CHAPTER V
RESULTS

5.0 RESULTS:

IRS LISS III satellite data proved effective in bringing out different forest density classes of Narmada district, which comes in Rajpipla East Forest Division. For forest resource mapping at division level, Roy *et al.,* 1996 have suggested LISS III data to be most reliable data. Several other workers like Singh *et al.,* 2002, Natarajan *et al.,* 2004, Balaguru *et al.,* 2003, Porwal *et al.,* 2003, Jayakumar *et al.,* 2002 have advocated for the use LISS III data for different forestry related studies.

Forests of the study area are mainly of dry/moist deciduous type (Plate 3) and attain full foliage condition in the month of September (Plate 4). Since it is difficult to get a cloud free data for the month of September and thus October/ November was the best alternative to distinguish different forest classes from other landcover classes.

5.1 RS & GIS ANALYSIS:

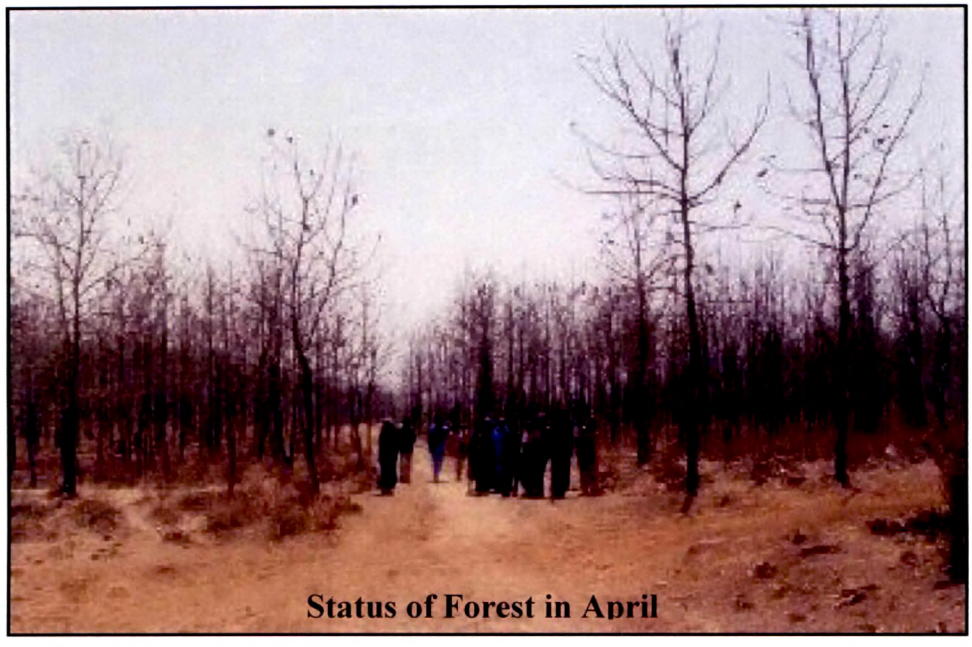
5.1.1 Spatial Frame Work:

The spatial frame work generated for the study area is depicted in plate 5.

5.1.2 Thematic Map Generation:

The major landuse/landcover features such as roads & rail network, settlements and forest boundary formed the benchmark for the precise location of the resources under the study. These features which are the major inputs helped in generation of thematic maps for the forest density classification as well as study of the JFM plantations. Forest map of the district generated from the SOI maps formed the base for the forest density classification (Plate 6). While for mapping of potential sites for JFM plantations and JFM mapping, thematic layers generated viz. forest map, settlements (Plate 7), Rivers and Streams (Plate 8) and road/rail network (Plate 9) formed the benchmark.

Plate 3. Major Forest Types of Study Area According to Champion & Sheth



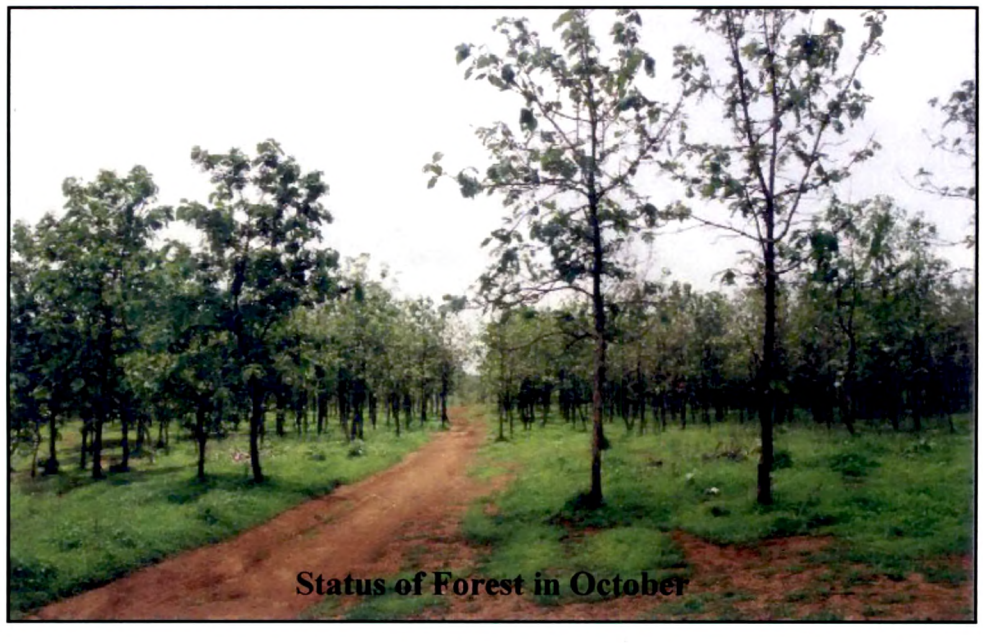


Plate 4. Seasonal Variation at the Same Forest Site

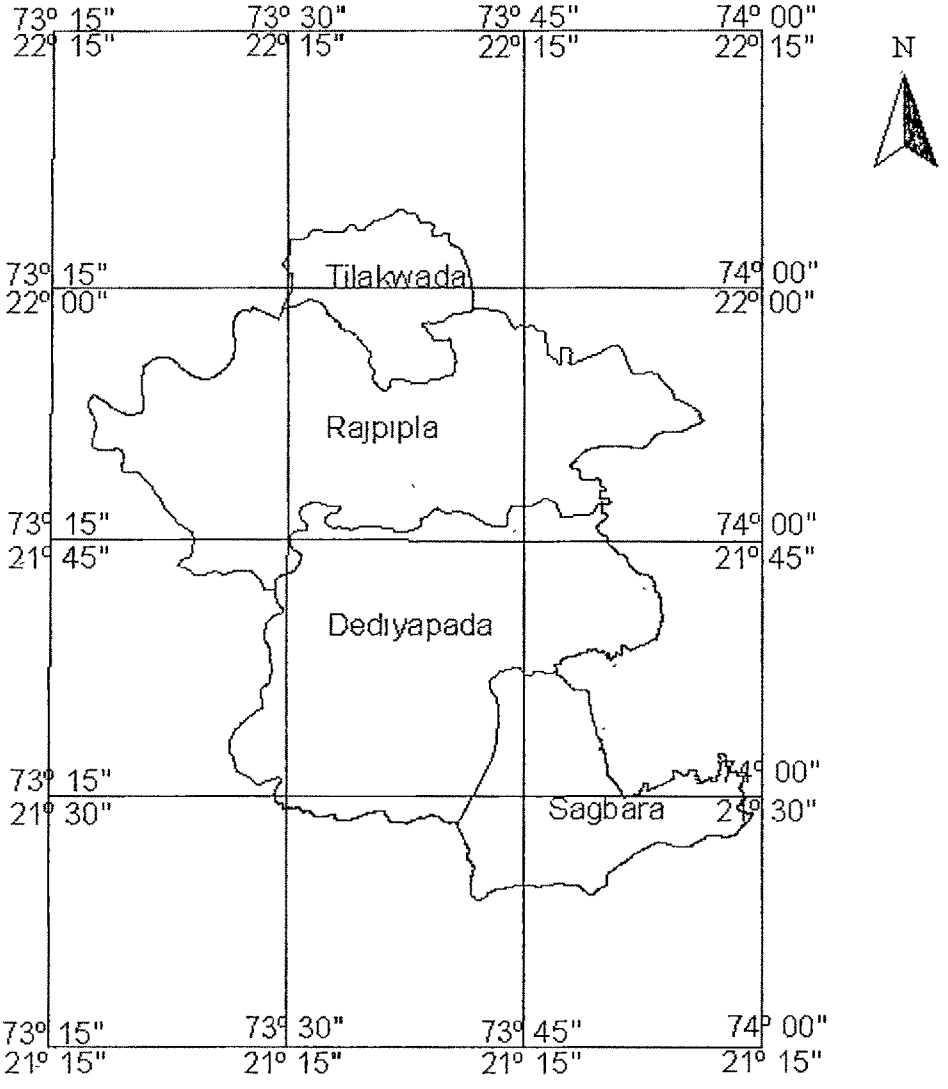


Plate 3. Spatial Frame Work of the Study area

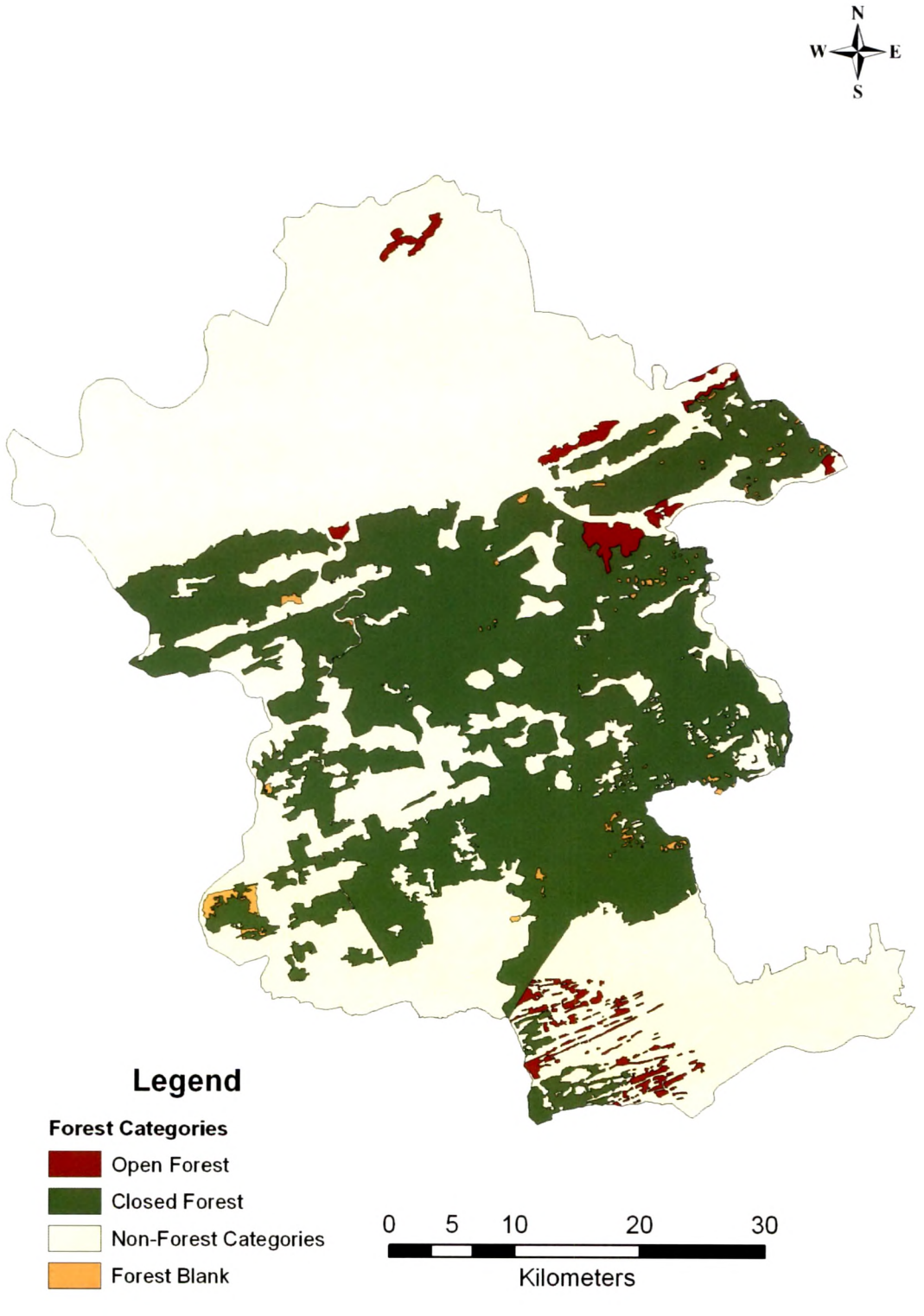


Plate 6. Forest Map of Narmada District

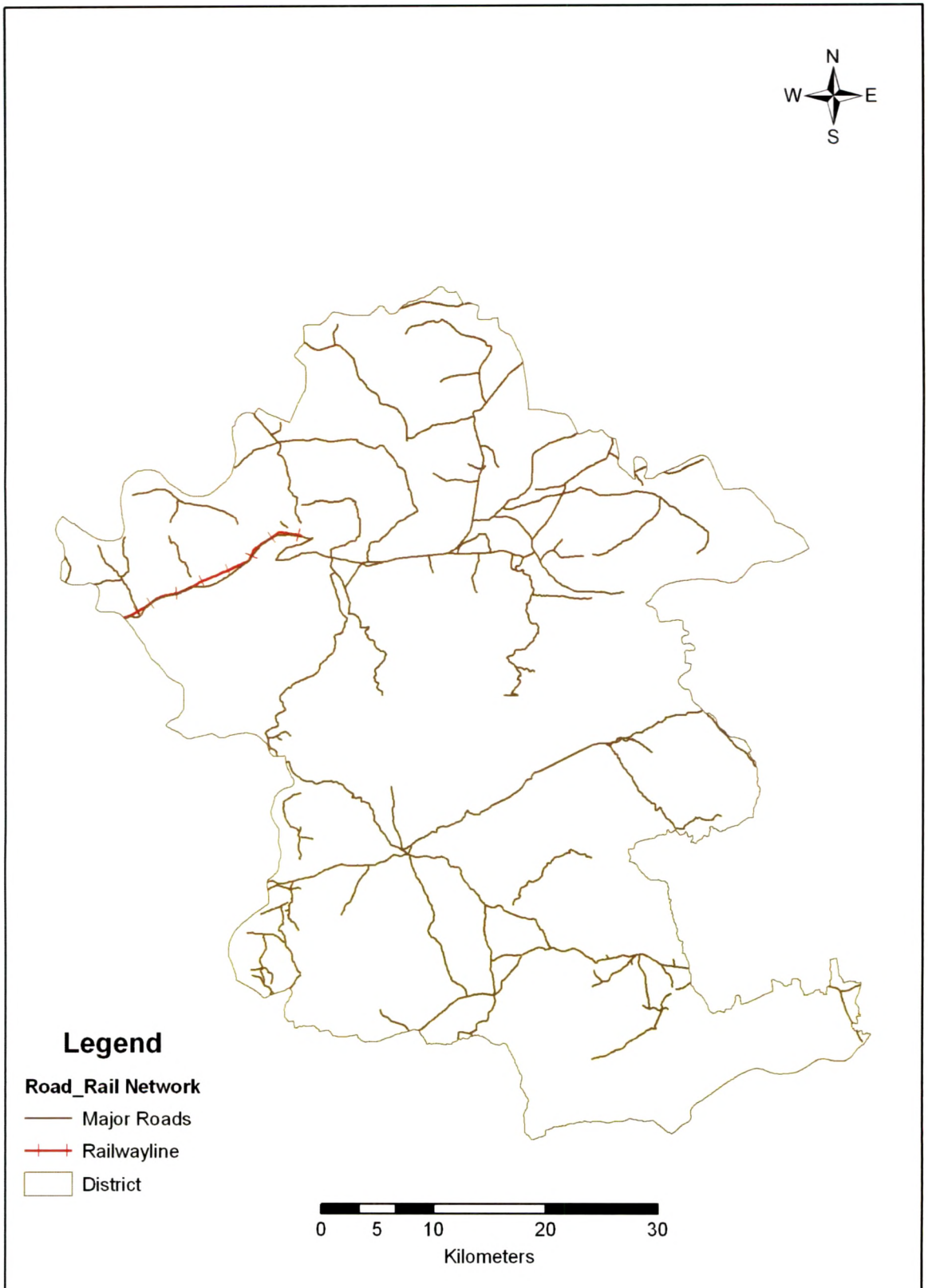


Plate 9. Road and Rail Network of Narmada District

5.1.3 Image Enhancements:

The raw satellite data of the study area was subjected to various interplay of bands, to find out the best protocol for forest density classification in the study area. Different digital techniques like band combinations, contrast enhancements, NDVI and PCA exhibited varying capabilities of achieving better interpretability and contrast between different features.

5.1.3.1 Band Combinations:

Out of the different band combinations attempted for the purpose of image enhancement, band combination 3, 2 & 1 of the image helped in distinguishing different land use categories with clarity. Combination of bands 4, 2 & 1 and 3, 4 & 2 were unable to differentiate these categories.

5.1.3.2 Raster Editing:

In order to achieve better enhancements, various raster editing was done on the image such as Linear, Gamma, Gaussian, Histogram equalization and Standard deviation (Plate 10). Standard deviation, linear and gamma stretches did not gave the desired results and no discrimination between different forest density classes could be achieved. Also, the separability between the agriculture and forest became difficult. Gaussian stretch was to some extent successful in achieving better discrimination among the land features. However, histogram equalization gave the best results increasing the overall distinction amongst the different landuse/landcover classes. A considerably good discrimination of the forest density classes viz. closed, open and degraded was obtained but in the shadow region delineation of forest classes was difficult. However the discrimination among the classes, agriculture and Sparse Tree-cover with Agriculture (STA) was not satisfactory.

5.1.3.3 Band Ratioing:

Ratio image of Simple Index (R/IR) and the NDVI (Normalized Difference Vegetation Index) images were successful in segregating the vegetated areas from non-vegetated areas (Plate 11). However the discrimination among the different land

features was found to be better in NDVI when compared to R/IR images. The grey level scaling in NDVI image, proved very much successful in highlighting the vegetated areas such as standing crop and forests and suppressing non-vegetated areas such as fallow lands and wastelands. However this band ratioing technique was not much successful in bringing discrimination within the forest classes.

5.1.3.4 Principal Component Analysis (PCA):

The transformation of the raw remote sensing data using Principal Components resulted in new PC images which were more interpretable than the original data. PC Analysis showed PC1 to contain maximum information having 96.11 % of variance (Plate 12).

Table 12 . Principal Component Eigen Vector Matrix Resulting from General Sampling of Landuse/Landcover

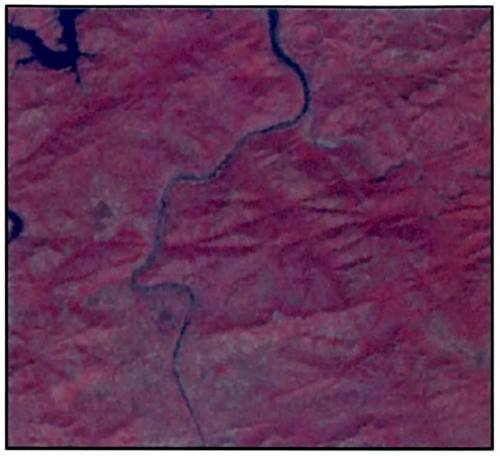
Principal Components	Eigen Vectors		
	Band 1	Band 2	Band 3
PC1	0.589	0.35	-0.728
PC2	0.507	0.541	0.67
PC3	0.629	-0.765	0.14
Eigen Values	3243.115	115.815	15.248
% Variance	96.11	3.43	0.45

PC1 showed much better discrimination among the forest density classes when compared to NDVI images. However, similar to NDVI it failed to differentiate between the classes, agriculture and STA. It completely removed the shadow effect and also very distinctly brought out the different forest classes therein.

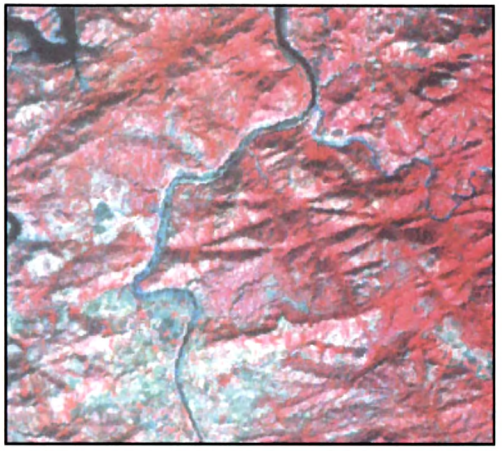
5.1.4 Layer Stacking:

Among the various permutations and combinations of bands tried in layer stacking, combined image of NDVI, PC1 and NIR band gave the best enhancement of the image features (Plate 13). This combined image succeeded in separating STA from agriculture and other forest classes (Plate 14).

