A city plan should not only focuss on areas within its administrative boundaries, because urban lands are always expanding parallel with the growth of its population and activities. In order to anticipate the future pace of development, an inter governmental coordination is promptly expected, viz. the city government itself and the regencies that are located next to the municipal government. Slowly but sure, the existing urban land will overspill the administrative city boundaries. An extra-territorial zoning policies (Isberg, 1975) can be adopted in order to cope with this problem.

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MONITORING MANGROVE DISAPPEARANCE BY REMOTE SENSING
A case study in Surabaya, East Java-Indonesia

by
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ABSTRACT

This study deals with the application of remote sensing in monitoring mangrove disappearance. Color aerial photograph scaled to 1:30.000 of 1981, numerical data of Landsat satellite taken in 1985 and SPOT satellite data of August 30, 1988 were used. The photograph was interpreted manually, while the digital analysis with DIDACTIM software was applied to the Landsat and SPOT data. Barycentric supervised classification procedure was used in clasifying mangrove and land use classes. Key interpretation of mangrove type was obtained by field check in 1989.

Two types of mangrove (Avicennia sp and mixed mangrove) could be identified both on the aerial photograph and on the SPOT data. The extent of mangrove in 1981 was measured manually, while those in 1985 and 1988 were obtained by multiplying the number of pixel (picture element) and the spatial resolution of Landsat and SPOT respectively. During seven years (1981-1988), there were 852 hectares of mangrove in the study area which have been cut.

For mangrove reforestation purposes, two mangrove zonations are presented ; one is based on the salinity gradient, while the other is based on the Ciloto formula. It seems that the second zonation is quite good for the study area.

INTRODUCTION

In many parts of the world, destructions of mangrove, an halophyte formation, have been increasingly more and more serious. This type of forest

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lies actually in the tropics and the subtropics regions with a surface of about 8 and 15 millions hectares. From the economic point of view, most of the mangroves were treated as westeland to be sweeten (Blasco, 1989). Practically, management of mangrove means to change them into other type of land use, e.g. harbour, airport, residential and industrial areas, agriculture and fishery fields, etc.

Actually, as a forest resource, mangroves are very useful. Saenger *et al.* (1983) stated that they have first some physical function, e.g.: stabilization of coastland, expansion of coastline, and protection of the coast agains abrassion and storm. Secondly, they can be a place of sprawning and seedling for fishes and shrimps, a nesting sites of sea birds and accommodate the other types of fauna. Thirdly, they have economic values as wood, charcoal, tannin, pulp, etc. An other important advantage of mangrove is probably to prevent the intrusion of salt water to the ground water. It has a great value for groundwater used for domestic purposes. Hence, the destruction of mangrove is really in acceptable.

In Surabaya (East Java, Indonesia), deforestation of mangrove was recently reported by Surabaya Post neswpaper issued on March 11, 1989. It was about 50 hectares of mangrove illegally cut by people surrounding the mangrove forest in the last five years. The number is in reality rather small, but for being a conservation forest of Surabaya city with three millions of population and with a very limited extent of mangrove forest, it has a great influence for the local environment.

The study was carried out by the application of remote sensing in monitoring mangrove extent. The objective of this study is to investigate the decrease of Surabaya mangrove since 1981 by aerial and spatial data, and then present the limit of potential region which theoretically might be reforested.

LOCATION

The study area is located between 112°48'E to 112°50'E and 7°18'S to 7°21'S, and administratively it belongs to Surabaya city region and Sidoarjo regency in the south which is bordered by Buntung river (figure 1). According to the land use map published in 1963 by the Directorate of Land Use, the mangrove of Surabaya lying along the eastern coast of Surabaya varied from 1 to 2 km in width from the coastline. Based on Smith and Ferguson climate criteria, the region has C type of climate, with 8 wet months and 4 dry months. In Surabaya meteorological station the annual rainfall is 1752 mm/year and the mean monthly temperature is 27°C. The ombrothermic diagram of the region is presented in figure 2. Physiographically, the region consists of alluvial plain and party estuary of the Brantas delta in the north. So the region is annually submerged by tides. Four rivers are found in this region i.e.: Wonokromo river

