The Indonesian Journal of Geography Vol.26, No.68
December 1994, pp. 11-26

THE USE OF SPOT IMAGE FOR MANGROVE INVENTORYIN CIMANUK DELTA WEST JAVA, INDONESIA

by
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ABSTRACT

This study deals with an application of SPOT satellite data for mangrove forest inventory in Cimanuk Delta West Java (Indonesia). Mangrove of the area (7100 Ha) has been gradually decreasing by human pressure especially for fisheries purposes. In fact, mangrove here is a result of afforestation since 1960, with Rhizophora mucronata and R. apiculata as main planted species. Other species are Lumnitzera racemosa, Excoecaria agallocha, Bruguiera gymnorhiza and Avicennia which grow naturally. SPOT data were digitally analysed using Didactim software. A color composite image was analysed. A barycentric supervised classification and a textural analysis were applied. As an intermediate data, infrared color aerial photographs at 1/30,000 (1981) were interpreted manually.

At least two mangrove types of mangrove could be identified from the SPOT image. Dense mangrove was found in Petak 7, Petak 8, Petak 9 and Petak 12. In the other Petaks, mangrove were less than 20% of their surface. Mangrove of Rhizophora in 26 Petaks covered 290 Ha only.*

INTRODUCTION

One of the major scientific issues today is the accelerating conversion of tropical forest to agriculture (Achard and Blasco, 1990). This type of conversion can currently be found in mangrove forest. Mangrove forest is an halophytic plant community especially found in the intertidal zone of tropical countries. Up until 1960s, mangrove forests were considered as almost useless formations. So practically, management of mangrove means to change them into other types of land use, e.g. residential areas, airports, agricultural lands, fish ponds, etc. In many parts of the tropical world where mangrove forest exists, destruction of this formation takes place continously. In fact, from these forests, many resources (timber, leaves, tanin, etc) can

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Petak is the smallest surface of forest territory for management purposes

be exploited. In Indonesia, Martosubroto and Naamin (1982, in Soewito, 1984) showed a positive relation between the surface of mangrove and prawn production. So the ecological function of mangroves (fishery, coastal protection, coastal accretion, etc) are now recognized all over the world.

Awareness of mangrove disappearance in Indonesia was initialized since the last thirty years. It was stressed at the first national mangrove seminar hold in Jakarta in 1978. In Java, some efforts for mangrove conservation, by the government of private initiative, have been encouraged. Mangrove afforestation has been carried out by Perhutani of Forest Service (in Tanjung Kerawang, Cemara, Cangkring, RPH Rawa Timur, etc), by "ABRI Masuk Desa" program and local people e.g. in Curah Sawo, Probolinggo (Soeroso and Hadipurnomo, 1984). But actually, such positives actions are not yet sufficient for conserving mangrove.

One can find that mangroves in Java have been gradually decreasing: Sagara Anakan mangrove, the biggest one in the island, 22.000 Hectares in 1917 (De Haan, 1931), had 13.000 hectares in 1957; 11.000 Ha in 1979 (Haditejono, P.S and Abas, Ts, 1984) and 8600 hectares in 1987 (Hartono, 1991). Deforestation has been extremely active in western and northern parts of the lagune, primarily in Petak 1, Petak 2, Petak 7, Petak 11, Petak 12, Petak 18, and Petak 19 for agricultural purposes. In Cimanuk delta, the mangrove covered 7137 Ha in 1968; 100 Ha remained in 1982 and only 267 Ha in 1990 (Anonymous, 1990). It has been cut by human intervention for aquaculture practices (especially prawns and milk fish) and domestic uses. Degraded mangrove can also be found in Tanjung Kerawang and RPH Pondok Tengah of Citarum delta (Blasco, 1982; Djaja et al, 1984; Tim Peneliti, 1989).

SPOT satellite data have been used for about more than five years for mangrove forest analysis and monitoring in many parts of the world. Blasco (1984) carried out a mangrove type identification in Sunderbands using a color composite image of SPOT simulation decorelated bands. Barkey (1987) in Sulawesi (Indonesia) used distance classification for classifying several mangrove types on SPOT oblique image. For mapping purposes, SPOT images have been used in Viet Nam (Phan Phu Bong, 1990); and in Guinea (Moreau and Vercesi, 1989; Bertrand, 1991). It was reported that several types of mangrove according to their density and floristic composition could be identified from these data. Recently, a monitoring of mangroves has been performed with SPOT and aerial data in Brantas delta, East Java (Hartono and Bangun Muljosukojo, 1990). It showed that SPOT image can be used for a rather accurate mapping of mangrove vegetation.

The aim of this study is to inventory the mangrove forest of Cimanuk delta by analysing SPOT digital data acquired in 1987. As a potential area for aquaculture activities, these mangroves of this region changed intensively by human pressure and coastal erosion. In consequence, the mangrove has more and more decreased. Informations about the actual condition of the forest is necessary in relation to its management. As an orbital satellite with a high spatial resolution (20 metres), SPOT can be used for this purpose.