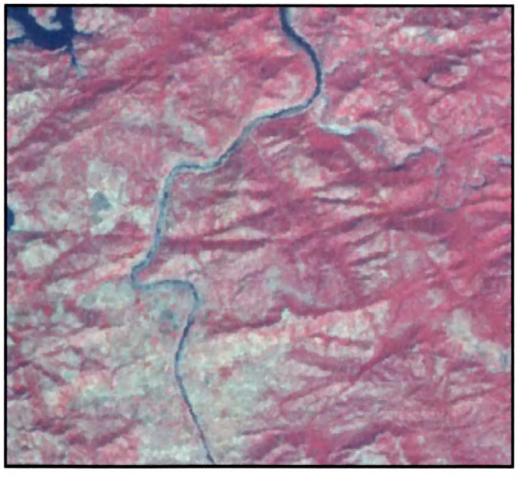
Original Image



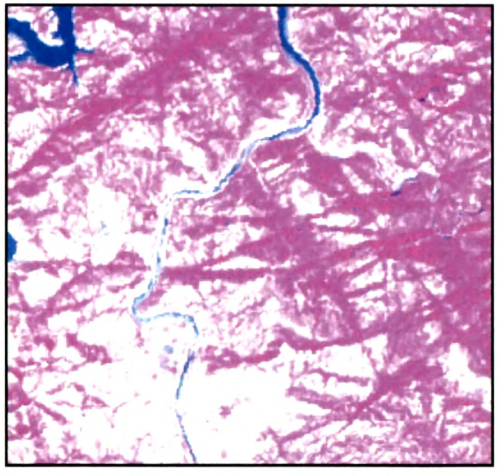
Linear Stretch



Gaussian Stretch



SD Stretch



Gamma Stretch

Histogram Equalization

Plate 10. Image Enhancements

Plate 11. Band Ratioing

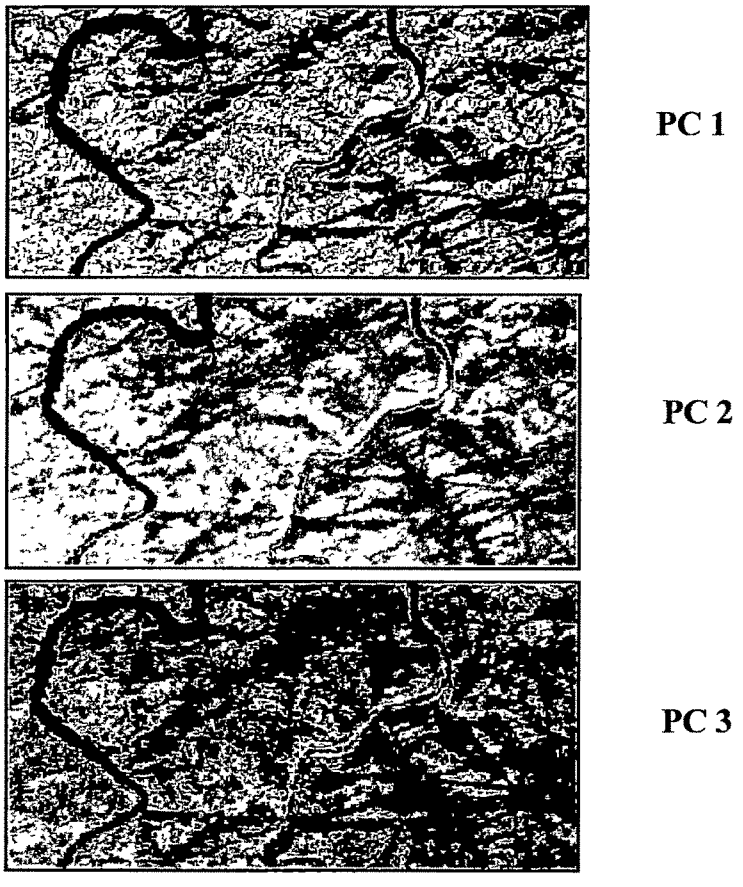


Plate 12. Principal Component Analysis

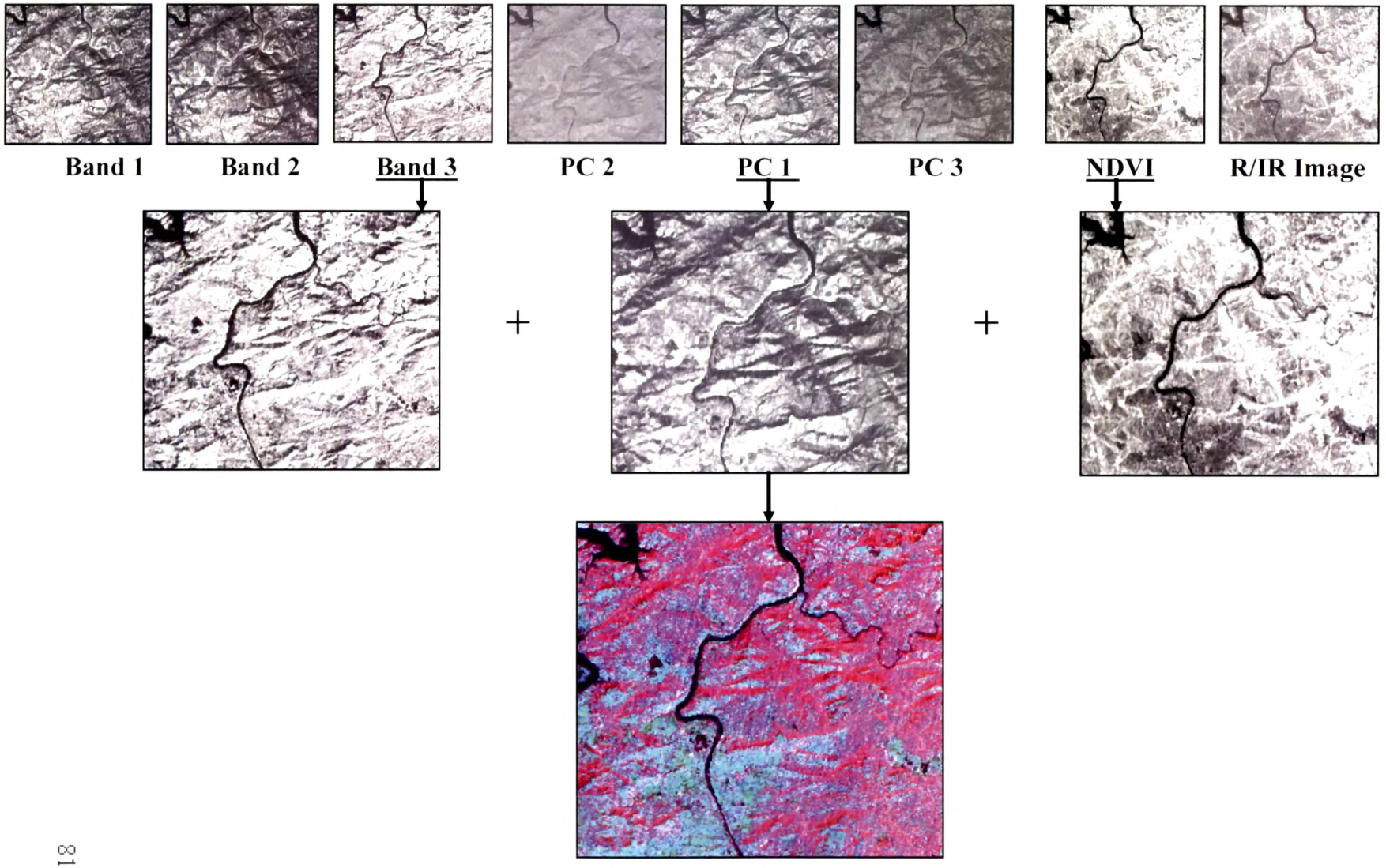


Plate 13. Steps Involved in Layer Stacking Satellite Data

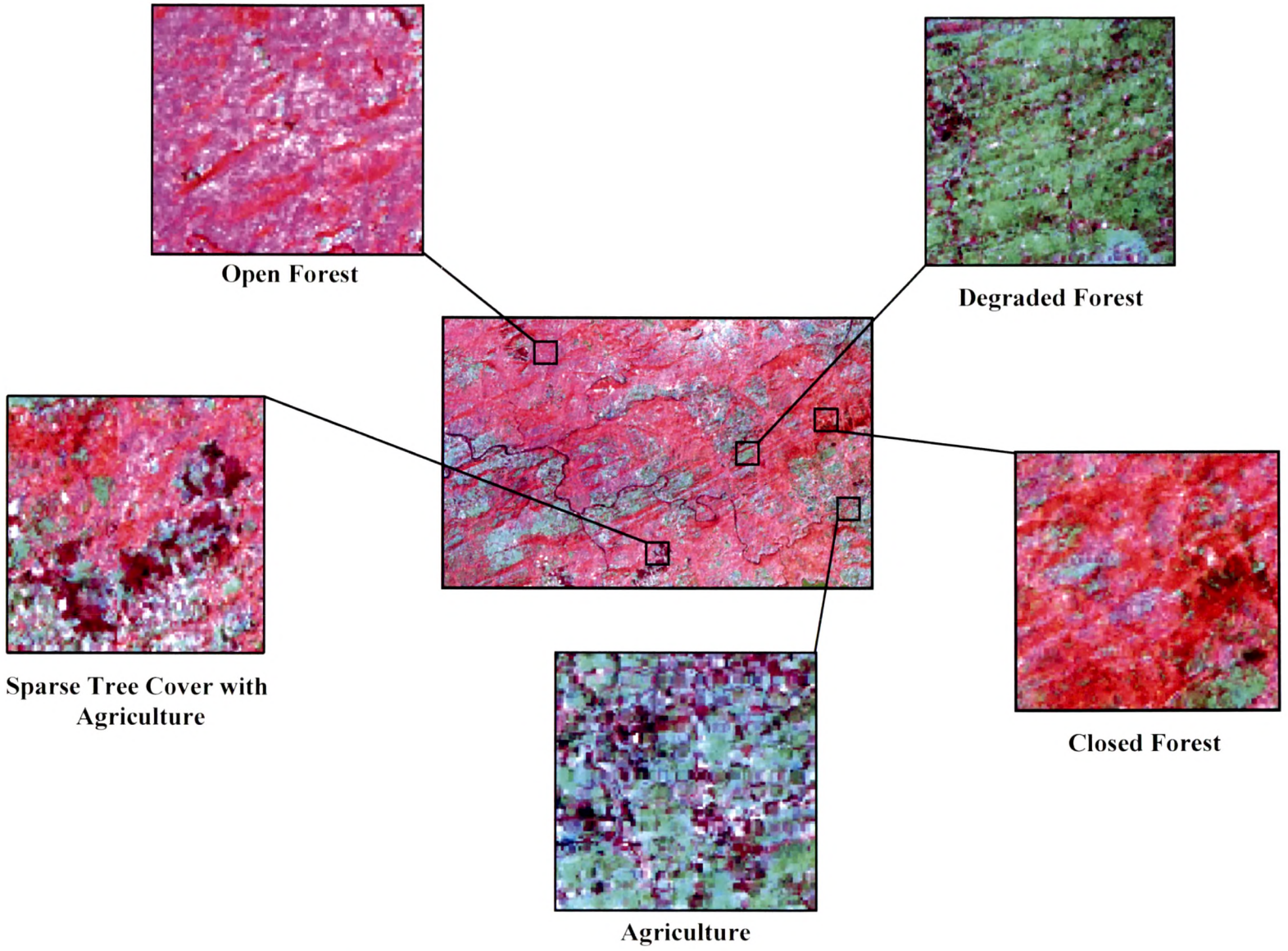


Plate 14. Forest Classes Segregated in Layer Stacked Image

5.2 FOREST DENSITY CLASSIFICATION:

5.2.1 Supervised Classification:

The ultimate result of the classification is to distinguish the study area into various forest and non-forest categories. Supervised classification using maximum likelihood classifier with sufficient training helped in bringing out different landuse/ landover classes of the study area (Plate 15). Maximum likelihood classification is most widely used parametric classifier for remote sensing data analysis and it relies on the second order statistics of a Gaussian probability density function model for each class (Schowengedrt, 1983).

The ellipsoidal plots showing the spectral overlap among the various forest classes are depicted in plate 16. A very good discrimination could be observed between classes closed forest and open forest. However, maximum overlap was observed between the classes, STA & agriculture and also between degraded forests & STA, hence resulted in mixed pixels. As a result, maximum misclassification occurred between the classes STA, agriculture and degraded forest. Due to these misclassifications, the overall classification accuracy obtained through digital analysis was found to be less i.e. 74.29% while the kappa statistics was found to be 0.704 (Table 13). Due to lesser accuracy obtained by digital analysis the visual interpretation was also attempted.

Table 13. Classification Accuracy Assessment of Digital Interpretation

	CF	OF	DF	STA	Ag	WL	R	C	W	Set	Total	Producer's Accuracy	User's Accuracy
CF	4	0	0	0	0	0	0	0	0	0	4	100	100
OF	0	1	0	0	0	0	0	0	0	0	1	100	100
DF	0	0	2	3	0	1	0	0	1	0	7	28.57	66.67
STA	0	0	1	4	1	0	0	0	0	0	6	66.67	57.14
Ag	0	0	0	0	1	0	0	0	0	0	1	100	50
WL	0	0	0	0	0	0	0	0	0	0	0	-	-
R	0	0	0	0	0	0	6	0	0	0	6	100	100
C	0	0	0	0	0	0	0	2	0	0	2	100	66.67
W	0	0	0	0	0	0	0	1	5	0	6	83.33	83.33
Set	0	0	0	0	0	1	0	0	0	1	2	50	100
	4	1	3	7	2	2	6	3	6	1	**35**		
Overall Classification Accuracy = 74.29%													
Overall Kappa Statistics = 0.704													

CF = Closed Forest, OF = Open Forest, DF = Degraded forest, STA = Sparse Tree-cover with Agriculture, Ag = Agriculture, WL = Waterlogged, R= River, C= Canal, W=Wasteland, Set= Settlement

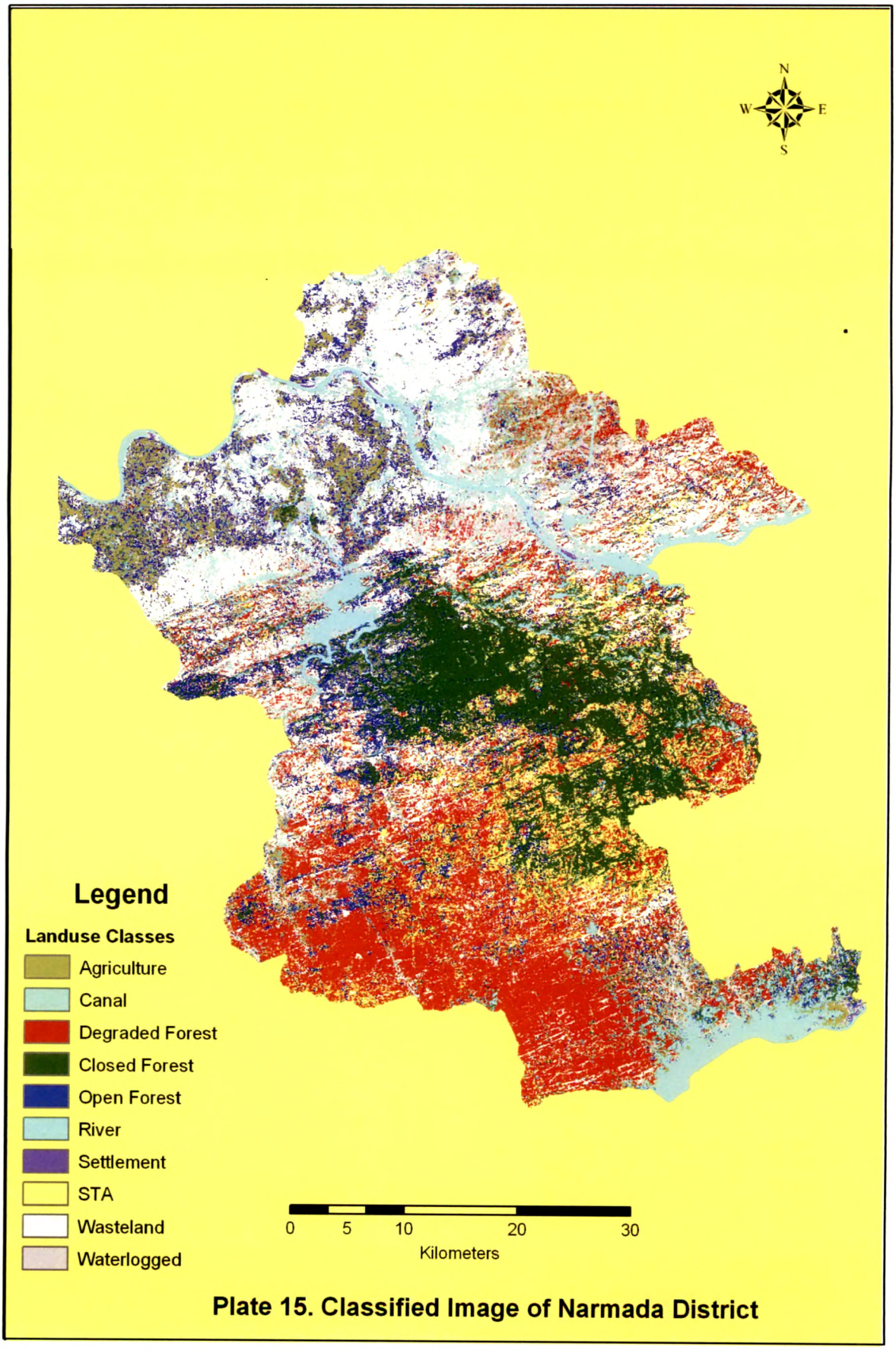


Plate 15. Classified Image of Narmada District

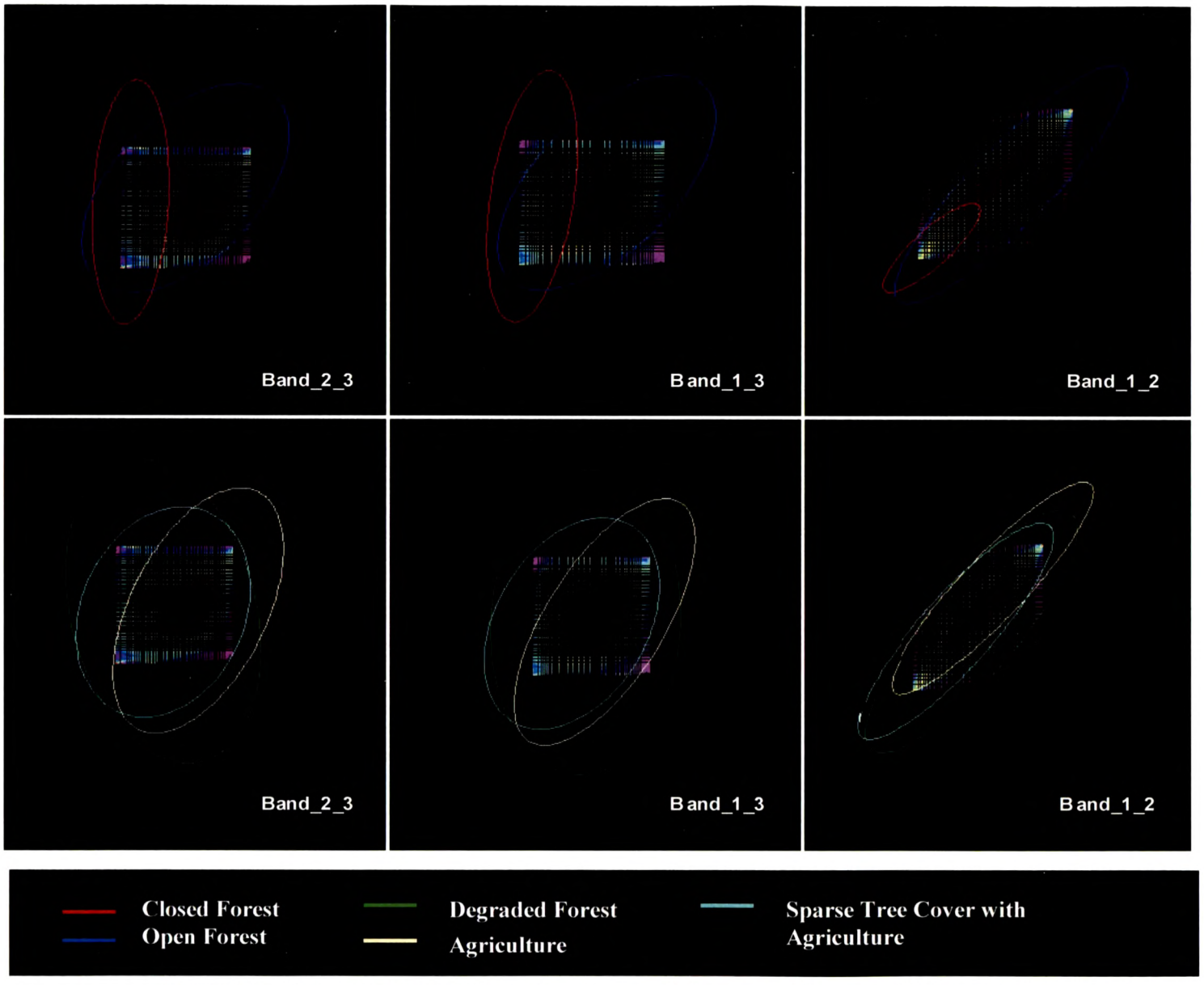


Plate 16. Ellipsoidal Plots Showing Spectral Overlap Between Different Classes

5.2.2 On-Screen Visual Interpretation:

Interpretation key developed based on the basic elements of satellite image interpretation such as tone/colour, size, shape, texture, pattern, location and association yielded different types of forest and landuse classes (Plate 17 & 18). The forest and landuse categories of the study area have been described here below:

- **Closed Forest:** The forest class, closed forests exhibited itself in a deep red tone on the satellite data. Density of this forest class was greater than 40%. Some of the species found in this class include *Tectona grandis* Linn., *Madhuca indica* J. F. Gmel. *Butea monosperma* (Lamk.) Taub etc.

- **Open Forests:** In open forests the density ranged between 10-40% and was seen as a light pink tone on the satellite image. *Tectona grandis* Linn., *Morinda tomentosa* Heyne., *Diospyros melanoxylon* Roxb., *Annona squamosa* L. etc. were dominant species in this class.

- **Degraded Forests:** Degraded forests had canopy density less than 10% and exhibited as greenish-blue tone and rough texture on the image. *Acacia catechu* Willd. and *Albizzia lebbeck* Benth represented the degraded forest of this area.

- **Forest Blank:** This class included any part of forest area where, for any reason, only a few or no trees were growing (FSI, 1999). These areas were demarked from the SOI maps and which falls within the forest boundary. In the study area forest blanks mainly constituted of rural habitation.

- **Sparse Tree-cover with Agriculture (STA):** This class had widely spaced trees; mainly composed of *Azadirachta indica* Juss., *Gmelina arborea* Roxb., *Cassia fistula* L. etc. Greenish white with scattered bright red to pink color patches and rough texture were its characteristic features. Fosberg (1967) has mentioned such type of forest class in the forest classification he proposed.

Plate 17. Forest Density Classes of the Study Area

Plate18. Non-forest Classes of the Study Area

This class, where agricultural practices were carried out within the forest boundary, was identified as Sparse Tree-cover with Agriculture.

- **Agriculture:** It was delineated as a mosaic of red and deep green regular patches. The major crop grown in this area was cotton and groundnut. Both these crops are rainfed as well as irrigated.

- **Canal:** Canal being a man-made feature could be differentiated by its pattern. It had cyan to white tone, indicating that they were dry or had very little water content.

- **River:** It was delineated based on its pattern, shape and tone. The color ranged from white to deep blue based on the presence or absence of water. Pattern and shape played a vital role in separation of this class.

- **Waterlogged:** These areas were seen mainly distributed along the catchments area of the river, cyan to bluish irregular patches can be easily delineated as waterlogged area based on its location and association.

