LAND USE CHANGES WITH THE IMPLEMENTATION OF DEVELOPMENTAL PROJECTS IN UTTARA KANNADA DISTRICT

Forest ecosystems in Uttara Kannada district have witnessed major transformations during the post-independence. Uttara Kannada district has the distinction of having highest forest cover among all districts of Karnataka. Land use analysis using temporal remote sensing data reveal distressing trend of deforestation in the district, evident from the reduction of evergreen - semi evergreen forest cover from 67.73% (1973) to 32.08% (2013). Taluk-wise analyses reveal similar trend for evergreen - semi evergreen forest cover during 1973 to 2013; Ankola (75.66 to 55.33%), Bhatkal (61.37 to 30.38%), Honnavar (70.63 to 35.71%), Karwar (72.26 to 59.70%), Kumta (62.89 to 29.38%), Siddapur (71.42 to 23.68), Sirsi (64.89 to 16.78), Supa (93.56 to 58.55%), Yellapur (75.28 to 18.98%), Haliyal (35.45 to 2.59%), Mundgod (2063 to 1.52). Forest cover has declined from 81.75 (1973) to 60.98% (2013) in the coastal zone, 91.45 (1973) to 59.14% (2013) in the Sahyadrian interior, and 69.26 (1973) to 16.76% (2013) in plains zone. Implementation of developmental activities without taking into account the ecological significance of ecosystems, services provided by them in meeting the livelihood of local population has resulted in the degradation of forests. These changes in the landscape structure (through large scale land use changes) have altered functional abilities of an ecosystem evident from lowered hydrological yield, disappearing perennial streams, higher instances of human –animal conflicts, declined ecosystem goods, etc. This necessitates the restoration of native forests in the region to ensure water and food security apart from livelihood of the local people. About **62814.48 Ha** of forest land is diverted for various non-forestry activities during the post-independence period. About **7071.68 Ha** of forest area has been encroached for agriculture, horticulture activities, etc. Maximum encroachments of forest lands are in Sirsi, Honnavar forest divisions i.e., 3641.66 Ha and 1851.93 Ha respectively. An appropriate policy framework is required to prevent further encroachments of forest land and ensure sustainable management of natural resources.

2.0 Introduction:

Development is process of improving the quality of all human lives with economic advancement considering social, ecological, psychological and political processes. More than 1.6 billion global populations depend to varying degrees on forests for their livelihoods (World Bank 2006c). Local livelihood either through goods of either aquatic or terrestrial ecosystems depend on the health of the respective ecosystems. Altering the ecological integrity would impact the ecological services and hence affect the livelihood of the dependent population. Unplanned developmental activities though succeeded in providing the handful of jobs and resources to the influential sections of the society but have deprived ecosystem people of their livelihood. The adverse effects of the developmental activities are evident from alteration of natural topography, deforestation, soil erosion, loss of nutrients in the soil, sedimentation, soil compaction, spread of invasive exotic species, fragmentation forests, enhanced human-animal conflicts, etc. This emphasizes the need for ecosystem approach involving all stakeholders in the management of natural resources. The ecosystem approach will take into account ecologically sensitive areas, habitats of endangered (threatened) species, rare and “keystone” (ecologically important) species while formulating policies.

The cumulative effects of adverse developments are evident from the extent of fragmentation of forests, which is the manifestation of the landscape pattern changes (Ramachandra and Uttam Kumar, 2011). Disturbance corridors created by forest fragmentation alter the natural mix of habitats and species by providing conditions suitable for early succession in plants and animals. They replace forest trees with grasses and shrubs, eliminating nesting habitat for forest-interior species. The ecosystem approach in ecosystem management will help in addressing the impacts of habitat fragmentation through the analysis of both habitat pattern and connectivity. The Uttara Kannada district has the distinction of having highest forest cover in the State. However, without proper valuation of natural resources extracted the State administration has branded the district as backward district. Many projects such as paper and pulp based industries, plywood Industries, power projects, mining etc. were taken up in the district without proper planning. The unplanned developmental activities led to the large scale changes in land cover affecting the hydrology, productivity of soil and has affected livelihood of people. Table 1 explains the land allotments made for various developmental activities by the forest department due to the pressure from the State government since 1956.

