IRS-1C data utilization for forestry applications

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The IRS-1C satellite with its sensors onboard has the immense potential to provide information on forest resources for their surveillance and monitoring. Towards this the early results on the use of high temporal wide swath WiFS data for rapid forest mapping have been demonstrated. The data from LISS-III and capability for 1 : 25,000 scale forest cover mapping amply demonstrate the potential of IRS-1C for effective monitoring of forest resources. The use of WiFS data for fire monitoring and LISS data for assessing afforestation and deforestation has been discussed. The PAN data for microlevel studies have been found adequate and discussed in this article.

THE IRS-1C satellite carries onboard three sensor payloads, viz. panchromatic camera operating in the visible region, LISS-III camera operating with four spectral channels (green, red, reflective infrared (RIR) and middle infrared (MIR) regions) and wide imaging field sensor (WiFS) operating in two spectral channels, viz. visible and IR bands. The microlevel details for stock mapping are expected to be achieved by the panchromatic stereo data with 5.8 m resolution. The stereo image will enable orthomapping for accurate terrain presentation. The various forest types in different bioclimatic regions can be mapped using LISS-III multispectral data of 23.5 m spatial resolution. The incorporation of MIR data will enable better discrimination of forest types. The LISS-III data is to be the most reliable data source for resource mapping at forest division level. The WiFS payload with repetitivity of every five days permit rapid forest cover monitoring and mapping. The study presents early evaluation results of the IRS-1C data.

WiFS data for rapid forest cover assessment

The Forest Survey of India (FSI) monitor the forest cover of India biennially, using IRS-1B LISS-I data. The maps being generated on 1 : 250,000 scale provide information with respect to dense, open and mangrove forests in India. The status of forest cover is also provided for various states, at district level. For certain regions obtaining cloud-free image using IRS-1B data with 22 days revisit cycle becomes difficult. One of the advantages of WiFS data with five-day repeat cycle is that the probability to obtain cloud-free data would increase. Besides, for certain episodic events like forest fire, damage due to cyclone, drought, disease, shifting cultivation, etc. more frequent data of WiFS will enable rapid change assessment. To demonstrate the utility for mapping India's forests, southern Indian region WiFS coverage of 24 January 1996 has been analysed for forest cover classification. An attempt has been made to evaluate this unique sensor for the first time in two different bioclimatic situations, viz. Western Ghats and Gujarat.

The WiFS colour composite has been simulated by combining visible, infrared and 3 × visible channels in red, green and blue combination (Figure 1). The per pixel supervised classification using maximum likelihood classifier indicates that it is possible to achieve forest cover/types classes. The forest cover classification has been achieved using maximum likelihood algorithm by defining various forest cover training areas. The spectral separability and class distinction have been taken care by observing the mean spectral reflectance values and also the standard deviation (Table 1). The analysis revealed that the min–max DN values in the visible and IR for forest vegetation are 28–103 and 14–162 respectively. The mean spectral separability response of various forest cover types is shown in Figure 2. Finally, the classification of three forest types, based on forest condition, viz. dense, open and deciduous open forests, has been achieved. The classified output of the entire southern India showing three forest cover classes is shown in Figure 3. The analysis on forest cover when compared with the forest maps generated by FSI and the available state forest maps of Kerala and Karnataka revealed high correlation. The confusion matrix also revealed a classification accuracy of 80% for all the classes. However, by careful analysis and combining 2–3 dates of different phenological stages data there is a possibility to improve the accuracy on forest cover maps.

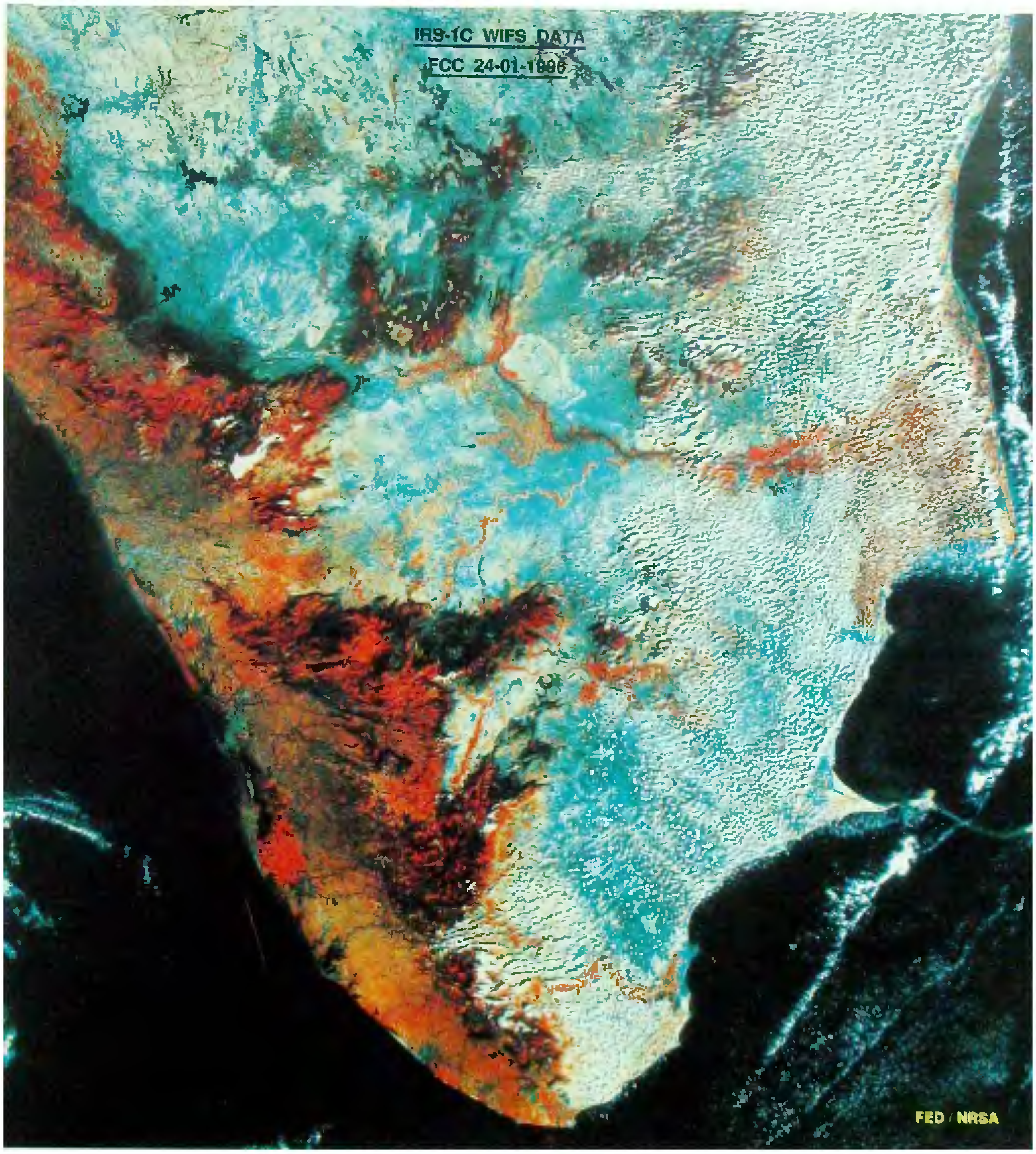

Figure 1. False colour composite of WiFS data.

