LANDSCAPE CHARACTERISTIC OF JAVAN HAWK-EAGLE HABITAT'S USING REMOTE SENSING AND GIS IN WESTERN PART OF JAVA

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Abstrak

Elang Jawa Spizaetus Bartelsi merupakan hewan endemic pulau Jawa dan merupakan burung predator hutan. Spesies ini hidup secara eksklusif pada hutan – hutan di Pulau Jawa. Daerah penelitian ini dipilih karena tingkat bahaya yang semakin meningkat pada berkurangnya jumlah populasi spesies ini, sebagai akibat dari hilang dan berkurangnya habitat Elang Jawa serta penangkapan untuk penjualan hewan langka di daerah penelitian. Pengertian akan habitat ciri - ciri suatu spesies sangat penting, tidak hanya untuk memperbaiki pengetahuan ekologi mengenai spesies tertentu, tetapi juga untuk menemukan suatu cara untuk melindungi habitatnya. Data dengan skala yang besar dari daerah yang luas seperti habitat Elang Jawa, membuat proses dan integrasi dengan data lainnya menjadi sulit dilakukan. Kemampuan satelit citra untuk menangkap informasi spasial pada daerah yang luas, khususnya pada daerah yang inaccessible, curam, dan terpencil, dan memprosesnya merupakan keuntungan dalam pemetaan habitat. Penggunaan SIG untuk input, menyimpan, analisis, dan menampilkan informasi spasial merupakan suatu permulaan untuk menngatasi kesulitan - kesulitan yang ada.

Abstract

Javan Hawk–eagle Spizeatus bartelsi is endemic to Java and is the dominant avian forest predator. The species lives exclusively in the forests of Java. The study area in this research is selected because of the increasing danger in populations of the species in the study area by the habitat loss and degradation, and trapping for the wildlife trade. An understanding of the habitat preferences of a species is important, not only to improve ecological knowledge about that species but also to devise strategies for the protection of its habitat. Large scale data from a large area such as habitat preferences of Javan Hawk–eagle, also made the complex processing and integration with other data difficult. The capabilities of the satellite imagery to capture spatial information in a large area, especially in inaccessible, rugged and remote area, and process it are the advantages in mapping habitat preferences. The use of GIS for input, storage, analysis, and display of spatial information is beginning to overcome these difficulties.

I. INTRODUCTION

Javan Hawk–eagle *Spizeatus bartelsi* is endemic to Java and is the dominant avian forest predator. It has been considered to be one of the world's rarest and most endangered birds of prey according to current IUCN threat categories (Prawiradilaga, 1998 *in* Asian Raptor Research & Conservation, 1998).

The Javan Hawk-eagle *Spizaetus bartelsi* lives exclusively in the forests of Java. Its range has been fragmented over many years so that now it is only about 10% of its former range (Sozer *et al.*, 1998) (see figure 1). The study area in this research is selected because of the increasing danger in populations of the species in the study area by the habitat loss and degradation, and trapping for the wildlife trade.

An understanding of the habitat preferences of a species is important, not only to improve ecological knowledge about that species but also to devise strategies for the protection of its habitat.

Consistent data about the earth's surface and it's cover at the regional scale were difficult the get, time consuming, and expensive to collect. Large scale data from a large area such as habitat preferences of Javan Hawk-eagle, also made the complex processing and integration with other data difficult. The capabilities of the satellite imagery to capture spatial information in a large area, especially in inaccessible, rugged and remote area, and process it are the advantages in mapping habitat preferences.

The use of GIS for input, storage, analysis, and display of spatial information is beginning to overcome these difficulties. Remote sensing information produced by satellite or aerial photography must be interpreted before they can be used in a GIS. Generally, data from remote sensing are imported into a GIS after classification and georeferencing.

1.1 Habitat Preferences of Javan hawk-eagle

In *Javan Hawk-eagle Recovery Plan* (1998) has been stated that the species occupy rain forest area from sea – level to 3000 meters (MacKinnon and Phillipps, 1993), although it has been known to favor lower slopes at 200 – 1200 meters (Kuroda, 1933 – 1936). The evidence of recent study is that the species concentrated in slopes at 500 – 2000 meters from sea level (van Balen, 1991; Sozer and Nijman, 1995; and Rov *et al.*, 1997).

According to MacKinnon (1991) the Javan Hawk-eagle is strongly associated with natural forest, open field in the forest hilly area, and mountain area. The common condition of the species habitat's is along the slope of a hilly and valley, but the species are also found in the lower forested area (Nuraeni *et al.*, 1999). Nevertheless, occasionally juveniles, but even establish pairs, are observed in less disturbed forests (van Balen, 1991; Sozer and Nijman, 1995 *in* Sozer *et al.*, 1998).

In 1997 discovered that the species also uses secondary forest for both hunting and nesting, although extensive areas of primary forest were always close by and were doubtless necessary for breeding success (Rov *et al.*, 1997 *in* Sozer *et al.*, 1998). The discovery that the species can nest in pine *Pinus merkussi* trees and even pine plantations is, however, an indication that such areas may be considerable importance to the eagle (Rov *et al.*, 1997; Hapsoro *et al.*, 1998 *in* Sozer *et al.*, 1998).

1.2 Landscape Structure

Landscape is a heterogeneous land area composed of interacting ecosystems that is repeated in similar form throughout. Landscapes can be varying in size down to a few kilometres in diameters. Landscape structure studied about the distribution of energy, materials, and species in relation to the sizes, shapes, numbers, kinds, and configurations of landscape elements or ecosystems. Landscape elements are the basic, relatively homogeneous, ecological unit, whether of natural or human origin, on land at the scale of a landscape (Forman and Godron, 1986).