THE STUDY AREA

The study area is shown in Figure 1. It covers the Cimanuk delta in West Java, (Indonesia). Bioclimate features are a moderate dry season (3-4 months) and a mean

annual rainfall ranging between 1000 and 1500 mm. Coastal erosion takes place in the northern part of the delta, Pabean Hilir and Cangkring coastal regions, while accretion processes can be found western (Cemara) and Eastern parts (relatively new deltas of Pancer Payong, Pancer Balok). New deltas development is due to change of river courses from north to east directions. The direction change lies in northern part of Indramayu. So the coastal development of Cimanuk delta was rapid. Physical condition of this delta have been studied by Lukman Effendi, et al (1981). Van Bemmelen (1949 in Macnae, 1968) reported that coastal accretion in this areas was 125 metres per annum. This type of process provides a good environment for mangrove development.

DATA AND MATERIALS

The primary data used in the study are digital data of SPOT acquired on July 14, 1987. From it was extracted a 512 x 512 pixels training zone. The corresponding scene is K=287, J=363. The preprocessing level is 1B, with 0% of cloud cover. The image covers the western and central parts of the delta. Infrared aerial photographs at 1981 on 1/30,000 were used as intermediary data between SPOT and field data. Geologic, Soil and Land Use maps available were used as supplementary data. Field checks were conducted in 1989.

METHOD

The method used in the study is combination of image analysis and field works. The field works been carried out in order to get some interpretation key for mangrove and other land use classes. SPOT digital data were analysed using the DIDACTIM software available in the Institute de la Carte Internationale de la Vegetation, Toulouse, France. While the infrared aerial photographs were interpreted manually in Bakosurtanal, Indonesia.

A Color composite image was visualized, then a Barycentric supervised classification and a textural analysis have been applied for informations extraction from the SPOT numerical data. The Barycentric classification uses euclidean distance for classifying the pixels. Classification precision was obtained from a confusion matrix of the classification result.

THE MANGROVE OF CIMANUK DELTA

The mangrove forest of Cimanuk Delta is under direction of the "Kesatuan Pengangkutan Hutan" (KPH) Indramayu, a subdivision of PERHITANI, the forest government company. The area which covers 7137 hectares consists of 70 Petaks organized in four "Resort Polisi Hutan" (RPH), a subdivision of KPH : RPH Cemara (1748.3 Ha) in the west, RPH Cangkring (2080.73 Ha), RPH Purwa (1903.18 Ha) and RPH Pabean Hilir (1395.35 Ha) in the east.

Actually, the mangrove has been undergone by human pressure, especially for fisheries purposes. Our field check showed that some good mangrove could be found

in Petak 18, 16, 20. In RPH Cemara, good stands of mangrove could be found in Petak 6, 7, 8 and 9 (Tim Peneliti, 1989). While in RPH Pabean Hilir and RPH Purwa the Mangrove was degraded; even one could find some Petaks with less than 10% of trees, surrounded by fisheries. This type of landscape is common in all of the four RPHs.

In fact, the mangrove of Cimanuk delta is a result of afforestation carried out since 1960. Almost all Petaks have been afforested (table 1a, 1b and 1c). Between 1964 and 1988, 500,34 Ha in RPH Cemara have been reafforested with Rhizophora (dominant) and Avicennia (table 1a). Most of the afforestations activities were done in 1970s. In RPH Cangkring, the afforestation were realized between 1969 and 1984, most of them in 1970s. Afforestation has given good results (table 1b). While conservation forest (table 1a), We found that there were many problems in realizing the reafforestation. Some of the lands designed for this purpose were not ready to be planted e.1. erosion took place in Petak 17, 19, and 22; occupied by people for Petak 31, 37, and 38; and in conflict with Pemda for Petak 25, Petak 33 and Petak 34. In this case, we think that lands in conflict usually concern the status of new lands built by sedimentation processes. Coastal line measures realized by KPH Indramayu in December 1982 showed that there were 590,10 Ha of new land. This type of conflict can also be found in Segara Anakan especially in Petak 9 and Petak 10. Natural regeneration of Rhizophora almost totally succeeded in Petak 15, Petak 16 and Petak 32. One advantage of using SPOT image in this study is to obtain the existing mangrove area and then to compare it with the mangrove reported.

Table 1a. Reafforestation in RPH Cemara, KPH Indramayu - Java Ouest

Petak	Mangrove	Year	Surface (Ha)
7	Rhizophora	1975	35
	Rhizophora	1977	86,01
	Rhizophora	1971	8
	Rhizophora	1967	5
	Rhizophora	1966	2
	Rhizophora	1964	8
	Rhizophora	1970	20
8	Rhizophora	1977	63
	Avicennia	1972	20
	Rhizophora	1966	8
9	Rhizophora	1978	40,04
	Rhizophora	1976	48,04
	Avicennia	1978	8
12	Rhizophora	1988	12
	Rhizophora	1978	25
	Rhizophora	1974	35
	Rhizophora	1975	38,70
	Avicennia	1981	8,55
	Avicennia	1975	2
	Avicennia	1978	28

Source: RPH Cangkring-KPH Indramayu, in Tim Peneliti, 1989.

