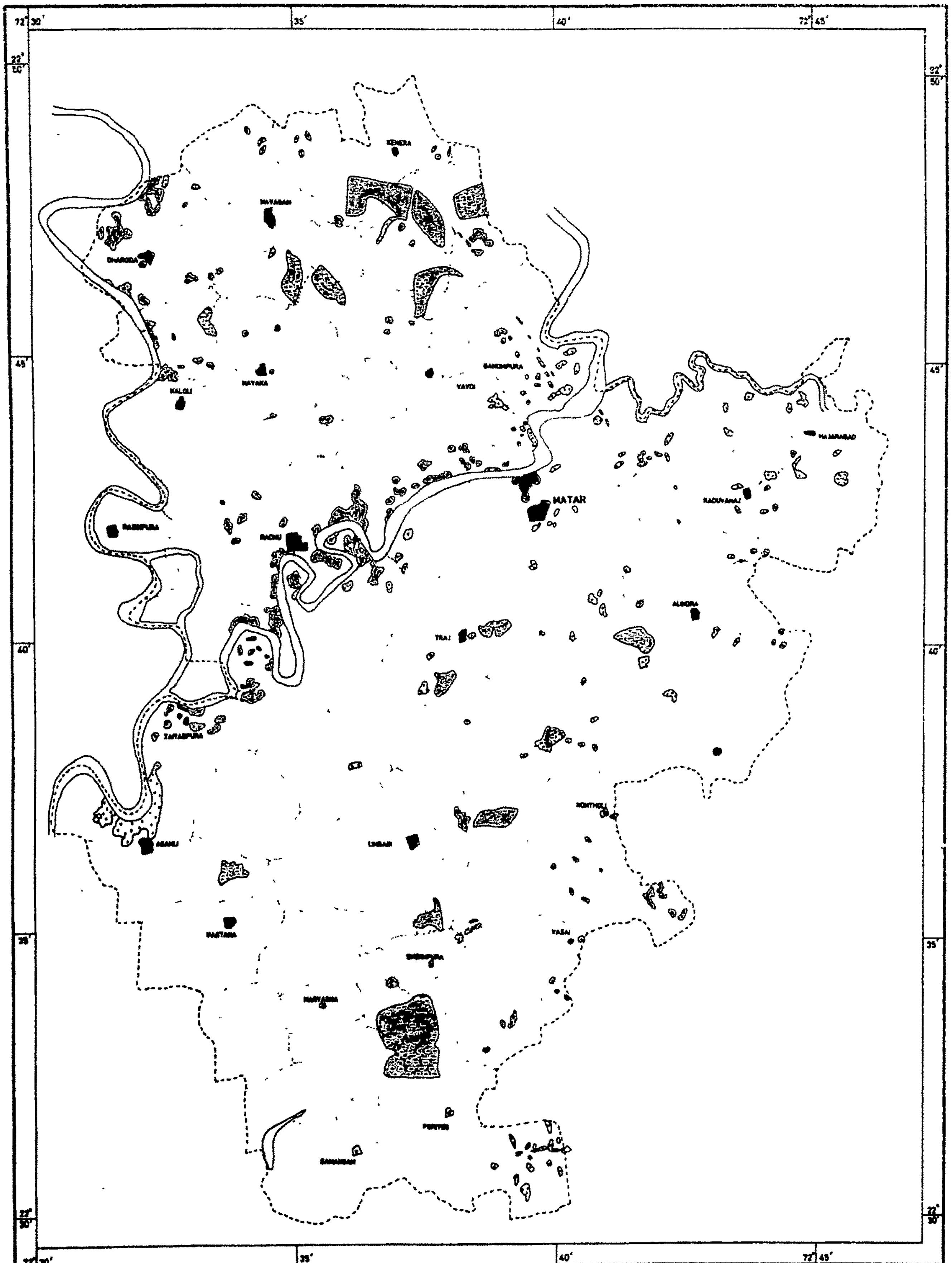
5. Results and Discussion

5.1 Visual Interpretation

The interpretation and assessment of satellite imageries have successfully delineated three different categories of social forestry plantations viz., roadside, canalside, and other plantations which included farmlands, orchards, village woodlots, Rehabilitation of Degraded Farm Lands (RDFL), etc. The categorisation on plantation types was not possible, due to the absence of distinct tonal variation for different species except for the Eucalyptus species which appeared dark brown in colour. The delineation was mainly based on the limitation and precision of the False Colour Composite (FCC) used.

Landsat MSS-1983 data could delineate other plantation category, (Fig.14). However, it did not provide any information on linear plantation such as roadside and canalside. The difficulty in identification of such type of linear feature in MSS imagery was mainly due to the pixel averaging with roadside and other linear categories (Pant, 1993). The resolution constraints in Landsat MSS tended to preclude a detailed assessment of social forestry land.

The difficulties met with the MSS data were surmounted by the data derived from Landsat TM (1986) (Fig.15). Landsat TM has vividly distinguished the strip plantation into different subcategories viz., National Highway (N.H.8) and State Highway alongwith other plantation category. The TM data could not differentiate the strip plantations along canals and other taluka roads. However, the Landsat TM has marked advantage over Landsat MSS due to its improved better spatial resolution and spectral contrast. Though Porwal and Pant (1989) stressed the potentials of TM data in forestry mapping, Crist and Cione (1984), Ahern and Archibald (1986) and Bansal *et al.*, (1991) specifically showed the potentials of TM



L E G E N D

PLANTATION TYPES

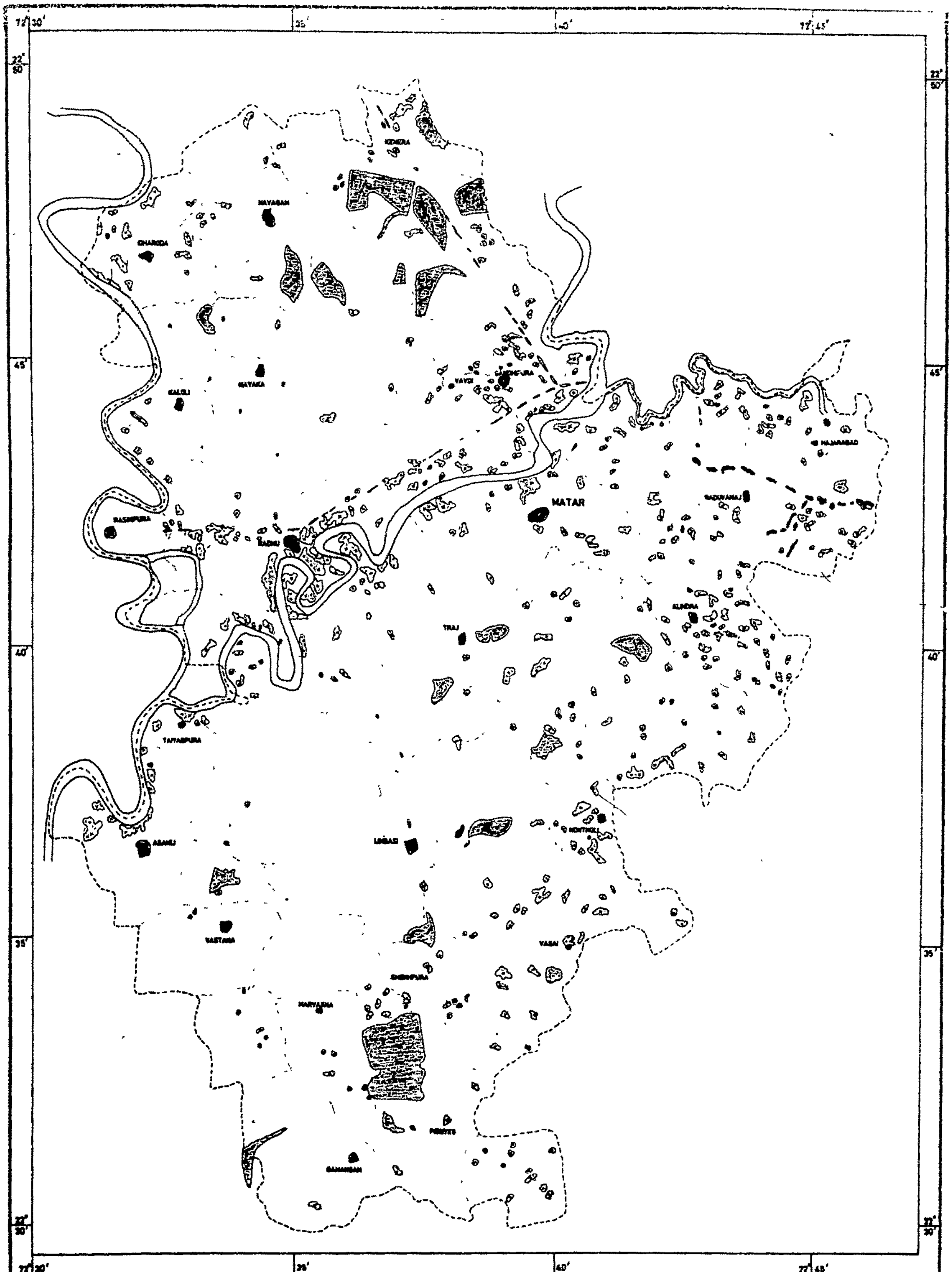
1. Other plantations
2. VILLAGE BOUNDARY
3. WATER BODIES

INDEX TO SHEETS

ADMINISTRATIVE INDEX

DATA USED		
SATELLITE / SENSOR	SEASON	PRODUCT
LANDSAT / MSS	MAY 1, 1983	FCC

FIG. 14



LEGEND

PLANTATION TYPES

1. Other plantations
2. ROAD LINE
3. WATER BODIES
4. VILLAGE

INDEX TO SHEETS

ADMINISTRATIVE INDEX

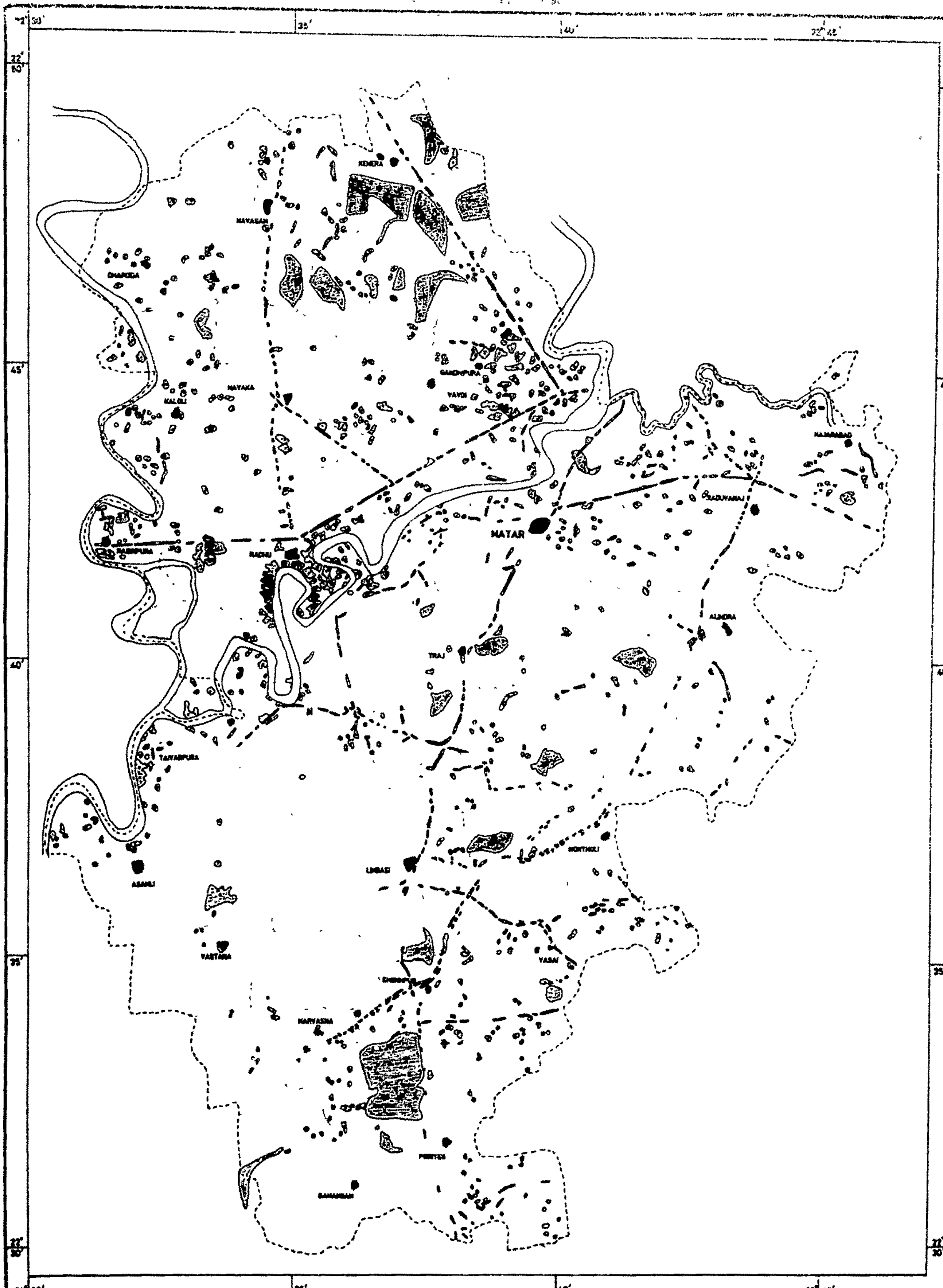
DATA USED		
SATELLITE / SENSOR	SEASON	PRODUCT
LANDSAT / TM	Oct 21, 1986	FCC

FIG.15

in mapping over MSS data in forest plantation differentiation.

The social forestry plantation categories exhibited by the SPOT imagery (1989) provided more details in different categories when compared to any other data used (Fig.16). The roadside plantations could be clearly demarcated not only along the N.H.8., state highway but also along the minor roads of the taluka. The canal plantations could be distinguished into major and minor types. Pathan *et al.*, (1988) and Bansal (1992) have shown that major network can be identified with the help of linear feature or pattern. Minor unmetalled road network pattern was also identified to some extent with the help of light grey tone. It was difficult to distinguish the farmlands and woodlot, even in the SPOT data. The reason for such limitation appears to be the absence of a clearcut demarcation in terms of geographical area for such segregation. However, such differentiation could be possible if microlevel studies are carried out using cadastral maps.

The IRS 1993 data brought out information regarding the roadside plantations along N.H.8, state highway and main roads of taluka (Fig.17). However, the other taluka roads could not be delineated here. Also no segregation between the minor and major canal plantation was made. On the other hand, the IRS data showed its superiority over TM data, giving more details of strip plantations. This may be due to local acquisition time of the data or spectral range of the sensor. Previous workers have also identified the superiority of IRS data over TM data in the identification of linear features (Pathan *et al.*, 1988; Mehta *et al.*, 1988). The higher resolution of TM and IRS provides improved accuracies for detection of small features due to reduction in number of mixed pixel (Sahai *et al.*, 1987) and higher radiometric resolution alongwith improved band placement (Dadhwal and Parihar, 1988). The imageries did not exhibit any plantation types in some of the areas of the taluka such as Chanor, Vastana, Bamangam, Valotri, Hadeva, Mahemdabad. This is mainly due to emergence of salinity and alkalinity.