Large reservoirs for hydroelectricity generation of Kali and Sharavathi have submerged vast tracts of natural forest and displaced large number of families. Large scale migration to the catchment area of these projects due to availability of water, led to the large scale land cover changes with retreat of forests, soil erosion, loss of productive top soil layer, alterations in hydrologic regime in each basin leading to lowered catchment yield in the respective sub-basins. Encroachment of forest lands, conversion of natural forests to monoculture plantations of exotic species, etc. led to fragmentation of forests with higher instances of human-animal conflicts. All these cumulative effect is evident from the disappearance of endemic species and erosion of biodiversity. Any afforestation project will fulfill the goals only when the underlying causes for deforestation are adequately addressed. The compensatory afforestation programmes in arid areas do not compensate for the loss of rich evergreen and moist deciduous forests of the Western Ghats. In 1970's the State Government acquired about 1800 acres of estuarine lands of Aghanashini River, in the Hiregutti-Madnagiri villages of Kumta, and handed over the same for salt production to the Ballarpur Industries Ltd., Binaga (Karwar taluk). These lands were mostly estuarine rice fields (gajnis) and mangrove areas aiding in nutrient cycling and productivity of the coastal ecosystems. Subsequently the Ballarpur Industries Ltd. abandoned salt production in these lands. And these lands remain fallow now. Kali river with 6 major dams has submerged about **14602 ha** of prime forests in Uttara Kannada district. At peak construction activities, the work force was around 50,000. Housing colonies were set up after denuding the surrounding hills. During the Kali stage I, the township of Ambika nagar in Uttara Kannada was located in an area that still then was covered by dense forests. Before handing over the area to Karnataka Power Corporation, the forest department removed all the trees and handed over a totally denuded area. A similar denudation occurred at Ramanagara, the rehabilitation area for the Supa reservoir onsets.

Main objective of the current work is to assess the temporal land use dynamics with the implementation of developmental projects during 1973 to 2013. Figure 1 show the major

developmental projects in the district. Temporal land use analyses have been done considering the project region with 1 km buffer to account for changes in the vicinity due to the implementation of the project. The length of railway line in the district is 176 km and for railway project buffer of 0.5 km was considered

Table 1: The extent of forest areas released for other purposes from 1956

S.No.	Particulars.	Area in Ha.
1	The forest area released for cultivation by 3 member committee from 1964 to 1969	6042.500
2	Forest area released as per special G.O.No.AFD.116 of 16/4/69.	11593.342
3	Forest area released as per G.O.No.AFD-282-FGL74 of 17/19-12-1974.	3399.400
4	Forest area released for long lease.	162.100
5	Hangami Lagan in Notified area.	8034.450
6	Extension of Gouthana.	390.400
7	Forest area released for township.	1096.900
8	Mining area leased & area actually in operation.	1591.250
9	Released to House sites to Houseless (1972-1979)	366.000
10	Rehabilitation of Tibetans displaced Ryots of Sharavathi Ghataprabha & Malaprabha, Gowli families etc.	4548.170
11	Area under submersion & other Project. 1. Kali Hydro Project. 2. Bedti Project (for colony) 3. Other irrigation tanks etc.	14602.000 300.000 303.365
12	Released to KSFIC for Napier Hybrid grass cultivation (Sirsi Division)	441.450
13	Released to KAMCO (Dairy & fruit processing Unit)	153.993
14	Released to KSFIC for Pineapple cultivation.	163.320
15	Karnataka State Veneers Ltd.	24.000
16	Power transmission lines.	677.979
17	For establishment of Industries.	95.000
18	Area released to Horticulture department (1969-70).	71.847
19	Released to Agricultural University, Dharwad.	214.000
20	Sharavathi Tail Race.	700.000
21	Kaiga Atomic Power Project.	732.000
22	Sea Bird Naval Base Project.	2259.000
23	Rehabilitation of Sea Bird out seas.	643.720
24	Area released for non-agriculture & other purposes.	394.870
25	Konkan Railway.	272.140
26	Area released for improvement & widening of Ankola-Hubli Road.	49.431
27	Area released for rehabilitation of displaced persons of KHEP & Kaiga Project.	316.410
28	Area released to regularise the encroachments, which have taken place before 27-04-1978.	2845.446
29	Area released to construction of 400 KVDC alternate transmission line between Kaiga NPP and 200 KV sub-station at Narendra in favour of M/s. P.G.C.I.L, Karnataka.	330.00
	TOTAL	**62814.483**

*Source: Forest working plan of Kanara circle (year 2009-10)

Figure 1: Developmental projects of Uttara Kannada district

SUPA DAM: Supa Dam is the second largest dam in the state of Karnataka, built across the Kali river in Supa (Joida) Taluk of Uttara Kannada District in India. Supa Dam (figure 2(a, b)) is 101 Mtrs high and 332 Mtrs long concrete gravity dam for power generation. The Supa dam was perceived in 1972 by the clearance of Central Water and Power Commission (CWPC) and the Planning Commission. According to the statistics provided by the KPCL, 10,692 hectares of forest land; 2,248 hectares of private land and 466 hectares of revenue land were acquired for construction of the Supa dam. That accounts to a total of 13,406 hectares. Out of this, the reservoir stretches to 123 km^2. The construction started in 1974 and ended in 1987. The power house was commissioned in 1985. It has a catchment area of 1057 km^2 and the live storage capacity is 145 Tmcft. (Thousand Million Cubic Feet). Three radial gates of size 15 x 10 Mtrs are provided to regulate the flood discharge. The reservoir has two saddle dams of length 705 Mtrs and 940 Mtrs. The power house at the foot of the dam has two electricity generators of fifty megawatt each. The electricity generated is supplied to different parts of Karnataka. The total area submerged under Kali stage-I was 36000 acres of which 25000 acres were forests. Stage-II involved construction of dams at Kodsalli, Kadra and Dandeli. Supa was a town which is now in the deep water of this reservoir. This was an area called Sangam (where two river met) the river Kali (black) and Pandri (White) joined. This Supa dam project refugee's settlement was established at a place called Ramanagar near Londa on the border of Belgaum and Uttara Kannada districts of Karnataka. This tract of land was earlier under reserved forest, and was taken over for resettlement around 1975. At the time of' handing over; the entire tree crop was removed, and the land was allowed to lie fallow without the institution of any soil conservation measures at least till 1979. The displaced population is not being rehabilitated in the irrigated command area, but rather in the catchment area, including places right on the fringes of the reservoir. The contribution of' such settlements to increased si1tation of' the river is not documented, but appears to be significant. Land use analysis at Supa hydroelectric dam with buffer

