Changing landuse/land cover pattern in the Kali River Basin in Western Ghats, South India

V. R. Hegde, V. Shreedhara and V. S. Hegde

Multidate satellite data have been used to quantify the landuse/land cover changes in the Kali River Basin for the period 1975–88. The analysis of spatial data showed that there have been significant changes in the landuse/land cover of the region owing to execution of the Kali Hydel Project. An attempt has also been made to predict the changes in landuse/land cover that would be induced in the area to be submerged due to the proposed dams of the Bedti and the Aghanashini Hydel Projects.

LAND cover and landuse, though different concepts, are generally considered together to understand the extent of natural resources and their utilization. Land cover refers to the natural or artificial coverings of the land surface while landuse is related to the management of ecosystems by human society[1]. Thus, land cover and landuse are subject to change either by natural causes or anthropogenic causes like deforestation, agriculture, grazing, habitation, mining, power projects, etc. Whatever be the causes inducing change in land cover and landuse pattern of a region, their change in space and time, if quantified gives an idea of the changing environment.

Remote sensing, by virtue of its synoptic, multispectral coverage of terrain on repetitive basis provides spatial and temporal information about land cover/landuse of a region and thus the changes taking place therein, enabling the same to be monitored[1–3]. Case studies have shown that satellite data could be used to assess the impact of mining, and river valley projects/power projects on land cover in the country and elsewhere[4–7]. The present study carried out on similar lines is an attempt to analyse the landuse/land cover changes in parts of Western Ghats of Karnataka, which has been the loci of major power projects. The study highlights the changes in landuse/land cover that have taken place in the Kali Basin since commissioning of the Kali Hydel Project and extends the analogy to predict the changes in landuse/land cover of the areas to be submerged by the proposed dams of Bedti and Aghanashini Hydel projects.

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Study area

The Kali River Basin, a part of the Western Ghats in the northern Karnataka lies between latitudes 14°46'15" and 15°34'N and longitudes 74°7'30" and 75°12'38"E (Figure 1). The proposed dam sites of the Bedti and the Aghanashini Projects are located farther towards southeast of the Kali Basin.

Kali River Project

The Kali Hydroelectric Project envisages the construction of a series of dams across the Kali River and its tributaries, and tunnels and power houses to harvest the water resources for power generation. The project involves constructing ten dams (big and small), five on the main river Kali and the rest on its tributaries like Tattihalla, Kaneri and Waki. Already three dams, viz. the Supa dam, the Bommanalli and the Tattihalla dam, have been constructed and power generation at Nagjhari power house has begun. The other dams are being constructed. The proposed Bedti and Aghanashini Hydel Projects are also similar in nature. Preliminary works are being carried out to construct dams near Magod Falls across the Bedti River and near Hurlamane across the Aghanashini River.

Methodology

The basemap of the Kali River Basin was prepared using Survey of India toposheets on 1:50,000 scale. For the Bedti and the Aghanashini Projects the supposed waterspread area was mapped considering the full reservoir level (FRL) at the proposed dam sites. The relevant satellite data in the form of standard false