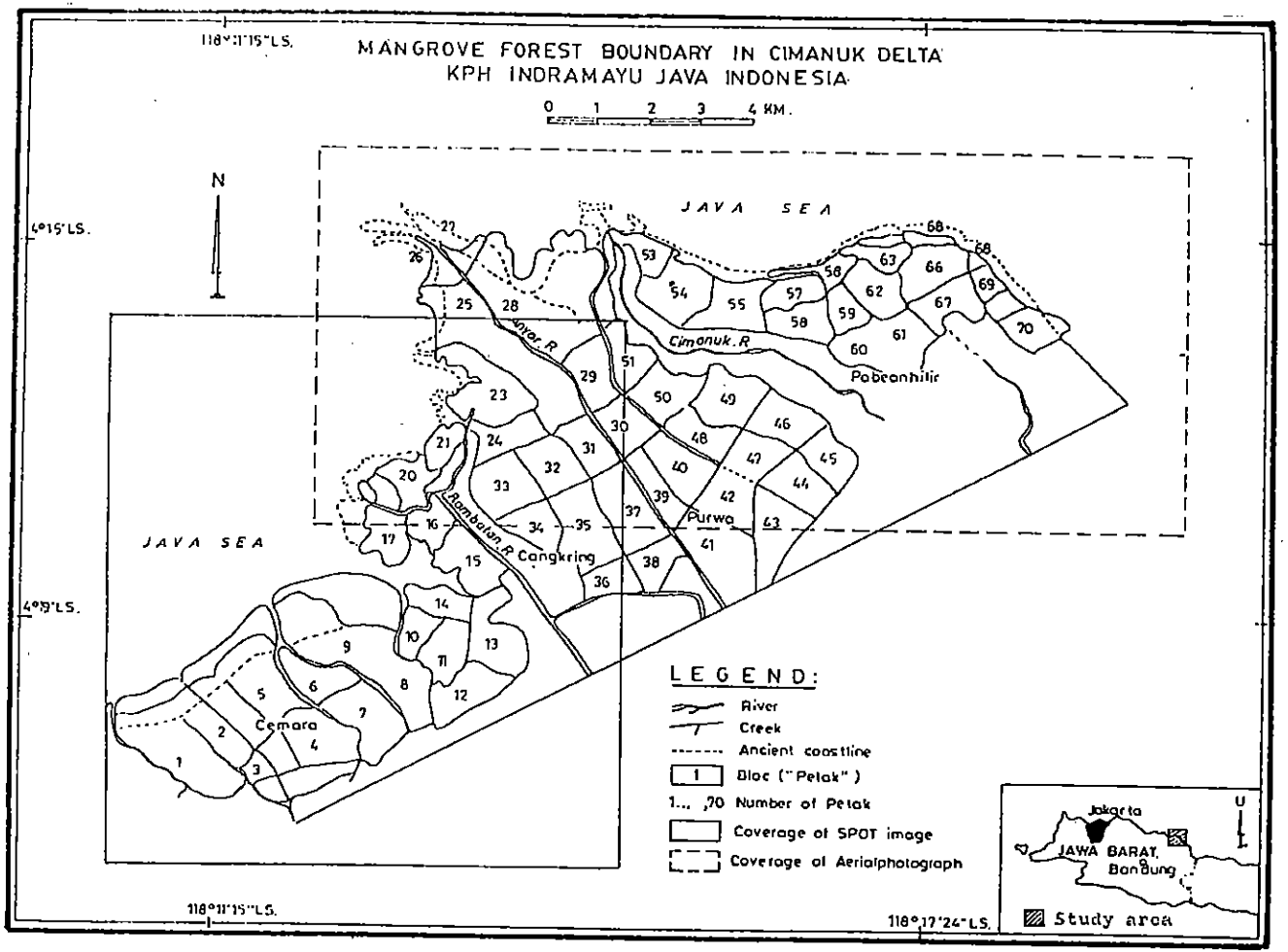

MANGROVE FOREST BOUNDARY IN CIMANUK DELTA
KPH INDRAMAYU JAVA INDONESIA
0 1 2 3 4 KM.
N
JAVA SEA
JAVA SEA
Jatar R.
Cimanuk R.
Pabeanhilir
Bambangan R.
Cangkring
Purwa
Cemara
LEGEND:
River
Creek
Ancient coastline
Bloc ("Petak")
1..., 70 Number of Petak
Coverage of SPOT image
Coverage of Aerialphotograph
Jakarta
JAWA BARAT
Bandung
Study area

Table 1b. Reafforestation of Conservation Forest in RPH Cangkring

Petak	Type	Surface*	Success	Explanation
15	Rhizophora	3	80%	Natural regeneration
16	Rhizophora	15	85%	Natural regeneration
17	-	-	-	Destroyed by wave
19	-	-	-	Destroyed by wave
22	Avicennia	102,86	65%	Destroyed by wave
25	-	50	-	Area in conflict with Pemda**
31	-	2	-	Occupied by people
32	Avicennia	112,4	70%	-
33	-	138,9	-	Occupied by Pemda
34	-	24,78	-	Area in conflict with Pemda
35	-	8	-	Borrowed by Pertamina***
37	-	12	-	Occupied by People
38	-	17,0	-	Occupied by People