- **Non-Forest Categories:** Any land use/ landcover category falling outside the forest boundary obtained from the SOI toposheets were considered as non-forest classes. It included settlements, roads, railways, aquatic bodies etc. However if any forest area comes outside the forest boundary i.e. unclassed forest then it was delineated and merged with the existing forest boundary.

5.2.3 Spectral Profile of Different Classes:

All the forest and non-forest categories mentioned above were easily demarcated based on their spectral characteristics. Each class had a unique spectral feature. The three major forest density classes of closed, open and degraded forests could be separated based on the differences in their NIR reflectance which were 245, 216 and 67 respectively (Figure 11). Good separatibility of these classes was observed even in red band.

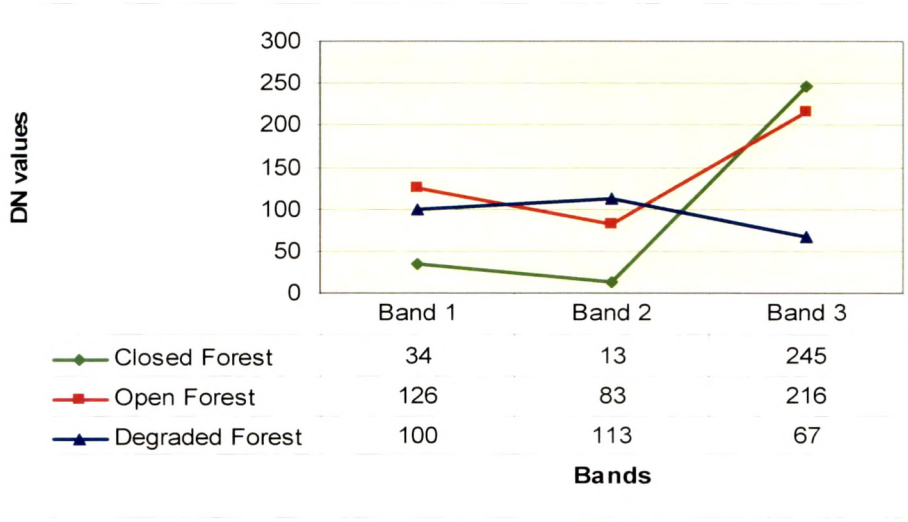


Figure 11. Spectral Reflectance Pattern of Closed, Open and Degraded Forests

The mixing of two classes viz. agriculture and STA is due to similarities in the spectral reflectance patterns in band 1 and 2. However both these classes showed a marked difference in the NIR bands with the DN values being 218 and 106 respectively. These differences in the NIR band were exploited while layer stacking the images to get the best separability between these two classes (Figure 12).

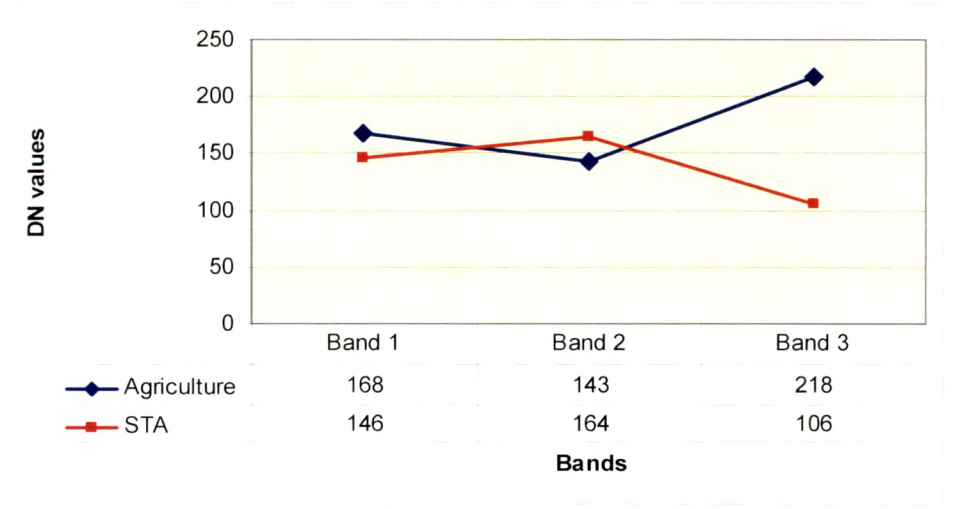


Figure 12. Spectral Reflectance Pattern of Agriculture and Sparse Tree-cover With Agriculture

Canal showed a high reflectance in all the bands while river showed low reflectance in all the bands. The DN values increased with the decrease in depth of any aquatic body. Thus canal with shallow water showed much higher reflectance than river. Waterlogged areas showed a high reflectance in band 1 and 2 and comparatively a low reflectance in band 3 (Figure 13).

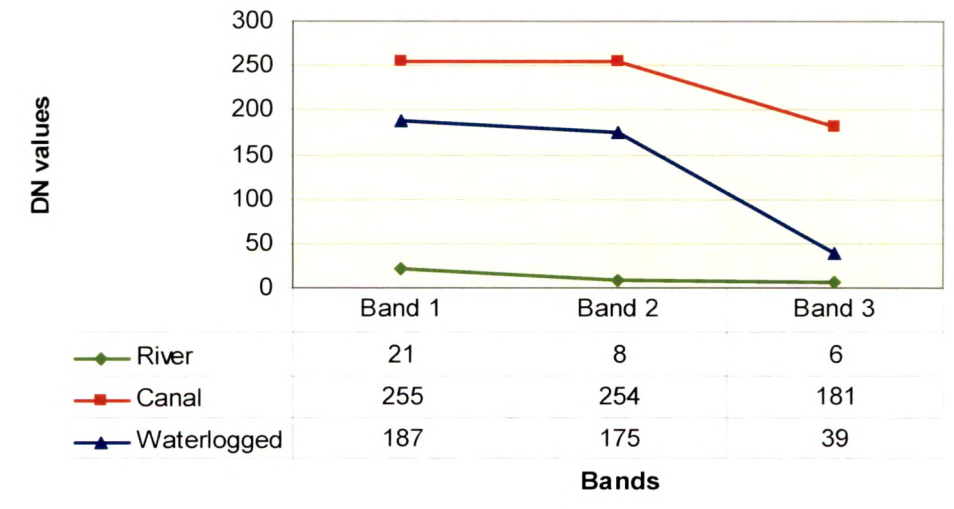


Figure 13. Spectral Reflectance Pattern of Non-Forest Classes

5.2.4 Landuse/ Landcover Statistics of the Study Area:

The total area covered by each forest and non-forest class in respective taluka of the district is depicted in table 14. Area statistics of the study area showed that Dediyapada had the maximum forest area i.e. 64,552.25 ha followed by Rajpipla, Sagbara and Tilakwada. The number of landuse classes present within the forest boundary of Tilakwada, Rajpipla, Dediyapada and Sagbara were found to be 4, 9, 8 and 6 respectively.

Table 14. Landuse/Landcover Statistics of the Study Area

No.	Classes	Tilakwada (ha)	Rajpipla (ha)	Dediyapada (ha)	Sagbara (ha)
1.	Closed Forest	103.32	12248.02	33273.83	1851.5
2.	Open Forest	20.43	8486.45	7754.14	756.9
3.	Degraded Forest	313.31	12129.09	14374.59	6388
4.	Sparse Tree-cover with Agriculture	78.81	2801.243	9149.69	2832.8
5.	Forest Blank	-	268.14	182.24	170.79
6.	Agriculture	-	845.67	276.44	-
7.	River	-	54.59	276.44	-
8.	Waterlogged	-	727.85	96.34	10.48
9.	Canal	-	57.73	-	-
10.	Non-Forest Classes	23917.62	73901.18	39047.29	29316.55
	Total	**24433.49**	**111520.0**	**104431.0**	**41327.02**

5.2.5 Forest Classes in Each Taluka of the Study Area:

All the talukas of the study area had their own distribution of forest classes. The percentage distribution of the forest classes in each taluka has been depicted in plate 19. Forest categories present in each taluka has been described separately here below-

1. Tilakwada:

The forest cover in Tilakwada was found to be quite negligible. The total area under the forest cover was found to be 515.88 ha, which is merely 2.11 % of the total geographic area of the taluka. Categories of forest observed were closed, open, degraded forest and the category of Sparse Tree-cover with Agriculture (STA) (Plate 20). Major portion of this taluka i.e. 61% exhibited degradation.

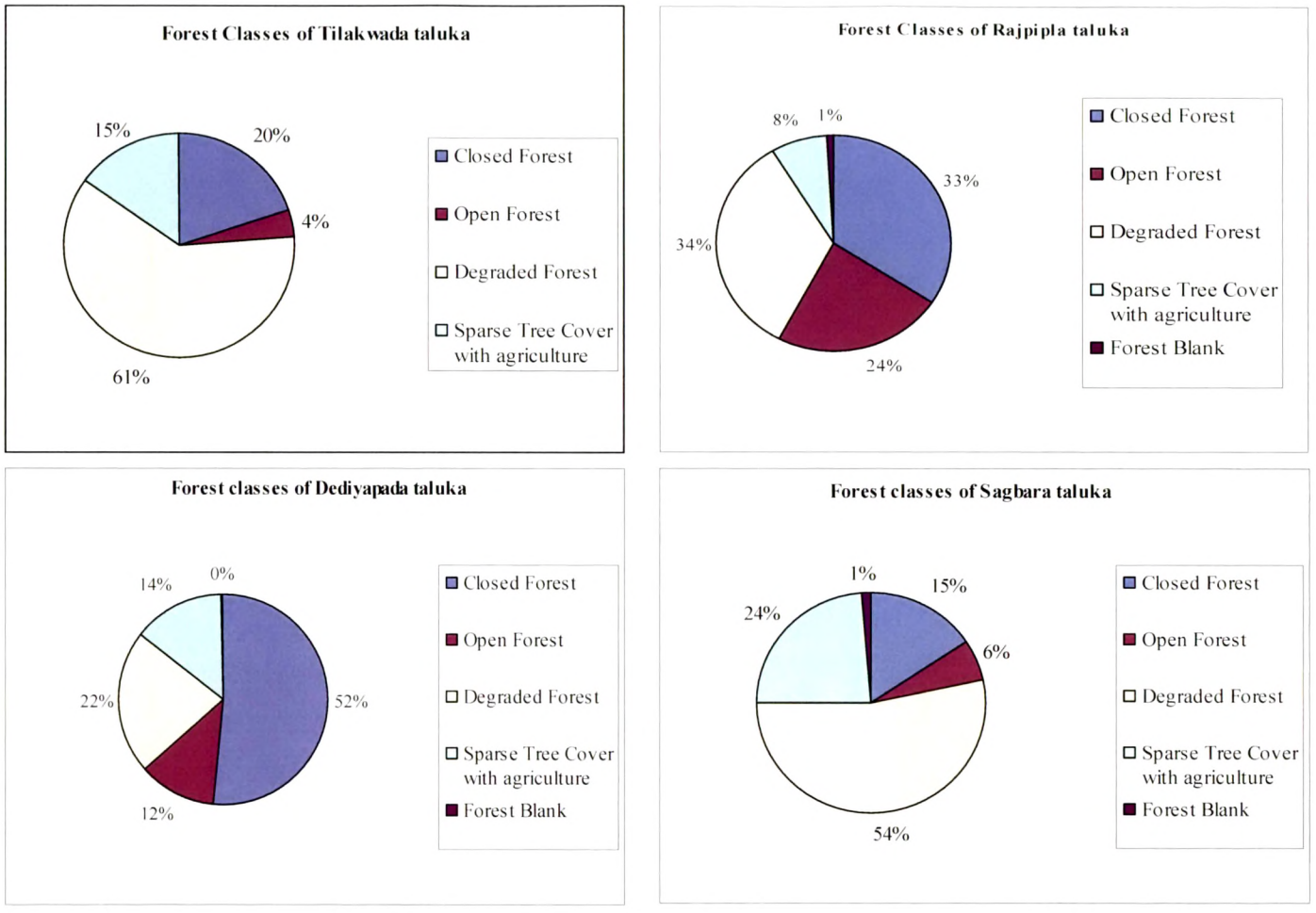


Plate 19. Forest Density Classes of the Study Area

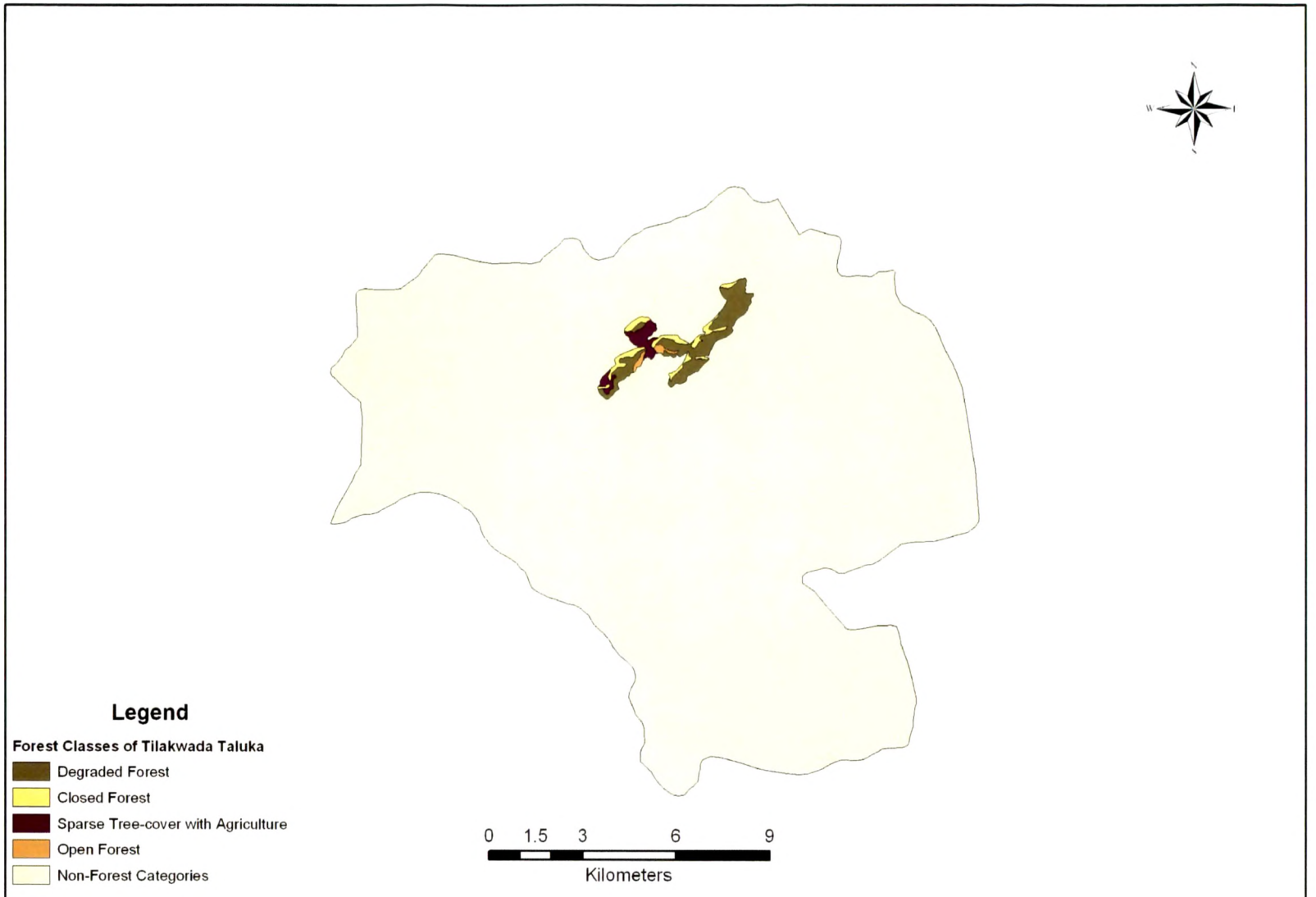


Plate 20. Forest Density Classification of Tilakwada Taluka

2. Rajpipla:

In Rajpipla taluka, the total area under the forest cover was found to be 35,932.94 ha, which is 32.22 % of the total geographic area of the taluka. Based on the tonal variation, nine different landuse classes were delineated in this taluka (Plate 21). 34% of the forests of this taluka are under high state of degradation. It is important to note here that in this taluka in addition to the class STA which accounts for 8% of the taluka, 845.67 ha of the forest area of this taluka was found to be totally under agriculture. Thus, an encroachment in the forest area through agricultural practices was distinct. Also, 727.85 ha of forest land are affected by waterlogging or submergence due to the construction of Narmada dam.

3. Dediyapada:

The interpreted map of Dediyapada showing eight different landuse classes is depicted in Plate 22. The total area under the forest cover was 64,734.49 ha accounting for 62.15 % of the total geographic area of the taluka. Of the total forest area of this taluka, 52% falls under closed forest category which was mainly of moist deciduous type. Thus, the figures leads to the conclusion that Dediyapada not only possesses the highest forest area of this district but also possessed the best forest cover. A major portion of the forest of this taluka comes under protected area - Shoolpaneshwar Wildlife Sanctuary wherein the forest crown density was found to exceed 60%.

Similar to Rajpipla taluka a considerable portion of the forest i.e. 14% falls in the category of STA showing encroachments in the forest area.

4. Sagbara:

Based on the tonal variation, eight different forest classes were delineated in this taluka (Plate 23). The total area under the forest cover was found to be 11,999.99 ha, which is 29.04 % of the total geographical area of the taluka. In contrast to Dediyapada taluka, in this taluka 52% of the total forest area was recorded to be degraded. Also a considerable percentile i.e. 24% falls in the category of STA. It is important to note here that out of the total forest cover of this taluka, 76% of the forest area is degraded due to anthropogenic reasons.