<u>L E G E N D</u>

PLANTATION TYPES

1. Other plantations
2. ROAD LINE
3. CANAL
4. VILLAGE BOUNDARY
5. WATER BODIES
6. VILLAGE

INDEX TO SHEETS

ADMINISTRATIVE INDEX

DATA USED		
SATELLITE / SENSOR	SEASON	PRODUCT
SPOT / HLA	APRIL 24, 1959	FCC

FIG.16

MAPPING OF PLANTATIONS GROWN UNDER SOCIAL FORESTRY PROGRAMME IN MATAR, KHEDA DISTRICT, GUJARAT

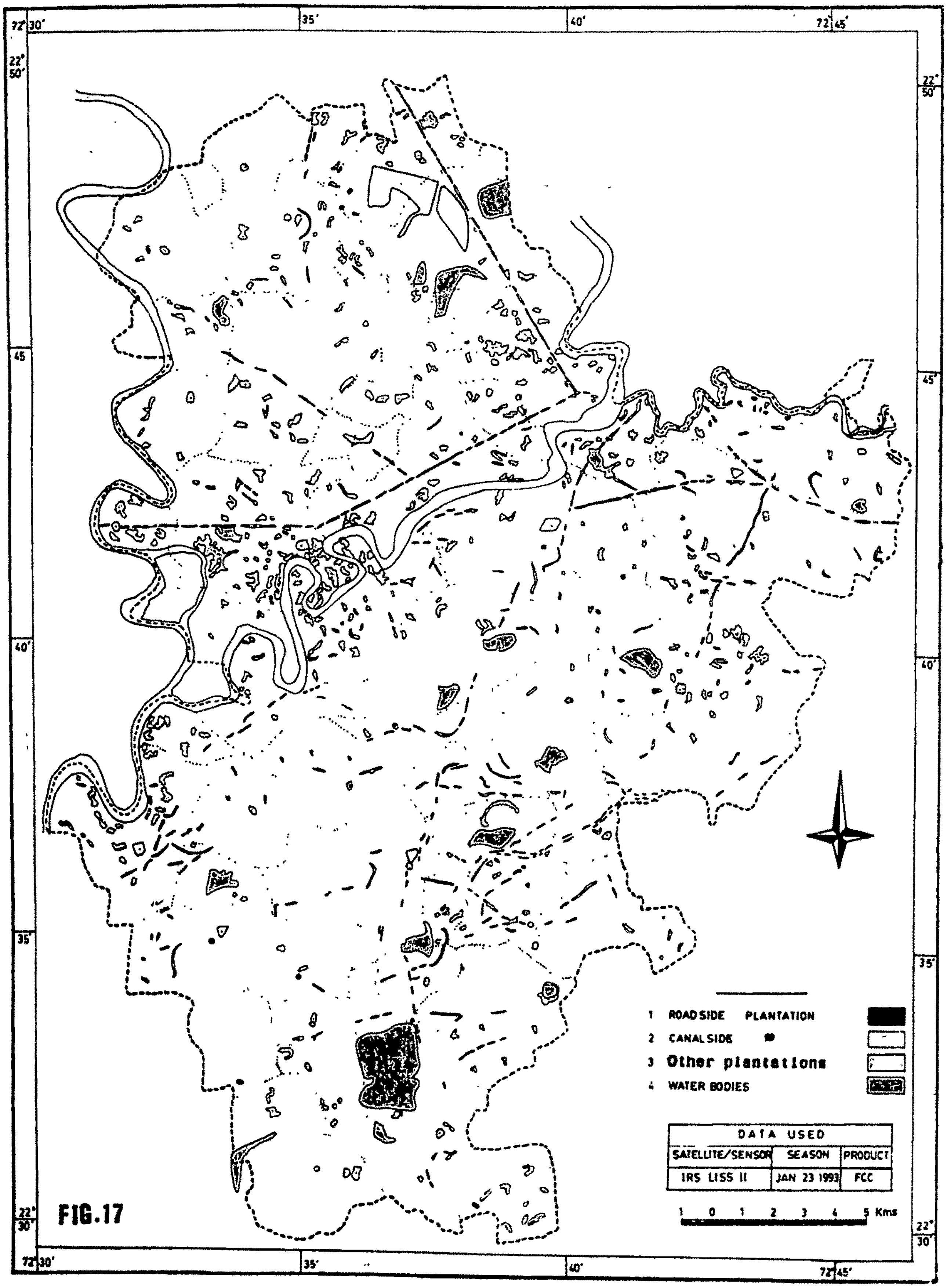


FIG.17

The assessment and interpretation of above imageries from 1983 to 1993 aided in monitoring of social forestry plantation in the study area. The area statistics for these plantations was done using `mm' dotgrid, and given in the table 8. It could be seen from the table that the area covered by the plantations was about 15.09, 20.54, 27.95 and 30.56 sq.km during 1983, 1986, 1989 and 1993 respectively. This clearly exhibits that not much difference could be observed from 1983 to 1986 but a notable change was observed from the year 1986 to 1989.(The reason for such change could be either implementation of massive afforestation programmes during this period or selection of imageries from different sensors.)

The village-wise area computed using SPOT data clearly broughtout the occurrence of roadside, canalside and other plantation in 47, 7 and 71 villages respectively (Table 9). Selection of SPOT data for village-wise computation was due to its superiority over other satellite data used. The overall picture of the area vividly brought out that the canalside plantations occupied less area i.e., 6.05% of the total social forestry plantations, despite the presence of a number of canals. The reason being the biotic interference from the nearby habitat (Local communication). On the other hand, road side and other plantation categories showed a gradual increase in the taluka. Considering the limitations like resolution constraints of sensor, season of the imageries and cartographic error the overall accuracy estimated for all different data viz., MSS, TM, SPOT and IRS was 76.10%, 84.61%,90.69% and 87.29% respectively at 90% confidence level (Tables 10 - 13).

The delineation, area calculation, and the accuracy estimation of plantations depend on many factors such as phenology, data acquisition date, cartographic problem, ancillary data used, and selection of satellite data. This is the reason that though the MSS data was collected in May when the land had no agriculture cover there was mis-classification due to naturally occurring Prosopis spp. present in the pasture/grazing land.

Table 8. Social forestry plantations (sq.kms) in Matar taluka as computed from multitemporal satellite images.

Sr. No.	Plantation Types	Year (Area in sq.km) 1983	1986	1989	1993
1.	Roadside	-	1.26	4.47	4.92
2.	Canalside	-	-	1.32	1.63
3.	Other Plantations	15.09	19.28	22.16	24.01
	Total	15.09	20.54	27.95	30.56
	In per cent	2.61	3.55	4.84	5.29

Table 9 Village-wise distribution of social forestry plantation of Matar taluka computed from SPOT data.

Sr. No.	Village Name	Roadside	Canalside	Other plantations
1	2	3	4	5
1.	DHARODA	-	-	29.4
2.	KATHWADA	-	-	20.2
3.	NAVAGAM	14.0	-	21.1
4.	PINGLAJ	07.1	-	20.2
5.	KANERA	12.4	-	20.4
6.	MALAKPUR	-	-	14.6
7.	VAIKUNTHPURA	-	-	-
8.	KAJIPURA	3.2	-	23.1
9.	GOBHALAJ	12	-	12.5
10.	PANSOLI	-	-	10.1
11.	CHALINDRA	7.8	-	72.4
12.	CHITRASAR	-	-	42.12
13.	NAIKA	23.4	-	40.56
14.	BHERAI	-	-	6.24
15.	DHATHAL	-	-	7.81
16.	VADALA	-	-	3.12
17.	HARIYALA	43.04	-	134.8
18.	VAVDI	7.1	-	48.4
19.	DAMRI	3.12	-	-
20.	GOVINDAPURA	-	-	7.8
21.	KALOLI	-	-	54.6
22.	SHETRA	-	-	3.2
23.	VASNA BUJARG	-	-	-
24.	SHOKDA	11.2	-	24.96
25.	VANSAR	-	-	12.1
26	RATANPUR	4.13	-	4.18

1	2	3	4	5
27	ANTROLI	3.28	-	112.48
28	HAJARABAD	4.68	-	85.88
29	SANDHANA	5.92	-	95.92
30	RADHVANJ	14.32	-	44.68
31	UNDHELA	11.2	-	82.40
32	MATAR	26.16	-	89.28
33	PIPARIA	5.92	-	20.61
34	KOSHIAL	1.21	-	13.24
35	CHANDNA	23.32	-	124.02
36	RADHU	49.54	-	149.40
37	RASIKPURA	11.84	-	55.24
38	VARSANG	-	-	20.12
39	MAHELAJ	19.64	-	63.41
40	TRAJ	15.61	-	43.43
41	GARMALA	-	-	9.36
42	KHADIYARPURA	4.68	-	12.48
43	UNTAI	10.04	-	10.24
44	ALINDRA	4.32	-	24.96
45	SIHOLDI	-	-	3.24
46	MALIYAIAJ	6.24	-	15.6
47	HERANJ	4.68	-	12.48
48	MACHHIEL	-	-	-
49	ASLALI	-	-	4.10
50	PUNAJ	1.2	-	3.70
51	KUNJARA	5.16	-	18.42
52	BARODA	8.08	-	62.12
53	PALLA	3.24	-	12.48
54	ASAMALI	-	-	60.84
55	NADHANPUR	-	-	3.28
56	KHARENTI	-	-	-

1	2	3	4	5
57	TRANJA	6.52	-	37.42
58.	KATHODA	-	-	8.48
59.	KHANDLI	9.3	-	4.28
60.	LAVAL	8.42	-	19.16
61.	NANDOLI	-	26.52	14.32
62.	NAGRAMA	12.34	27.32	46.52
63.	MARALA	14.36	20.28	21.34
64.	LIMBASI	9.48	4.14	15.42
65.	MEHEMDABAD	-	-	-
66.	VASTANA	-	-	-
67.	CHANOR	-	-	-
68.	SHEKHPUJR	9.12	31.2	16.24
69.	RANASAR	-	-	19.32
70.	MALAWADA	1.42	-	19.48
71.	DETHLI	11.21	-	55.48
72.	VASAI	1.8	-	13.8
73.	BHALADA	5.4	-	31.68
74.	SAYLA	-	10.92	9.48
75.	INDERVERNA	-	12.48	15.6
76.	HADEVA	-	-	-
77.	VALOTRI	-	-	-
78.	DALOLI	-	-	1.48
79.	VIROJA	-	-	31.2
80.	BAMANGAM	-	-	-
81.	PARIYEJ	1.12	-	4.1
82.	SINJIWADA	3.36	-	51.21
	TOTAL	447.69	132.86	2216.88
	% total geographical area	0.77	0.22	3.83

Table 10. Summary of Commision and Omission errors for visual interpretation of MSS data

Sr. No.	Category	Commission errors		Omission errors		Correct	
		Total	Per cent	Total	Per cent	Total	Per cent
1	Roadside plantation	-	-	-	-	-	-
2	Canalside plantation	-	-	-	-	-	-
3	Other plantation	-	-	5	23.90	16	76.10

- Not seen on the satellite data. Accuracy 76% at 90% confidence level

Table 11. Summary of Commission and Omission errors for visual interpretation of TM data

Sr. No.	Category	Commission errors		Omission errors		Correct	
		Total	Per cent	Total	Per cent	Total	Per cent
1	Roadside plantation	1	12.5	-	-	7	87.5
2	Canalside plantation	-	-	-	-	-	-
3	Other plantation	3	16.6	1	12.5	15	83.4

- Not seen on the satellite data. Accuracy 84.6 at 90% confidence level

Table 12. Summary of Commision and Omission errors for visual interpretation of SPOT data

Sr. No.	Category	Commission errors		Omission errors		Correct	
		Total	Per cent	Total	Per cent	Total	Per cent
1	Roadside plantation	1	5.2	-	-	18	94.7
2	Canalside plantation	-	-	1	5.2	5	100.0
3	Other plantation	3	15	-	-	17	85.0

- Accuracy 90.69 at 90% confidence level

Table 13. Summary of Commision and Omission errors for visual interpretation of IRS data

Sr. No.	Category	Ommission errors		Commission errors		Correct	
		Total	Per cent	Total	Per cent	Total	Per cent
1	Roadside Plantation	2	8.6	0	0.0	21	9.4
2	Canalside plantation	0	0	1	4.3	5	100.0
3	Otherside plantation	4	21.10	0	0	15	78.9

- Accuracy 87.2% at 90% confidence level

This observation was made during the field study. On the other hand, inspite of the better spatial and spectral resolution of SPOT data, the area estimated was less, since the detection of other plantation mainly Acacia plantation was not precise. The month of data being April, it did not take up these plantations due to the absence of foliage in these plants during this period (Table 14).

The phenological studies of different plants in this area have exhibited that most of the trees have distinct leaves in the month of September, November, December and March (Table 14). Thus, due to less interference of other vegetation, March is considered as the best month for plantation studies using remote sensing, particularly for this area. Studies on Normalised Difference Vegetation Index (NDVI) by several authors have also shown that March is suitable for differentiation of land cover and more specifically the plantations (Srivastav et al., 1993). In the month of April, the NDVI values of plantations come closer to that of bare soil, hence there is a possibility of confusion in spectral signatures of bare soil and plantations.

From this study it is evident that the SPOT data of April was unable to differentiate accurately the Acacia plantations. Several reports have also shown that satellite imageries pertaining to the leaf less period poses problem for accurate delineation due to variation in spectral reflectance (FSI report, 1991; Oza and Sharma, 1990).

In the other case, it was found that the IRS data of January gave much error in the case of other plantations category due to the mingling of plantation with crop, which was also observed during the ground survey (Plate 4). Wooding (1986) showed the similar possibilities of confusion between the crop and woodland in early summer in Scotland, U.K.

Table 14 : Phenological Observations of common species of the study area.

Sr. No.	NAME OF THE PLANT	JAN		FEB		MAR		APR		MAY		JUNE		JULY		AUG		SEP		OCT		NOV		DEC	
		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
1	Ailanthus excelsa Roxb	O	O	@	@	$	$	#	#	&	&	$	$	$	$	O	O	O	O	O	O	O	O	O	O
2	Peltophorum pterocarpum (DC.) Backer ex Heyne	#	#	&	&	&	*	*	*	*	*	*	*	*	*	$	$	$	$	$	$	$	#	#	#
3	Syzygium cuminii (Linn) Skeels	+	+	<	<	< >	<	@	@	@	$	$	$	$	$	O	O	O	O	O	O	O	O	O	O#
4	Cassia siamea Lamk	*	*	*	*	$	$	$	$	$	$	$	$	$	$	$	$	$	$	*	*	*	*	*	*
5	Albizia lebbeck (L.) Bth.	O	-	-	+	+	<	@	@	*	*	$	$	$	$	O	O	O	O	O	O	O	O	O	O
6	Cassia fistula Linn	$	$	$	$	#	#	#	|	|	&	@	@	@	*	*	*	*	*	$	$	$	$	$	$
7	Samanea saman (Jacq) Merr	O	O	-	-	+	<	@	@	@	@	@	*	*	*	*	$	$	$	O	O	O	O	O	O
8	Cassia renigera wall ex.Bth.	$	$	$	$	#	#	#	#	$	$	*	*	*	*	*	*	*	$	$	$	$	$	$	$
9	Dalbergia sissoo Roxb	O	O	#	#	+	@	@	*	*	*	*	*	$	$	$	$	$	$	O	O	O	O	O	O
10	Pithecellobium dulce (Roxb.) Bth	O	O	@	@	$	$	$	$	$	O	O	O	O	O	O	O	O	O	O	O	O	<	<	<
11	Acacia nilotica (linn) del	O	O	O	O	O	O	-	-	-	+	+	@	@	@	@	*	*	$	$	$	O	O	O	O
12	Azadirachta indica A.Juss	-	-	+	+	@	@	@	@	*	*	*	$	$`	$	$	O	O	O	O	O	O	O	-	-

		With flowers	With fruits
Older leaves	0	@	$
New leaf coming	+	< >	&
Leaf fall/leafless	-	|	#

With leaves, flowers and fruits *

1=1 to 15 days

2=16 to 31 days

PLATE 4

Mingling of plantations with agricultural crops in the study area.