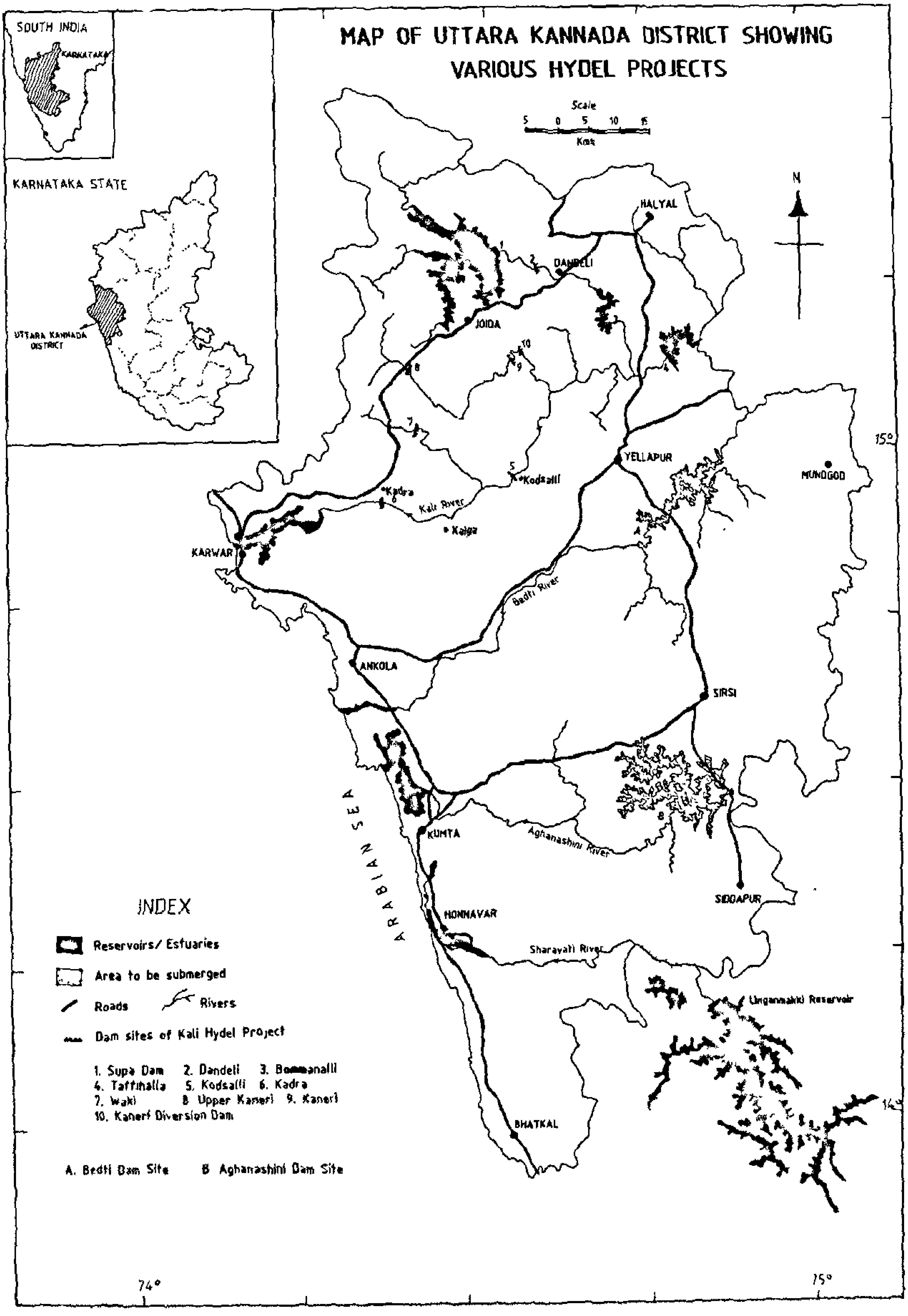
MAP OF UTTARA KANNADA DISTRICT SHOWING
VARIOUS HYDEL PROJECTS
SOUTH INDIA
KARNATAKA
KARNATAKA STATE
UTTARA KANNADA DISTRICT
Scale
Kms
N
HALYAL
DANDELI
JOIDA
YELLAPUR
MUNDGOD
Kodsalli
Kadra
Kali River
Kaiga
KARWAR
Bedti River
ANKOLA
SIRSI
KUMTA
Aghanashini River
SIDDAPUR
HONNAVAR
Sharavati River
Linganmakki Reservoir
BHATKAL
ARABIAN SEA
INDEX
Reservoirs/ Estuaries
Area to be submerged
Roads
Rivers
Dam sites of Kali Hydel Project
1. Supa Dam 2. Dandeli 3. Bommanalli
4. Taffinalla 5. Kodsalli 6. Kadra
7. Waki 8. Upper Kaneri 9. Kaneri
10. Kaneri Diversion Dam
A. Bedti Dam Site B. Aghanashini Dam Site
74°
75°
15°
14°

Figure 1.

Table 1

Landsat 2	MSS	FCC	19th March 1975	P157	R50
Landsat 2	MSS	B&W	10th April 1981	P157	R49
Landsat 4	MSS	FCC	14th January 1984	P146	R50
Landsat 5	TM	FCC	30th January 1987	P146	R50
Landsat 5	TM	FCC	29th October 1987	P146	R50
IRS-1A	LISS-I	FCC	26thDecember 1988	P28	R57
IRS-1A	LISS-I	FCC	8th February 1989	P28	R58
IRS-1A	LISS-II	B1	FCC 4th January 90	P28	R58
IRS-1A	LISS-II	B2	FCC 4th January 90	P28	R58