There are many variants of landscape definition depending on the research or management context. From a wildlife perspective, for example, landscape might be define as an area of land containing a mosaic of habitat patches, within which a particular "focal" or "target" habitat patch often is embedded (Dunning and others, 1992 *in* McGarigal *et al.*, 1995). Because habitat patches can be define only relative to a particular organism's perception of the environment (that is, each organism defines habitat patches differently and at a different scales), landscape size would be differ among organism (Wiens, 1976 *in* McGarigal *et al.*, 1995).

1.2.1 Patch

Most wildlife research and management activities have focused on the within – patch scale, typically small plots or forest stands (McGarigal *et al.*, 1995). Patch is a nonlinear surface area differing in appearance from its surroundings. Patches is vary widely in size, shape, type, heterogeneous, and boundary characteristics. In addition, patches are often embedded in a matrix, a surrounding area that has a different species structure or composition. Normally, patches in the landscape are plant and animal communities, that is, assemblages of species. However, some patches could be lifeless, or at least contain primarily micro organism, and are then much more prominently characterized by the presence, for example, of rock, soil, pavement, or buildings (Forman and Godron, 1986).

1.2.2 Spatial Pattern Analysis

Landscape configuration can be quantified by using statistics in terms of the landscape unit itself (that is, the patch). The spatial pattern being represented is the spatial character of the individual patches. Landscape metrics quantified in terms of the individual patches (for example, mean patch core area or mean patch shape). Such metrics represent recognition that the ecological properties of a patch are influenced by the surrounding neighbourhood (for example, edge effects) and that the magnitude of these influences are affected by patch size and shape (Pickett and White, 1985 *in* McGarigal *et al.*, 1995).

1.3 Remote Sensing and GIS in Landscape Ecology

The digital nature of land cover information from satellite imagery enables a potentially large number of landscape metrics to be derived (Haines – Young and Chopping, 1996 *in* G.H Griffiths *et al.*, 1996). The larger area coverage and repeat viewing of remotely sensed data provides information at relatively fine spatial (typically 10 – 25 m) and temporal resolution for mapping the type and dynamics of biotope patches in the landscape. However, whilst there are a number of good examples of the use of satellite data for deriving indices of landscape pattern, very few studies have used an explicitly landscape ecological approach for biodiversity monitoring (G.H Griffiths *et al.*, 1996).

More typically, remote sensed data have been used to map biotope type and quality (productivity, biomass, species composition) and from this information indices of, for example, bird diversity (Norh and Jorgensen, 1997), breeding success (Green and Griffiths, 1993), and abundance (Avery and Haines – Young, 1990) have been derived. Fewer studies have included a specially landscape ecological approach in which the spatial arrangement of landscape elements measured from satellite imagery has been used to determine their ecological importance (G.H Griffiths *et al.*, 1996).

The objectives of this research are to:

1. Plot the locality records and determine habitat of the species based on the existed data;
2. Quantify the landscape structure and Principal Component Analysis (PCA) to determine the habitat preference;
3. Utilize the remote sensing, GIS technique, spatial analysis concept, and experience gained in this research as a base for knowledge transfer to other area.

II. METODOLOGY

2.1 Study Area

The study area is located on $6^0 33^1 00^{11}$ - $7^0 22^1 30^{11}$ North Latitude and $106^0 17^1 00^{11}$ - $107^0 44^1 30^1$ East Longitude, which lies between Halimun National Park to Bandung area. Administratively, the study area are include in Kabupaten Bogor, Cianjur, Sukabumi, Garut, and Kabupaten Bandung. This research are conducted from January to June 2001.

2.2 Data Sources

Datas and maps that used in this research include :

a. Locality records of the Javan Hawk-eagle

The data refereed to in the research have been analysed from literature on the conservation of the Javan Hawk-eagle. The data consist of geographical coordinates and information about known site or nesting records of the species. This existed data set is provided by TELAPAK Foundation (Sempur, Bogor) based on research conducted by researchers and commitments to conservation of the Javan Hawk-eagle such as Hapsoro *et al.* (1998), Sozer *et al.* (1998), Nuraeni *et a.l* (1999), Setiadi *et al.* (1999), van Balen (1999), and Afianto *et al.* (2000).

b. Remote sensing data

The selected sensor that provided the remote sensing data is Landsat TM, which include:
Landsat TM path / row 122 / 65 (acquisition date : 28 August 1997) in BSQ format, which consist of 7 bands with the resolution of 30 x 30 meter.

c. "Rupa Bumi" maps

Maps which covered the study area, that used as a reference in geometric correction and land cover classification. Published by Bakosurtanal (Cibinong) in 1999 with the scale of 1: 25,000.

d. Topography maps

Maps that covered the study area, used as a reference in survey and analysis of topographic condition (elevation and slope), scale of the maps is 1: 50,000.

2.3 Methods

Locality records of the Javan Hawk-eagle are plotted to the rectified image, then create buffering area of 15 km from the each sites. The result will be 29 habitats that after classification processed will be used in Principal Component Analysis (PCA). The overlapping areas, which also created in buffering processed, will make 3 landscapes that will be quantifying landscape structure using Fragstat. Figure 2 showed the research procedures.