The study carried out using WiFS data of Western Ghats and Gujarat (Dang forest division) indicates that the data are excellent sources for rapid forest survey. Availability of such data would also reduce computer processing time and data cost. Around 6.5 lakh km^2 area in Western Ghats could be analysed (single frame) with a high degree of consistency and fidelity. The study also recommend the use of WiFS data for annual forest cover mapping which can save adequate time and money while providing equally efficient forest cover details, at 1 : 250,000 scale. Hence the WiFS is ideal

Table 1. WiFS data reflectance values for forest cover details

	Mean		SD	
Class	IR	VIS	IR	VIS
Dense forest	88.99	29.46	8.64	5.87
Dense deciduous forest	75.08	46.57	4.71	3.25
Open forest	111.03	32.59	8.95	4.75
Deg. forest	82.41	54.44	6.74	14.15
Agriculture	98.76	51.56	5.04	6.21
Fallow	110.88	103.18	6.82	11.07
Water	14.81	28.83	3.01	5.04
Cloud	162.68	176.7	54.92	67.73

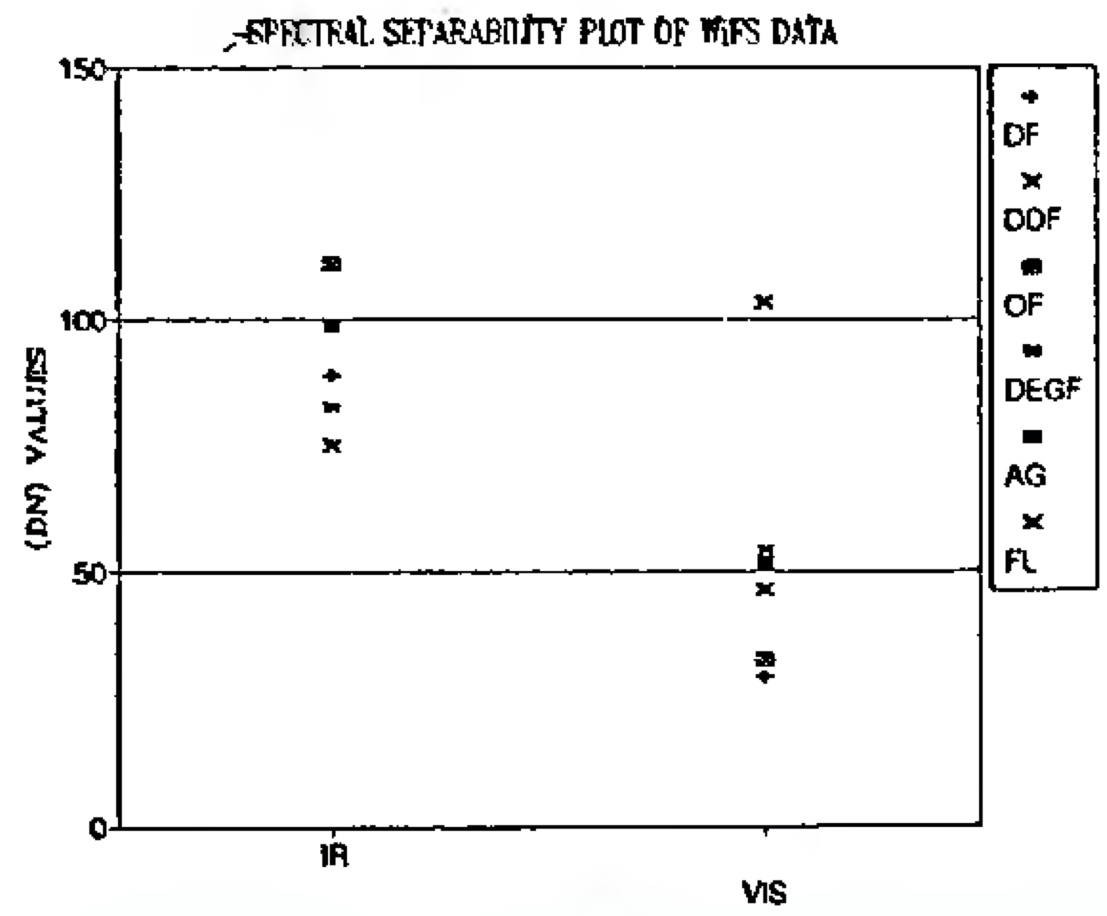

Figure 2. Spectral separability plot using WiFS data.

for the rapid national level forest cover mapping or even at the state level for periodic monitoring of forest wealth.

In addition to the above, WiFS data could be used for annual inseason forest fire monitoring and to account damages and suggest control measures for large scale forest fires because the WiFS data can be acquired for every five days subject to the availability of cloud-free data. Besides, WiFS data have an added advantage for closely monitoring phenological changes and subsequently choosing appropriate data for any specific application and to study episodic events (fire, cyclone damage, etc.).

