CHAPTER - 4
RESULTS

4.0 RESULTS

The phenological calendar of the trees of the forest cover in the study area showed maximum foliage in late October and early November (Figure 3a). This proved the suitability of the IRS LISS III November data for monitoring forest cover. Interpretation key developed visually using November 1999 IRS LISS III data, yielded different types of forest and landuse classes. Each type of class along with the microlevel studies carried out has been described separately for each round viz. the Sajwa, Kalarani and Boriad.

4.1 Sajwa round

4.1.1 Forest Cover

The total area under forest cover is 44.96 sq. km, which is 28 % of the total geographical area of the round. Based on the tonal variation, six different forest classes were delineated in this round viz. the Closed teak forests, Closed mixed forest, Degraded forests, Scrub, Sparse tree cover and Sparse tree cover with agriculture (Plate 2).

The forest class, closed teak forests exhibited itself in a reddish tone on the satellite data. Density of this forest class was greater than 30%. Teak was abundant in this area. Similarly, the forest with mixed species and with density greater than 30% was designated as closed mixed forest. Some of the species found in this class include *Holarrhena antidysenterica* Wall, *Butea monosperma* (Lam) Taub., *Lagerstroemia parviflora* Roxb., *Morinda tomentosa* Roth, etc.

Degraded forests had a density ranging between 10-20 % and were seen as a light pink tone on the satellite image. *L. parviflora* & *B. monosperma* were the dominant species of this class.

Figure 3a: Phenology of some of the Forest Species

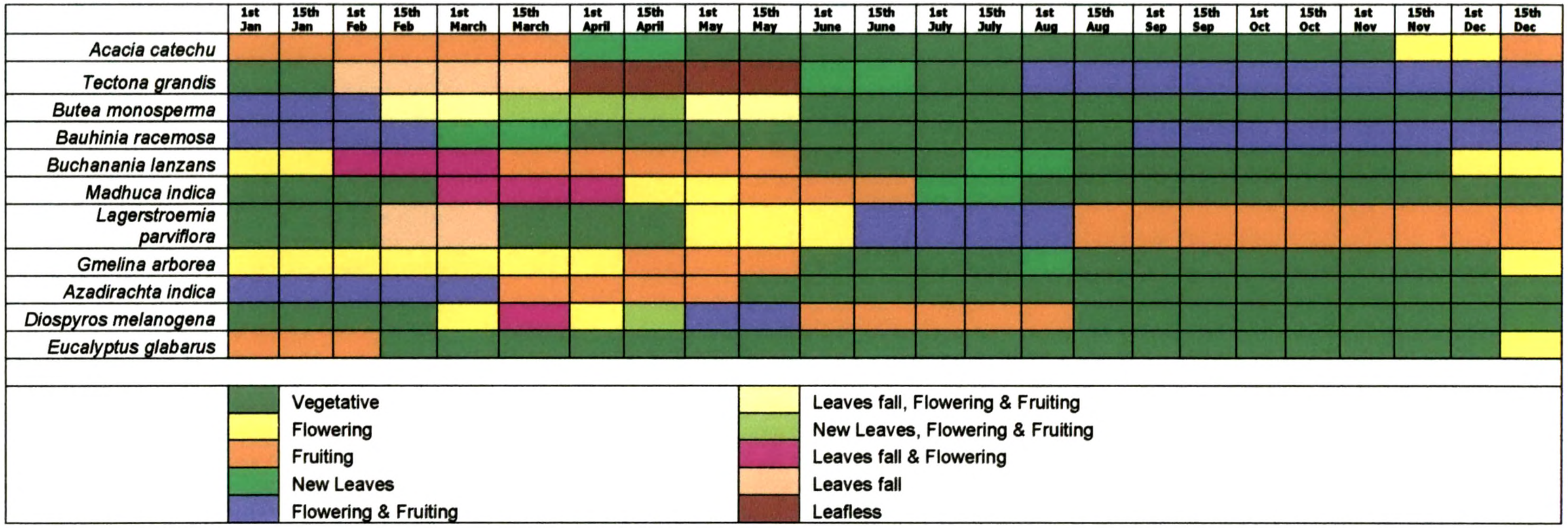
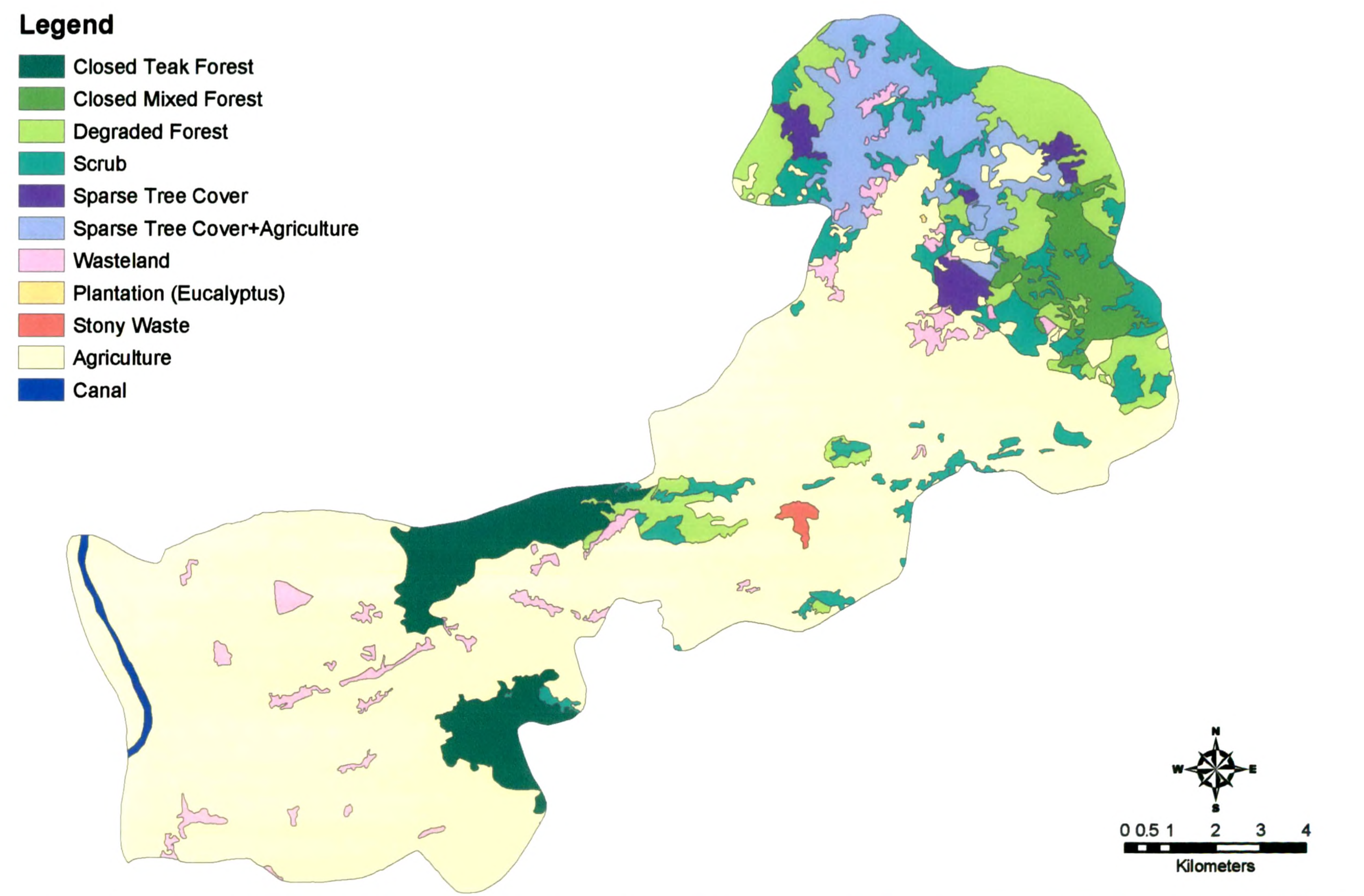


Plate :2 Sajwa Round Forest Cover & major Landuse Classes delineated using 1999 IRS LISS III data



Scrub forests had canopy density less than 10 % with bluish red tone and rough texture. Such a class has also been described by FSI in 1999. The class Sparse tree cover had widely spaced trees. This class showed tree distribution of *Madhuca latifolia*. Rough texture and bluish white tone were its characteristic features. Fosberg, (1967) has mentioned such type of forest class in the forest classification he proposed. This class, where agricultural practices were carried out, was identified as sparse tree cover with agriculture. Visual classification of forests based on tonal variation had been earlier done by Porwal & Roy, (1992), Porwal & Pant, (1989) and Singh, (1989).

The visually interpreted map of this round generated from 1999 satellite data showed that the major portion of the forest cover is taken up by degraded forests (Plate 3, Table 14).

4.1.2 Land use Classes

Five land use classes observed in this area were eucalyptus plantation, wasteland, stony waste area, agriculture and canal area (Plate 4). Agriculture occupies the largest portion in the landuse category. The area statistic of these classes is presented in Table 14. Each category is specific in its own as described below.

a. Wasteland: The land having constraints like meager vegetation cover but having potential for development was classified as wasteland. The yellowish white tone of this class was very distinct on the image.

b. Eucalyptus plantation: It occurred as a dark red tone. The eucalyptus plantation has been carried out in a small percentage of the area in the scrub forest and some outside forest area by the Forest Department.

Table : 14 Sajwa Round Forest Cover & Major Landuse Classes Area Statistics (1999)

Sr. No.	Classes	Area (sq km)	Area (%)
1	Closed Mixed Forest	5.23	2.86
2	Closed Teak Forests	10.03	5.47
3	Degraded Forests	12.89	7.03
4	Scrub	10.17	5.55
5	Sparse Tree Cover	2.42	1.32
6	Sparse Tree Cover+Agriculture	11.25	6.14
7	Wasteland	6.4	3.49
8	Plantation (Eucalyptus)*	0.02	0.01
9	Stony Waste	0.44	0.24
10	Agriculture	123.6	67.46
11	Canal	0.79	0.43
		183.23	

* Plantations within RF boundary only.

c. Stony waste: This was seen as a greenish blue tone, due to the stony area. The area was full of black stones and was completely barren.

d. Agriculture: It was delineated as a bright red tone with regular patches. The major crop grown in this area was maize, both rainfed as well as irrigated.

e. Canal: Canal being a man-made feature could be differentiated by its pattern. The tone was similar to the river. It had a blue tone as it had water.

Correlation of all the forest cover classes and landuse classes with the ground showed a good interpretation accuracy.

The mapping accuracy and classification accuracy estimation were 91.67 % and 95.65 % respectively. The KAPPA coefficient was 0.95 (Table 15). The misclassification occurred when the class sparse

Plate : 3 Forest Cover Classes in Sajwa Round

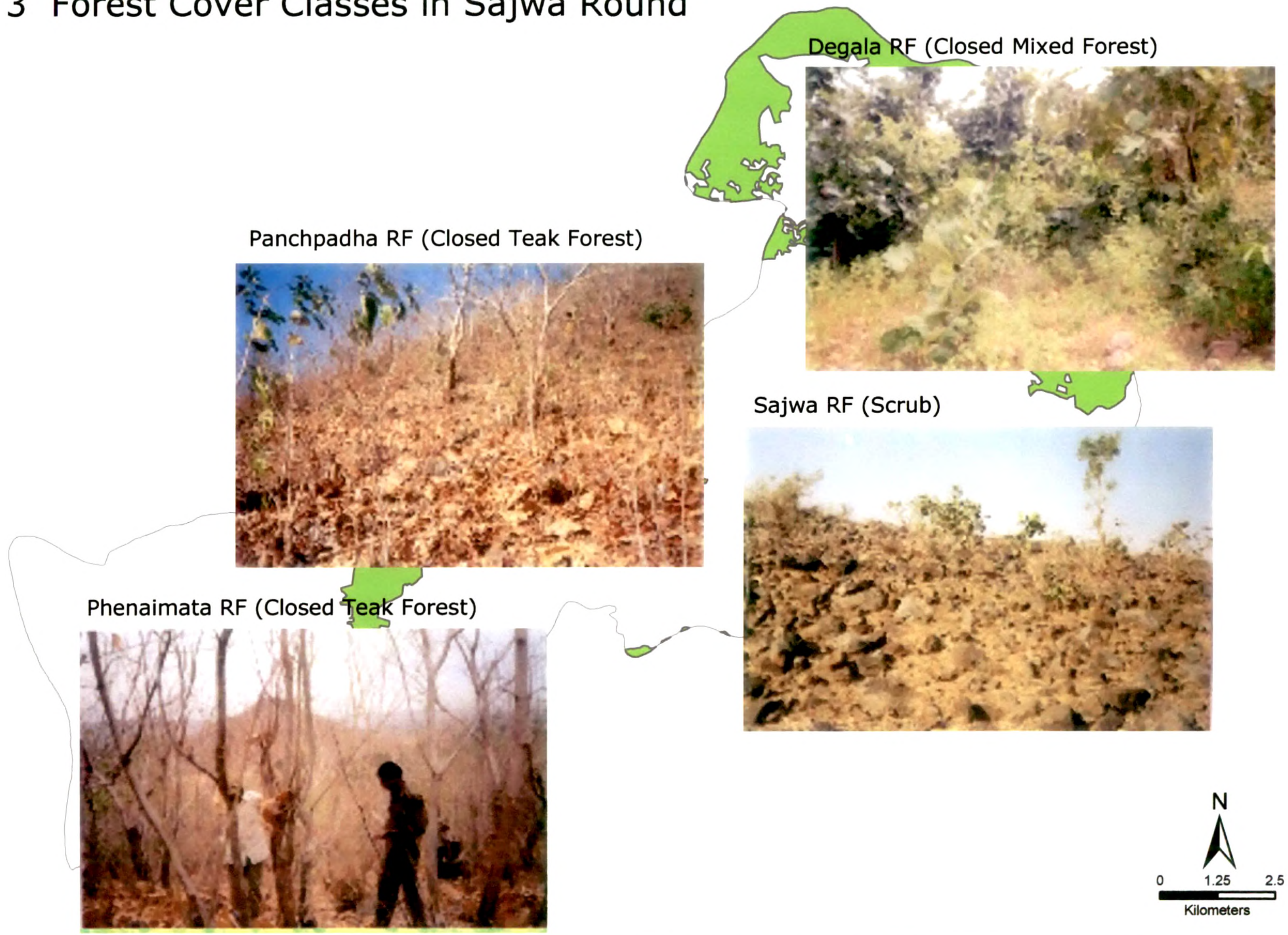


Plate : 4 Land use Classes in Sajwa Round

Table 15 : Sajwa Round Accuracy Table

Class	CTF	CMF	DF	S	STC	STC+A	W	PE	SW	A	C	T	O/E	C/E	C/A (%)	M/A (%)
CTF	2											2	0	0	100	100
CMF		1										1	0	0	100	100
DF			3									3	0	0	100	100
S				2								2	0	0	100	100
STC					2	1						3	0	1	66.67	66.67
STC+A						2						2	1	0	100	66.67
W							3					3	0	0	100	100
PE								2				2	0	0	100	100
SW									1			1	0	0	100	100
A										3		3	0	0	100	100
C											1	1	0	0	100	100
T	2	1	3	2	2	3	3	2	1	3	1	**23**				

Overall Classification Accuracy = 95.65 %

Overall Mapping Accuracy = 91.67 %

K_{hat} statistics = 0.95

CTF=Closed Teak Forests, CMF= Closed Mixed Forest, DF=Degraded Forests, S=Scrub, STC=Sparse Tree Cover, W=Wasteland, PE= Eucalyptus Plantation, SW= Stony waste, A=Agriculture, C=Canal, O/E=Omission Error, C/E=Commission Error, C/A=Classification Accuracy, M/A=Mapping Accuracy tree cover was confused with the class sparse tree cover with agriculture.

4.1.3 Spots surveyed in field analysis

Species composition and soil status of different forest classes was understood when selected spots were surveyed in each class. The areas selected were Phenaimata and Panchpadha RF having Closed teak forests, Degala RF having Closed mixed forest, Panchpadha RF with Degraded forest area and Sajwa RF for Scrub forest.

4.1.3.1 Soil & Phytosociology in different forest classes

4.1.3.1.1 Closed Teak Forests

This class was distributed in two different patches, one on the northern and the other on the southern side of the range. To understand the variation and similarity between these areas, two spots were studied i.e. Panchpadha RF and Phenaimata RF.

Panchpadha RF

This area covered a part of Sajwa and some part of the Kalarani round.

Soil Studies

The soil colour of Panchpadha was observed to be yellowish brown and the texture sandy clayey loam. The surface soil had a higher percentage of moisture i.e. 4% compared to the bottom soils, with 2.2% of moisture (Table16). This indicated a lower moisture retention capacity of the soil.

Concentration of macronutrient phosphorus and potassium and all micronutrients was higher in surface soil when compared to bottom soils except for Zn and Mn which had almost similar

Table 16: Soil Physical Properties of Closed Teak Forests

Spots	Dry Soil Colour/ Value	Wet Soil Colour/ Value	Texture	Moisture (%) - T	Moisture (%) - B
Panchpadha (T)	yellowish brown /5/6	dark yellowish brown /4/6*	sandy clayey loam	4	2.2
Phenaimata (T)	very dark grey/ 3/1	very dark grey/3/1*	clay loam	3.8	5.8
T= Surface soils, B = one foot depth, *Hue 10YR					

concentration in top as well as bottom soils (Table 17). This exhibited the accumulation of ions in the surface layer due to lesser amount of leaching. Concentration of nitrogen both in top as well as bottom soils was almost similar (Figure 3). Its higher concentrations in both layers proved the soil to be in good condition. There was no difference in C/N ratio between top and bottom soils i.e. 11.89 and 11.38 respectively. The EC values were very low and the pH of the soils proved the soil to be normal according to NBSS standards (Figure 4).

Phytosociology

Phytosociological studies in the closed teak forest of Panchpadha showed presence of few species only. The understorey vegetation was full of *Holarrhena antidysentrica* saplings. Thus, though it was a teak forest, *Holarrhena antidysentrica* showed high abundance and IVI (Importance Value Index). Trees of *Tectona grandis* were also fairly abundant (Table 18).

The distribution of species was not even as seen from the evenness index. Since the diversity index was high, the species' richness was comparatively low as it could be seen that only few

Table 17: Soil nutrients content in Closed Teak Forests

Spots	P (ppm)	K (ppm)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
Panchpadha (T)	0.46	31.09	1.07	111.07	20.6	31.6
Panchpadha (B)	0.28	24.31	1.13	50	18.93	31.13
Phenaimata (T)	0.62	58.31	1.53	85.8	8.47	29.07
Phenaimata (B)	0.41	46.21	1	62.67	7.93	30.4
T= Surface soils, B = one foot depth						

Figure 3 : Nitrogen percentage in Forest Soils of Study Area

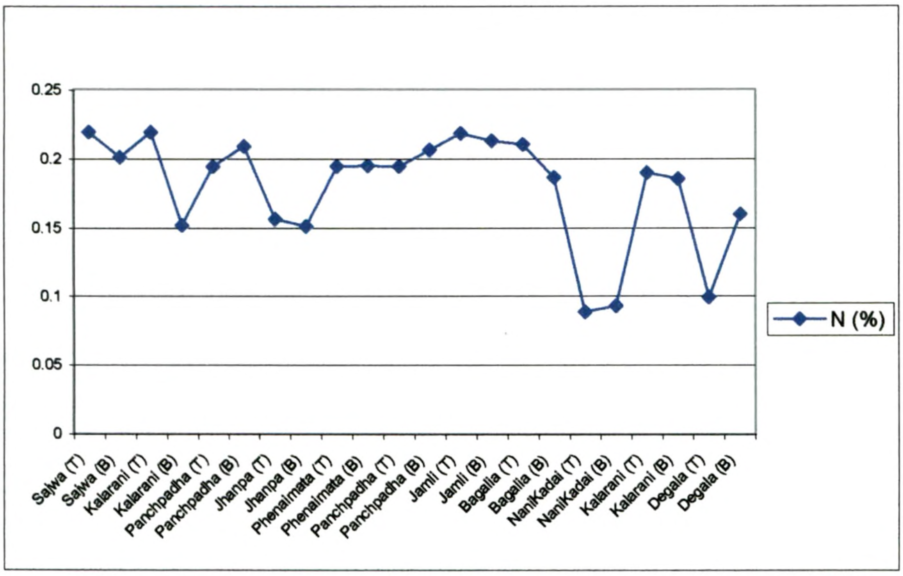


Figure 4 : EC & pH values in Forest Soils of Study Area

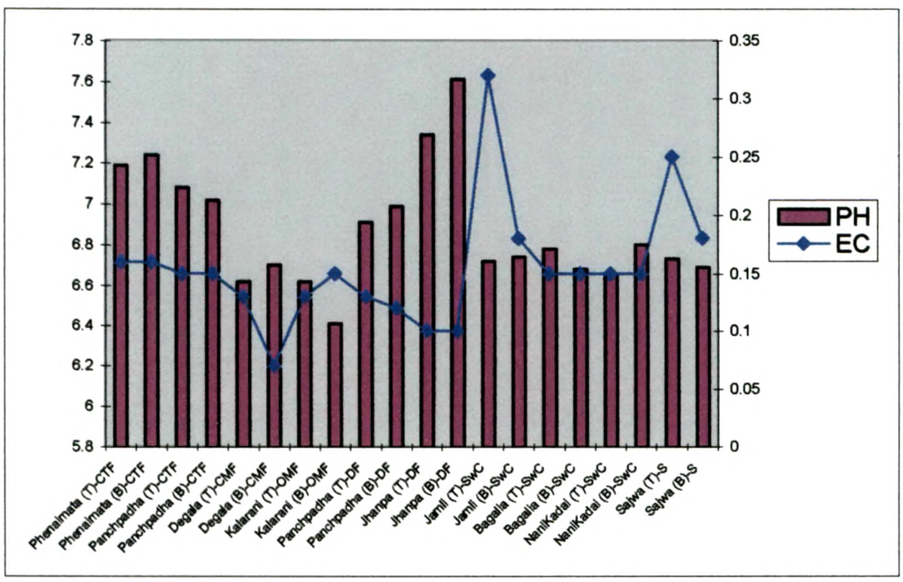


Table 18: Plant Species Status in Closed Teak Forest of Panchpadha RF

Sr. No.	Species	Ab	IVI
1	*Butea monosperma* (Lam) Taub.	1.00	13.61
2	*Morinda tomentosa* Heyne ex Roth	2.00	39.17
3	*Triumfetta rotundifolia* Lam	12.00	16.75
4	*Tectona grandis* L.f.	13.67	69.04
5	*Holarrhena antidysenterica* (Heyne) ex Roth Wall	46.00	161.45

species were present, only two of them showing a very high dominance (Table 19).

Phenaimata RF

Soil Studies

The Phenaimata RF soil colour was observed to be very dark gray in the range of 10YR hue and texture clay loam. The bottom soil exhibited higher percentage of moisture when compared to surface soils (Table 16).

Table 19: Vegetational indices estimated from Closed Teak Forest of Panchpadha RF

Index	Value
Simpson Dominance Index	0.53
Shannon-Wiener Diversity Index	1.30
Evenness Index	0.76
Species Richness Index	0.36

The ionic studies showed phosphorus and potassium and micronutrients to be higher in surface soils than in the bottom soils except for Mn which had lower in top soils than in bottom soils (Table 17). There was no difference in nitrogen concentration in top and bottom soils (Figure 3). C/N ratio of top and bottom soils was 11.84

and 11.89 respectively exhibiting a great similarity. The EC being 0.16 and the pH between 7.19-7.24 indicated the soil to be normal (Figure 4).

Phytosociology

The closed Teak forest of Phenaimata RF on the southern side also showed *Holarrhena antidysentrica* with higher IVI and abundance. *Tectona grandis* also exhibited high IVI. Other species with good IVI were *Capparis decidua*, *Leptadenia reticulata*, and *Butea monosperma* (Table 20).

The number of species in this area was more than that of Panchpadha RF as seen from the diversity index, with high species richness. The dominance index therefore was low. Uneven species distribution could be judged from the low evenness index (Table 21).

The two patches of Closed Teak Forests though being in the same range had only 47 % similarity as was estimated from the similarity index between the two.