Source: RPH Cangkring-KPH Indramayu, 1989

* Surface in Hectares

** Pemda: Government administration in District level

*** Pertamina: Government Oil Company.

Table 1c. Reafforestation for Production Forest in RPH Cangkring

Petak	Area	Mangrove	Year	Surface*	Success (%)
15	123,55	Rhizophora	1969	20	80%
		Rhizophora	1970	20	65%
		Rhizophora	1974	25	65%
		Rhizophora	1977	25,55	65%
		Rhizophora	1977	20	20%
16	68,55	Rhizophora	1977	53,35	65%
17	82,55	Rhizophora	1978	72,55	80%
18	50,78	Rhizophora	1978	12	70%
		Rhizophora	1978	18	-
		Rhizophora	1978	20,78	-
19	62,99	Rhizophora	1978	11	65%
		Rhizophora	1978	31	-
		Rhizophora	1978	20	-
20	101,25	Rhizophora	1978	90	70%
		Rhizophora	1978	11,25	-
21	77,65	Rhizophora	1977	48,50	70%
		Rhizophora	1977	29,15	-
22	102,86	-	-	-	-
23	109,40	Rhizophora	1982	55	56%
		Rhizophora	1982	54,40	85%
24	103,80	Rhizophora	1977	12	35%
		Rhizophora	1977	91,80	ex INPRES**
25	255,87	Rhizophora	1980	79,99	es INPRES
		Rhizophora	1981	71,75	ex INPRES
		Avicennia	1983	10	65%
		Leucaena glauca	1984	10	80%

26	46,12	-	-	46,12	-
31	89,55	Avicennia	1974	72,55	70%
32	112,40	-	-	-	-
33	138,90	-	-	-	-
34	86,05	Rhizopora	1976	15	60%
		idem	1976	-	-
		idem	1977	36,27	60%
35	162,75	Avicennia	1975	154,75	65%
		idem	-	8	-

Source : RPH Cangkring-KPH Indramayu, 1989. Source : surface planted in hectares;

**INPRES : a government project

Generally, mangrove in the delta are young to mature. Three mean height is not more than 9.0 metres. Tim Peneliti (1989) found that mangrove in RPH Cemara was Rhizophora, the height of which varies between 3.0 m to 7.0 m. In the RPH, Rhizophora mucronata is dominant, then followed by R. apiculata, Rhizophora sp, and Avicennia. Mean heights of the mangroves are presented in table 2 (after Tim Peneliti, 1989).

Table 2. Mean height of mangrove in RPH Cemara (in metres)

Species	Plot 6	Plot 7	Plot 8	Plot 9
R. mucronata	5,1	5,5	6,9	5,1
R. apiculata	4,6	4,8	4,3	4,7
Rhizophora sp.	5,4	6,6	3,6	7,0
Avicennia sp.	3,0	3,0	3,0	3,8

In RPH Cangkring, Rhizophora apiculata is dominant, with a density of about 1300 trees/Ha. The height varies between 7 and 8 metres. In the RPH, important value of Rhizophora apiculata was 211.5, while R. mucronata was 88.5. One can find mangrove which grows naturally e.g. Lumnitzera racemosa, Bruguiera gymnorrhiza, Excoecaria agallocha and Avicennia. These formations can be found around Petak 16. The regeneration of mangrove takes place naturally with the participation of forest guards in the regularity, the density of seedlings and saplings. In RPH Pabean Hilir, Rhizophora mucronata was present, mixed with R. apiculata and Rhizophora sp. The important values of Rhizophora mucronata was 152.2, R. apiculata was 10.1, and Rhizophora sp was 137.7. Mangrove in the area is presented in figure 2. In RPH Purwa, mangrove was degraded, and in some places, e. g. Petak 44, 45, 47, small bush formation (dominated by Pluchea indica) can be found.

SPOT IMAGE ANALYSIS

First of all, the image was presented in a linearized color composite visualization with the following combination :