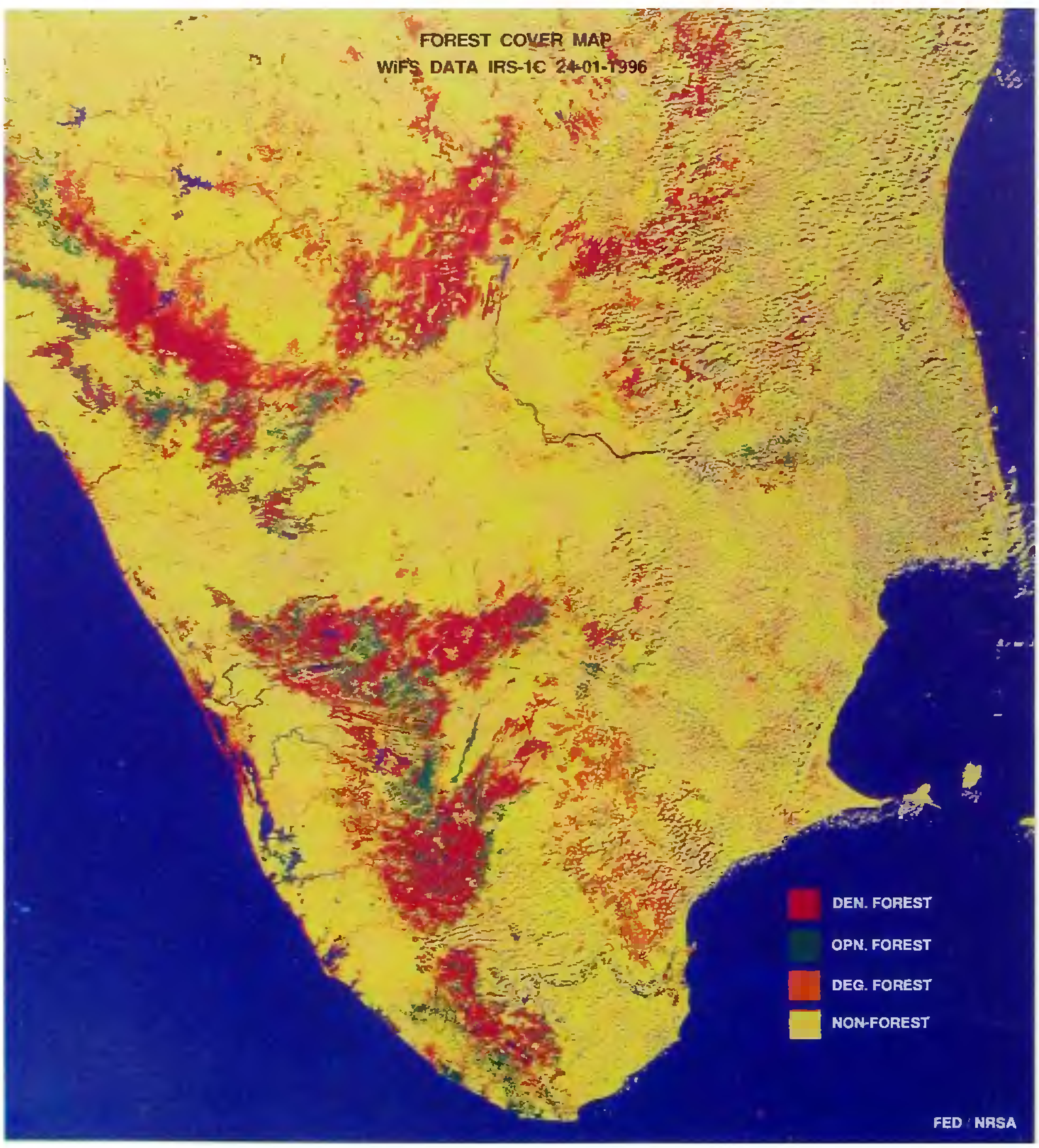

Figure 3. Forest cover map generated from WiFS data.

Comparison of WiFS with IRS-1B LISS-I

From the southern Indian peninsular WiFS data, a subset in and around Iddukki of Kerala has been selected for comparison with IRS-1B LISS-I (Figures 4 and 5). The results showed a great amount of similarity in the forest cover classes. The level of classification achieved in IRS-1B LISS-I and WiFS remained the same. The classes mapped using supervised maximum likelihood are: dense, open and degraded forests and grasslands. The mapping output was compared with the available forest cover maps on 1 : 250,000 scale. It was found that the accuracy of different classes was more than 80%. Significantly, the WiFS data provided reliable information on the distribution of grasslands also.

IRS-1C LISS-III data for forest resource mapping

It is expected that the IRS-1C with 23.5 m spatial resolution will provide data outputs adequate/comparable to the scale of 1 : 25,000. A study area in North Kanara has been selected using 24 January 1996 data and was analysed using maximum likelihood classification algorithm. The training areas are selected using the available aerial photographs and detailed stock maps for the region on 1 : 25,000 scale. The training statistics and reflectance values are given in Table 2. The FCC and the classified output of LISS-III are shown in Figure 6. The analysis clearly showed that IRS-1C LISS-III data can provide forest cover details, adequate to a scale of 1 : 25,000. The classification accuracy and mapping accuracy have been found to be of the order of 85% when compared with the recently prepared stock maps. The analysis of LISS-III in the study area showed bamboo mixed forests and teak plantations besides dense and open forests. The separability curves of various forest cover classes based on reflectance values are shown in Figure 7.

Biotic pressure zone mapping

With the increase of human population, pressure on Indian forests has reached far beyond their productive potential. The proximity of human habitats creates a disturbance gradient which need to be monitored regularly. The rural population of India depends on the forests for firewood and fodder. The forest periphery is subjected to various degradation processes due to extraction of