Table 20: Plant Species Status in Closed Teak Forest of Phenaimata RF

Sr. No.	Species	Ab	IVI
1	*Anogeissus latifolia* (Roxb) Wall ex Bedd	1.00	5.30
2	*Holoptelea integrifolia* Planch	1.00	5.37
3	*Morinda tomentosa* Heyne ex Roth.	1.50	12.06
4	*Azadirachta indica* A Juss.	1.50	12.23
5	*Diospyros melanoxylon* Roxb.	2.00	6.38
6	*Butea monosperma* (Lam) Taub.	2.00	26.14
7	*Dendrocalamus strictus* Nees	3.00	6.81
8	*Heteropogon contortus* (L.) P.Beauv.ex R.&S.	5.00	7.85
9	*Leptadenia reticulata* (Retz) W.& A.	7.00	32.28
10	*Tectona grandis* L.f.	8.33	46.94
11	*Holarrhena antidysentrica* (L.) Wall ex.Don	31.50	95.43
12	*Capparis decidua* (Forsk) Edgew	65.00	43.22

Table 21: Vegetational indices estimated from Closed Teak Forest of Phenaimata RF

Index	Value
Simpson Dominance Index	0.23
Shannon-Wiener Diversity Index	2.76
Evenness Index	0.21
Species Richness Index	0.85

4.1.3.1.2 Closed Mixed Forest

This forest occupied only a small part of the round on the eastern side. The spot, which was studied in detail for this round, was the Degala Reserve Forest.

Degala RF

Soil Studies

The soil colour of Degala was observed to be dark yellowish brown and the texture sandy loam. The percentage of moisture was found to be 0.01% in both layers (Table 22). This indicated a lower moisture retention capacity of the soil.

Very high concentration of Mn and slightly high concentration of Cu and Zn was observed in surface soils. But Zn concentration in surface soil layer seem to be adequate (NBSS standards). All the macronutrients were higher in Degala forest (Table 23 & Figure 3). C/N ratio of top and bottom soil did not vary i.e. 11.5 and 11.56 respectively. Soils had low EC values and normal pH range (Figure 4).

Phytosociology

Closed mixed forest had many varieties of species. The number of species was quite high. The highest IVI was of tree species *Butea monosperma* followed by *Holarrhena antidysentrica* and then the grass species (Table 24). Good growth of grasses was observed from their increased abundance.

Table 22: Soil Physical Properties of Closed Mixed Forest, Degala RF

Spots	Dry Soil Colour/ Value	Wet Soil Colour/ Value	Texture	Moisture (%) - T	Moisture (%) - B
Degala (T)	dark yellowish brown / 4/4	dark yellowish brown / 3/6*	sandy loam	0.01	0.01
T= Surface soils, B = one foot depth, *Hue 10YR					

Table 23: Soil nutrients content in Closed Mixed Forest, Degala RF

Spots	P (ppm)	K (ppm)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
Degala (T)	0.62	17.70	1.2	60	4.8	108
Degala (B)	0.54	9.79	0.6	66	3.4	46
T= Surface soils, B = one foot depth						

The closed mixed forest showed high values of diversity, richness and evenness indices indicating an even distribution of varied species diversity. This might have resulted in lower dominance index (Table 25).

4.1.3.1.3 Degraded Forests

Panchpadha RF

Soil Studies

The soil colour of Panchpadha was dark yellowish brown and the texture was clay loam. The surface soil had a higher percentage of moisture (Table 26).

In this Degraded Forest, higher concentration of all macronutrients was observed in surface soils but micronutrient exhibited reverse condition with low concentration in surface soils (Table 27 & Figure 3). C/N values was slightly higher in top soil

Table 24: Plant Species Status in Closed Mixed Forest of Degala RF

Sr. No.	Species	Ab	IVI
1	*Abrus precatorius* L.	1	2.74
2	*Peterocarpus marsupium* Roxb.	1	2.76
3	*Albizzia odoratissima* (L.f.) Bth	1	2.76
4	*Morinda tomentosa* Heybe ex Roth	1	2.84
5	*Dalbergia lanceolaria* L.f.	1	2.96
6	*Zizyphus xylopyra* (Retz.) Willd	1	5.68
7	*Flacourtia indica* (Burm.f.) Merr.	1	7.05
8	*Ficus amplissima* Sm.	1	26.3
9	*Morinda tomentosa* Heyna	1.7	8.95
10	*Soymida febrifuga* (Roxb.) O.Ktze	2	3.14
11	*Ficus racemosa* L.	2	3.36
12	*Terminalia crenulata* Roth.	2	6.25
13	*Lagerstroemia parviflora* Roxb.	2	9.61
14	*Butea monosperma* (Lam.) Taub.	3.8	79
15	*Azadirachta indica* A.Juss	4	4.07
16	*Aegle marmelos* (L.) Corr.	4	4.46
17	*Diospypros melanoxylon* Roxb.	4	4.66
18	*Madhuca latifolia* (Roxb.) Macbr.	4.5	8.17
19	*Tectona grandis* L.f.	5	13
20	*Anogeissus latifolia* (Roxb.) Wall ex Bedd.	7	5.91
21	*Buchanania lanzan* Spr.	12	17.7
22	*Holarrhena antidysenterica* (L.) Wall ex G.Don	23	54.3
23	*Heteropogon contortus* (L.) P.Beauv.ex R.&S.	26	24.6

Table 25: Vegetational indices estimated from Closed Mixed Forest of Degala RF

Index	Value
Simpson Dominance Index	0.22
Shannon-Wiener Diversity Index	3.043
Evenness Index	2.23
Species Richness Index	1.38

Table 26: Soil Physical Properties of Degraded Forest, Panchpadha RF

Spots	Dry Soil Colour/ Value	Wet Soil Colour/ Value	Texture	Moisture (%) - T	Moisture (%) - B
Panchpadha (T)	dark yellowish brown / 3/4	dark yellowish brown / 3/4 *	clay loam	21.6	4.6
T= Surface soils, B = one foot depth, *Hue 10YR					

Table 27: Soil nutrients content in Degraded Forest of Panchpadha RF

Spots	P (ppm)	K (ppm)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
Panchpadha (T)	0.46	46.66	1.2	71.13	17.33	24
Panchpadha (B)	0.31	17.18	1.6	80.67	30.93	30.13
T= Surface soils, B = one foot depth						

(11.84) compared with bottom soils (11.52). The soils can be considered as normal, looking at EC and pH values (Figure 4).

Phytosociology

Euphorbia hirta was found in abundance in this area followed by *Pueraria tuberose, Alysicarpus ovalifolius, Grewia hirsutus, Dichanthium annulatum,* etc. (Table 28).

The dominance, diversity, evenness and species richness in this area were 0.11, 3.52, 0.09 & 1.36 respectively (Table 29).

4.1.3.1.4 Scrub

Sajwa RF

Soil Studies

The soil colour of Sajwa RF was observed to be yellowish brown and the texture clay loam. The surface soils had a lower percentage of moisture when compared with bottom soils (Table 30).

Table 28: Plant Species Status in Degraded Forest of Pachpadha RF

Sr. No.	Species	Ab	IVI
1	*Acacia leucophloea* (Roxb.) Willd	1	9.17
2	*Zizyphus mauritiana* Lam.	1	9.21
3	*Acacia catechu* Willd.	2	9.78
4	*Azadirachta indica* A.Juss	2	10.5
5	*Tectona grandis* L.f.	2	10.5
6	*Heteropogon contortus* (L.) P.Beauv. ex R.&S.	2	5.58
7	*Phoenix sylvestris* (L.) Roxb.	2	17.2
8	*Cassia tora* L.	3	5.73
9	*Indigofera oblongifolia* Forsk. Fl.	3	5.77
10	*Grewia abutifolia* Vent.	7	8.19
11	*Butea monosperma* (Lam.) Taub.	7	44.4
12	*Albizzia lebbeck* L.Bth.	8	50.6
13	*Vernonia* sp.	10	10.3
14	*Dichanthium annulatum* (Forsk) Stapf.	10	30.6
15	*Grewia hirsutus* Vahl.	12	11
16	*Alysicarpus ovalifolius*	15	12.9
17	*Pueraria tuberose* (Roxb.) DC.	30	21.5
18	*Euphorbia hirta* L.	37	26.5

Table 29: Vegetational indices estimated from Degraded Forest of Pachpadha RF

Index	Value
Simpson Dominance Index	0.11
Shannon-Wiener Diversity Index	3.52
Evenness Index	0.09
Species Richness Index	1.36

Table 30: Soil Physical Properties of Scrub Forest, Sajwa RF

Spots	Dry Soil Colour / Value	Wet Soil Colour / Value	Texture	Moisture (%) - T	Moisture (%) - B
Sajwa (T)	yellowish brown / 4/6	yellowish brown 3/4 *	clay loam	3.8	5.6
T= Surface soils, B = one foot depth, *Hue 10YR					

The soils were normal as reflected from EC & pH (Figure 4). The micro and the macro nutrient analyses also proved the soils to be fertile enough for proper plant growth. The nitrogen percentage was higher in the soil (Figure 3). Similarly, phosphorus and potassium levels were also good. Zn, Fe, Cu and Mn were in adequate amounts with more concentration in the top rather than in the bottom soil, with the exception of Cu, which had a slightly greater concentration in the bottom soil (Table 31). A C/N value of top soil was 12.09 and that of bottom soil was 11.65.

Table 31: Soil nutrients content in Scrub Forest, Sajwa RF

Spots	P (ppm)	K (ppm)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
Sajwa (T)	0.72	52.68	1.73	50.47	38	29.67
Sajwa (B)	0.41	40.23	1.4	38.2	39	29.07
T= Surface soils, B = one foot depth						

Phytosociology

Species composition reflected a variety of species with abundance of *Crotalaria juncea.* Amongst the tree species *Butea monosperma* and *Azadirachta indica* had a high status (Table 32).

Since the diversity of plants was high, dominance index was very low i.e. 0.14 (Table 33).

Table 32: Plant Species Status in Scrub Forest of Sajwa RF

Sr. No.	Species	Ab	IVI
1	*Zizyphus mauritiana* Lam.	1	3.65
2	*Acacia leucophloea* (Roxb.) Willd	1	3.66
3	*Borreria articularis* (L.f.) F.N.Willd	1	3.73
4	*Ocimum Americanum* L.	1	3.85
5	*Morinda tomentosa* Heyne ex Roth	1	4.01
6	*Acacia catechu* Willd	1	5.97
7	*Ocimum canum* Sims	2	3.97
8	*Chloris virgata* Sw.	3	4.37
9	*Heteropogon contortus* (L.) P.Beauv.	3	4.54
10	*Azadirachta indica* A.Juss	3.7	14.8
11	*Tephrosia purpurea* Pers.	4	4.77
12	*Cocculus hirsutus* (L.) Diels	5	14.8
13	*Breynia retusa* (Dennst.) Alst.	5.5	11
14	*Butea monosperma* (Lam.) Taub.	6	30.3
15	*Ficus hispida* L.	10	12.2
16	*Jatropha curcus* L.	11	9.05
17	*Cassia tora* L.	20	19.2
18	*Fumaria indica* (Harssk.) Pugsley	35	14.2
19	*Dichanthium annulatum* (Forsk) Stapf	36	94.6
20	*Crotalaria juncea* L.	80	31

Table 33: Vegetational indices estimated from Scrub Forest of Sajwa RF

Index	Value
Simpson Dominance Index	0.14
Shannon-Wiener Diversity Index	3.22
Evenness Index	0.11
Species Richness Index	1.16

4.1.3.2 Field Information

Village level inventory in this round generated using RS-GIS gave a clear cut idea of the forest cover area of each village in 1999 (Table 34 & Plate 5). During the survey of these villages, it was observed that on an average 6 kgs of fuelwood was consumed by each household of the village.

In the Sajwa round, 29 villages out of 53 villages had forest cover accounting for just more than 50% of the total villages. Among these, Bordha village had the highest forest cover in 1999 followed by Degala village. Ambalag village showed total disappearance of forests in 1999.

The villages having highest livestock population had also high population with high fuelwood consumption but low forest cover.

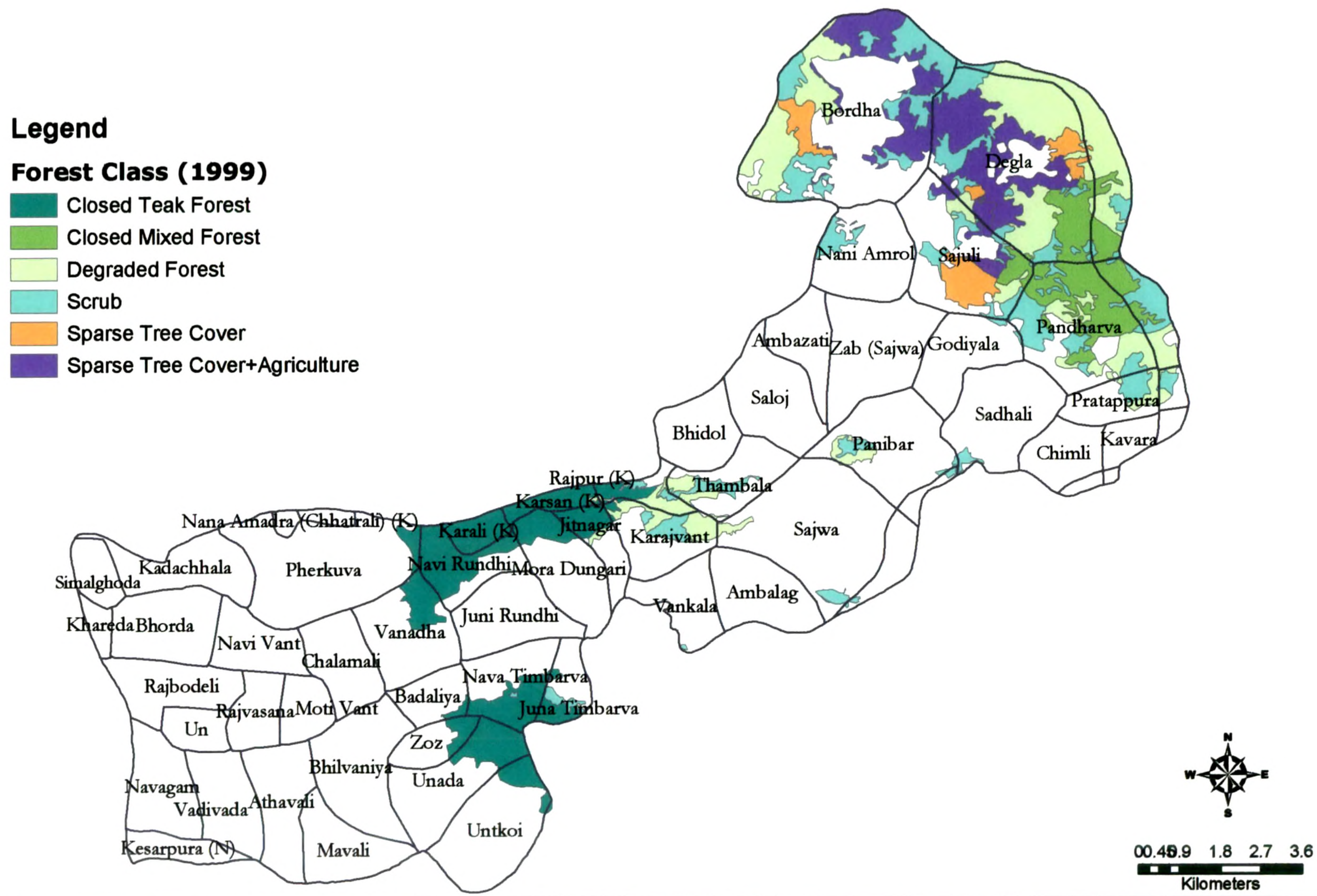
Table 34 : Villagewise forest cover for 1999 along with census, fuelwood and livestock details of Sajwa round

Name	Forest Class 1999	Forest Area (ha)	Total Forest Area (ha) 1999	Population		No Of House holds	Fuel wood used/day (Kg)	Live stock Pop.
				1981	1991			
Ambalag		1.42		804	981	156	936	
Ambazati	NF			569	604	116	696	
Athavali	NF			1406	1386	309	1854	
Badaliya			10.81	447	449	92	552	
	CTF	10.81						
Bhidol	NF			1052	1296	227	1362	
Bhilvaniya	NF			582	610	121	726	
Bhorda			882.17	504	1789	303	1818	
	DF	256.64						
	S	284.58						
	STC	64.57						
	STC+A	276.39						
Chalamali	NF			1517	1383	299	1794	650
Chhatrali (K)	NF			1022	1103	271	1626	
Chhota Udepur villages			534.05					
	DF	279.57						
	CMF	120.04						
	S	132.58						
	STC	1.87						
Chimli	NF			982	1136	136	816	
Degla			842.09	442	591	82	492	
	DF	366.58						
	CMF	126.61						
	S	151.96						
	STC	59.00						

Name	Forest Class 1999	Forest Area (ha)	Total Forest Area (ha) 1999	Population 1981	Population 1991	No Of House holds	Fuel wood used/day (Kg)	Live stock Pop.
	STC+A	137.93						
Godiyala			6.42	419	421	68	408	
	S	6.42						
Jitnagar			67.95	206	243	45	270	178
	DF	6.87						
	CTF	61.08						
Juna Timbarva			60.52	67	56	14	84	
	CTF	42.19						
	S	18.33						
Juni Rundhi	NF			396	410	73	438	
Kadachhala	NF			2797	3100	551	3306	
Karajvant			118.9	728	758	137	822	
	DF	69.99						
	CTF	8.45						
	S	40.46						
Karali (K)			90.63	2062	2426	381	2286	
	CTF	90.63						
Karsan (K)			86.97	1456	1659	330	1980	
	DF	2.32						
	CTF	84.65						
Kavara	NF			1043	1326	164	984	
Kesarpura (N)	NF			449	503	100	600	
Khareda	NF			190	249	58	348	
Mavali	NF							
Mora Dungari			72.95	1122	1272	218	1308	833
	DF	0.003						
	CTF	72.95						
Moti Vant	NF			850	788	166	996	
Nana Amadra (Chhatrali) (K)	NF			973	952	214	1284	
Nani Amrol			41.27	788	1071	87	522	
	S	39.75						
	STC+A	1.53						
Nava Timbarva			122.63	1172	1220	220	1320	
	CTF	120.97						
	S	1.67						
Navagam	NF			580	649	132	792	
Navi Rundhi			162.57	108	155	30	180	
	CTF	162.57						
Navi Vant	NF			21	139	40	240	
Pandharva			486.35	258	317	49	294	
	DF	113.70						
	CMF	238.59						
	S	134.06						
Panibar			53.72	1473	1964	231	1386	1200
		50.55						
	DF	28.56						
	S	22.16						
Pherkuva			27.56	1197	1372	306	1836	

Name	Forest Class 1999	Forest Area (ha)	Total Forest Area (ha) 1999	Population 1981	Population 1991	No Of House holds	Fuel wood used/day (Kg)	Live stock Pop.
	CTF	27.56						
Pratappura			63.6	281	311	32	192	
	DF	27.69						
	S	35.91						
Rajbodeli	NF			817	1091	159	954	436
Rajpur (Karali) (K)			90.86	957	1088	193	1158	
	DF	40.81						
	CTF	37.99						
	S	12.06						
Rajvasana	NF			155	191	35	210	
Sadhali			11.68	1705	1938	282	1692	
	S	11.68						
Sajuli			276.4	200	256	28	168	
	DF	42.55						
	CMF	37.51						
	S	70.32						
	STC	99.55						
	STC+A	26.47						
Sajwa			30.15	2264	2662	483	2898	
	DF	14.04						
	S	16.12						
Saloj	NF			1072	1176	223	1338	
Simal Ghoda	NF			269	308	59	354	
Thambala			70.54	502	583	89	534	
	DF	35.75						
	S	34.80						
Un	NF			814	827	142	852	
Unada			114.05	374	478	93	558	310
	CTF	114.05						
Untkoi			57.17	1008	1031	179	1074	
	CTF	57.17						
Vadivada	NF			303	356	61	366	
Vanadha			74.81	911	866	173	1038	
	CTF	74.81						
Vankala			1.48	367	399	70	420	
	S	1.48						
Zab (Sajwa)	NF			1133	1330	203	1218	
Zoz			36.94	234	303	54	324	
	CTF	36.64						

Plate : 5 Sajwa Round Villagewise Forest Cover (1999)



4.2 Kalarani round

4.2.1 Forest Cover

In this round with respect to tonal variation, seven different forest classes were delineated. The round takes up 20.35 sq. km. of the total forest cover area. Along with the six forest cover classes identified in the Sajwa round, there was an additional class of open mixed forest (Plate 6).

The open mixed forest had a 20-30% of the canopy density. It exhibited a greenish red tone on the satellite image. The species noted in this category were the *Lagerstroamia parviflora, Diospyros melanoxylon,* etc.

Out of the seven classes delineated the major forest cover class the round had was the scrub forests. The latter covered 8.3 sq. km. (Plate 7). The other classes which followed this class, were the Sparse Tree cover, Degraded Forests, Sparse Tree cover with Agriculture and Closed Teak forest with an area of 5.9 sq. km., 4.8 sq. km., 4.9 sq. km. and 4.4 sq. km. respectively. This round had only 1.1 sq. km. of open mixed forest. A small patch of 0.15 sq. km. area of closed mixed forest has also been depicted in Table 35.

4.2.2 Land use Classes

The Kalarani round had land use classes similar to those of the Sajwa round but the class of stony waste was absent. There was an additional land use class viz. the acacia plantation. It appeared as a pinkish green tone on the satellite image.

Amongst the land use classes, the maximum area was taken up by agriculture (148 sq km). About 11.9 sq km of the area was covered by wasteland. Eucalyptus & acacia plantations occupied

Plate : 6 Kalarani Round Forest Cover & Landuse Classes Delineated using 1999 IRS LISS III data