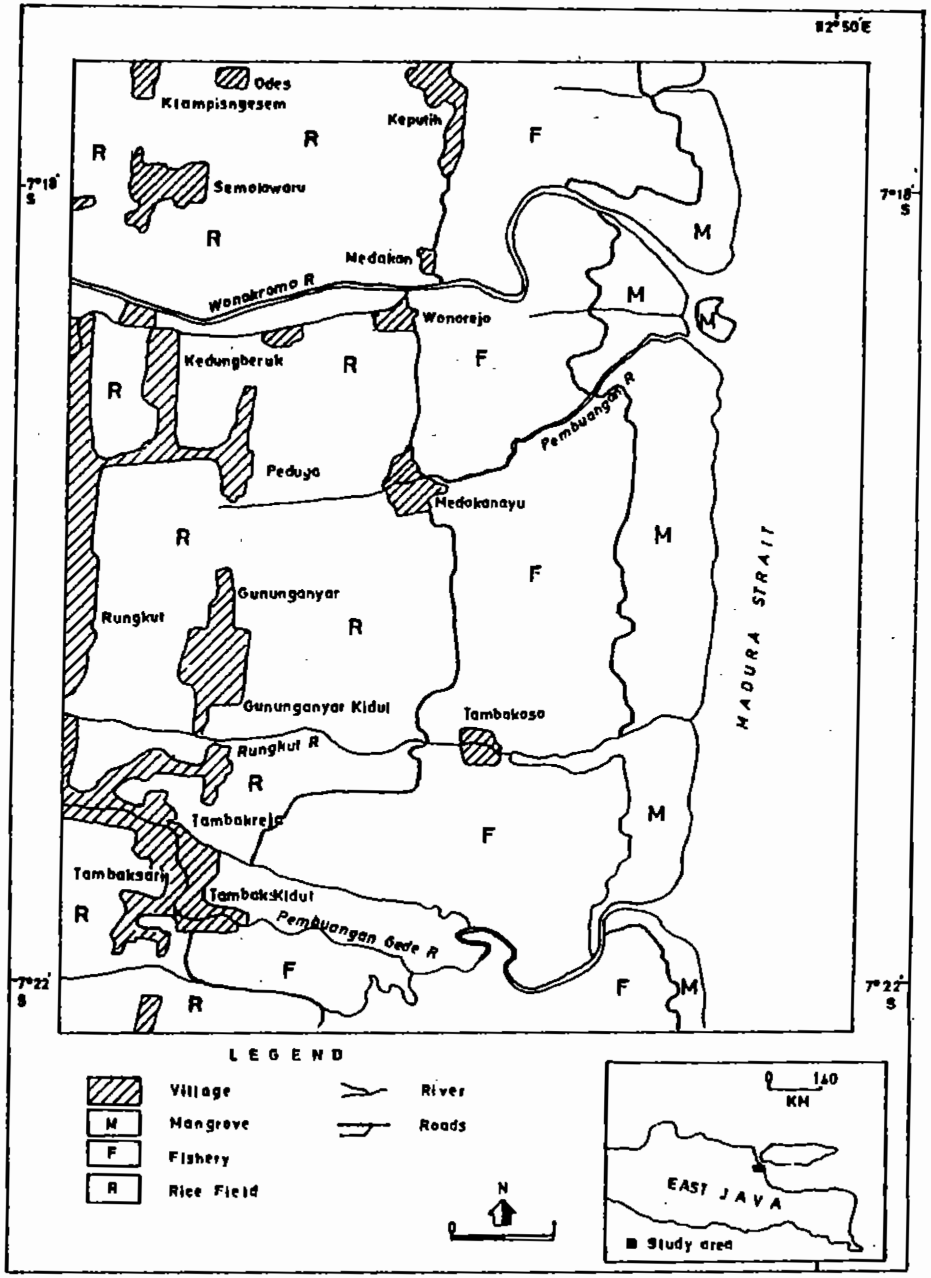

Figure 1. Location map mangrove of Surabaya

in the north with 320 cubic meters/sec of maximum debit (90 m of width), Rungkut Mejoyo river, Rungkut and Buntung river in the southern part. In fact, the Wonokromo river is a prolongation of Brantas river in the north side, while in the south there is Porong river which is excluded from the study area. The rivers bring materials from the river basin deposited in the estuary. There is a continous expansion of the coastline in the mouth of the river, especially Wonokromo and Buntung rivers, both with the rate of expansion of 20 m/year. Not too far from the study area, there is a new industrial area in Rungkut subdistrict as a satellite industrial zone for Surabaya city. A reservoir of industrial waste is located 6 km landward of mangrove formation. The industrial waste water is discharge to the rivers in the study area. It seems that physiographic, hydrologic and climatic conditions provide an advantage to the region to be a mangrove forest conservation.

MATERIALS AND METHOD

Infrared color aerial photograph at 1:30,000 scale taken in 1981, a magnetic tape of Landsat image of 1985 and numerical data of SPOT satellite image of August 30, 1988 were used as a primary data. Topographic, geologic, land use, administrative, and isosaline maps were included in this research as supplementary data. Socio-economic condition was obtained from statistical data. The aerial photograph was manually interpreted with a mirror stereoscope, while the magnetic tape of Landsat and SPOT were digitally analysed with the DIDACTIM software available at the Institut de la Carte Internationale de la Vegetation (ICIV) under the direction Dr. Francois BLASCO, Toulouse-France. In this case, some enhancement techniques and two supervised classification procedures (barycentric and hypercube) have been applied. Field checks in the study area were conducted by authors in 1989.

RESULT

Aerial Photographic Interpretation

The aerial photographic interpretation showed that in 1981 the mangrove of Surabaya covered a surface area of about 1120 hectares. It lied administratively in Keputih village (295 hectares), Wonorejo (263 hectares), Medokan Ayu (144 hectares), Gununganyar Tambak (109 hectares), and Tambakoso (309 hectares). It showed a notably dense mangrove coverage especially in the southern part of the area (Tambakoso territory). The density of the forest is estimated 1000 trees/Ha. Based on the color, the density and the

