YEAR 2001
LAND COVER
MERU BETIRI NATIONAL PARK
EAST JAVA
SCALE 1 : 130.000
LEGENDS :
Primary Dry Land Forest
Secondary Dry Land Forest
Primary Mangroove Forest
Bushes
Swamp with Bushes
Plantation
Urban Area
Bare Land
Cloud
No Data
INTERNATIONAL TROPICAL TIMBER ORGANISATION
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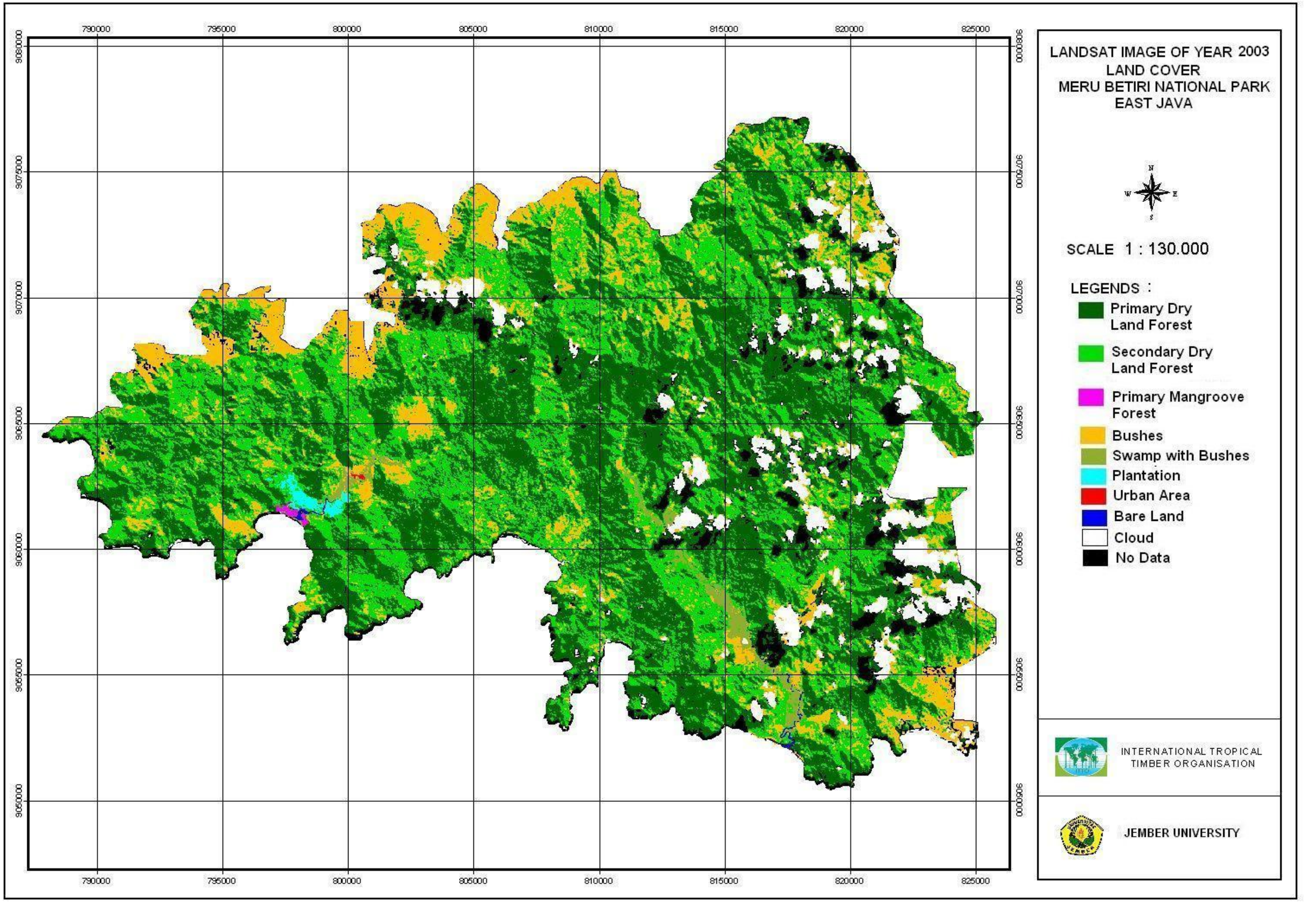
Annex -4


LANDSAT IMAGE OF YEAR 2003
LAND COVER
MERU BETIRI NATIONAL PARK
EAST JAVA
SCALE 1 : 130.000
LEGENDS :
Primary Dry Land Forest