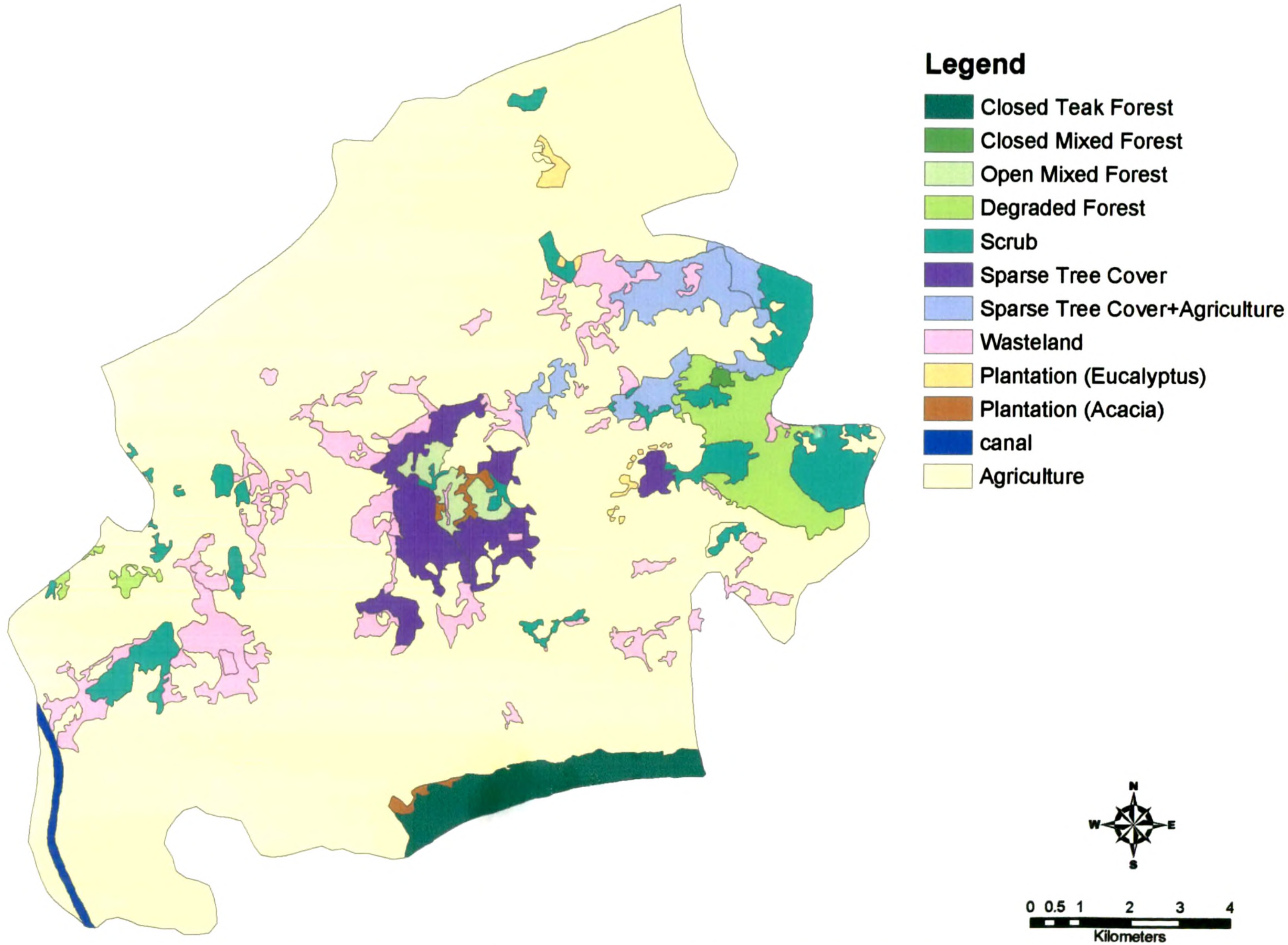
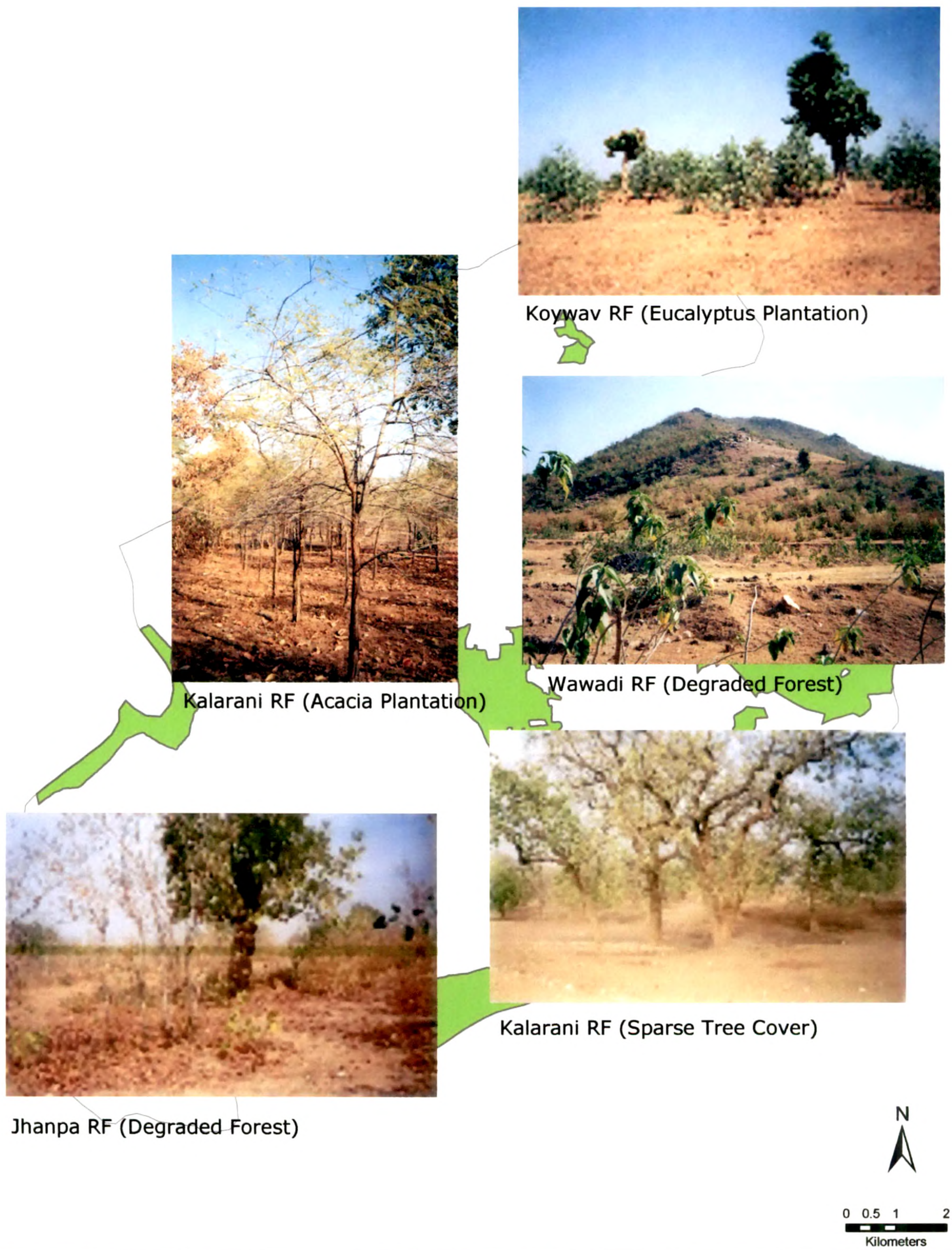


Plate : 7 Forest Cover Classes in Kalarani Round



0.6 sq. km. and 0.55 sq. km. respectively. A canal passing through this area covered 0.8 sq. km. (Table 35).

Table : 35 Kalarani Round Forest Cover & Major Landuse Classes Area Statistics (1999)

Sr. No.	Classes	Area (sq km)	Percentage Area
1	Closed Teak Forest	4.37	2.27
2	Closed Mixed Forest	0.15	0.08
3	Open Mixed Forest	1.10	0.57
4	Degraded Forest	4.82	2.51
5	Scrub	8.36	4.35
6	Sparse Tree Cover	5.93	3.08
7	Sparse Tree Cover+Agriculture	4.87	2.53
8	Wasteland	11.97	6.12
9	Plantation (Eucalyptus)*	0.59	0.31
10	Plantation (Acacia)*	0.55	0.29
11	Agriculture	148.64	77.37
12	canal	0.77	0.40
	Total Area	192.13	

*Plantations within RF boundary only.

The mapping accuracy and the classification accuracy obtained for these classes were 92% and 95.83% respectively with KAPPA coefficient of 0.95 (Table 36). The misclassification occurred when the class scrub was confused with sparse tree cover.

4.2.3 Spots surveyed in field analysis

Soil studies and vegetational distribution was carried out in the open mixed forest and degraded forests. The forest class scrub was only surveyed in order to understand the vegetational survey. The spots selected were Kalarani RF for Open mixed forest, Jhanpa & Wawadi for Degraded forests area and Koywav RF for Scrub.

Table 36 : Kalarani Round Accuracy Table

Classes	CTF	CMF	OMF	DF	S	STC	STC+A	PE	PA	W	A	C	TOTAL	O/E	C/E	C/A (%)	M/A (%)
CTF	2												2	0	0	100	100
CMF		1											1	0	0	100	100
OMF			1										1	0	0	100	100
DF				2									2	0	0	100	100
S					3	1							4	0	1	75	75
STC						2							2	1	0	100	66.67
STC+A							1						1	0	0	100	100
PE								1					1	0	0	100	100
PA									2				2	0	0	100	100
W										3			3	0	0	100	100
A											4		4	0	0	100	100
C												1	1	0	0	100	100
Total	2	1	1	2	3	3	1	1	2	3	4	1	**24**				
Overall Classification Accuracy = 95.83%																	
Overall Mapping Accuracy = 92%																	
Khat statistics = 0.95																	
CTF=Closed Teak Forest, CMF=Closed Mixed Forest, OMF=Open Mixed Forest, DF=Degraded Forests, S=Scrub,																	
STC=Sparse Tree Cover, PE= Plantation Eucalyptus, PA=Plantation Acacia, W=Wasteland, A=Agriculture,																	
C=Canal, O/E=Omission Error, C/E=Commission Error, C/A=Classification Accuracy, M/A=Mapping Accuracy																	

4.2.3.1 Soil & Phytosociological Studies

4.2.3.1.1 Open Mixed Forest

<u>Kalarani RF</u>

Soil Studies

The soil colour of Kalarani was observed to be yellowish brown and the texture, sandy loam. The bottom soils had a higher percentage of moisture when compared with the surface layer i.e. 2.2% and 3.2% respectively (Table 37).

Table 37: Soil Physical Properties of Open Mixed Forest, Kalarani RF

Spots	Dry Soil Colour/ Value	Wet Soil Colour/ Value	Texture	Moisture (%) - T	Moisture (%) - B
Kalarani (T)	yellowish brown / 5/6	yellowish brown / 5/4 *	sandy loam	2.2	3.2

T= Surface soils, B = one foot depth, *Hue 10YR

Micronutrient Zn, Cu and Mn had higher values in surface soils compared with bottom soils. Only Fe concentration was less in surface soil compared with bottom soils. Macronutrients on the other hand, i.e. phosphorus and potassium had less concentration in top soils compared with bottom soils (Table 38) whereas nitrogen showed high concentration in top soils (Figure 3). Open mixed forest showed top soil with higher (12.22) C/N value compared with bottom soil (11.32). The EC values were very low, indicating the soil to be normal. pH value indicated the bottom soils to be slightly acidic according to NBSS standards (Figure 4).

Phytosociology

The vegetational study in the open mixed forest revealed a variety of tree species along with one or two herbs and grass species.

A good grass cover was observed in this forest as seen from plant status studies in this forest (Table 39). Among the tree species, *Holarrhena antidysentrica,* showed maximum abundance and IVI followed by *Azadirachta indica* and *Butea monosperma.*

Table 38: Soil nutrients content in Open Mixed Forest, Kalarani Round

Spots	P (ppm)	K (ppm)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
Kalarani (T)	0.33	37.72	1.06	45.07	2.93	25.73
Kalarani (B)	0.39	46.15	1	72.2	2	25.6
T= Surface soils, B = one foot depth						

Table 39 : Plant Species Status in Open Mixed Forest of Kalarani RF

Sr. No.	Species	Ab	IVI
1	*Madhuca latifolia* (Roxb) Macbr.	1	1.04
2	*Dendrocalamus strictus* Nees	1	1.14
3	*Acacia catechu* Willd.	1	5.41
4	*Lagerstroaemia parviflora* Roxb.	2.67	15.81
5	*Butea monosperma* (Lam.) Taub.	4	4.13
6	*Euphorbia hirta* L.	5	4.4
7	Dichanthium annulatum (Forsk) Stapf.	5	19.95
8	Morinda tomentosa *Heyne* ex Roth	9	7.9
9	*Diospyros melanoxylon* Roxb.	9.67	26.64
10	*Alysicarpus ovalifolius*	11.5	30.02
11	*Azadirachta indica* A. Juss	13	11.38
12	*Holarrhena antidysentrica* (L) Wall ex G.Don	14	62.33
13	*Cenchrus ciliaris* L.	43	41.9
14	Heteropogon *contortus* (L.) P. Beauv.ex R. & S.	50	67.74

The significant aspect observed was that the *Madhuca latifolia, Dendrocalamus strictus* and *Acacia catechu* exhibited equal abundance. But Acacia catechu had a higher IVI value due to higher percentage of frequency.

On making a secondary vegetation analysis, different vegetation indices generated showed a lower richness and dominance index when compared with diversity or evenness index (Table 40).

Table 40 : Vegetational indices estimated from Open Mixed Forest of Kalarani RF

Index	Value
Simpson Dominance Index	0.14
Shannon-Wiener Diversity Index	2.91
Evenness Index	2.53
Species Richness Index	0.92

4.2.3.1.2 Degraded Forests

Jhanpa RF

Soil Studies

The soil colour of Jhanpa was observed to be yellowish brown and the texture, sandy loam with the lowest moisture, 0.01%, indicating lowest moisture retention capability (Table 41).

Soils here had lowest Mn concentration in bottom soils when compared with other classes. Zn, Fe, and Cu were 1.13, 40.87 and 2.13 ppm respectively in surface soil and 0.6, 52.47 and 2.67 ppm respectively in bottom soils. As in other categories, concentration of nitrogen (Figure 3) was more when compared with that of phosphorus and potassium (Table 42). C/N ratio was 12.06 in top soils and 11.67 in bottom soils. The low EC and pH value showed slightly alkaline in bottom soils according to NBSS standards (Figure 4).

Table 41: Soil Physical Properties of Degraded Forest of Jhanpa RF

Spots	Dry Soil Colour/ Value	Wet Soil Colour/ Value	Texture	Moisture (%) - T	Moisture (%) - B
Jhanpa (T)	yellowish brown / 5/6	yellowish brown / 5/4 *	sandy loam	0.01	0.01
T= Surface soils, B = one foot depth, *Hue 10YR					

Table 42 : Soil nutrients content in Degraded Forest of Jhanpa RF

Spots	P (ppm)	K (ppm)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
Jhanpa (T)	0.28	28.22	1.13	40.87	2.13	18.67
Jhanpa (B)	0.26	27.47	0.6	52.47	2.67	16.13
T= Surface soils, B = one foot depth						

Phytosociology

Degraded forest of Jhanpa RF vegetation studies showed highest IVI of *Holarrhena antidysentrica* followed by grass species and *Lagerstroemia parviflora* as it had high frequency (Table 43). This forest showed high species diversity (Table 44).

Wawadi RF

Degraded forest showed that grass species had highest IVI and abundance. Another tree species that was abundant in the degraded forest was *Lagerstoermia parviflora* and *Diospyros melanoxylon* (Table 45).

The Wawadi RF showed more diversity of species with low dominance and evenness index. The species richness is also low (Table 46).

Table 43: Plant Species Status in Degraded Forest of Jhanpa RF

Sr. No.	Species	Ab	IVI
1	*Acacia catechu* Willd	1	5.75
2	*Azadirachta indica* A.Juss	1	5.783
3	*Albizzia odoratissima* (L.f.) Beth	1	5.79
4	*Morinda tomentosa* Heyne ex Roth	2	6.21
5	*Diospyros melanoxylon* Roxb.	6.67	24.32
6	*Lagerstroemia parviflora* Roxb.	12	26.53
7	*Holarrhena antidysentrica* (L.) Wall ex G.Don	59.3	124.1
8	*Cenchrus ciliaria* L.	61	58.21
9	*Heteropogon contortus* L.	63	43.33

Table 44: Vegetational indices estimated from Degraded Forest of Jhanpa RF

Index	Value
Simpson Dominance Index	0.27
Shannon-Wiener Diversity Index	2.08
Evenness Index	0.28
Species Richness Index	0.38

Table 45 : Plant Species Status in Degraded Forest of Wawadi RF

Sr. No.	Species	Ab	IVI
1	*Cassia tora* L.	1	6.47
2	*Alysicarpus ovalifolius*	1.67	19.78
3	*Butea monosperma* (Lam.) Taub.	2	7.94
4	*Vernonia sp.*	4	7.16
5	*Diospyros melanoxylon* Roxb.	5	20.28
6	*Lagerstoermia parviflora* Roxb.	5	33.69
7	*Jatropha curcas* L.	9	10.37
8	*Cynadon dactylon* (L.) Pers.	10	8.71
9	*Cenchrus ciliaris* L.	34	54.09
10	*Heteropogon contortus* L.	119.7	131.6

Table 46: Vegetational indices estimated from Degraded Forest of Wawadi RF

Index	Value
Simpson Dominance Index	0.55
Shannon-Wiener Diversity Index	1.03
Evenness Index	0.55
Species Richness Index	0.45

The Jhanpa RF & Wawadi RF degraded forests showed 42% of similarity of species between the two areas of the Kalarani round.

4.2.3.1.3 Scrub

Koywav RF

The scrub forest showed grasses with highest IVI and abundance. Other species also, like *Holarrhena antidysenterica* and *Diospyros melanoxylon* had high IVI (Table 47). Koywav RF had low species diversity and richness (Table 48).

Table 47 : Plant Species Status in Scrub of Koywav RF

Sr. No.	Species	Ab	IVI
1	*Euphorbia microphylla* Heyne	1	7.81
2	*Cenchrus ciliaris* L.	1	7.85
3	*Euphorbia hirta* L.	2	7.96
4	*Dichanthium annulatum* (Forsk.) Stapf	2	9.44
5	*Alysicarpus ovalifolius*	5	8.35
6	*Tridax procumbens* Linn.	10	18.02
7	*Diospyros melanoxylon* Roxb.	15.5	34.24
8	*Holarrhena antidysenterica* (L) Wall ex.Don	22	11.23
9	*Heteropogon contortus* L.	228	195.1

Table 48 : Vegetational indices estimated from Scrub Forest of Koywav RF

Index	Value
Simpson Dominance Index	0.8
Shannon-Wiener Diversity Index	0.63
Evenness Index	0.66
Species Richness Index	0.32

4.2.3.2 Field Information

The 1999 village level information of this round is as depicted in Table 49 & Plate 8. It was observed that 65% of the total villages in this round showed the presence of forest cover. The percentage of villages with forest cover exceeded that of Sajwa round.

Vavdi village with highest forest cover showed good forest area of closed mixed forest.

A large number of villages with low forest cover had dense population with high fuel wood consumption.

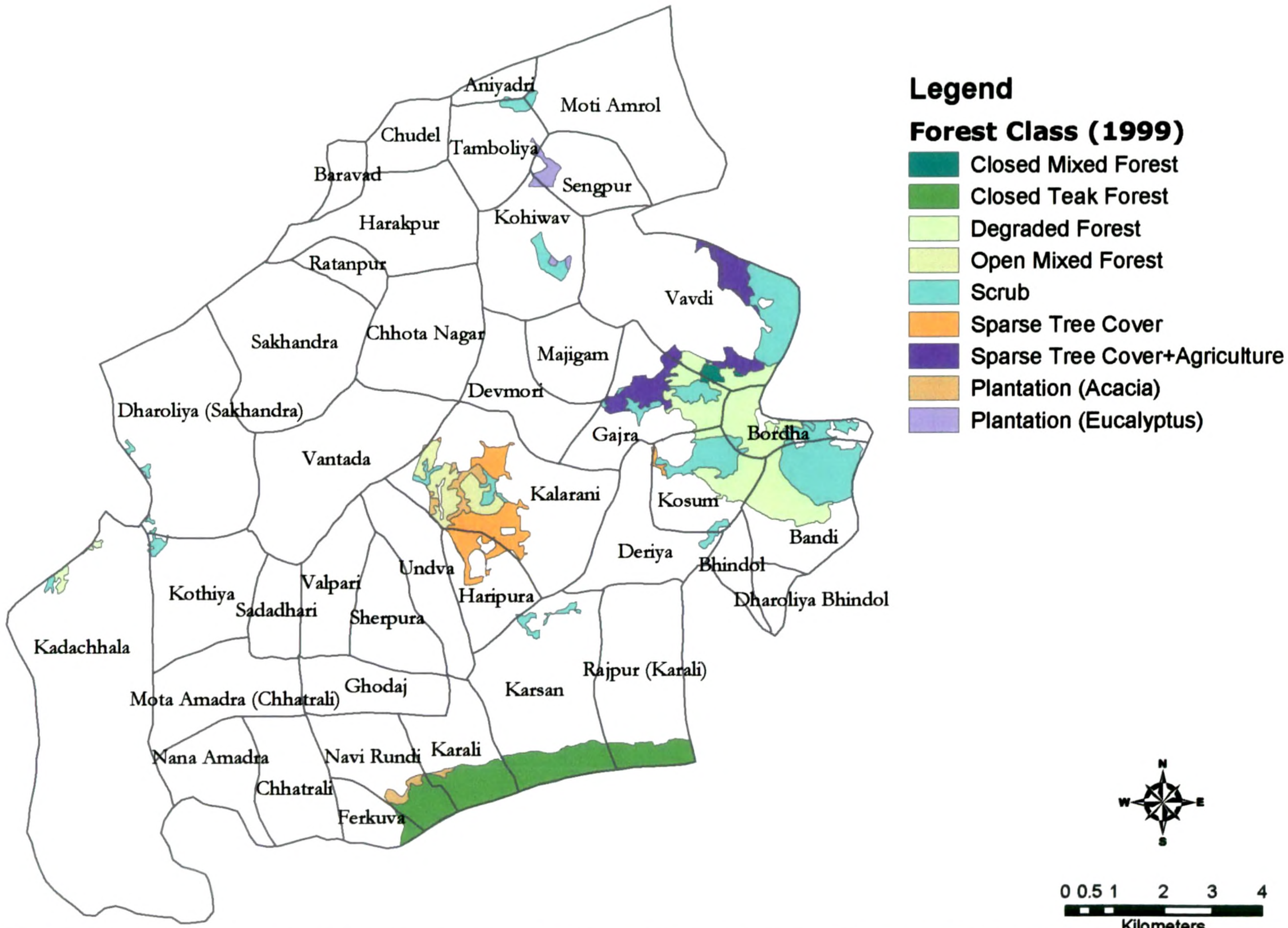
Table 49 : Villagewise forest cover for 1999 along with census, fuelwood and livestock details of Kalarani round

Name	Forest Class 1999	Forest Area (ha)	Total Forest Area (ha) 1999	No. Of House holds	Population		Fuel wood used/day (Kg)	Live stock Pop.
					1981	1991		
Aniyadri			1.03	237	1293	1933	1422	
	S	1.032						
Bandi			286.92	89	494	554	534	
	DF	124.171						
	S	162.754						
Baravad	NF			246	1239	1608	1476	
Bhindol			0.065	227	1052	1296	1362	
	S	0.065						
Bordha			166.49	303	504	1739	1818	
	DF	119.615						
	S	46.875						
Chhatrali	NF			271	1022	1103	1626	
Chhota Nagar	NF			70	308	457	420	

Name	Forest Class 1999	Forest Area (ha)	Total Forest Area (ha) 1999	No. Of House holds	Population 1981	Population 1991	Fuel wood used/day (Kg)	Live stock Pop.
Chudel	NF			150	803	923	900	
Deriya			7.16	127	515	748	762	
	S	6.408						
	STC	0.752						
Devmori			0.17	58	408	459	348	
	S	0.170						
Dharoliya (Sakhandra)			9.15	167	1338	1502	1002	
	S	9.145						
Dharoliya Bhindol	NF			29	164	173	174	
Ferkuva			16.960	306	1197	1372	1836	
	CTF	16.963						
Gajra			204.67	66	373	504	396	2280
	CMF	1.920						
	DF	84.268						
	PE	0.020						
	S	45.646						
	STC+A	72.819						
Ghodaj	NF			39	139	175	234	
Harakpur	NF			173	753	1015	1038	
Haripura			47.84	70	374	445	420	625
	OMF	0.089						
	S	0.461						
	STC	47.291						
Kadachhala			18.72	551	2797	3100	3306	
	DF	13.903						
	S	4.817						
Kalarani			284.03	344	1777	1967	2064	1695
	OMF	108.988						
	PA	32.925						
	S	23.585						
	STC	118.535						
Karali			120.4	381	2062	2426	2286	
	CTF	115.637						
	PA	4.767						
Karsan			153.09	330	1456	1659	1980	
	CTF	136.176						
	S	16.906						
Kohiwav			36.7	124	559	747	744	745
	PE	8.734						
	S	27.974						
Kosum			173.15	113	686	784	678	2282
	DF	86.219						
	PE	0.016						
	S	81.371						
	STC	5.538						
Kothiya			9.17	70	267	341	420	
	S	9.173						
Majigam			0.304	105	495	649	630	
	S	0.303						

Name	Forest Class 1999	Forest Area (ha)	Total Forest Area (ha) 1999	No. Of House holds	Population 1981	Population 1991	Fuel wood used/day (Kg)	Live stock Pop.
	STC+A	0.001						
Mota Amadra (Chhatrali)	NF			102	460	503	612	
Moti Amrol			5.12	565	3214	4930	3390	
	S	5.118						
Nana Amadra (Chhatrali)	NF			214	973	952	1284	
Navi Rundi			94.58	30	108	155	180	
	CTF	77.730						
	PA	16.853						
Rajpur (Karali)			83.85	193	957	1088	1158	
	CTF	83.851						
Ratanpur	NF			219	1304	1710	1314	
Sadadhari	NF			64	213	238	384	
Sakhandra	NF			257	1690	1576	1542	
Sengpur			20.58	33	267	281	198	550
	PE	20.578						
Sherpura	NF			35	196	273	210	325
Tamboliya			14.21	129	590	1093	774	1100
	PE	2.050						
	S	12.161						
Undva			0.34	81	374	434	486	
	OMF	0.274						
	PA	0.066						
	STC	0.001						
Valpari	NF			123	512	661	738	
Vantada			0.66	62	328	313	372	
	OMF	0.656						
	STC	0.0002						
Vavdi			307.51	216	881	1354	1296	
	CMF	13.251						
	DF	53.874						
	S	143.073						
	STC+A	97.313						

Plate : 8 Kalarani Round Villageswise Forest Cover (1999)



4.3 Boriad round

4.3.1 Forest Cover

The total area under forest cover in this round was 22.97 sq km. Two forest classes viz. Scrub and Scrub with coppice forests were delineated in this round (Plate 9). Though on the image it was slightly difficult to differentiate between these two classes, these classes were very distinct on the ground (Plate 10). The characteristics of the scrub forests were similar to the scrub classes of the Kalarani round. The scrub area having the growth of the tree species with coppice origin were classified as scrub with coppice forests. It appeared as a pink tone on the image. Area statistics exhibited that scrub covers a major area as compared with scrub with coppice forests (Table 50).

Table : 50 Boriad Round Forest Cover & Major Landuse Classes Area Statistics (1999)

Sr. No.	Classes	Area (sq.km)	% Area
1	Scrub	28.17	16.63
2	Scrub with Coppice Forest	19.38	11.44
3	Wasteland	2.62	1.55
4	Waterbody	0.27	0.16
5	Agriculture	118.91	70.21
	Total Area	169.36	

4.3.2 Land use Classes

Only three land use classes could be demarcated in this area viz. wasteland, waterbody and agricultural area. Waterbody was delineated based on its dark tone because of deep water. Agriculture occupied the major portion of the land use categories.