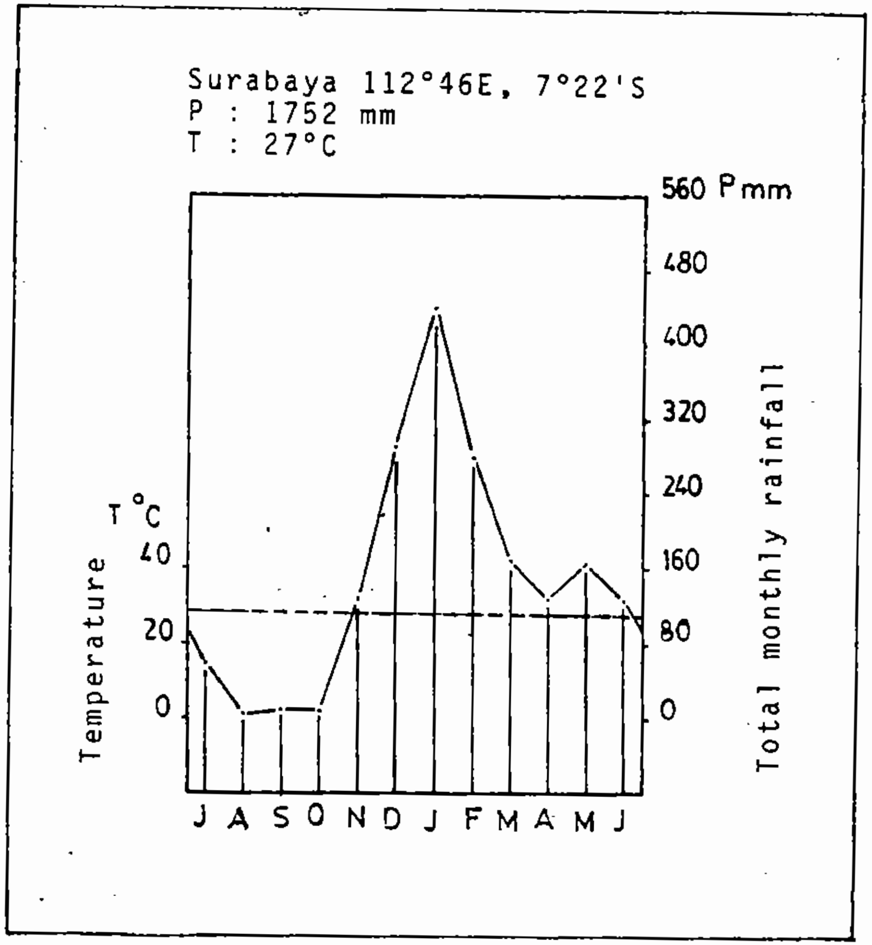

Figure 2. Ombrothermic diagram of Surabaya

location of the forest which appear on the aerial photograph and on the field check, as well at least three mangrove zones could be identified. Firstly, near the sea was the mangrove dominated by *Avicennia sp*, about 50 m of width. The second zone was mixed mangrove which consists of *Avicennia, Rhizophora* and *Excoecaria agallocha*. Under the mangrove we found grass and liana (dominated by *Derris heterophylla*). Along the river were found some *Gramineae* dominated by *Sacharum spontanium* ("glagah") and *Imperata cylindrica* ("alang-alang"). Lastly, the third zone was a mixed mangrove dominated by *Excoecaria agallocha* mixed with *Hibiscus tiliaceus, Pluchea indica* and *Acanthus ilicifolius* ("jeruju") under the trees. Map resulting from the aerial photographic interpretation is presented in figure 3.

Comparing the aerial photographs and the topographic/land use maps, we can identify that a rapid expansion of the land to the north occured in the south of Buntung river. It is probably due to the wave action from the south when the sediment was deposited in the sea. The accretion modified the estuary of Buntung river to the north and it was wholly occupied by *Avicennia sp*.

Digital Analysis of Landsat MSS Data

A supervised classification needs some training areas. In this case, we chose from the Landsat imagery nine training areas of mangrove and land use types that represent nine classes. The classes are; (1) Avicennia, (2) mixed mangrove, (3) grass, (4) fishery 1, (5) fishery 2, (6) dry field, (7) wet ricefield, (8) bare land (abandoned fishery pond) and (9) village/settlement. There was a different phenologic stage between the two rice field classes. Dry rice field means a rice field in which the rice is ready to be harvested or after harvested, while the other one is a rice field where the rice is maturing. The difference between fishery 1 and 2 is the existence of mangrove vegetation in the fishery field. In the fishery 1 the trees cover more or less 10 percent of the area, while in the fishery 2 are 50 percent.

It is well known that field for shrimp and fishery are usually developed in mangrove land. The exploitation of the mangrove land in Surabaya and the vicinity (Gresik and Sidoarjo regencies) is primarily destinated to fishery and salt production. There is a unique system of mangrove exploitation for fishery in Java called "tambak forest" (mixed forest and fishery). It was in Citarum and Cimanuk deltas (exactly in Tanjung Krawang and Cemara) that the system was initiated. The system regulates both the development of mangrove and fishery in one place, with a maximum 10 percent of exploited land for fishery (Harun Al Rasyid, 1971). Mangrove forest in this system must be developed, while at the same time fishery can be applied by fishermen in the mangrove vicinity. The fishermen have also a duty for conserving the mangrove. In some regions (e.g. Cangkring, Cemara, and Jojok-Segara Anakan) the system is running quite well,