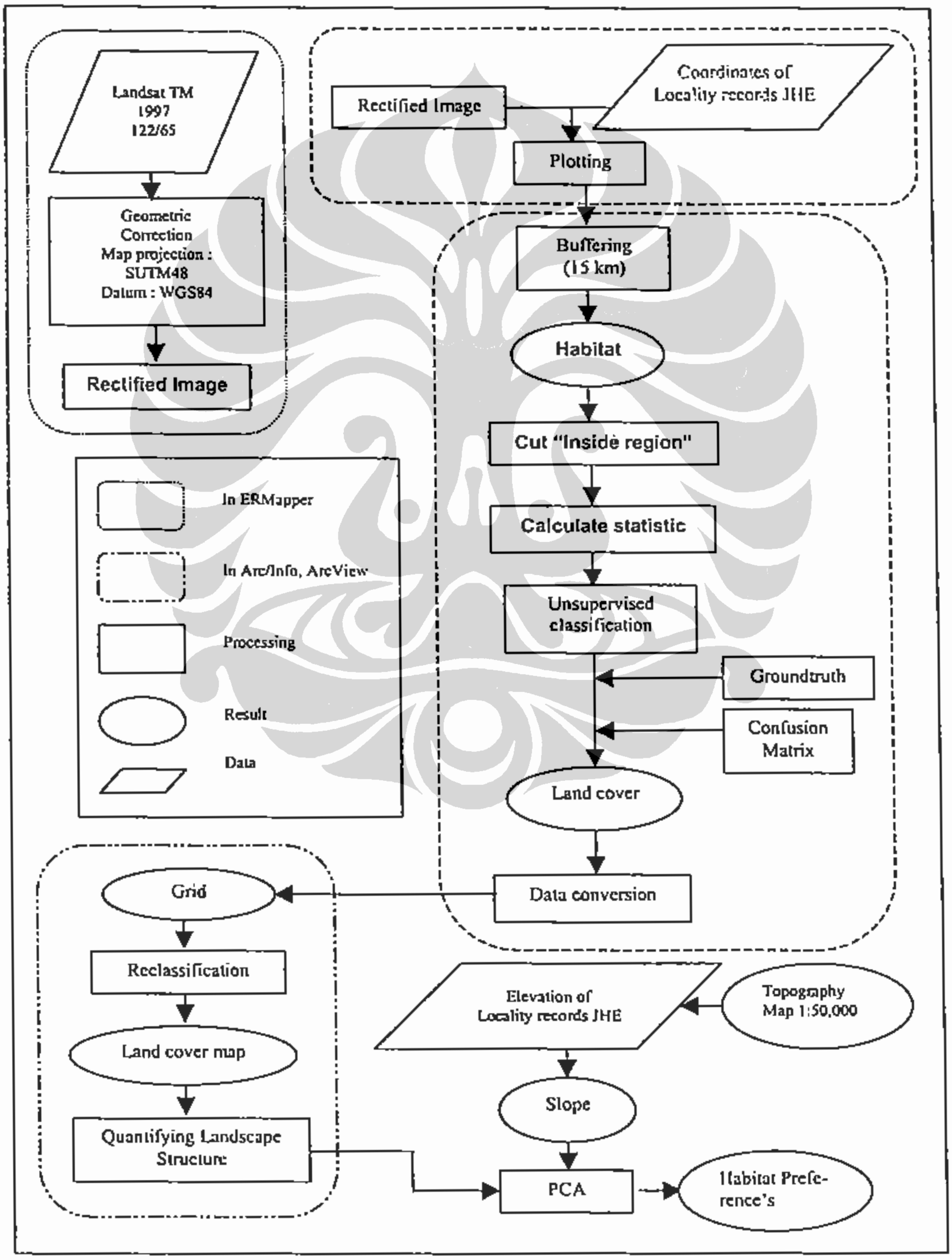


Figure 2. Methods flow chart

III. RESULTS AND DISCUSSIONS

3.1 Landscape Structure

The classified images are used as an input to quantify the landscape structure using Fragstats in each landscape. Class indices for the forest patch type and landscape indices in five landscapes are made from Fragstats analysis (see Table 1 and 2).

Table 1.Class Indices for Forest Patch for Javan hawk-eagle Habitat's

	Landscape A	Landscape B	Landscape C
class	forest	forest	forest
TLA (ha)	696779.62	168480.09	450732.78
NUMP	2635.00	1048	757
MPS (ha)	40.52	83.68	132.84
PSCOV	2844.67	2789.87	1142.5
PSSD (ha)	1152.66	2333.09	1517.71
TE (m)	6482100	4834940	3088320
ED (m/ha)	9.30	27.51	6.85
MSI	1.39	1.39	1.39
AWMSI	13.48	24.01	5.63
MPFD	1.05	1.06	1.05
MNN (m)	228.28	131.71	292.67
MPI	20957.54	78737.58	6030.48
IJI	50.53	97.85	57.78
CA (ha)	106769.88	87758.48	100560.33
AREA (m2)	1067698816	877584800	1005603328
%LAND	15.32	52.08	22.31

Source : Tabulation data, 2001

Table 2.
Landscape Indices for Javan hawk-eagle Habitat's

	Landscape A	Landscape B	Landscape C
class	all	all	all
TLA (ha)	696779.82	168480.09	450732.78
NUMP	31432	6518	5878
MPS	22.17	25.85	76.68
PSCOV	5297.14	3637.9	1609.29
PSSD (ha)	1174.26	940.34	1234.03
TE (m)	40398688	8357430	12024360
ED (m/ha)	57.98	49.6	26.68
MSI	1.39	1.39	1.4
AWMSI	23.72	14.15	7.53
MPFD	1.05	1.05	1.05
MNN (m)	161.5	198.4	230.6
MPI	55620.79	13115.8	13953.04
IJI	72.44	87.38	81.25
SDI	1.49	1.32	1.49
SEI	0.83	0.82	0.93

Source : Tabulation data, 2001

Abbreviation :

Total landscape area	:TLA
Class area	:CA
Number of patch	:NumP
Mean patch size	:MPS
Patch size standard deviation	:PSSD
Patch size coefficient of variance	:PSCOV
Total edge	:TE
Edge density	:ED
Mean shape index	:MSI
Mean patch fractal dimension	:MPFD
Mean nearest neighbor	:MNN
Mean patch index	:MPI
Interspersion juxtaposition index	:IJI
Shannon's diversity index	:SDI
Shannon's evenness index	:SEI

3.1.1 Area Metric (CA)

CLASS – LEVEL for FOREST

According to *class area (CA)*, landscape A has the biggest area compared to the other landscapes. Landscape B has the smallest forest habitat. The population of the Javan Hawk-eagle in landscape B has the smallest locality records of Javan hawk-eagle than the other landscapes and subject to a higher probability of local extinction than A or C.