Plate 9 : Boriad Round Forest Cover & Major Land use Classes
Delineated using 1999 IRS LISS III data

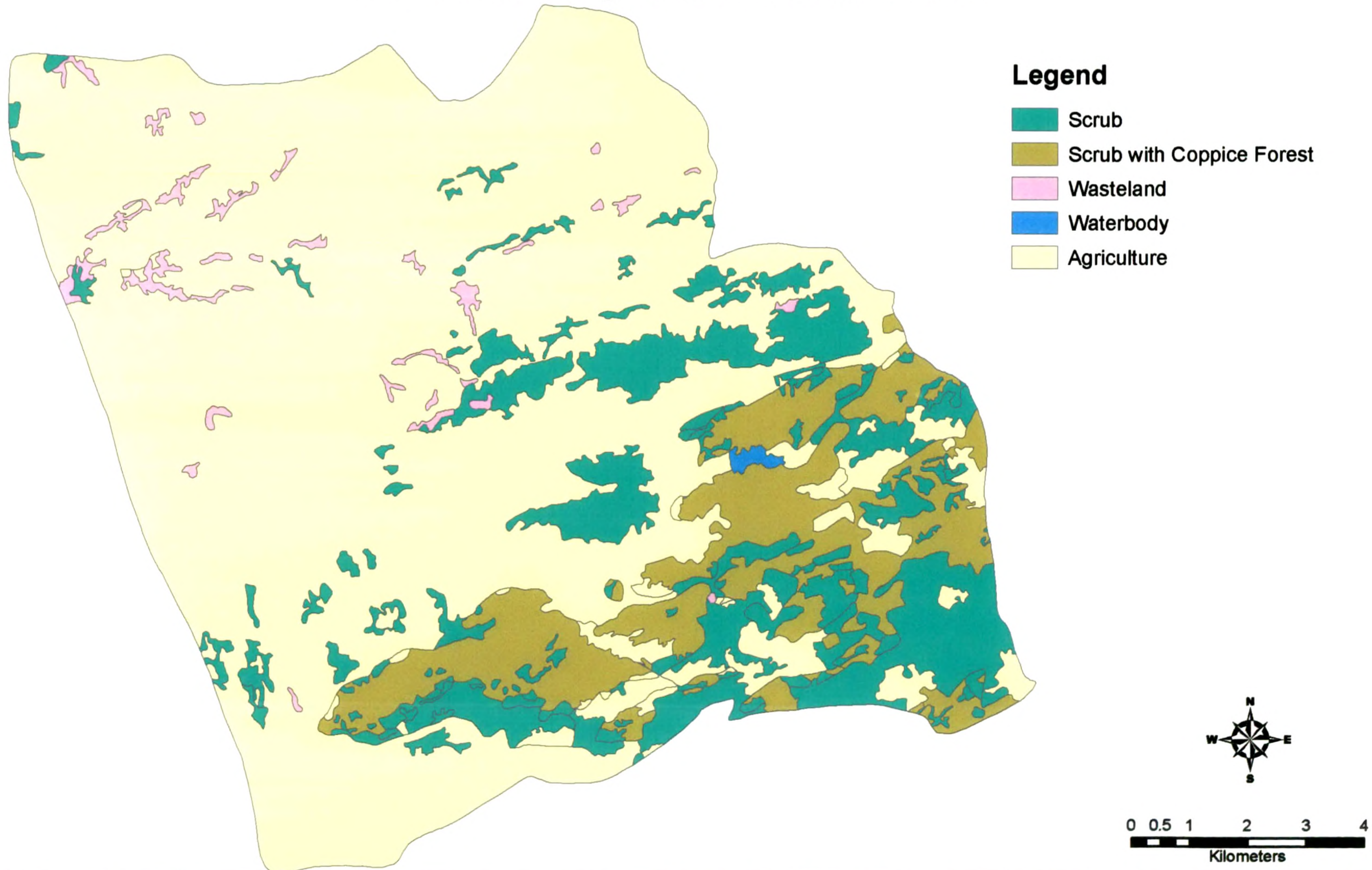
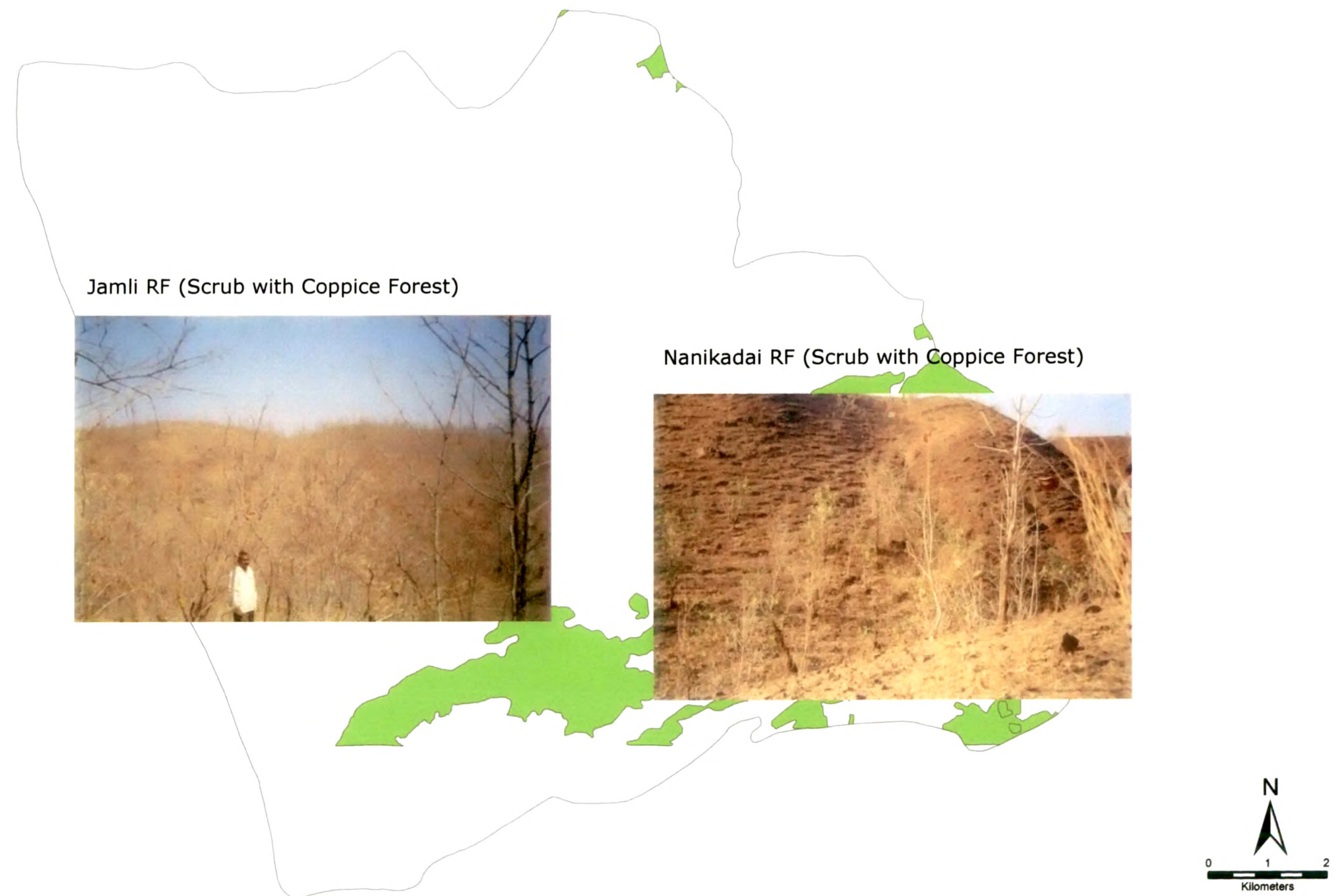


Plate :10 Forest Cover Classes in Boriad Round



The mapping accuracy and classification accuracy obtained for these classes were 84.62 % and 91.67% respectively with Khat statistics showing 0.89 accuracy (Table 51).

4.3.3 Spots surveyed in field analysis

A new class observed in this round when compared with the Kalarani and the Sajwa rounds was the class scrub with coppice forest. Three spots which were surveyed for this class were Jamli, Bagalia and Nanikadai.

4.3.3.1 Soil & Phytosociological Studies

4.3.3.1.1 Scrub with coppice forests

Jamli RF

Soil Studies

The soil colour of Jamli was observed to be dark yellowish brown and the texture, clay loam. The moisture retention was found to be 14% in top soil (Table 52).

The micronutrient analysis exhibited higher Zn, Fe, Cu and Mn concentrations on surface soil compared with bottom soils. The macronutrient analysis showed a higher concentration of nitrogen in surface soil (0.22%) compared with bottom soils (0.21%) (Figure 3). Phosphorus and potassium also showed the same trend (Table 53). C/N ratio was almost similar in top soils and bottom soils i.e. 11.5 and 11.76 respectively. The EC values were very low and the pH indicated the soil to be normal (Figure 4).

Phytosociology

Holarrhena antidysentrica, Tectona grandis, Azadirachta indica, Morinda tomentosa, etc. are the abundant species in decreasing order. *Tectona grandis* coppices exhibited highest IVIvalue (Table54).

Table 51 : Boriad Round Accuracy Table

Classes	S	SCo	W	WB	A	TOTAL	O/E	C/E	C/A (%)	M/A (%)
S	3	1				4	0	1	75	75
SCo		2				2	1	0	100	66.67
W			2			2	0	0	100	100
WB				1		1	0	0	100	100
A					3	3	0	0	100	100
TOTAL	3	3	2	1	3	**12**				
Overall Classification Accuracy = 91.67%										
Overall Mapping Accuracy = 84.62%										
K_{hat} statistics = 0.89										
S=Scrub, SCo=Scrub with coppice forests, W=Wasteland, WB=Water body, A=Agriculture,										
O/E=Omission Error, C/E=Commission Error, C/A=Classification Accuracy, M/A=Mapping Accuracy										

Table 52: Soil Physical Properties of Scrub with Coppice Forests

Spots	Dry Soil Colour / Value	Wet Soil Colour / Value	Texture	Moisture (%) - T	Moisture (%) - B
Jamli (T)	dark yellowish brown / 4/6	dark yellowish brown / 3/4 *	clay loam	14	10
Bagalia (T)	yellowish brown / 5/6	yellowish brown / 5/4 *	loamy sand	2	2
NaniKadai (T)	yellowish brown / 5/6	dark yellowish brown / 4/6 *	sandy clayey loam	6	6
T= Surface soils, B = one foot depth, *Hue 10YR					

Table 53: Soil nutrients content in Scrub with Coppice Forests

Spots	P (ppm)	K (ppm)	Zn (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)
Jamli (T)	0.76	74.28	2.4	44.2	3.17	32.87
Jamli (B)	0.49	64.29	1.47	36.47	2.4	29.47
Bagalia (T)	3.01	50.47	1.4	50	3.6	30.6
Bagalia (B)	1.54	51.53	1.4	46	3	30
NaniKadai (T)	1.16	32.70	0.6	42.8	3	30.4
NaniKadai (B)	0.62	31.19	0.4	45	4	27.6

Table 54: Plant Species Status in Scrub with Coppice Forest of Jamli RF

Sr. No.	Species	Ab	IVI
1	*Dendrocalamus strictus* Nees	1	13.02
2	*Acacia catechu* Willd	1	13.83
3	*Butea monosperma* (Lam.) Taub.	1	25.49
4	*Morinda tomentosa* Heyne ex Roth	2	14.87
5	*Azadirachta indica* A.Juss	2	20.85
6	*Tectona grandis* L.f.	5.33	128.03
7	*Holarrhena antidysentrica* (L) Wall ex G.Don	6	83.89

Jamli RF showed high species richness and diversity but low dominance of particular species and uneven distribution (Table 55).

Table 55: Vegetational indices estimated from Scrub with Coppice Forest of Jamli RF

Index	Value
Simpson Dominance Index	0.32
Shannon-Wiener Diversity Index	1.96
Evenness Index	0.38
Species Richness Index	1.08

Bagalia RF

Soil Studies

The soil colour of Bagalia was observed to be yellowish brown and the texture, loamy sand with 2 % of soil moisture retention capacity (Table 52).

The micronutrient analysis showed a higher level of Fe, Cu and Mn compared with Zn. The macronutrient analysis showed higher percentage of nitrogen in surface soil than in bottom soils (Figure 3). Phosphorus also showed high concentration in surface soil compared with bottom soils whereas potassium and C/N value showed a different trend with higher concentration in bottom soils compared with surface soil (Table 53). The EC and pH values were low (Figure 4).

Phytosociology

Abundant species in Bagalia RF were *Tectona grandis, Acacia catechu, Zizyphus mauritiana, Butea monosperma* in decreasing order. *Acacia catechu* and *Zizyphus mauritiana* showed uniform distribution but the *Tectona grandis* had a high relative dominance (Table 56).

In Bagalia RF, scrub with coppice forest showed more diversity of species and low dominance and evenness of species with species richness of 0.76 (Table 57).

Table 56: Plant Species Status in Scrub with Coppice Forest of Bagalia RF

Sr. No.	Species	Ab	IVI
1	*Butea monosperma* (Lam.) Taub.	1.6	49.68
2	*Zizyphus mauritiana* Lam.	2.5	51.74
3	*Acacia catechu* Willd.	2.7	66.83
4	*Tectona grandis* L.f.	5	131.86

Table 57: Vegetational indices estimated from Scrub with Coppice Forest of Bagalia RF

Index	Value
Simpson Dominance Index	0.25
Shannon-Wiener Diversity Index	1.9
Evenness Index	0.42
Species Richness Index	0.76

Nanikadai RF

Soil Studies

The soil colour of NaniKadai was found to be yellowish brown and the texture, sandy clayey loam with 6% of moisture retention in the soil (Table 52).

The micronutrient analysis exhibited low Zn concentration in bottom soils. Mn exhibited higher in surface soils than in bottom soils. Cu and Fe were higher concentration in bottom soils than in surface soils. The macronutrient analysis showed nitrogen with higher concentration in surface soils compared with bottom soils (Figure 3). Macronutrients potassium and phosphorus were higher in the surface layers (Table 53). Top soils C/N ratio was 12.87 and that of bottom soils was 12. The EC and pH values showed the soils to be normal according to NBSS standards (Figure 4).

Phytosociology

Anona squamosa and *Acacia senegal* were in abundance with *Annona squamosa* showing the highest density.

Butea monosperma showed high relative dominance followed by *Annona squamosa* (Table 58).

Table 58: Plant Species Status in Scrub with Coppice Forest of Nanikadai RF

Sr. No.	Species	Ab	IVI
1	*Albizzia odoratissima* (L.f.) Bth	1	9.52
2	*Albizzia lebbek* (L.) Bth.	1	9.56
3	*Tribulus terrestris* L.	1	11.75
4	*Zizyphus mauritiana* Lam.	1	20.12
5	*Leptadenia reticulata (*Roth) Willd	1	26.81
6	*Butea monsperma* (Lam.) Taub.	3	65.12
7	*Acacia catechu* Willd	3.5	31.11
8	*Heteropogon contortus* (L.) P.Beauv.ex R.&S.	5	32.64
9	*Acacia senegal* Willd	5	37.69
10	*Anona squamosa* L.	12	59.69

The dominance and evenness index in this site was 0.15, species richness index was 1.47 and diversity index was 2.66 indicating high diversity of the species in Nanikadai RF, scrub with coppice forest. (Table 59).

Table 59: Vegetational indices estimated from Scrub with Coppice Forest of Nanikadai RF

Index	Value
Simpson Dominance Index	0.15
Shannon-Wiener Diversity Index	2.66
Evenness Index	0.15
Species Richness Index	1.47

The similarity studies carried out for the three spots surveyed showed that Bagalia forest had a mixture of species from both Jamli and NaniKadai.

4.3.3.2 Field Information

Village level studies in the Boriad round exhibited presence of 13.56% of the forest cover in this area, which was better than the forest cover of the Kalarani round (Table 60 & Plate 11).

Almost all the villages showed a decrease in forest cover from 1970 to 1999. Village Chhoti Umer showed total disappearance of forests. It has been seen that in the same village though there was no forest cover, the fuelwood consumption per day was comparatively more.

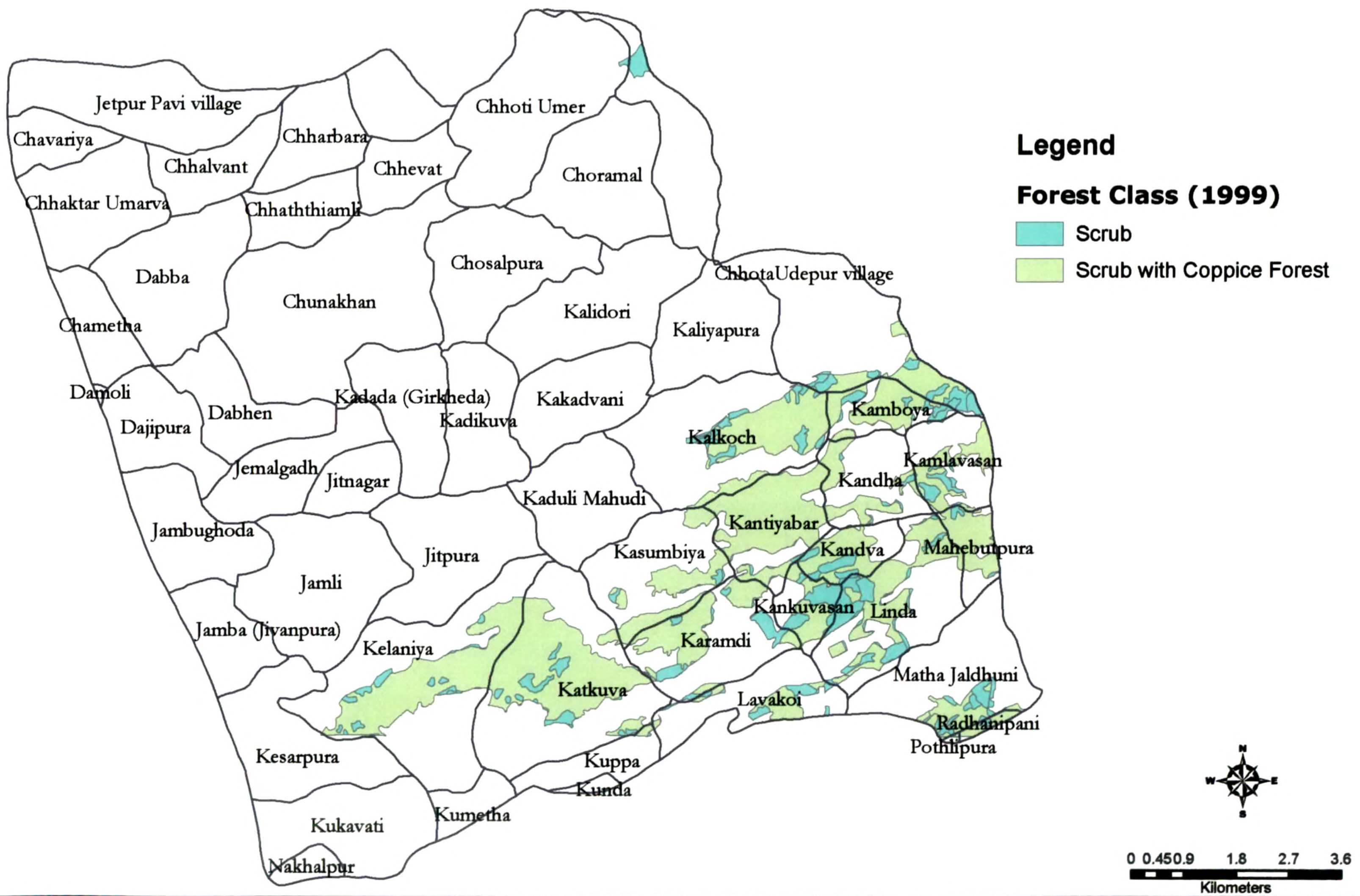
Table 60: Villagewise forest cover for 1999 along with census, fuelwood and livestock details of Boriad round

Name	Forest Class 1999	Forest Area (ha)	Total Forest Area (ha) 1999	Population		No. Of House holds	Fuel wood used/day (Kg)
				1981	1991		
Chametha	NF			1037	1147	220	1320
Chavariya	NF			45	34	4	24
Chhaktar Umarva	NF			568	711	89	534
Chhalvant	NF			460	695	118	708
Chharbara	NF			55	46	7	42
Chhaththiamli	NF			347	411	73	438
Chhevat	NF			308	473	73	438
Chhota Udepur			97.8				
	S	29.82					
	SWC	67.98					
Chhoti Umer	NF			89	168	27	162
Choramal	NF			333	386	85	510
Chosalpura	NF			409	410	82	492
Chunakhan	NF			164	185	36	216
Dabba	NF			38	66	10	60
Dabhen	NF			178	346	44	264
Dajipura	NF			166	203	41	246
Damoli	NF			330	385	68	408
Jamba (Jivanpura)	NF			331	442	82	492

Name	Forest Class 1999	Forest Area (ha)	Total Forest Area (ha) 1999	Population		No. Of House holds	Fuel wood used/day (Kg)
				1981	1991		
Jambughoda	NF			196	260	51	306
Jamli	NF			867	1020	221	1326
Jemalgadh	NF			668	840	150	900
Jetpur Pavi	NF						
Jitnagar	NF			621	666	135	810
Jitpura	NF			493	554	103	618
Kadada (Girkheda)	NF			400	969	143	858
Kadikuva	NF			96	174	34	204
Kaduli Mahudi	NF			555	743	116	696
Kakadvani	NF			201	166	36	216
Kalidori	NF			625	622	131	786
Kaliyapura	NF			395	470	85	510
Kalkoch			195.86	497	473	67	402
	S	29.63					
	SWC	166.23					
Kamboya			100.35				
	S	12.30					
	SWC	88.05					
Kamlavasan			82.09	101	124	16	96
	S	18.09					
	SWC	64.00					
Kandha			65.19	583	623	98	588
	S	2.32					
	SWC	62.87					
Kandva			72.06	342	391	72	432
	S	3.25					
	SWC	68.81					
Kankuvasan			67.61	299	385	61	366
	S	23.41					
	SWC	44.20					
Kantiyabar			224.2	98	236	30	180
	SWC	224.20					
Karamdi			138.94	457	492	81	486
	S	15.59					
	SWC	123.35					
Kasumbiya			103.96	170	258	46	276
	S	5.02					
	SWC	98.94					
Katkuva			325.19	383	502	79	474
	S	30.14					
	SWC	295.05					
Kelaniya			257.21	428	533	89	534
	S	19.83					
	SWC	237.38					
Kesarpura			0.17	449	503	100	600
	SWC	0.17					
Kukavati	NF			352	451	82	492

Name	Forest Class 1999	Forest Area (ha)	Total Forest Area (ha) 1999	Population		No. Of House holds	Fuel wood used/day (Kg)
				1981	1991		
Kumetha	NF			187	288	41	246
Kunda	NF			193	325	56	336
Kuppa			3.83	125	205	36	216
	S	0.01					
	SWC	3.82					
Lavakoi			51.55	572	681	109	654
	S	15.06					
	SWC	36.49					
Linda			186.04	382	517	83	498
	S	44.35					
	SWC	141.69					
Mahebutpura			71.22	54	59	12	72
	S	3.59					
	SWC	67.63					
Matha Jaldhuni			61.68	58	125	19	114
	S	17.49					
	SWC	44.19					
Nakhalpur	NF			305	403	64	384
Pothlipura			0.79	152	250	46	276
	S	0.18					
	SWC	0.61					
Radhanipani			15.6	159	194	27	162
	SWC	15.60					

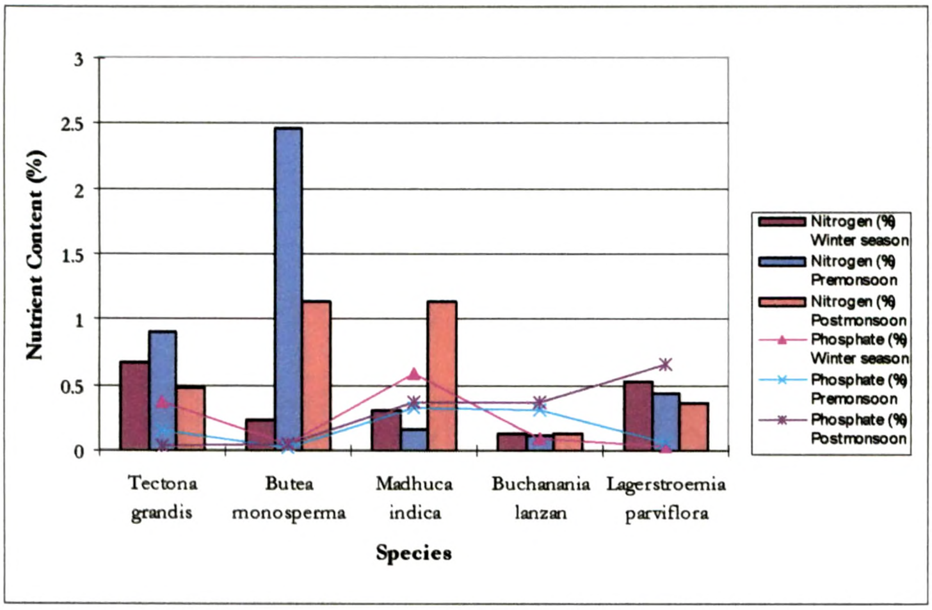
Plate : 11 Boriad Round Villageswise Forest Cover (1999)



4.4 Seasonal contribution of nutrients by leaf litter of different species

Five dominant species were selected for litter nutrient analysis viz. Teak (*Tectona grandis* L.), Khakhar (*Butea monosperma* (Lam.) Taub.), Mahuda (*Madhuca indica* (Roxb.) Macbr.), Charoli (*Buchanania lanzan* Spr.), Kakadio (*Lagerstroemia parviflora* Roxb.) (Figure 5).