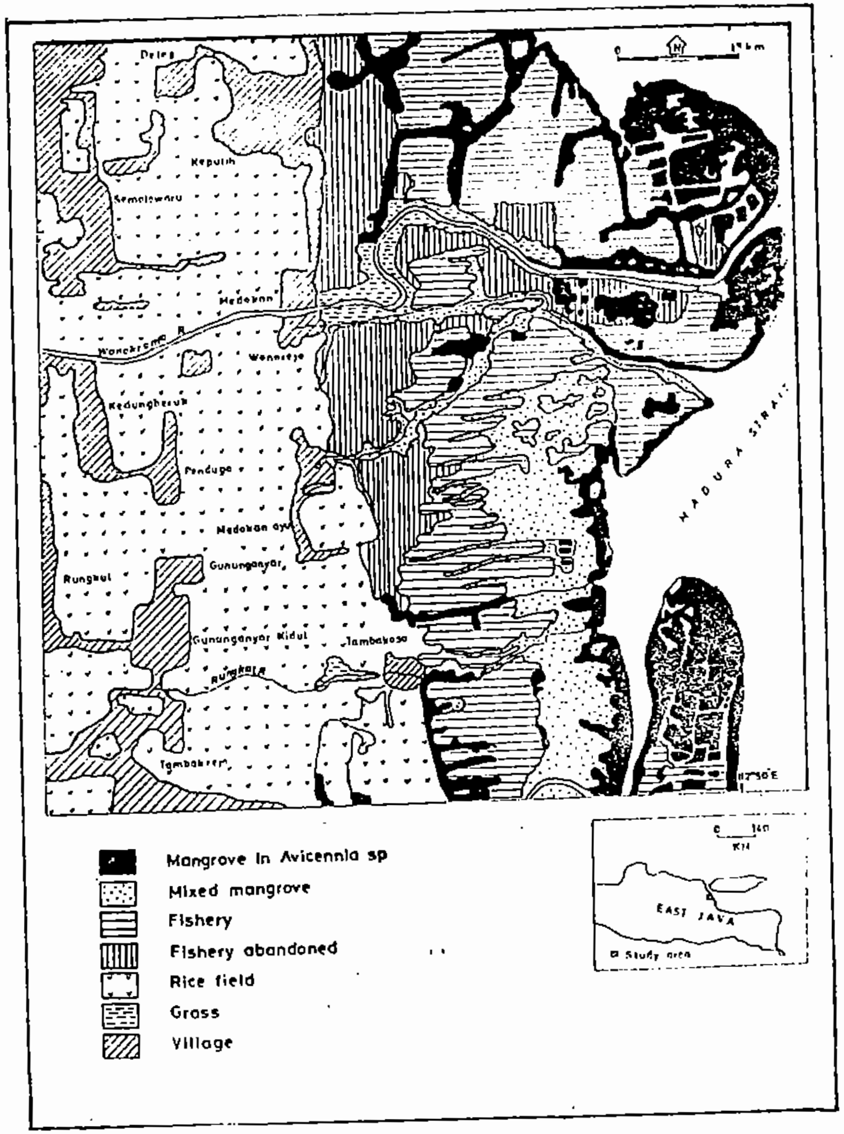

Figure 3. Map resulting from the aerial photograph's interpretation

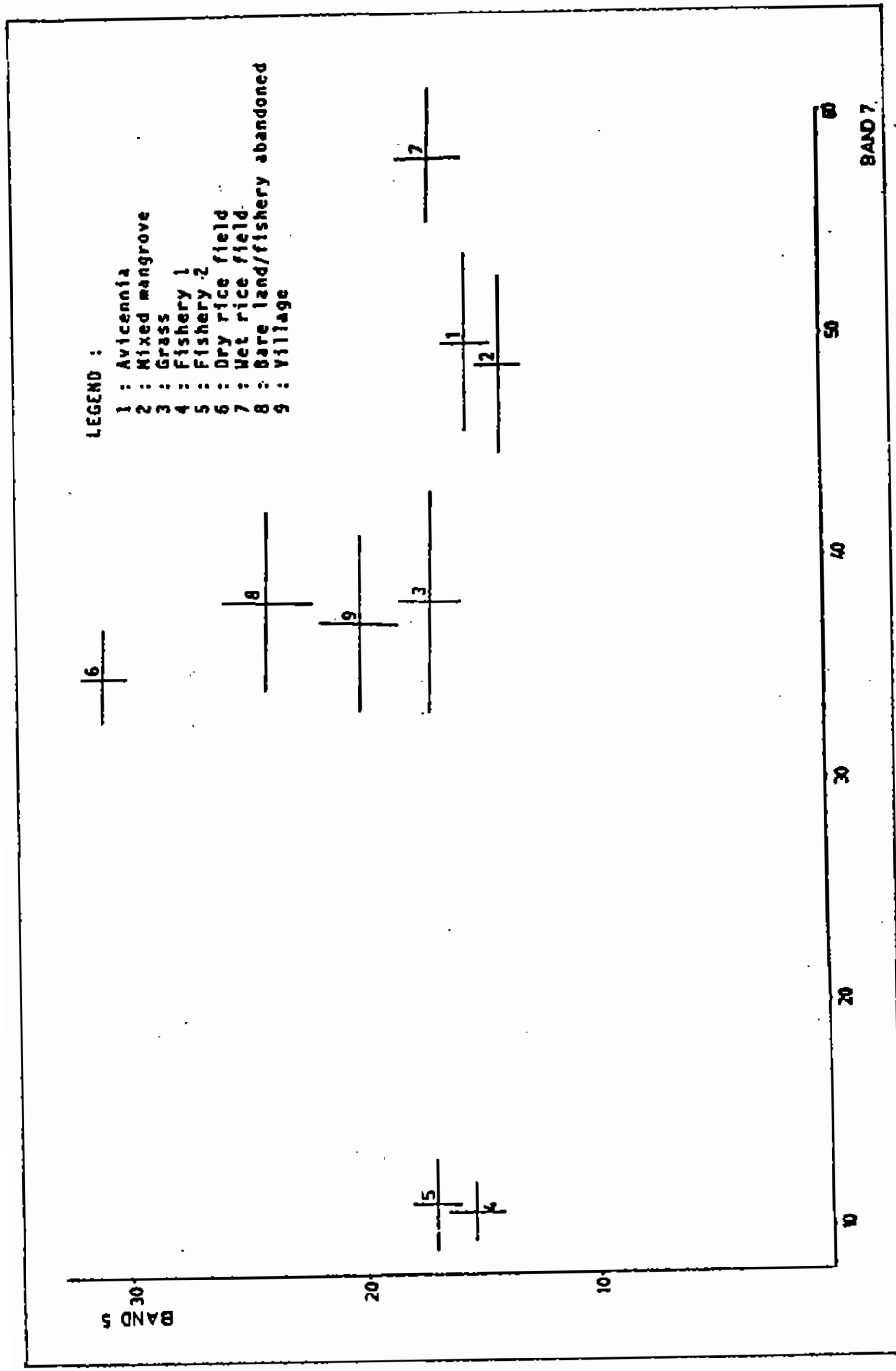

Figure 4. Scattergram of image classification

but there is a trend that the fishermen prefer to get more space and land for their fishery. So we found in many parts of Java that mangrove is more and more deforested. This phenomenon can be found in Tanjung Krawang, Pabean Hilir, Purwa, Bodri delta, Pemali delta, and Cisanggarung delta in the northern coast of Java and also in the study area (east coast of Java). Fishery product here is usually shrimps (primarily Penaeus monodon) and milk fish (Chanos chanos).

Landsat 1985 image analysis of Surabaya's mangrove was started by extracting some statistical values for each class. In this case values of the mean and the standard deviation of every class in four original bands were taken. From the values, a scattergramm of classes in two bands (band 5 and 7) was made to show the separation of classes. The scattergramm is presented in figure 4. It seems that the separation of class is quite good, especially between class number 3,6,7,8 and 9. But there is a little confusion between class number 1 and 2; 4 and 5 as well. In order to avoid the confusion, the class 1 and 2 were regrouped and also class number 4 and 5. This classification procedure produced a good result. The mangrove is well classified and it is separated from the other objects. Here, the accuracy of classification was 88 percent. Mangrove here covered more or less 943 hectares.

Digital Analysis of SPOT Data

SPOT image used in this study is a scene of multispectral mode which consists of 512 x 512 pixels in three bands (XS1, XS2 and XS3). The spatial resolution is 20 m.

Analysis of the image was firstly done by a display of enhanced Color Composite image (CC). In the CC image four mangroves and six land use features are identified. They are mixed mangrove 1, mixed mangrove 2, dense Avicennia, degraded Avicennia, new fishery, active fishery, old fishery, village, bare land and grass. Secondly, one training area of each feature is selected. Statistical values (mean and standart deviation) are then obtained (table 1). Thirdly, barycentric classification procedure is applied to the scene by using the statistical values. Mangrove and land use are well classified into ten classes. The accuracy of classification is 99 percent, which is obtained from a confusion matrix. A map derived from the SPOT image analysis is presented in figure 5, where for the presentation, the classes are generalized into seven classes.