3.1.2 Patch Size and Variability Metrics (NUMP, MPS, PSSD, PSCOV)

CLASS - LEVEL for FOREST

Landscape A has the highest total landscape area, the lowest total landscape area is landscape B. Landscape A also has the highest *number of patch (NUMP)*. The lowest number of patches is landscape C.

The greater patch size coefficient of variation in landscape A compared to the other landscape indicates a much larger relative variation in patch size. Differences in patch size variability suggest that the human altered landscapes contain more uniformly in patch size than the unaltered landscapes.

LANDSCAPE – LEVEL

Based on the four metrics (NumP, MPS, PSSD, PSCOV), landscape A is more fragmented and has strong diversity or heterogeneity compared to the other landscapes. However, landscape A and C has greater locality records of Javan hawk-eagle compared to landscape B. This indicate that the species is tolerance with habitat fragmentation and prefer landscape heterogeneity.

3.1.3 Edge Metrics (TE, ED)

CLASS - LEVEL for Forest

Total edge and *edge density* indicate that this habitat in landscape B is more highly fragmented than in landscape A and C. *Total edge* or *edge density* might be used to model habitat suitability. In this case, landscape B would be suitable for immatures of the species than landscape A and C.

LANDSCAPE – LEVEL

Landscape C also has been fragmented because of greater value in total edge and edge density. However, degree of fragmentation in landscape A is higher than landscape C. Landscape A and C has greater locality records of the species compared to landscape B, this indicate that this species is tolerance with fragmentation.

3.1.4 Shape Metrics (MSI, MPFD)

The *mean shape index (MSI)* values for class and landscape level are greater than 1, indicating that the average patch shape in all three landscapes is noncircular. . According to *mean patch fractal dimension (MPFD)*, all landscapes of the study area have the same degree of complexity of a polygon.

3.1.5 Nearest Neighbor Metrics (MNN, MPI)

CLASS – LEVEL for Forest
Mean nearest neighbor (MNN) is greatest in landscape C, suggesting that forest patches are most isolated in this landscape. The *mean proximity index (MPI)* indicates that forest in landscape C is most fragmented and insular. These metrics indicate that this species is tolerance with insularity of the habitat, because landscape C has greater locality record compared to landscape B.

LANDSCAPE – LEVEL
The greater mean nearest neighbor is in landscape C, which indicate that patches are most insular in this landscape. The *mean proximity index* is smallest in landscape B and indicates that patches are most fragmented and insular in this landscape. These results support the class analysis level, that the species is tolerance with insularity.

3.1.6 Diversity Metrics (SDI, SEI)

LANDSCAPE – LEVEL
Shannon's diversity index (SDI) mainly reflect differences in patch richness and represent the landscapes along continuum from most (A, C) and to least (B) diverse.

Landscape C has the most even area distribution among patch types, according to *Shannon's evenness index (SEI)*. This illustrates the potential importance of interpreting richness and evenness independently and the importance of interpreting evenness separate from diversity, which influenced strongly by richness. These metrics indicate that landscape A and C, which have greater locality records, have higher degree of patch richness and most even area distribution among patch types.

3.1.7 Interspersion Metric (IJI)

CLASS – LEVEL for Forest
Three landscapes differ in amount and pattern of forest habitat. The interspersion and juxtaposition index (IJI) indicates that the forest edge present in landscape B is more equitably distributed among patch types than the other landscapes.

LANDSCAPE – LEVEL
Interspersion juxtaposition index indicates that the interspersion of available patch types is roughly the same in all landscapes. This indicates that the edges of land cover classes in each patch at all landscapes are equitably distributed among patch types. So the species only influence by the forest edge.

3.2 Principal Component Analysis (PCA) for Javan hawk-eagle Habitat's

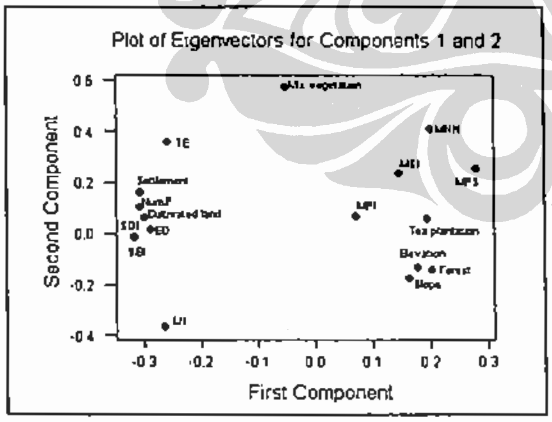
PCA involves eigenanalysis of a symmetric matrix of a similarities or correlation coefficient between the 17 variables of habitat preferences, which include NUMP, MPS, TE, ED, MSI, MNN, MPI, IJI, SDI, SEI, elevation, slope, forest, tea plantation, mix vegetation, settlement, and cultivated land.

The output of the first principal component has variance (eigenvalue) 7.9085, which accounts for 46.5% of the total variance. The second principal component that stored in PC2, has variance 2.6277, which accounts for 15.5% of the total variance.