Figure 5 : Nutrient Content in Leaf Litter



The analysis carried out during three different seasons for nitrogen and phosphorus showed that there occurred variations in the concentration of nitrogen and phosphorus in the leaf litter of different species during the three different seasons. In the winter season, highest amount of nitrogen was seen in the litter of *Tectona grandis* followed by *Lagerstroemia parviflora* (Plate12), *Madhuca indica* (Plate13), *Butea monosperma* (Plate14) and *Buchanania lanzan* (Plate15).

Plate 12: Lagerstroemia parviflora Roxb.

Plate 13 : Madhuca indica (Roxb.) Macbr.

Plate 14 : Butea monosperma (Lam.) Taub.

Plate 15 : Buchanania lanzan Spr.

During the premonsoon season the trend changed. *Butea monosperma*, had the highest nitrogen content, followed by *Tectona grandis*, *Lagerstroemia parviflora*, *Madhuca indica* and *Buchanania lanzan*. In the case of the postmonsoon, *Madhuca indica* and *Butea monosperma* had equal levels followed by *Tectona grandis*, *Lagerstroemia parviflora* and *Buchanania lanzan*.

The temporal collection of litter samples done, exhibited that on an average though *Butea monosperma* accumulated maximum of nitrogen, contributing possibly more of nitrogen to the forest soil when compared with other species, it accumulated the least amount of phosphorus.

Phosphorus content in *Madhuca indica* was the highest in the winter season, followed by *Tectona grandis* whereas *Buchanania lanzan*, *Butea monosperma* and *Lagerstroemia parviflora* showed a very small amount of phosphorus in winter.

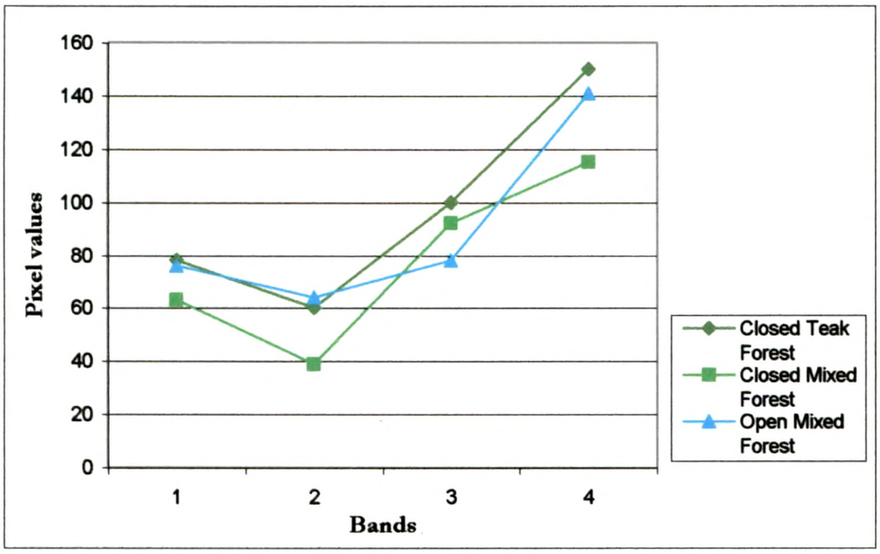
In the premonsoon and the postmonsoon seasons, both *Madhuca indica* and *Buchanania lanzan* had more phosphorus content when compared with that of *Tectona grandis*. *Butea monosperma* and *Lagerstroemia parviflora* exhibited a tremendous difference in phosphorus content between the pre and post monsoon seasons. There was almost a ten-fold increase in phosphorous content in these species from the pre to the post monsoon.

Madhuca indica had a major role to play in phosphorus accumulation. The contribution of *Tectona grandis* towards phosphorus accumulation though not high was quite uniform during the pre and the post monsoon seasons and slightly high during winter season. *Buchanania lanzan* in terms of nitrogen and *Lagerstroemia parviflora* in terms of phosphorus, exhibited least accumulation, except in post monsoon period.

4.5 Digital analysis

The digital analysis of the IRS LISS III data enabled the understanding of spectral characteristics of different forest classes, their misinterpretation and inseparability of classes agriculture and the sparse tree cover were removed. Each class had a unique spectral feature. The closed teak forest class distinguished itself from the closed mixed forest class by exhibiting higher values in all the four bands. The closed mixed forest class could be easily distinguished from the open mixed forest class because of higher values in NIR band (Figure 6).

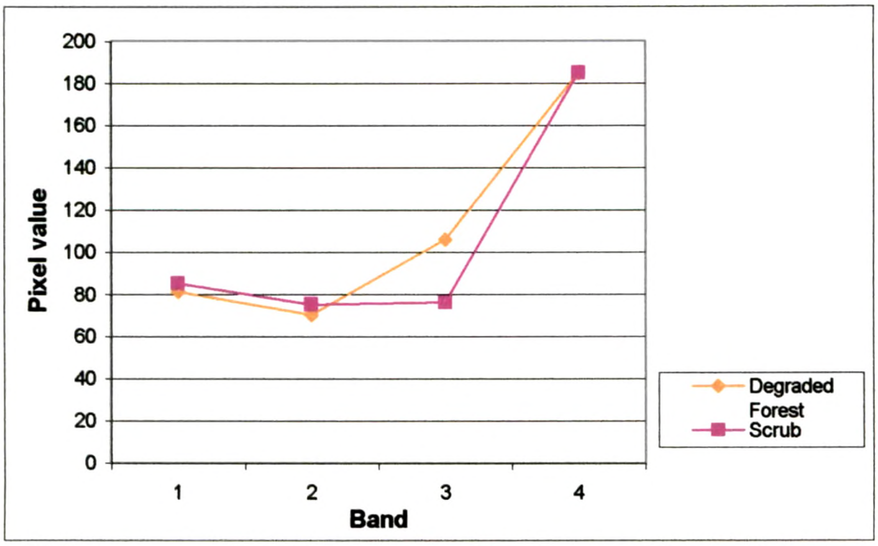
Figure 6 : Spectral Profile of Closed Teak Forests, Closed Mixed forests and Open Mixed Forests



The degraded forest class and scrub class could be distinguished from each other in band 3 in which the degraded forest class showed higher DN value i.e. 106 compared with the scrub class showing DN value 76 (Figure 7).

Sparse tree cover and scrub with coppice forest class were spectrally quite similar. The ground truth input in the case of sparse

Figure 7 : Spectral Profile of Degraded Forests and Scrub



tree cover and scrub with coppice forest aided in separating these classes (Figure 8).

Agriculture area had a distinct feature showing high spectral value in band 3. Acacia plantation differed distinctly from Eucalyptus plantation with increased reflectance values in all the four bands (Figure 9). The wasteland showed higher values in almost all the four bands and differed from stony waste, showing comparatively lower values (Figure 10).

The waterbody and canal could be differentiated by the DN values as well as the pattern. The DN values increased with decrease in the depth. Waterbody had higher reflectance values since the canals have a shallow depth and the rivers are almost getting dry. The pattern of canals was also very distinct (Figure 11).

Figure 8 : Spectral Profile of Sparse Tree Cover and Scrub with Coppice forests

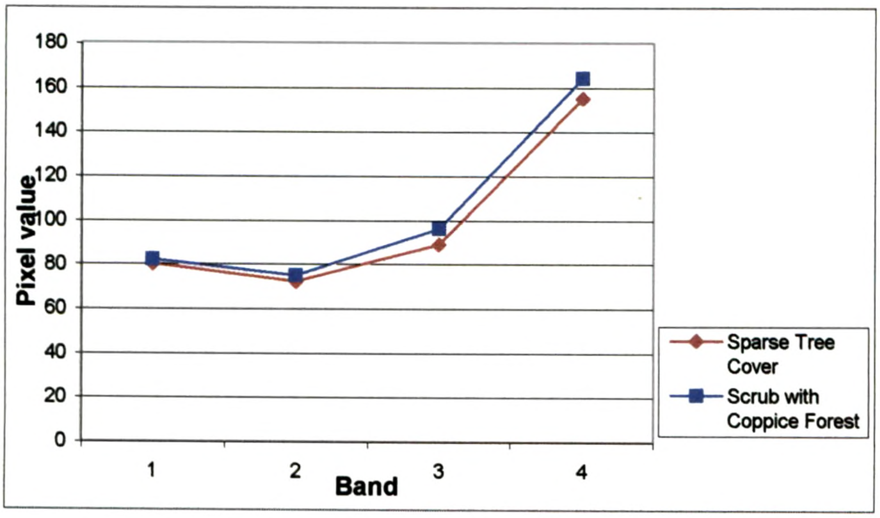


Figure 9 : Spectral Profile of Agriculture, Acacia and Eucalyptus plantations

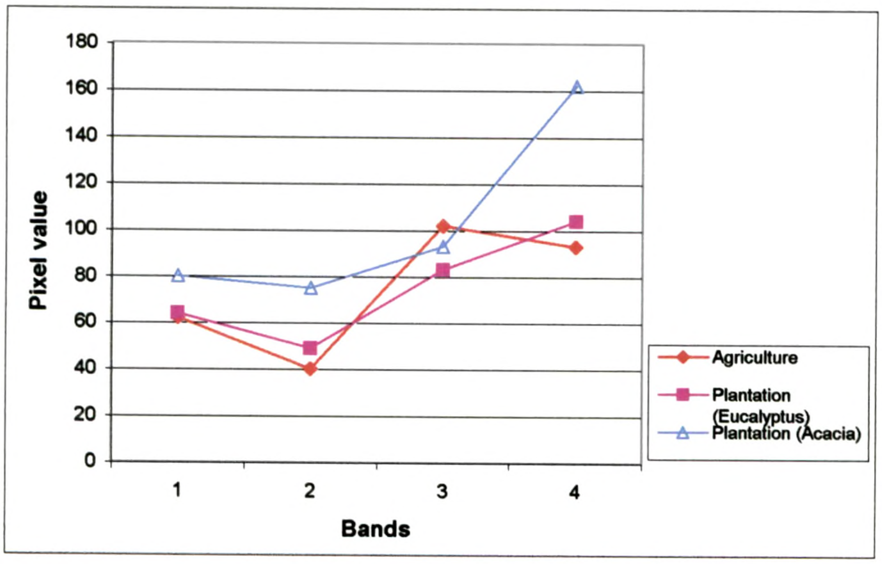


Figure 10 : Spectral Profile of Wastelands and Stony waste

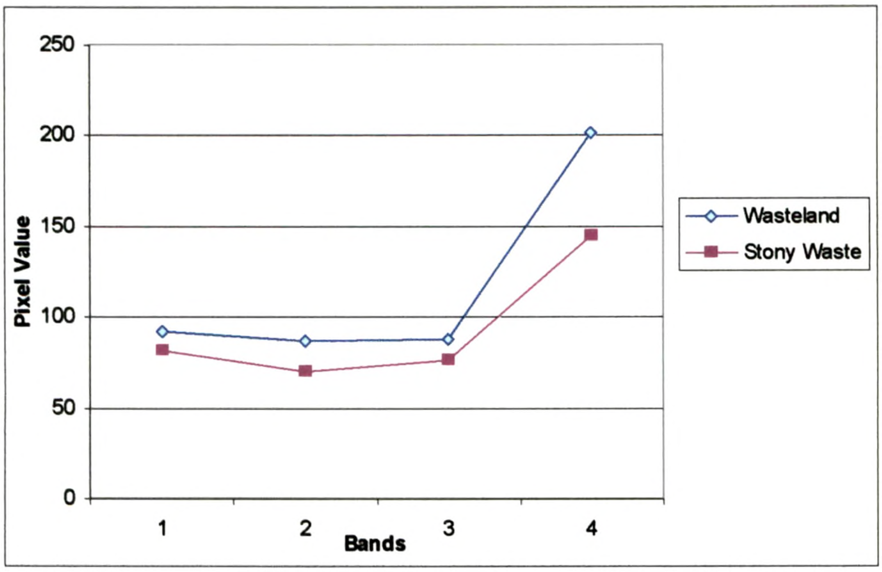
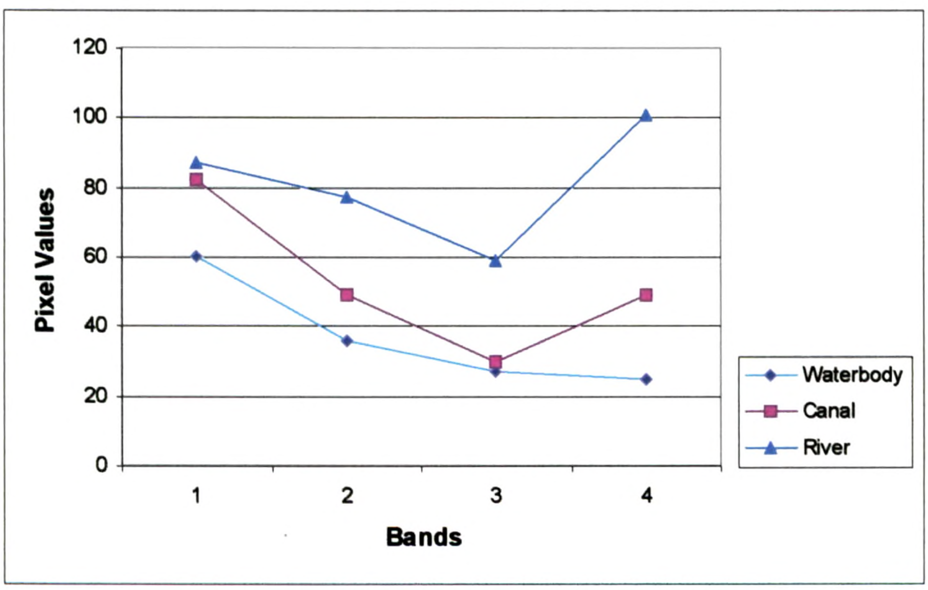


Figure 11 : Spectral Profile of Waterbody, Canal and River



4.5.1 Band Combination

Different band combinations attempted are given in Plate 16. Band combination 3,2 and 1 similar to band 2,3 and 4 of FCC image distinguished different forest categories with clarity. Combination of band 4,2 and 1 or 3,4 and 2 were unable to differentiate these categories. Different digital techniques like contrast enhancements, NDVI and PCA had varying capabilities of achieving better interpretability and contrast between different features.

4.5.2 Enhancements

From various contrast enhancement, histogram equalization and linear and gaussian stretch, histogram equalization yielded good output enhancing different forest classes, but it could not differentiate agriculture and forest.

Normalised Difference Vegetation Index (NDVI)

Grey level scaling done to segregate different forest type highlighted vegetation to certain extent but could not separate out sparse tree cover (STC) and scrub with coppice (SWC) with clarity.

Principal Component Analysis (PCA)

Principal component analysis showed PC2 to contain maximum information having 95-96 % of total variation of the scene. Similar to NDVI it failed to differentiate between STC and SWC.

Combined Image

Different images of NDVI, PC2, R and NIR having maximum vegetation information when layer stacked succeeded in separating SWC and STC. It also highlighted agriculture but could not separate out the agriculture mixed with sparse tree cover.

4.5.3 Classification

Supervised classification using maximum likelihood classifier with sufficient training sets could not only differentiate the different

Images depicting various Band Combination

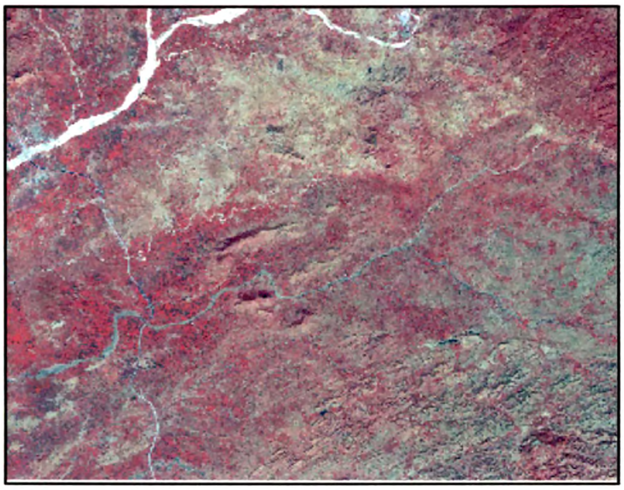


Plate : 16a 3-2-1

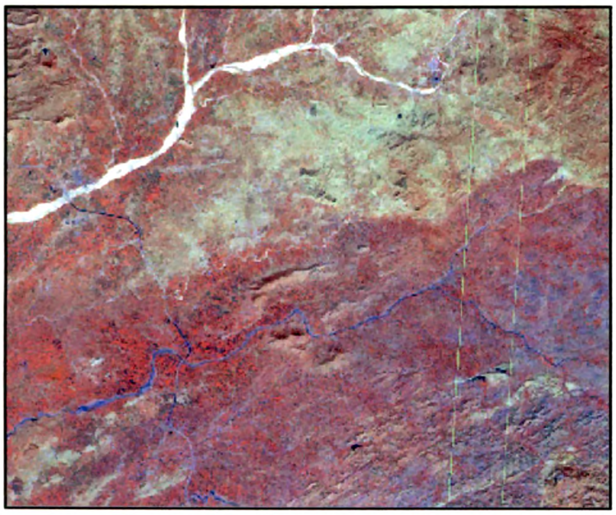


Plate : 16b 3-4-2

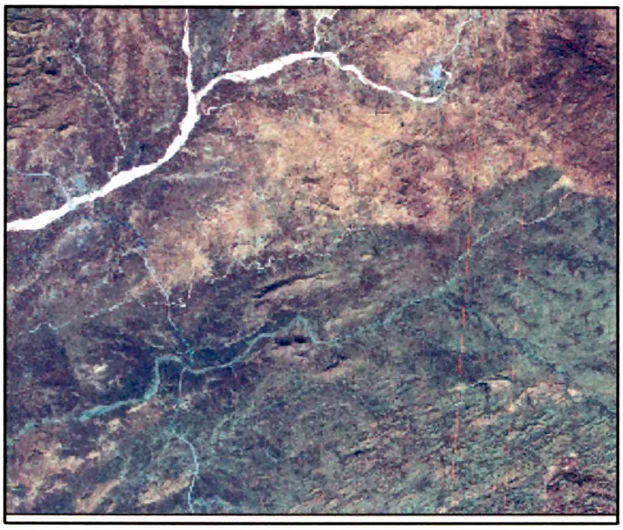
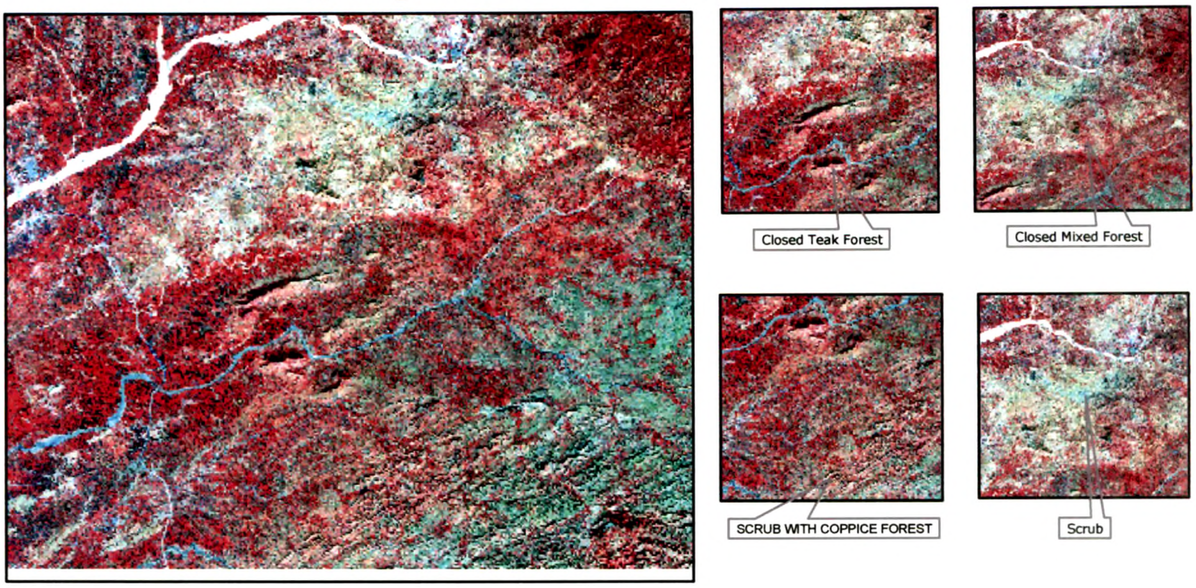
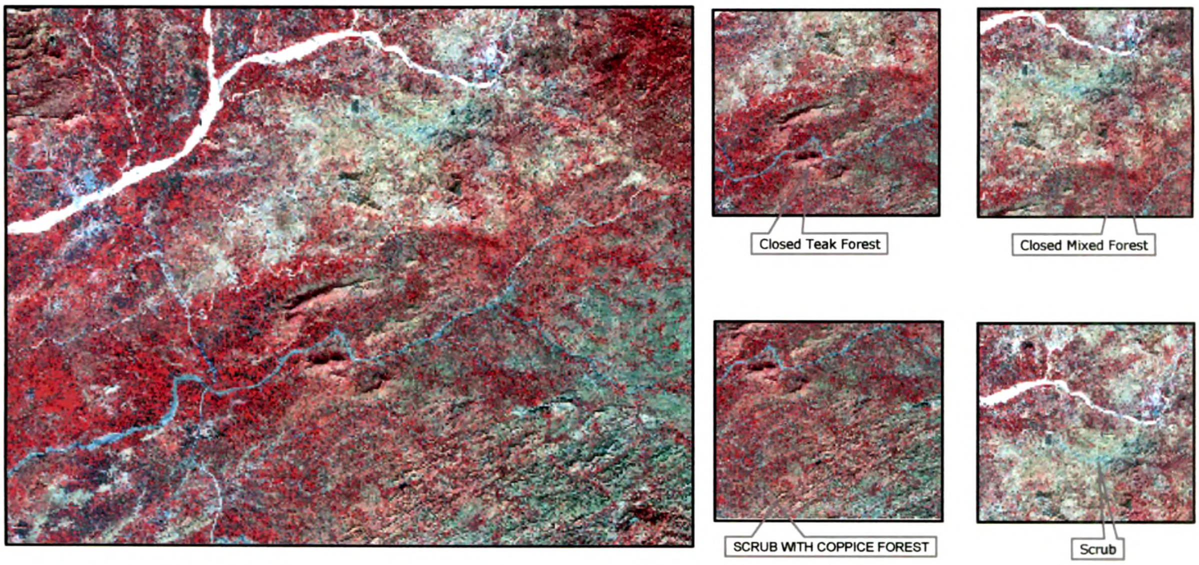