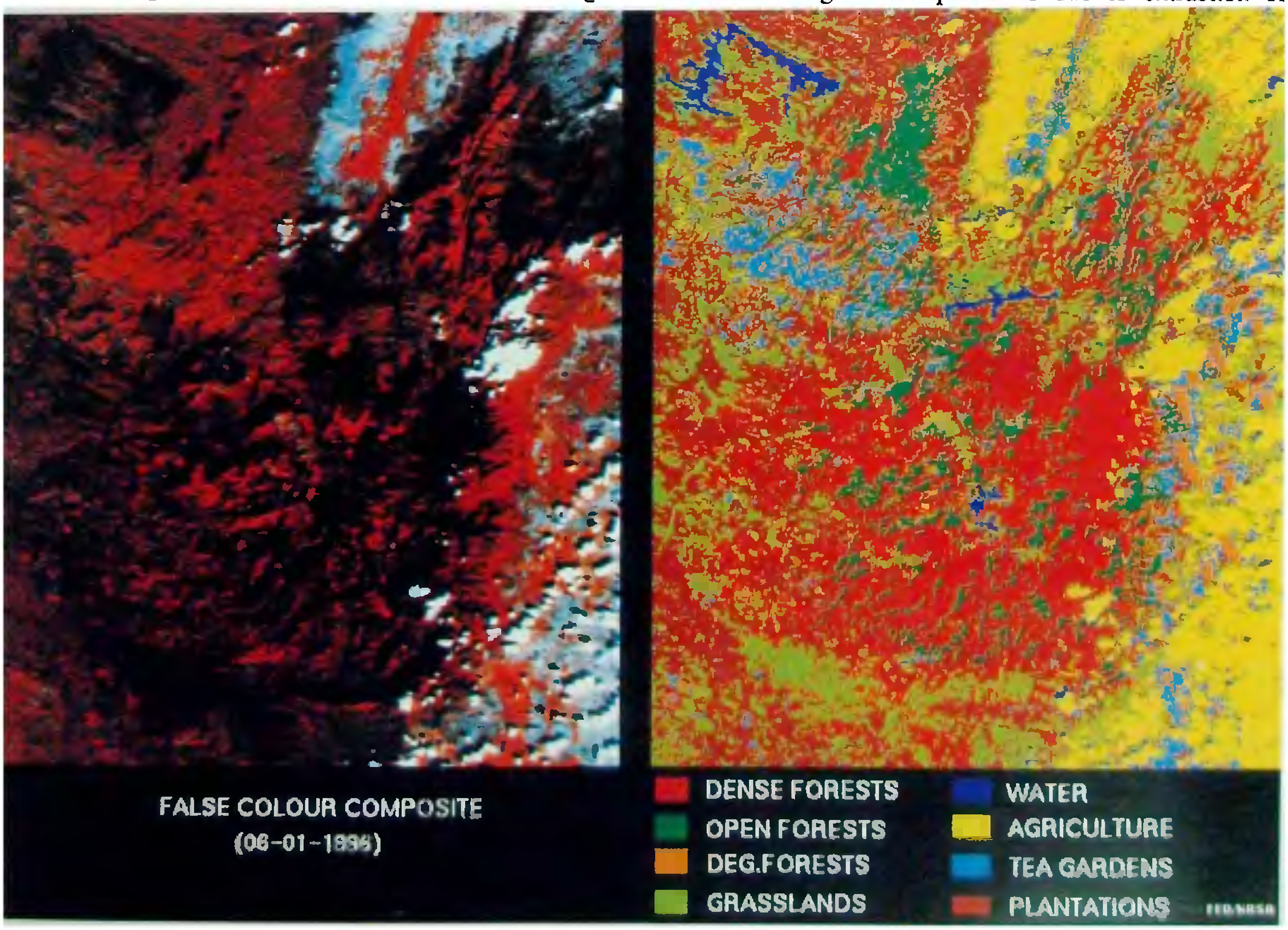

Figure 4. Forest cover classification in a sub area using WiFS data

firewood, illegal falling and grazing. Eco development planning around protected areas essentially requires information on such impacts on the forests.

It is essential to workout fire wood and fodder demand in conjunction with socioeconomic set up in and around forest patches and evolve remote sensing/GIS-based strategy to pinpoint protection measures in the biotic pressure zones to reduce the pressure.

An example for Biotic Pressure Zone Map (BPZM) of Agra reserve forest prepared using LISS-III data and its comparison with LISS-II is shown in Figures 8 and 9. The results indicate that level of details available in

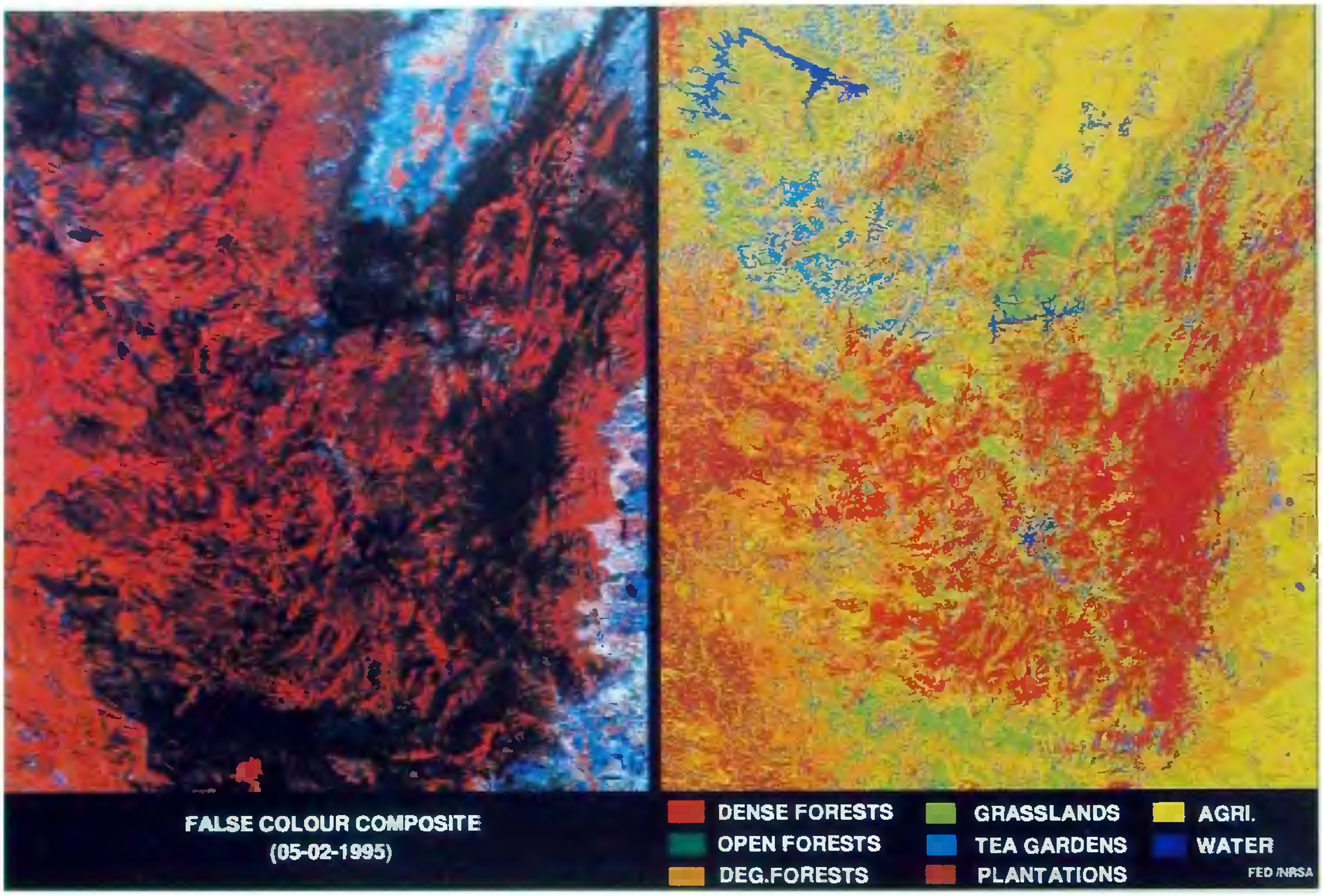

Figure 5. Forest cover classification using IRS-1B LISS-I data.