PLATE 4

5.2 DIGITAL ANALYSIS

The observation of various enhancement techniques has generated interesting results. Firstly, the various band combination composites generated in the form of photographs using DUNN camera showed that the FCC generated using band 2, 3 and 4 provided the best information for general landuse classification (Plate 5b), when compared to other combinations as seen in plate 5a, 5c and 5d. Similar observations have been reported by earlier workers (Singh, 1988; Rao *et al.*, 1991). In addition, NDVI image generated through ratioing band 3 and 4 in differentiating the vegetational strength into three categories viz., dense, moderate, and sparse as red, yellow and green respectively (Plate 6).

Based on the above enhancement, the training sets for different categories were fed to the FCC to perform the supervised classification scheme which yielded a colour coded output of landuse showing ten different categories viz., crop, fallow, weed, Prosopis spp., plantations, riversand, salt affected land, pasture/grazing land, waterlogged and water as given in the legend (Plate 7).

The area computed under each category is given in table 15. It is evident from the table that the crop forms a major portion of landuse i.e., almost 28.54% followed by fallow land almost similar to the crop land. The reason for the occurrence of more area under fallow land was that the data interpreted was of March during which the crops were mostly harvested. The salt affected and waterlogged land also constitutes about 20% of the total computed area of the land, showing that the taluka is also facing the tragic problem of soil degradation. The overall accuracy esitmated for the general landuse categories was about 93.7% at 90% confidence level (Table 16).

5.2.1 Social forestry mapping

The digital techniques were attempted specifically to classify social forestry plantation based on the plant types, which was subtle using visual interpretation technique. Thus, the social forestry plantation map was generated by suppressing the other categories of landuse and just highlighting or discerning the plantation categories. This has generated three different plantation categories based on the types viz., Eucalyptus spp., Acacia spp., and mixed spp. which are not exhibited in visually interpreted maps (Plate 8). Several workers have attempted the mapping of different plantation based on the types. Singh and Roy (1990) and Srivastav *et al.*, (1993) have used Landsat TM and IRS data respectively for Teak plantation in the forest

PLATE 5

Different enhanced digital outputs of IRS data generated using combinations of band 1, 2, 3, and 4.

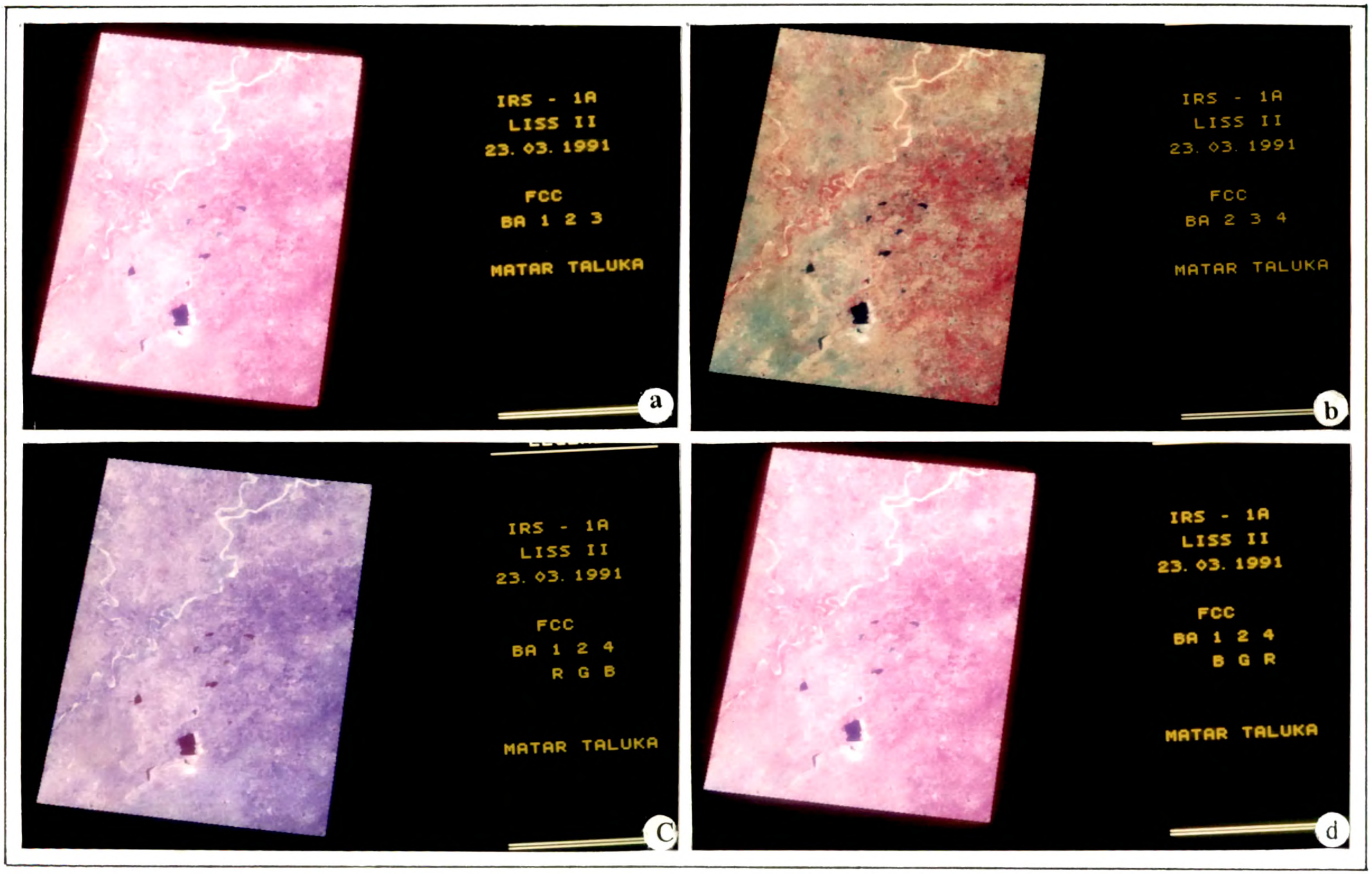

IRS - 1A
LISS II
23. 03. 1991
FCC
BA 1 2 3
MATAR TALUKA
a
IRS - 1A
LISS II
23. 03. 1991
FCC
BA 2 3 4
MATAR TALUKA
b
IRS - 1A
LISS II
23. 03. 1991
FCC
BA 1 2 4
R G B
MATAR TALUKA
C
IRS - 1A
LISS II
23. 03. 1991
FCC
BA 1 2 4
B G R
MATAR TALUKA
d

PLATE 5

PLATE 6

Distribution of vegetational pattern in Matar taluka, derived from Normalised Difference Vegetation Index (NDVI) using IRS 3 and 4 bands. (Red, yellow and green colour indicates dense, moderate and sparse vegetation respectively).

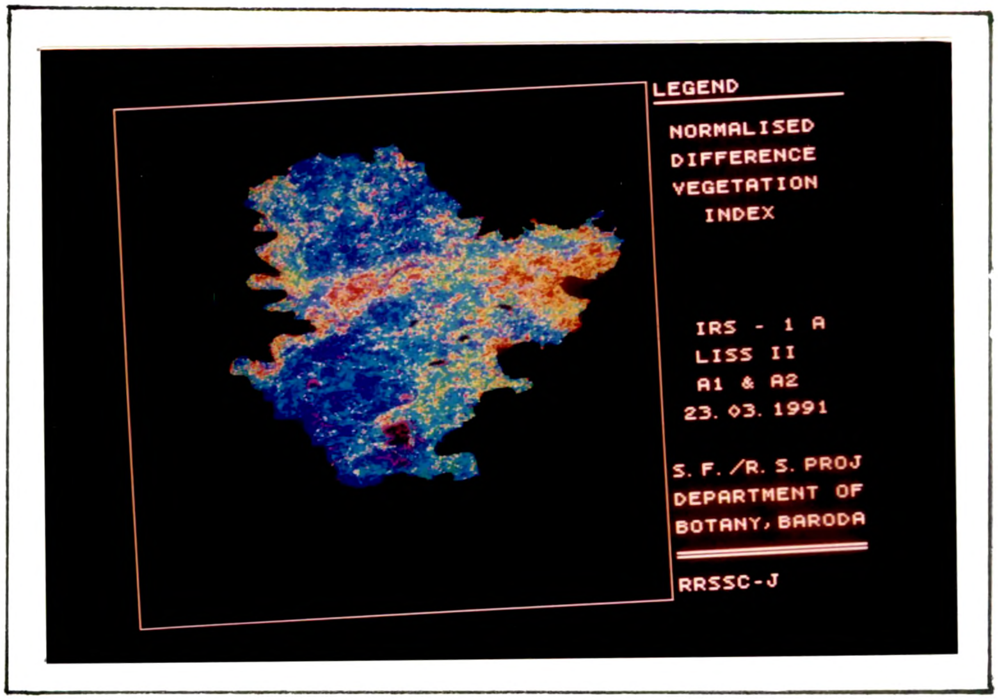

LEGEND
NORMALISED
DIFFERENCE
VEGETATION
INDEX
IRS - 1 A
LISS II
A1 & A2
23. 03. 1991
S. F. /R. S. PROJ
DEPARTMENT OF
BOTANY, BARODA
RRSSC-J

PLATE 6

PLATE 7

A Kaleidoscopic view of landuse/land cover of Matar taluka of Kheda district, generated from IRS LISS-II digital data using VAX 11/780 image processing system.

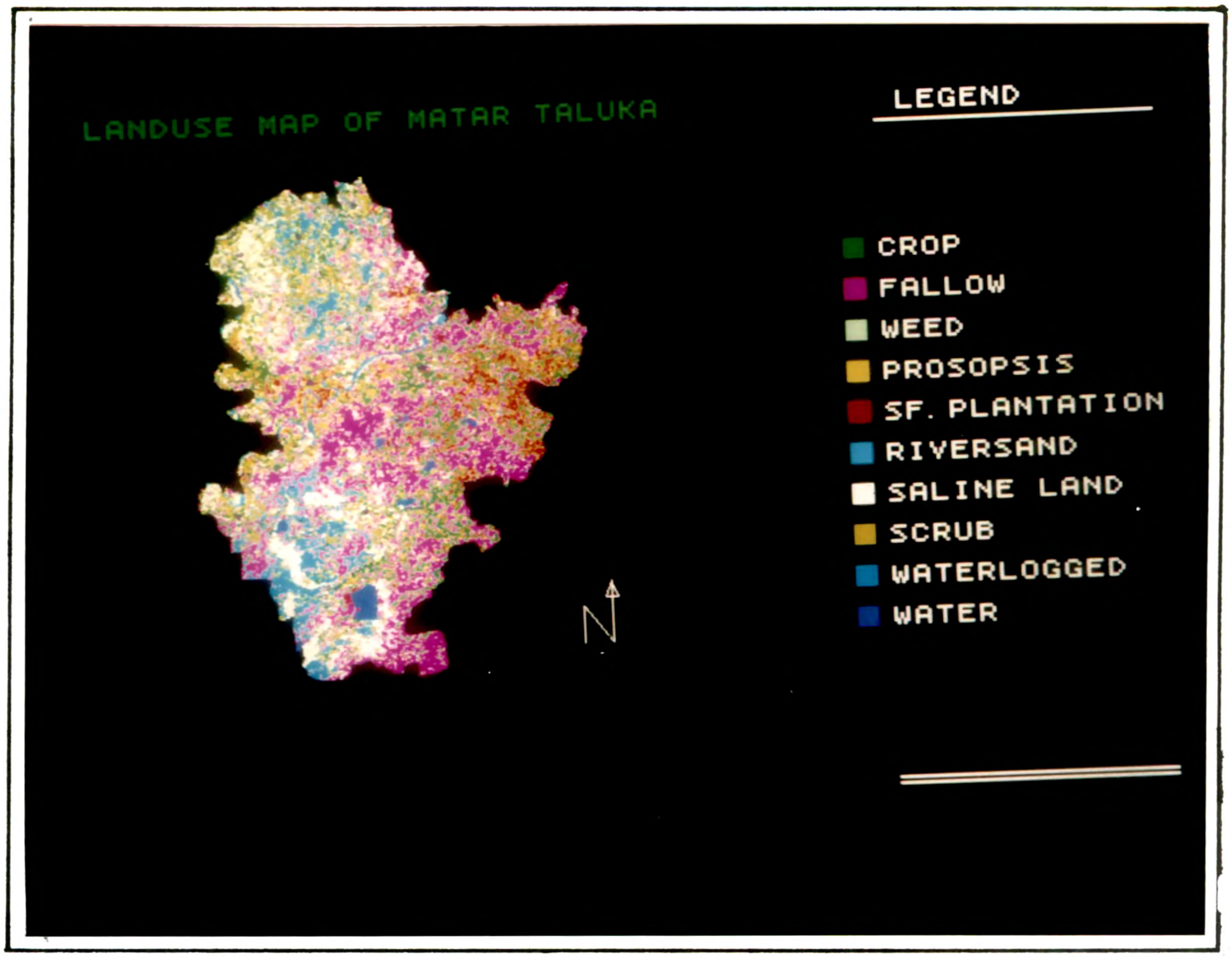

LANDUSE MAP OF MATAR TALUKA
LEGEND
CROP
FALLOW
WEED
PROSOPSIS
SF. PLANTATION
RIVERSAND
SALINE LAND
SCRUB
WATERLOGGED
WATER
N

PLATE 7

Table 15. Area computed from IRS LISS-II 1991 digital data for landuse/ landcover of Matar taluka

Sr. No.	Category	Area in ha	Area in %
1	Crop	16476.17	28.54
2	Fallow	15665.14	27.13
3	Salt affected	6501.77	11.26
4	Waterlogged	5105.00	8.84
5	Pasture/grazing	4649.01	8.05
6	Prosopis spp.	3547.67	6.14
7	Plantations	3314.77	5.74
8	Settlements	1628.74	2.82
9	Water	624.00	1.08
10	Riversand	197.00	0.34
11	Weed	15.25	0.06
	Total	57724.52	100.00

Table 16. Summary of commission and omission errors of IRS digital data for Landuse categories

Landuse Classes	Omission Errors Total	Per cent	Commission Errors Total	Per cent	Correct Total	Per cent
Crop	3	19.6	0	0	21	100.00
Salt affected land	2	16.6	3	7.8	43	93.02
Pasture/grazing	1	7.1	2	12.5	14	87.5
Waterlogged	2	9.5	0	0	15	100
Plantations	3	15	4	7.85	51	92.15
Weed	0	0	0	0	7	100
Prosopis spp	0	0	1	7.1	13	92.9
Riversand	0	0	1	8.4	11	91.6
Water	0	0	0	0	10	100

Accuracy was 93.7% at 90% confidence level.

PLATE 8

Distribution of different plantation types extracted from IRS digital data.