Secondary Dry Land Forest
Primary Mangroove Forest
Bushes
Swamp with Bushes
Plantation
Urban Area
Bare Land
Cloud
No Data
INTERNATIONAL TROPICAL TIMBER ORGANISATION
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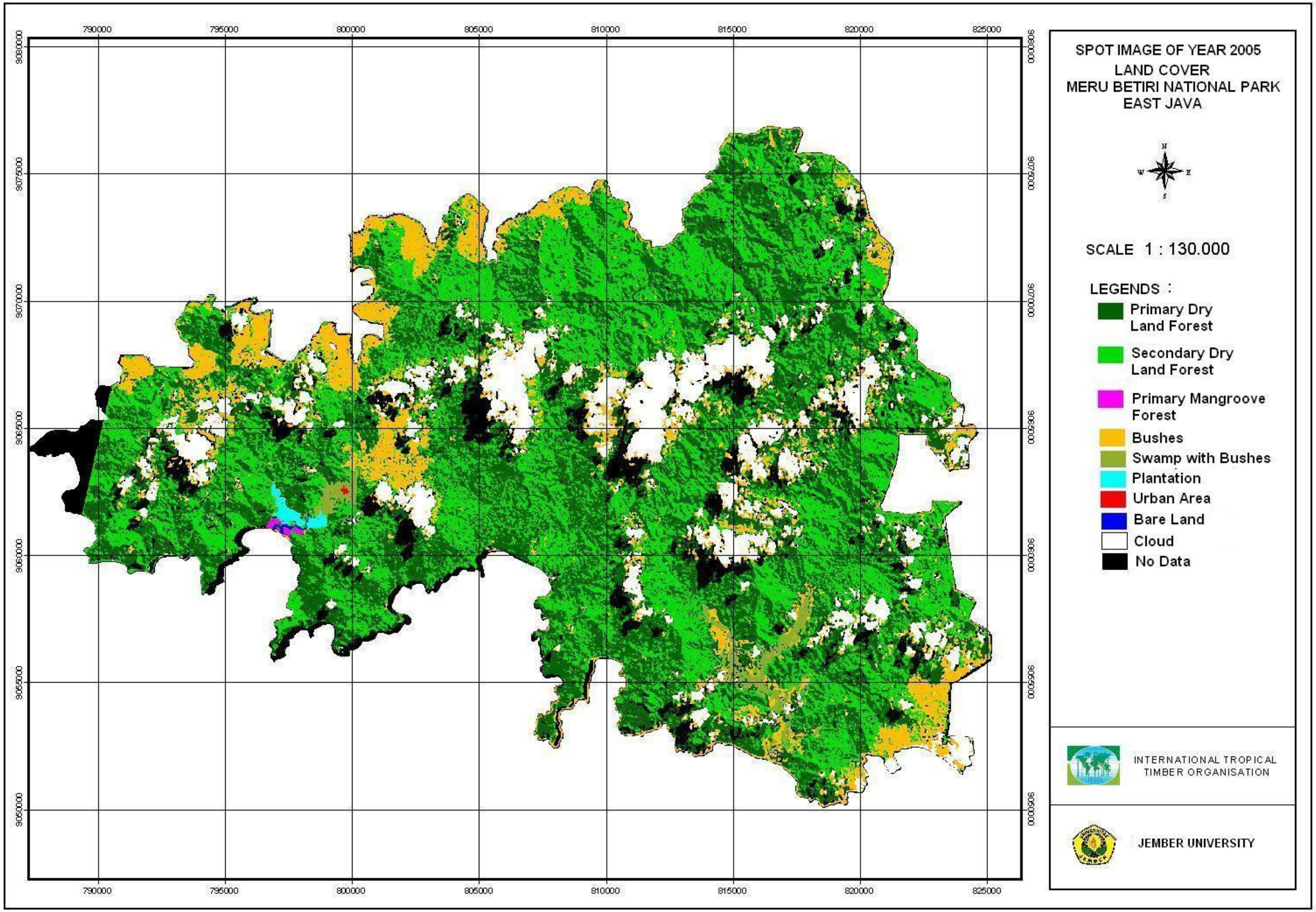
Annex -5


SPOT IMAGE OF YEAR 2005
LAND COVER
MERU BETIRI NATIONAL PARK
EAST JAVA
SCALE 1 : 130.000
LEGENDS :
Primary Dry Land Forest
Secondary Dry Land Forest
Primary Mangroove Forest
Bushes
Swamp with Bushes
Plantation