The first component is a measure of overall habitat preferences of the Javan hawk-eagle. First eigenvector has positive loadings on MPS, MSI, MNN, MPI, elevation, slope, forest, and tea plantation, and negative loadings on NUMP, TE, ED, IJI, SDI, SEI, mix vegetation, settlement, and cultivated land. The second eigenvector has positive loadings on MPS, TE, MSI, NUMP, ED, MPI, tea plantation, settlement, and cultivated land and mix vegetation, and negative loadings on IJI, SDI, SEI, elevation, slope, and forest. These components measure that habitat preferences that have greater influence in all habitats (29), are : MPS, MSI, TE, MNN, MPI, elevation, slope, forest, tea plantation, and mix vegetation.

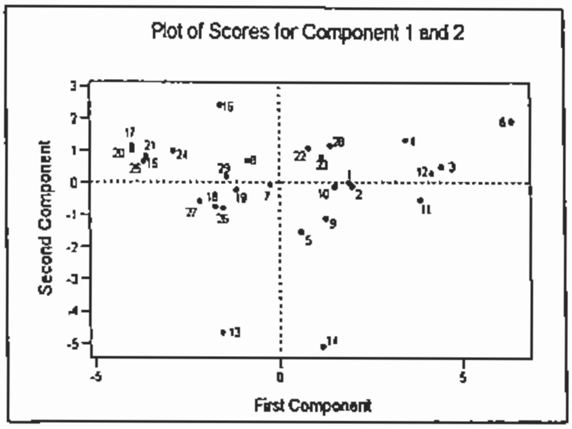
Plotting the individual habitats using their component scores reinforces the interpretation. There are 14 habitats grouped and oriented in a band along the first component in the positive axis, which include habitat number 5, 22, 14, 23, 9, 28, 10, 1, 2, 4, 11, 12, 3, and 6 (see Figure 4). These habitats are influenced by MPS, MSI, MNN, MPI, elevation, slope, forest, and tea plantation (see Figure 3).

It is possible to identify the regional trends on the plot of the first and second components. Habitat number 6 at the extreme right has high value of overall habitat preferences on MPS and MNN, located at Cimanggu (southern Bandung). It means that this habitat is influenced by MPS and MNN due to higher value compare to other habitat sites. Habitat number 20 and 17 at the left with low value of overall habitat has greater value in settlement and cultivated land. These habitats are located at Ciomas, Sukamantri (Bogor) and Pancar Mt. (northeast Bogor). Habitat number 13 and 14 tend to be in the bottom of the plot, with higher value on IJI, located at northern Bandung. Habitat number 16 tend to be in the upper part of the plot, with higher value on mix vegetation, located at Halimun NP.



Source : Tabulation data, 2001

Figure 3. Plot of Eigenvectors for Components 1 and 2 for Javan hawk-eagle Habitat's



Source : Tabulation data, 2001

Figure 4. Plot of Scores for Components 1 and 2 for Javan hawk-eagle Habitat

3.3 Management Implications

Referring to the landscape characteristics of the Javan hawk-eagle habitat's that explained, some management activities that can be done for securing the Javan hawk-eagle habitat's are :

1. Create buffer zone surrounding the forest patch, that can be used by the species as their home range, and protect them by rules and law regulation,
2. Keep the forest patches from hunting and encroachment along the forest edge, that used by the species for hunting their prey,
3. Forest patches in landscape B which located in northern Bandung, have higher value in total edge and edge density, which is suitable habitat for immature Javan hawk-eagle, should be protected,
4. Giving ecological education and information about Javan hawk-eagle and their habitat to the local community which also used the forest habitat,
5. Building up local community participation in protection and securing of the nest trees.

CONCLUSIONS

1. According to the 29 sites of locality records from the existed data, habitat of Javan hawk-eagle in western part of Java are distributed at the mountainous and forested areas. Habitat distribution are clustered in 3 landscapes area which include :

- Gede – Pangrango NP, Halimun NP, and Salak Mt. at central mountain complex (Landscape A), with 15 existed locality records (Map 3),
- Burangrang and Tangkubanprahu Mts. at Southern Bandung (Landscape B), with 2 existed locality records (Map 5),
- Situ Patengan, Malabar, Patuha, and Tilu Mts. at northern Bandung (Landscape C), with 12 existed locality records (Map 7).

2. Result of habitat preference analysis, using landscape structure and Principal Component Analysis reinforce the interpretation of most desirable habitat of Javan hawk-eagle, which are : forest, tea plantation, and mix vegetation, elevation, and slope condition.
3. The digital nature of land cover information from satellite imagery in remote sensing enables a potentially large number of landscape matrices to be derived and cover large coverage area, at relatively fine spatial (typically 10 – 30 meters). GIS is used for storing, retrieving, maintaining, manipulating, analyzing, and producing the digital and hard copy format of spatial data. GIS improve remote sensing information in extraction capabilities. It's also support spatial statistical analysis of ecological distribution.

   The remote sensed data combine with GIS could provide data in regional scale and used in mapping habitat preferences. These methods can be used as methods in formulate the conservation strategies for protection the critical habitat of Javan hawk-eagle.