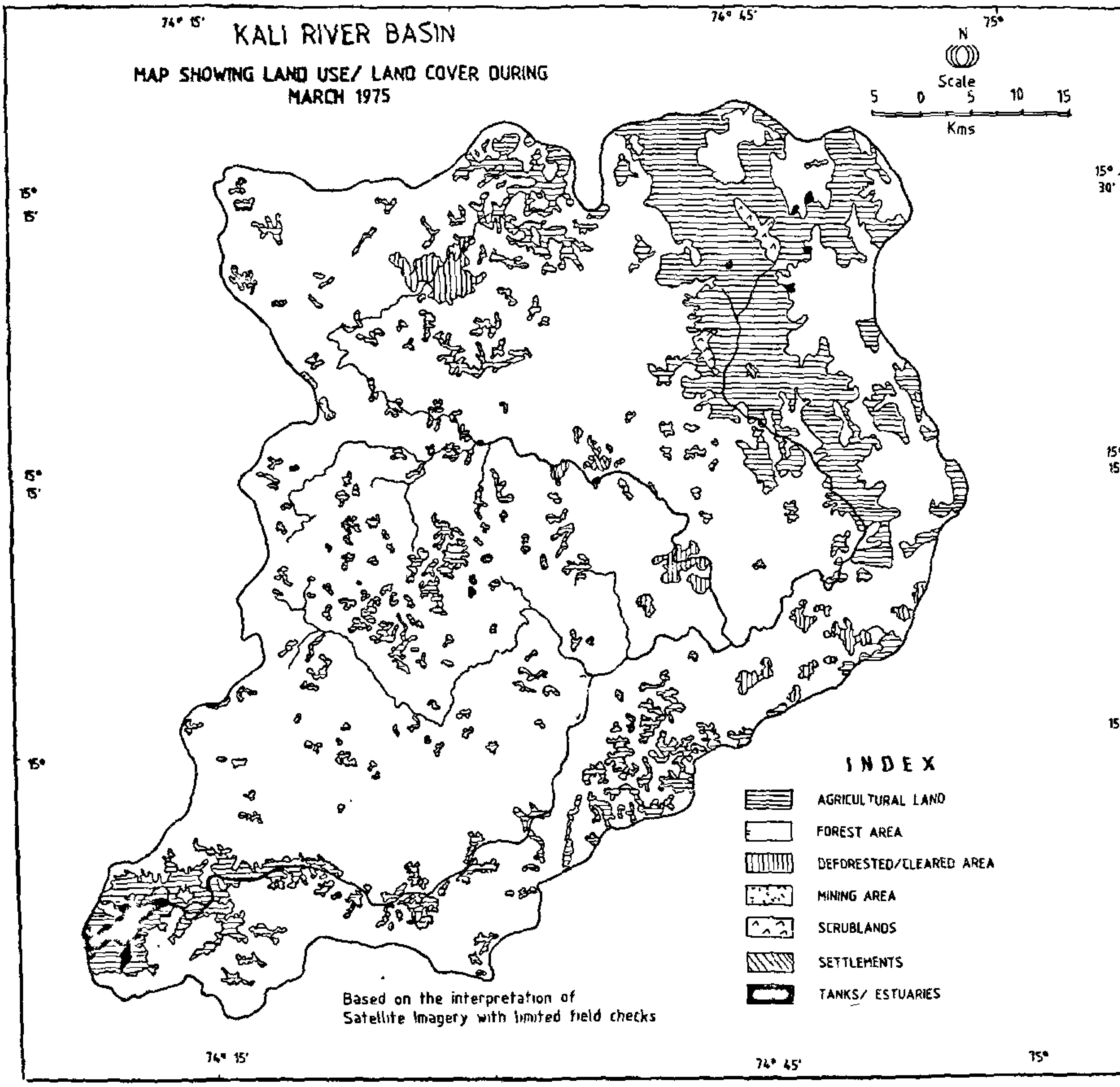

Figure 2.

colour composites (FCC) were interpreted visually using high-magnification enlarger (Procom-2) to extract land-use/land cover details. Adequate groundtruth was also collected to substantiate the results. Various land cover and landuse categories were classified based on the classification system adopted by NRSA[8]. The minimum interpretation accuracy and reliability in identification of landuse/land cover categories from satellite data were found to be 85%. Area estimation of the various categories was made using digital planimeter. Since the minimum mappable unit on 1:50,000 scale is 2.25 ha, the landuse and land cover categories less than this minimum possible unit were niether mapped nor taken for area estimation. In addition, the waterspread in the reservoirs of the already completed dams of Kali Project (during different seasons) was estimated.

Data used

Satellite data used for the study are listed in Table 1.

Collateral data used were: (i) Survey of India toposheets, (ii) Key map of the Kali Hydel Project (KPC) and KPC Brochure and limited groundtruth, (iii) The Uttara Kannada District Gazetteer 1987.

Results

The spatial distribution of different landuse/land cover categories in Kali River Basin in different years is shown in Figures 2–4. The waterspread in different reservoirs is shown in Figure 5. The landuse/land cover categories of the area to be submerged under the