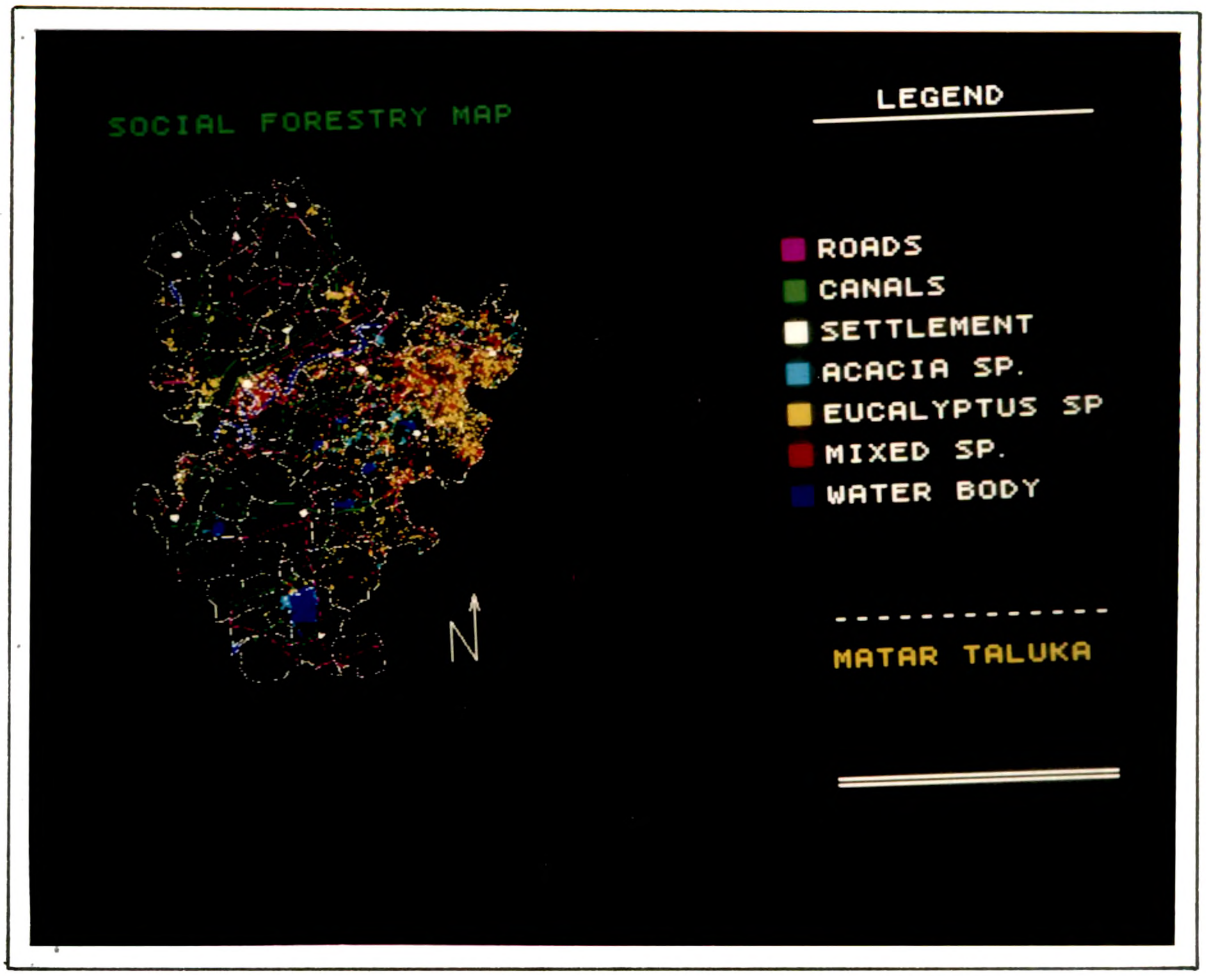

SOCIAL FORESTRY MAP
LEGEND
ROADS
CANALS
SETTLEMENT
ACACIA SP.
EUCALYPTUS SP
MIXED SP.
WATER BODY
N
MATAR TALUKA

PLATE 8

area. Whereas, Adiga (1992) has mapped Eucalyptus plantation in the nonforest area.

The area computed for the above three categories viz., Eucalyptus spp., Acacia spp., and mixed spp. was about 3.4%, 0.5% and 1.9% respectively of the total geographical area of the taluka (Table-17). The total area covered by all these plantations together calculated for each village separately showed that 69% of the villages have less than 5% of the plantation and remaining 31% have mainly concentrated on the eastern region of the taluka. Only four villages, namely Undhela, Alindra, Heranj and Sandhana have more than 30% of social forestry plantations. Further, the number of villages with social forestry plantations greater than 20% and 10% were 10 and 10 respectively. The above results clearly brought out the fact that for achieving national goal of reaching minimum or above 30% greenery, massive afforestation programmes are to be carried out in about 93% of the villages.

Perusal of the database shows that Eucalyptus plantation is predominant amongst the other plantations covering an area of about 1926 ha. in the study area (Table 17). The village-wise distribution of this piantations has exhibited that about 9 villages have more than 10% of their total geographical area under Eucalyptus plantation covering mainly in the eastern side of the taluka. Some of these villages are Antroli, Radhvanaj, Haijerabad, Undhela etc. Eucalyptus plantation appeared very distinct in FCC by its bright brown colour tone as reported by Sahai *et al.*,(1985) and Sudhakar *et al.*,(1992). The detected areas of this plantation as seen in the zoomed digital output have clearly correlated with their actual sites on the ground (Plate 9a & 9b).

The second category comprising of Acacia spp. has occupied mainly the woodlots and community land. Photographs a and b in plate 10 exhibit the digital output of woodlots and ground truth of Acacia plantation in it. The area occupied by Acacia plantation was only 318 ha. although in reality it was observed quite often during the field study. This variation was mainly due to the occurrence of plantations in small patches which could not be delineated using remote sensing in the limited spatial resolution of the imagery used (Pant, 1993, Sudhakar *et al.*, 1992) and mixing of these plantation with mixed spp. category. Singh, (1988) and Kachhwaha (1990) have successfully categorised the Acacia catechu dominant forest using Landsat TM and MSS respectively in the forest area. Similarly, Tiwari *et al.*, (1990) and Sudhakar *et al.*, (1992) have classified the Acacia spp. using Landsat MSS and IRS LISS-II respectively in the nonforest area. The village-wise distribution clearly depicted three

Table 17. Village-wise distribution of social forestry plantation computed from IRS digital data for MATAR taluka (in ha)

Sr No.	Village name	Eucalyptus plantation	Acacia plantation	Mixed plantation
1	2	3	4	5
1	DHARODA	8.29	1.55	1.55
2	KATHWADA	-	-	2.57
3	NAVAGAM	2.33	-	13.44
4	PINGLAJ	12.12	11.12	14.61
5	KANERA	24.88	2.55	12.46
6	MALARPURA	1.48	1.91	6.41
7	VAIKUNTHPURA	-	-	1.55
8	KAJIPURA	14.53	1.55	-
9	GOBHALAJ	5.31	-	-
10	PANSOLI	-	-	-
11	CHALINDRA	1.94	-	-
12	CHITRASAR	8.16	-	3.51
13	NAIKA	22.44	2.20	-
14	BHERI	1.94	-	-
15	DHATHAL	-	-	1.55
16	VADALA	-	-	1.93
17	HARIYALA	84.36	1.55	8.31
18	VAVDI	15.34	-	1.51
19	DAMRI	8.71	6.41	16.54
20	GOVINDAPURA	6.99	1.38	-
21	KALOLI	24.88	1.55	2.46
22	SHETRA	-	1.94	-
23	VASNA BUJARG	31.88	1.64	24.36
24	SOKHDA	2.46	-	14.32
25	VANSAR	13.21	24.5	12.46
26	RATANPUR	25.27	2.46	22.20
27	ANTROLI	99.79	9.64	18.14
28	HAJARABAD	73.74	3.04	52.67

1	2	3	4	5
29	SANDHANA	75.81	4.53	75.81
30	RADHVANJ	76.98	2.07	59.61
31	UNDHELA	87.83	7.64	153.05
32	MATAR	63.00	6.99	14.66
33	PIPARIA	10.22	-	11.11
34	KOSHIAL	16.35	-	4.66
35	CHANDNA	13.41	8.71	16.41
36	RADHU	122.12	18.15	88.38
37	RASIKPURA	12.10	3.71	14.68
38	VARSANG	12.18	1.19	4.14
39	MAHELAJ	19.82	2.77	2.46
40	TRAJ	28.64	8.03	6.60
41	GARMALA	28.72	15.16	29.80
42	KHADIYARPURA	41.21	6.41	2.71
43	UNTAL	4.92	1.64	4.66
44	ALINDRA	110.50	3.36	77.88
45	SIHOLDI	78.79	2.85	12.57
46	MALIYAIAJ	76.72	2.59	6.35
47	HERANJ	148.61	36.39	16.32
48	MACHHIEL	24.62	31.75	12.31
49	ASLALI	26.17	8.81	8.94
50	PUNAJ	2.1	-	-
51	KUNJARA	2.46	-	-
52	BARODA	14.38	-	18.92
53	PALLA	5.31	-	3.49
54	ASAMALI	22.68	-	8.42
55	NADHANPUR	3.11	1.81	-
56	KHARENTI	1.31	-	3.71
57	TRAMKA	17.23	-	6.35
58	KATHODA	20.47	4.66	5.83
59	KHANDHLI	32.52	5.31	46.39
60	LAVAL	40.00	-	63.11
61	NANDOLI	23.67	-	16.97

1	2	3	4	5
62	NAGRAMA	32.52	5.31	17.10
63	MARALA	-	1.29	-
64	LIMBASI	-	1.29	-
65	MEHMEDABAD	-	9.72	-
66	VASTANA	-	2.33	-
67	CHANOR	1.03	1.94	-
68	SHEKHPUR	4.01	-	1.16
69	RANASAR	2.41	-	3.12
70	MALAWADA	-	1.29	-
71	DETHLI	61.41	4.07	3.75
72	VASAI	-	2.14	-
73	BHALADA	35.12	4.27	4.40
74	SAYLA	21.25	-	-
75	INDARVARNA	-	-	-
76	HADEVA	2.59	1.09	7.76
77	VALOTRI	-	-	1.29
78	DALOLI	1.12	-	1.12
79	VIROJA	6.89	1.69	-
80	BAMANGAM	-	-	-
81	PARIEJ	2.59	2.41	-
82	SINJIWADA	4.53	-	1.81
	TOTAL	1926	318	1069
	TOTAL GEOGRAPHICAL AREA IN PER CENT	3.41	0.56	1.89

PLATE 9 a

Zoomed digital output of Eucalyptus plantations acquired from digital data.

PLATE 9 b

Eucalyptus plantations in a field near village Traj.

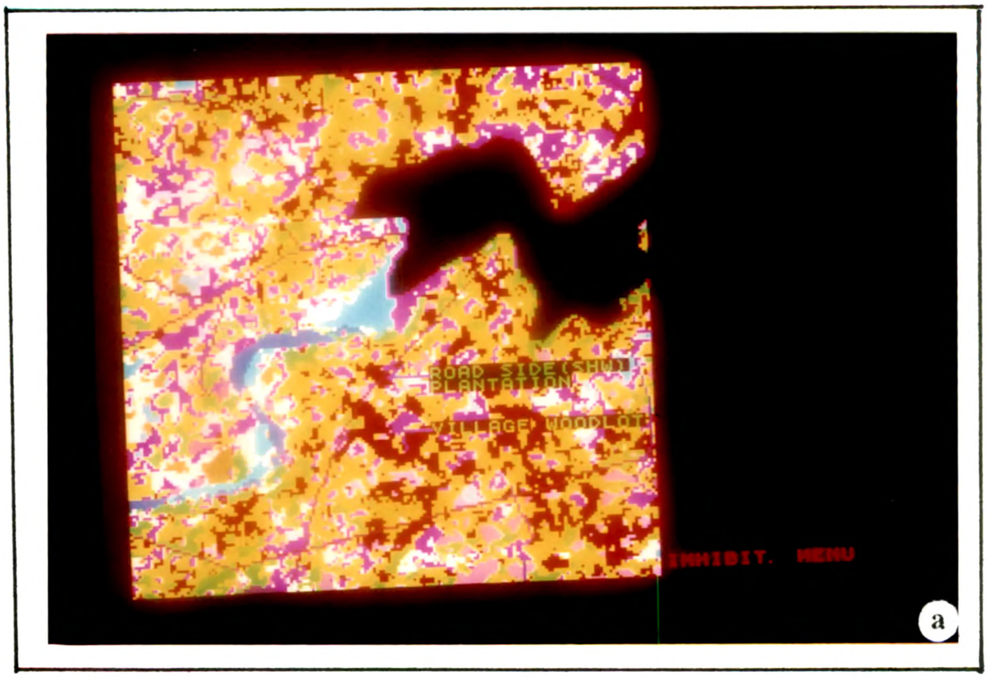


PLATE 9

PLATE 10 a

Digital enlarged output exhibiting Acacia plantation (pink) in a woodlot near Matar.

PLATE 10 b

Correlation of the above detected area on the ground.

* The arows indicate Matar-Kehda road passing through the woodlot.


LEGEND
S. F. /R. S. PROJ
MATAR TALUKA
DEPARTMENT OF
BOTANY, BARODA
VILLAGE WOODLOT
ENLARGED VIEW
OF VILLAGE
WOODLOT
RRSSC-J
a


b

PLATE 10

villages having more than 10% of Acacia plantation.

The third category namely mixed spp. is comprised of different species of Dalbergia, Acacia, Psidium, Ziziphus, Peltophorum, Albizzia etc. (Plate 11). These were not spectrally seperable and hence remained unclassified. Similar observations were reported by Kachhwaha (1990) from the studies made on the U.P. forest area. Natarajan (1992) and Kachhwaha (1992) have also classified the mixed or miscellaneous forest in U.P. In the present study these plantation were distributed mainly in the central and eastern side of the taluka covering an area of 1069 ha. The village-wise distribution of these plantations showed that villages namely, Haijerabad, Radhvanaj, Undhela, Alindra and Laval are occupied with more than 10% of such plantation.

The accuracy estimated for all the above three categories viz., Eucalyptus spp., Acacia spp. and mixed spp. was 100%, 85% and 93% respectively at 90% confidence level. (Table 18). The overall accuracy showed about 92.15% at 90% confidence level.

5.2.2 Wasteland Mapping

An attempt was made to map and assess the wasteland categories based on Soil Brightness Index (SBI) output, tonal variation of FCC, digital number obtained from the satellite data and field observation. This has brought out three different categories viz., waterlogged, pasture/grazing and three different salt affected soil, viz., strongly, moderately and slightly (Plate 12). Several workers have successfully classified the salt affected land into different categories. For instance, Venkatratnam (1984) categorised the salt affected land into two categories, Mothikumar (1992) into three categories and Gore and Bhagwat (1991) into six categories.

The SBI output given in the plate 13 . clearly shows the three categories of soil namely salt affected, waterlogged and normal soil indicated as red, yellow, and green respectively based on their brightness. Kauth and Thomas (1976) and Gore (1992) have also used such index for the categorisation of degraded land.

On the other hand the digital numbers for different wasteland categories were also noted from IRS digital data. Implicit in this approach is the premise that the different soil classes manifest different combinations of digital number values based on the inherent spectral reflectance properties, attributable to their physical make up and chemical constituents (Montogromery and Baumgardner, 1974). This is evident from the spectral reflectance values

PLATE 11

Mixed plantation in village commonland near Limbasi.

PLATE 11

Table 18. Summary of commission and omission errors of IRS digital data for social forestry plantations

Plantation	Omission Errors		Commission Errors		Correct	
Types	Total	Per cent	Total	Per cent	Total	Per cent
Eucalyptus spp.	0.0	0.0	0.0	0.0	20.0	100.0
Acacia spp.	0.0	0.0	3.0	15.0	16.0	85.0
Mixed spp.	3.0	15.0	1.0	6.2	15.0	93.8

Overall accuracy 92.15 at 90% confidence level.

PLATE 12

Wasteland categories in the study area generated through Supervised classification algorithm.