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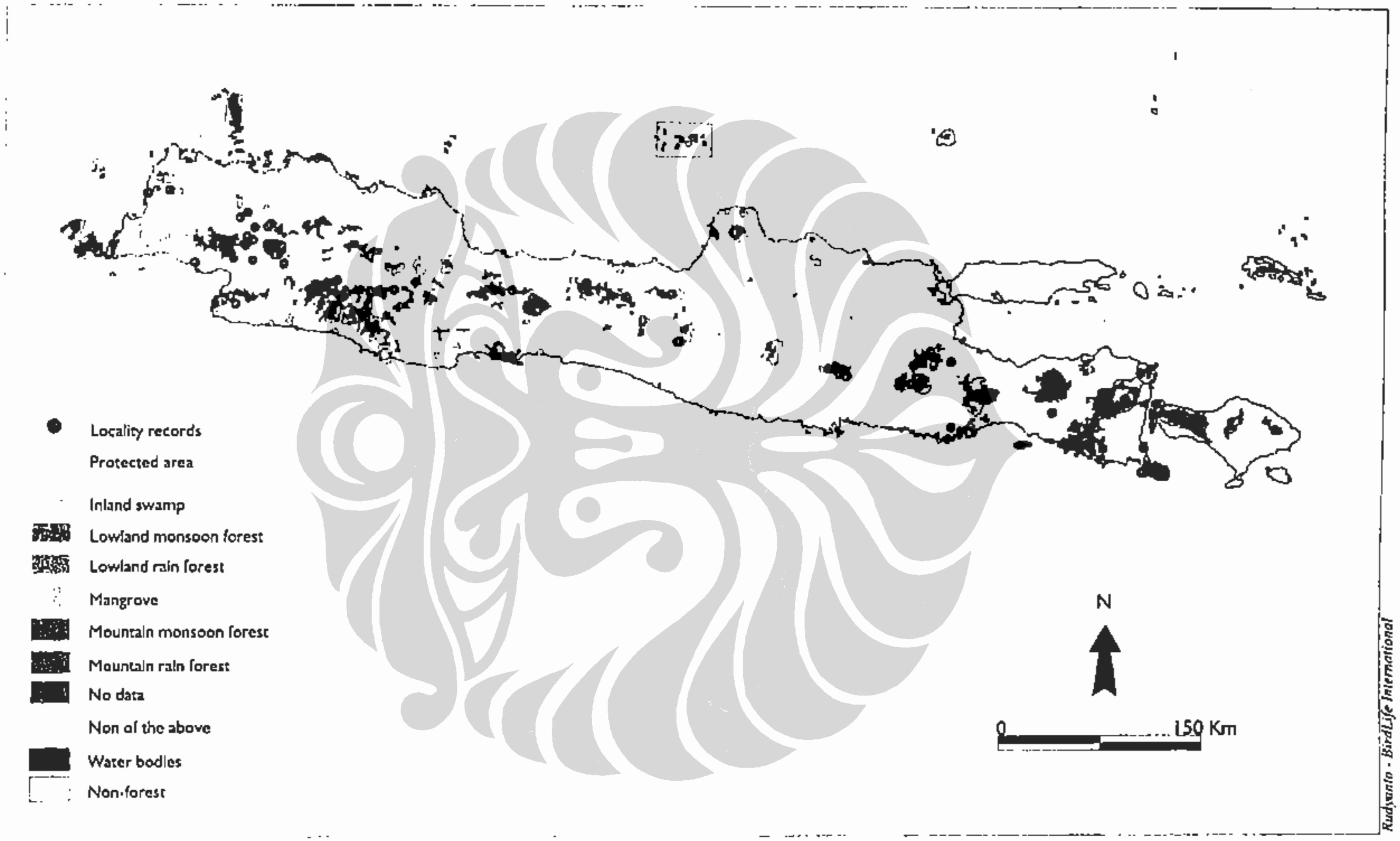
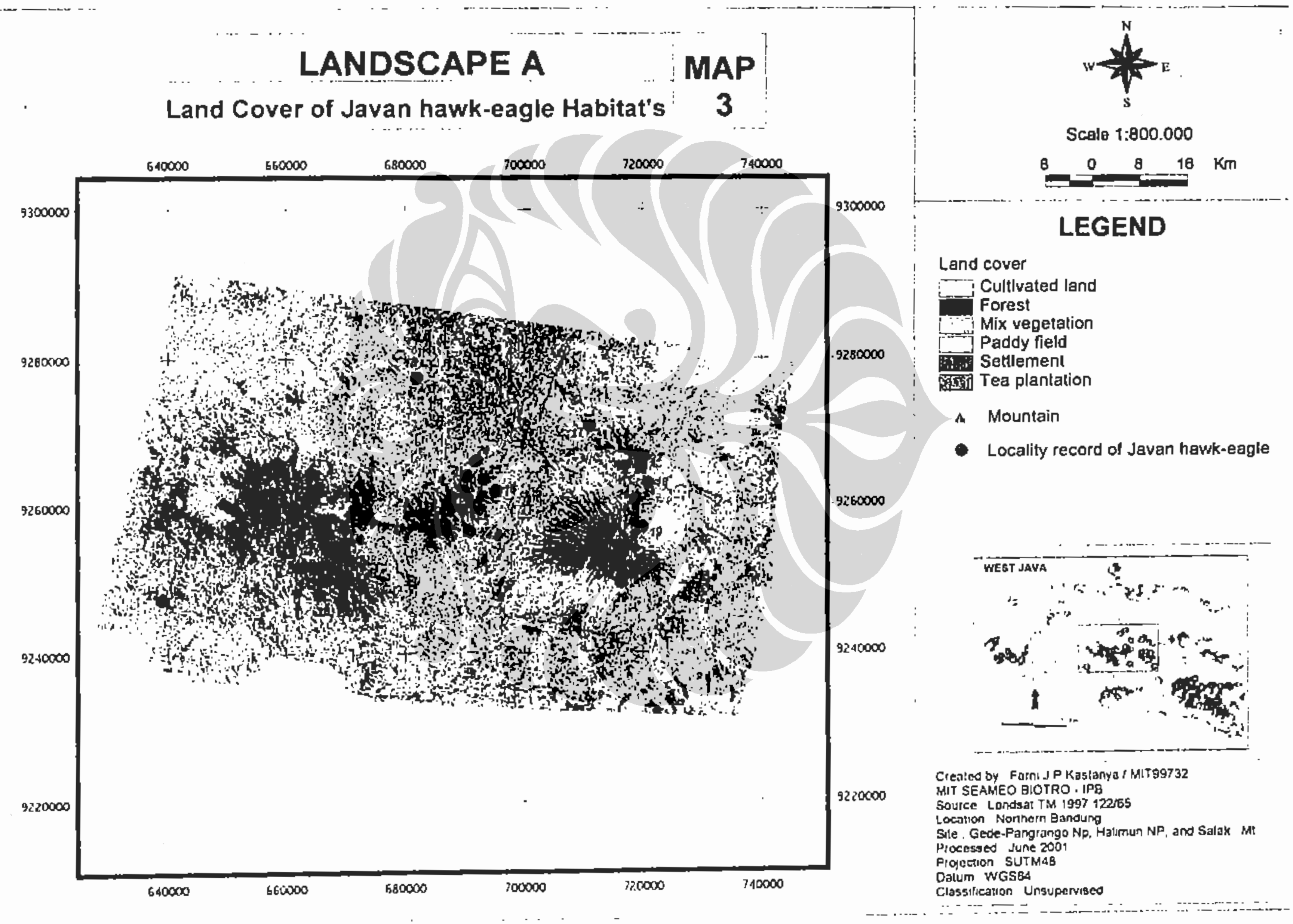
Appendix-1