Plate : 16c 4-2-1

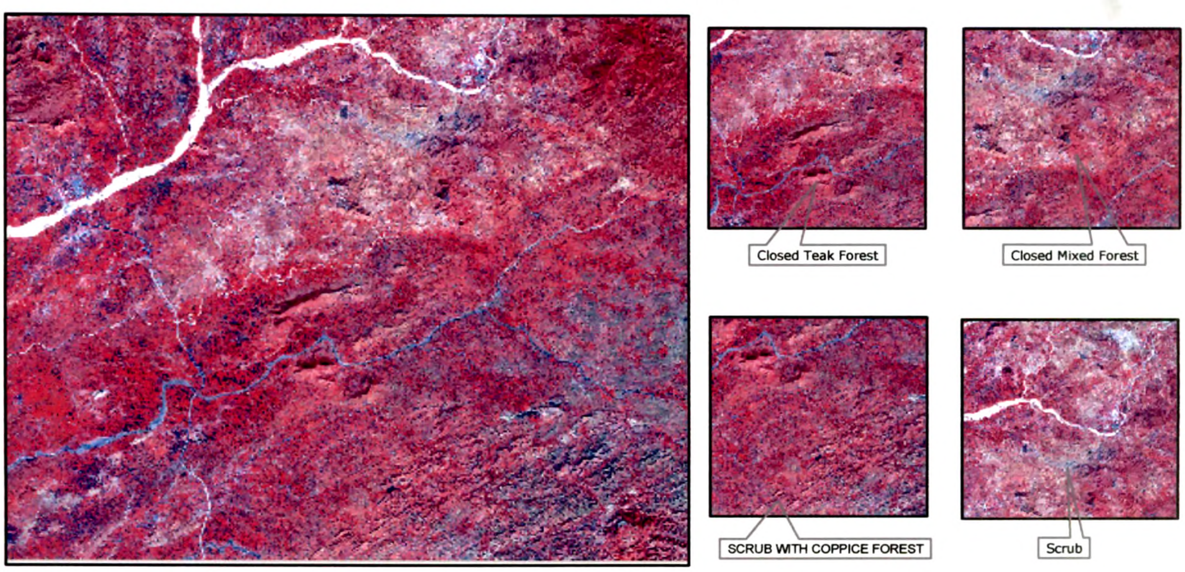
Plate :17 Output generated from different Enhancements



Histogram Equalization

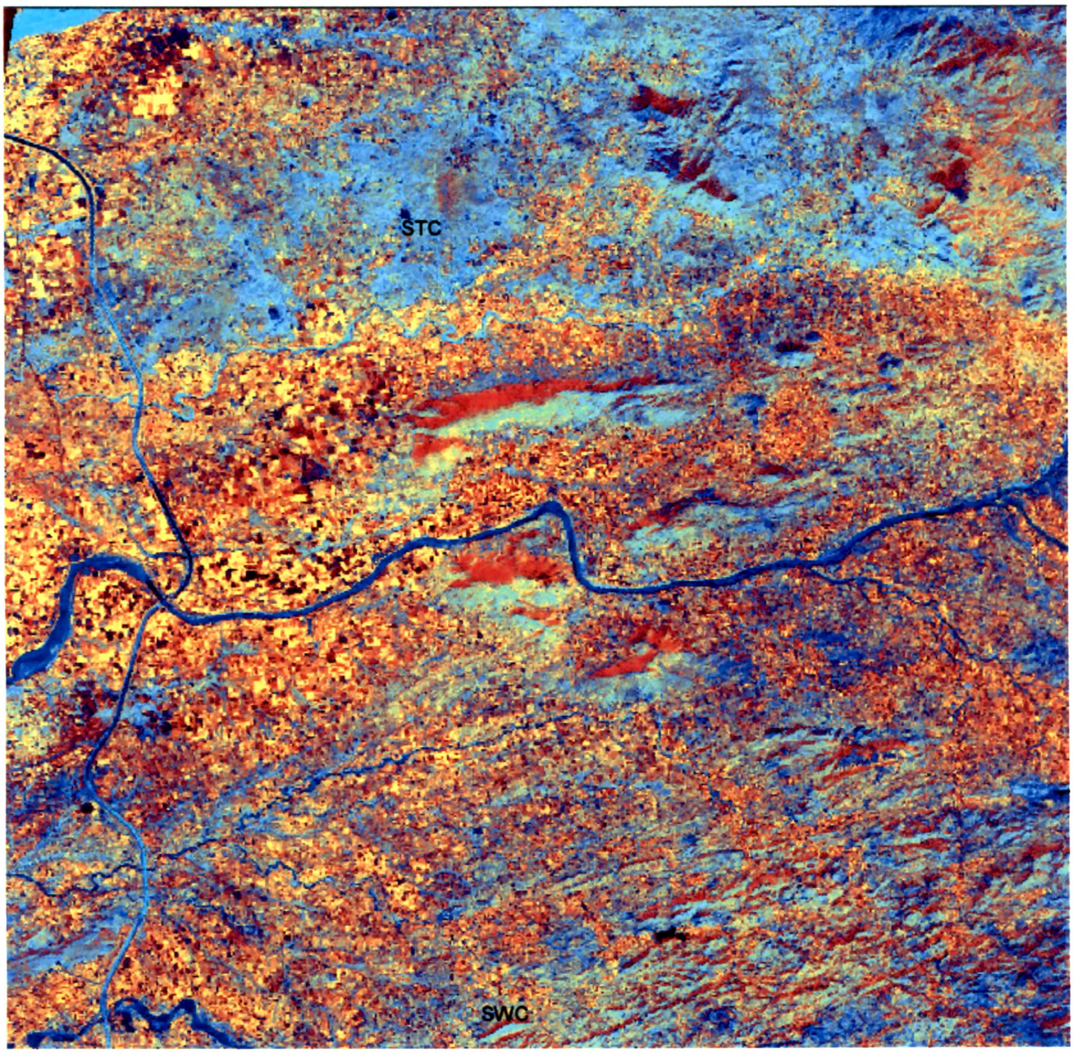


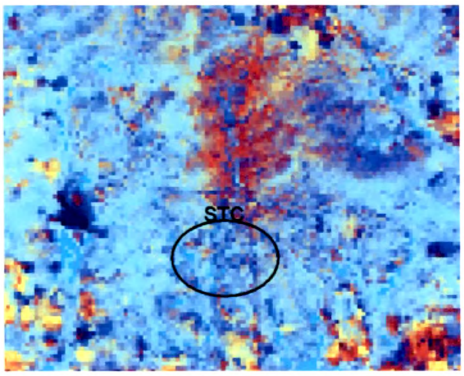
Gaussian



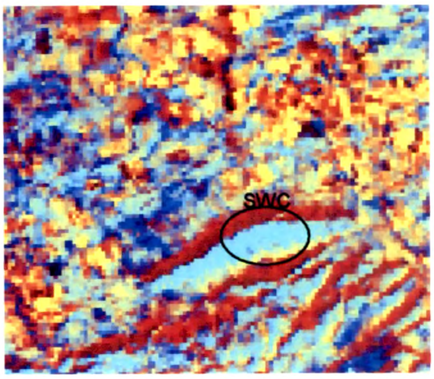
Gamma

Plate :18 Layer stacked image of four bands (red band, near infrared band, NDVI and PCA)





Sparse tree cover (STC)



Scrub with coppice forest (SWC)

forest classes but it also segregated the class sparse tree cover & agriculture into the sparse tree cover and the agriculture.

Out of fourteen classes generated seven forest and seven landuse classes were generated (Plate 19). Statistics have shown dominance of scrub in the forest and agriculture in the forest cover landuse classes and others respectively (Table 61).

Table 61: Forest Cover Classes, Area Statistics of the Study area

Sr. No.	Classes	Area (sq.km.)
1	Closed Teak Forests	14.33
2	Closed Mixed Forests	5.38
3	Open Mixed Forests	1.10
4	Degraded Forests	17.71
5	Scrub	46.50
6	Scrub with Coppice Forests	19.38
7	Sparse Tree Cover	19.33
8	Acacia plantation	0.74
9	Eucalyptus plantation	0.70
10	Wasteland	20.90
11	Stony waste	1.90
12	Waterbody	1.07
13	Canal	1.55
14	Agriculture	394.12
	Total	544.71

The overall classification accuracy and overall mapping accuracy obtained was 96.15 % and 92.59 % respectively with KAPPA coefficient of 0.96 (Table 62).

Plate : 19 Classified Image of the Study Area

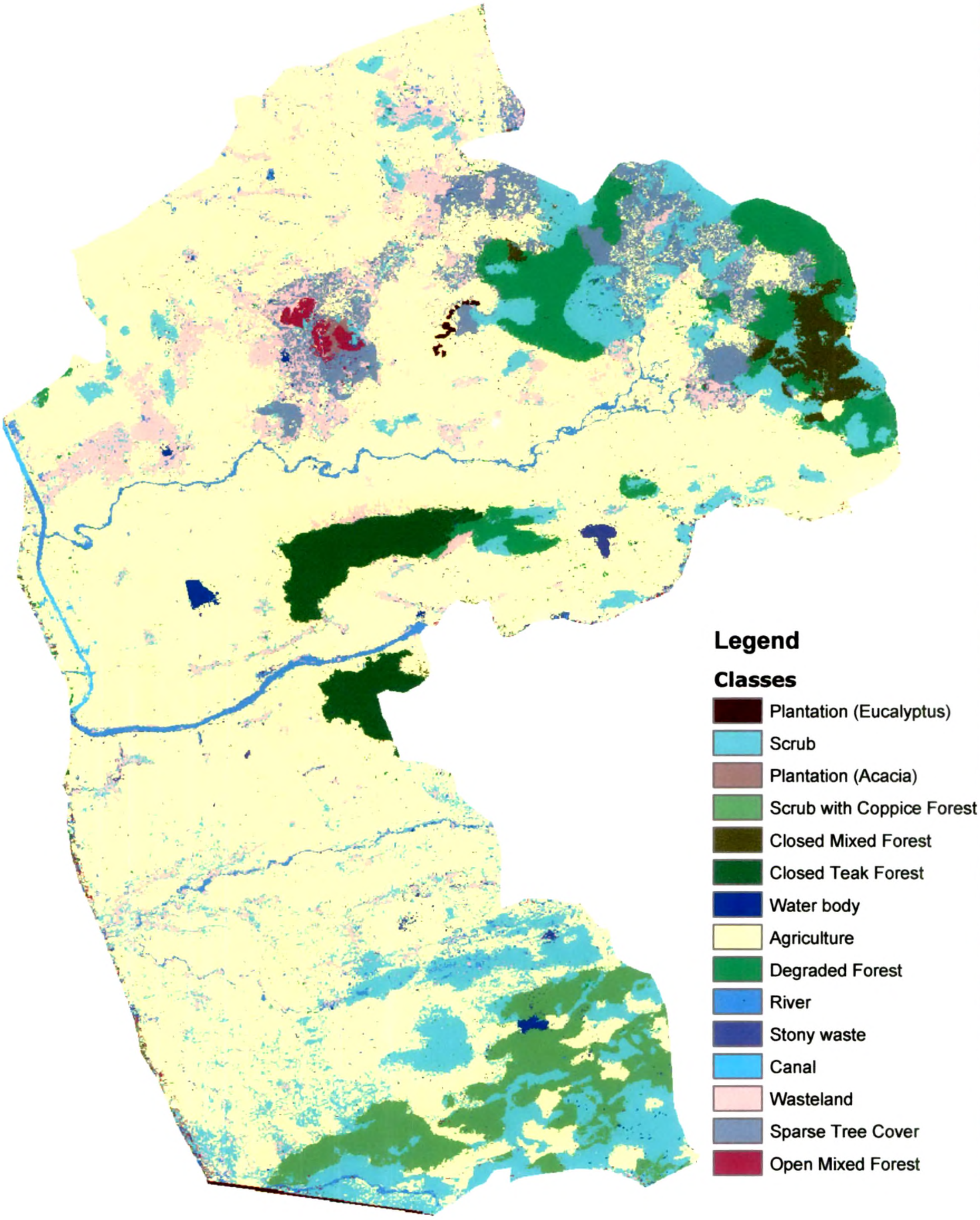


Table 62 : Accuracy Assessment of the Classified Image

Class	OMF	CTF	CMF	DF	S	SCo	STC	PE	PA	SW	W	A	C	TOTAL	O/E	C/E	C/A (%)	M/A (%)
OMF	1													1	0	0	100	100
CTF		7												7	0	0	100	100
CMF			3											3	0	0	100	100
DF				1	1									2	0	1	50	50
S					1									1	1	0	100	50
SCo						2								2	0	0	100	100
STC							1							1	0	0	100	100
PE								1						1	0	0	100	100
PA									1					1	0	0	100	100
SW										1				1	0	0	100	100
W											2			2	0	0	100	100
A												3		3	0	0	100	100
C													1	1	0	0	100	100
TOTAL	1	7	3	1	2	2	1	1	1	1	2	3	1	**26**				

Overall Classification Accuracy = 96.15 %

Overall Mapping Accuracy = 92.59 %

Khat statistics = 0.96

OMF=Open Mixed Forest, CTF=Closed Teak Forest, CMF=Closed Mixed Forest, DF=Degraded Forest, S=Scrub, SCo=Scrub with coppice forest, STC=Sparse Tree Cover, PE= Plantation Eucalyptus, PA=Plantation Acacia, SW=Stony waste, W=Wasteland, A=Agriculture, C=Canal, O/E=Ommission Error, C/E=Commission Error, C/A=Classification Accuracy, M/A=Mapping Accuracy

4.6 GIS Analysis

4.6.1 Change analysis

The change analysis studies for the period 1970-1989 and 1989-1999 for each different round brought out a clear picture of change in actual forest cover along with specific changes in forest categories. Changes that have occurred in each different round, have been mentioned separately.

4.6.1.1 Sajwa Round

4.6.1.1.1 Major changes between 1970 and 1989

In 1970, the Sajwa round had five different forest categories viz. fairly dense mixed jungle class, fairly dense mixed jungle mainly Teak, open mixed forest, open jungle and open forest (SOI, 1970). In 1989, new forest classes or other classes were formed by conversion of the existing classes based on their current landuse status. Six forest cover classes viz. closed mixed forest, closed Teak forest, degraded forest, scrub, sparse tree cover, sparse tree cover with agriculture and two landuse classes viz. agriculture and wasteland were formed during the span of 20 years.

The total area of this round was approximately 183 sqkm. In 1970, this round had 4,958 ha of area under forest cover but in 1989, this area decreased to 4,933 ha. The conversion of each class of SOI as in 1970 to other classes in 1989 (Table 63 & Plate 20) reveals clearly that 1,278 ha of land had totally undergone degradation. About 1,69 hectares had gone to agriculture, 6.46 hectares under wasteland, 9,15 ha under scrub, 1,95 hectares under sparse tree cover and 7,27 hectares under sparse tree cover with agriculture.

Table 63 : Sajwa Round forest cover change statistics (1970-1989)

Sr. No.	Forest Class (1970)	Area (1970) (ha)	Forest Class (1989)	Area (1989) (ha)
1	Fairly dense mixed jungle mainly Teak	1296.85	Agriculture	74.69
			Degraded Forest	111.91
			Scrub	27.66
			Closed Teak Forest	1082.60
2	Fairly dense mixed jungle	3470.45	Agriculture	66.91
			Degraded Forest	1037.23
			Closed Mixed Forest	584.24
			Scrub	853.25
			Wasteland	6.46
			Sprase Tree Cover	195.09
			Sprase Tree Cover with Agriculture	727.27
3	Open Jungle	84.04	Agriculture	13.39
			Degraded Forest	70.65
4	Open mixed jungle	52.33	Agriculture	6.83
			Degraded Forest	45.50
5	Open Forest	54.97	Agriculture	7.18
			Degraded Forest	13.01
			Scrub	34.78

4.6.1.1.2 Major changes between 1989 and 1999

The forest cover that was 4,933 ha in 1989 got reduced to 4,496 ha in 1999. In 1999, there occurred an increase in all the different forest categories viz. degraded forest, scrub, sparse tree cover, sparse tree cover with agriculture except for closed mixed forest and closed Teak forest. Almost 8 % of the area had undergone change and 92 % remain unchanged.

The conversion of each class of 1989 to other classes in 1999 (Table 64 & Plate 21) reveals clearly that 1,321 ha of land had undergone total degradation by getting converted to degraded forests whereas 4,55.25 ha of land were under agriculture, 1.29 ha under wasteland, 9,94 ha under scrub, 2,18 ha under sparse tree cover and 4,37 ha under sparse tree cover with agriculture.

Plate : 20 Sajwa Round Forest Cover Change Map (1970-1989)

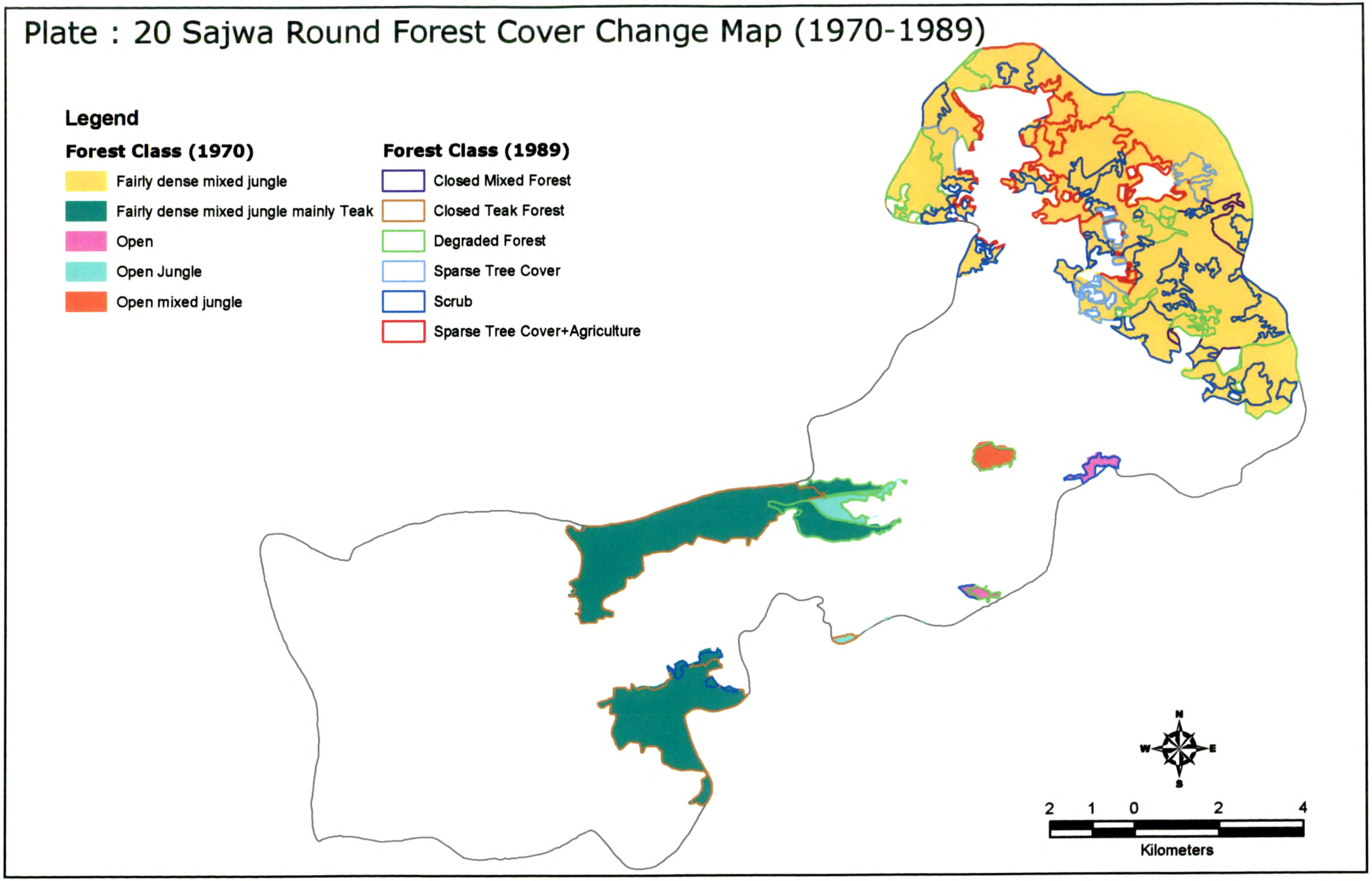


Plate 21 : Sajwa Round Forest Cover Change Map (1989-1999)

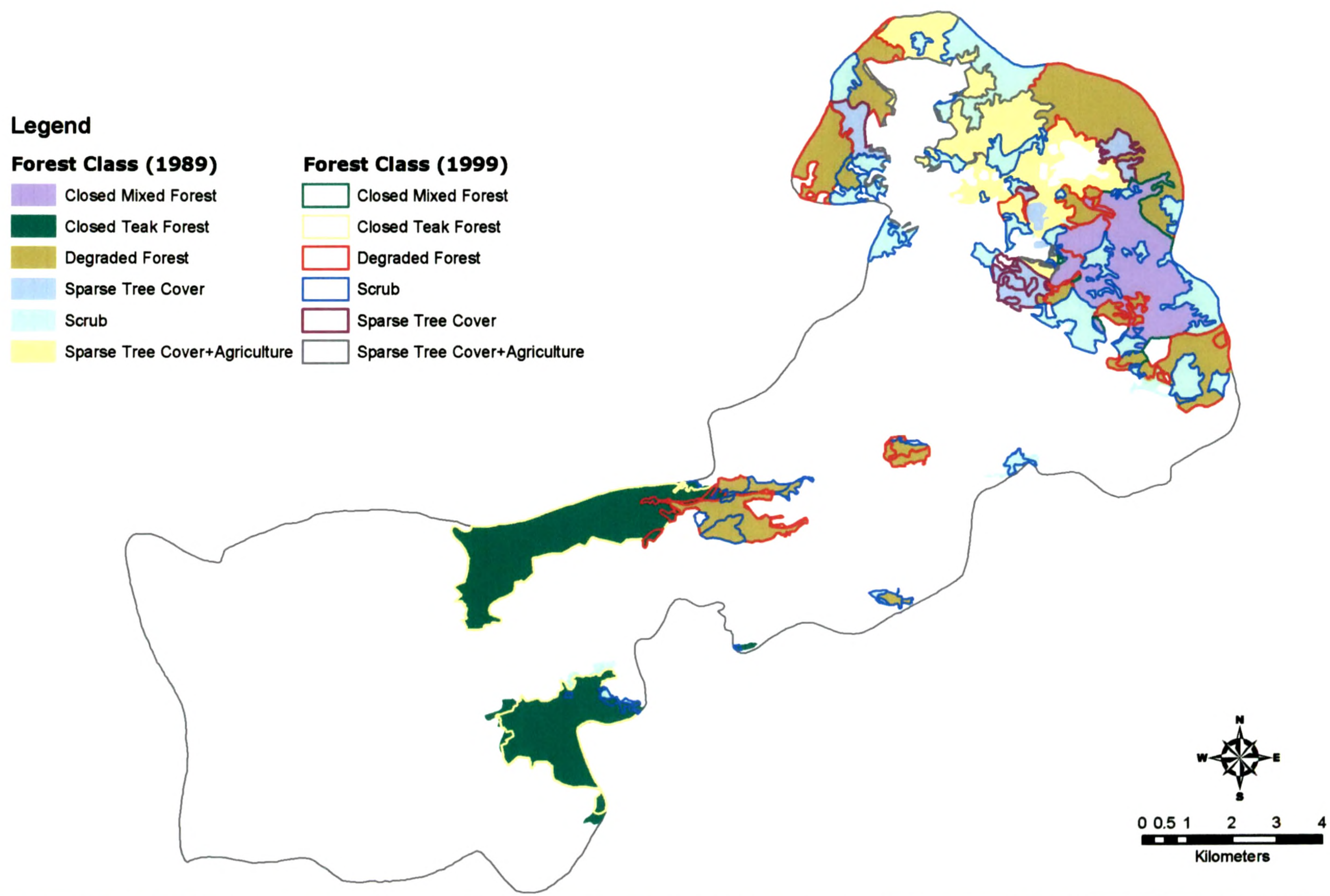


Table 64 : Sajwa Round forest cover change statistics (1989-1999)

Sr. No.	Forest Class (1989)	Area (1989) (ha)	Forest Class (1999)	Area (1999) (ha)
1	Degraded Forests	1321.66	Agriculture	21.4540
			Degraded Forests	1189.9889
			Scrub	108.7453
			Wasteland	0.1689
			Sprase Tree Cover	1.3016
			Sprase Tree Cover with Agriculture	0.0022
2	Closed Mixed Forest	585.25	Agriculture	0.0011
			Degraded Forests	76.8582
			Closed Mixed Forest	503.3191
			Scrub	4.9389
			Wastelands	0.0003
			Sprase Tree Cover	0.0007
			Sprase Tree Cover with Agriculture	0.1359
3	Scrub	939.26	Agriculture	79.0458
			Scrub	853.4394
			Wastelands	1.1228
			Sprase Tree Cover	1.2000
			Sprase Tree Cover with Agriculture	4.4495
4	Closed Teak Forests	1091.04	Agriculture	37.1418
			Degraded Forests	27.3915
			Closed Teak Forests	1001.9706
			Scrub	24.5350
5	Sprase Tree Cover with Agriculture	750.56	Agriculture	289.7154
			Sprase Tree Cover with Agriculture	460.8414
6	Sprase Tree Cover	244.72	Agriculture	27.8938
			Sprase Tree Cover	216.8284

4.6.1.2 Kalarani Round

4.6.1.2.1 Major changes between 1970 and 1989

In 1970, the Kalarani round had five different forest categories viz. fairly dense mixed jungle class, fairly dense mixed jungle mainly Teak, open mixed forest, open jungle and open forest (SOI, 1970).