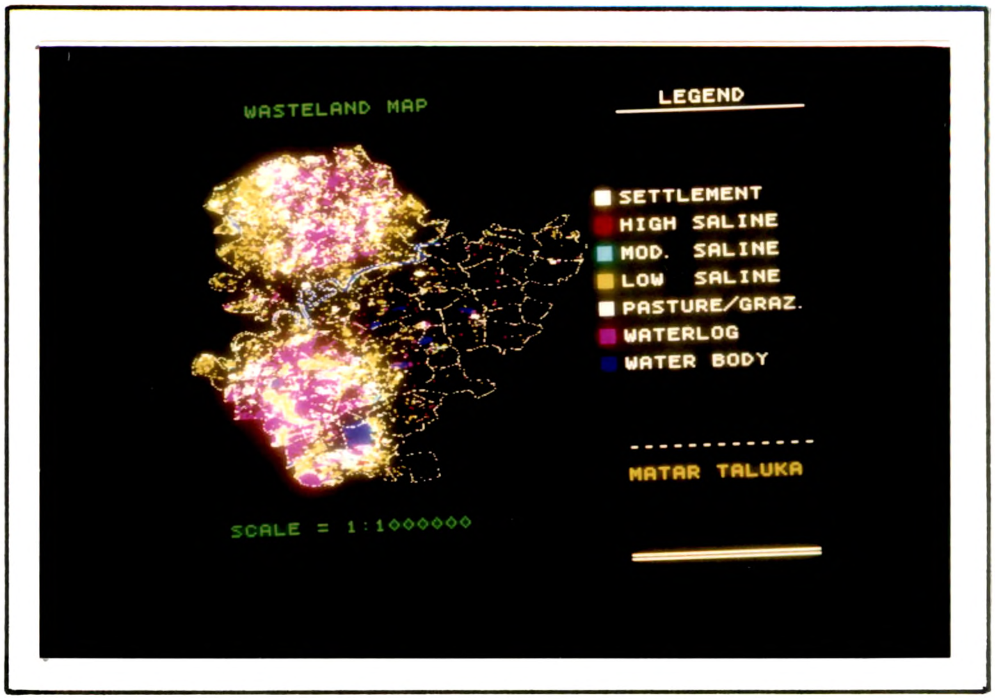

WASTELAND MAP
LEGEND
SETTLEMENT
HIGH SALINE
MOD. SALINE
LOW SALINE
PASTURE/GRAZ.
WATERLOG
WATER BODY
MATAR TALUKA
SCALE = 1:1000000

PLATE 12

PLATE 13

Soil Brightness Index (SBI) output of the study area depicting different levels of soil degradation viz., strongly and moderately salt affected as red, waterlogged and slightly salt affected as yellow. The normal soil is exhibited as green.


LEGEND
SOIL
BRIGHTNESS
INDEX
IRS - 1 A
LISS II
A1 & A2
23. 03. 1991
S. F. /R. S. PROJ
DEPARTMENT OF
BOTANY, BARODA
RRSSC-J

PLATE 13

of the wasteland studied in terms of mean digital number values as shown in fig. 18. The graph clearly exhibits a decrease in reflectance pattern from highly salt affected soils to slightly salt affected soils. The higher reflectance in the salt affected soil is due to data being of the March month when the salt encrustations are clearly seen (Saxena *et al* ., 1991). Venkatratnam and Ravishankar (1992) also made similar observations for the degraded lands in Mainpuri district of U.P.

The overlay of taluka map with village boundaries gave precisely the distribution of different categories of wastelands in the study area. Based on the potential to support the vegetative growth all the wasteland categories could be mainly grouped under culturable wastelands. The area under these categories is about 16253 ha. i.e., about 28.38% of the total geographical area of the taluka. The village-wise distribution of these wastelands clearly brought out that out of the 82 villages of the taluka, the number of villages having wastelands greater than 20%, 10% and 5% are 22, 13 and 9 respectively (Table 19).

The salt affected lands have amounted to more than 40% of the total wasteland. It is also seen that the area covered by these lands was in the order of slightly > moderately > strongly salt affected soil i.e., 88.27%, 9.33% and 2.40% of total wastelands respectively. The strongly salt affected soil appeared on the FCC as bright white patches which are seen mainly distributed in the villages around the MRBC command area and Pariej tank. These include the Pariej, Inderverna, Bamangam, Chanor, Daloli etc. This has also confirmed the occurrence of salt affected lands due to improper irrigation methods. Several workers have proved the emergence of salt affected lands due to improper land and water management practices before implemention of irrigation schemes (Kalubarme *et al* ., 1983; Bapat, 1988). The moderately salt affected soils were found in areas adjacent to the highly salt affected land and appeared as dull white colour patches on FCC. Photographs a and b in plate 14 show the positive correlation between highly and moderately salt affected soils around the Pariej tank, in the digital output correlating

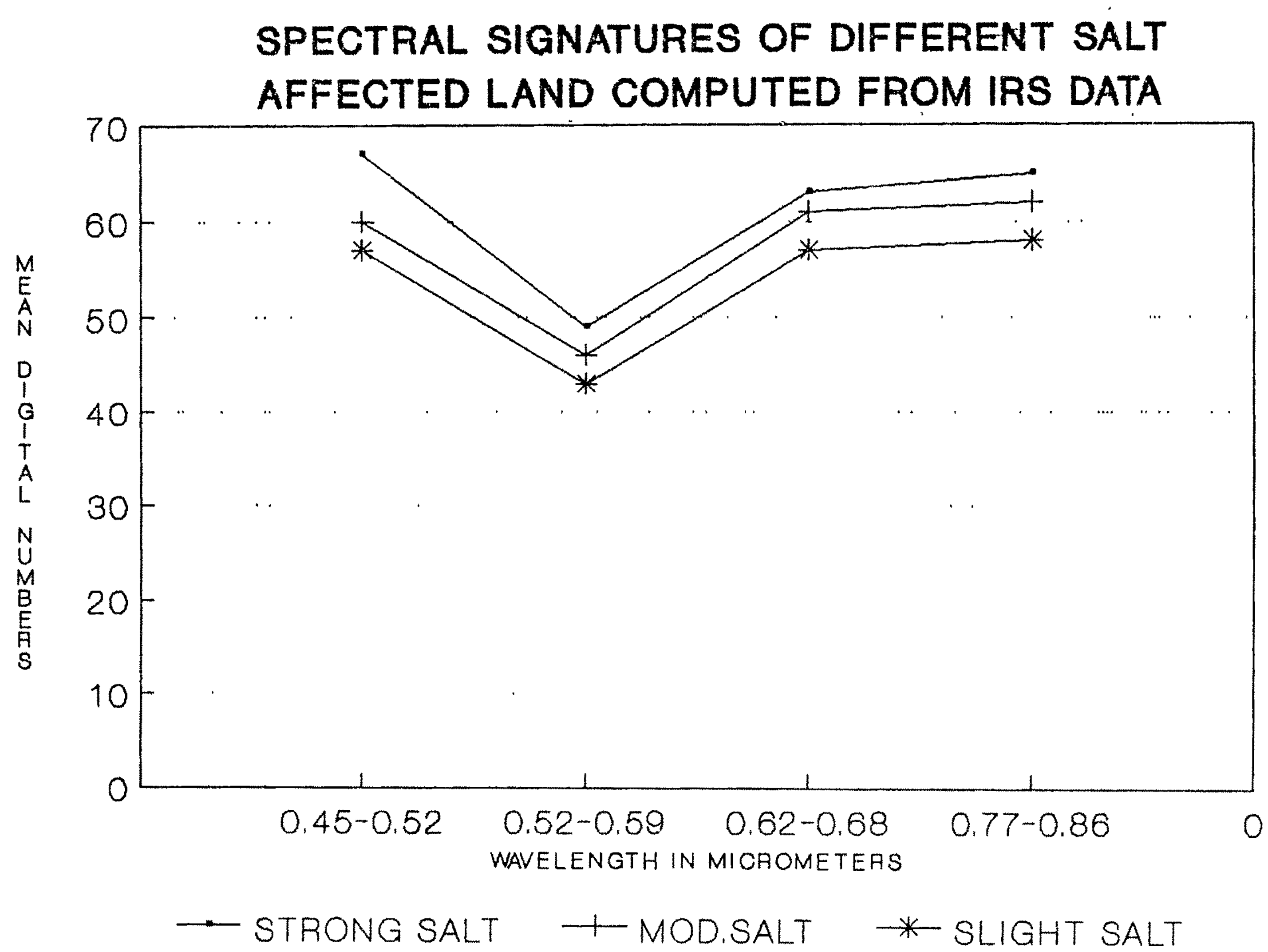

SPECTRAL SIGNATURES OF DIFFERENT SALT
AFFECTED LAND COMPUTED FROM IRS DATA
MEAN DIGITAL NUMBERS
70
60
50
40
30
20
10
0
0.45-0.52
0.52-0.59
0.62-0.68
0.77-0.86
0
WAVELENGTH IN MICROMETERS
STRONG SALT
MOD.SALT
SLIGHT SALT

FIGURE : 18

Table 19. Village-wise distribution of different wasteland categories (in ha) computed from IRS digital data

Sr. No.	Village name	Strongly salt affected	Moderately salt affected	Slightly salt affected	Waterlogged	Pasture/ grazing
1	2	3	4	5	6	7
1	DHARODA	-	10.51	83.42	23.21	143.81
2	KATHWADA	-	-	94.32	115.89	258.01
3	NAVAGAM	-	3.24	68.55	96.75	186.23
4	PINGLAJ	-	2.59	130.06	78.92	86.70
5	KANERA	-	-	83.59	-	114.41
6	MALARPURA	-	5.7	61.81	4.79	129.16
7	VAIKUNTHPURA	-	-	-	10.75	10.12
8	KAJIPURA	-	-	77.76	8.53	141.45
9	GOBHALAJ	-	-	67.20	120.61	106.91
10	PANSOLI	-	-	-	-	23.97
11	CHALINDRA	-	-	162.85	75.29	217.33
12	CHITRASAR	-	9.07	190.25	23.06	72.83
13	NAIKA	-	1.16	228.60	-	203.81
14	BHERI	-	-	22.16	97.45	67.01
15	DHATHAL	-	-	-	40.17	189.53
16	VADALA	-	-	-	-	13.21
17	HARIYALA	-	-	-	-	-
18	VAVDI	-	-	23.58	14.10	59.76
19	DAMRI	-	-	96.99	37.06	48.08
20	GOVINDAPURA	-	-	170.01	22.03	66.74
21	KALOLI	-	5.18	-	12.96	32.65
22	SHETRA	-	-	73.53	-	23.97
23	VASNA BUJARG	-	-	42.50	18.53	135.82

1	2	3	4	5	6	7
24	SOKHDA	-	-	14.32	-	14.64
25	VANSAR	-	-	-	-	10.90
26	RATHANPUR	-	-	-	-	7.38
27	ANTROLI	-	-	-	-	7.38
28	HAJARABAD	-	-	-	-	50.10
29	SANDHANA	-	-	112.1	-	52.16
30	RADHVANJ	-	-	-	-	2.16
31	UNDHELA	-	-	20.1	25.70	5.40
32	MATAR	-	-	12.05	-	16.86
33	PIPARIA	-	-	-	26.35	8.42
34	KOSHIAL	-	-	112.05	-	16.86
35	CHANDNA	-	-	46.41	-	37.32
36	RADHU	-	2.20	101.60	73.20	93.52
37	RASIKPURA	-	-	-	-	14.73
38	VARSANG	-	1.90	73.87	167.10	364.73
39	MAHELAJ	1.38	2.23	38.62	-	57.51
40	TRAJ	-	1.77	181.90	218.66	14.12
41	GARMALA	-	1.90	69.05	-	44.12
42	KHADIYARPURA	-	10.10	98.92	24.92	3.88
43	UNTAL	-	-	-	-	51.12
44	ALINDRA	-	-	40.12	-	-
45	SIHOLDI	-	-	-	-	4.32
46	MALIYAIAJ	-	-	-	-	53.14
47	HERANJ	-	-	-	49.33	52.96
48	MACHHIEL	-	-	-	-	-
49	ASLALI	-	1.12	67.13	122.55	57.49
50	PUNAJ	-	-	31.32	14.71	31.76
51	KUNJARA	-	4.32	49.43	44.72	11.41
52	BARODA	-	1.55	80.74	157.75	48.10
53	PALLA	-	1.76	29.93	101.29	12.57
54	ASAMALI	6.7	9.84	289.40	111.32	243.30
55	NADHANPUR	2.01	1.16	98.62	408.40	91.40
56	KHARENTI	-	-	41.41	72.41	31.33

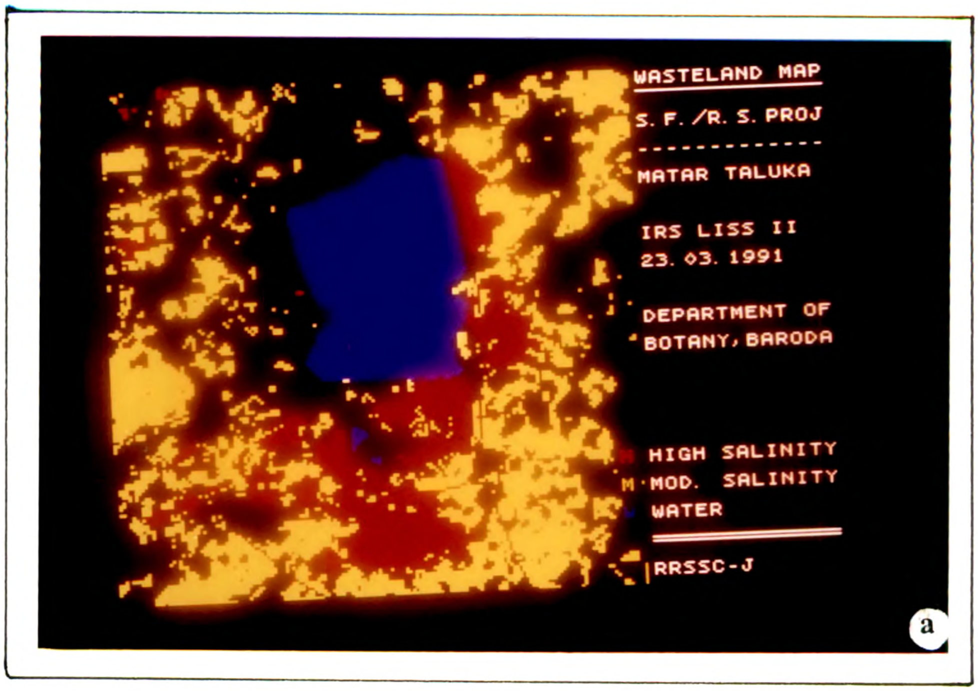
1	2	3	4	5	6	7
57	TRANJA	-	2.25	72.18	46.22	22.42
58	KATHODA	-	-	-	16.35	7.34
59	KHANDHLI	-	1.19	148.92	4.92	3.88
60	LAVAL	-	2.10	-	-	10.77
61	NANDOLI	1.51	5.70	128.16	53.78	3.88
62	NAGRAMA	0.50	4.25	91.04	-	27.08
63	MARALA	-	14.20	-	44.32	19.37
64	LIMBASI	2.38	13.47	384.60	263.21	353.34
65	MEHMEDABAD	10.10	31.40	66.82	105.75	51.92
66	VASTANA	1.19	14.77	216.89	313.63	142.04
67	CHANOR	4.30	13.71	150.54	311.81	103.93
68	SHEKHPUR	3.77	10.34	25.27	73.40	49.11
69	RANASAR	1.10	11.27	61.43	16.72	19.22
70	MALAWADA	-	2.25	61.04	24.23	27.08
71	DETHLI	-	-	-	-	41.42
72	VASAI	-	-	15.14	34.71	16.73
73	BHALADA	1.51	10.77	256.37	59.84	31.49
74	SAYLA	9.10	15.40	60.36	49.85	7.25
75	INDARVARNA	14.12	34.29	83.80	224.61	74.64
76	HADEVA	2.40	21.29	64.02	59.05	14.37
77	VALOTRI	3.18	29.46	125.96	335.20	103.55
78	DALOLI	22.12	52.10	14.76	149.64	51.21
79	VIROJA	1.42	33.34	41.12	69.59	72.57
80	BAMANGAM	4.66	69.16	240.78	265.85	210.08
81	PARIEJ	62.01	126.60	42.45	105.80	126.36
82	SINJIWADA	1.10	10.10	112.83	52.72	2.98
	TOTAL AREA	156.00	607.00	5736.00	5105.00	4649.00
	TOTAL GEOGRAPHIC AREA IN %	0.27	1.07	10.18	9.05	8.24

PLATE 14 a

Zoomed supervised image showing salt affected soil around Pariej tank (blue coloured).