Table 2. LISS-III data reflectance values for forest cover details

Class	Mean			SD		
	Band 1	Band 2	Band 3	Band 1	Band 2	Band 3
Dense forest	53.56	28.24	71.32	2.01	1.79	5.98
Dense deciduous forest	57.83	33.9	60.03	1.73	1.79	3.98
Water	54.12	26.17	15.06	3.54	3.7	4.12
Open forest	55.66	29.81	78.52	2.32	1.99	6.37
Bamboo mixed	61.67	33.18	78.76	2.71	2.33	7
Teak	65	40.99	62.14	3.83	5.06	5.4
Open deciduous forest	63.28	40.32	63.21	3.19	3.89	3.72
Agriculture	104.18	83.29	86.08	10.9	11.79	6.3

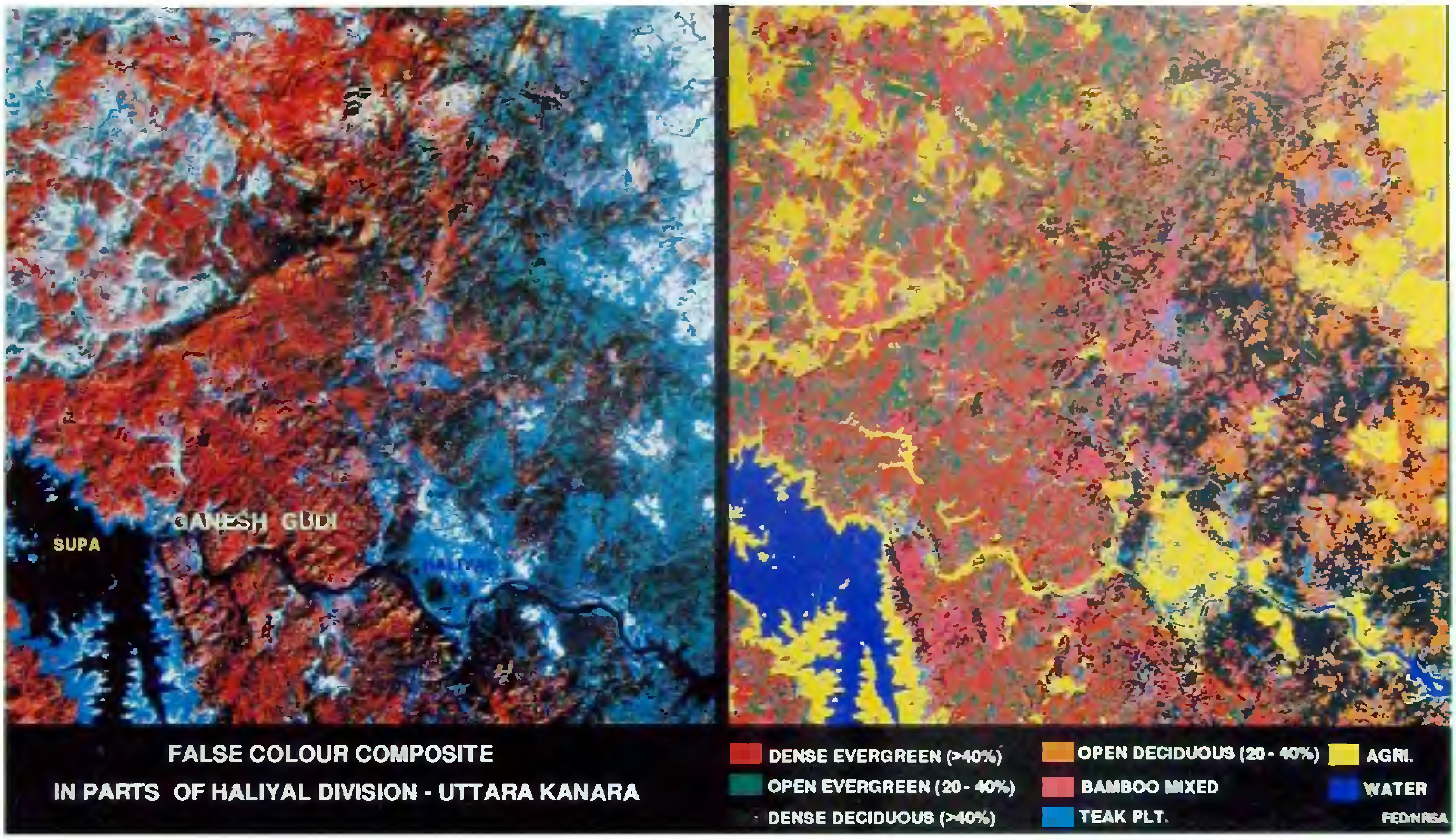

Figure 6. Forest cover and stock map generated using IRS-1C LISS-III data.