is shown in figure 3 and table 2. The Supa dam submerged thick evergreen forests which was covered 94.7% (1973) of region. The current cover remained is only 42.79%. The evergreen forest in 1km buffer of project area declined from 94.55% (1973) to 49.02% (2013). The land use analyses for the period 1973 and 2013 illustrate the increase in built-up area (human habitations) from 0.03% to 0.12% with the implementation of the project. The built-up area has increased in project area. Many small agglomerations for work force colonies can be seen in the buffer region.

Table 2: Land use at Supa dam region from 1973 to 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	**15.30**	**0.03**	**60.49**	**0.12**	**20.70**	**0.04**	**163.82**	**0.28**
Water	142.05	0.1	10126.05	20.57	52.48	0.09	10940.05	19.00
Agriculture	421.81	0.86	2101.20	4.27	594.27	1.03	2661.38	4.62
Open space	277.24	0.56	2169.70	4.41	341.33	0.59	2292.37	3.98
Moist deciduous forest	869.27	1.77	9100.07	18.49	992.05	1.72	11127.87	19.33
Evergreen to Semi evergreen forest	**46522.08**	**94.7**	**21063.30**	**42.79**	**54426.84**	**94.55**	**25216.00**	**43.80**
Scrub/Grass lands	530.09	1.08	1341.39	2.73	608.59	1.06	1466.80	2.55
Acacia/Eucalyptus plantations	275.08	0.56	1545.72	3.14	309.11	0.54	1698.85	2.95
Teak / Bamboo plantations	79.57	0.16	1072.34	2.18	102.44	0.18	1263.11	2.19
Coconut/Areca nut plantations	0.00	0	263.56	0.54	0.00	0	342.40	0.59
Dry deciduous forest	87.58	0.18	376.26	0.76	117.65	0.2	392.80	0.68
Total area	49220.08				57565.45			

Kaneri dam: Upper Kaneri reservoir (figure 4) is constructed across the Kaneri river, a tributary to Kali river near Kumbarwada village in Joida Taluk, Uttara Kannada District. Kaneri reservoir draining a small area of 98 sq km, will supplement the storage of water in the Supa dam. The construction of this reservoir left an immense and unrecoverable foot print on the farmers who dependent on this river. Since the river has become seasonal, this led to agriculture activities seasonal. The temporal land use analysis of Kaneri reservoir (figure 5 & table 3) shows that evergreen forest declined from 94.82% (1973) to 42.68%. In the buffer region, evergreen cover is about 63.83% (2013). It is also observed the plantation activities have increased from 1973 to 2013 and area under scrub lands have increased from 0.72% (1973) to 57.88% (2013).

Table 3: Land use in Kaneri reservoir region from 1973 to 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	0.00	0.00	12.25	**4.76**	0.00	0	23.86	**2.01**
Water	0.00	0.00	93.24	36.23	0.99	0.08	147.54	12.41
Agriculture	9.88	3.84	7.74	3.01	6.12	0.51	35.74	3.01
Open space	0.00	0.00	6.48	2.52	0.45	0.04	24.57	2.07
Moist deciduous forest	0.00	0.00	7.29	2.83	0.00	0	70.79	5.96
Evergreen to Semi evergreen forest	244.03	**94.82**	109.83	**42.68**	1171.89	**98.58**	758.73	**63.83**
Scrub/Grass lands	3.45	1.34	9.90	3.85	8.46	0.72	57.88	4.87
Acacia/Eucalyptus plantations	0.00	0.00	6.48	2.52	0.00	0	48.63	4.09
Teak / Bamboo plantations	0.00	0.00	1.08	0.42	0.00	0	11.62	0.98
Coconut/Areca nut plantations	0.00	0.00	2.88	1.12	0.00	0	6.93	0.58
Dry deciduous forest	0.00	0.00	0.18	0.07	0.81	0.07	2.43	0.20
Total area	257.36				1188.73			