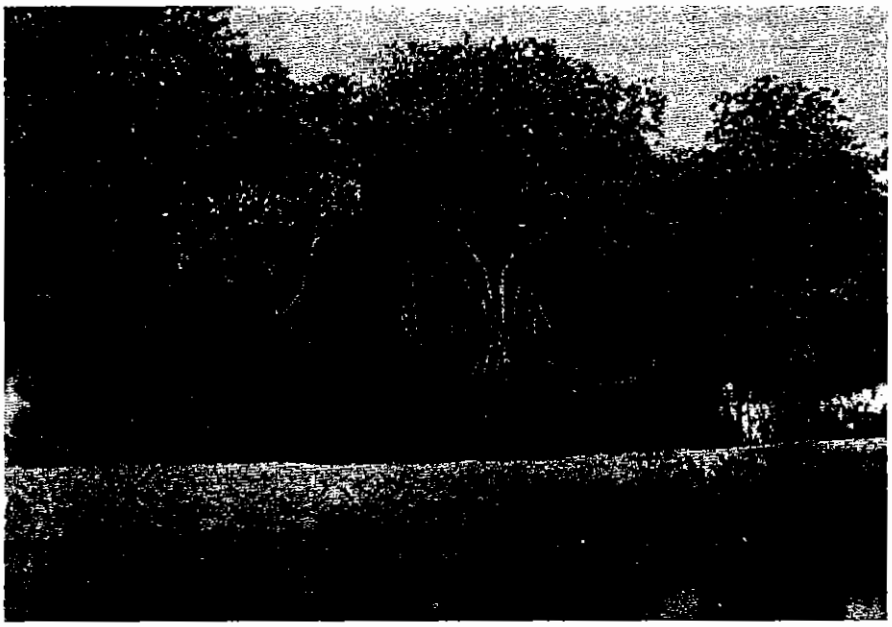


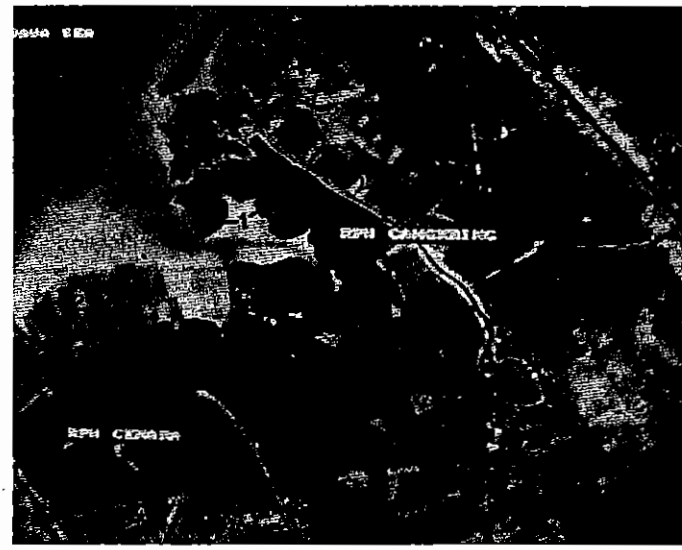
Figure 2. Mangrove of Rhizophora mucronata in RPH Cangkring (July 17, 1989)

Table 3. Combination of SPOT Color Composite Image in Cimanuk Delta

Band	Color	Grey levels
XS1 (Green)	Blue	256 (8 bits)
XS2 (Red)	Green	256 (8 bits)
XS3 (Infrared)	Red	256 (8 bits)

The image obtained is good (figure 3) and from it training areas can be chosen. From the color composite image, at least two types of mangrove vegetation (red color) in mangrove forest territory can be identified. Out of mangrove, can be seen aquaculture basins (dark blue). In the other part of the image: rice fields, villages, homestate gardens are also present. Linear objects (rivers, creeks, irigation, chanels, can also be easily identified.

Secondly, based on field data, twenty training areas which represent seventeen classes have been chosen. Mangrove include by five classes : 1. Mangrove with Lumnitzera, 2. Mangrove with Rhizophora, 3. Mangrove with Avicennia, 4. Mixed floristies 5. Degraded mangrove. While the other twelve classesinclude. Bush (Plucea indica), 6. Leucaena leucocephala plantation, 7. horticulture, 8. dry grass, 9. Dense village, 11. Hygrophyts, 12. Shrub, 13. Village, 14. Wet grass, 15. Bare land, 16. Sand and 17. Pioneer mangrove. From the training areas, mean and standard deviation values were obtained. The values are then presented on a two dimensions (XS2 and XS3) (figure 4) scattergram. The figure 4 shows that there are some overlaps between classes number 1 and 2;2 and 8;3 and 9;6 and 6. While the others are well separated.



1: Mangrove 2: Fisheries

Figure 3. SPOT Color Composite Image of Cimanuk Delta

The barycentric classification was then applied five times with different numbers of classes for each processing. It was conducted with 5 classes, then increased to 7, 9, 12 and 17 classes. These steps were chosen in order to evaluate the spectral accuracy of SPOT image to differenciate mangrove types and land use units in the study area. For thematic presentation purposes, a textural analysis based on logic decision, has been applied to the classified image. This process omitted some isolated pixels and generalized envelopes of classes. After changing the classified image into a binary one, on the basis nine pixels (3x3), we obtain a new value of the central pixel. Finally, evaluation of classification was obtained from a confusion matrix between the training areas and classified image (appendix 1 and 2).