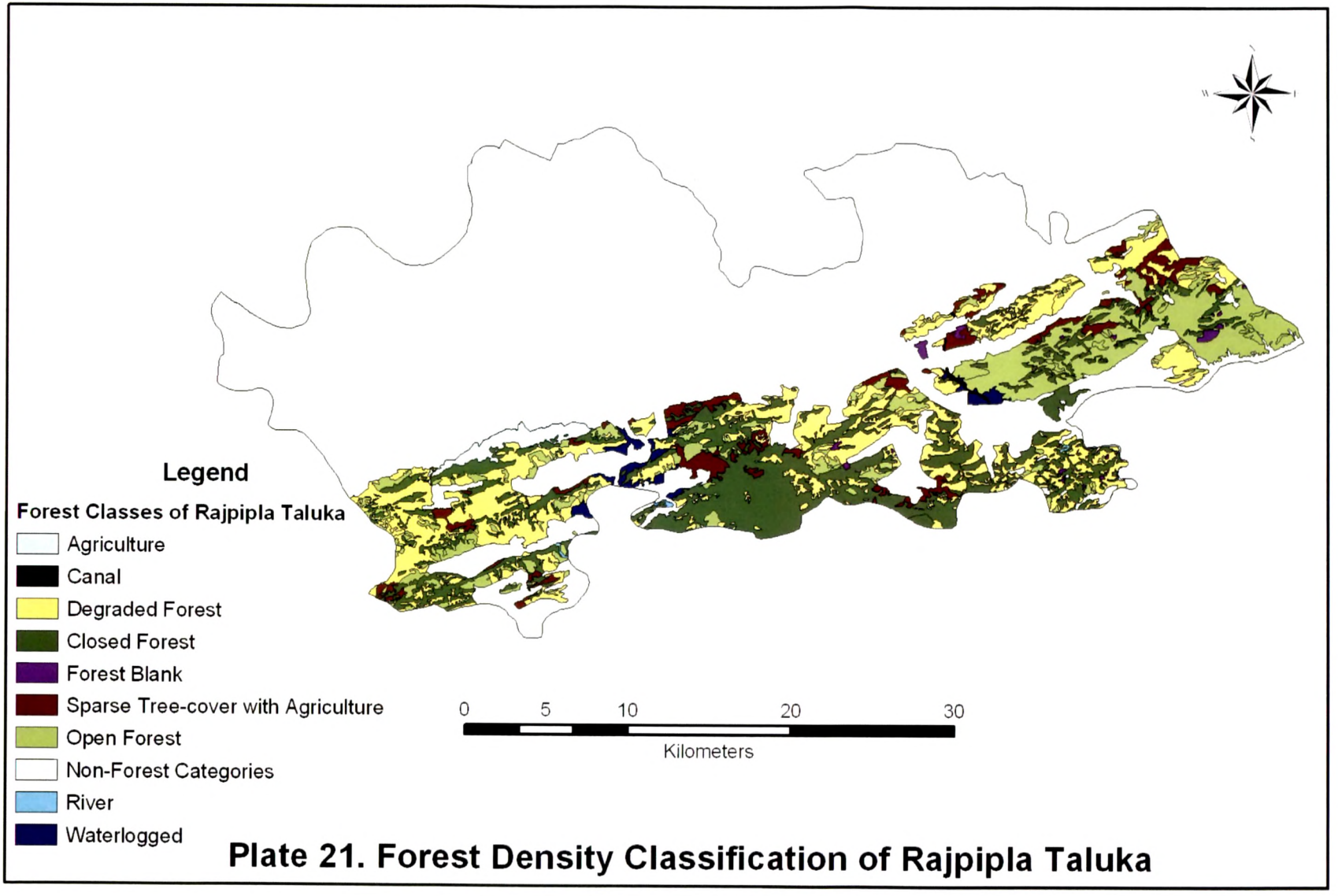


Plate 21. Forest Density Classification of Rajpipla Taluka

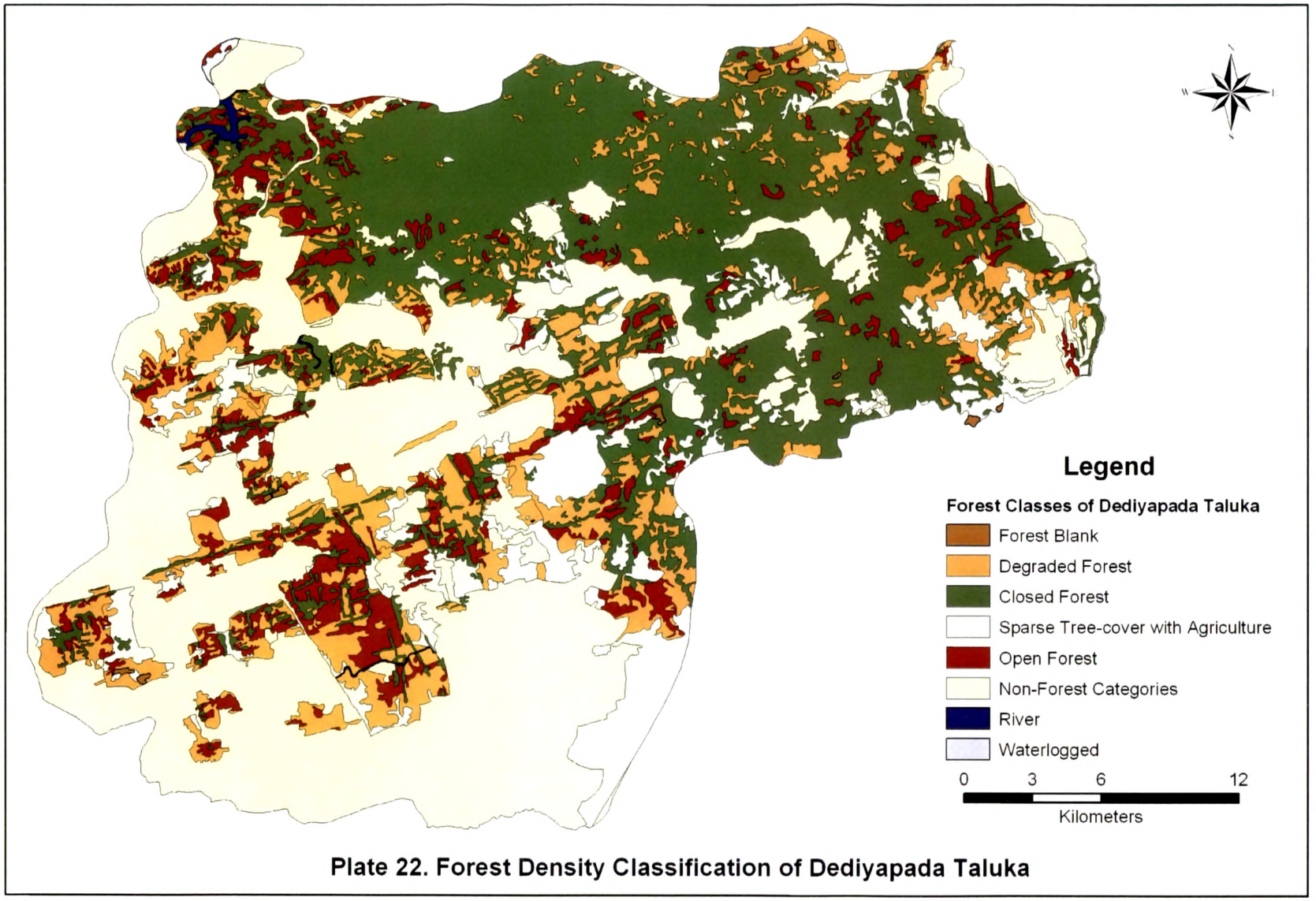


Plate 22. Forest Density Classification of Dediyapada Taluka

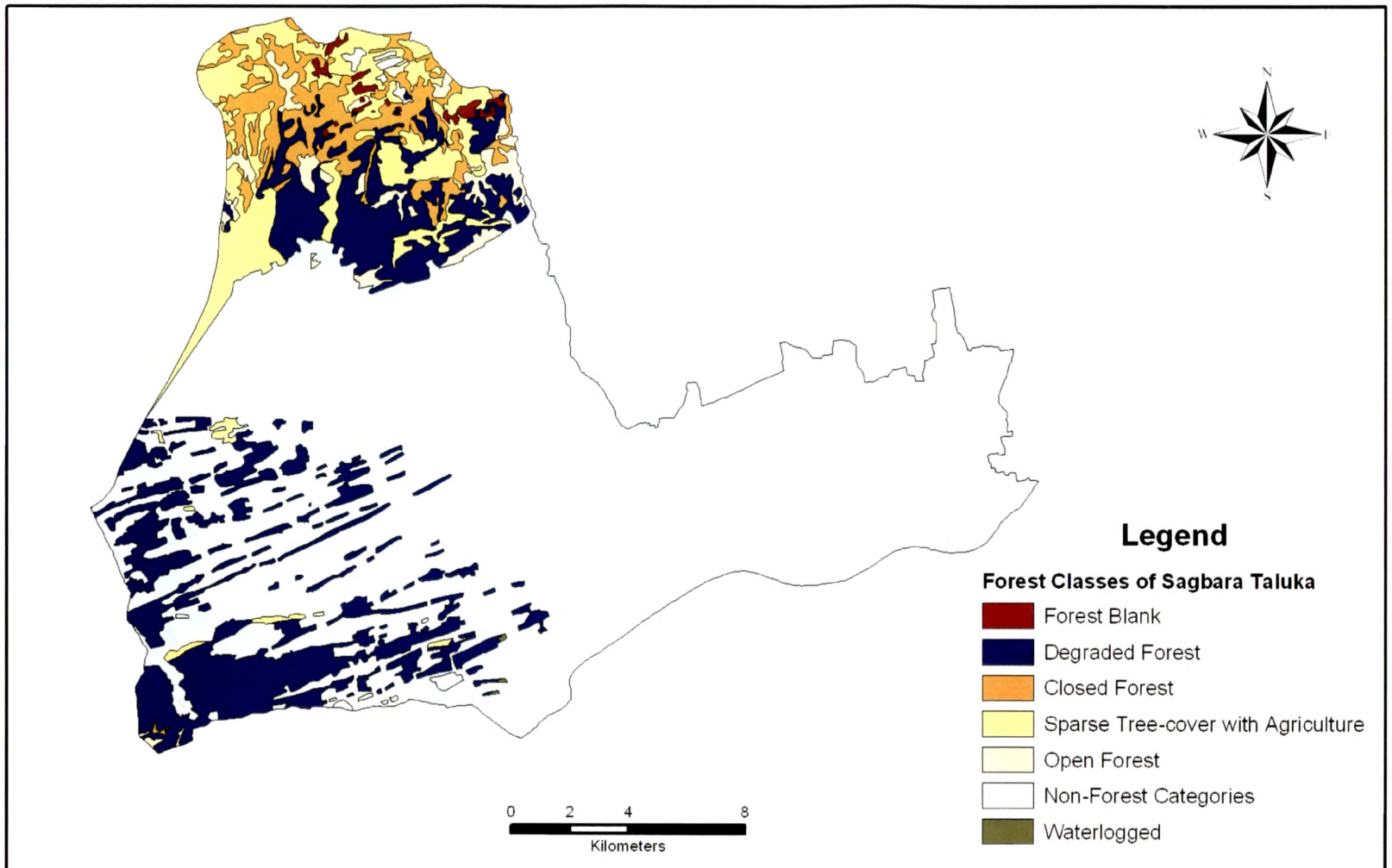


Plate 23. Forest Density Classificaiton of Sagbara Taluka

5.2.6 Accuracy Assessment:

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

The mapping accuracy and classification accuracy was estimated to be much high i.e. 93.10% and 91.76% respectively (Table 15). The KAPPA coefficient was 0.91. This was mainly achieved by the supportive information obtained from the digital technique. The on-screen visual interpretation method with the inputs from digital classification along with the ground phytosciological data aided in producing better vegetation map of the study area.

Table 15 . Classification Accuracy Assessment of Visual Interpretation

	CF	OF	DF	STA	Ag	WL	R	C	Total	O/E	C/E	C/A	M/A
CF	15	1	0	0	0	0	0	0	16	0	1	93.75	100
OF	0	11	1	0	0	0	0	0	12	2	1	91.66	84.62
DF	0	0	9	0	0	0	0	0	9	1	0	100	90
STA	0	1	0	12	1	0	0	0	14	0	2	85.71	100
Ag	0	0	0	0	3	0	0	0	3	1	0	100	75
WL	0	0	0	0	0	2	0	0	2	0	0	100	100
R	0	0	0	0	0	0	1	0	1	0	0	100	100
C	0	0	0	0	0	0	0	1	1	0	0	100	100
	15	13	10	12	4	2	1	1	**58**				
Overall Classification Accuracy= 93.10 %													
Overall Mapping Accuracy =91.76%													
K_{hat} statistics = 0.91													
CF = Closed Forest, OF = Open Forest, DF = Degraded forest, STA = Sparse Tree-cover with Agriculture, Ag = Agriculture, WL = Waterlogged, R= River, C= Canal, O/E = Omission Error, C/E = Commission Error, C/A = Classification Accuracy, M/A= Mapping Accuracy.													

5.3 JFM MAPPING:

Plantations included under JFM program are practiced within the forest area itself and these plantations have no physical boundary. Their delineation using spatial data seems to be slightly subtle. In this case a more detailed ground survey with increased number of GCPs help in identifying the features more precisely. Thus with the help of GPS reading collected from JFM plantation mapping was done on the satellite data based on the tonal variation (Plate 24).

The JFM plantations which were observed in the study area mainly follow two plantation strategies viz. polyculture and monoculture (Plate 25). Monoculture plantations mainly consisted of pure stands of teak having a high reflectance in the NIR band i.e. 216, while polyculture plantations possessed a mixed stand of both timber and non-timber trees. The number of trees species in each mixed plantation varied from 8 to 20. This was proved when spectral pattern was compared (Figure 14). Here the resolution being 3 band and coarse resolution there was limitation in extraction of features digitally as well as visually but still certain distinct JFM plantations were identified and the changes in them over the years were analyzed.

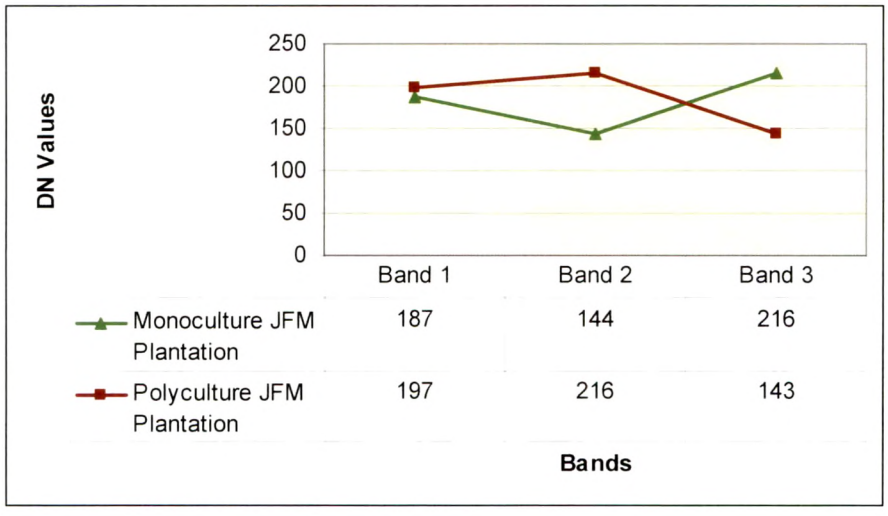


Figure 14. Spectral Reflectance Pattern of Monoculture and Polyculture Plantations

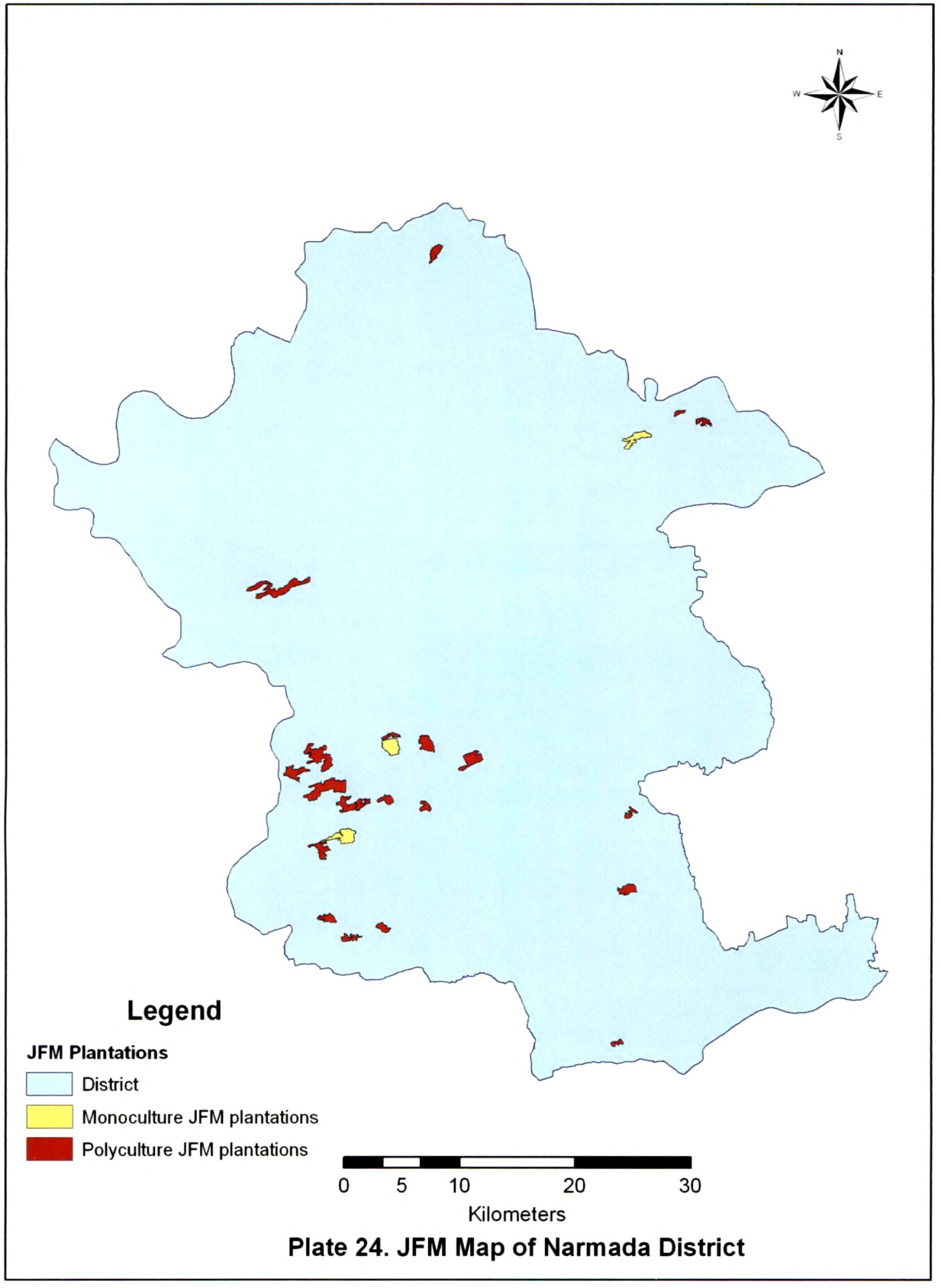


Plate 24. JFM Map of Narmada District

Monoculture Plantation in Kunbar

Polyculture Plantation in Limkhetar

Plate 25. Plantation Strategies Adopted in JFM Sites of the Study Area

5.4.1 Potential Sites for JFM Plantations:

The visual interpretation of the enhanced satellite data of the study area was successful in bringing out the forest coming under different density classes. Since JFM program is by and large implemented on degraded forest area, there is a need to delineate such forest areas which can be the potential sites wherein the plantation program can be implemented with the active participation of the locals residing in the nearby area. Here, STA is also considered as a potential site for JFM plantations as this class occurs within the forest boundary and is degraded due to anthropogenic reasons.

The present study showed that Dediyapada had maximum degraded forests (14,374.59 ha) as well as Sparse Tree-cover with Agriculture (9,149.69 ha); wherein the JFM program can be implemented (Figure 15). STA class in Rajpipla and Sagbara occupy almost similar forest area; however degraded forest class in Rajpipla is much more when compared to that of Sagbara taluka.

The villages coming in the 500 m radius of these degraded forest patches can be considered as potential sites wherein the JFM committee can be formed by the

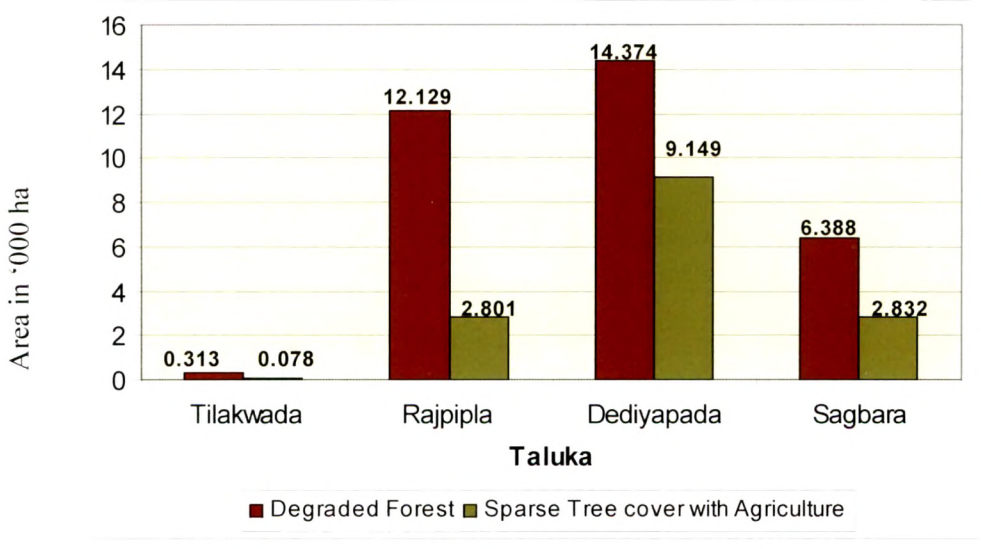


Figure 15. Potential Sites for JFM Plantations

active participation of the villagers residing therein. The buffer analysis of the study area precisely brought out the total number of the villages falling in the buffer wherein the JFM program can be implemented (Table 16).

Table 16. Potential JFM Villages of Narmada District

Sr. No.	Talukas	Total Number of villages	Number of JFM Villages (2001)	Number Villages within buffer	Number of potential JFM villages
1.	Tilakwada	115	1	8	7
2.	Rajpipla	313	39	54	15
3.	Dediyapada	233	61	118	57
4.	Sagbara	114	13	49	36
	Total	**775**	**114**	**229**	**115**

Narmada district had a total of 775 villages of which, 229 villages were found in the vicinity of degraded forest area including Sparse Tree-cover with Agriculture (STA) (Table 5). Reports available from the forest department say that only 114 villages have adopted and implemented the JFM program since 1990 (FD, 2001). Thus now potentially 115 villages are still available in the district where in JFM program can be implemented. Among this total number of villages, maximum potential JFM villages are present in Dediyapada i.e. 57 followed by Sagbara and Rajpipla. The potential JFM villages are found to very less in Tilakwada taluka i.e. 7 owing to the very less forest cover present in this taluka.

5.5 MICRO-LEVEL ASSESSMENT OF JFM PROGRAM:

In Narmada district the spread of JFM have occurred ever since its initiation in 1990. The villages which have been registered under the JFM program formed Forest Protection Institute/*Van Suraksha Samiti* for protection and regeneration of forests. In addition to the main institution, other secondary organization such as *Mahila Mandal* i.e. women's organization have strengthened the functioning of the forest protection committee (Plate 26).

Criterion based selection of 13 JFM villages revealed not only the status of the JFM therein but also the contribution of these institutions in development of the program in respective villages.

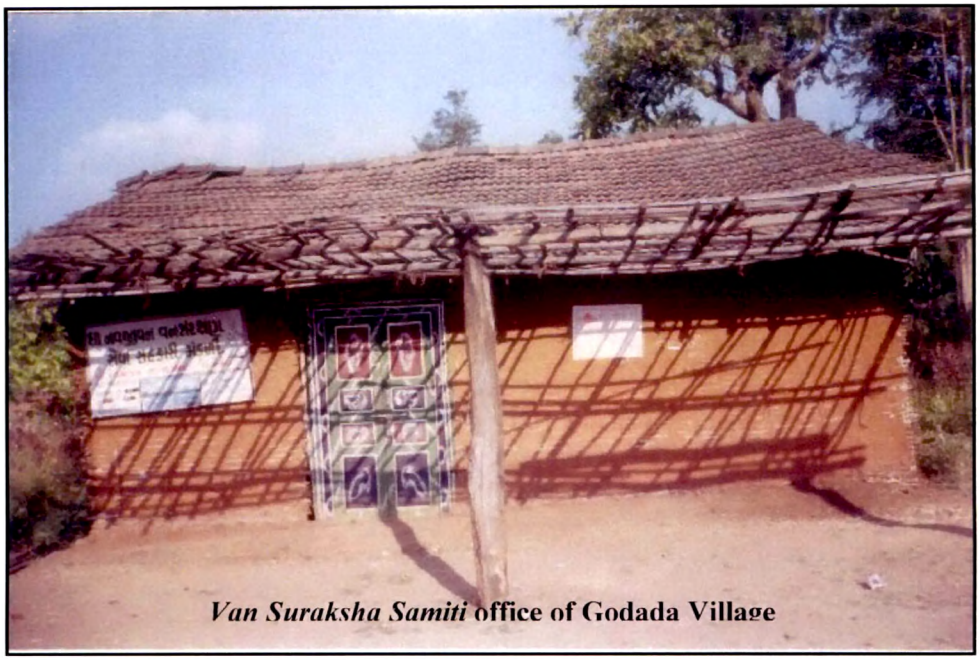
5.5.1 JFM Villages:

5.5.1.1 Geographic and Socio-economic Features:

13 JFM villages were selected from different forest ranges of the three talukas viz. Rajpipla, Dediyapada and Sagbara. The location of these villages with respect to their forest and administrative boundary is presented in table 17. The forests of the selected JFM villages in Rajpipla taluka were mainly dominated by teak except for in Nani Chikhli, while the forests of Dediyapada taluka were of mixed type mainly comprising of teak and bamboo. The forests of Sagbara taluka were a deviation from other two taluka since it was of open scrub type.

The profile of the selected villages depicting its geographical as well as socio-economic features is presented in Table 18. It brings out that all these JFM villages had maximum tribal population, though the percentage of JFM area was not that significant except in few villages.

The socio-economic features of the JFM villages of Rajpipla taluka showed that Naghatpur village had maximum human and cattle population but the geographic area was found to be highest in Limkhetar. Out of the total geographic area of Limkhetar village a major portion was covered by gochar area i.e. 1,168 ha though it had comparatively lesser cattle population. Though maximum forest area was found in Naghatpur and Limkhetar but the area under JFM was found to be highest in Nani Chikhli i.e. 240 ha.