Kodasalli dam: Kodasalli Dam was built across the Kali River (Kali nadi) in Yellapura taluk of Uttara Kannada district of Karnataka state, India (figure 6). The Kodasalli Power house (3x40 MW) commissioned in 1998, is located on the right bank of the Kodasalli Dam - utilising an average yield of 647 M cum of water. The Catchment area of this reservoir is about 1049 Sq. Km. The average annual energy available from this project is about 511 MU. The reservoir formed behind Kodasalli dam has a water spread area of 17.35 Sq. Km. at F.R.L. with a gross storage capacity of 286.49 M cum. The total area of the river's course is 123.71 ha. and the area under various islands is 12.31 ha. The Kodsalli dam submerged 1214 Ha of forests and 485 Ha of cultivated lands. The land use at Kodasalli dam region is given in figure 7 and table 4 for 1973 and 2013. Evergreen forest cover has declined from 97.6 (1973) to 30.95% (2013) and considering a buffer of 1 km the change is 97.57% (1973) to 52.91% (2013). The agricultural activities constitute 4.14% and plantations about 9.17%(2013).

Table 4: Land use at Kodasalli dam location in 1973 and 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	0.72	0.01	11.07	0.2	0.72	0.01	7.74	0.23
Water	25.47	0.46	795.72	14.37	34.21	0.38	885.33	2.51
Agriculture	36.01	0.65	229.36	4.14	48.88	0.55	409.91	3.24
Open space	13.95	0.25	102.35	1.85	15.84	0.18	130.60	0.9
Moist deciduous forest	24.57	0.45	1555.26	28.08	47.35	0.53	1838.66	24.71
Evergreen to Semi evergreen forest	**5405.26**	**97.6**	**1714.23**	**30.95**	**8714.08**	**97.57**	**2595.33**	**52.91**
Scrub/Grass lands	7.83	0.14	267.97	4.84	22.05	0.25	2065.36	4.87
Acacia/Eucalyptus plantations	**13.68**	**0.26**	**507.77**	**9.17**	**26.10**	**0.29**	**538.22**	**5.9**
Teak / Bamboo plantations	9.63	0.17	189.57	3.42	19.98	0.22	219.63	3.53
Coconut/Areca nut plantations	0.00	0	163.74	2.96	0.00	0	240.06	1.18
Dry deciduous forest	0.81	0.01	0.90	0.02	2.16	0.02	0.54	0.02
Total area	5537.94				8931.38			

Kadra dam: Kadra power house commissioned in 1997,has been built on the left bank of the river Kali with an installed capacity of 150 MW. Work on the Kadra dam and power house in Uttar Kannada started in February 1986 and the project was to finish by 1997. The power house integrates three 50 MW turbines which are coupled to the generating units. The annual generation is 570 MU. The design head is 32 metres. The Kadra Dam is an integral part of the Kaiga Project, provides adequate water to meet the total plant water requirement (figure 8). Due to Kaiga NPH activity this region's aquatic fauna is intensely affected. The plankton diversity showed high sensitivity to elevated temperature, resulting in decreased diversity and similarity indices near the discharge point (Zagar et al., 2006).

Land use at Kadra dam (figure 9 & table 5) region and buffer region show decline of evergreen forest from 69.92% (1973) to 50.98% (2013). The built-up area is increased from 0.63% (1973) to 1.51% (2013). Similar trends of increase from 0.48% to 2.23% (2013) are noticed in the buffer region due to construction of roads and infrastructure. This reservoir was constructed in 2000 mainly to provide enough water resources to Kaiga NPH project. There is intensive plantation activities observed in 2013. The evergreen forest has reached to 47.40% by 2013 at project location with 1km buffer.

Table 5: Land use at Kadra dam region during 1973 and 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	**72.55**	**0.63**	**172.56**	**1.51**	**80.02**	**0.48**	**371.65**	**2.23**
Water	112.16	0.98	2239.28	19.55	124.13	0.75	2961.79	17.81
Agriculture	225.85	1.97	322.34	2.81	335.12	2.01	644.94	3.88
Open space	47.26	0.42	303.71	2.65	65.17	0.39	409.26	2.46
Moist deciduous forest	1936.11	16.91	816.16	7.13	2377.54	14.3	1854.84	11.15
Evergreen to Semi evergreen forest	**8008.19**	**69.92**	**5839.40**	**50.98**	**12342.46**	**74.21**	**7882.77**	**47.40**
Scrub/Grass lands	542.25	4.73	809.41	7.07	660.88	3.97	989.23	5.95
Acacia/Eucalyptus plantations	222.52	1.94	359.88	3.14	303.71	1.83	687.16	4.13
Teak / Bamboo plantations	168.33	1.47	485.27	4.24	205.32	1.23	689.30	4.14
Coconut/Areca nut plantations	0.00	0	102.89	0.90	0.00	0	138.80	0.83
Dry deciduous forest	118.46	1.03	2.79	0.02	137.36	0.83	1.99	0.01
Total area	11453.66				16631.73			