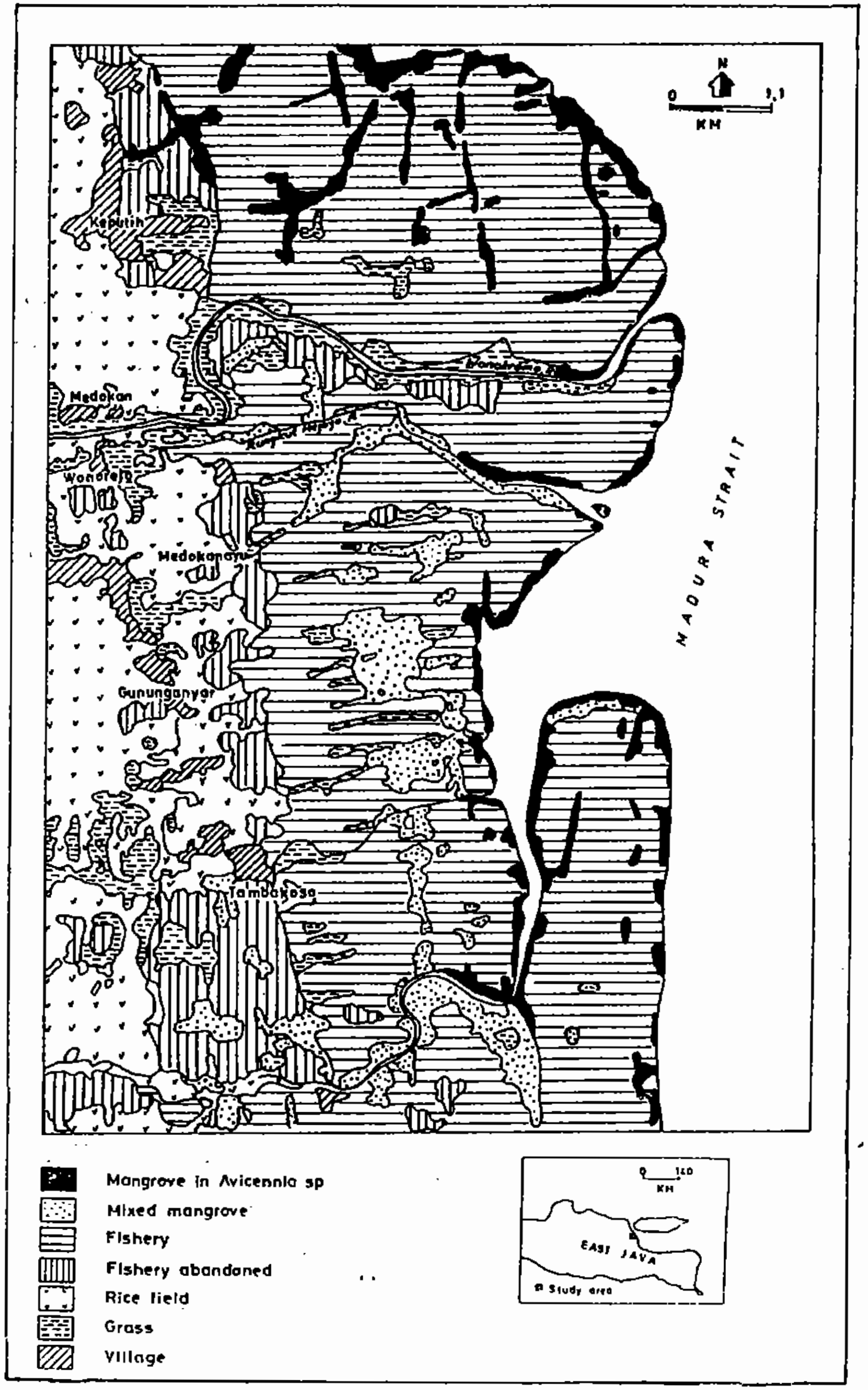

Figure 5. Mangrove of Suranaya (1988) derived from digital analysis of SPOT satellite image

TABLE 1. STATITISTICAL VALUES OF TRAINING AREA

Classes	XS1		XS2		XS3	
	Mean	SD	Mean	SD	Mean	SD
Mixed mangrove1(15)*	87.87	2.36	22.53	0.72	37.87	0.62
Dense Avicennia (12)	87.67	3.27	24.50	0.50	39.87	0.47
Degraded Avicennia(9)	64.00	2.98	31.78	1.62	44.00	0.67
Mixed mangrove2(9)	60.11	2.84	27.33	0.82	39.89	0.88
New Fishery (12)	14.58	1.19	33.08	0.28	47.00	0.58
Active Fishery (12)	35.67	2.81	39.50	0.96	49.17	0.90
Old Fishery (14)	19.64	2.99	23.21	1.57	34.93	2.05
Village (12)	42.08	1.04	43.42	1.60	49.75	1.78
Bare land (12)	49.58	1.26	58.50	2.40	65.58	2.63
Grass (17)	49.71	1.71	35.76	0.81	43.41	1.03

Note: * = number of pixel; SD = standart deviation.

Mangrove extent in five coastal villages in the study area for 1981, 1985 and 1988 is fiven in table 2, while the mangrove disappearence in those period is presented in table 3.

TABLE 2. MANGROVE AREA OF SURABAYA

Village	1981	1985	1988
Keputih	295	269	51
Wonorejo	263	246	70
Medokan Ayu	144	127	44
Gununganyar Tambak	109	78	52
Tambakoso	309	223	51
Total	1120	943	268

The mangrove extent in 1985 was 15.8 percent smaller than those in 1981. Mangrove degradation was found especially in the new accretion land in the northern part of the study area. The existing mangrove were found in the southern part of Wonokromo river. In the period between 1981 and 1985 171 Ha mangrove was cleared. They were in Keputih (26 Ha), Wonorejo (17 Ha), Medokan Ayu (17 Ha), Gununganyar Tambak (31 Ha), and in Tambakoso (86 Ha). The rate of clearing is 44.25 Ha/year.