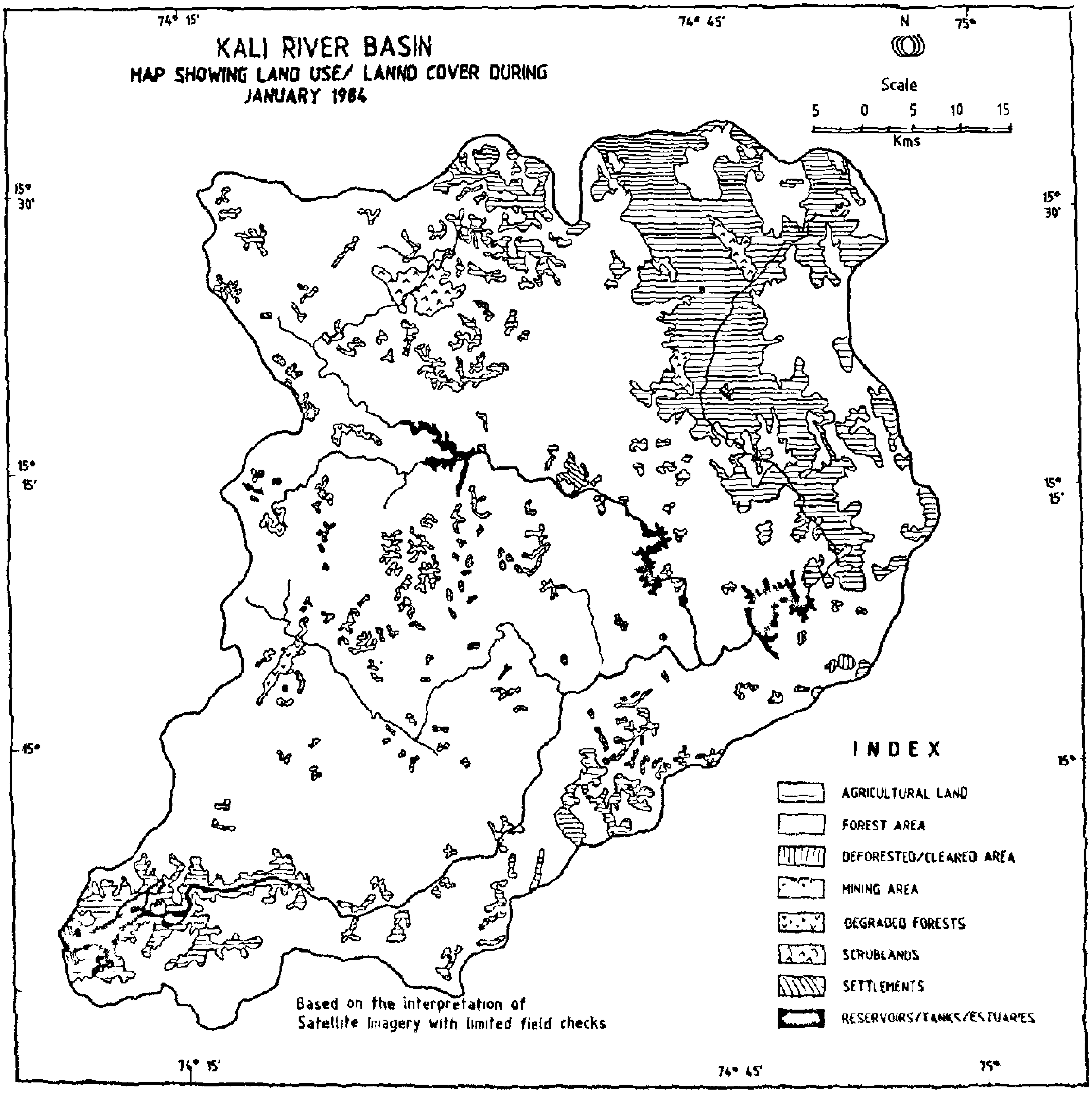

Figure 3.

Table 2 Land use/land cover statistics* of Kali River Basin for 1975–88 (total geographical area = 481125 ha)

	Planimetric area in ha					
	1975		1984		1988	
Category	Area	%	Area	%	Area	%
Agricultural area	77864 25	16.20	77524 25	16 10	77236 75	16 05
Forest area	392995 75	81 70	388599.75	80 76	383292 05	79 66
Deforested/cleared area	5062 50	1 00	312 00	0 06	—	—
Mining area	935 00	0 20	1185 00	0 24	1247 50	0 27
Degraded forest	—	—	2785 00	0 60	—	—
Settlement	642 50	0 13	688 00	0 14	688 00	0 14
Scrublands	812 50	0 17	3187 50	0 66	3187 50	0 66
Water bodies						
Reservoirs	—	—	3125 00	0 64	11530 00	2 40
Others (tanks, estuaries)	2812 50	0 60	3718 50	0 80	3943 20	0 82

*Based on the interpretation of multidate satellite imagery with limited field checks