Van Suraksha Samiti office of Godada Village

Mahila Mandal of Kunbar

Plate 26. Forest Protection Institute

In Dediyapada taluka, Pansar village with maximum geographic area also had maximum human and cattle population. However, in this village the gochar area was just 25.16 ha which is not adequate to suffice the needs of a huge cattle population. Pansar in addition to Tilipada showed the maximum percentile of landless i.e. 57.64% and 68.18 % respectively. Maximum area under JFM was seen in Singalvan and Dhanor villages with an area of 329.03 ha and 292.18 ha respectively. It is important to note here that, the JFM area of Singalvan was much more than the forest area of the village. In Bore village the geographic area and the forest area were same, with the total absence of grazing land. All the villages of this taluka had comparatively greater forest area except in Tilipada. Though forest area was found to be less in this village but still it possessed the maximum gochar area of this taluka.

In Sagbara taluka, Godada village supports a huge human population. The geographic area of this village was found almost equivalent to its forest area. In all these three villages the percentage of landless was found to be much higher when compared to all the villages of other talukas of this district. The forest area in Kodba village was quite negligible but the JFM area was found to be much higher. Godada and Dabka with maximum livestock population of 1,234 and 1,806 respectively did not have any grazing area. Thus, the grazing area of JFM villages did not correlated with the livestock population therein.

5.5.1.2 Status of the Vegetation and Wildlife Before Protection:

All the JFM villages selected for the present study exhibited a very poor state of forest by 1980s. The forests in these villages were totally degraded. As per the local information and questionnaire, the forests were mainly dominated by teak and other species which were associated with teak, like Siras (*Albizzia lebbeck* Benth), sisso (*Dalbergia sisoo* Roxb.), sadad (*Terminalia tomentosa* W. & A.). Bamboo was also found in abundance in those days. Wildlife was very rich with a large number of birds such as blue rock pigeon, green pigeon, babler and animals specifically elephants, tigers, leopards, wild foxes and bisons were seen in those days but now seem to have been endangered because of degrading forest status (Sharma, 1994).

Table 17. Location of Selected Villages

District	Taluka	Range	Round	Beat	Village	Type of forest
Narmada	Rajpipla	Kevadia	Naghatpur	Naghatpur	Naghatpur	RF(Fairly dense forest mainly teak)
			Haripura	Haripura	Limkhetar	RF(Fairly dense forest mainly teak)
		Rajpipla	Khutamba	Ambli	Nani Chikhli	RF(Dense forest)
	Dediyapada	Dediyapada	Khatam	Bore	Bore	RF(Fairly dense mixed forest of teak and bamboo)
				Khatam	Pansar	RF(Dense mixed forest of teak and bamboo)
			Singalvan	Singalvan	Singalvan	RF(Dense mixed forest of teak and bamboo)
				Singalvan	Koyalivav	RF(Dense mixed forest of teak and bamboo)
			Solia	Solia	Dhanor	RF(Fairly dense mixed forest of teak and bamboo)
		Sorapada	Khaidipada	Vadva	Tilipada	RF(Fairly dense mixed forest of teak and bamboo)
				Kaliyabhut	Kunbar	RF(Fairly dense mixed forest of teak and bamboo)
	Sagbara	Sagbara	Sagbara	Sagbara	Kodba	Open scrub
			Devmogra	Godada	Godada	Open scrub
			Patalamau	Mahupada	Dabka	Open jungle

Table 18. Profile of JFM Villages Selected For Micro Level Analysis*

	Naghat-Pur	Limkhe-tar	Nani Chikhli	Bore	Pansar	Singalvan	Koyali-vav	Dhanor	Tilipada	Kunbar	Kodba	Godada	Dabka
No.of house holds	381	31	68	17	203	171	60	71	132	212	97	274	135
Popula-tion	2115	203	359	66	1013	884	NA	334	696	1044	365	1378	588
No. of landless house holds	200	9	11	2	117	30	1	12	90	25	58	182	68
Percentag e of tribal population	99.5	100	98.9	100	99.6	99.5	NA	100	100	100	93.2	99.7	100
Geogra-phic area (ha)	957.29	1920.61	484.55	360.53	757.05	600.25	NA	418.35	187.31	465.73	114.10	2,662.82	242.52
Forest area (ha)	408.88	475.96	382.49	360.53	428.27	47.27	NA	299.19	27.71	217.42	0.29	2,639.78	93.93
Gochar area (ha)	86.06	1168.04	24.74	nil	25.16	22.50	NA	4.35	57.15	16.30	3.02	nil	nil
Live stock	3000	890	265	64	4000	728	185	90	595	360	400	1234	1806
Area under JFM	40	25	240	163	200	329.03	126	292.18	15	50	25	50	15

*Source= Forest Department

5.5.1.3 Motivation for Protection:

In general, the increasing inability of forest to meet the basic requirements of firewood, fodder and NTFPs was the major motivating factor for the villagers to take up forest protection and restoration. In most of the JFM villages of the study area, 90% of the population was dependent on the forest. Forest resource depletion have enforced women to trek long distance to collect firewood and dry leaves and forced the village to cut the forest and carry out agricultural practices which they could not sustain longer due to climatic changes and soil erosion. As such in majority of the villages selected for the study the contribution of the forest department in motivating and creating awareness among the villagers to implement the JFM program was tremendous.

In villages of Rajpipla taluka the initiation of JFM was mainly by forest department except for Naghatpur where it could be attributed to self awareness of villagers. Moreover, Nani Chikhli was further benefited from the financial backup received from external funding agency OECF, Japan.

In Dediyapada taluka also, majority of JFM initiation was done by forest department except for Tilipada and Kunbar wherein the JFM was initiated by NGOs such as AKRSP (Aga Khan Rural Support Program) and WWF (World Wide Fund for Nature) respectively. In Tilipada village, AKRSP initially worked on farm forestry, trench forestry and various other social forestry programs and thereafter JFM program was initiated by the this NGO on gochar area by the total involvement and participation of the villagers. Forest department had moved one step ahead in finding out alternatives for the forest protection and restoration of the degraded forests by adopting a village, Bore called as a *dattak gam*. A special case was seen in Pansar village, as the Forest Protection Committee was established in this village by the forest department since the forest of this area was in high state of degradation even without any cooperation from Pansar villagers. Villagers of the neighboring villages were involved in the management, protection and restoration of the forests of this village.

Villages of Sagbara taluka exhibited JFM initiation by the forest department except for in Dabka, wherein AKRSP initiated watershed management project. This

initially helped in capacity building with the villagers and thereafter gave a base to JFM program.

5.5.1.4 The Institutional Arrangement – An Assessment:

An overview of the structure and functions of the Forest Protection Institute associated with JFM plantations in the selected villages is presented in table 19.

1. **Rajpipla Taluka:**

In all three villages of Rajpipla taluka viz. Naghatpur, Limkhetar and Nani Chikhli, though the plantation activities were initiated at different time, the official approval letter was issued by the forest department in year 1999. In case of Naghatpur the plantation activities started even before the JFM resolution was passed in the state. All the villagers of Naghatpur and Limkhetar got involved in the JFM program and agreed a benefit sharing of 50% with the forest department from the plantation area. In case of Nani Chikhli though complete participation of all the villagers was not there but benefits to the villagers were much more when compared to other two villages as this village got financial backup from OECF, Japan, under the program of Integrated Gujarat Forestry Development Project.

Selection of plant species for plantation as well as the supply of the saplings in all the three JFM sites was done by the forest department.

The forest management institute also called as VSS (*Van Shurksha Samiti*) of Naghatpur and Limkhetar village were highly motivated and cohesive, and had candid discussions about the forest protection. In Limkhetar open grazing was strictly prohibited in the plantation area while in case of Naghatpur fodder requirements were sufficed from the plantation area in addition to the agricultural waste and grass obtained from the gochar area. Conservation of undercover showed the level of awareness of Limkhetar villagers. Contradictorily, Nani Chikhli was not using any alternate means for fuelwood and fodder and was totally dependent on the forest in order to satisfy its fodder and fuelwood requirements. This showed the lack of awareness among the villagers of Nani Chikhli.

Table 19. Portfolio of Forest Protection Institute (FPI) in JFM Villages

Name of the JFM village	Year of formation of FPI	Year of registration of FPI	Percentage of membership in FPI	Executive committee	Women in Executive committee	JFM area (ha)	Benefit sharing of villages (%)	Supporting agency
Naghatpur	1989	1999	100	11	3	130	50%	Nil
Limkhetar	1997	1999	100	9	0	25	50	Nil
Nani Chikhli	1991	1999	80.88	7	3	50	75-90	OECF
Bore	1996/97	1999	100	11	3	163	NA	Nil
Pansar	1998	1999	10.85	9	0	143	No benefit	Nil
Singalvan	1996/97	1999	17.54	9	2	329.03	50	Nil
Koyalivav	1990	1999	78.33	11	2	126	50	Nil
Dhanor	1996/97	NA	84.25	-	-	292.18	No benefit	Nil
Tilipada	1989	1992/93	100	12	6	35+17	50	AKRSP
Kunbar	1991	1992/93	100	14	2	180	50	WWF
Kodba	1998	1999	100	11	2	50	50	Nil
Godada	1989	1999	62.75	11	7	50	50	nil
Dabka	2000	2001	100	11	0	30	NA	AKRSP

Regarding the problem of illegal felling, no cases had been recorded from Limkhetar JFM area, as the villagers gave night watch to the plantation area. While in Naghatpur village, neighboring villagers were involved in illicit felling and in Nani Chikhli villagers themselves were involved in the illegal felling from the JFM area.

In case of involvement of women in the JFM program all the three villages stood apart. In Naghatpur village women were actively involved in the decision making process as the active members of executive committee. However in Nani Chikhli women participation was seen in the executive committee but they acted merely as spectators with no role to play. While in Limkhetar complete lack of women participation was seen in the entire JFM program. Women were neither the part of the executive committee nor they took part in any of the decision making process.

2. Dediyapada Taluka:

Among the villages of this taluka, Tilipada was the pioneer in the initiation of JFM program which was mediated by AKRSP, an NGO. While in Kunbar the responsibility of creating awareness for forest protection and conservation was done by WWF. As a result these villages showed complete participation in the JFM program. Even in Bore village which is forest department adopted village, complete participation was seen. While in rest all villages lesser participation in the JFM activities was seen. Minimum cooperation from the villagers was seen in Pansar village and Singalvan village. The villagers of Pansar as well as Dhanor FPI did not had a share in the benefit sharing. In Dhanor village initially FPI was formed in 1996/97 but since 2000 the VSS had completely stopped functioning and people were not involved in any of the forest protection and management activities. The people there were engaged in agricultural practices inside the forest area, and women carried head loads from the plantation area and also burn the forest as a result of which the forests are getting degraded at an alarming rate (Plate 27). Thus, an extreme case of illicit felling and unauthorized cultivation are met with in this village. Contradictorily, a commendable level of awareness regarding conservation of forest and sustainable use of forest resources was seen in Tilipada and Kunbar.

Open grazing was not allowed in the JFM sites of Bore in addition to Tilipada and Kunbar. While in Singalvan and Koyalivav fodder requirement was satisfied from the agri-waste such as pods of *Cajanus cajan*, waste of paddy and jowar and natural grasses growing agricultural field and to some extent also from the forest area.

In Tilipada, Kunbar and Bore women were not only part of the executive committee but also took part in the decision making process. Selection of plant species for plantation as well as the supply of the saplings in all the JFM sites was done by the forest department from the nursery established in Bore village (Plate 28).

3. Sagbara Taluka:

In Sagbara taluka, Godada village had the oldest FPI which was self initiated in 1989 [redacted], while Dabka had the youngest FPI initiated in 2001 by the active intervention of AKRSP. The whole village of Kodba and Dabka participated in plantation activities of the JFM area, while comparatively Godada had lesser participation in the committee. However, the benefit sharing was done equally between the forest department and the villagers in all the villages.

The role of women in this management, though major was not consistent in all the villages. Women had membership in executive committee in Godada and Kodba village. But women folk of Kodba did not took an active participation in the decision making process. In Dabka village though women were not part of managing committee but they had formed their own women's organization- *Mahila mandal* which worked under the VSS.

For sufficing their needs of timber, fuel wood and fodder requirements the committees of all the villages had established their own set of rules. For the timber requirements of the villagers the timber could be harvested from the forest area after taking prior permission from the forest department. Cutting was not allowed for fuelwood requirements. However litter collection was allowed. Fodder requirements were satisfied by agri-waste.

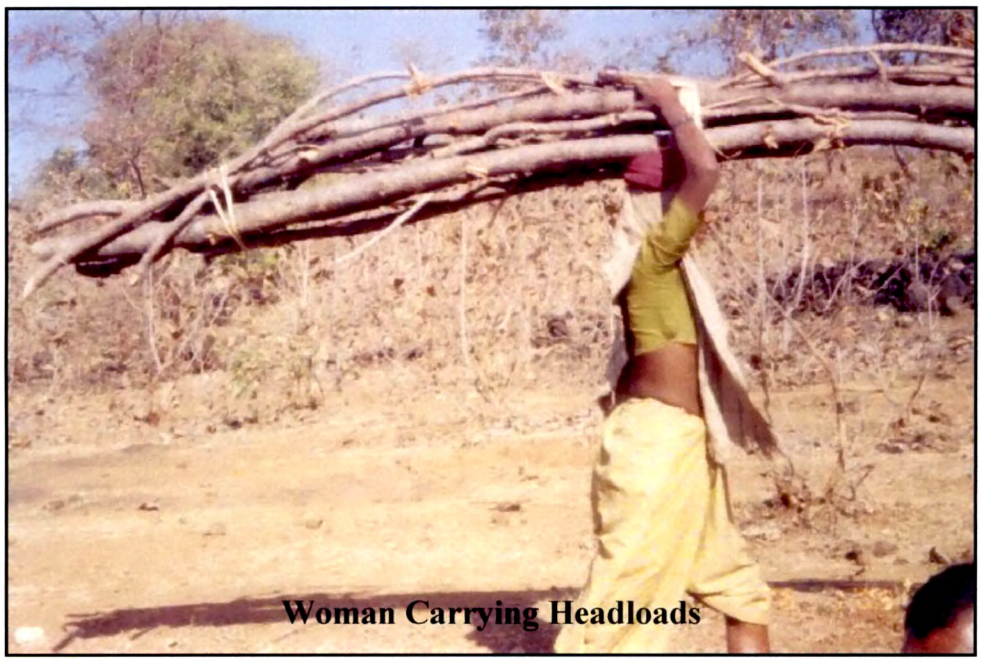


Plate 27. Degradation of JFM Site in Dhanor Village

Plate 28. Forest Department Model Nursery

5.5.2 Vegetational Analysis of JFM Plantations:

The initial survey of vegetational pattern had brought out the awareness of the village communities with respect to the protection of severely degraded forest. The shortage of biomass has resulted in increased protection because of paucity of day to day requirements. The vegetational status with response to their protection and management strategy is therefore changing (Plate 29). Each JFM village had its own forest management strategy and selection of species for the plantation.

5.5.2.1 Plantation Strategy and Choice of Species:

Monoculture plantation strategy was adopted in JFM plantation sites of villages such as Naghatpur, Kunbar and Bore wherein single species was used for plantation, while in rest all villages mixed type of plantation strategy was adopted. Studies revealed that teak was the most commonly preferred species for monoculture as well as polyculture plantations. In case of monoculture plantation, timber yielding plants were selected, while in mixed plantations timber yielding as well as NTFP yielding plants were selected. As a result in mixed plantations, in addition to timber which gives long-term benefit, the villagers received a regular income from the plantation area. A list of tree species selected for plantation and the forest products obtained from JFM plantations site is presented in table 20.

Plate 29. Difference in the Status of Forest after the Initiation of JFM

Table 20. List of Forest Products Available in Selected JFM Villages

Species Name		End Use
Botanical Name	**Local**	
Tectona grandis Linn	Teak	Timber
Dendrocalamus strictus Ness.	Bamboo	Timber, firewood
Terminalia tomentosa W. & A.	Sadad	Timber, firewood
Emblica officinalis Gaert.	Amla	Fruits edible, firewood
Acacia catechu Willd.	Khair	Firewood, katha
Albizzia procera Benth	Kilai	Timber, firewood
Azadirachta indica Juss	Neem	Timber, firewood, medicine
Albizzia lebbek Benth	Black siras	Timber, firewood
Terminalia bellerica Roxb.	Bahado	Timber, medicine
Morinda tomentosa Heyne.	Al	Timber, firewood
Wrightia tinctoria Br.	Kudi	Firewood, making toys
Gmelina arborea Roxb.	Sevan	Timber, firewood
Madhuca indica J. F. Gmel.	Mahuda	Timber, fruits for liquor, firewood, medicine
Butea monosperma Konig.	Khakra	Fodder, firewood
Holarrhena antidysenterica Wall.	Kada	Firewood, medicine
Ziziphus jujube Lam	Ber	Fruits, medicine
Dalbergia sisoo Roxb.	Sisoo	Timber, firewood
Garuga pinnata Roxb.	Kakad	Timber, firewood
Tamarindus indica L.	Amli	Fruits, firewood
Diospyros melanoxylon Roxb.	Timru	Leaves for beedi making, fruits edible, firewood
Ailanthus excelsa Roxb.	Arduso	Firewood
Cassia fistula L.	Garmalo	Agricultural implements, medicine
Grewia tilifolia Vahl.	Dhaman	Timber
Bombax ceiba	Semal	Cotton used for making beds
Bridelia retusa Spr.	Asan	Timber, firewood

5.5.2.2 Phyto-sociological Studies:

Depending upon the years of protection there occurred variation in the plant forms such as herbs, shrubs and trees. This variation correlated with the basal area which was derived from GBH and which gives an indication of biomass of the forest.

The effect of years of protection on girth class distribution of the selected JFM plantations is depicted in table 21.

Table 21. Plantation Analysis of JFM Villages

Village	Year of Plantation	Percentage of Girth Class			Basal Area (m^2/ha)
		Tree	Shrub	Herb	
Naghatpur	1989	59.26	1.85	38.89	14.66
Limkhetar	1997	5.0	68.33	26.67	4.3
Nani Chikhli	1991	38.71	6.45	54.84	19.45
Bore	1996/97	12.09	46.20	41.80	4.98
Pansar	1998	22.97	39.86	37.16	6.6
Singalvan	1996/97	14.14	29.29	56.57	5.88
Koyalivav	1990	17.21	50.82	31.97	19.34
Dhanor	1996/97	5.82	71.84	22.33	4.54
Tilipada	1989	65.73	1.39	32.86	28.09
Kunbar	1991/92	37.64	15.38	46.15	10.11
Kodba	1998	7.75	25.58	66.67	3.25
Godada	1989	19.49	11.86	68.64	15.75
Dabka	2001	3.39	25.42	71.19	7.81

Among the JFM villages of Rajpipla taluka viz. Naghatpur, Limkhetar and Nani Chikhli, maximum years of protection was provided to Naghatpur JFM plantations i.e. 14 years, this was followed by Nani Chikhli which was 12 years. Greater years of protection provided to the Naghatpur and Nani Chikhli plantations resulted in greater number of plants with higher GBH class, which was recorded to be 64 and 60 plants respectively (Figure 16). In spite of having more number of years of protection given to Naghatpur plantations as compared to Nani Chikhli, the basal area of Nani Chikhli was found to be greater than Naghatpur. But, Limkhetar plantations with lesser years of protection showed much lesser density of trees with a greater percentile of shrub population exhibiting much lower basal area. The under storey vegetation dominated by herbaceous population was highest in Nani Chikhli followed by Naghatpur and Limkhetar.

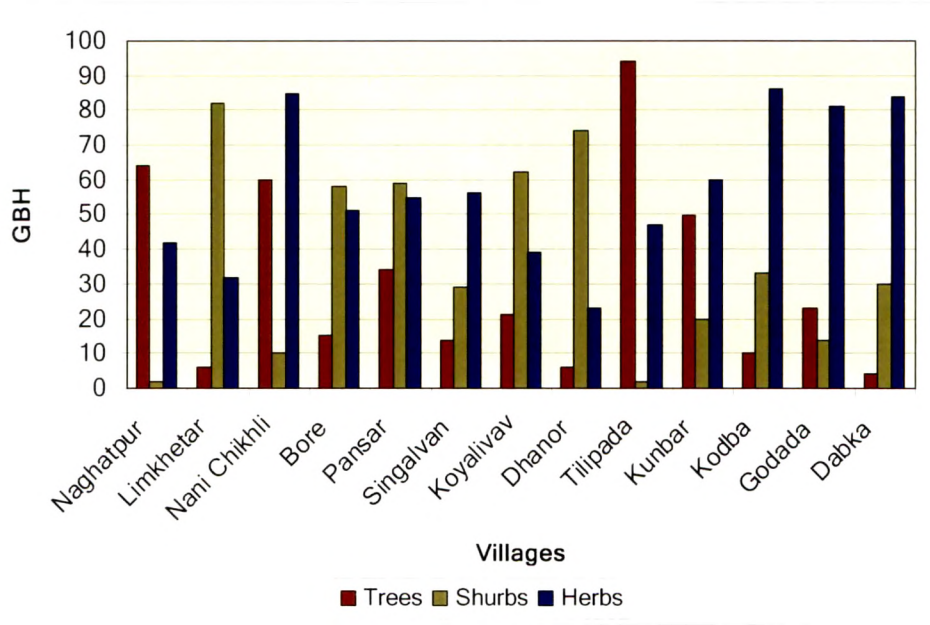


Figure 16. Number of Individuals in Each Girth Class in Selected Villages

In Dediyapada taluka, proportion of tree population in Tilipada was much higher when compared to all the other JFM plantations. It is important to note here that though the years of protection provided to Tilipada and Koyalivav are almost similar, the number of individuals recorded as trees in Koyalivav was less than half to that of Tilipada i.e. 21. The shrub population was found to be highest in Dhanor followed by Koyalivav. Comparatively good shrub population was also found in monoculture plantations of Bore though tree population was less. Contradictorily to Bore, Kunbar which also practiced monoculture plantation, showed greater proportion of tree population as compared to shrub population. Pure teak stands of both Bore and Kunbar JFM sites supported comparatively good herbaceous population. Also in Singalvan and Dhanor, lesser canopy closure supported greater herbaceous population.

In all the three villages of Sagbara taluka, the proportion of tree and shrub forms was found to be comparatively less than that of herbaceous population. Godada having maximum years of protection exhibited lesser proportion of tree population and resembled Dabka with minimum years of protection. However, the basal area of canopy cover of Godada was almost double to that of Dabka.

5.5.2.3 Phytodiversity:

Species diversity in JFM plantation sites was found to be low for both tree species as well as undercover as these ecosystems are physically controlled by the locals (Figure 17). The forest floor comprised of few climbers but very few grasses and epiphytes. Average depth of the ground cover ranged from 12 to 15 cm. The floor was not much covered with decomposed and semi-decomposed humus.