TABLE 3. MANGROVE DISAPPEARENCE IN SURABAYA (1981, 1985, 1988)

Village	1981-1985			1985-1988			1981-1988		
	Ha	%	Rate*	Ha	%	Rate*	Ha	%	Rate*
Keputih	26	8.8	6.5	218	81	72.6	244	82.7	34.8
Wonorejo	17	6.6	4.25	176	71.5	58.6	193	73.4	27.5
Medokan Ayu	17	11.8	4.25	83	65.4	27.6	100	69.4	14.3
Gn.Anyar Tambak	31	8.4	7.75	26	33.3	86	57	52.3	8.1
Tambakoso	86	27.8	21.5	172	77.1	57.3	258	83.5	36.8
Total	177	15.8	44.25	675	71.5	224.7	852	76.1	121.5

Note: * = Ha/year.

In 1988, the mangrove covered 268 Ha only. It means that 71.5 percent of mangrove have been deforested since 1985. The most intensive deforestation of mangrove in the study area went on between 1985 and 1988. There were 675 Ha of mangrove deforested for only three years. More than 50 percent of mangrove deforestation occured in four villages, i.e.: Keputih (81 percent), Wonorejo (71.5 percent), Medokanayu (65.4 percent) and Tambakoso (77.1 percent). This phenomena can perhaps be related to the increase of fishery exploitation (especially shrimps) in that period.

In seven years (1981-1988), the total decrease of mangrove is 852 Ha (76.1 percent of those in 1981). The rate of deforestation is 121.5 Ha/year. In all of the five coastal villages, more than 50 percent of mangrove was cleared and changed into fishery fields. From the image analysis, one can identify that mangrove in the area, as a mangrove forest, lives poorly. In the accretion land, there is no more mangrove. Pure stand of mangrove in a good condition as used to be in 1981 can not be found. Only two relatively big communities of mangrove are found in Medokanayu and Gununganyar Tambak villages. They are mixed mangroves (Excoecaria agallocha, Avicennia, Rhizophora). The others are Avicennia along the coast and on the artificials dykes which separates fish or shrimps ponds.

The zonation of Surabaya mangrove in 1981 and in 1988 are presented in figure 6a and 6b. It was extracted from the overlay of aerial photograph, SPOT image and field check. The figure were traced from the sea to landward in figure 3 and 5.

In figure 6a, the area can be divided in more detail into two parts i.e.: the accretion zone in the front part with active mangrove and fishery zone and the remaining mangrove in the rear. On the accretion zone, Avicennia in pure stand (number 10), Avicennia trees with drainage canals in side (number 9) and seedling of mangrove (number 8) can be found. The pure stand of Avicennia is