Source : Sozer *et al* 1998

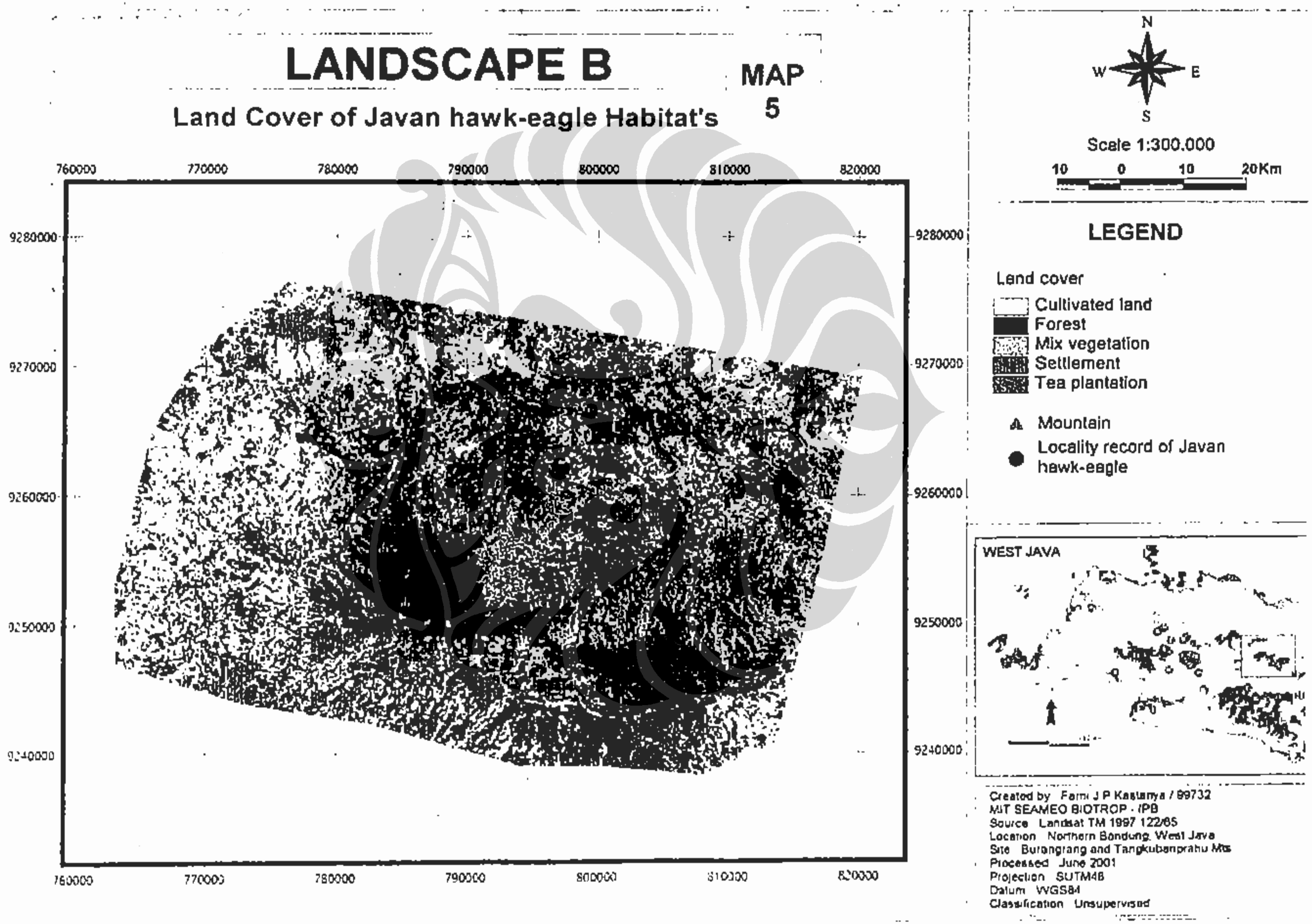
Figure 4. Distribution of Javan Hawk–eagle in Java Island