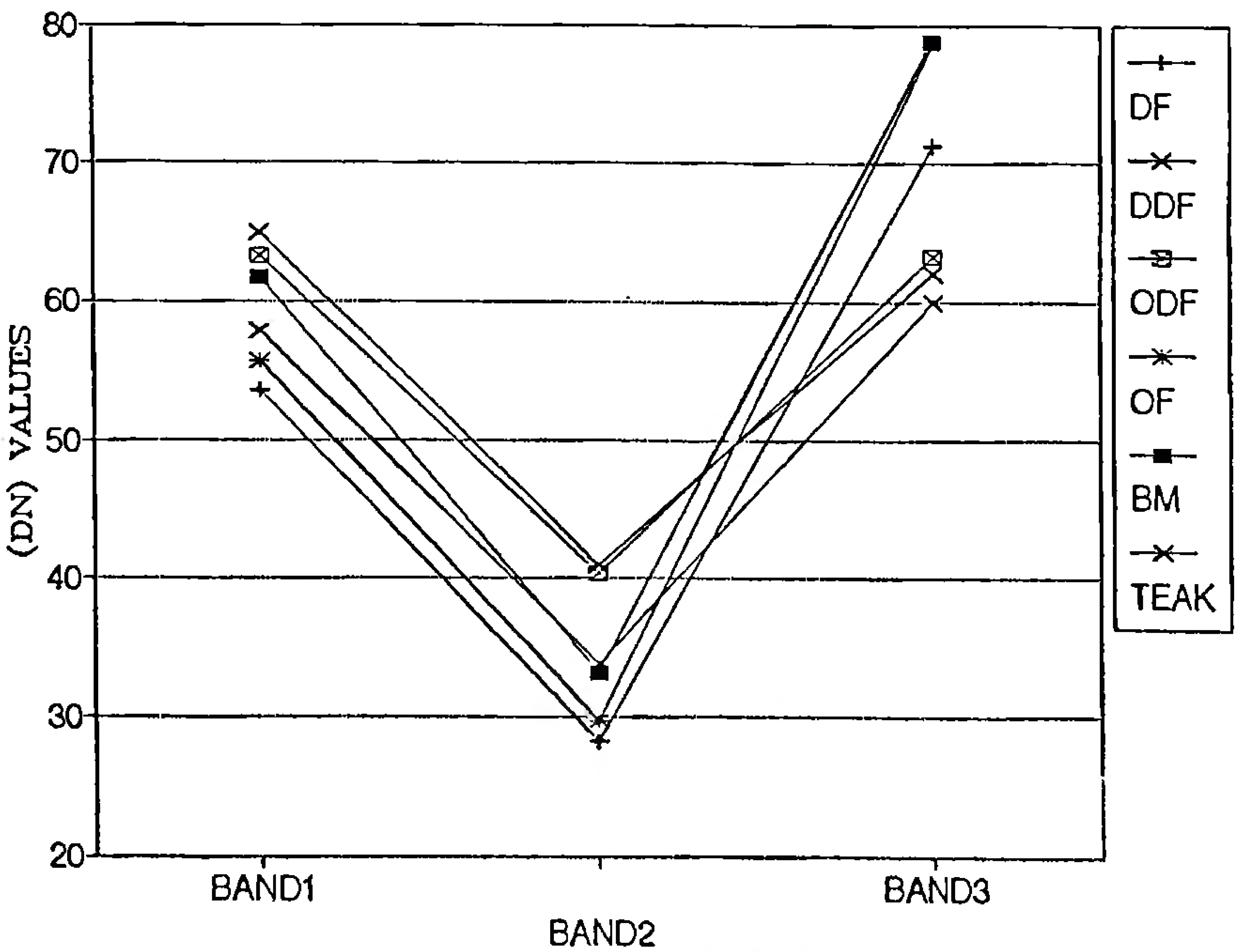

Figure 7. Spectral separability curves of various forest classes using LISS-III data.

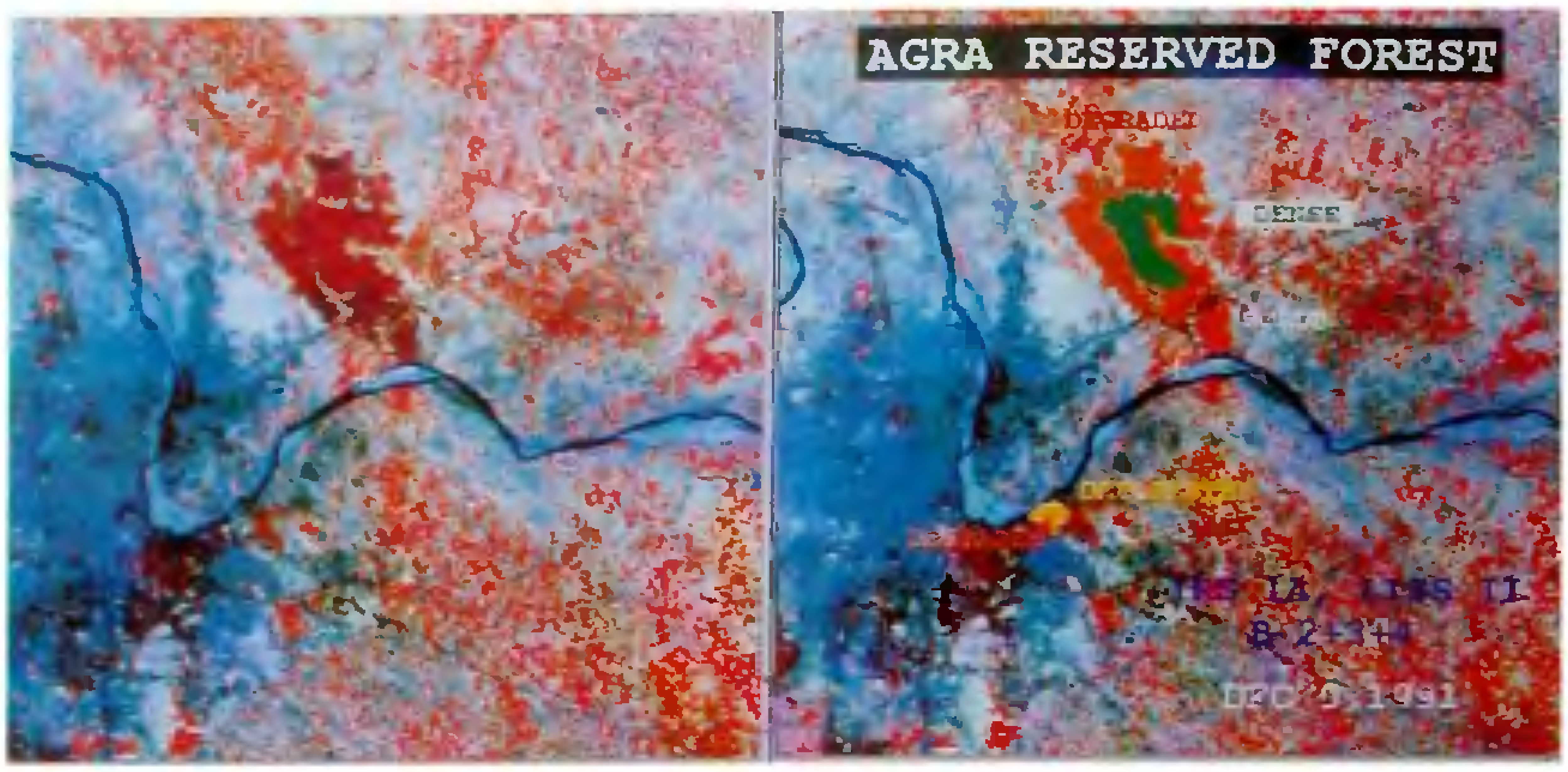

Figure 8. Biotic pressure zone mapping in Agra using IRS-1C and LISS-I data.