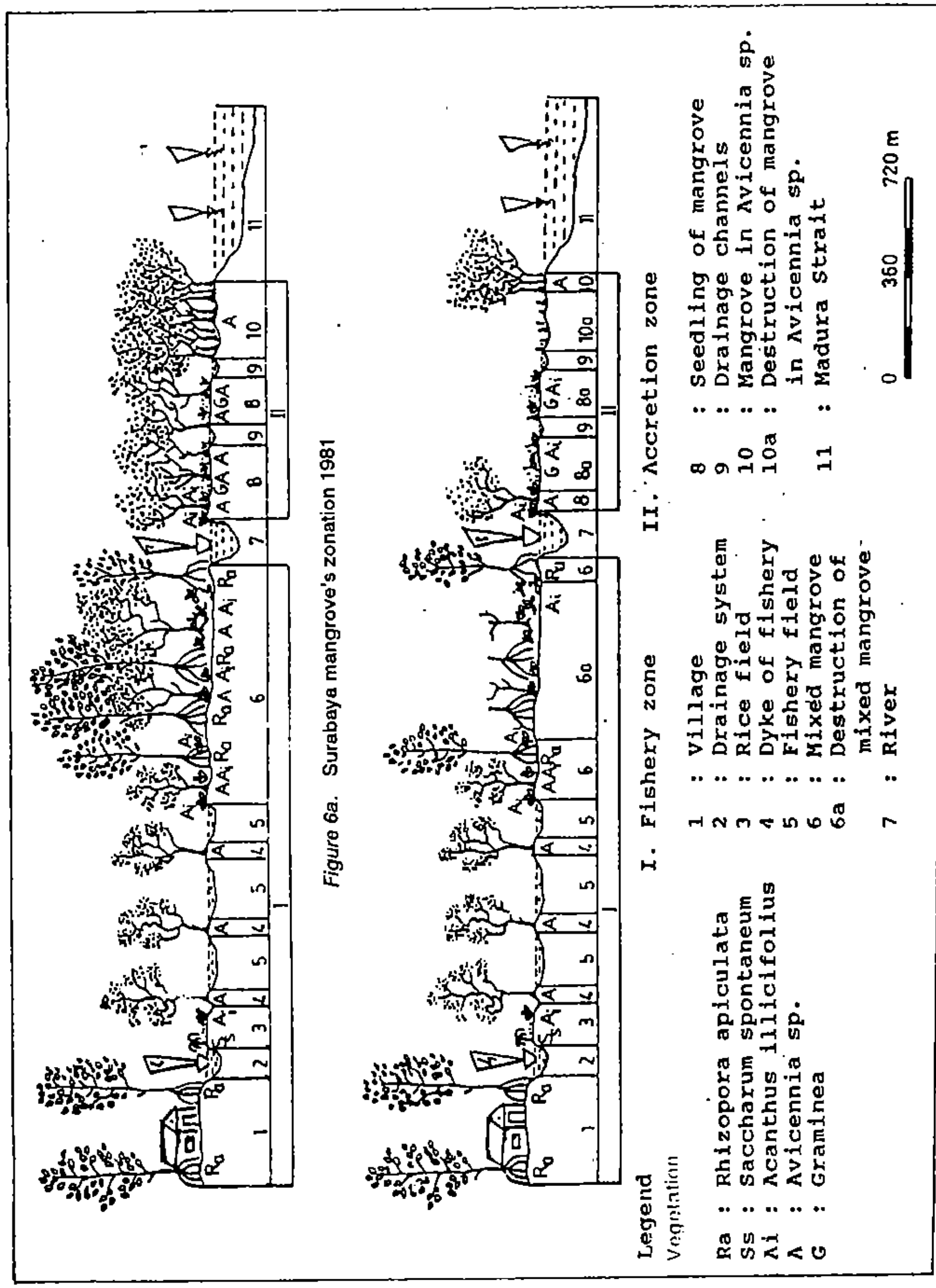

Figure 6a. Surabaya mangrove's zonation 1981

Figure 6b. Surabaya mangrove's zonation 1988 estimated 25 trees/0.01 Ha. This natural formation is pioneer mangrove in the region. The drainage canal are artificial as a man made action that might be a stade of preparation for fishery. Seedlings of Avicennia dominated the undergrowth of Avicennia mangrove. The accretion zone is extending to the sea with the rate of 20 m/year. It is due to the sediments transported by Brantas river. Avicennia spp and Sonneratia spp are pioneers mangrove trees as in Segara Anakan, Central Java. In the study area, only the Avicennia sp. is found.

In the fishery zone, we could identify successively mixed mangrove (6), fishery field (5), dyke of fishery (4), drainage system (2), rice field (3), and village (1). The mixed mangrove consists of Rhizophora apiculata and Excoecaria agallocha (dominant). Inside of the fishery field, we have no tree anymore. According to the regulation of "tambak-forest", mangrove trees must be left in the centre of fishery field, and the surface of fishery field, surrounding the mangrove trees may not exceed 10 percent of the exploited land. On the dyke, it is usually found Avicennia sp. as remaining mangrove. Behind the fishery field there are drainage system, rice field, and village that the influenced by inland climate. Pes-capree formation is situated between the mangrove formation and the village. Associated with the village, one find coconut, acasia, jackfruit, hibiscus tiliaceus, and pluchea trees around the house. The drainage system is used for precipitation and waste water sewage, and for traditional transportation by cannoes and small boats.

The mangrove zonation in 1988 in general was much smaller than in 1981, especially in the accretaion zone. Pure Avicennia stand existing in 1981 was largely cleared and the resulted bare land was developed for fishery. We could identify some new canals of drainage system in this zone. Avicennia was situated only along the coast for about 30 m width. Similarly , some trees in the mixed mangrove zone have been cleared. Rhizophora sp and Excoecaria agallocha might only be found sparcely in many parts as remaining mangrove. Almost the whole area has been transferred into fishery field. Some degraded stands of mangrove were only found around the cost and in Medokanayu and Gununganyar villages.

Some parts of old shrimp fish field abandoned. This parts transferred into bare land which might be allocated for residential area e.g. BTN (Bank Tabungan Negara). This phenomenon occurs especially near the residential area of Medokan Ayu village which has been drained. We can find many parcels (preparation for settlements) on the old shrimp and fish fields. It is understandable because Surabaya city with 2 percent annual population increase needs more land and space for agglomeration of the city. In the city itself, space is not enough for residential area because the density of population is very high (7878 person/sq.km, in 1987).

DISCUSSION

In the Master Plan of Surabaya City for the twenty first century (Number 23/1978), Surabaya mangrove was determined as a "conservation forest". The region consists of Medokan Ayu, Gununganyar Tambak and Wonorejo villages which are naturaly bordered by Wonokromo river in the north and Rungkut river in the south.

In this study, before 1981 the decrease of mangrove could not be traced because of the lack of data. If mangrove deforestation did occure, it might be due to the boom of shrimp fishery exploitation introduced since PELITA (Five Years Development of Indonesia Government) started in 1969. At the time, shrimp export was encouraged so that people were stimulated to open new fishery along the northern coast of Java, e.g.: Tanjung Krawang, Indramayu, Kendal, Gresik, Sidoarjo, Banyuwangi, and also Surabaya. The new fisheries were usually established in mangrove land. Between 1981 and 1985, the mangrove deforestation in Surabaya continued, even on the accretion lands in the mouth of Buntung and Wonokromo rivers. Mangrove forest of 177 hectares (Table 2) have been cleared in that period. It means the rate of deforestation was 44.25 hectares/year. Untill 1988, mangrove forest in the region kept on decreasing. The existing mangrove is only 268 Ha, with the mean rate of decrease of 121.5 Ha/year. Suppose the deforestation goes on with the same speed, we can predict that in the next five years the mangrove will completely disappear, unless there is real effort to stop them. In order to analysis the case, two questions can be raised; first, are there any physical causes for the mangrove deforestation; and second, why did people cleared the mangrove until 30 m from the coast line?

From the ecological point of view, the existing mangrove in one area must be supported by specific condition of salinity, tides, temperature, regular discharge, and protected coast. A good mangrove formation can be found in an area where the salinity varies between 0.5 per cent - 2.5 per cent. For the salinity between 2.5 per cent - 4 percent, the mangrove starts decreasing, for 4 percent - 9 per cent the mangrove decrease and for more than 9 per cent there is no mangrove anymore (Blasco, 1984). Certain species of mangrove, e.g. Avicennia marina can resist to the salinity around 9 percent (Macnae, 1968). Mangrove can be developed well in regions with a mean temperature of around 27^0C. Protected coast against storm and wave action is preferable for developing mangrove (Champman, 1976). Watson (1928) classified mangrove in detail based on the period of inundation. The classification is as follows: inundated by all high tide/56-62 times a month (*Rhizophora mucronata*, on the stream bank); by medium high tide/45-56 times a month (*Avicennia, Sonneratia, Rhizophora mucronata*); by normal high tide/20-45 times a month (*Rhizophora mucronata, Rhizophora conjugata, Ceriop candolleana, Carapa obovata*); by spring tide/2-20 times month (*Bruguiera gymnorrhiza, Bruguiera carryophylloides, Bruguiera parviflora, Bruguiera eriopetala*); and by abnormal/equinoctial tide/2 times a month (*Bruguiera gymnorrhiza, Rhizophora conjugata* as remain).