Urban Area
Bare Land
Cloud
No Data
INTERNATIONAL TROPICAL TIMBER ORGANISATION
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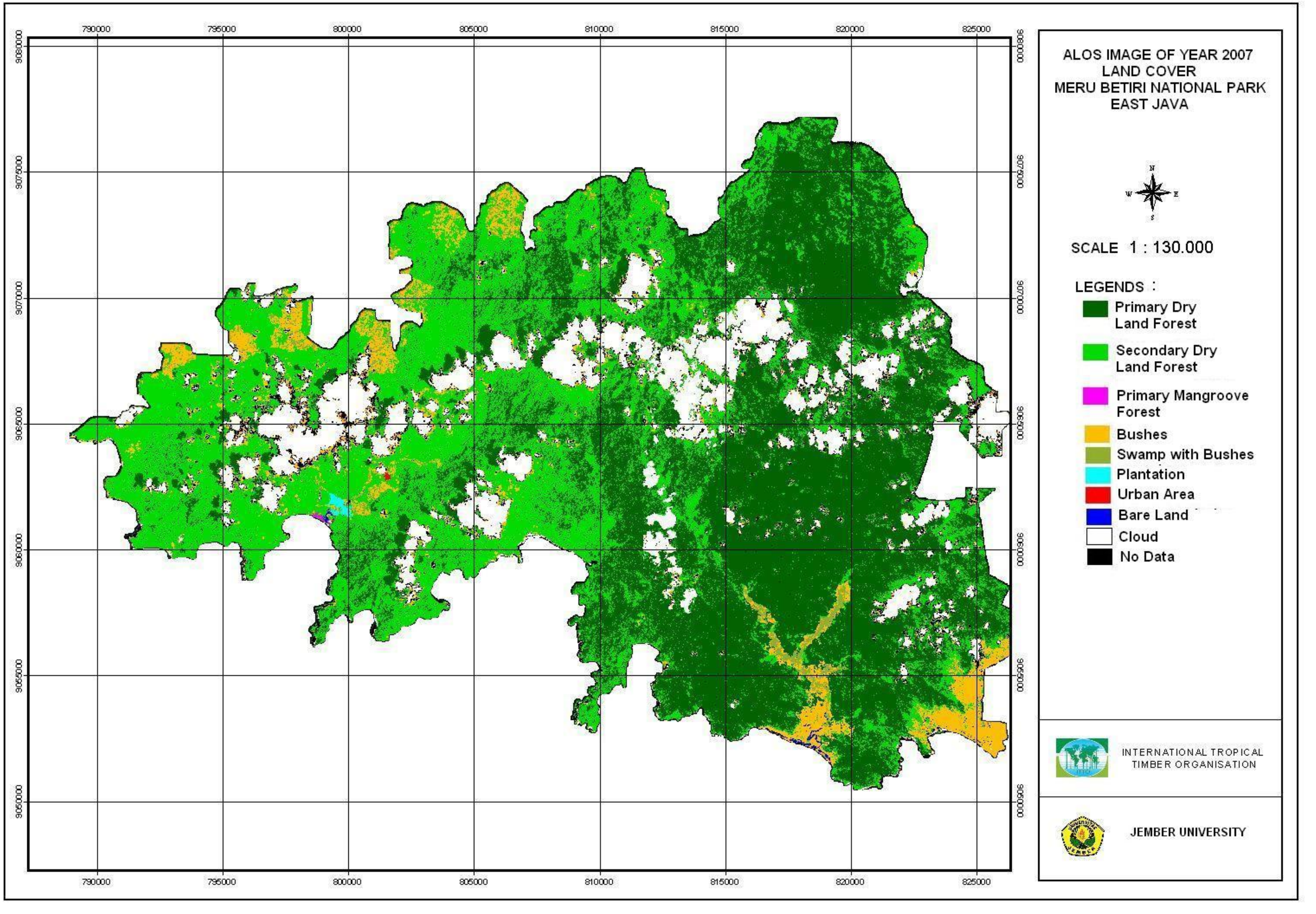
Annex -6


ALOS IMAGE OF YEAR 2007
LAND COVER
MERU BETIRI NATIONAL PARK
EAST JAVA
SCALE 1 : 130.000
LEGENDS :
Primary Dry Land Forest
Secondary Dry Land Forest
Primary Mangroove Forest
Bushes
Swamp with Bushes
Plantation
Urban Area
Bare Land
Cloud
No Data
INTERNATIONAL TROPICAL TIMBER ORGANISATION