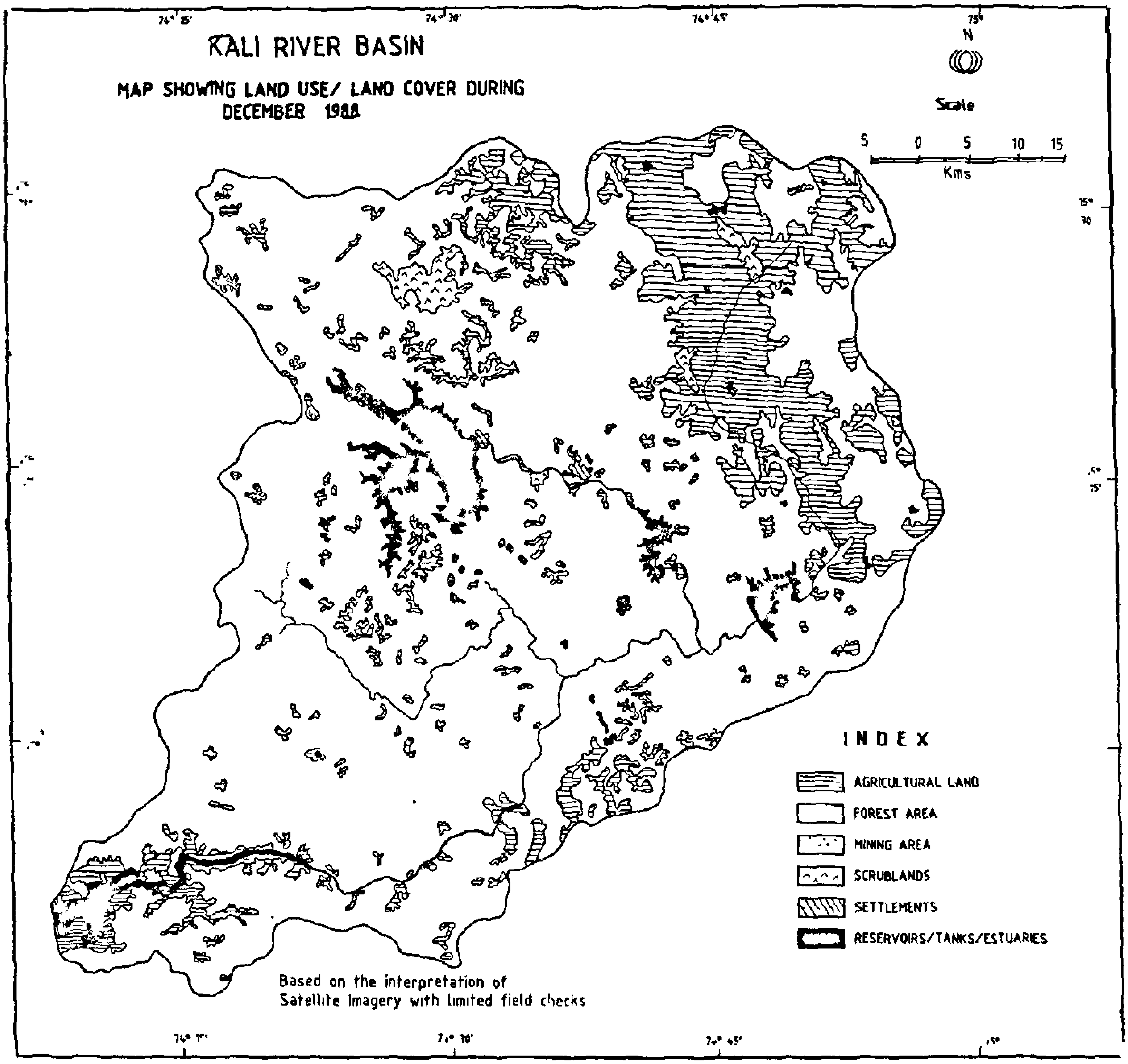

Figure 4.

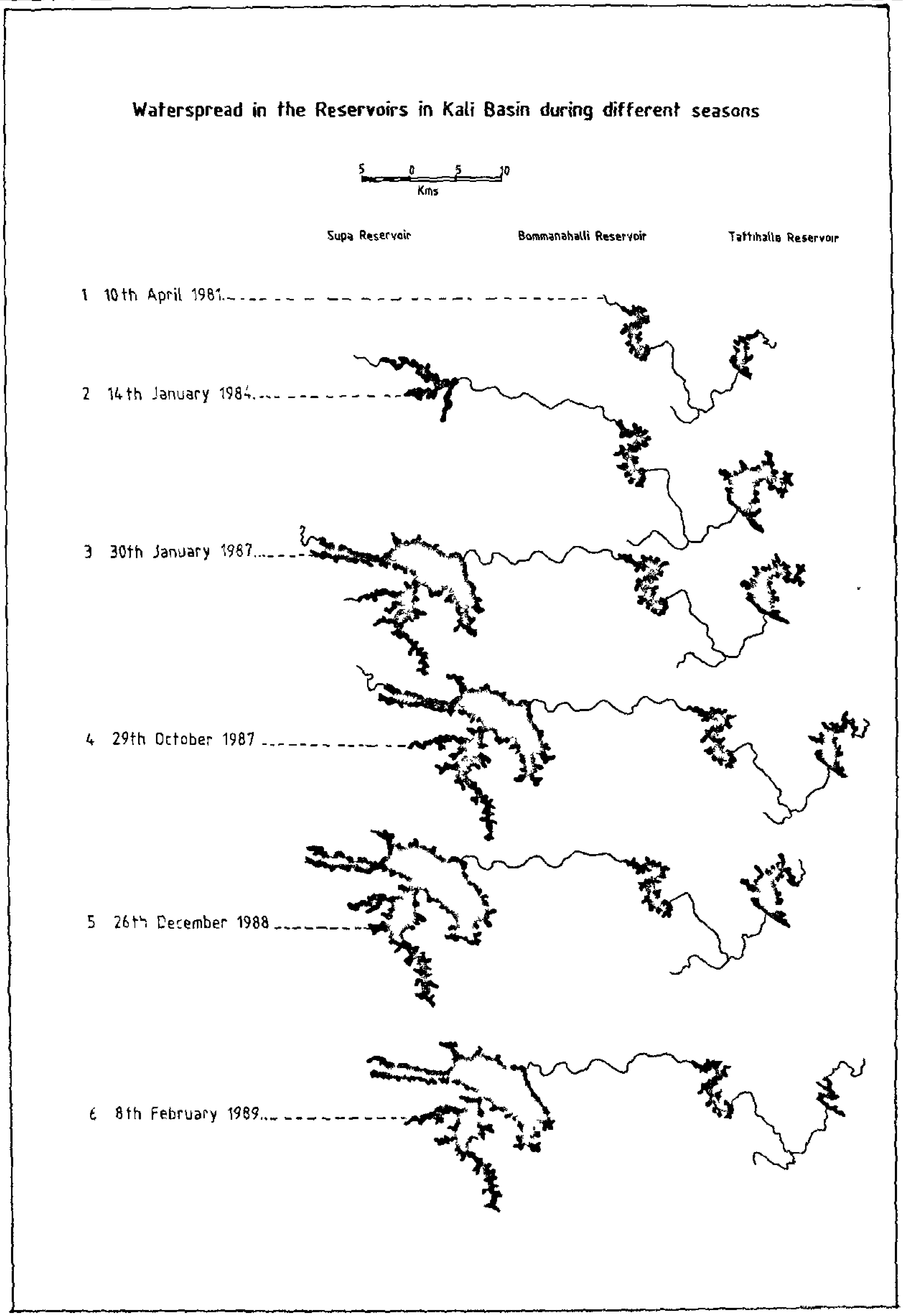
Waterspread in the Reservoirs in Kali Basin during different seasons
5 0 5 10
Kms
Supa Reservoir
Bommanahalli Reservoir
Tattihalla Reservoir
1 10th April 1981
2 14th January 1984
3 30th January 1987
4 29th October 1987
5 26th December 1988
6 8th February 1989

Figure 5.