PLATE 14 b

The invivo condition of the above delienated land.


WASTELAND MAP
S. F. /R. S. PROJ
MATAR TALUKA
IRS LISS II
23. 03. 1991
DEPARTMENT OF
BOTANY, BARODA
HIGH SALINITY
MOD. SALINITY
WATER
RRSSC-J
a

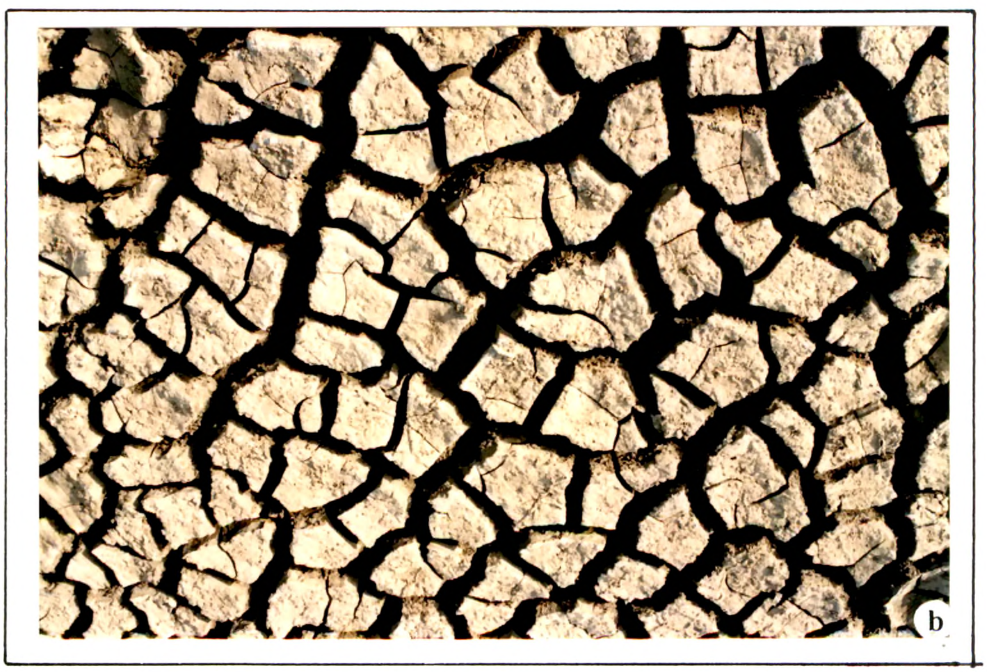

b

PLATE 14

with the ground area.

The slightly salt affected soils constituted a major portion when compared to other categories of wasteland and appeared as dull white patches with red tinge on FCC. It was also found that the waterlogged soil with different shades of blue on FCC are found interspersed with salt affected soil. The main reason for the cause of waterlogging is the implementation of MRBC system in 1958, which transformed the fertile soils into wet deserts (Kalubarme *et al.*, 1983). Such transformation of fertile soils into wet deserts have also been observed by Bapat (1985) in Kakrapar area of South Gujarat. Photographs a and b in plate 15 exhibit the enlarged digital output of waterlogged areas correlating with ground view. The slightly salt affected and waterlogged areas form the priority areas for reclamative measure. These are the areas which are prone to become strongly salt affected land in posterity.

The last category of pasture/grazing land are located mainly on the northern portion of the taluka (Plate 16). These are considered as potential areas for taking appropriate afforestation measures to restore the ecological balance in the taluka. The accuracy estimated for all the above categories clearly exhibited 91.7%, 100%, 90.5%, 100% and 87.5% for strongly, moderately, slightly salt affected, waterlogged and pasture/grazing land respectively at 90% confidence level (Table 20).

5.2.3 Soil Analysis

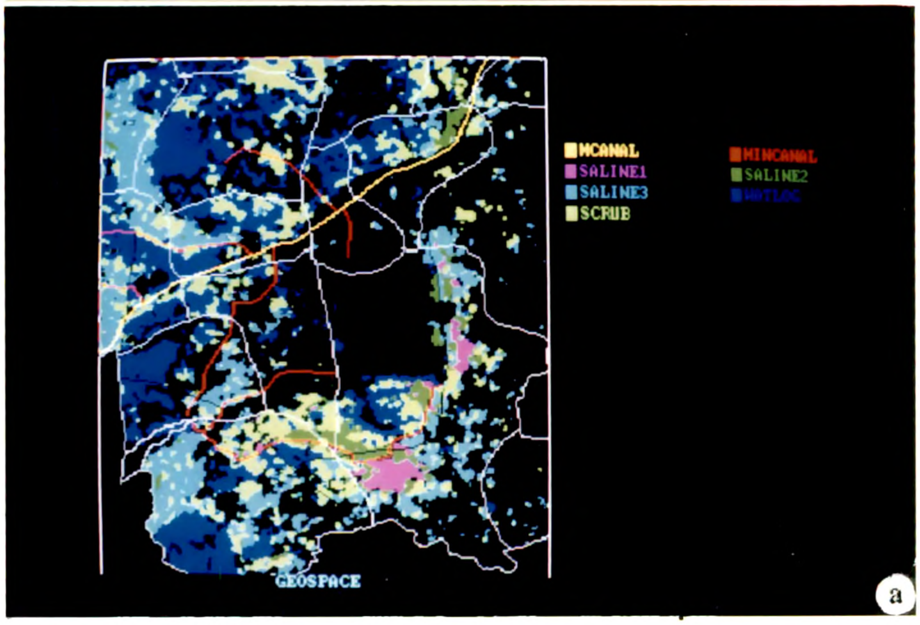
The soil samples collected from different wasteland categories and analysed in the laboratory have brought out some striking results. The analysis clearly showed a positive correlation with the soil ionic status and the wasteland categories. The physical characteristics of the soil varied for the different categories of wastelands. Texturally, the soil of all these categories ranged from clay to sandy with soil type being very deep. Physiography is fairly leveled but there are two large areas of depression in both the northern and the southern part of the taluka.

PLATE 15 a

Enlarged digital scene of the waterlogged area alongwith canal network.

PLATE 15 b

A ground view of waterlogged area with the dominance of the weed Typha angustata.


MCANAL
SALINE1
SALINE3
SCRUB
MINCANAL
SALINE2
WATLOG
GEOSPACE
a


b

PLATE 15

PLATE 16

Picture exhibiting pasture/grazing cover in the study area.

PLATE 16

Table 20. Summary of commission and omission errors of IRS digital data for wasteland categories

Wasteland Categories	Omission Errors Total	Omission Errors Per cent	Commission Errors Total	Commission Errors Per cent	Correct Total	Correct Per cent
Pasture/grazing	1	7.1	2	12.5	14	87.5
Strongly salt affected	1	8.3	1	8.4	11	91.6
Moderately salt affected	1	8.3	0	0.0	13	100.0
Slightly salt affected	0	0.0	2	9.5	19	90.5
Waterlogged	2	9.5	0	0.0	15	100.0

Overall accuracy was 93.02% at 90% confidence level.

The detailed chemical analysis of different soils taken from a depth of 1-30 cm and 30-60 cm is shown in figures from 19 - 22. It was observed that the pH of soil was more than 8 with ECe and ESP less than 4dSm^{-1} and more than 15% respectively, for all the categories of salt affected soil at both the depths, confirming their sodic nature (Richards, 1968). The strongly salt affected soil had pH values ranging from 8.5 to 9.1, ECe from 2.1 to 2.6 dSm^{-1} and ESP from 21.5% to 23.4%.

The moderately salt affected soil had the pH values between 8.4 to 8.6, ECe ranging from 0.59 to 0.65 dSm $^{-1}$, and ESP between 19.8 to 21.7%. Similar correlation was also made by Venkatratanam and Ravishankar (1992) in Mainpuri district of U.P. On the other hand, the slightly salt affected soil showed the pH ranging from 8.0 to 8.25 with ECe and ESP between 0.6 to 0.75 dSm $^{-1}$ and 14.5 to 16.3% respectively. The ESP of all the above soils was significantly high. Pathak and Patel (1980) also made similar observation on the soils of this area. There is no much variation for pH, ECe, and ESP at different depths.

The ionic status of the soils showed the cationic content in the order of Na > Ca > Mg > K and anions like chloride, to be more than sulphates with trace of carbonates and bicarbonates in all the three categories of salt affected soils. Prabhu *et al* ., (1987) explained that due to the presence of high sodium concentration the permeability is lowered in soil with higher percentage of silt size particles. In general ionic status of these soils did not show much variations at different depth in the study area.

The analysis of the soils from the waterlogged category exhibited either the characteristics of slightly salt affected soil or moderately salt affected soil (Figs. 19 - 22), confirming these lands as potential areas for the development of salinity/sodicity. The chemical nature of the pasture/grazing land showed a normal soil ionic status (Figs. 19 - 22).

FIG. 19 SOIL CHARACTERISTICS OF DIFFERENT WASTELAND CATEGORIES (1–30cm Depth)

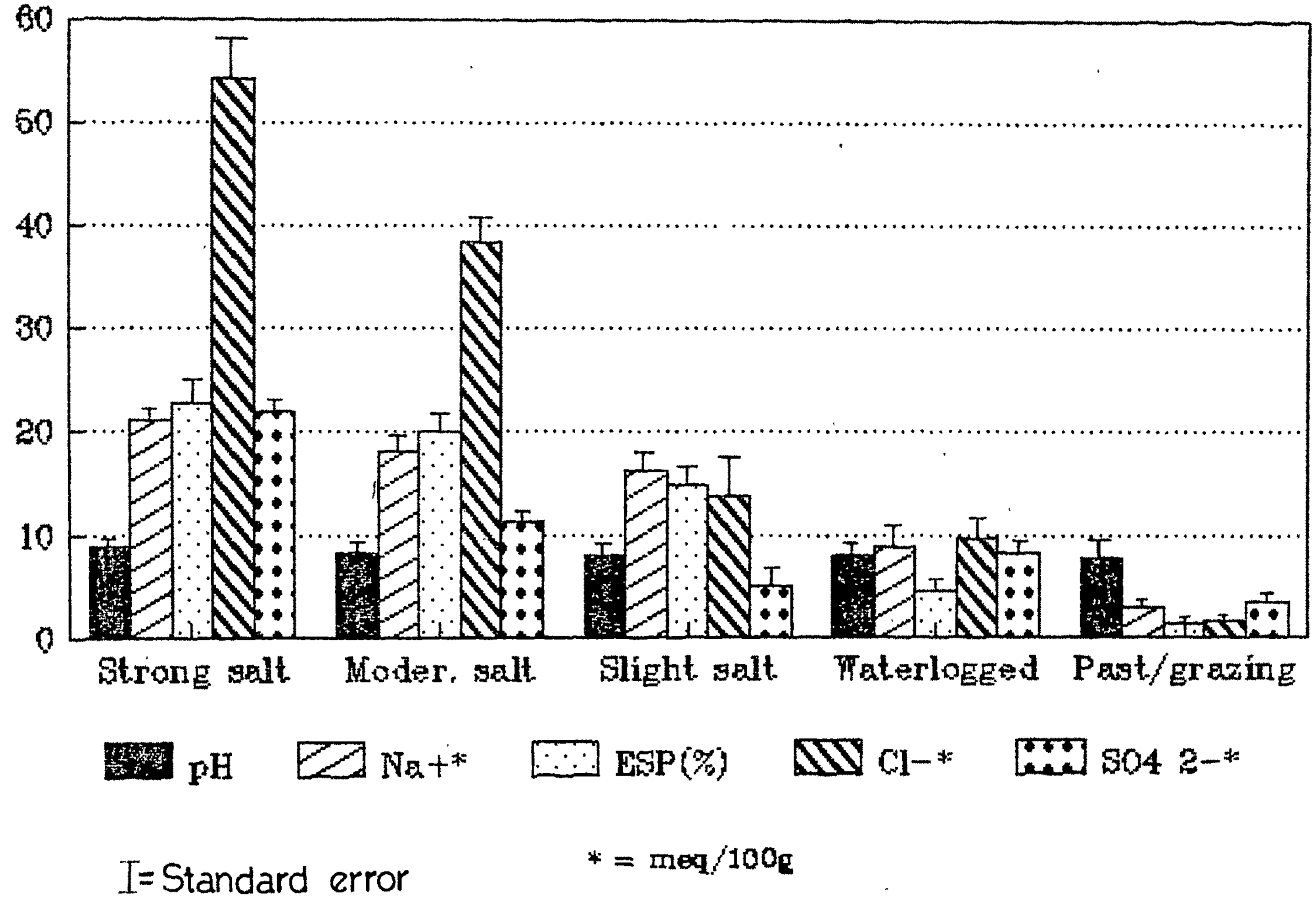


FIG. 20 SOIL CHARACTERISTICS OF DIFFERENT WASTELAND CATEGORIES (1–30cm Depth)