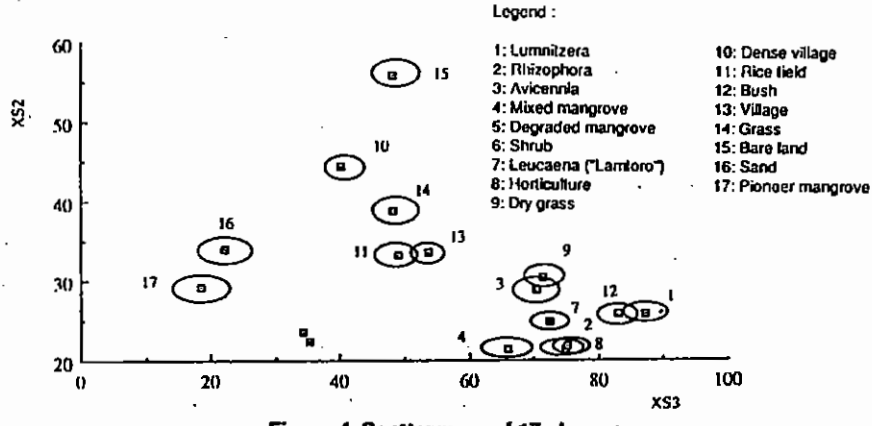


Figure 4. Scattergram of 17 classes

RESULT AND DISCUSSION

Mangrove Identification

The barycentric classification which has been applied five times provided five confusion matrix, from which the statistic and classification accuracies were calculated (table 4).

Table 4. Mean Precision of on Classification

No.	Class number	PC (%)	PS (%)
1	5	94	95,5
2	7	92	93,3
3	9	83,4	84,1
4	12	78,4	78,8
5	17	83,9	83,5

PC: Precision of Classification PS: Precision of Statistics

The first classification realized with the first five classes, provided a good result with more than 90% of pixels classified for each class of mangrove. In this phase, there no isclass with 100% success. Some confusions: Lumnitzera is confused with 8,3% Avicennia; Rhizophora confused with mixed mangrove. In the second classification, with addition of classes number 6 and 7, the result is almost the same. Lumnitzera has 91,7% pixels classified, Rhizophora 92,2%, Avicennia 83,3%, Mixed mangrove 96,9% and Degraded mangrove 88,7%. Lumintzera was not in confusion with Avicennia anymore but it mixed with Leucaena (class number 7). This little confusion occurred also in Rhizophora and Avicennia. In this process, the accuracy decreased. for the third classification, two new classes (classes number 8 and 9) have been added. Rhizophora has only 50% pixels classified, Lumnitzera 91,7%, Avicennia 75%, Mixed mangrove 96,9% and Degraded mangrove 88,7%. It confused with mixed mangrove, Leucaena and holticulture. The accuracy decreased (83,4% and 84,1% respectively).

In the fourth classification, classes number 10, 11, 12 were introduced. At this stage, the confusion between mangrove and land use classes increased. Lumnitzera has 66,7% pixels classified, Rhizophora 48,4%, Avicennia 75%, Mixed mangrove 96,9% and Degraded mangrove 88,7%. In the fifth classification, when five new classes with high spectral values (sand, bare land, etc) were introduced, the mean accuracy increased. It can be understood that the new classes are spetrally extremely different. But the accuracy for the mangroves themselves still decreased, especially for Avicennia. Lumnitzera has 66,7% pixels classified, Rhizophora 48,4%, Avicennia 58,3%, Mixed mangrove 96,9% and Degraded mangrove 92,6%. A little increase is found in Degraded mangrove. In this process, mean accuracy increased (table 4).

The accuracy of mangroves classes decreased when new classes are added. The tendance took place up to the fourth classification. The mean accuracy increased again in the fifth process when five new distinct classes were introduced. Only two classes of mangrove (Mixed mangrove and Degraded mangrove) were stable with

more than 90% pixels well classified. The remaining three classes of mangrove could be well classified when the number of classes is nine or less.

Surface of Mangrove in Cimanuk Delta

An advantage of using remote sensing data is to present the surface of the objects identified on the image. In the study area, surface under mangrove on 26 Petaks are given in table 5. The surfaces were calculated by multiplying the number of pixels which represent mangrove with spatial resolution of SPOT data (0,04 Ha).

Table 5 shows that vegetation surface in the Petaks is 909 Ha, out of which Mangrove of Rhizophora (principal stand in the area) is 290 Ha or 10,3%. Fisheries fields are dominant in the area with 1912.04 Ha (67.8%), while the other vegetation types (Avicennia, Excoeraci agallocha, etc.) are 619.02 (22.2%). Only three Petaks (12%) have Mangrove with Rhizophora more than 20%. They are Petak 7 (21.21%), Petak 8/9 (31.1%) and Petak 12 (24.57%). Seven Petak (27%) have Rhizophora between 10% - 20% (Petak 10, 11, 17, 31, 32, 35, 36) and 15 Petaks (58%) have 10% (Petak 2, 3, 4, 5, 6, 13, 14, 15, 16, 20, 23, 24, 33, 34 and 37). By and large, deforestation activities takes place in all of Petaks.