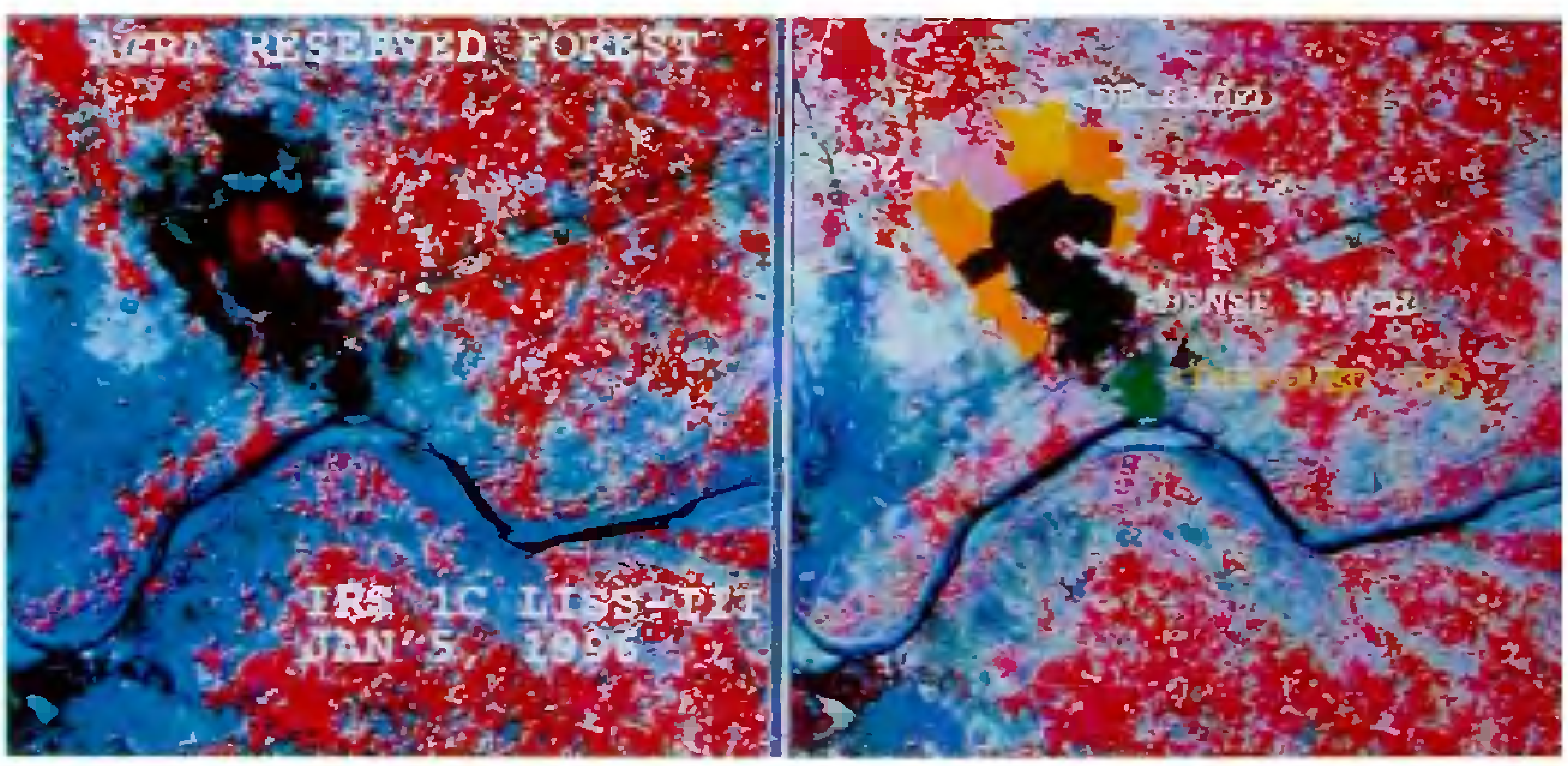

Figure 9. Biotic pressure zone mapping using IRS-1C LISS-III data.

LISS-III is higher than LISS-II. This is due to the higher resolution of the data. The LISS-III data also provide information on the accessibility to the forest which is otherwise difficult to observe.

Thus, the initial evaluation of IRS-1C data indicates that WiFS and LISS-III together provide multilevel information to the forest managers for rapid forest cover mapping, detailed forest cover mapping at the divisional level and enable monitoring of rapid changes in the forests due to forest fires, shifting cultivation, etc. The combined use of IRS-1C, IRS-1B and IRS-P2 data would provide better feasibility and enhanced capability to evolve new programmes in the forest management sector, especially in the forest inventories and microplanning like Joint Forest Management (JFM) activities. National forest policy (1988) emphasizes the need to protect forests and calls for the involvement of forest dwellers in forest management. Towards this JFM activities have been initiated in most of the states. LISS-III and PAN data with their better resolutions are capable of giving details at compartment or village level. A case study in North Dangs, Bheskatri range covering 35 compartments has been initiated (Figures 10 and 11).