New forest classes viz. closed Teak forest, closed mixed forest, open mixed forest, degraded forest, scrub, sparse tree cover, sparse tree cover with agriculture and four landuse classes viz. agriculture, wasteland, Eucalyptus & Acacia plantation were observed in 1989 due to changes in the earlier classes.

The total area of this round was approximately 1,92 sq.km. In 1970, this round had 2,358 ha of land under forest cover; in 1989, this decreased to 1,965 ha. The conversion of classes of SOI in 1970 to other classes in 1989 (Table 65 & Plate 22) reveals clearly that 5,41.18 ha of fairly dense mixed jungle had totally converted to degraded forest. About 3,32.85 ha of land had been utilized for agriculture. Wastelands were formed almost in all the forest classes except in the fairly dense mixed jungle mainly Teak covering about 1,41.37 ha of forest cover. Scrub covered 4,56.8 ha. About 1,67.16 ha had gone under sparse tree cover and 90.77 ha under sparse tree cover with agriculture. Open mixed forest covered 1,21.75 ha of land. Plantations were carried out in 36.71 ha of land.

4.6.1.2.2 Major changes between 1989 and 1999

The forest cover that was 1,965 ha in 1989 got increased a bit to 2,055 ha due to plantation activities carried out. In 1989, the Kalarani round had eight different forest categories viz. closed mixed forest, closed Teak forest, open mixed forest, degraded forest, scrub, sparse tree cover, sparse tree cover with agriculture.

The other classes formed by conversion of the existing classes based on their current landuse status were agriculture, wasteland and Acacia & Eucalyptus plantation. Almost 9 % of the area had undergone change and 91 % remain unchanged.

Table 65 : Kalarani Round forest cover change statistics (1970-1989)

Sr. No.	Forest Class (1970)	Area (1970) (ha)	Forest Class (1989)	Area (1989) (ha)
1	Fairly dense mixed jungle mainly Teak	473.98	Agriculture	28.959
			Closed Teak Forest	445.020
2	Fairly dense mixed jungle	1370.005	Agriculture	225.045
			Closed Mixed Forest	15.548
			Degraded Forest	541.182
			Plantation (Eucalyptus)	0.036
			Scrub	412.618
			Sparse Tree Cover	6.314
			Sparse Tree Cover+Agriculture	90.774
			Wasteland	78.486
3	Open Jungle	66.42	Agriculture	24.310
			Closed Teak Forest	9.064
			Scrub	10.750
			Wasteland	22.295
4	Open mixed Jungle mainly Mahuwa	354.6	Plantation (Acacia)	31.878
			Agriculture	21.326
			Open Mixed Forest	121.753
			Scrub	15.019
			Sparse Tree Cover	160.846
			Wasteland	3.772
5	Open Forest	93.23	Agriculture	33.206
			Plantation (Eucalyptus)	4.789
			Scrub	18.415
			Wasteland	36.817

The conversion of each class of 1989 to other classes in 1999 (Table 66 & Plate 23) reveals clearly that 0.51 hectares of closed mixed forests had converted to degraded forests. About 38.05 ha of land was encroached for agriculture. Wastelands were formed in closed Teak forest, open mixed forest, scrub and sparse tree cover, constituting 3.5 ha of land. Scrublands were formed in almost all the classes, constituting 5,68 hectares. 1,71 hectares were under sparse

Plate : 22 Kalarani Round Forest Cover Change Map (1970-1989)

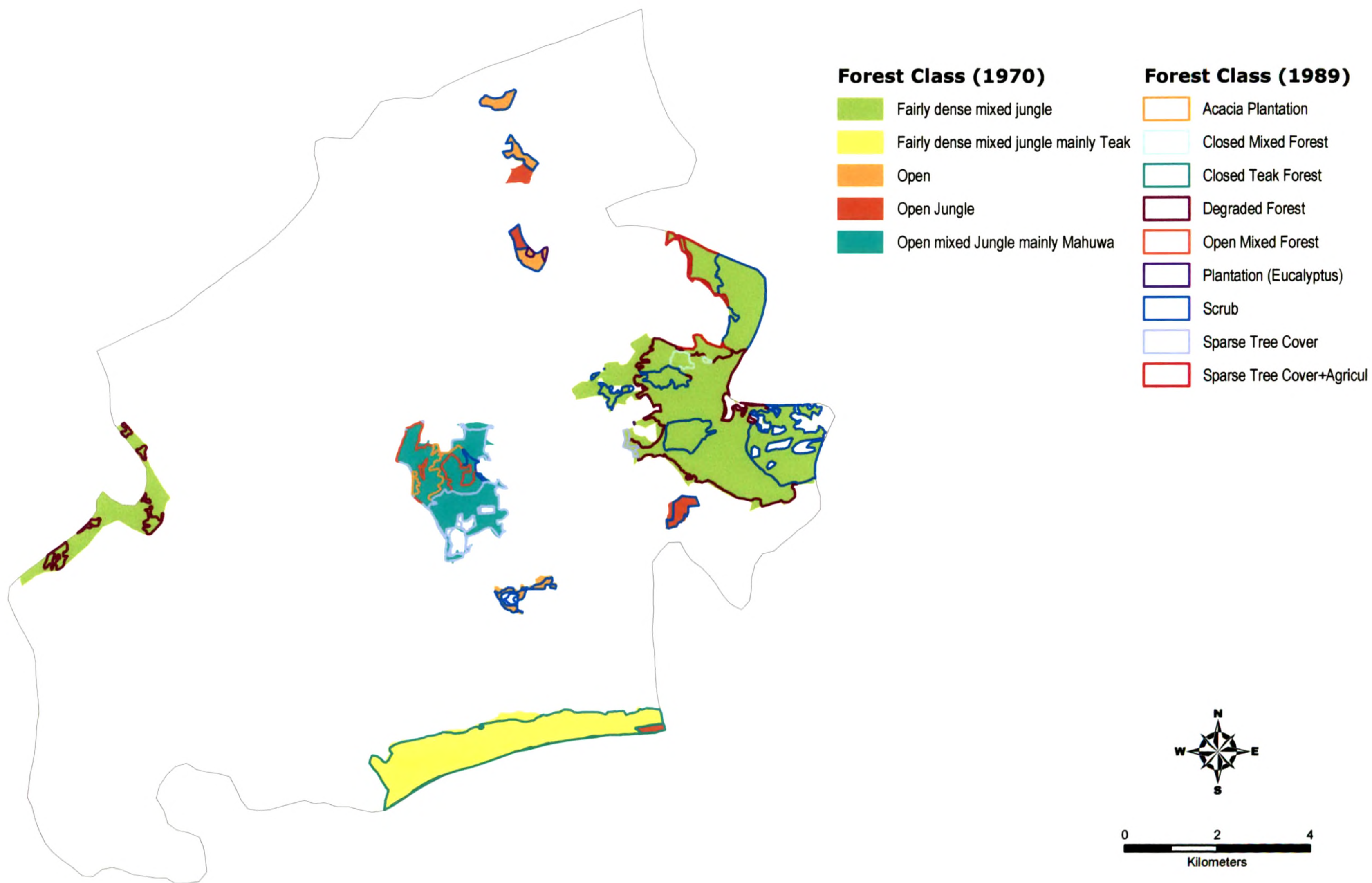
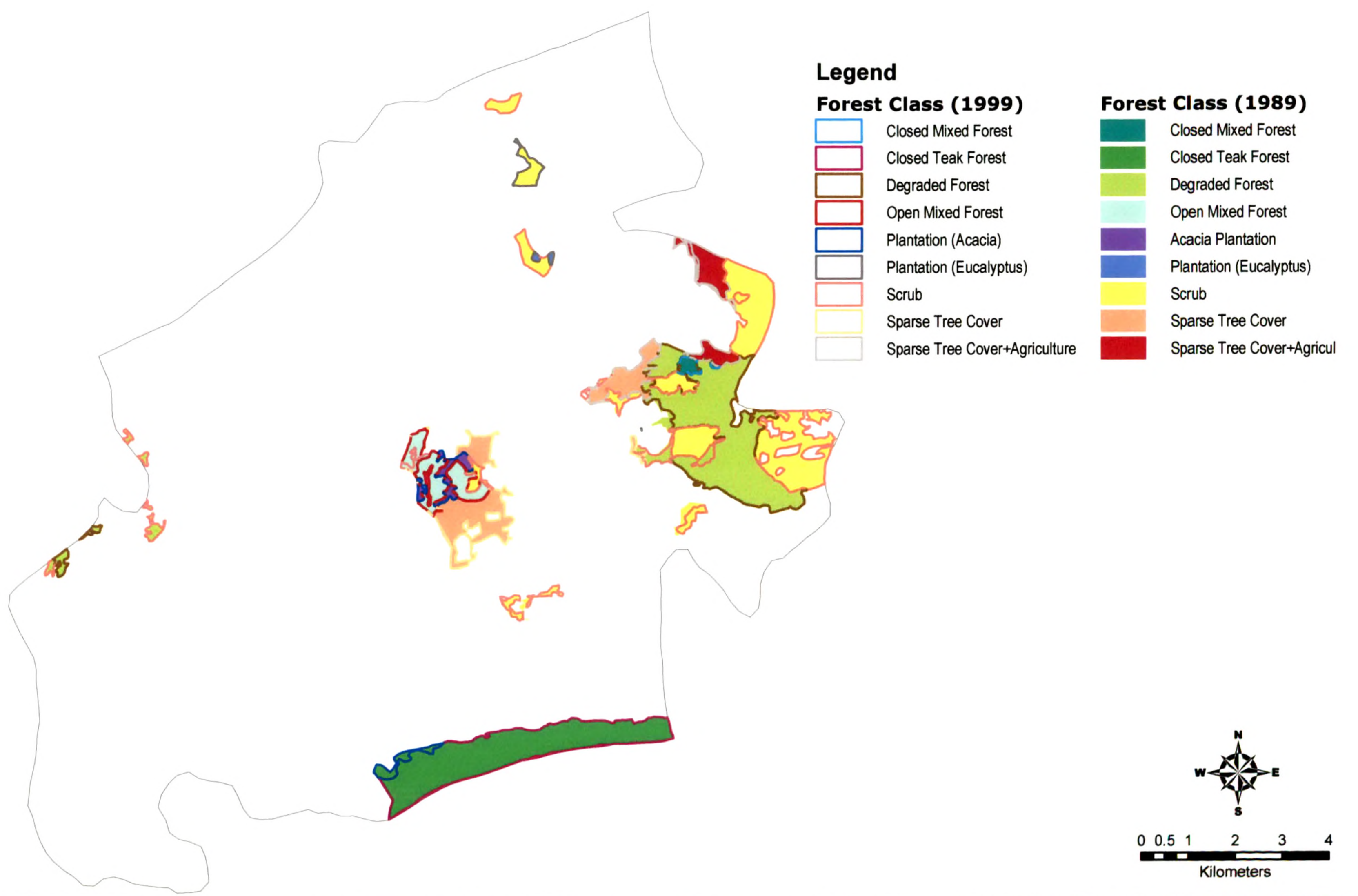


Table 66 : Kalarani Round forest cover change statistics (1989- 1999)

Sr. No.	Forest Class (1989)	Area (1989) (ha)	Forest Class (1999)	Area (1999) (ha)
1	Plantation (Acacia)	31.88	Agriculture	0.011
			Plantation (Acacia)	31.827
			Scrub	0.040
2	Closed Mixed Forest	15.55	Closed Mixed Forest	14.985
			Degraded Forests	0.505
			Scrub	0.002
			Sparse Tree Cover+Agriculture	0.057
3	Closed Teak Forests	454.08	Agriculture	2.210
			Closed Teak Forests	430.281
			Plantation (Acacia)	21.592
4	Degraded Forests	545.6	Agriculture	14.356
			Wasteland	0.209
			Degraded Forests	479.100
			Scrub	51.362
			Sparse Tree Cover	0.048
			Sparse Tree Cover+Agriculture	0.515
5	Open Mixed Forest	121.75	Agriculture	0.119
			Wasteland	2.324
			Open Mixed Forest	109.037
			Plantation (Acacia)	1.469
			Scrub	8.737
			Sparse Tree Cover	0.067
6	Plantation (Eucalyptus)	4.83	Agriculture	0.001
			Plantation (Eucalyptus)	4.821
			Scrub	0.003
7	Scrub	530.27	Agriculture	20.542
			Plantation (Acacia)	0.039
			Plantation (Eucalyptus)	0.027
			Scrub	508.330
			Sparse Tree Cover	0.119
			Sparse Tree Cover+Agriculture	0.355
			Wasteland	0.855
8	Sparse Tree Cover+Agriculture	90.77	Agriculture	0.099
			Sparse Tree Cover+Agriculture	90.671
9	Sparse Tree Cover	171.71	Agriculture	0.716
			Wasteland	0.116
			Sparse Tree Cover	170.875

Plate : 23 Kalarani Round Forest Cover Change Map (1989-1999)



tree cover, 91.6 ha under sparse tree cover with agriculture and open mixed forest covered 1,09.04 ha of land. Plantations were carried out in 59.78 ha of land in 1999.

4.6.1.3 Boriad Round

4.6.1.3.1 Major changes between 1970 and 1989

In 1989, the three categories of 1970 changed to three forest categories viz. degraded forest, scrub, scrub with coppice forest and three landuse categories viz. agriculture, wasteland and waterbody.

The total geographical area of this round was approximately 169 sq. km. In 1970, this round had 2,412 ha of area under forest cover; in 1989, this decreased to 2,357 ha. These changes show clearly that 9.72 ha of fairly dense mixed jungle mainly Teak had converted to degraded forests (Table 67 & Plate 24). About 1.53 hectares of land became wasteland and 100.64 hectares of forestland were taken over for agriculture. Scrub had spread in almost all the forest classes, taking over 2,92 hectares. 6.89 ha of land showed the presence of waterbody and 2,001 ha were occupied by scrub with coppice forests.

4.6.1.3.2 Major changes between 1989 and 1999

The forest cover which was 2,357 ha in 1989, got reduced to 2,297 ha in 1999. In 1989, the Boriad round had three different forest categories viz. degraded forest, scrub with coppice forest and scrub. The classes observed in 1999 were the scrub and scrub with coppice. Almost 13 % of the area had undergone changes and 87 % remain unchanged.

The changes brought about during the span of ten years from 1989 to 1999 show that 4,86.09 ha of land had undergone total

Table 67 : Boriad Round forest cover change statistics (1970-1989)

Sr. No.	Forest Class (1970)	Area (1970) (ha)	Forest Class (1989)	Area (1989) (ha)
1	Fairly dense mixed jungle mainly Teak	2086.13	Agriculture	92.105
			Degraded Forest	9.417
			Scrub	195.909
			Wasteland	1.532
			Waterbody	6.645
			scrub with coppice forest	1780.525
2	Fairly dense mixed jungle	244.84	Agriculture	3.043
			Scrub	21.124
			Waterbody	0.249
			scrub with coppice forest	220.421
3	Open Jungle	80.69	Agriculture	5.493
			Scrub	75.192

degradation by getting converted to scrub (Table 68 & Plate 25). 86.1 hectares of land had changed to agriculture, 0.41 hectares of scrub and scrub with coppice forest became wasteland. Waterbody was found in 2.84 ha and scrub with coppice forest occupied 1,782 hectares of land.

Plate 24 : Boriad Round Forest Cover Change Map (1970-1989)

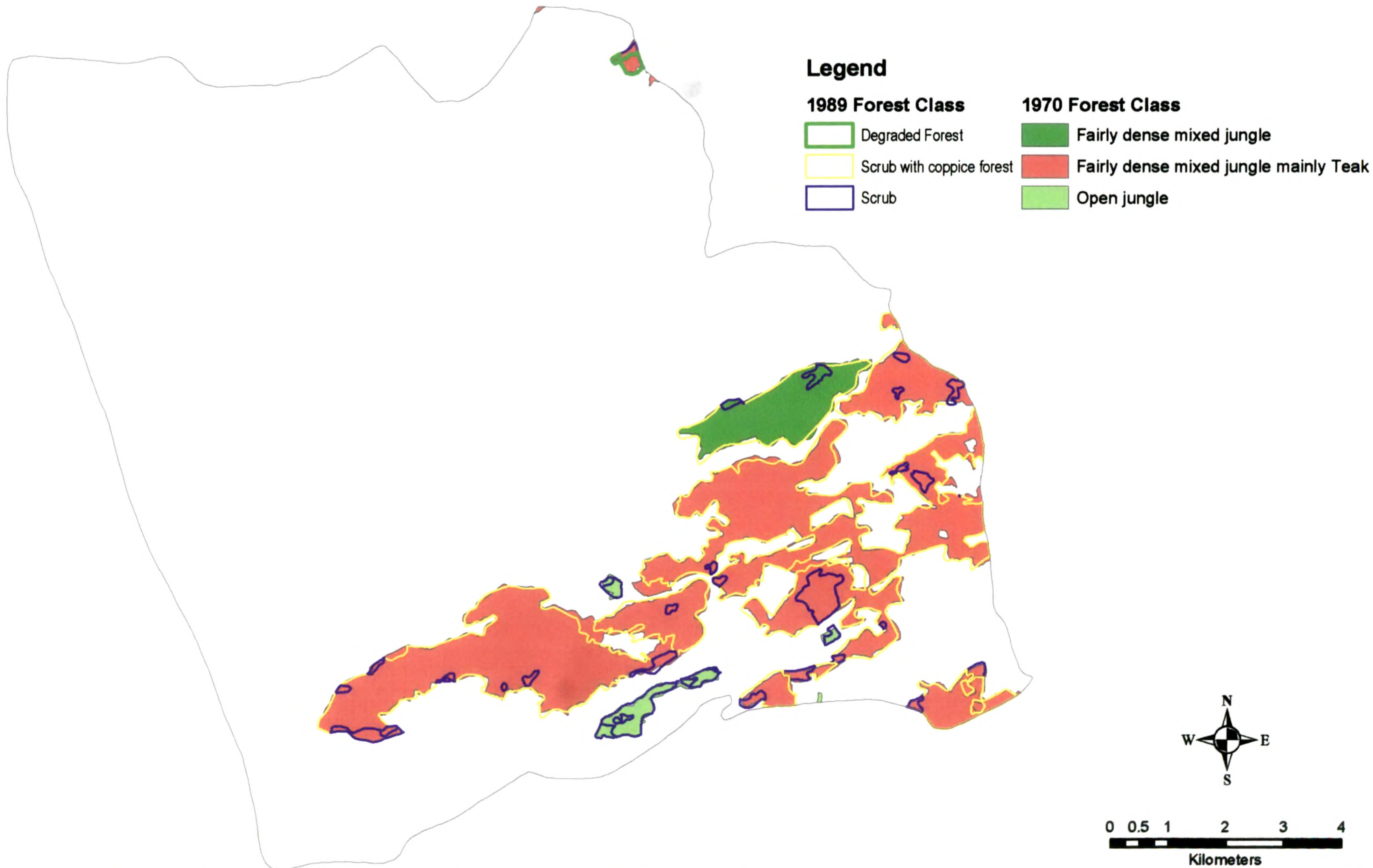
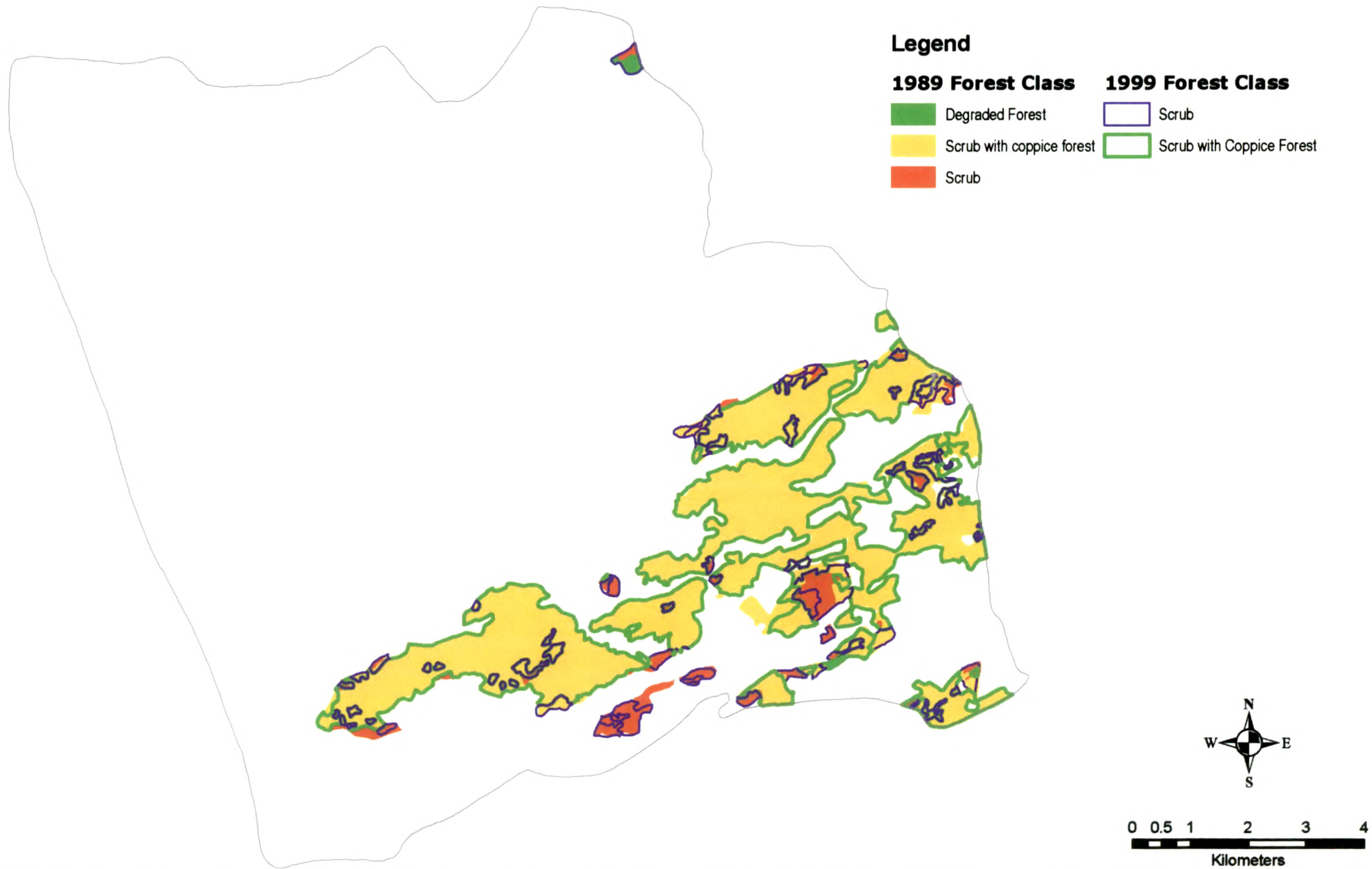


Table 68 : Boriad Round forest cover change statistics (1989- 1999)

Sr. No.	Forest Class (1989)	Area (1989) (ha)	Forest Class (1999)	Area (1999) (ha)
1	Degraded Forests	11.42	Agriculture	0.003
			Scrub	11.413
2	Scrub	227.95	Agriculture	17.376
			Wasteland	0.364
			Scrub	210.210
3	Scrub with Coppice Forests	2118.17	Agriculture	68.725
			Scrub	264.467
			Scrub with Coppice Forest	1782.097
			Wasteland	0.044
			Waterbody	2.839

Plate 25 : Boriad Round Forest Cover Change Map (1989-1999)



4.6.2 Suggestions for sustainable development of forest

The spatial and the non-spatial data when correlated and merged using predefined criteria generated a map of the suggested working circles. Predefined criteria viz. the proximity to road and river, diversity and dominance of species, slope and soil characteristics, aided in categorizing and in suggesting changes for the existing working circles (Table 69). Three different maps showing the changes required in the existing plan were generated for the three different rounds chosen during the study. Of the three rounds viz. the Kalarani, the Sajwa and the Boriad selected for forest cover monitoring, the Boriad round had no existing working circle. The suggested working circle map was the one generated from this study for its implementation in the near future. The Kalarani and the Sajwa rounds have defined working circles where changes have been suggested for their proper development.

4.6.2.1 Suggestions for the working circle in the Sajwa round

Presently, there are three main working circles in this round i.e. the Main working circle, Afforestation working circle and Protection working circle (Plate 26). In addition to this, the Bamboo and the Minor Forest Produce working circles are overlapping working circles and have not been depicted in the map separately.