Table 3. Net change in land use/land cover of Kali Basin from 1975 to 1988

Category	Area in 1975	%	Area during 1988	%	Net change
Agricultural land	77864 25	16 20	77236.75	16 05	− 0 15
Forest	398058 25*	82 73	383292 05	79 67	− 3 06
Mining area	935 00	0 20	1247 50	0 26	+ 0 06
Scrublands	812 50	0 16	3187 50	0 66	+ 0 50
Settlement	642 50	0 13	688 00	0 14	+ 0 01
Tanks/estuaries	2812 50	0 58	3943 20	0 82	+ 0 24
Reservoirs	—	—	11530 00	2 40	+ 2 40
Total	481125 00	100 00	481125 00	100 00	0 00

*Includes the deforested/cleared areas

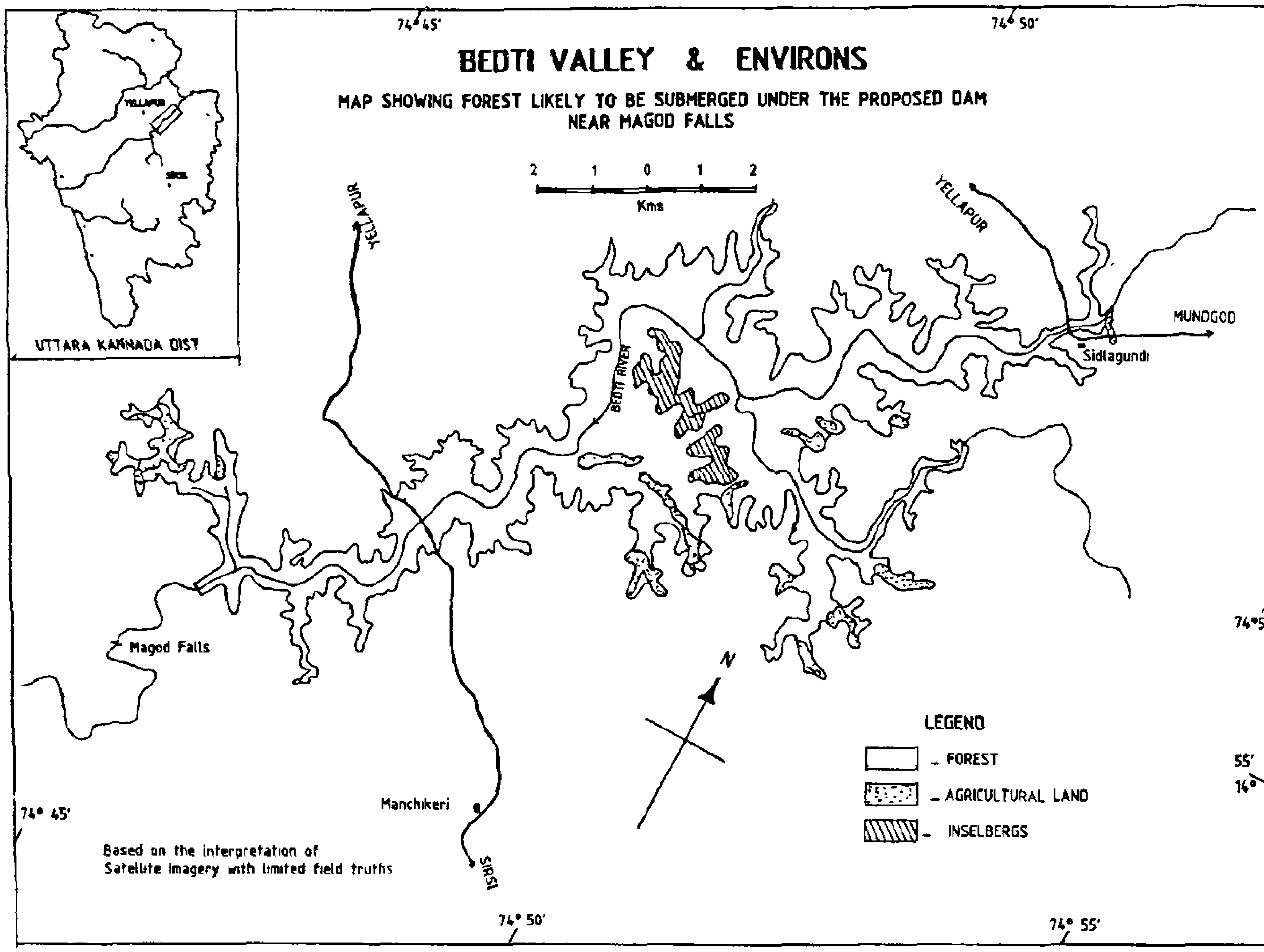

Figure 6.

proposed reservoirs of the Bedti and Aghanashini projects are shown in Figures 6 and 7. The area coverage of each of the landuse/land cover category in different years is given in Tables 2, 3 and 5. Table 4 shows the water-spread in the Kali reservoirs during different seasons.

Discussion

The original land use/land cover categories of Kali River Basin (prior to the project) may be classified mainly as natural forests, agricultural lands confined mostly to narrow valleys in the. downstream and broad wider valleys in the Malnad areas with a few urban settlements like Dandeli, Alnavar, Halyal and Supa. In recent years, it is clear from the satellite data as well as field observations that many changes have taken place in landuse/land cover of the basin solely due to exploitation of the natural resources within the basin. It may be mentioned that the execution of the Kali Hydel Project in 1973 has contributed maximum for the same.