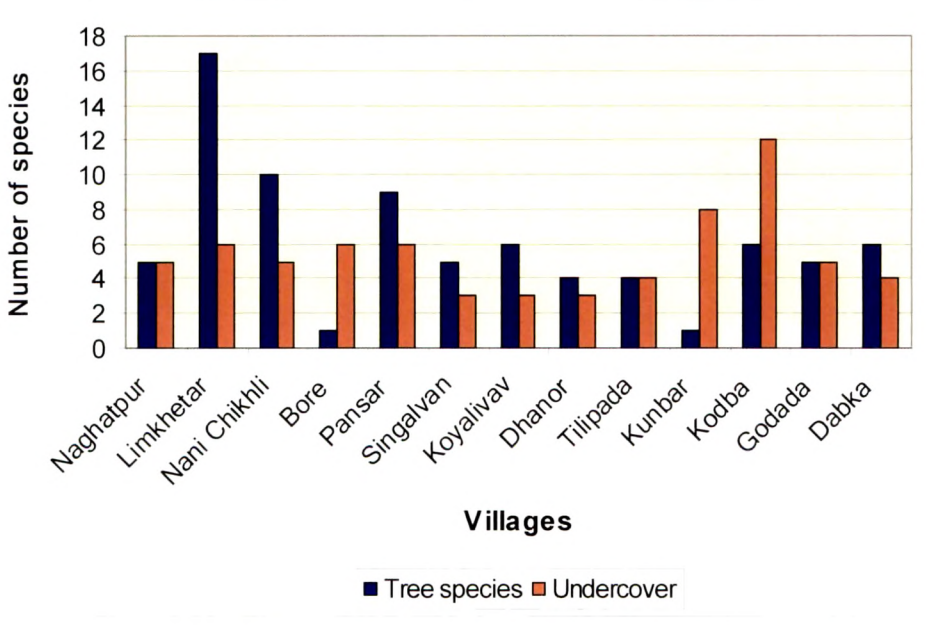


Figure 17. Number of Plant Species In Selected JFM Plantations

- **Floristic Composition of Canopy Cover:**

Phytosociological studies of JFM sites of Rajpipla taluka, revealed that the number of plant species (trees and shrubs) was quite high in Limkhetar wherein *Tectona grandis* Linn, *Butea monosperma*(Lamk.) Taub and *Gmelina arborea* Roxb were found to be equally dominant (Plate 30). Teak was found in all the 3 JFM sites though their IVI values differed (Plate 31). Maximum IVI value of teak was found in Naghatpur JFM plantation i.e.194.97. In addition to teak, monoculture plantations of Naghatpur exhibited natural regeneration of other associated species of teak such as *Terminalia bellerica* (Gaerth) Roxb and *Cordia wallichii* G. Don. However, in Nani Chikhli plantations *Acacia catechu* Willd (106.66) was found to be most dominant.

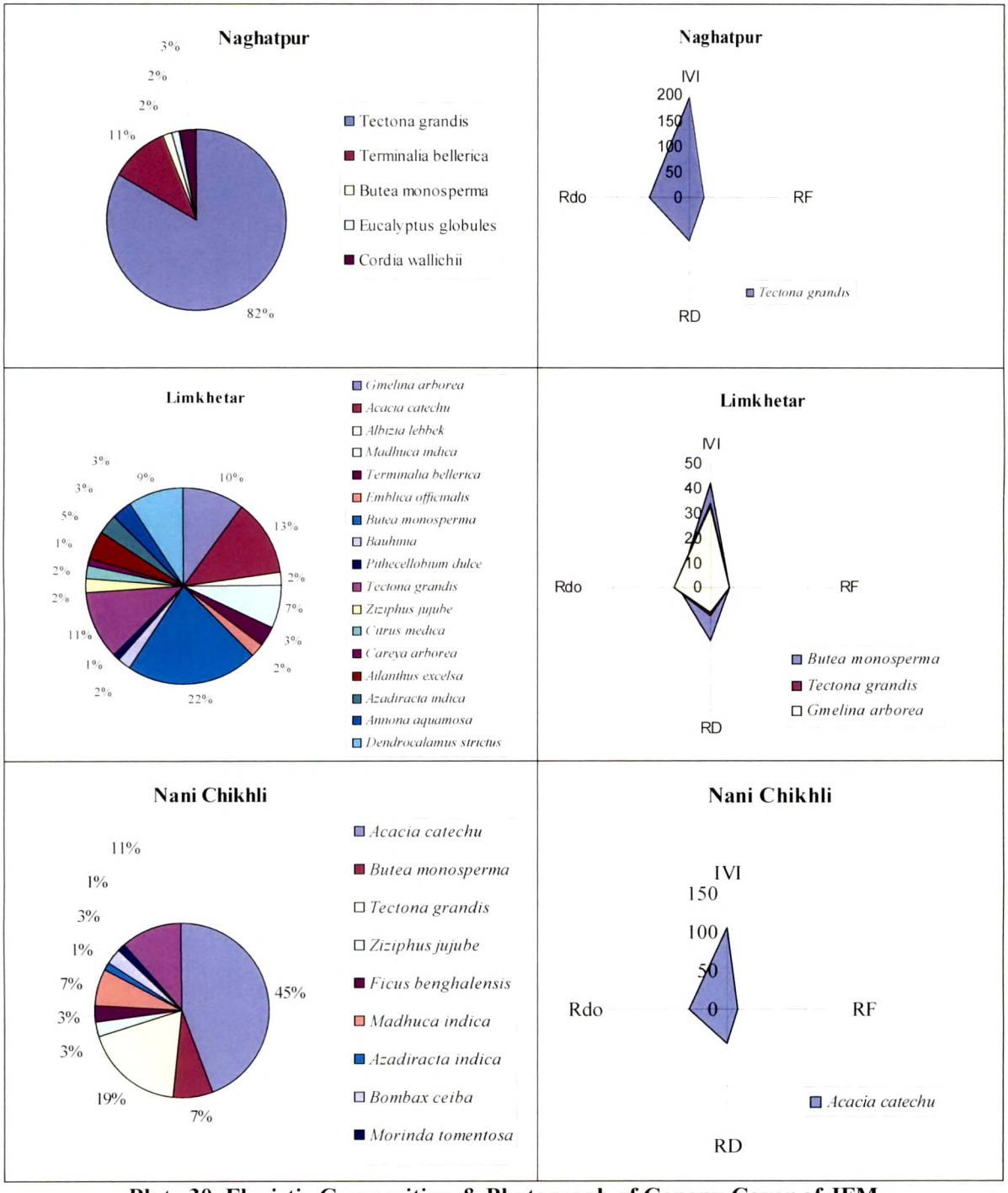


Plate 30. Floristic Composition & Phytograph of Canopy Cover of JFM Plantations in Rajpipla Taluka

Plate 31. *Tectona grandis* L. –Most Dominant Species of JFM Plantations

In Dediyapada, two villages i.e. Kunbar and Bore were distinct from all other JFM plantations as pure teak stands were found in both these villages (Plate 32 & 33). These plantations did not support any natural regeneration. In rest all villages mixed plantation was quite predominant. Teak was also the most important species in Singalvan plantations with the IVI values of 144.38, though it was much lower than Kunbar and Bore. NTFP yielding *Butea monosperma* (Lamk.) Taub, was found to be dominant in both Tilipada and Koyalivav but their status differed. *Albizzia lebbek* Benth showed a scattered distribution in this area (Plate 34). In Tilipada it was 212.75 while in Koyalivav it was just 97.48. While in Dhanor *Aegle marmalos* Corr. was most dominant (Figure 18).

In Sagbara taluka the diversity of tree species was recorded to be almost same in all the villages (Plate 35). Teak showed the highest IVI in Kodba (143.11) and Godada (107.75). In Godada plantations in addition to teak, *Garuga pinnata* Roxb. was found to be dominant with the IVI value of 96.04. While in Dabka the importance values of *Holarrhena antidysenterica* (Heyne ex. Roth) Wall was found to be highest.

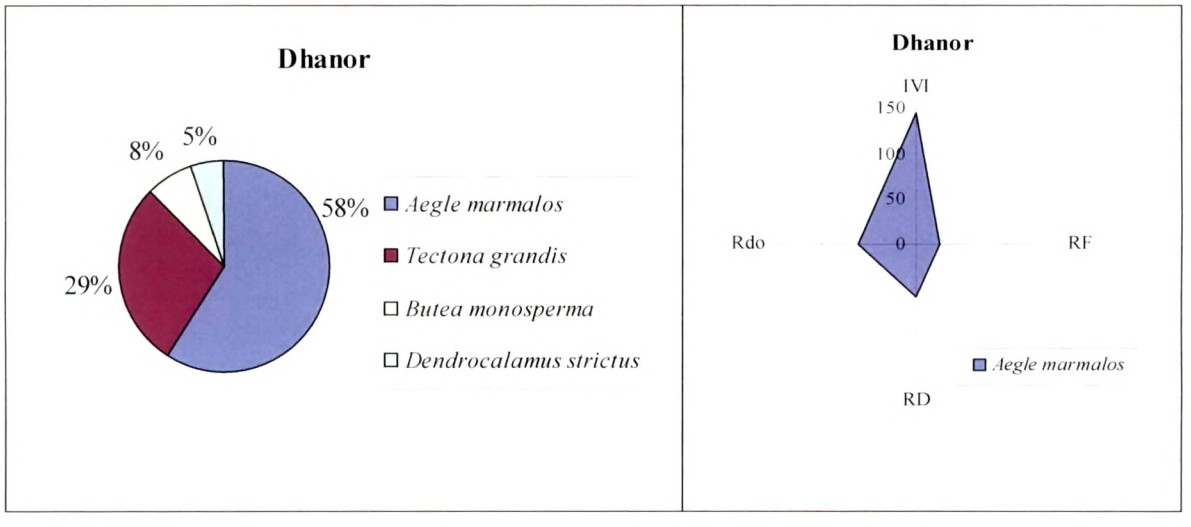


Figure 18. Floristic Composition and Phytograph of Canopy Cover in JFM Plantations of Dhanor (Dediyapada Taluka)

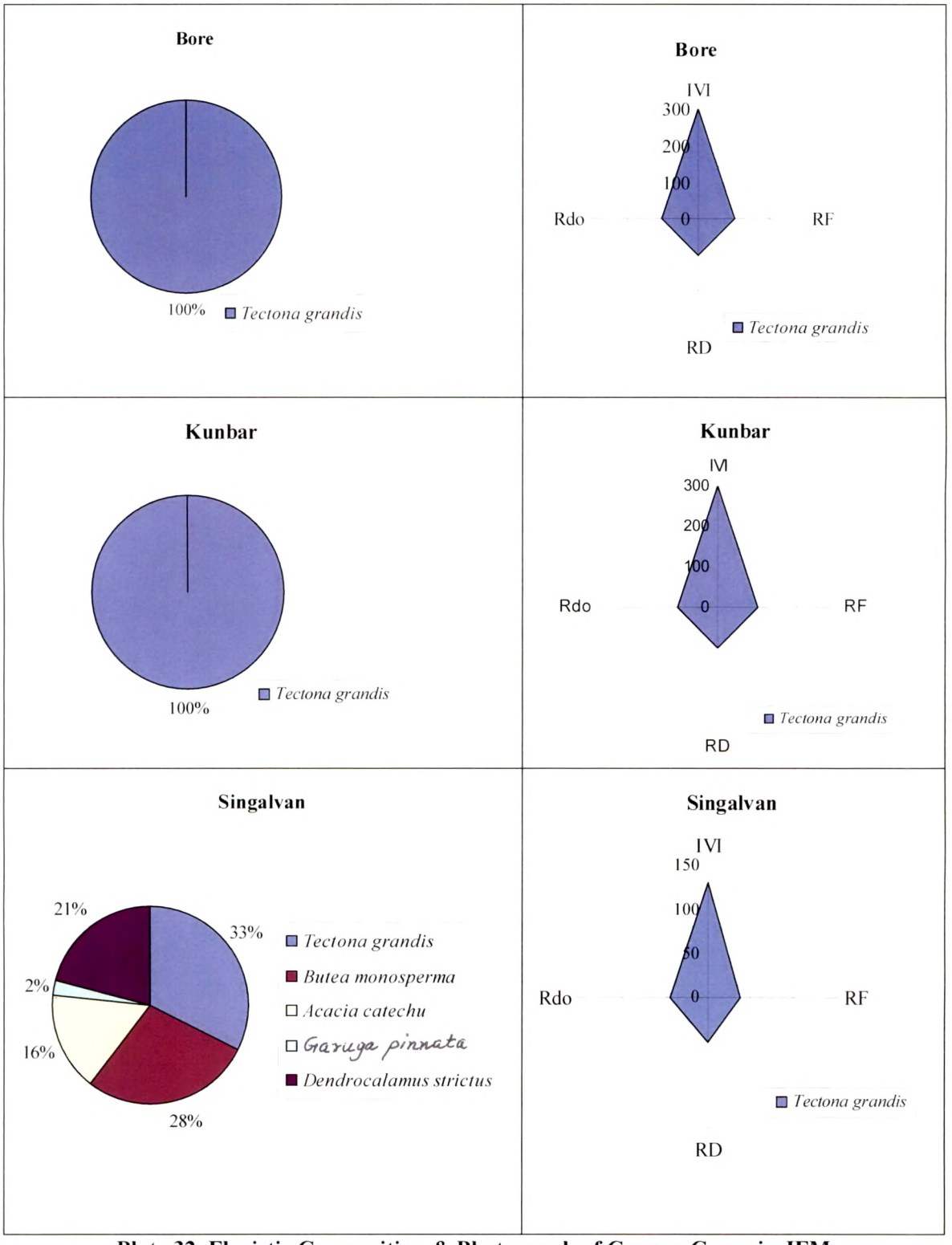


Plate 32. Floristic Composition & Phytograph of Canopy Cover in JFM Plantations of Dediyapada Taluka.

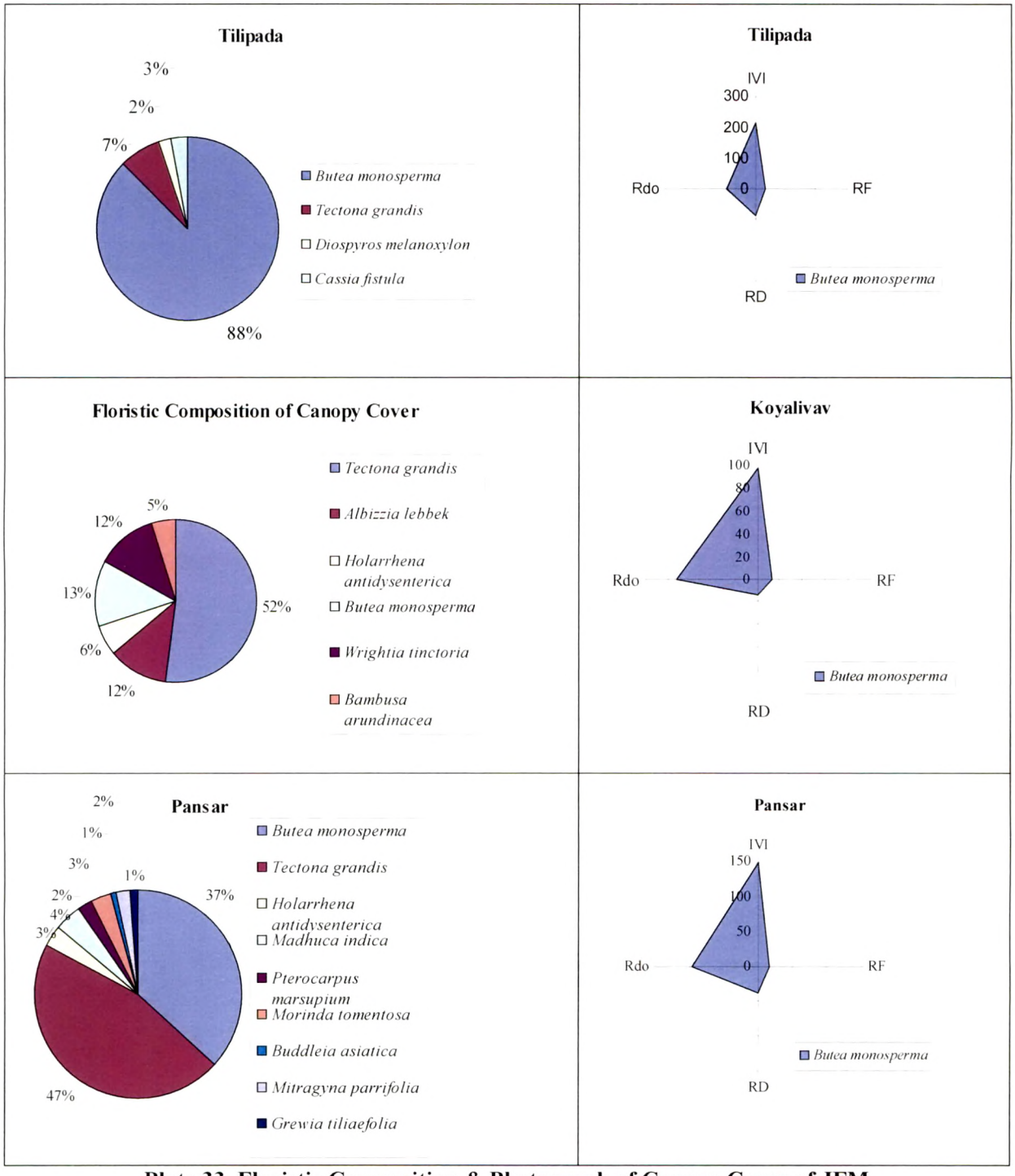


Plate 33. Floristic Composition & Phytograph of Canopy Cover of JFM Plantations in Dediyapada Taluka

Plate 34. Common NTFP Yielding Plants Dominant In Polyculture JFM Plantations

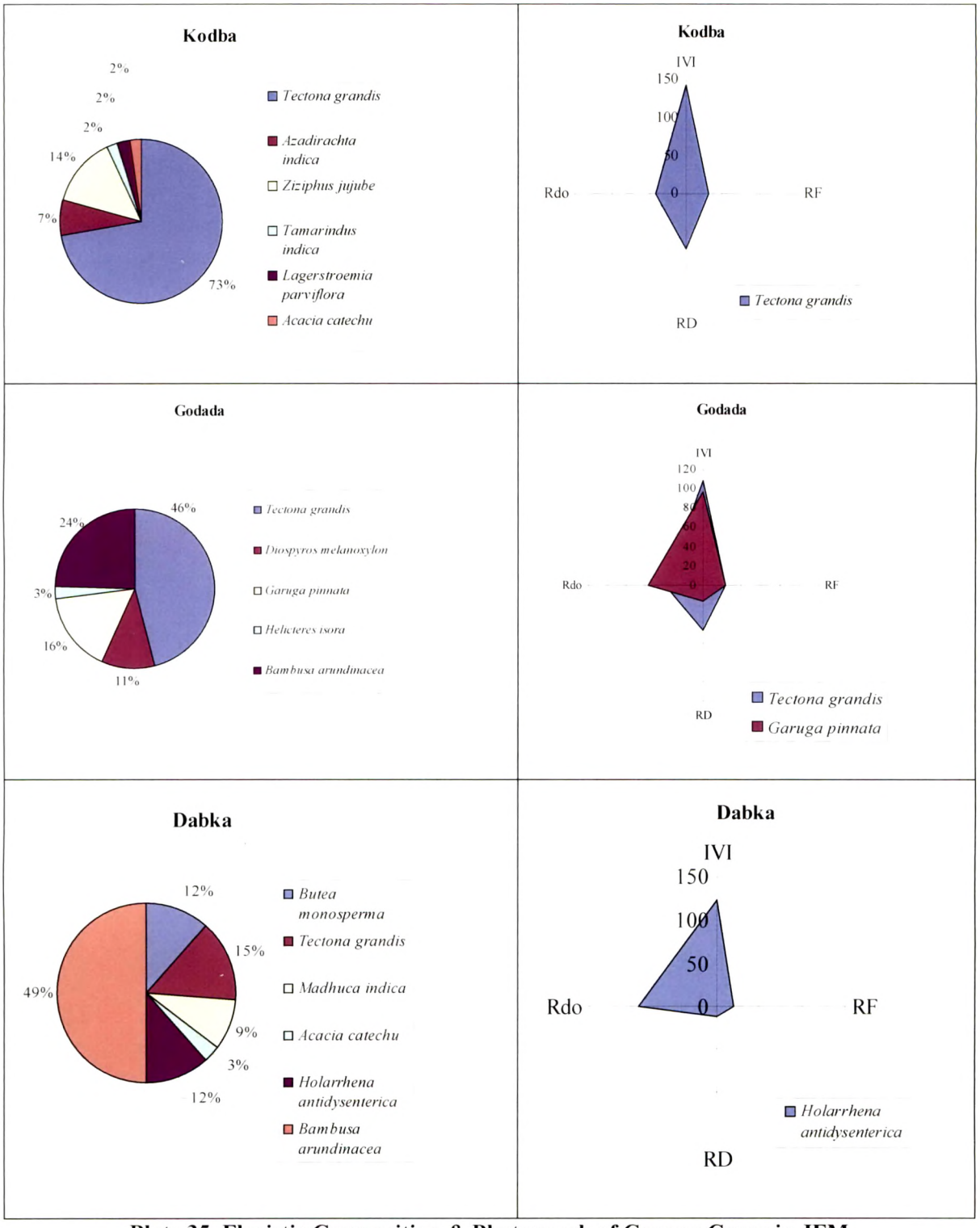


Plate 35. Floristic Composition & Phytograph of Canopy Cover in JFM Plantations of Sagbara Taluka.

➢ **Floristic Composition of Undercover:**

Floristic composition of undercover is mainly controlled by composition and density of the canopy cover. Gaps in the canopy cover promote very good growth of undercover due to better availability of light.

In Rajpipla taluka, undercover diversity of Nani Chikhli plantations was found to be much higher when compared to other two villages of this taluka. *Cassia tora* L. was found as the most dominant species of under cover vegetation in Limkhetar while, *Xanthium strumarium* L. was found to be the most dominant in Naghatpur plantations with their IVI values as 110.28 and 134.74 respectively. *Cassia tora* L. was also dominant in Nani Chikhli but their IVI value was found to be lower than *Lantana camara* auct.non L (Plate 36).

The undercover of JFM plantations of Dediyapada taluka was composed of various palatable and non-palatable species such as *Celosia argentea* L., *Tribulus terrestris L., Sida acuta* Burm f, *Xanthium strumarium L, Synedrella nodiflora* (L. ex Willd.) Gaertn and others (Figure 19, Plate 37 & 38). Pure teak stands of Kunbar and Bore promoted similar type of undergrowth. Cultivated species like *Cajanus cajan* (L.) Millsp were found in Pansar JFM site.