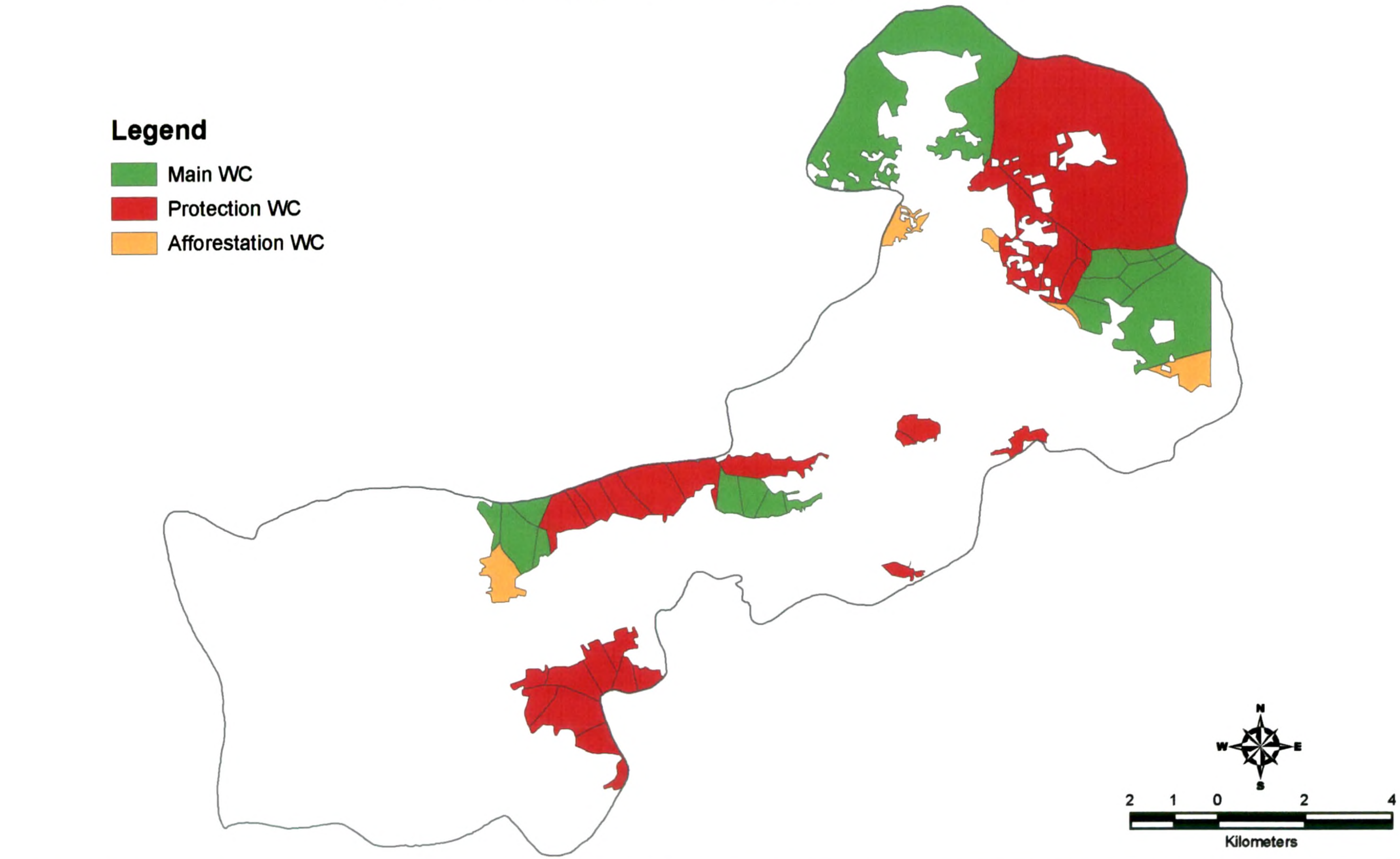
a. Main working circle: This circle had forests with Teak as the dominant species, constituting 35% of the growing stock. It had steep terrain with soil fairly deep and fertile. The area is well covered with tree growth though occasionally it is blank or sparsely wooded. It is understocked, and has top tree height of

Table 69 : Parameters wise suggested working circle

Sr No	Forest Density 1	Forest cover/Species 2	River 3	Road 4	Slope 5	Soil Type 6	Soil Condition 7	Species Diversity 8	Species Dominance 9	Suggested WC on the basis of Parameters 1-9
1	>≤10%	Teak, mixed, grass	Areas within the proximity of 1.5 km	Areas within the proximity of 1 km	steep and very steep	42	normal	1.5-2.5	1.5-2.5	Perservation WC
2	<10 %	Grass	> 1.5 Km of the river	>1 Km to the road	not steep slope	other soils	normal	0.5-1.5	0.5-1.5	Grass WC
3	<20 %	Plantation areas and mixed species	> 1.5 Km of the river	>1 Km to the road	not steep slope	other soils	normal	2.5-3.5	0.5-1.5	Afforestation WC
4	>20 %	Teak, Mixed	> 1.5 Km of the river	>1 Km to the road	not steep slope	other soils	normal	2.5-3.5	2.5-3.5	Improvement WC

soil type 42: Rock outcrops; associated with shallow well drained loamy-skeletal soils on moderately steep sloping, basaltic hills and ridges with severe erosion and moderate stoniness.

Plate : 26 Sajwa Round Working Circle



about 15 meters. Consequently, the area has been adjudged as second quality class by the Forest Department.

a. Afforestation working circle : It exhibits miscellaneous species. The soil is poor, shallow, compact and desiccated with boulders. It is prone to heavy erosion. It consists of degraded and understocked areas with large blanks, denuded hills and open scrub. The terrain is undulating and has low lying hills. The area of this circle is of quality three and four.

b. Protection working circle: This circle has mixed species not covered under the main and the afforestation working circles. Tree height varied between 6-12 meters with tree growth malformed and stunted. Shallow soil, exposed boulders and rocks are the other characteristic features of this circle. Hilly and steep areas requiring protection and improvement and where artificial regeneration is difficult, are included in this area.

In the suggested map of the working circles generated from this study, the afforestation working circle has been retained. The main working circle and the protection working circle should be removed. Instead of these circles, new working circles viz. the improvement working circle, the grassland working circle and the preservation working circle have been suggested. The reallocation of the working circles as per the suggested output is as mentioned in Plate 27. The area allotted to different working circles revealed that 5.16% of the area which was under the afforestation working circle should be increased to 42.72% of the area. 18.1 % of the area should be allotted to the grass working circle. The improvement working circle and the preservation working circle should be given 15.62% and 23.56% of the area respectively (Table 70).

Plate : 27 Sajwa Round Suggested Working Circle

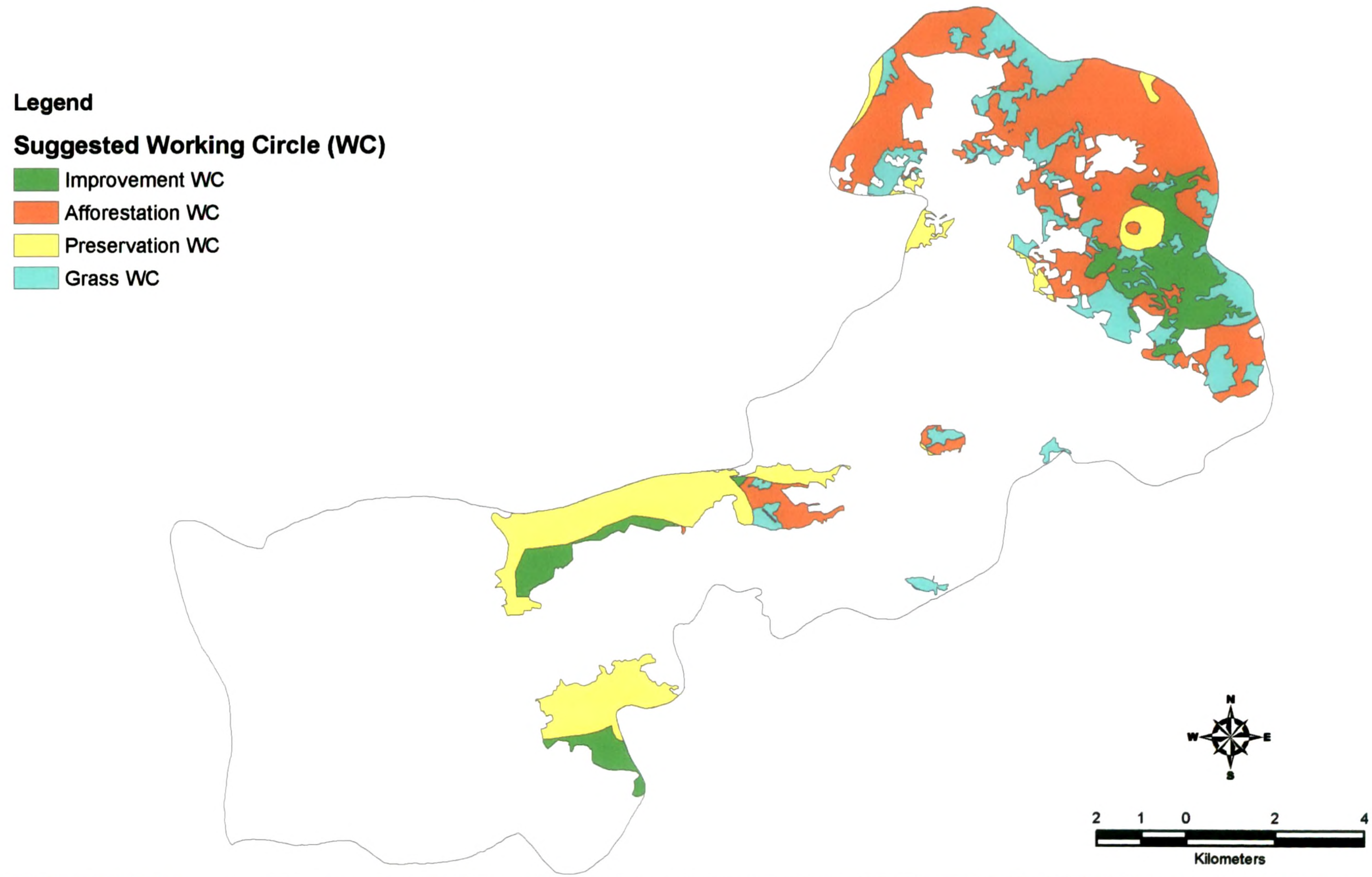


Table 70 : Suggestions for the Sajwa Round Working Circle

Sr. No.	Existing Working Circles (WC)	Area (%)	Suggested Working Circles (WC)	Area (%)
1	Afforestation WC	5.16	Afforestation WC	1.54
			Grass WC	1.09
			Improvement WC	0.45
			Preservation WC	2.08
2	Main WC	39.2	Improvement WC	7.84
			Afforestation WC	16.76
			Grass WC	10.78
			Preservation WC	3.81
3	Protection WC	55.64	Preservation WC	17.67
			Afforestation WC	24.42
			Grass WC	6.22
			Improvement WC	7.33

4.6.2.2 Suggestions for the working circle in the Kalarani round

The existing working circle in this round has two working circles viz. the afforestation working circle and the protection working circle (Plate 28). The suggested map of the working circle of this round shows the redistribution of these circles (Plate29). The area allotment to different working circles shows that the major forest area of the round should be allotted to the preservation working circle i.e. 61.6%. Out of 31.6% of the afforestation working circle area only 12% of the area should be retained as the afforestation working circle. The improvement working circle and the grass working circle should be allotted 3.2% and 23.2% of the area respectively (Table71).

Plate : 28 Kalarani Round Working Circle

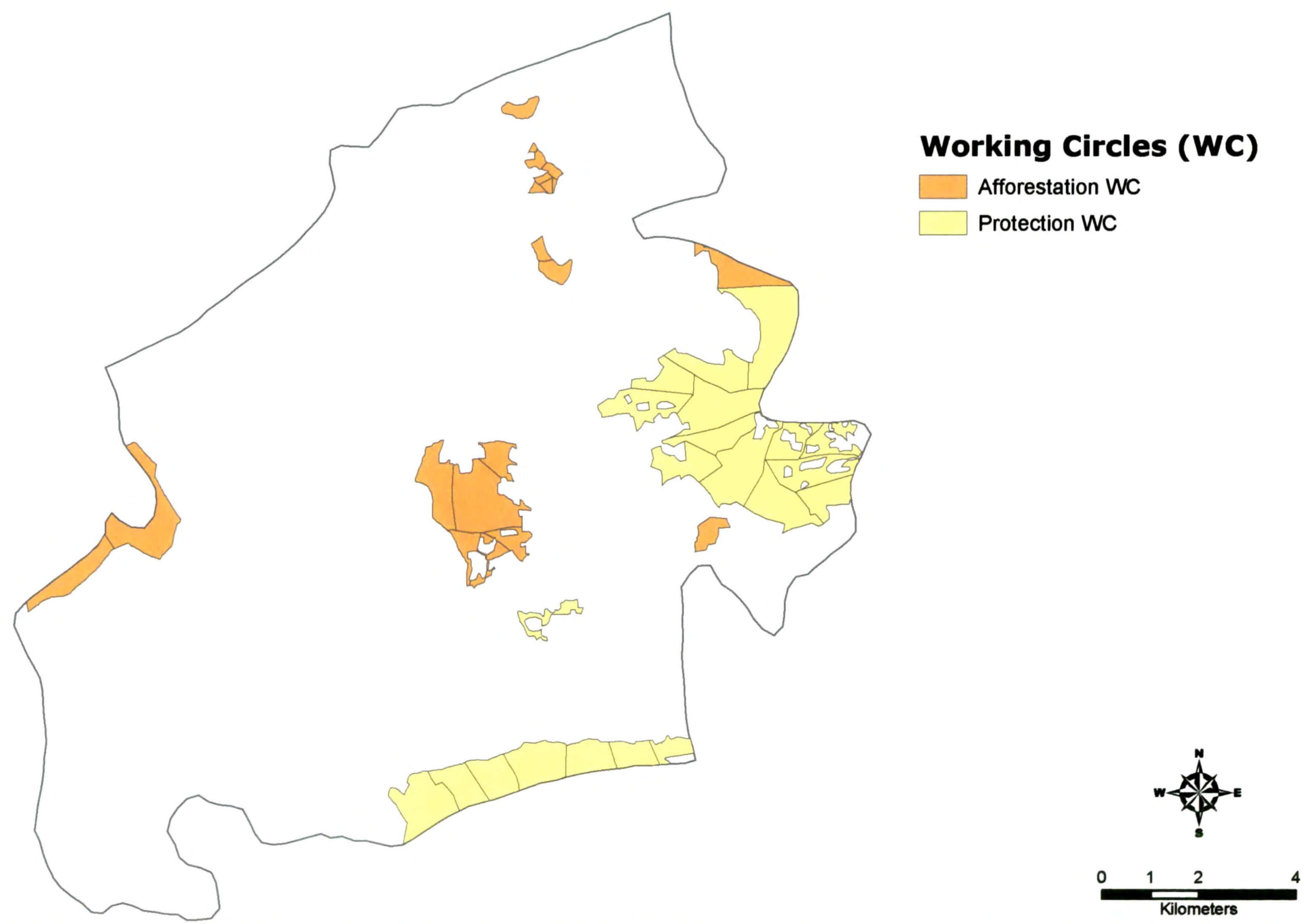


Plate : 29 Kalarani Round Suggested Working Circle

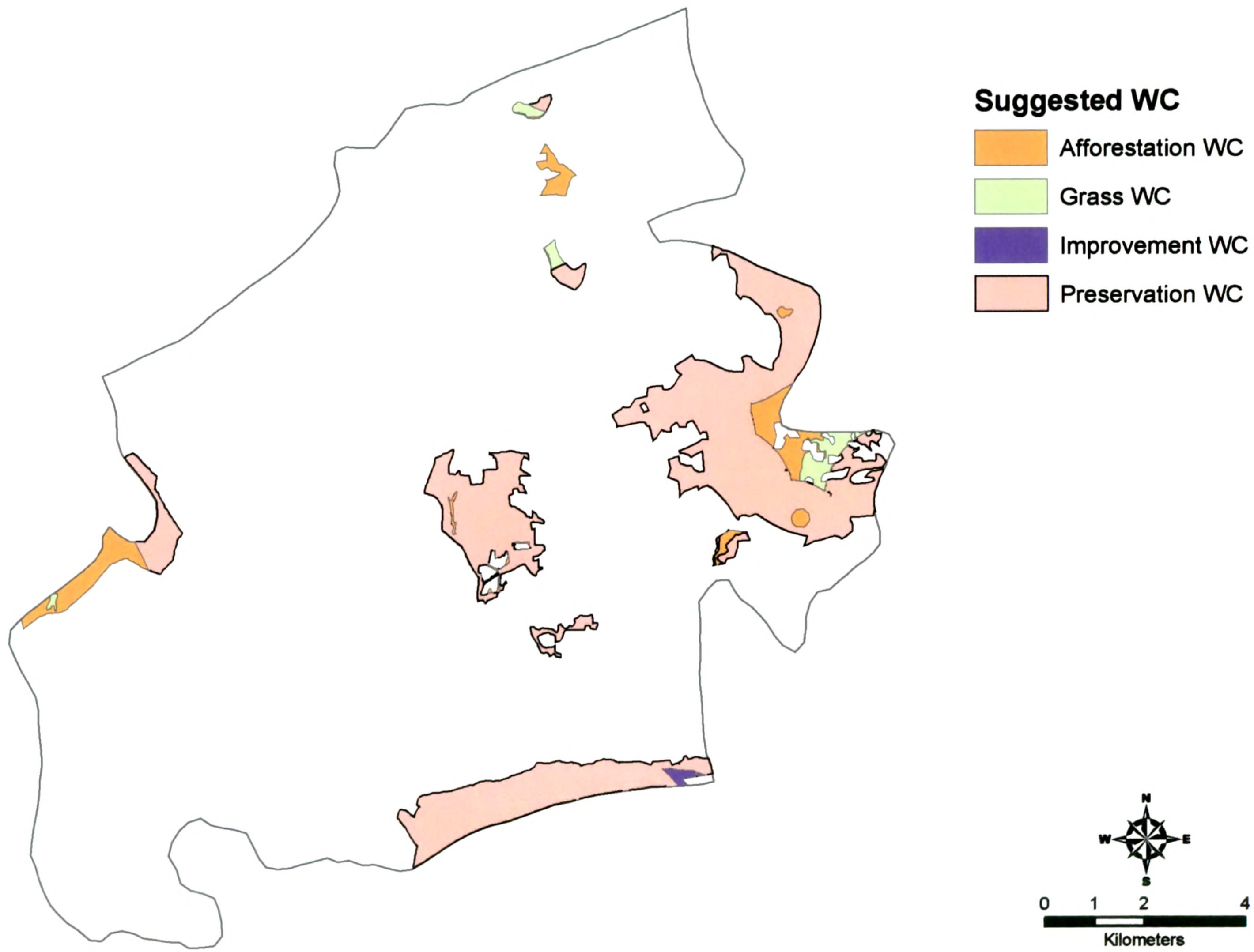


Table 71 : Suggestions for the Kalarani Round Working Circle

Sr. No.	Existing Working Circles (WC)	% Area	Suggested Working Circles (WC)	% Area
1	Afforestation WC	31.6	Afforestation WC	7.8
			Improvement WC	1.1
			Grass WC	22.7
2	Protection WC	68.4	Preservation WC	61.6
			Afforestation WC	4.2
			Improvement WC	2.1
			Grass WC	0.5

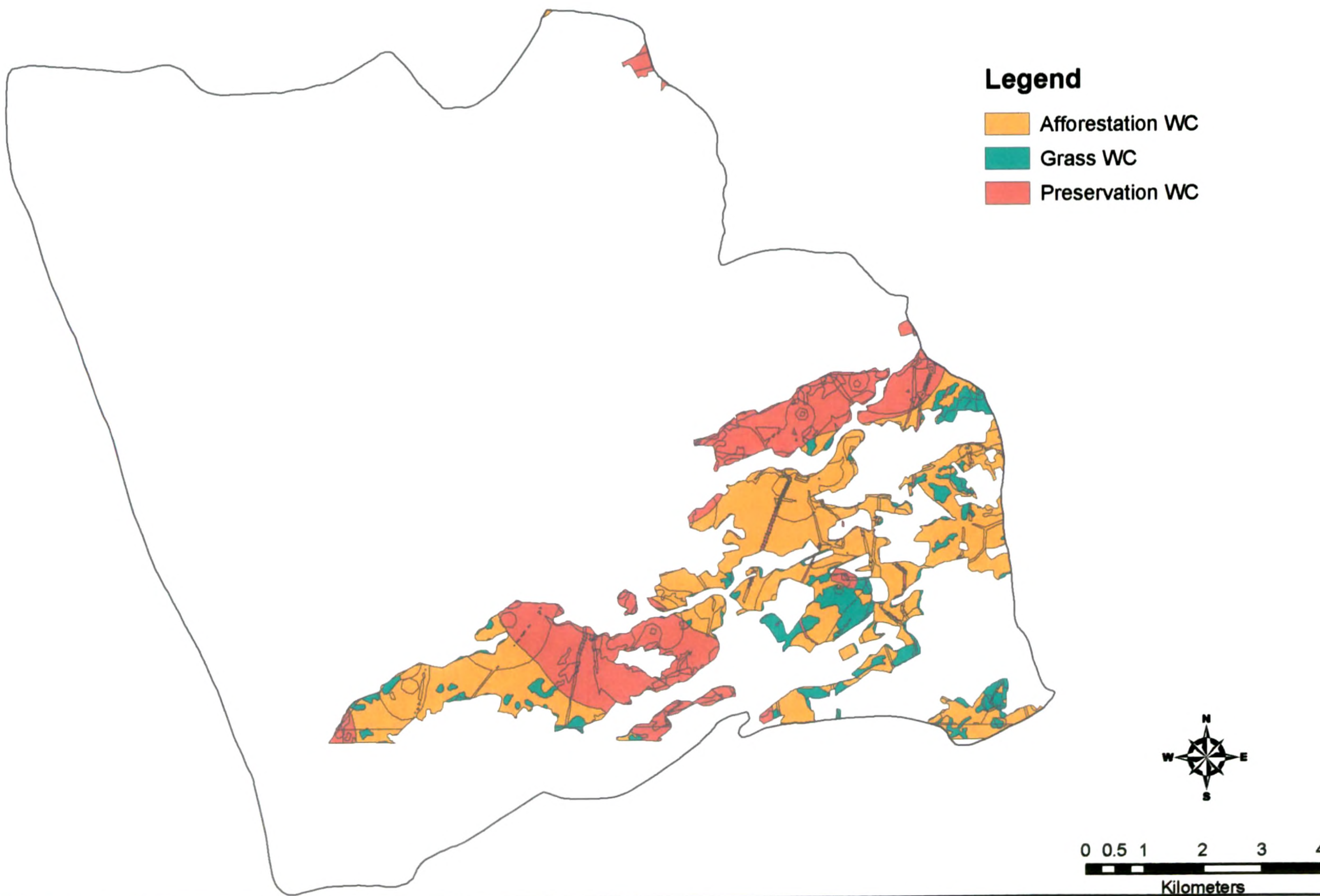
4.6.2.3 Suggestions for the working circle in the Boriad round

Based on predefined criteria, three working circles have been suggested in this round viz. the Afforestation working circle, the Preservation working circle and the Grass working circle. The afforestation working circle should take a major portion i.e. more than 50%. 35.53% area should be considered as the Preservation working circle. In this round, looking at the grass cover, the Grass working circle should be given at least 11.36 % of the area (Table 72 & Plate 30).

Table 72 : Suggestions for the Boriad Round Working Circle

Sr. No.	Suggested Working Circles	Percentage Area
1	Afforestation working circle	53.11
2	Preservation working circle	35.53
3	Grass working circle	11.36

Plate 30 : Boriad Round Suggested Working Circle



4.7. Cost Estimates

The cost effectiveness of satellite data in the forest cover monitoring was proved when the cost estimates of conventional and non conventional method i.e. using satellite data, for the survey of forest compartments were compared (Table 73). The procedures for forest cover monitoring through conventional and non conventional techniques did not vary much, except for the additional data cost and data processing cost in the non conventional mode.

The present study area consists of 213 forest compartments. The survey of these compartments using the non conventional technique would require 81 days with reference to the 80 compartment per man months as computed by Jadhav et al, (1988). On the other hand, the conventional technique completes the survey of 17 compartments per man months as recorded by Tomar, (1976). Thus the cost of survey increases four-fold using the conventional technique. To be precise, a net amount of Rs. 7,02,410/- can be saved if we adopt the new advanced technique of remote sensing.

Table 73: Cost estimates for conventional and non conventional methods of survey

Sr. No.		Conventional Method Cost	Nonconventional Method (satellite data) Cost
1	Conveyance	1150	1150
2	Lodging & Boarding	250	250
3	Consumables	100	100
4	Labour charges	100	100
5	Scientist's & technichian's salaries	800	800
6	GPS Rental		100
	Total Cost/day	**2400**	**2500**
7	Data Cost		10000
8	Data Processing Cost		4290
9	Total man days for the study area	383	81
	Total Cost Incurred in Study	**9,19,200**	**2,16,790**