Depletions in the forest area could be ascribed to clearing of forest for rehabilitation and also for

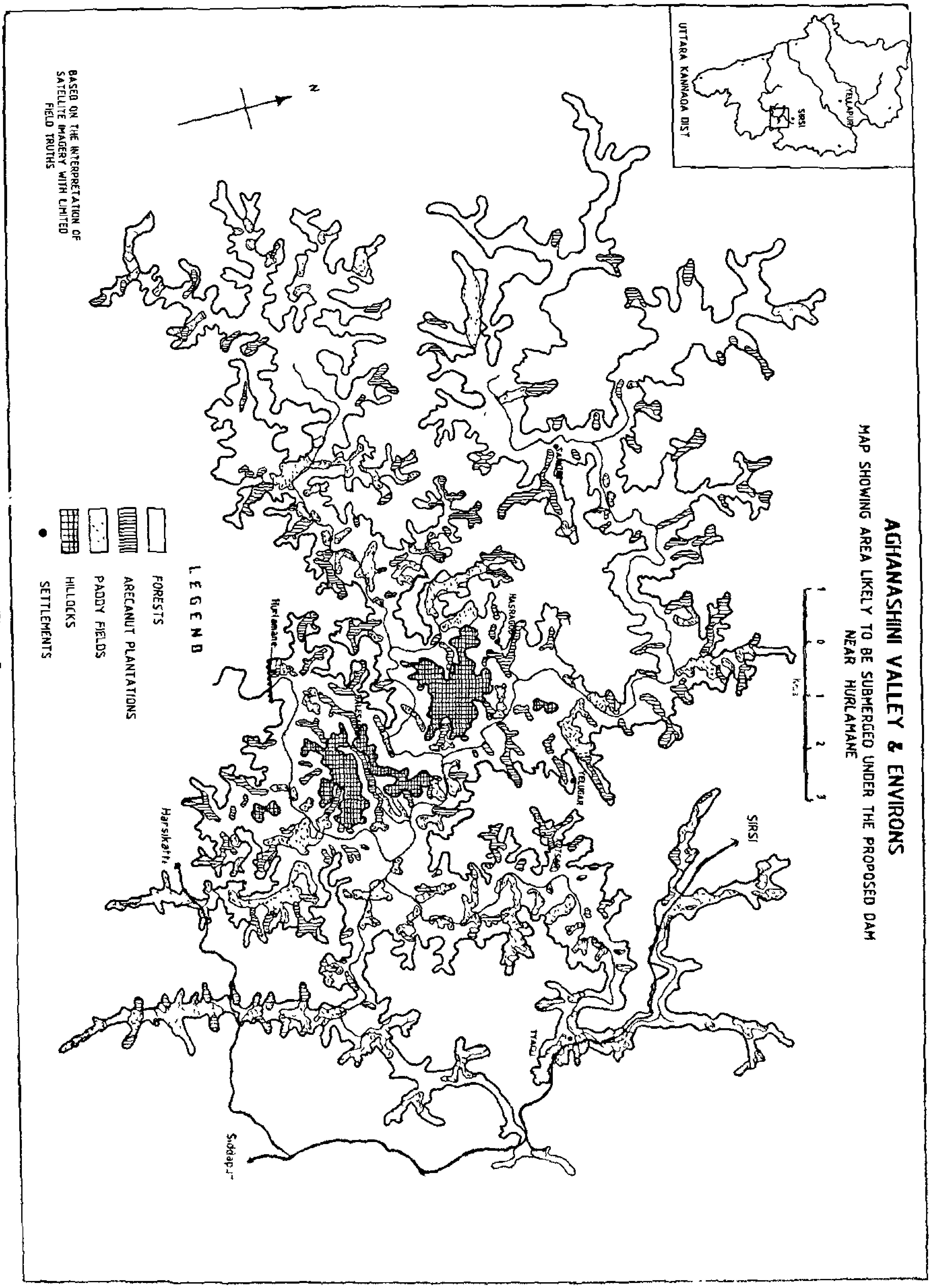
AGHANASHINI VALLEY & ENVIRONS
MAP SHOWING AREA LIKELY TO BE SUBMERGED UNDER THE PROPOSED DAM NEAR HURLAMANE
Kms
1 0 1 2 3
UTTARA KANNADA DIST
YELLAPUR
SIRSI
N
BASED ON THE INTERPRETATION OF SATELLITE IMAGERY WITH LIMITED FIELD TRUTHS
LEGEND
FORESTS
ARECANUT PLANTATIONS
PADDY FIELDS
HILLOCKS
SETTLEMENTS
SIRSI
Hurlamane
Harsikatti
Siddapur

Figure 7.

accommodating project workers. The deforested cleared area alone, as interpreted from the satellite data of 1975, has been estimated to be 5062.5 ha or 1% of the total area of the basin. Some of the cleared areas have been converted into settlements like Ambikanagar, Ramanagar and Ganeshgudi. The Ramanagar area, accounting for 2375 ha has not been fully built up and is more of a scrubland in appearance and hence included under scrubland category. Deforestation due to mining activity to extract manganese ores and limestone around Bisgod, Joida, Diggi, etc., has been gradually increasing. However, it could be seen that considerable effort has also been made for raising plantations in cleared areas and in those areas prone to natural degradation. As a result, these deforested degraded forests are not seen in the satellite imagery of 1988. Thus, the total forest cover that has diminished so far is an integrated effect of (i) increase in settlement area, (ii) increase in mining area, (iii) increase in scrublands, (iv) increase in total area submerged and (v) increase in estuary/tank area, i.e. 14,766 ha or 3.06% of the total basin area.