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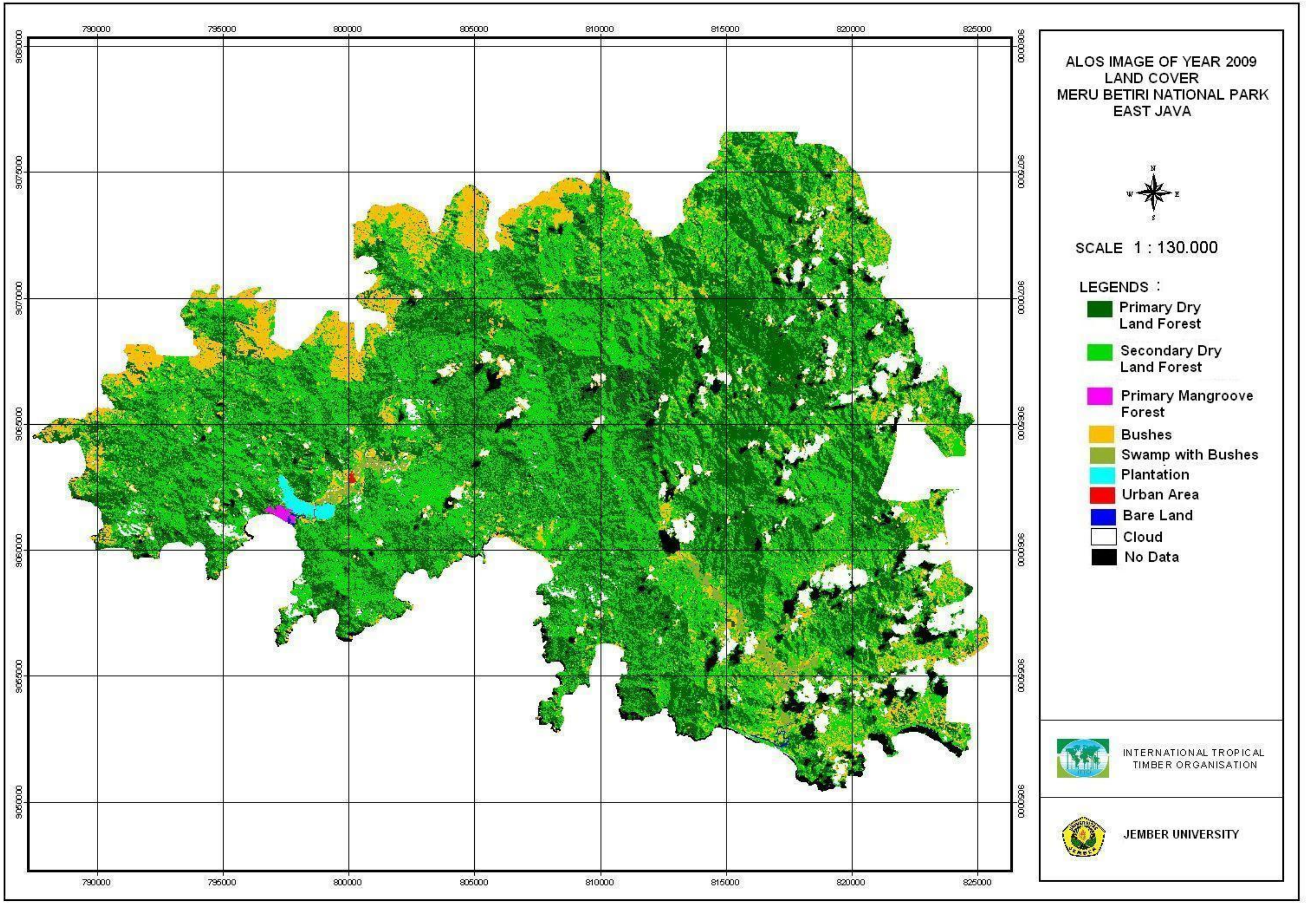
Annex -7



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ALOS IMAGE OF YEAR 2009
LAND COVER
MERU BETIRI NATIONAL PARK
EAST JAVA
SCALE 1 : 130.000
LEGENDS :
Primary Dry Land Forest
Secondary Dry Land Forest
Primary Mangroove Forest
Bushes
Swamp with Bushes
Plantation
Urban Area
Bare Land
Cloud
No Data
INTERNATIONAL TROPICAL TIMBER ORGANISATION
JEMBER UNIVERSITY

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