Bommanalli reservoir: Bommanahalli reservoir built across the Kali River is situated in Haliyal taluk of Uttara Kannada District (figure 10). This pick-up dam is constructed to cater water to Supa dam, is 2,896 m high and 1,025 m long, with a catchment area of 1,683 km^2. Monoculture plantations of exotic species has increased from 1.10 (1973) to 43.04% (2013) highlight the large scale changes of forests at Bommanalli, Tattihalla project regions. The land use analysis (figure 11 & table 6) at temporal scale with respect to Bommanalli pick up reservoir highlight the fragmentation of forests during 1973 to 2013. The crop land has increased from 2.21% to 6.22% by 2013. Deforestation is evident with the decline of evergreen forests from 41.18 to 2.90% (2013).

Table 6: Land use at Bommanalli reservoir region during 1973 and 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	45.73	0.46	96.55	0.97	61.84	0.43	277.56	1.94
Water	49.24	0.49	1070.99	10.76	60.40	0.42	1179.99	8.24
Agriculture	246.73	2.48	822.73	8.27	316.31	2.21	994.34	6.94
Open space	58.42	0.59	213.37	2.14	92.63	0.65	256.62	1.79
Moist deciduous forest	4085.38	41.04	1007.08	10.12	5760.27	40.2	1006.06	7.02
Evergreen to Semi evergreen forest	3989.15	40.08	394.17	3.96	5900.24	41.18	428.37	2.99
Scrub/Grass lands	767.73	7.71	14.67	0.15	1094.12	7.64	5.40	0.04
Acacia/Eucalyptus plantations	109.46	1.10	4284.22	43.04	177.96	1.24	6680.02	46.62
Teak / Bamboo plantations	377.07	3.79	1919.19	19.28	592.47	4.14	3261.64	22.76
Coconut/Areca nut plantations	0.00	0.00	3.87	0.04	0.00	0	12.43	0.09
Dry deciduous forest	225.13	2.26	127.19	1.28	271.39	1.89	225.20	1.57
Total area	9954.03				14327.64			

Tattihala reservoir: Tattihalla is a tributary of Kali river and a dam at Tattihalla (across the Tattihalla river, near Tatwal village in Haliyal Taluk) helps to generate power at Nagjhari Power House (3 X 135 MW + 3 X 150MW). Tattihala dam is constructed (figure 12) to divert the bulk of the monsoon flows of the river into the Bommanahalli Pick-up reservoir. Tattihalla dam is a composite dam in nature with concrete spillway in the gorge and earther flanks on either side 42.4m high 1225 m long. Four radial gates of size 15m x 12m are provided to regulate the flood discharge. The temporal land use analysis (figure 13 & table 7) in the locality of Tattihalla pick up reservoir indicates the forests in the region getting fragmented. The land use analysis in the region with 1km Buffer shows the loss of forest land and increase of area under agriculture and plantations. The crop land has increased from 4.29 (1973) to 11.96% in 2013 and human habitations constitute 2.98%.

Table 7: Land use at Tattihalla from 1973 to 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	**20.08**	**0.25**	**123.49**	**1.56**	**34.39**	**0.31**	**334.30**	**2.98**
Water	67.02	0.85	1747.65	22.14	11.34	0.1	1869.00	0.03
Agriculture	**222.60**	**2.82**	**748.13**	**9.48**	**481.04**	**4.29**	**1192.81**	**11.96**
Open space	80.83	1.02	769.99	9.75	138.53	1.24	829.73	12.76
Moist deciduous forest	**2331.46**	**29.53**	**123.80**	**1.57**	**3069.39**	**27.36**	**247.26**	**4.37**
Evergreen to Semi evergreen forest	4117.54	52.16	11.08	0.14	5829.85	51.97	14.86	0.14
Scrub/Grass lands	336.56	4.26	86.50	1.10	499.85	4.46	215.84	0.47
Acacia/Eucalyptus plantations	**175.26**	**2.22**	**2615.27**	**33.13**	**224.32**	**2**	**3960.57**	**43.37**
Teak / Bamboo plantations	**134.66**	**1.71**	**1537.71**	**19.48**	**268.51**	**2.39**	**2370.10**	**23.73**
Coconut/Areca nut plantations	0.00	0.00	2.43	0.03	0.00	0	11.35	0.04
Dry deciduous forest	408.66	5.18	128.63	1.63	659.71	5.88	171.11	2.11
Total area	7894.69				11216.93			