Evaluation of Reafforestation

Since 1960s, reafforestation of mangrove with Rhizophora has been done in the area. It was reported that it has been successful for more than 60%. In this study, surface reported in eleven Petaks are compared to those measured from SPOT image (table 6). Table 6 shows that most of the surface reported are large than those found from SPOT image. About ten years after afforestation the mean mangrove deflection is 44% in each Petak respectively. Petak 24 is stable in this period.

Mangrove in this area is decreasing more and more. This can be caused by natural processes (coastal erosion, river change direction, change in salinity, etc) or by human intervention. Coastal erosion takes place particulaly in some areas in Pabean Hilir and Cangkring coasts. Coast line measurements carried out by KPH Indramayu, in December 1982, showed that 339,03 Ha of coastal sediments have been eroded. But the eroded land is smaller than the new land resulted by accretion processes. In RPH Purwa, shrub formation (Pluchea indica) occur in some Petaks e.g Petak 44 and 45, which are far enough from the coast (around 6 km), so as the tides probably do not reach the areas anymore. Mangrove needs regular amount of saline water.

One of the most important causes of mangrove destruction is human activity through deforestation. Mangrove in the delta have been cut and changed into fisheries fields. It is a crucial problem, especially in Java which has more than 500/sq.km of population density. In fact in the area, fisheries have been well regulated with 10% to 20% for fisheries and mangrove is kept in the middle (80%). But one can find in almost all the Petaks that fisheries have been enlarged and the mangrove is decreasing. To solve this problem strict, limitations of deforestation by strict ragulation are not enought without a consideration of jobs availabilty (fisheries and agriculture) for fisherman whose life depends entirely on these resources. Perhaps it is time to evaluate exactly how many hectares of land a fisherman needs

for his fisheries fields in mangrove environment. And how they can cultivate their fields properly, and conserving in the same time mangrove in their responsability. For that, presidential decision "KEPPRES 32/1990" which regulates that green belt of mangrove has to be protected being equal to 130 multiplied by local tide fluctuation measured in the lowest tide, must be applied in mangrove environment like the delta. Protected and favorable lands for mangrove should be mapped precisly and reafforestation of mangrove in the protected land which has degraded mangrove, should be carried out as soon as possible.

Table 5. Surface of 26 Petaks of Mangrove in Cimanuk Delta

	A	B	C	D	E	F	G
1	N°	Location	Rhizopora		Other Vegetation	Fishery	Total
2			Ha	%	Ha	Ha	Ha
3	1	Petak 2	0,28	0,34	6,00	75,96	82,24
4	2	Petak 3	0,04	0,05	7,96	65,32	73,32
5	3	Petak 4	4,20	4,87	17,56	64,40	86,16
6	4	Petak 5	4,72	3,15	4,92	137,92	149,56
7	5	Petak 6	9,52	8,38	18,92	85,08	113,52
8	6	Petak 7	39,56	21,21	63,24	83,68	186,48
9	7	Petak 8/9	44,04	31,10	31,36	66,24	141,64
10	8	Petak 10	11,24	15,38	16,04	45,76	73,04
11	9	Petak 11	14,52	13,57	21,20	71,28	107,00
12	10	Petak 12	34,30	24,57	49,42	55,84	139,56
13	11	Petak 13	4,12	2,99	21,44	111,84	137,40
14	12	Petak 14	2,92	2,81	17,20	83,84	103,56
15	13	Petak 15	10,68	7,47	24,24	106,56	141,48
16	14	Petak 16	6,36	7,84	17,56	57,20	81,12
17	15	Petak 17	8,68	15,30	13,72	34,32	56,72
18	16	Petak 20	2,60	3,47	8,36	63,88	74,84
19	17	Petak 23	0	0	1,62	129,24	130,84
20	18	Petak 24	0,56	0,36	3,88	150,32	154,76
21	19	Petak 31	16,88	14,77	71,60	25,80	114,28
22	20	Petak 32	11,24	10,48	23,68	72,32	107,24
23	21	Petak 33	0,20	0,166	3,16	117,08	120,44
24	22	Petak 34	3,08	3,28	11,72	78,82	93,62
25	23	Petak 35	35,56	17,72	53,36	65,36	144,28
26	24	Petak 36	8,44	13,59	23,66	30,08	62,08
27	25	Petak 37	11,60	7,95	100,36	33,92	145,88
28	26	TOTAL	290,00	10,30	619,02	1912,04	2821,06

Table 6. Comparison of Surface Reported and Those Obtained from SPOT

No	Petak	Year	SR	SS	D	%
1	Petak 7	1964/1977	163.74	102.80	-60.94	37.22
2	Petak 8/9	1966/1978	187.08	75.40	-111.68	59.70
3	Petak 12	1974/1988	149.10	83.72	-65.45	49.90
4	Petak 15	1969/1977	64.10	34.92	-29.17	45.60
5	Petak 16	1978	58.04	29.48	-28.56	49.20
6	Petak 20	1978	63.00	10.96	-52.04	82.60
7	Petak 24	1977	4.20	4.44	0.24	5.70
8	Petak 31	1974	50.78	88.48	37.70	74.20
9	Petak 32	1976	78.65	34.93	-43.73	0.60
10	Petak 34	1976	30.70	14.80	-15.90	51.79
11	Petak 35	1975	100.59	78.92	-27.67	27.50

SR: Surface reported; SS: surface from SPOT (1987); D: difference

CONCLUSION

Rhizophora mangrove in Cimanuk delta covers only 290 Hectares which lie especially in Petaks 7, 8, 9, and 12. Today more than 50% of Petaks have less than 10% mangrove. In ten years, mangrove destruction has reached 44% in each Petak. SPOT image can be used for mangrove inventory in the area and it showed at least two physiognomic types of mangrove in a radiometric classification processing with 17 classes. Different mangrove types colud be identified in a 5 classes classification, excepting the inland vegetation types.