Among the three villages of Sagbara taluka, Kodba stood out in having the highest undercover diversity. *Cassia tora* Linn. (89.62), *Synedrella nodiflora* (L. ex Willd.) Gaertn.(112.29), *Celosia argentea* L (125.42) were found to be most important species of Kodba, Godada and Dabka plantations respectively (Plate 39).

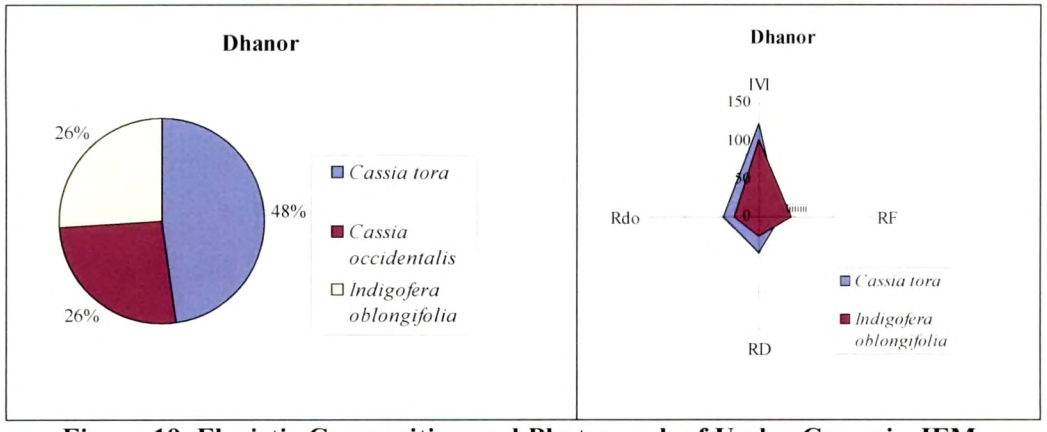


Figure 19. Floristic Composition and Phytograph of Under Cover in JFM Plantation of Dhanor (Dediyapada taluka)

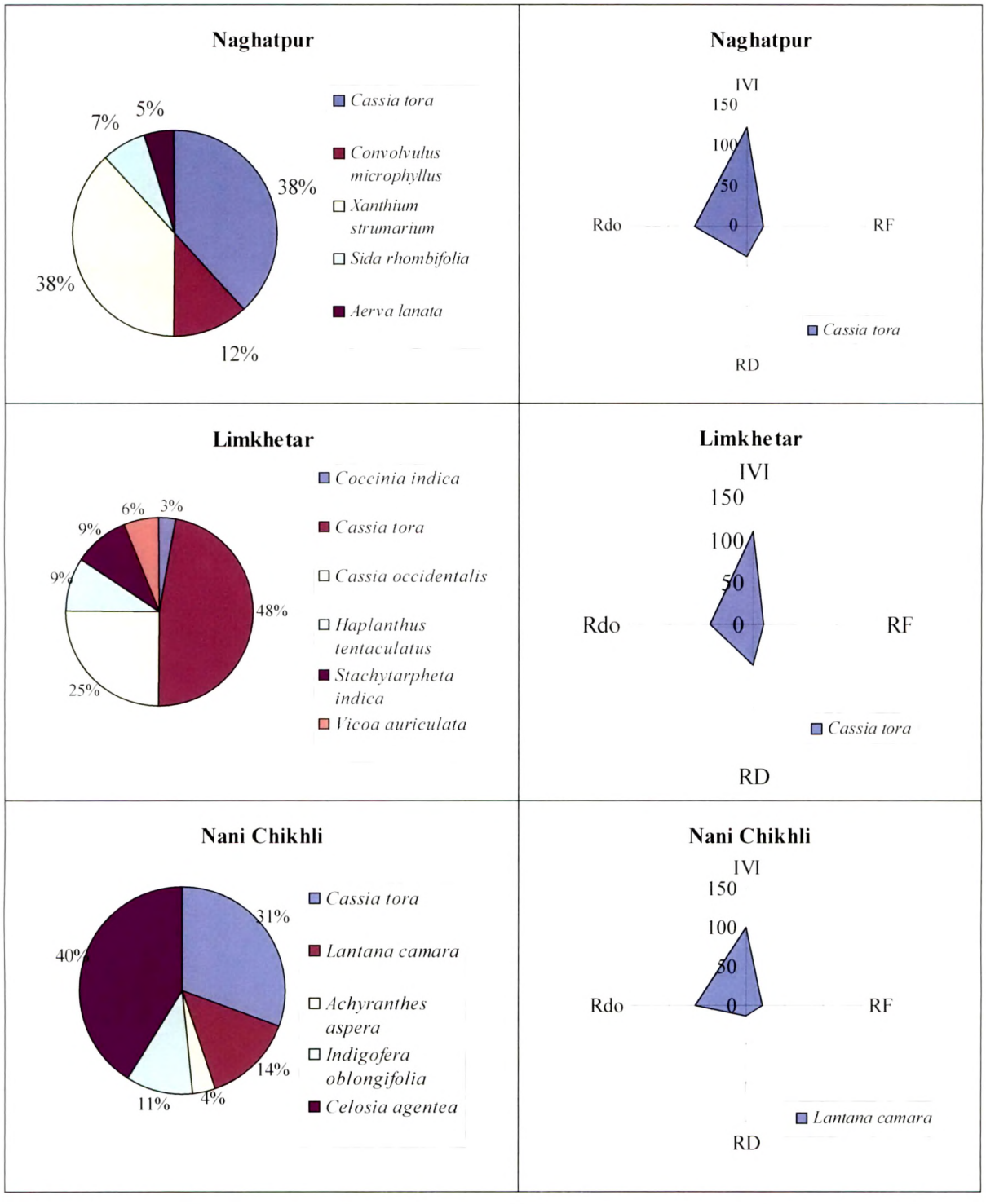


Plate 36.Floristic Composition and Phytograph of Under Cover of JFM Plantation of Rajpipla Taluka.

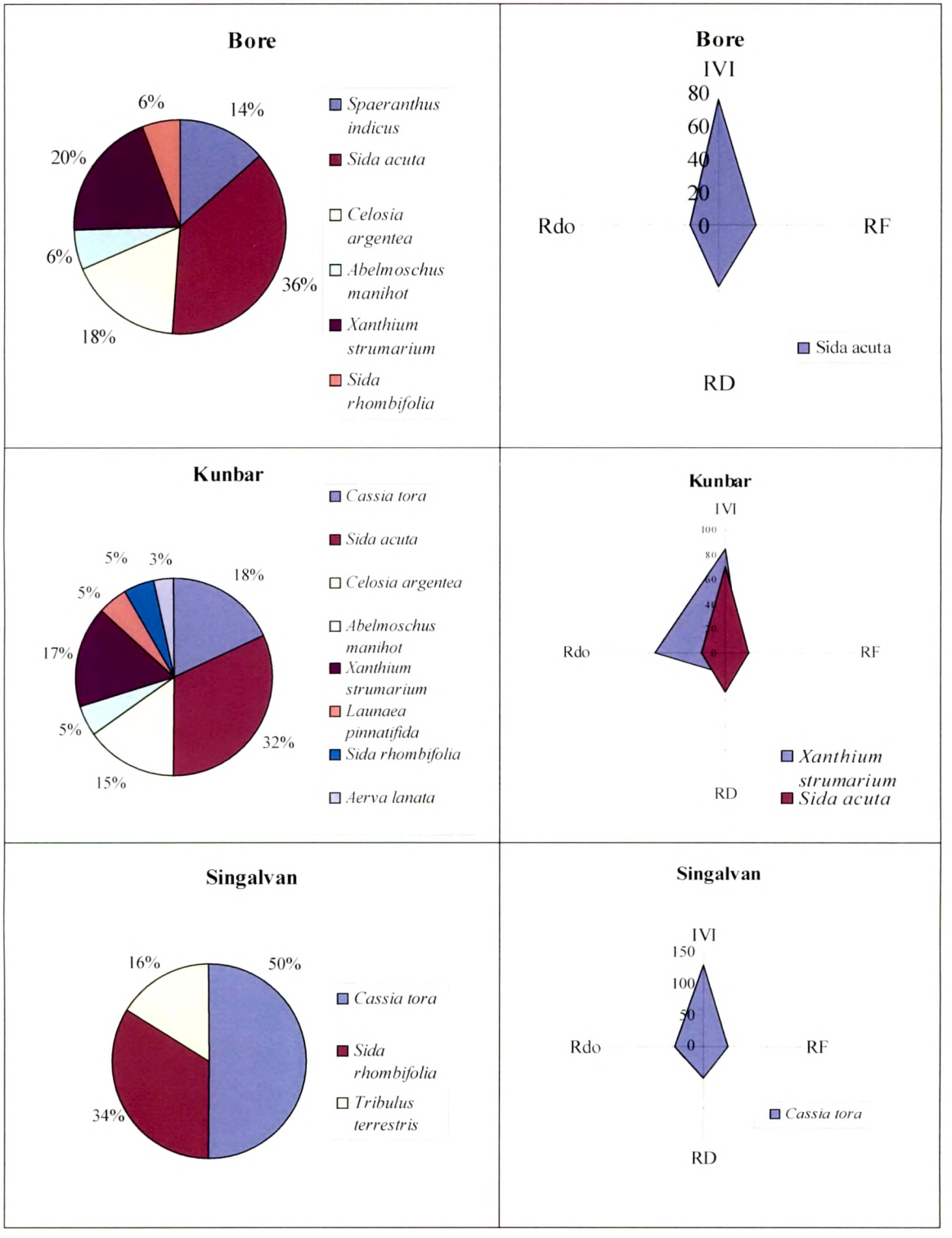


Plate 37. Floristic Composition and Phytograph of Under Cover of JFM Plantation in DediyapadaTaluka.

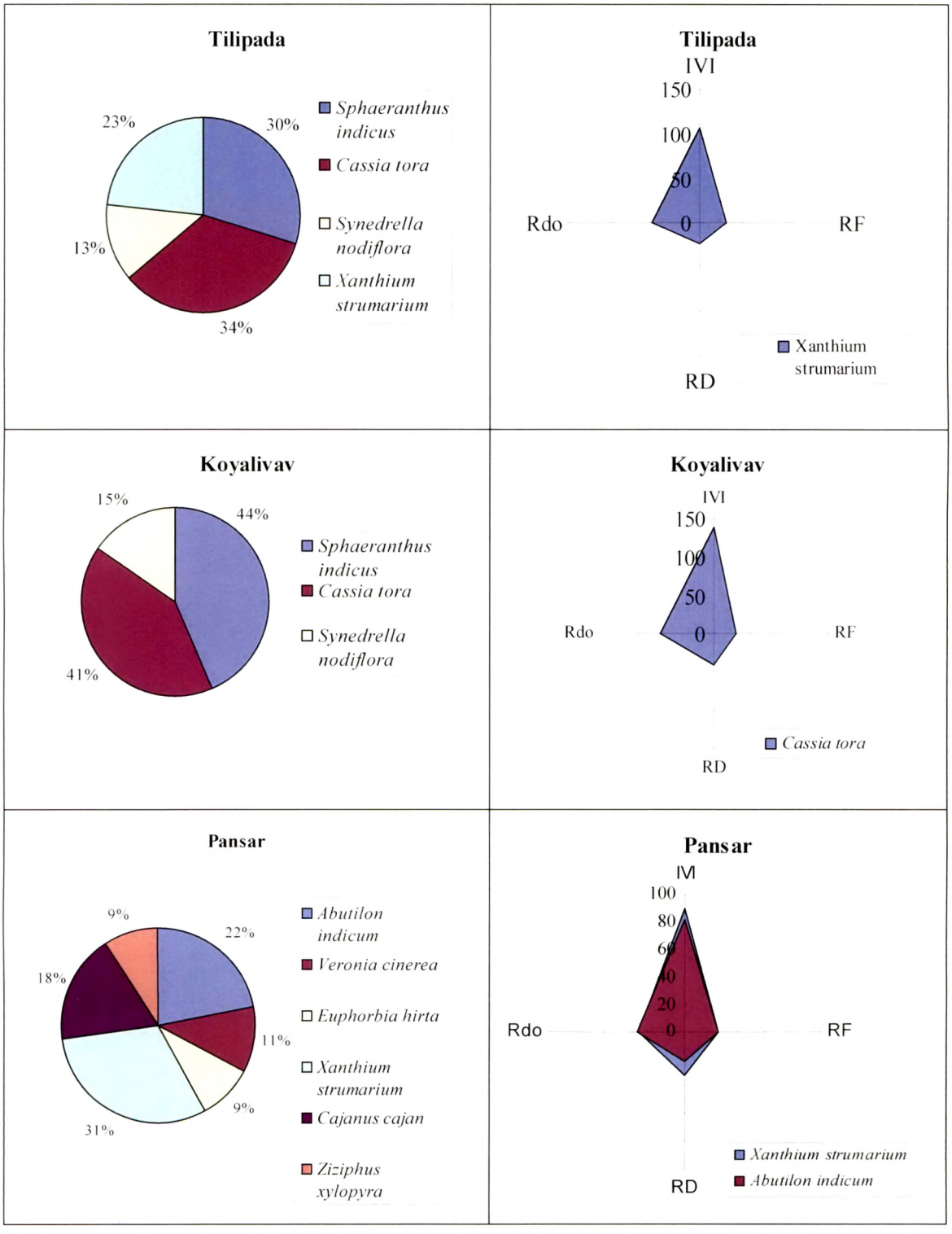


Plate 38. Floristic Composition and Phytograph of Under Cover of JFM Plantation in DediyapadaTaluka.

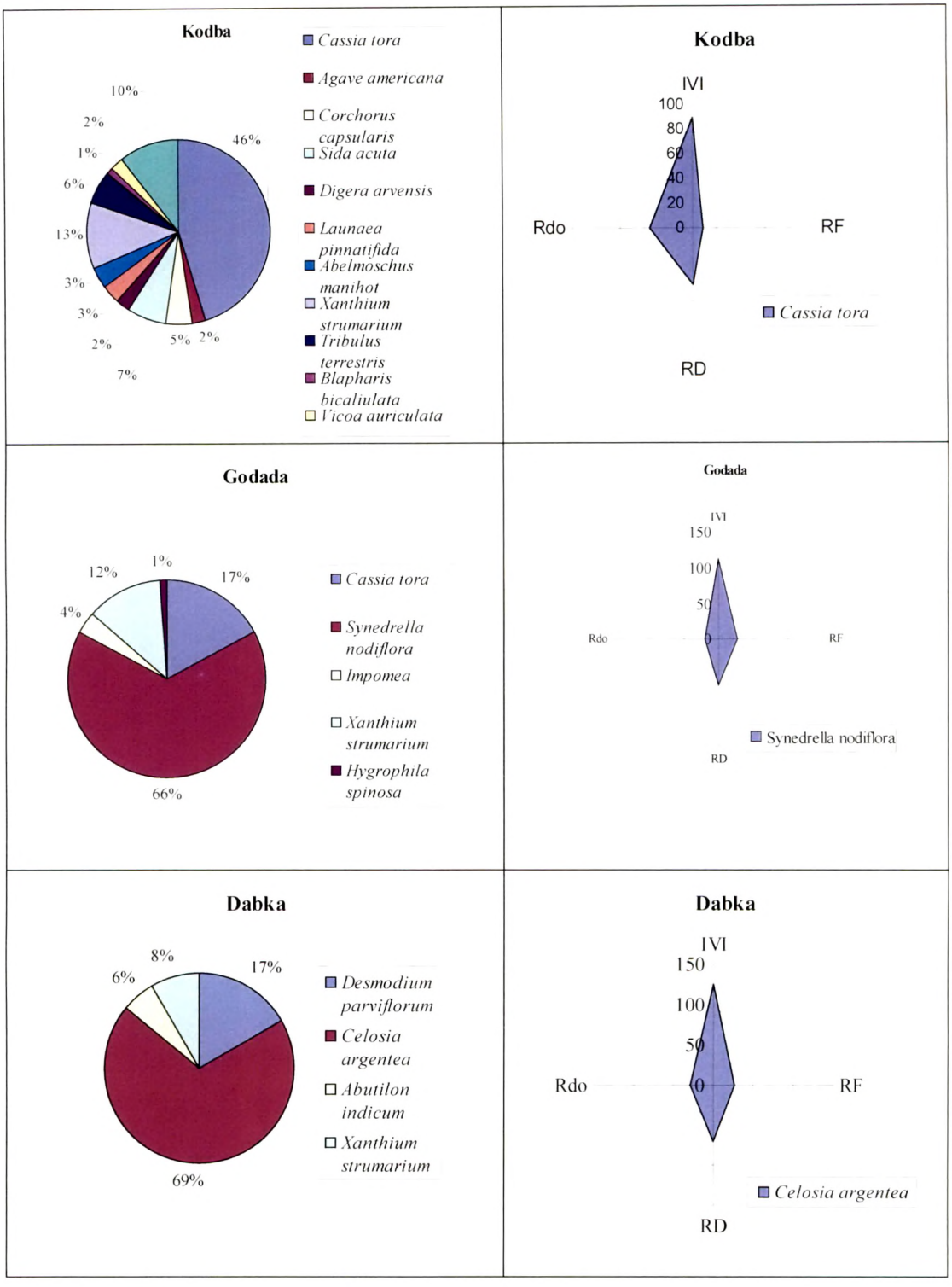


Plate 39. Floristic Composition and Phytograph of Under Cover of JFM Plantation in SagbaraTaluka.

5.5.2.4 Diversity and Dominance Index:

Shannon function or H index, which gives the picture of general diversity of any ecosystem, brings out that the diversity of any JFM plantation is controlled by the plantation strategy adopted therein. While, Simpson dominance Index which predicts basically the heterogeneity of community demarcates monoculture plantations from polyculture plantations. An array of diversity values were found in the JFM plantations of all the three talukas (Table 22).

In Rajpipla taluka, the diversity values for trees species showed a greater range i.e. 0.270-1.076, while in case of undercover the diversity values showed a greater uniformity with very little variation. Thus, monoculture plantation of Naghatpur and polyculture plantations of Nani Chikhli & Limkhetar supported almost similar undercover diversity. The diversity value for tree species (including shrubs) was found to be highest in Limkhetar. Usually ecosystems managed by men, do not support high diversity but Limkhetar JFM plantations contradicted this hypothesis by showing a good diversity index. Dominance index was found to be the highest in Naghatpur plantations.

Table 22. Indices of Diversity and Dominance

Sr. no.	Villages	Diversity Index		Dominance Index	
		Tree sp.	Undercover	Tree sp.	Undercover
1.	Naghatpur	0.270	0.574	0.706	0.307
2	Limkhetar	1.076	0.618	0.105	0.303
3	Nani Chikhli	0.748	0.591	0.257	0.295
4	Bore	0.00	0.695	1.00	0.234
5	Pansar	0.584	0.731	0.352	0.205
6	Singalvan	0.623	0.437	0.254	0.391
7	Koyalivav	0.623	0.441	0.320	0.382
8	Dhanor	0.441	0.458	0.436	0.365
9	Tilipada	0.216	0.577	0.772	0.276
10	Kunbar	0.00	0.791	1.00	0.193
11	Kodba	0.416	0.820	0.546	0.245
12	Godada	0.579	0.441	0.309	0.475
13	Dabka	0.630	0.404	0.308	0.515

Tree species diversity values for Dediyapada taluka in different JFM sites ranged between 0.0 - 0.623 while that for undercover ranged between 0.441 - 0.791. Least diversity index and correspondingly the highest dominance index was found in Kunbar and Bore plantations closely followed by Tilipada. Even though Tilipada had adopted polyculture plantation strategy the dominance index was found to be quite high. Diversity values for tree species in Singalvan and Koyalivav was found to be same and undercover diversity was found to be almost similar. Monoculture plantations of Kunbar and Bore showed good herbaceous growth. Also, mixed plantations of Pansar supported good undergrowth.

In the JFM sites of Sagbara taluka, varied diversity values were seen in tree species while for undercover the diversity values of Kodba plantations was almost double to that of Godada & Dabka. Dominance index for tree species in Godada and Dabka was found to be almost same.

5.5.2.5 Index of Similarity:

Similarity index revealed similarity in plantation strategies between some villages and dissimilarity between other (Table 23 & 24).

Significant similarity was not found between the JFM plantations of Rajpipla taluka both in case of tree species as well as undercover. However the similarity between the canopy cover of Nani Chikhli and Limkhetar was found to be 0.52 which was some what significant.

In Dediyapada taluka maximum similarity was found between monoculture plantations of Bore and Kunbar both in case of canopy cover as well as undercover. While in case of mixed plantation, similarity among tree species between Koyalivav and Singalvan was found to be 0.73 which was quite high. Significant similarity among canopy cover was also found between Singalvan and Dhanor. While in case of undercover significant similarity was not found between any of the plantations.

In Sagbara taluka also the similarity between trees species as well as undercover of different JFM plantations was found to be quite less.

Table 23. Sorenson's Similarity Index for Tree Species of JFM Areas

	Naghatpur	Limkhetar	Nani Chikhli	Bore	Pansar	Singalvan	Koyalivav	Dhanor	Tilipada	Kunbar	Kodba	Godada	Dabka
Naghatpur	-	0.27	0.26	0.33	0.41	0.20	0.36	0.44	0.44	0.33	0.18	0.20	0.36
Limkhetar			0.52	0.11	0.15	0.36	0.35	0.29	0.19	0.11	0.35	0.18	0.43
Nani Chikhli				0.20	0.53	0.53	0.50	0.43	0.29	0.18	0.5	0.27	0.63
Bore					0.20	0.33	0.25	0.40	0.40	1.0	0.29	0.33	0.28
Pansar						0.29	0.40	0.31	0.31	0.20	0.13	0.14	0.53
Singalvan							0.73	0.66	0.44	0.33	0.36	0.60	0.73
Koyalivav								0.60	0.40	0.29	0.33	0.36	0.83
Dhanor									0.50	0.40	0.20	0.44	0.60
Tilipada										0.40	0.20	0.44	0.40
Kunbar											0.29	0.33	0.29
Kodba												0.18	0.33
Godada													0.36
Dabka													-

Table 24. Sorenson's Similarity Index for Herb Species of JFM Areas

	Naghatpur	Limkhetar	Nani Chikhli	Bore	Pansar	Singalvan	Koyalivav	Dhanor	Tilipada	Kunbar	Kodba	Godada	Dabka
Naghatpur	-	0.18	0.20	0.36	0.18	0.50	0.25	0.25	0.44	0.62	0.23	0.40	0.22
Limkhetar			0.13	0.0	0.0	0.22	0.22	0.44	0.20	0.14	0.22	0.18	0.0
Nani Chikhli				0.0	0.0	0.25	0.25	0.50	0.22	0.30	0.23	0.20	0.22
Bor					0.17	0.22	0.22	0.0	0.4	0.71	0.44	0.18	0.40
Pansar						0.0	0.0	0.0	0.20	0.17	0.11	0	0.40
Singalvan							0.33	0.33	0.29	0.44	0.40	0.25	0.0
Koyalivav								0.33	0.18	0.18	0.13	0.50	0.0
Dhanor									0.29	0.18	0.13	0.25	0.0
Tilipada										0.33	0.25	0.67	0.25
Kunbar											0.50	0.31	0.33
Kodba												0.23	0.25
Godada													0.22
Dabka													-

5.5.2.6 Secondary Analysis:

The primary plantation analysis of the JFM sites subjected to secondary analysis brought out the status of standing woody biomass. This helped in derivation of carbon sequestration rates and estimation of Mean Annual Increment (MAI) of these JFM sites (Table 25).