Gerusoppa Dam: Gerusoppa dam was constructed across the river Sharavathi before entering Arabian Sea in Uttara Kannada District. Four generating units of 60 MW each, totalling to 240 MW

is installed at the Gerusoppa Dam (figure 14) which is functional since 2001. Sharavati Tail Race project submerged 575 ha of biodiversity rich forests; another 125 ha of lands were acquired for other associated works for the township, roads, etc. Before the construction of the dam on Sharavathi, the river used to be more active during the monsoon compared during summer. The tidal water would extend up to Gerusoppa village making the water saline after the monsoon to support estuarine ecosystem. After impoundment at Linganamakki, Talakalale and Gerusoppa dam the consequent constant flow in the river, the impact of tidal water has pushed saline water leading to the damage of mangroves and associated estuarine ecosystem. Figure 15 and table 8 details land uses in Gerusoppa dam region, which shows the decline of evergreen forest from 87.15 (1973) to 43.17% (2013). Increase in built-up from 2.07% to 7.38% (dam region with 1km buffer) during 1973 to 2013.). Cash crops like coconut have increased due to water availability in region. The current spatial extent of coconut plantation is 6.06% with in project area and 5.34% (the dam region with 1km buffer). Also a fraction of workforce of this project settled in the buffer region occupying forest lands.

Kaiga Nuclear power plant: Kaiga Nuclear power generating station located at 14°51′55.16″N 74°26′22.71″E in Kaiga, on the branches of river Kali, in Uttar Kannada district of Karnataka, India. Kaiga is located in the green environs of Western Ghats about 60 Km east of the beach town of Karwar (figure 16). The plant has been in operation since March 2000 and is operated by the Nuclear Power Corporation limited (NPCIL) of India. Annual generation is 2,231 GWh. Pressurized Heavy Water Reactor (PHWR) for producing saturated steam to drive a double stage Turbo Generator. Natural Uranium bundles are used as fuel for the reactors. Heavy water is used to transport the heat generated in reactors to steam generators. It is also used, as a moderator for neutrons, to aid the process of fission reaction. Because of these biochemical properties of stocked tritium heavy water, the process of cleaning up the spills and recovering the heavy water or flushing it into the environment almost invariably leads to radiation doses to workers and, potentially, the general public (Harrison et al., 2002; Ramana et al., 2010). The forest land of 732 ha was released for the Kaiga Atomic Energy Plant. The dome of the first reactor unit collapsed in May 1994 delaying its construction by a few more years. In 1999 and again in 2001, people of Sirsi and Yellapur taluks staged a protest against the laying of a high tension power line from Kaiga through the thick forest region. About 677 ha forest lands were cleared for power transmission lines. Now there is a proposal to establish two more units at the site. Villagers of Bare, Malavalli, Vajralli and Kalache in Yellapur taluk have reported more cancer cases after the establishment of the Kaiga project. Studies have demonstrated adverse effect on aquatic diversity due to water discharge from power plant to Kali river (Zargar et al., 2006). Figure 17 and table 9 provides the picture of land use dynamics in the region due to Kaiga NPH. Evergreen forests have declined from 63.27 (1973) to 21.93%(2013) due to setting up of power house and employee quarters and associated developments (8.91%).

Table 8: Land use analysis of Gerusoppa dam from 1973 to 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	**0.00**	**0.00**	**48.79**	**1.67**	**4.30**	**0.10**	**138.51**	**3.13**
Water	59.41	2.03	529.28	18.12	99.52	2.25	686.27	15.49
Agriculture	61.32	2.10	153.94	5.27	91.92	2.07	326.75	7.38
Open space	9.45	0.32	32.95	1.13	89.46	2.02	137.18	3.10
Moist deciduous forest	72.33	2.48	247.65	8.48	297.35	6.71	644.75	14.55
Evergreen to Semi evergreen forest	**2545.06**	**87.15**	**1260.56**	**43.17**	**3565.06**	**80.47**	**1437.43**	**32.44**
Scrub/Grass lands	**16.92**	**0.58**	**217.95**	**7.46**	**96.92**	**2.19**	**380.75**	**8.59**
Acacia/Eucalyptus plantations	11.80	0.40	174.54	5.98	11.88	0.27	268.66	6.06
Teak / Bamboo plantations	14.85	0.51	77.68	2.66	44.85	1.01	173.36	3.91
Coconut/Areca nut plantations	**128.99**	**4.42**	**176.97**	**6.06**	**128.99**	**2.91**	**236.77**	**5.34**
Dry deciduous forest	0.18	0.00	0.00	0.00	0.18	0.00	0.00	0.00
Total area	2920.31				4430.43			

Table 9: Land use analysis of Kaiga NPH from 1973 to 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	**32.50**	**1.75**	**165.41**	**8.91**	**66.02**	**1.03**	**222.86**	**4.01**
Water	60.65	3.27	128.77	6.94	115.22	0.33	354.93	6.38
Agriculture	95.67	5.15	88.27	4.75	165.80	4.21	227.36	4.09
Open space	74.76	4.03	133.02	7.16	145.49	0.35	335.11	6.02
Moist deciduous forest	191.79	10.33	441.96	23.80	736.92	21.57	867.42	15.60
Evergreen to Semi evergreen forest	1174.72	63.27	407.23	21.93	3919.04	58.84	2615.07	47.02
Scrub/Grass lands	183.50	9.88	110.97	5.98	267.24	4.3	382.51	6.88
Acacia/Eucalyptus plantations	42.94	2.31	273.66	14.74	83.35	5.34	355.27	6.39
Teak / Bamboo plantations	0.00	0.00	0.00	0.00	48.07	3.08	88.89	1.60
Coconut/Areca nut plantations	0.00	0.00	107.30	5.78	0.00	0	112.15	2.02
Dry deciduous forest	0.09	0.00	0.00	0.00	14.76	0.95	0.36	0.01
Total area	1856.62				5561.92			