Appendix-2

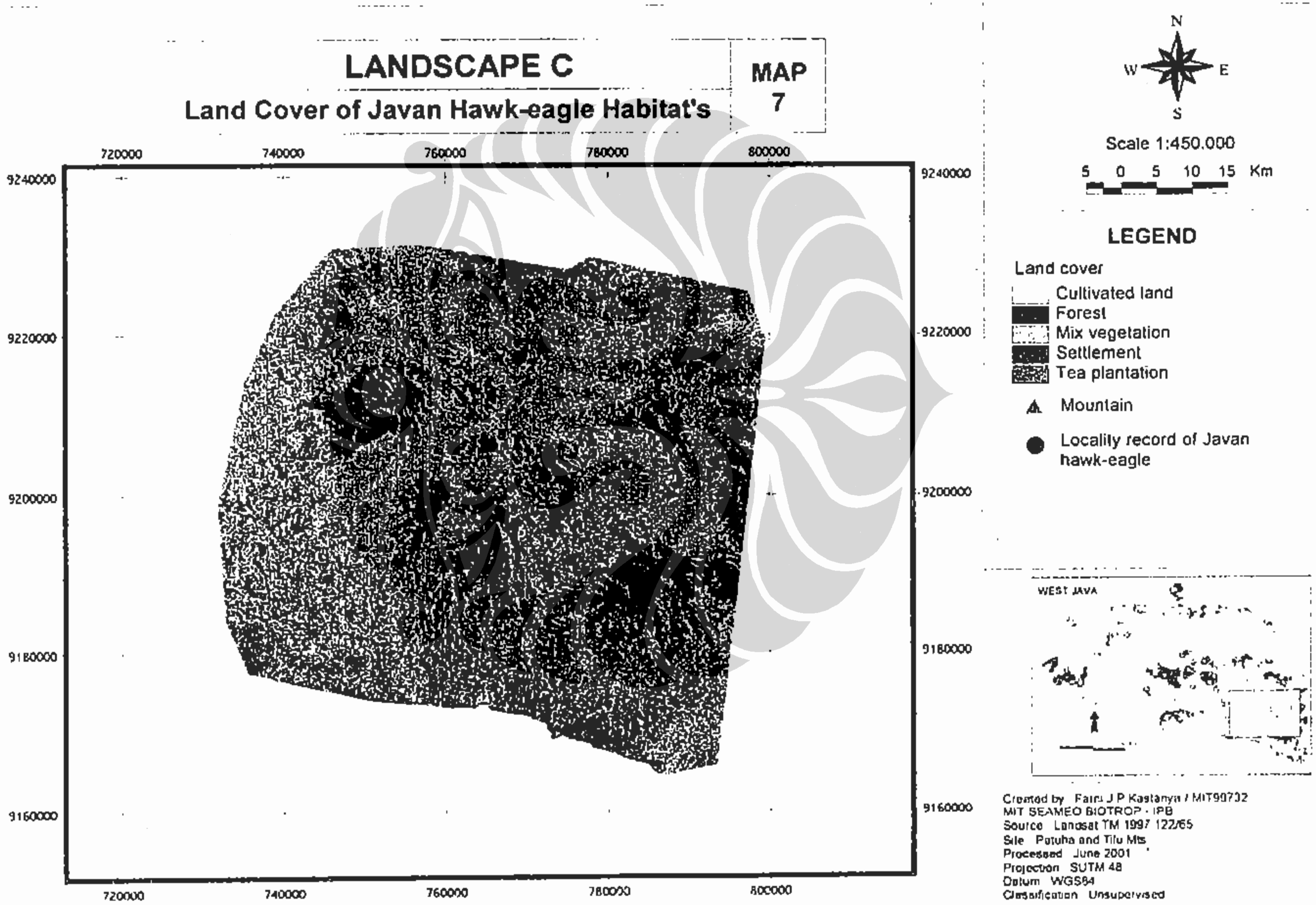


LANDSCAPE A
Land Cover of Javan hawk-eagle Habitat's
MAP
3
640000
660000
680000
700000
720000
740000
9300000
9280000
9260000
9240000
9220000
N
W
E
S
Scale 1:800.000
8
0
8
16
Km
LEGEND
Land cover
Cultivated land
Forest
Mix vegetation
Paddy field
Settlement
Tea plantation
Mountain
Locality record of Javan hawk-eagle
WEST JAVA
Created by Farni J P Kastanya / MIT99732
MIT SEAMEO BIOTRO - IPB
Source Landsat TM 1997 122/65
Location Northern Bandung
Site . Gede-Pangrango Np, Halimun NP, and Salak Mt
Processed June 2001
Projection SUTM48
Datum WGS84
Classification Unsupervised

Appendix-3


LANDSCAPE B
MAP 5
Land Cover of Javan hawk-eagle Habitat's
760000
770000
780000
790000
800000
810000
820000
9280000
9270000
9260000
9250000
9240000
N
W
E
S
Scale 1:300.000
10 0 10 20Km
LEGEND
Land cover
Cultivated land
Forest
Mix vegetation
Settlement
Tea plantation
Mountain
Locality record of Javan hawk-eagle
WEST JAVA
Created by Fami J P Kastanya / 99732
MIT SEAMEO BIOTROP - IPB
Source Landsat TM 1997 122/65
Location Northern Bandung, West Java
Site Burangrang and Tangkubanprahu Mts
Processed June 2001
Projection SUTM48
Datum WGS84
Classification Unsupervised

Appendix-4


LANDSCAPE C
Land Cover of Javan Hawk-eagle Habitat's
MAP 7
720000
740000
760000
780000
800000
9240000
9220000
9200000
9180000
9160000
N
W
E
S
Scale 1:450.000
5 0 5 10 15 Km
LEGEND
Land cover
Cultivated land
Forest
Mix vegetation
Settlement
Tea plantation
Mountain
Locality record of Javan hawk-eagle
WEST JAVA
Created by Fairu J P Kastanya / MIT99732
MIT SEAMEO BIOTROP - IPB
Source Landsat TM 1997 122/65
Site Patuha and Tilu Mts
Processed June 2001
Projection SUTM 48
Datum WGS84
Classification Unsupervised