Soil salinity of the study area varied between from 0.94 percent to 4.8 percent. Small salinity value (<3 percent) is situated in the southern side of Wonokromo river: the salinity increases regularly seaward. While in the northern side of the river, it is more than 3 percent. Tide measurements in Buntung river by Noerendah (1988) showed that the highest and the lowest tide of the river was 265 cm and 41 cm respectively, and the mean sea level was 153 cm accordingly. Therefore the maximum increase of sea level is 112 cm above the mean sea level. With a mean calculated slope angle of 0.11 degree, the highest tide would have submerged the coast of 560 m away from the coastline. The coast of Surabaya is a protected coast type, because of the Madura Island which exists in the north side, acting as a barrier against the storm and other marine actions and it is far enough from the Indian Ocean in the south. The turbulance of Java sea is more calm than in the Indian Ocean. In reality, the estuary of Brantas delta is cuspate or lobate type according to Galloway Triangle diagram (1975, in Ongkosongo, 1984). In this type of delta, the form is influenced by the wave and the fluvial energy. Some material deposits are seasonaly carried in the mouth of the river which provide expansion of the land and wave action influences the direction of material deposited. In this area, the material is deposited seasonaly through the Wonokromo and Porong rivers with a rate of erosion in the river basin of 0.58 mm/year in 1987. The mean air temperature was 27°C.

Based on the salinity, the material deposits, the temperature, and the coastal physiographic condition, it seems that the area is suitable for developing mangrove. Hence, for realizing the forestation of mangrove in the area, a mangrove zonation is proposed as follows: firstly, 50 m - 100 m from the coastline is allocated for Avicennia sp as pioneer mangrove; secondly, 100 m - 150 m for Rhizophora and lastly, 150 m - 200 m for mixed mangrove (*Excoecaria agallocha, Nypa* and other non exclusive species of mangrove). The proposed width of the zonation is based on the salinity contour and on inundation. In the Rhizophora and mixed mangrove zones, fishery field can be developed with "tambak forest" system. In this case, the extend of fishery field may not exceed 10 percent of the exploited land must be respected. Otherwise, the Avicennia zone is preferable to be conserved, as it is important for dyke protection and for other ecological function of the mangrove as well.

A seminar hold by The Mangrove Committee of Indonesia in Ciloto (1987) decided that the green belt of mangrove being suitable in one area is determined by a formula of 130 multiplied by the difference between the lowest and the highest tide. Based on that formula, the mangrove of Surabaya must be only 150 m away from the coastline. For this purpose, the second proposal for

mangrove zonation in Surabaya is given as follows : first 30 m - 50 m for Avicennia sp, followed by Rhizophora for 50 m - 80 m, and finally by the mixed mangrove for the rest of the land. Along the fishery dyke, Avicennia and Rhizophora can be planted for stabilizing it.

The northern side of Wonokromo river (the coast of Keputih village) is also suitable for mangrove development, especially on the cap, northern part of the Wonokromo estuary (see figure 3 and figure 5). Farther from the area, the salinity is higher (around 4.5 percent) and soil texture is coarser than in the cape and its vicinity.

The mangrove zonation in the second proposal is smaller than that in the first one. Looking the actual condition of Surabaya's mangrove, it is more reliable, because the land up to 150 m away from the coastline might be owned by government. New land produced by natural process is owned by the government (Sandy, 1987). In practice, ownership status of the new land will not be clear if there is no strict control and inventory in the terrain. We need to be worry to individual propietor of the new land. Keeping in one coordination, the reforestation is easier to be realized. On the contrary, for developing an ideal mangrove forest as a conservation forest, the first proposal is better. But, it is more difficult in the clearing the land that is now occupied by some private fisheries.

By and large, for answering the questions above, it seems that there is no problem on salinity, temperature, deposited material, and coastal physiographic condition factors for mangrove's deforestation in Surabaya. One thing should be taken into consideration in this respect; it is that influences the width of the submerged area. The fact that there were some fishery fields abandoned and changed into other types of land use, is an indication that the highest tide did not reach the area anymore. Hence, people were stimulated to open new fishery field in the submerged region which is used to be occupied by mangrove. It can be the reason why Surabaya mangrove disappears recently. As stated by Blasco (1982); in the humid regions of the Third World, the primary responsibility of mangrove decline lies with deforestation and aquaculture. The other causes are probably socio-economic condition and rapid population increase in Surabaya (Java, in general). In this case, the government role is very important, especially to improve the society awareness on the environmental conservation. Without cooperation between the government and the people, the effort in mangrove reforestation seems likely to fail.

CONCLUSION

In conclusion, it can be said that the disappearance of mangrove in Surabaya can be monitored by color aerial photograph MSS Landsat and SPOT data, with an accuracy of image classification about 90 percent. In this study, it is obvious that SPOT data can be used for identifying mangrove and land use objects as nearly similar as those obtained by medium scale aerial photograph.

The rate of mangrove disappearance in the area is 121.5 hectares/year. The mangrove will totally disappear in five years, if the deforestation goes on just like what happens new. For realizing a mangrove reforestation in Surabaya, two proposals of mangrove zonation are given with some trade-off between both. Considering the actual mangrove condition of the area, the second proposals, i.e.: 150 m of mangrove landward from the coastline, is more suitable than the first one.

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POPULATION AND ENVIRONMENT IN INDONESIA

by
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ABSTRACT

The present environmental situation is not compatible with our expectations. Pollution, erosion, floods and droughts have hit many parts of the world, and these disasters give us reflections on how serious are the environmental problems that befalls this planet of ours. In meeting its needs, mankind has exploited the environment to the utmost without caring about environmental conservation. Moreover, with the population explosion after the 1950s and the dependency of life upon the natural processes, the cultivated land to be inherited by future generations has gradually become increasingly barren and fertile.

Efforts are absolutely necessary to check increasing population growth rates, to raise the standard of living for all people and to arouse and awareness of sustainable development policies so that a compability between development activities and environment can be achieved.

INTRODUCTION

Since the 1970s many countries in the world, particularly the industrialised nations, have been confronted with environmental problems. News about pollution, erosion, floods and droughts can always be found in the newspaper, on the radios and televisions, reflecting how serious are the environmental problems that befall nations. So grave is the problem that the United Nations held a special conference on environment (the 1st World Environment Conference in Stockholm) on June 5, 1972, the day which later was established as the Environment day (Salim, 1979).

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