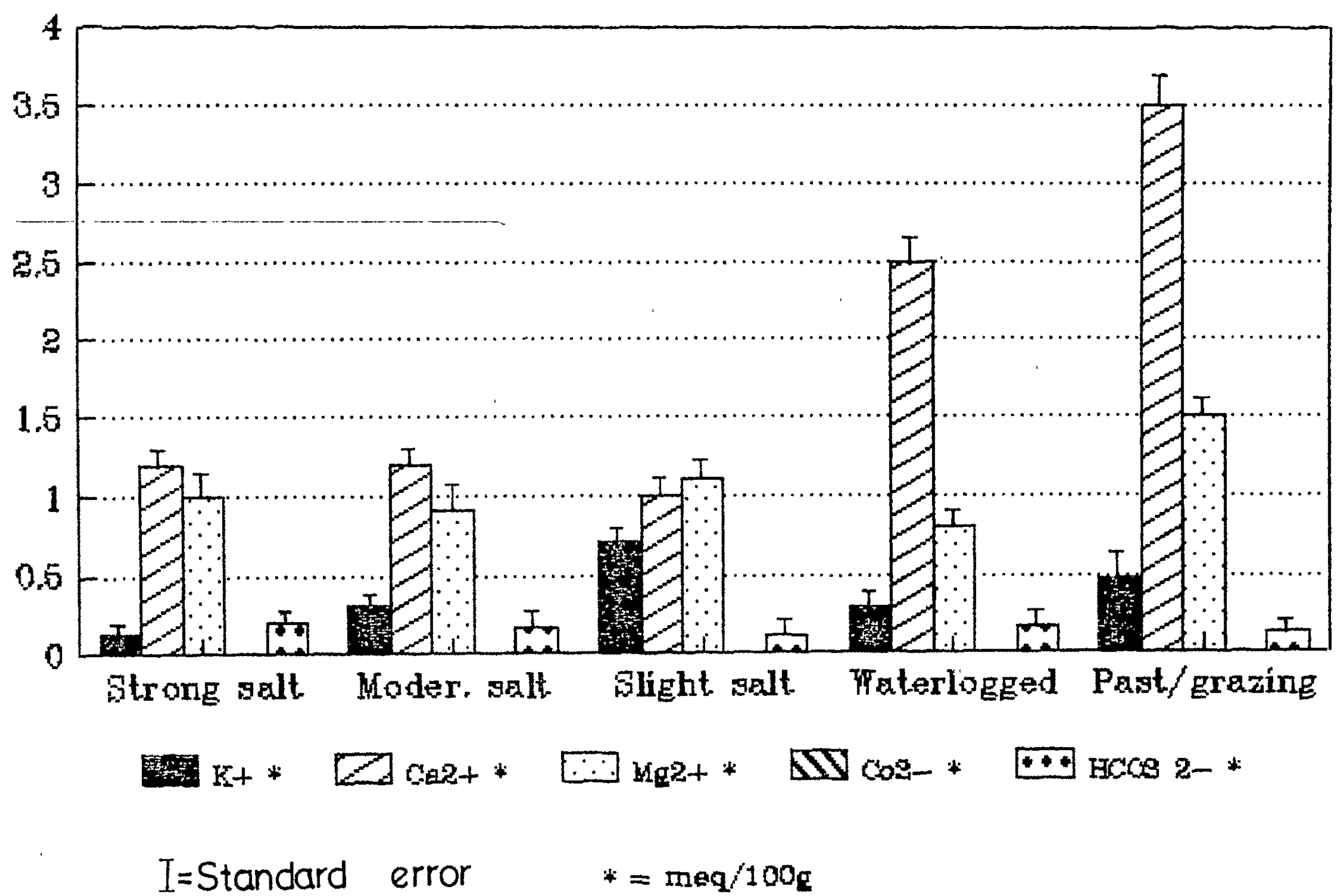


FIG. 21 SOIL CHARACTERISTICS OF
DIFFERENT WASTELAND CATEGORIES
(31–60cm Depth)

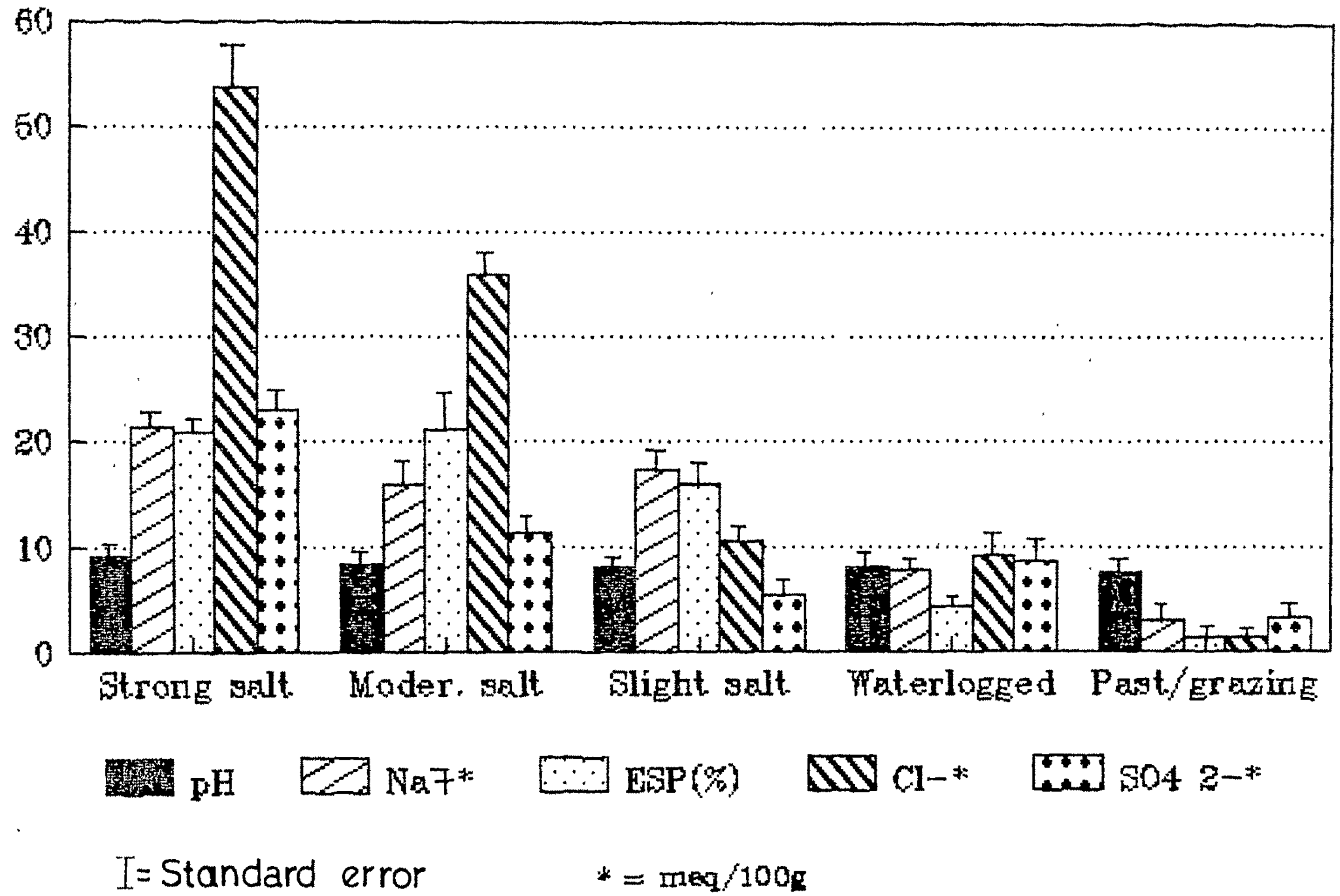
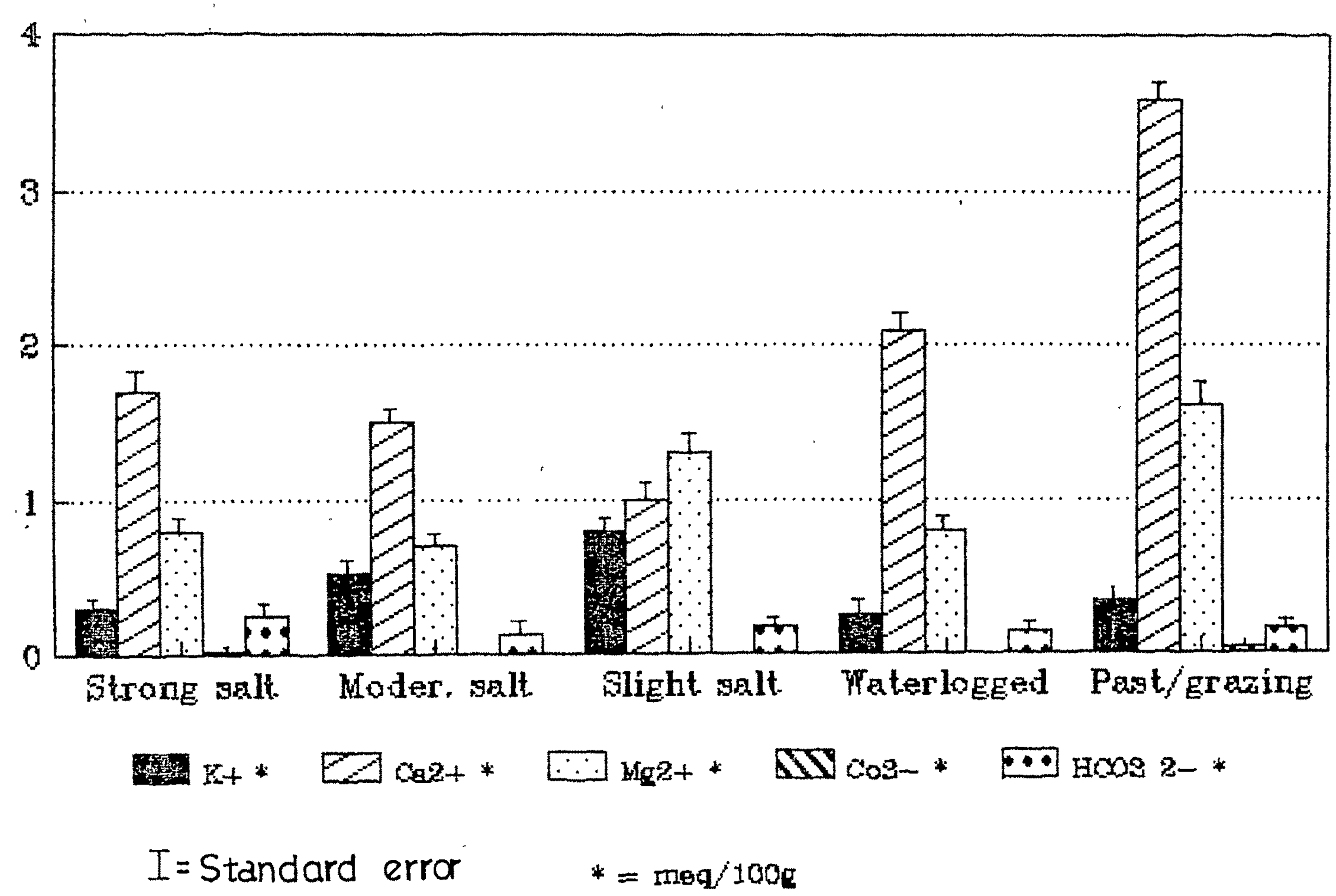


FIG. 22 SOIL CHARACTERISTICS OF DIFFERENT WASTELAND CATEGORIES (31–60cm Depth)



5.3 GEOGRAPHICAL INFORMATION SYSTEM

The integration of RS-GIS technology for the study of social forestry plantations has generated interesting and encouraging results. It clearly demonstrated the usefulness of RS-GIS in planning and managing the plantation in Matar taluka through its output in the form of site suitability map. Maps of different sources used for the production of this single map, were the land capability map, the need vs availability map and the wasteland map. The results from these maps yielded useful information and are discussed in the following paragraphs.

5.3.1 Land capability map

In order to identify the sustainable use of the land it is necessary to identify the capability of land and needs of the local population. Several workers have generated land capability for different natural resources such as for agriculture (Storie, 1964; Jere and Sridhar, 1993), for slope land management (XingHong and Hua, 1992) and for wasteland development (Rao, 1993). In the present study criterion based analysis was used in generating different categories of land capability in the study area viz., Good, Moderately Good, Moderately Poor and Poor alongwith water category depending on their limitations it holds (Plate 17). The overlaying of village boundaries gave a village-wise statistics of the land capability (Table 21).

The Good and Moderately Good capability classes were correlated with normal soil without salinity/alkalinity, well drained, excellent ground water prospects and silty loamy soils. On the other hand, the Moderately Poor and Poor classes were correlated with the land having salinity/alkalinity, waterlogging, poor drainage, and sandy texture of soil. These lands were mostly seen in the northern and southern parts of the taluka. The slope and soil depth though studied were not taken into account since no much variation were observed in these parameters all throughout the area. The area covered by these categories viz., Good, Moderately Good,

PLATE 17

Land capability map of Matar taluka developed through GIS.

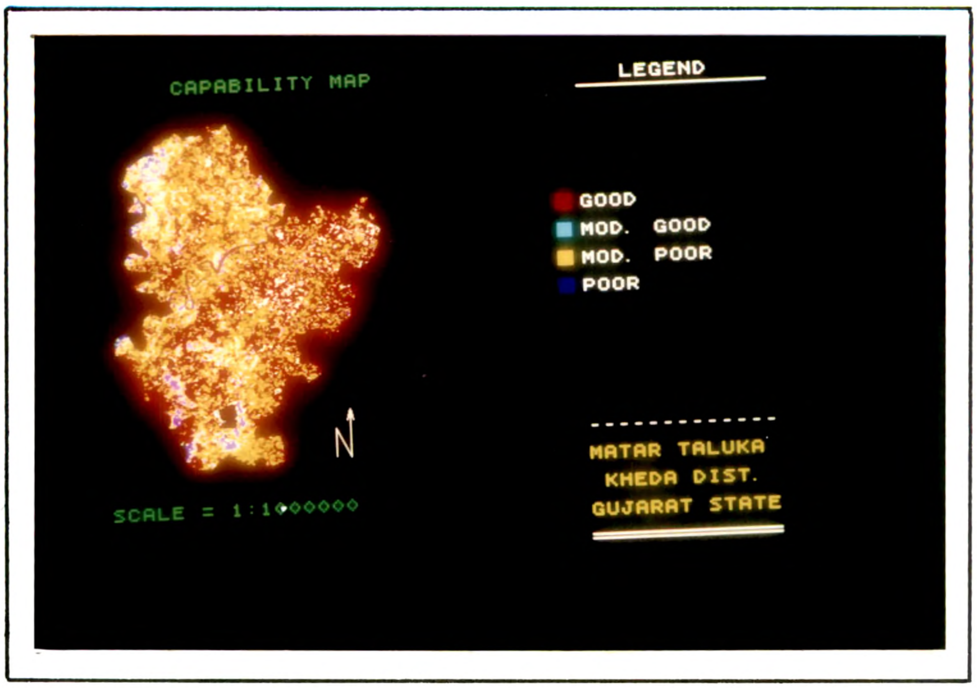

CAPABILITY MAP
LEGEND
GOOD
MOD. GOOD
MOD. POOR
POOR
MATAR TALUKA
KHEDA DIST.
GUJARAT STATE
SCALE = 1:1000000

PLATE 17

Table 21). Village-wise distribution of Land capability (in sq.kms.) in Matar taluka computed through GIS

Sr. No.	Village name	Good	Moderately Good	Moderately Poor	Poor
1	2	3	4	5	6
1	DHARODA	2.75	0.18	8.8	0.14
2	KATHWADA	5.31	0.33	1.58	0.99
3	NAVAGAM	3.94	-	0.7	1.71
4	PINGLAJ	1.95	0.24	0.64	0.4
5	KANERA	3.31	0.32	1.49	0.79
6	MALARPURA	1.89	0.19	0.5	0.39
7	VAIKUNTHPURA	0.31	-	1.27	-
8	KAJIPURA	0.84	0.16	0.4	-
9	GOBHALAJ	7.01	1.13	0.28	0.64
10	PANSOLI	1.36	0.51	1.69	-
11	CHALINDRA	3.31	0.24	2.49	0.95
12	CHITRASAR	4.01	0.47	2.16	1.53
13	NAIKA	12.94	0.51	6.43	0.8
14	BHERI	2.09	0.16	1.81	-
15	DHATHAL	1.31	0.21	0.91	0.89
16	VADALA	1.29	0.44	1.8	-
17	HARIYALA	8.31	0.41	5.63	0.7
18	VAVDI	1.97	0.16	1.31	0.86
19	DAMRI	2.09	-	2.09	-
20	GOVINDAPURA	1.21	0.21	0.87	0.89
21	KALOLI	4.34	0.29	3.9	1.67
22	SHETRA	3.20	0.21	1.10	-
23	VASNA BUJARG	6.44	0.14	2.16	0.52
24	SOKHDA	4.25	0.33	2.28	-
25	VANSAR	2.41	0.42	0.71	-