Panchromatic data for forestry applications

PAN scene covering parts of Ahmedabad was evaluated

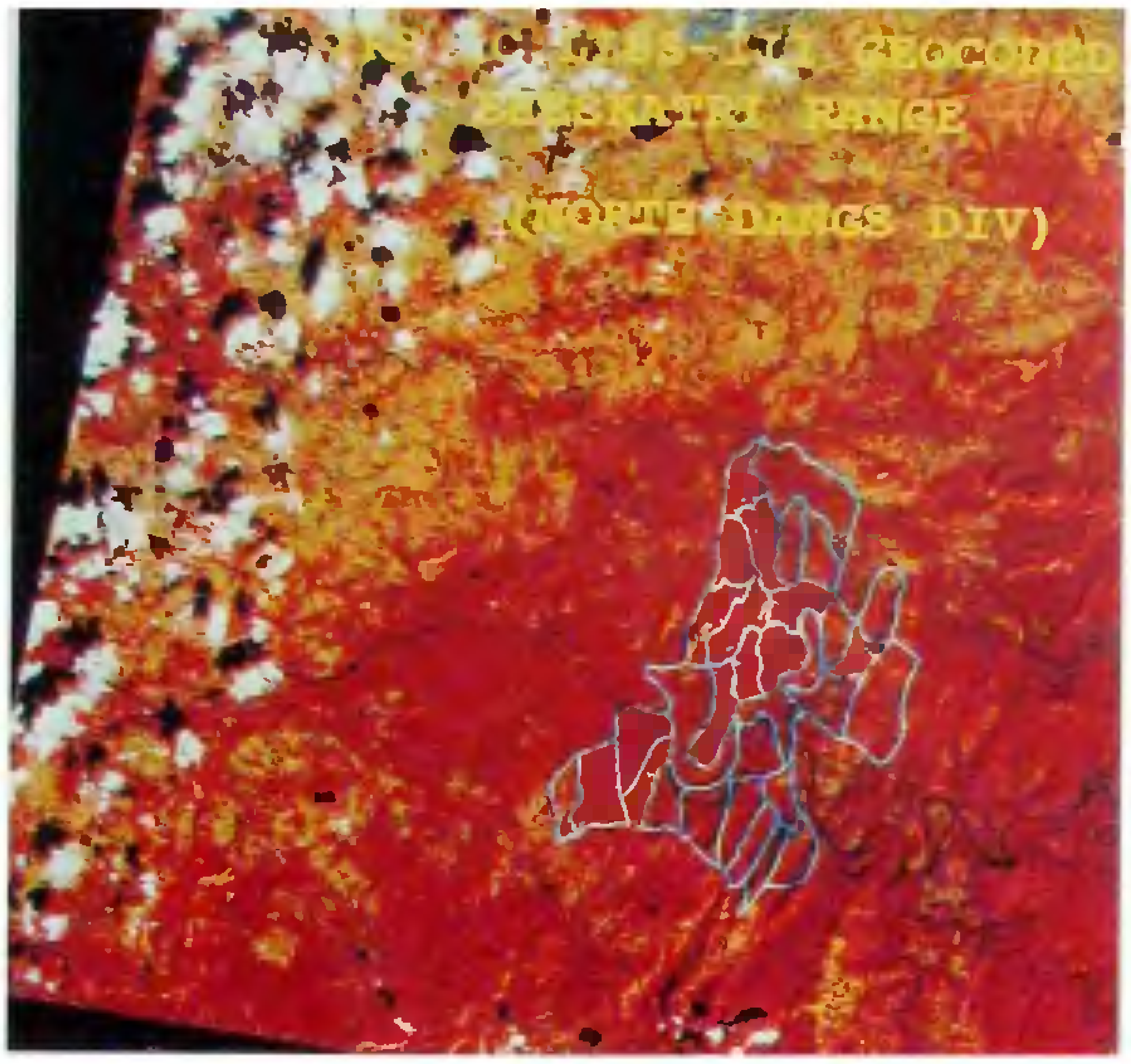

Figure 10. North Dangs with compartments on LISS-III data.

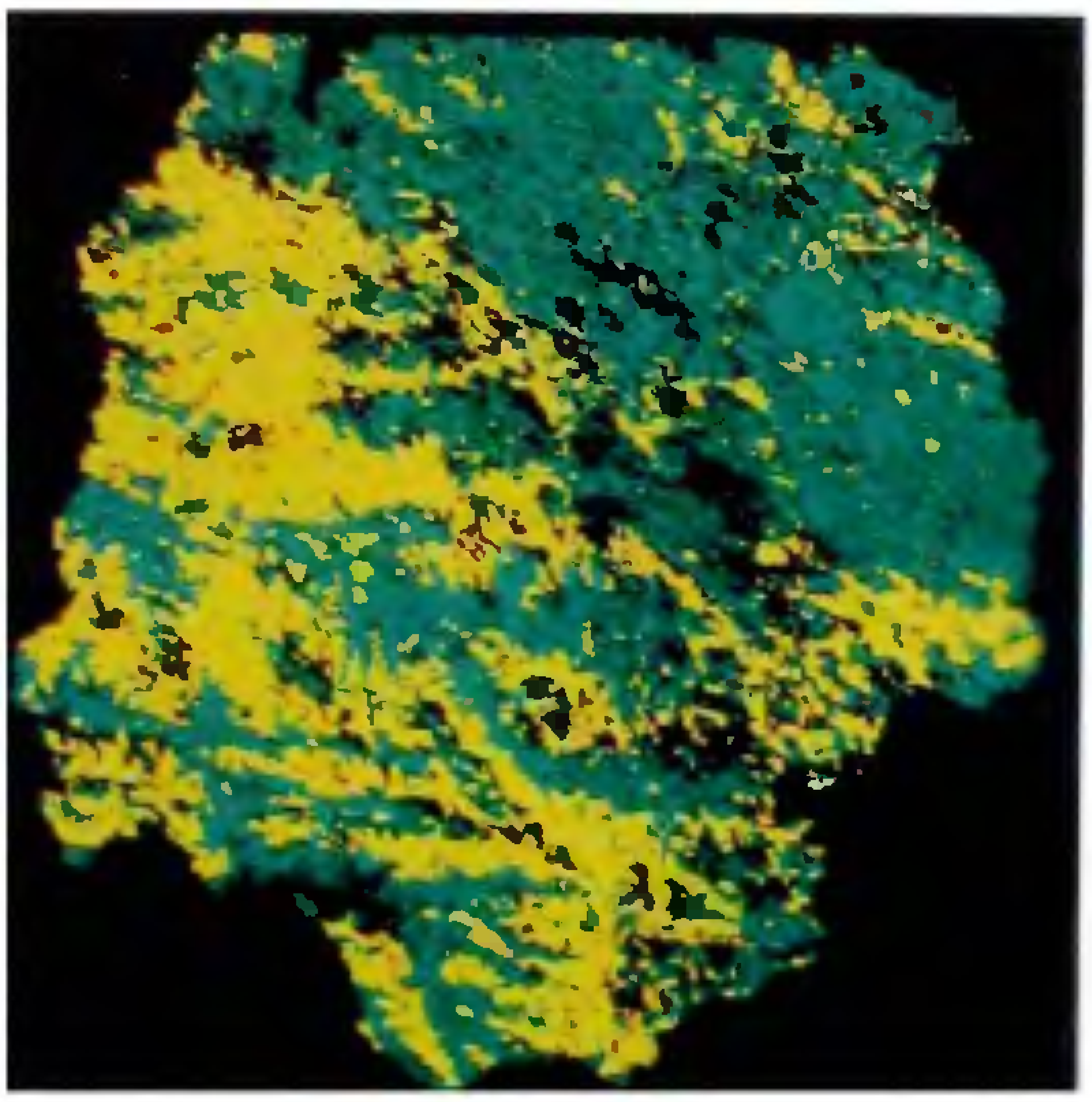

Figure 11. North Dangs classified for forest cover.

and vegetational details were physically verified on ground (Figure 12). The salient features are as follows:

- Linear plantation, having width of 7–8 m, could be mapped.
- Tree vegetation of 7–8 m (length wise) is picked up.
- A cluster of 3–4 trees is identifiable.

Figure 12. PAN data in parts of Ahmedabad.

- Barren lands within the urban area are mappable.
- Avenue plantations identifiable.

Conclusions

The initial results based on the analysis of IRS-1C WiFS, LISS-III and PAN data show considerable potential in the field of forestry. While the use of WiFS data for the rapid national or even at state level forest cover monitoring has been demonstrated, the LISS-III data is found adequate to provide forest cover/stock levels on 1 : 25,000 scale as required for management plans and also for biotic pressure zone mapping. The organized use of LISS-III and panchromatic data would also find its role in the JFM planning and monitoring programmes as well as in urban forestry.

1. *IRS-1C Data Users Hand Book*, NRSA, 1966.
2. *Kerala Forests – A satellite overview*, (a report submitted to MOEn, 1987.
3. *The State of Forest Report*, GOI, 1993.
4. *Manual of procedures for forest mapping and damage detection*, SAC, 1990.

ACKNOWLEDGEMENT. We thank our colleagues for providing support in the image processing of IRS-1C data.