Konkan Railway: The construction of the Konkan Railway through the west coast, while revolutionising coastal transportation had also its own inevitable environmental impact in the form of landscape changes, diversion of agricultural and forest lands etc. The Konkan Railway line was commissioned in phases from 1993 onwards in 11 sectors and finally fully commissioned in 1998. Total Railway track is 179 KM with fifteen numbers of Railway Stations (figure 18). First time Indian Railways built tunnels longer than 2.2 kms are prepared with more than 1000 cuttings in the track. Land use analysis of Konkan railway (figure 19 and table 10) show fragmentation of forests though it provides connectivity of many regions. In the buffer region (0.5km), built-up area has increased from 1.65% (1973) to 17.06% (2013). The increase in open fields (11.13%) is due to the clearance along the track. Moist deciduous forests in Konkan railway project region show a decline from from17.80 (1973) to 4.55% (2013). Cutting of the hills, removal of vegetation cover and vibrations due to frequent movement of rail has enhanced landslide susceptibility in the region.

Table 10: Land use analysis of Konkan railway line from 1973 to 2013

Year / Land use Category	Project area			
	1973		2013	
	Ha	%	Ha	%
Built-up	**214.23**	**1.65**	**2205.62**	**17.00**
Water	331.97	2.56	626.05	4.82
Agriculture	2619.86	20.19	4438.78	34.21
Open space	486.26	3.75	1444.28	11.13
Moist deciduous forest	**2310.03**	**17.80**	**589.77**	**4.55**
Evergreen to Semi evergreen forest	4142.00	31.92	942.09	7.26
Scrub/Grass lands	618.04	4.76	720.03	5.55
Acacia/Eucalyptus plantations	1240.57	9.56	486.44	3.75
Teak / Bamboo plantations	58.51	0.45	68.77	0.53
Coconut/Areca nut plantations	933.63	7.19	1452.92	11.20
Dry deciduous forest	21.16	0.16	1.53	0.01
Total area	12976.26			

Project Sea Bird: Indian Navy established a major Naval Base at Karwar (Karnataka), about 120 km south of Goa on the west coast of India under 'Project Seabird' also known as 'INS Kadamba' in 1986 (figure 20), for creation of infrastructure and facilities for the basing of ships/ submarines, with all associated operational/support facilities. Phase I of Project Seabird has been completed in 2005, spread over an area of 45 square kilometres with a 26km-long coastline, which is 5.5 km of breakwaters, reclaimed areas for development of ship lift and berthing facilities, aircraft carrier berthing facilities, large onshore developments with residential complexes, admin facilities etc.. It is a larger naval base in Asia and has an exclusive military harbour and the base has 1,200 officers and sailors. The construction of Project Seabird Naval Base involved eviction of thousands of families of fishermen and farmers from the coastline of Karwar and Ankola taluks. Environmental modifications of great magnitude, such as building of breakwaters, dredging of the sea, filling up of coastal swamps, intensified construction activities and other landscape changes are being executed in the Project Seabird area. The rehabilitation of the evacuees brought greater pressure in other coastal villages as well as in the forest areas of hinterland. Project Seabird Phase IIA work, commissioned in 2011 involves construction of a wide range of new facilities and augmentation of certain existing facilities which spans 4km over 50 Ha land. Land use in the project Seabird region is given in table 11 and figure 21 show an increase of built-up area from 1.77% (1973) to 32.09% (2013) due to marine ship basements and port construction. Evergreen forests have declined from 34.63 (1973) to 5.22% (2013).

Table 11: Land use analysis of Project Sea Bird from 1973 to 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	**12.78**	**1.77**	**231.58**	**32.09**	**52.39**	**2.88**	**383.75**	**21.09**
Water	**110.16**	**15.26**	**6.77**	**0.94**	**130.15**	**7.15**	**63.94**	**3.51**
Agriculture	95.52	13.24	115.43	15.99	254.74	14.00	163.87	9.01
Open space	216.65	30.02	109.33	15.15	255.99	14.07	187.75	10.32
Moist deciduous forest	36.67	5.08	33.03	4.58	394.49	21.68	126.97	6.98
Evergreen to Semi evergreen forest	**249.93**	**34.63**	**37.64**	**5.22**	**586.87**	**32.26**	**408.73**	**22.47**
Scrub/Grass lands	0.00	0.00	116.56	16.15	35.38	1.94	290.08	15.94
Acacia/Eucalyptus plantations	0.00	0.00	19.83	2.75	104.84	5.76	88.53	4.87
Teak / Bamboo plantations	0.00	0.00	0.00	0.00	0.81	0.04	12.70	0.70
Coconut/Areca nut plantations	0.00	0.00	51.54	7.14	0.00	0.00	92.58	5.09
Dry deciduous forest	0.00	0.00	0.00	0.00	3.69	0.20	0.45	0.02
Total area	721.71				1819.35			