1	2	3	4	5	6
26	RATANPUR	5.34	0.23	0.50	-
27	ANTROLI	3.24	0.21	2.33	-
28	HAJARABAD	3.87	0.17	0.94	-
29	SANDHANA	6.60	0.52	4.10	-
30	RADHVANJ	3.79	0.11	0.77	-
31	UNDHELA	4.15	0.35	2.93	-
32	MATAR	10.36	0.41	3.11	1.73
33	PIPARIA	2.71	0.38	1.02	0.66
34	KOSHIAL	2.29	0.24	1.31	-
35	CHANDNA	2.54	0.11	1.09	0.47
36	RADHU	15.34	-	7.64	2.70
37	RASIKPURA	9.12	-	0.97	1.03
38	VARSANG	6.12	0.42	0.16	-
39	MAHELAJ	8.54	0.37	5.12	1.73
40	TRAJ	8.16	0.21	4.63	2.19
41	GARMALA	2.18	0.37	1.77	1.31
42	KHADIYARPURA	0.79	-	0.73	-
43	UNTAL	4.36	0.42	1.21	1.01
44	ALINDRA	-	-	1.49	-
45	SIHOLDI	1.96	-	-	-
46	MALIYAIAJ	2.49	-	1.37	0.62
47	HERANJ	6.93	-	-	-
48	MACHHIEL	2.16	-	2.34	0.49
49	ASLALI	1.66	0.24	0.91	-
50	PUNAJ	3.00	-	1.54	0.46
51	KUNJARA	1.64	-	0.91	0.37
52	BARODA	6.31	0.16	-	1.94
53	PALLA	1.56	0.34	1.52	-
54	ASAMALI	11.16	0.24	5.91	1.41
55	NADHANPUR	5.74	-	3.45	0.49
56	KHARENTI	7.12	0.16	2.01	-
57	TRAMKA	8.16	-	1.32	-
58	KATHODA	2.47	0.49	-	0.35
59	KHANDHLI	3.16	0.19	2.47	-

1	2	3	4	5	6
60	LAVAL	2.91	0.49	2.39	-
61	NANDOLI	2.41	0.39	1.31	0.12
62	NAGRAMA	1.71	0.11	1.31	1.08
63	MARALA	0.94	0.13	0.37	0.61
64	LIMBASI	12.49	0.17	7.19	1.65
65	MEHMEDABAD	1.64	0.37	0.81	0.79
66	VASTANA	-	0.19	2.31	3.21
67	CHANOR	2.15	-	3.44	1.16
68	SHEKHPUR	1.01	-	0.64	1.47
69	RANASAR	5.11	0.23	1.93	1.9
70	MALAWADA	2.76	0.11	3.44	2.24
71	DETHLI	4.01	-	3.31	0.94
72	VASAI	0.39	0.21	0.59	0.99
73	BHALADA	10.40	-	0.11	2.36
74	SAYLA	0.6	-	0.61	1.14
75	INDARVARNA	1.17	-	1.19	1.01
76	HADEVA	1.67	-	0.92	2.01
77	VALOTRI	1.01	0.16	0.64	0.39
78	DALOLI	1.72	0.17	0.96	1.59
79	VIROJA	1.12	0.19	1.16	1.72
80	BAMANGAM	7.15	-	1.41	1.73
81	PARIEJ	12.17	-	1.97	3.56
82	SINJIWADA	4.80	0.15	1.66	1.97
	TOTAL	336.3	17.80	158.01	62.14
	TOTAL GEOGRAPHICAL AREA IN %	58.27	3.08	27.37	10.79

Moderately Poor, Poor was about 58.2%, 3.08%, 27.37% and 10.79% of the total geographical area (Table 21).

5.3.2 Need vs Availability map

The requirement and availability analysis for fuelwood and fodder are given in the table 22. From the database it is evident that Matar, the headquarter of the taluka has got the highest requirement of fuel wood . This is related to the thick population of the town. While the lowest requirement for fuel wood is needed by Mehamadabad where the population is lowest. The highest and lowest requirement and availability of fodder was in Hariyala, and Dhathal villages respectively. The overall estimate exhibited that out of 82 villages, 21 villages have surplus, 10 villages have sufficient and 39 villages have scarcity of fuel and fodder based on the estimation done using requirement and availability studies in each village. (Plate 18).

5.3.3 Composite map

The composite map has broughtout four types of lands based on their decreasing degree of suitability viz., Highly or Mostly, Moderately, Less, and Least, for the better planning of social forestry plantation in Matar taluka (Plate 19). Similar suitability map for planning of various resources were developed by several workers. Jurracek (1988) developed land suitability map for potato in Nebraska, Chang *et al.*, (1988) for tea and pineapple in Taitang of Taiwan, Kuhad and Karwasra (1987) for wheat, paddy and sugarcane in Hariyana.

The overlay of wasteland map on the suitability map clearly broughtout a positive correlation between different classes of the suitability and different categories of wasteland. The pasture/grazing land and some slightly salt affected areas correlated with most and moderately suitable land whereas the area which were highly salt affected, moderately salt affected and waterlogged correlated with less and least suitable land.

Table 22. Fuel and Fodder Availability vs Requirement in Matar taluka (in tonnes/year)

Sr No.	Village Name	Fodder		Fuel	
		Requirement	Availability	Requirement	Availability
1	2	3	4	5	6
1	DHARODA	2042	1815	919	1540
2	KATHWADA	1058	203	765	270
3	NAVAGAM	1004	969	239	223
4	PINGLAJ	975	1049	1600	501
5	KANERA	317	1047	588	1645
6	MALARPURA	1447	2055	276	150
7	VAIKUNTHPURA	173	22	136	30
8	KAJIPURA	548	552	399	290
9	GOBHALAJ	770	476	883	678
10	PANSOLI	193	1105	243	390
11	CHALINDRA	132	2363	318	586
12	CHITRASAR	1015	1824	594	803
13	NAIKA	2021	1546	2492	612
14	BHERI	574	2126	392	658
15	DHATHAL	575	152	326	298
16	VADALA	455	1655	289	30
17	HARIYALA	3272	816	1677	1330
18	VAVDI	310	2899	353	556
19	DAMRI	753	2162	193	52
20	GOVINDAPURA	529	273	216	366
21	KALOLI	1943	1096	1064	570
22	SHETRA	530	1105	327	108
23	VASNA BUJARG	1129	943	1042	910
24	SOKHDA	1327	2760	991	234

1	2	3	4	5	6
25	VANSAR	159	213	787	558
26	RATANPUR	715	1977	1540	306
27	ANTROLI	1320	4290	926	1396
28	HAJARABAD	1091	945	660	2152
29	SANDHANA	1973	501	2024	2584
30	RADHVANJ	1025	960	696	1518
31	UNDHELA	1500	1285	1469	1436
32	MATAR	1121	3040	4345	2372
33	PIPARIA	576	570	886	588
34	KOSHIAL	737	2837	281	518
35	CHANDNA	665	2946	788	518
36	RADHU	2040	1989	3325	2618
37	RASIKPURA	245	1431	683	294
38	VARSANG	1131	981	764	918
39	MAHELAJ	1042	2737	1723	1268
40	TRAJ	1137	1437	1396	780
41	GARMALA	660	1637	648	684
42	KHADIYARPURA	710	1510	229	110
43	UNTAL	309	416	663	393
44	ALINDRA	1666	495	1338	1978
45	SIHOLDI	954	445	893	866
46	MALIYAIAJ	911	1929	1202	810
47	HERANJ	1492	209	719	966
48	MACHHIEL	942	1371	1011	614
49	ASLALI	349	2120	413	794
50	PUNAJ	497	546	325	312
51	KUNJARA	252	2426	109	394
52	BARODA	852	3364	772	1184
53	PALLA	1314	421	662	182
54	ASAMALI	1507	2519	1163	920
55	NADHANPUR	694	494	593	472

1	2	3	4	5	6
56	KHARENTI	619	419	684	280
57	TRAMKA	652	2542	531	442
58	KATHODA	402	1399	354	330
59	KHANDHLI	808	1386	1140	924
60	LAVAL	301	386	473	1184
61	NANDOLI	787	2029	620	510
62	NAGRAMA	324	284	199	300
63	MARALA	399	413	360	679
64	LIMBASI	704	1214	2493	1496
65	MEHMEDABAD	91	491	102	59
66	VASTANA	899	900	702	190
67	CHANOR	342	1654	237	200
68	SHEKHPUR	620	1385	443	220
69	RANASAR	399	490	250	414
70	MALAWADA	1411	2222	1108	1216
71	DETHLI	1711	1417	1659	960
72	VASAI	473	593	294	516
73	BHALADA	2103	3609	1908	690
74	SAYLA	747	2352	533	488
75	INDARVARNA	541	1989	287	114
76	HADEVA	453	1039	450	151
77	VALOTRI	643	2745	305	120
78	DALOLI	566	2784	437	192
79	VIROJA	706	506	1317	420
80	BAMANGAM	1044	915	734	204
81	PARIEJ	1605	247	1171	253
82	SINJIWADA	1441	1114	2333	198
	TOTAL	73469	115578	70548	54886

PLATE 18

Need vs availiability map for fuel and fodder - GIS output.

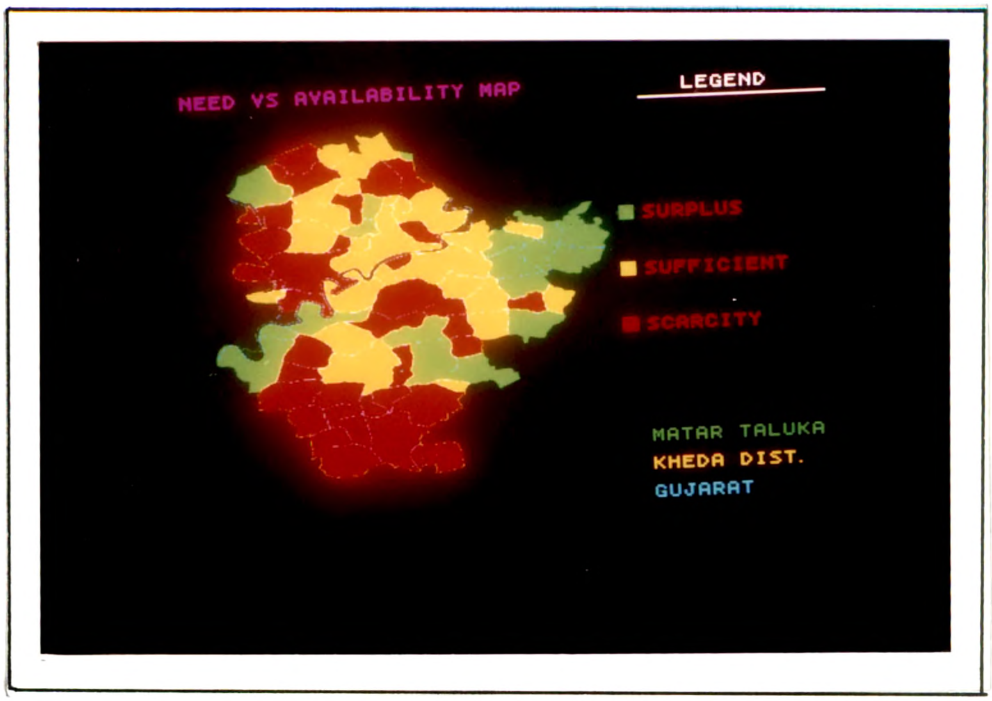

NEED VS AVAILABILITY MAP
LEGEND
SURPLUS
SUFFICIENT
SCARCITY
MATAR TALUKA
KHEDA DIST.
GUJARAT

PLATE 18

PLATE 19

Site suitability map specifically for wastelands produced using GIS.

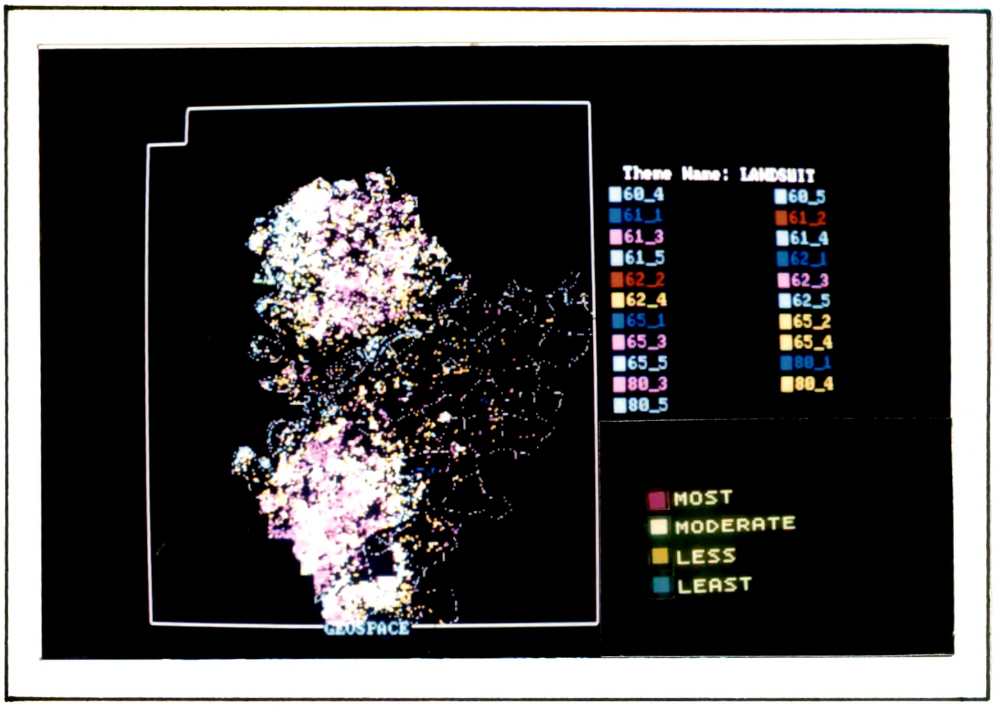

Theme Name: LANDSUIT
60_4
60_5
61_1
61_2
61_3
61_4
61_5
62_1
62_2
62_3
62_4
62_5
65_1
65_2
65_3
65_4
65_5
80_1
80_3
80_4
80_5
MOST
MODERATE
LESS
LEAST
GEOSPACE

PLATE 19

The most or highly suitable land has been prepared by combining good capability with scarcity of fuel and fodder. Any type of plant species based on the requirement of local inhabitants can be recommended in such areas. In second category i.e., moderately suitable land, similar species as in first category could be recommended, with some reclamative measures.

The less suitable land needed definite chemical or biological amendments. Only selected species which are tolerant to such conditions could be grown. Considering the limitation of the land and to fulfill the requirement of fuel and fodder for the local people spp. like Tamarindus indica, Acacia nilotica, Albizzia lebbeck, Zizyphus mauritiana, Leucaena leucocephala and Dalbergia sissoo could be recommended (Gill *et al.*, 1990). Finally the least suitable land needs major reclamative measures without which the plants cannot survive, except for some salt tolerent species like Prosopis chilensis, Prosopis juliflora, Casuraina equisetifolia, Tamarix aphylla and Ailanthus excelsa as suggested by Gill *et al.*, 1990.

Area calculated under the different suitability classes was about 52.29, 1.83, 56.94 and 38.08 sq.km. i.e., 9.06%, 0.31%, 10.33% and 6.59% of the total geographical area for highly, moderately, less and least suitable land respectively. The above results clearly broughtout that 16% of the land needed tremendous reclamation and remaining 10% can be utilised to fulfil the urgent requirement of rural populace.

From the above discussion, it is apparent that the integration of RS-GIS technology used for the studying of social forestry plantations and making of a planning model generated interesting and encouraging results. It clearly demonstrated the usefulness of RS-GIS for social forestry plantations management studies.