It is known that the Kali Hydel Project has not been completed as yet and many other dams are coming up. There are certain areas where manual mining is practiced. Though such areas are small, they are significant in the sense that they could also cause change in the landuse/land cover. The decrease in the agricultural land is entirely due to submergence, most of it under Supa reservoir. The total waterspread in the basin due to the dams is 11,530 ha. or 2.4% of the basin. There has been a continuous change in the waterspread of each of these reservoirs in different seasons. It may be noted that none of these reservoirs has so far filled up to its estimated capacity.

Table 4. Waterspread (in ha) in the reservoirs of Kali Hydel Project

Date	Supa reservoir	Bommanahalli reservoir	Tattihalla reservoir
10/04/1981	—	998	650
14/01/1984	—	1125	2000
30/01/1987	5437	954	1281
29/10/1987	5462	956 25	1031 25
26/12/1988	8937	1093	1500
08/02/1989	8600	831 25	412

Table 5. Land use/land cover of the area likely to be submerged under the proposed Bedti and Aghanashini Valley Projects (areas in ha)

Category	Bedti	%	Aghanashini	%
Forests	3075 0	95 5	7283 2	79 9
Agricultural land	157 5	4 5		
Arecanut plantations			870 0	9 5
Paddy fields			966 8	10 6
Total area	3232 5		9120 00	

Landuse/Land cover of Bedti and Aghanashini Projects

The proposed dam sites of the Bedti and the Aghanashini hydel projects are located near Magod Falls and near Hurlamane, respectively. The areas of submergence for the full-reservoir level of 460 m (Bedti) and 516 m (Aghanashini) have been estimated to be 3232.5 and 9120 ha, respectively. The landuse/ land cover of this area is shown in the Figures 6 and 7 and their area estimates are given in Table 5.

The area to be submerged under Bedti Dam is covered with luxuriant forests, with little agricultural land. The landuse/land cover of the Aghanashini valley, though similar to that of Bedti, has different classes. The agricultural area is classified into (i) horticultural gardens, i.e. arecanut plantation and (ii) paddy fields. The rest is forest. The forest area likely to be submerged has been estimated as 3075 ha in Bedti and 7283.3 ha in Aghanashini. The area covered by arecanut plantation in Aghanashini project has been estimated as 870 ha (approximately 2150 acres).

Since the settlement in this Ghat region is of scattered type, confining to valley portions, more than 100 villages in Aghanashini and 25 villages in Bedti projects will be submerged. Thus, for an average of 100 inhabitants per settlement, about 12,500 human population and an equal number of livestock has to be rehabilitated, which might involve deforestation in some other areas in addition to the forest area that is going to be submerged.

Conclusion

The present study has brought out clearly the changes that have taken place in landuse/land cover of the Kali river basin since the time the Kali Hydel Project has been commissioned. By extending the analogy to the proposed Bedti and Aghanashini hydel projects, it has been possible to estimate the extent of different landuse/ land cover categories that would be submerged.

In the light of many new projects that are coming up/ proposed in the Western Ghats, like the Kaiga Atomic Power Plant, Konkan Railway, etc., the possible damage to natural forest cover of the region and to the ecology in general needs to be assessed, possibly to plan effective corrective measures.

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Microbial biodiversity and its relevance to screening for novel industrially useful enzymes

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Biodiversity is widespread among natural populations of microbes. Its recognition as well as efforts to isolate microbes in pure cultures to conserve their gene pools are essential for biotechnological progress. Selective screening methods for discovering the rare genera and species, application of the knowledge on microbial biodiversity to discover novel and industrially useful enzymes and the need for an integrated approach to combine classical microbiology with developments in modern biotechnology for sustained advances in research and development are discussed.

LIFE on earth is a unique system of coexistence and mutual interaction in more than one way. The living forms as we know them do not seem to be present elsewhere in the universe. Variations in form and function among the various components of the living system essentially constitute biodiversity. In several international forums, including the Earth summit held at Rio de Janiero, biodiversity has been given a great deal of importance and emphasis laid on the need for recognizing and conserving the natural biodiversity of living forms. Biodiversity has been defined by the International Union for Conservation of Nature and Natural Resources as encompassing all life forms, ecosystems and ecological processes, and acknowledges the hierarchy at genetic, taxon and ecosystem levels[1]. According to the American naturalist Edward Wilson[2], biodiversity is our planet's greatest but least developed resource for biotechnological innovation. The recent review by Bull *et al.*[3] on biodiversity as a source of innovative biotechnology provides an excellent analysis of various aspects of this important topic.

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Biodiversity and the estimate of the relative abundance of diverse species is being recognized in the case of plants and animals and this has led in turn to the identification of rare or 'endangered' species. Efforts to protect endangered species of plants and animals from extinction have gained momentum in all the countries. Our knowledge of microbes with reference to the extent of their diversity as well as their role in sustaining global life-support systems is rather meagre. This is despite the fact that microbial biodiversity is far greater than that exhibited by the higher forms of life and that the microbes include forms surviving and living under conditions which are too inhospitable for other living systems. The 'extremophiles', including thermophiles, alkalophiles and halophiles, are just representative examples of microorganisms recoverable from such natural hostile environments. Systematic surveys to explore natural habitats for their microbial populations have been relatively few in numbers and, as pointed out by Labeda[4], the level of expertise as well as interest in undertaking such ecological surveys of microflora has been on the decline among microbiologists. We have little information or knowledge on the ecological distribution of microorganisms, or on what is existing and what is lost or endangered through changes in the