ACKNOWLEDGEMENT

The author wishes to acknowledge with deep gratitude Dr. Francois BLASCO who accepted me in Institute in Toulouse France and made some valuable corrections of the manuscript of this article. Thanks are also addressed to Dr. Marie-France BELLAN, Mme. TERTRE,Mme AIZPURU, Mme. VASSAL, Mr PIVOT who gave suggestions and contributions.

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Appendix 1. Confusion matrix of 5 and 7 classes

N°	Class	NC	1	2	3	4	5	CI	St
1	Lumnitzera	0	91,7	0	8,3	0	0	91,7	90,3
2	Rhizophora	0	1,6	93,8	0	4,7	0	93,8	100
3	Avicennia	0	8,3	0	91,7	0	0	91,7	91,7
4	Mixed mangrove	3,1	0	0	0	96,9	0	96,9	95,4
5	Degraded mangrove	3,7	0	0	0	0	96,3	96,3	100
6	Total	6,8	101,6	93,8	100	101,6	96,3	470,4	477,4
7	Mean							94,1	95,5

N°	Class	NC	1	2	3	4	5	6	7	CI	St
1	Lumnitzera	0	91,7	0	0	0	0	0	8,3	91,7	90,3
2	Rhizophora	0	1,6	92,2	0	4,7	0	0	1,6	92,2	100
3	Avicennia	0	8,3	0	83,3	0	0	0	8,3	83,3	100
4	Mixed mangrove	3,1	0	0	0	96,9	0	0	0	96,9	90,4
5	Degraded mangrove	3,7	0	0	0	0	88,9	7,4	0	88,9	95,5
6	Plucea indica	0	0	0	0	0	4,2	95,8	0	95,8	92,8
7	Leucaena	0	0	0	0	5,6	0	0	94,4	94,4	83,3
8	Total	6,8	101,6	92,2	83,3	107,2	93,1	103,2	112,6	643,2	652,8
9	Mean									91,9	93,3

NC: Non classified; CI: Classification accuracy; St Statistical accuracy

Appendix 2. Confusion matrix of 17 classes

N°	Class	NC	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	PCI	PSt
1	Lumnitzera	0	66,7	0	0	0	0	0	8,3	0	0	0	0	25	0	0	0	0	0	66,7	57,1
2	Rhizophora	0	0	48,4	0	4,7	0	0	1,6	42,2	0	0	0	3,1	0	0	0	0	0	48,4	74,3
3	Avicennia	0	0	0	58,3	0	0	0	0	0	16,7	0	0	8,3	16,7	0	0	0	0	58,3	69,6
4	Mixed mangrove	3,1	0	0	0	96,9	0	0	0	0	0	0	0	0	0	0	0	0	0	96,9	83,8
5	Degraded mangrove	0	0	0	0	0	92,6	7,4	0	0	0	0	0	0	0	0	0	0	0	92,6	95,6
6	Plucea indica	0	0	0	0	0	4,2	95,8	0	0	0	0	0	0	0	0	0	0	0	95,8	93
7	Leucaena	0	0	0	0	5,6	0	0	94,4	0	0	0	0	0	0	0	0	0	0	94,4	78
8	Horticulture	0	0	16,7	0	8,3	0	0	0	75	0	0	0	0	0	0	0	0	0	75	63,9
9	Dry grass	0	0	0	17,1	0	0	0	0	0	82,9	0	0	0	0	0	0	0	0	82,9	83,2
10	Densely village	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	100	100
11	Rice field	0	0	0	0	0	0	0	0	0	0	0	95	0	5	0	0	0	0	95	95,5
12	Shrub	0	50	0	8,3	0	0	0	16,7	0	0	0	0	25	0	0	0	0	0	25	40,7
13	Village	0	0	0	0	0	0	0	0	0	0	0	4,5	0	95,5	0	0	0	0	95,5	85,1
14	Grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	100	100
15	Bare land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	100	100
16	Sand	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	100	100
17	Pioneer mangrove	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	100	100
18	Total	3,1	116,7	65,1	83,7	115,5	96,8	103,2	121	117,2	99,6	100	99,5	61,4	112,2	100	100	100	100	1426,5	1419,8
19	Mean																			83,9	83,5

NC: non classified; PCI: Classification accuray; PSt: Statistical accuracy