Secondary plantation analysis of the JFM sites of the Rajpipla taluka showed that Nani Chikhli exhibited the highest mean annual increment values i.e. 13.344 t/ha and correspondingly much higher standing woody biomass i.e. 160.135 m^2/ha. The carbon sequestration rate in Naghatpur was found to be almost half to that of Nani Chikhli.

In Dediyapada taluka, Tilipada showed noticeably high standing woody biomass and mean annual increment values. Also when compared to all other plantations carbon sequestration rate was found to be much higher i.e 6.672 t/ha/yr. Similar years of protection provided to monoculture plantation of Bore and polyculture plantation of Dhanor depicted almost same standing woody biomass and mean annual increment values. This shows that the plantation strategy had no influence on the standing woody biomass values.

Table 25. Secondary Plantation Analysis of JFM Villages

Village	Years of plantation	Standing woody biomass (m^2/ha)	Carbon Sequestration (t/ha/yr)	Mean Annual Increment (t/ha)
Naghatpur	14	120.338	3.954	8.595
Limkhetar	6	34.087	2.613	5.681
Nani Chikhli	12	160.135	6.138	13.344
Bore	8.5	39.772	2.152	4.679
Pansar	7	53.223	3.497	7.603
Singalvan	9.5	47.232	2.287	4.971
Koyalivav	15	159.248	4.883	10.616
Dhanor	8.5	36.111	1.954	4.248
Tilipada	16	232.089	6.672	14.505
Kunbar	12.5	82.471	3.035	6.597
Kodba	5	25.351	2.332	5.070
Godada	14	129.348	4.25	9.239
Dabka	5	63.345	5.827	12.669

Calculations of standing woody biomass for the JFM plantations of Sagbara taluka depicted maximum biomass in Godada. However the MAI values of Godada were much less compared to younger plantations of Dabka. In spite of having the same years of protection, Dabka and Kodba showed significant difference in the standing woody biomass, MAI values and carbon sequestration rates.

5.5.3 Carrying Capacity of JFM Plantations:

Carrying capacity of the JFM plantations depicts sustainability of these plantations in terms of their capability to suffice the demands of the local people. Locals are mainly dependent on the forest for their day-to-day requirements of fodder and fuel wood and the evaluation of each aspect has been done separately.

5.5.3.1 Evaluation of Fodder Consumption:

The cattle population of the study area mainly comprise of buffalo, bullock, cow and goats. The cattle population in each JFM village is depicted in figure 20. It was found that cattle population in each JFM village was independent of the plantation strategy adopted in the JFM area of that particular village. However a significant positive correlation of 0.51 was found between the percentage of landless and the cattle population of each village. After converting the cattle population into ACU (Animal Cattle Units) the total fodder demands of all the JFM villages in the district was found to be 27,335.266 tones (Table 26).

In Rajpipla taluka maximum cattle population was found in Naghatpur village with the total cattle count being 3000. Greater number of bullocks in Naghatpur led to greater fodder requirements, since the ACU count of bullock and buffalo is greater than cow and goat. The cattle population of Limkhetar and Nani Chikhli was found to be comparatively very less

In Dediyapada taluka, Pansar showed highest cattle count and hence much higher fodder demands. Other than Pansar none of the villages of this taluka showed a high cattle population.

In Sagbara taluka the maximum cattle population and correspondingly higher fodder requirements were found in Godada followed by Dabka and Kodba.

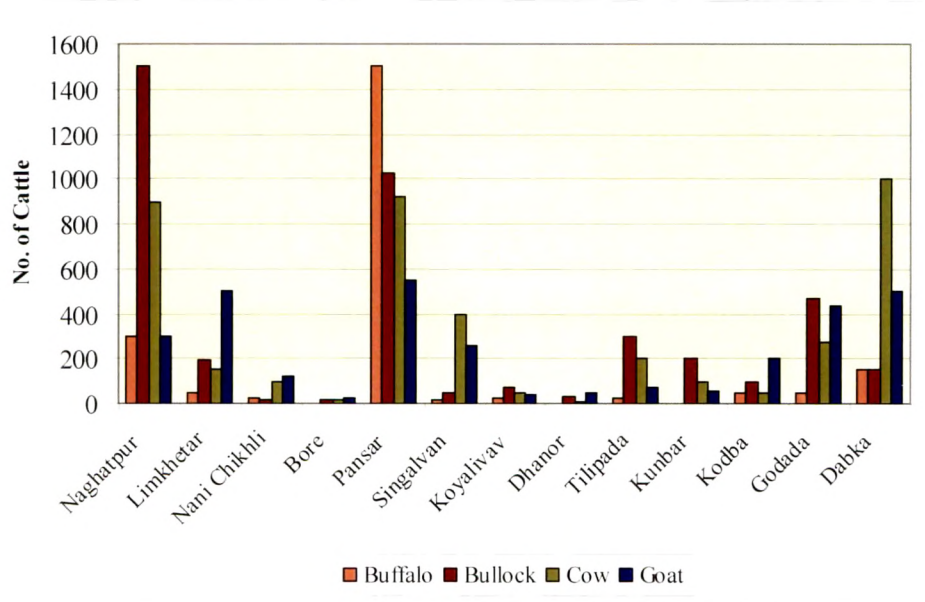


Figure 20. Cattle Population in the JFM Villages

Table 26. Demand of fodder from Each JFM village

Sr. No.	Villages	Total ACU	Demand of fodder in tons
1.	Naghatpur	3317.250	8624.850
2.	Limkhetar	432.185	1123.681
3.	Nani Chikhli	58.195	151.308
4.	Bore	42.230	109.798
5.	Pansar	3571.845	9286.797
6.	Singalvan	118.586	308.325
7.	Koyalivav	165.805	431.093
8.	Dhanor	60.345	156.897
9.	Tilipada	628.450	1633.970
10.	Kunbar	402.300	1045.980
11.	Kodba	251.150	652.990
12.	Godada	1001.428	2603.713
13.	Dabka	463.794	1205.864
	TOTAL	**10513.560**	**27335.266**

5.5.3.2 Evaluation of Fuel Wood Consumption:

Fuel wood consumption from each JFM village has been estimated based on the requirement of fuel wood per household which portray the dependence of locals on the forest (Figure 21).

In Rajpipla taluka, the fuel wood demand of Naghatpur village was found to be 695.32 t/yr, which was much more than other two villages of this taluka.

The demand of fuelwood from all the villages of Dediyapada taluka was found to be on the higher side. Of which the maximum was found in Pansar i.e. 592.76 t/yr and minimum was found in Bore i.e. 37.23 t/yr. Among the villages of Sagbara taluka Godada showed 650.06 t/yr of fuelwood requirement which was more than half to that of Kodba and Dabka.

5.5.3.3 Supply Potential of the Plantations:

The potential harvest limit for each JFM plantation was estimated based on the MAI values (Table 27). Potential harvest limit for any ecosystem is very important in order to maintain the sustainability of the ecosystems.

In Rajpipla taluka, Naghatpur plantations showed the maximum supply potential from the JFM area owing to greater MAI values and also the greater JFM area as compared to other two villages of this taluka.

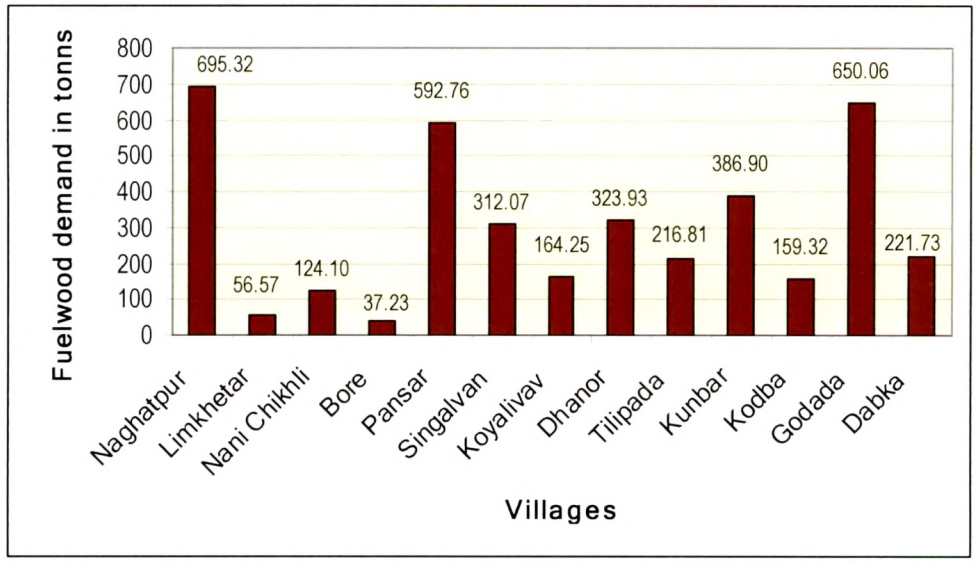


Figure 21. Fuelwood Consumption from the JFM Villages

Table 27. Demand of Fuel Wood in the JFM Villages

Village	Potential Limit of Harvest Per ha	JFM Area (ha)	Supply Potential from the JFM Plantations (t/yr)
Naghatpur	4.274	130	558.711
Limkhetar	2.868	25	71.014
Nani Chikhli	3.600	50	333.615
Bore	0.239	163	381.346
Pansar	3.811	143	543.635
Singalvan	2.485	329.03	817.944
Koyalivav	5.308	126	668.839
Dhanor	2.103	292.18	620.651
Tilipada	7.252	52	377.145
Kunbar	3.298	180	593.794
Kodba	2.539	50	126.755
Godada	4.619	50	230.979
Dabka	6.343	15	95.018

In Dediyapada taluka, Tilipada showed the maximum harvestable limit i.e. 7.252 t/ha and it surpassed all other JFM villages, followed by Dabka and Koyalivav. Though Tilipada showed the maximum potential harvestable limit but the supply potential of this village was less owing to lesser JFM area. It is to be noted that Tilipada with the highest and Bore with the least potential harvestable limit both had the same supply potential. Singalvan and Dhanor had lesser harvestable limit but due to greater JFM area the supply potential was found to be the highest.

In Sagbara taluka also, harvestable limit available per hectare was greater in Dabka but the total supply potential of the whole plantation of Godada was double to that of Dabka.

5.5.3.4 Sustainability of JFM Plantations:

Based on the supply potential of each JFM plantation and demand of fuelwood from each village the sustainability of the JFM plantation based on the difference between demand and supply is depicted in figure 22.

In Rajpipla taluka, though Naghatpur village had the maximum JFM area and correspondingly much higher supply potential but still the fuel wood demands of villages were found much higher, creating a wide gap between the demand and supply potential. Hence the JFM plantations of Naghatpur were not found to be sustainable in terms of fuel wood demands. While the JFM plantation of Limkhetar was found to be just over the sustainable limit and Nani Chikhli had surplus of fuelwood.

Among the villages of Dediyapada taluka, it is important to note here that Pansar was the only JFM site of this taluka which was not found to be sustainable with a deficit of 49.13 t/yr, while rest all villages were found to be sustainable.

In case of Sagbara none of the JFM sites had the capacity to suffice the needs of the local people therein. Hence none of the JFM villages were sustainable. Fuelwood demands of Godada village were found to be much higher than the harvestable limits and having the deficit of 419.086 t/yr.

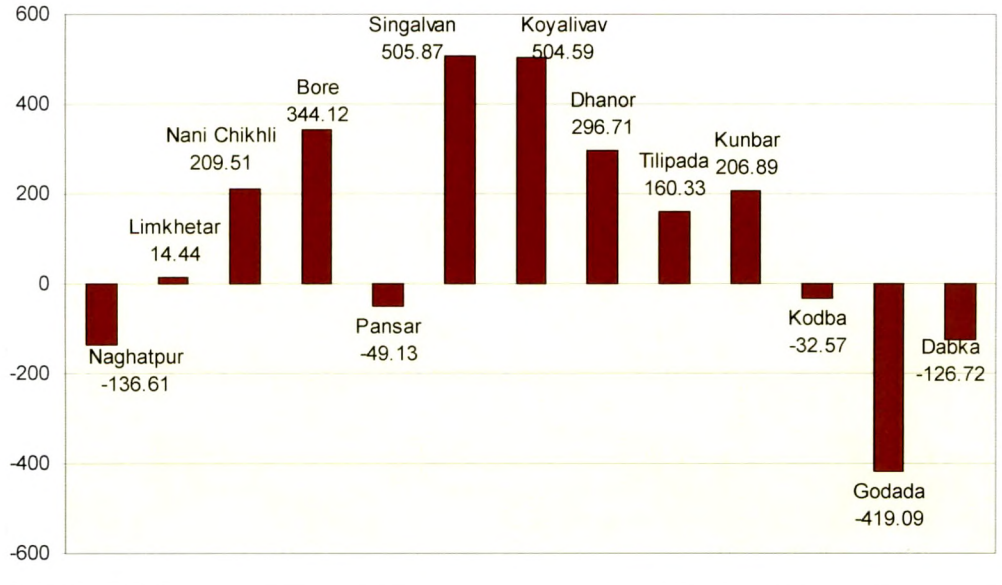


Figure 22. Difference Between Demand and Supply of Fuel Wood in JFM Villages

5.5.4 Ranking the Villages:

JFM is a forest management institution which is affected not only by ecological factors but management factors like structure, composition and functioning of Forest Protection Institution, as these are directly related to economic returns and sustainability of the plantation therein.

The data generated from ecological parameters derived from field study and socio-economic parameters collected through the questionnaire brought out the status of each village in terms of its sustainability. Ranking of these villages by giving weightage to these plantations helped in assessing them in terms of their ecological as well as socio-economic stability. Moreover it helped in highlighting the significance of plantation strategy and the role of the variables linked with these plantations.

5.5.4.1 Ecological Parameters:

The ecological stability of criterion based selected JFM villages was brought out based on the weightage points assigned to each ecological parameter.

In Rajpipla taluka all the 3 villages were widely separated in terms of its ecological weightages. In Dediyapada taluka the spectrum of the weightage varied from 32 to 40, while in Sagbara taluka it had a very narrow range between 34 to 38 points. This ecological point assessment of JFM plantation raised Dediyapada taluka at the highest level proving it to be ecologically more sound when compared to Rajpipla and Sagbara. Maximum villages of Dediyapada got higher values both in terms of ecological as well as economic value (Table 28).

In all the villages of Narmada district, Limkhetar occupied the first position while the second position was equally shared among three villages viz. Nani Chikhli, Koyalivav and Pansar. It stood first among all the JFM villages due to sustainable gochar area and forest land. In addition polyculture strategy adopted by this village had resulted into increased species diversity which contributed towards increased weightage of these plantations. However, high carbon sequestration rates and tree diversity values helped the JFM program of Nani Chikhli to secure second position. Nani Chikhli shared its second position with Koyalivav and Pansar due to better

Table 28. Weighted Sum Rank for Ecological Parameters of the Study Villages

Village	Carbon Sequestration (t/ha/yr)	Gochar land/ ACU (ha)	Forest/ Household (ha)	Diversity Index		Dominance Index		Weightage
				Tree Spp.	Undercover	Tree Spp.	Undercover	
Naghatpur	3.954	0.026	0.341	0.249	0.572	0.706	0.307	32
Limkhetar	2.613	2.703	0.806	1.076	0.618	0.105	0.303	50
Nani Chikhli	6.138	0.425	0.735	0.743	0.589	0.255	0.294	40
Bore	2.152	0.0	9.588	0.00	0.695	1.00	0.234	34
Pansar	3.497	0.006	0.704	0.584	0.731	0.352	0.205	40
Singalvan	2.287	0.19	1.924	0.623	0.437	0.254	0.391	34
Koyalivav	4.883	0.0	2.10	0.623	0.441	0.320	0.382	40
Dhanor	1.954	0.072	4.115	0.441	0.458	0.436	0.365	36
Tilipada	6.672	0.091	0.114	0.216	0.577	0.772	0.276	34
Kunbar	3.035	0.041	0.849	0.00	0.791	1.00	0.193	32
Kodba	2.332	0.012	0.515	0.415	0.818	0.544	0.244	34
Godada	4.25	0.0	0.182	0.579	0.441	0.309	0.475	36
Dabka	5.827	0.0	0.111	0.630	0.404	0.308	0.515	38

carbon sequestration rates, higher diversity values, lower dominance values and greater availability of forest area per household. Though Tilipada had the highest carbon sequestration rates but still it could not secure the first position due less tree species diversity and scarcity of grazing area and forest land.

5.5.4.2 Socio-economic Parameters:

The socio-economic features which included parameters like awareness among the villagers for forest conservation and protection, usage of alternate sources of fodder, percentage membership of households in FPI have shown that participation of the households in the FPI seems to be significant in the entire study area. Except Pansar and Singalvan, majority of the households of the villages were members of the FPI.

On the socio-economic basis three villages shared the first rank- Tilipada, Godada and Dabka, while the second position was again shared by two villages- Kunbar and Naghatpur (Table 29).

Self-initiation of JFM program in Tilipada and Godada shows the motivation of these villagers for forest conservation and protection. In addition, greater percentile of landless, active participation of women, lack of illicit felling in the JFM area helped Tilipada, Godada and Dabka to secure the top position. Using alternate source of fuel wood and fodder showed the level of awareness in all these three villages. The second position of Naghatpur and Kunbar may be attributed to complete participation of villagers in the JFM program as well the active participation of women. Kunbar scored better in the category of awareness regarding fodder and fuelwood consumption, while Naghatpur had greater percentage of forest dependent households to support the JFM program to make it a success.

Table 29. Weighted Sum Rank for Socio-economic Parameters of the Study Villages

Village	Initiation of JFM program			Mem-bership in the VSS (%)	Involvement of women			Awareness			Fodder requirement			Land-less (%)	Weigh-tage
	SI	NGO	FD		Active partici pation	Silent membe -rship	No role	No Illicit Felling	Illicit feeling from the neighboring village	Illicit feeling from members of VSS	agri-waste & gochar area	Depend-ent on the forest & agri-waste	Depend-ent on the forest		
Naghatpur	√			100	√				√			√		52.49	50
Limkhetar	√			100			√	√			√			29.03	45
Nani Chikhli			√	80.88		√				√			√	16.18	20
Bore			√	100	√					√	√			11.76	40
Pansar			√	10.85		√				√			√	57.64	15
Singalvan			√	17.54	√					√		√		17.54	20
Koyalivav			√	78.33	√					√		√		1.67	20
Dhanor			√	84.25			√			√			√	16.90	15
Tilipada		√		100	√			√			√			68.18	55
Kunbar		√		100	√			√			√			11.79	50
Kodba			√	100			√	√				√		59.79	45
Godada	√			62.75	√			√			√			66.42	55
Dabka		√		100	√			√			√			50.37	55

SI = Self Initiated, NGO = Non-Government Organization, FD = Forest Department

5.5.4.3 Sum Rank:

The ecological and socio-economic weightages assigned are brought together and sum total rank of each village is depicted in figure 23. Limkhetar secured first rank followed by Dabka and Godada. Each village when judged separately based on ecological and socio-economic parameters, Limkhetar scored better in ecological parameters, while Dabka and Godada scored better in socio-economic parameters. The integrated impact of both socio-economic and ecological factors have raised up or down each village on the ladder of rank.

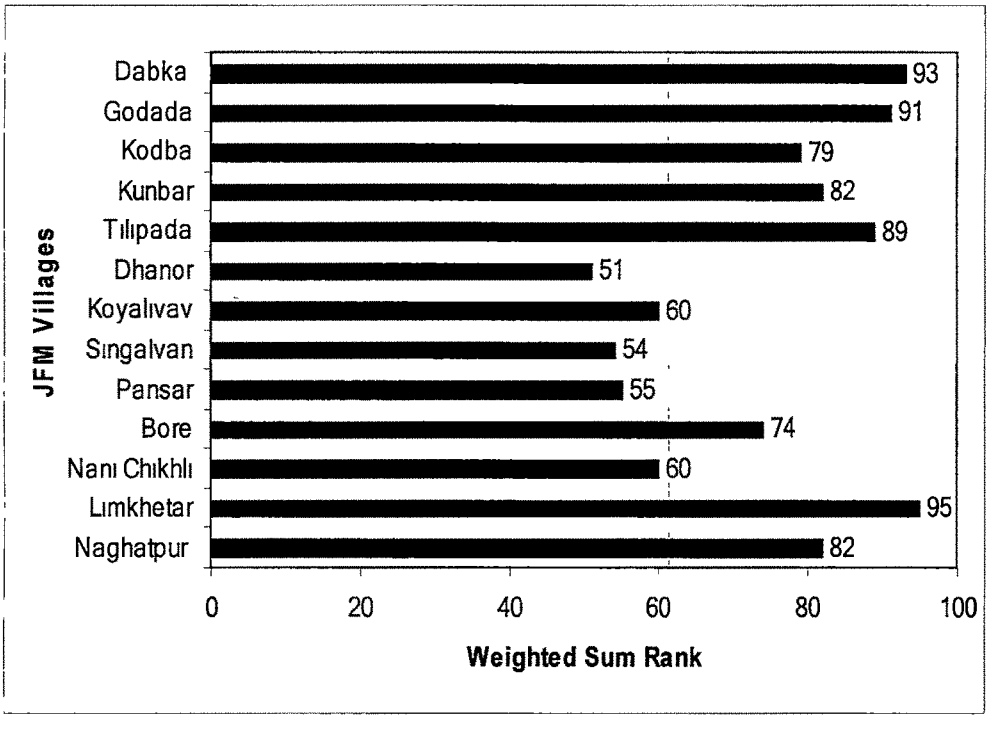


Figure 23. Weighted Sum Rank of JFM Villages.