West Coast Paper Mills, Dandeli: Situated in the heart of thick forests on the banks of Kali river with the assured supply of raw materials, water from Kali river, power supply from the state grid; vicinity of rail and road linkages (figure 22). Capacity of the mill was initially 18,000 metric tonnes (MT) per annum of writing, printing and packaging paper (1959), which were augmented to the current production level of 185000 (MT) per annum. The present raw material consumption is 400000 (MT) per annum of wood. Bamboo from Uttara Kannada forests was allotted at the rate of Rs. 3.12 per tonne of paper pulp produced, with periodic marginal revision in prices. The extraction limit of bamboo was fixed at 100,000 tonnes of bamboo per year. Bamboo, which was considered almost a weed in the timber forests, by the Forest Department, was nearly eliminated within four decades of the factory's operations. The depletion of bamboo known as "poor man's timber" caused great hardships to basket and mat weavers and rural people. Land use (table 12 & figure 23) in region due to the implementation of paper mills show a decline of evergreen forests from 29.46 (1973) to 2.24% (2013). The region is turning to more moist deciduous forest from semi evergreen forest. Built-up has increased from 17.17(1973) to 44.04% in 2013.

Table 12: Land use analysis of West Coast Paper Mills from 1973 to 2013

Year / Land use Category	Project area				Project area with 1km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Built-up	30.42	17.17	78.04	44.04	40.33	3.96	175.27	17.21
Water	2.07	1.17	3.24	1.83	13.32	1.31	27.99	2.75
Agriculture	21.15	11.94	23.58	13.31	88.21	8.65	167.55	16.45
Open space	0.63	0.36	20.61	11.63	13.50	1.33	50.25	4.93
Moist deciduous forest	23.58	13.31	3.87	2.18	271.84	26.69	93.65	9.19
Evergreen to Semi evergreen forest	52.21	29.46	3.96	2.24	458.71	45.03	98.79	9.70
Scrub/Grass lands	4.68	2.64	19.53	11.02	30.06	2.95	24.05	2.36
Acacia/Eucalyptus plantations	14.50	8.18	19.86	11.21	24.48	2.4	246.28	24.18
Teak / Bamboo plantations	5.00	2.82	0.45	0.25	1.08	0.11	98.39	9.66
Coconut/Areca nut plantations	0.00	0.00	4.05	2.29	0.00	0	5.87	0.58
Dry deciduous forest	22.95	12.95	0.00	0.00	77.14	7.57	30.60	3.00
Total area	177.21				1018.69			

Figure 2: the location of Supa dam (a) Google Earth (b) Dam site

Figure 3 (a, b): Supa dam Project area

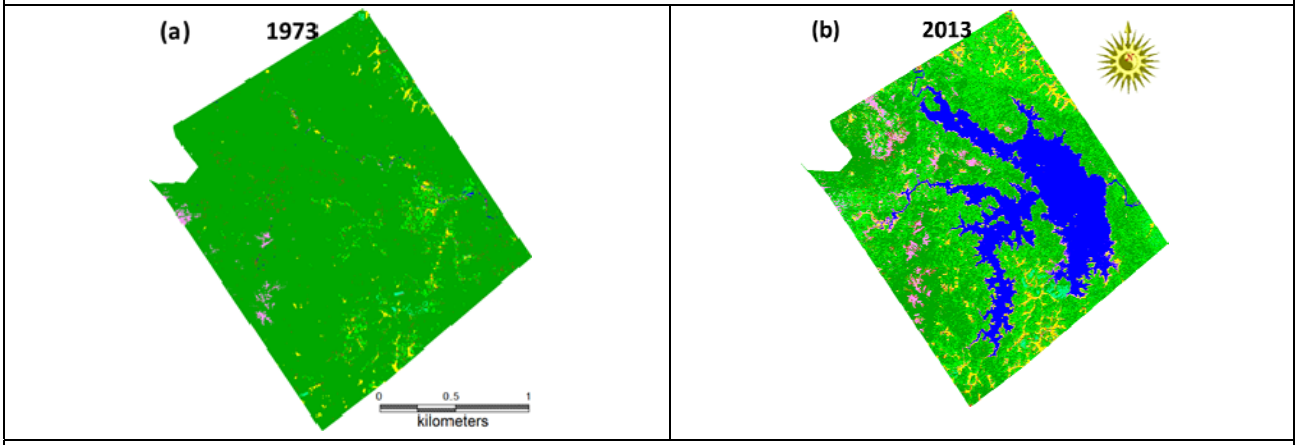
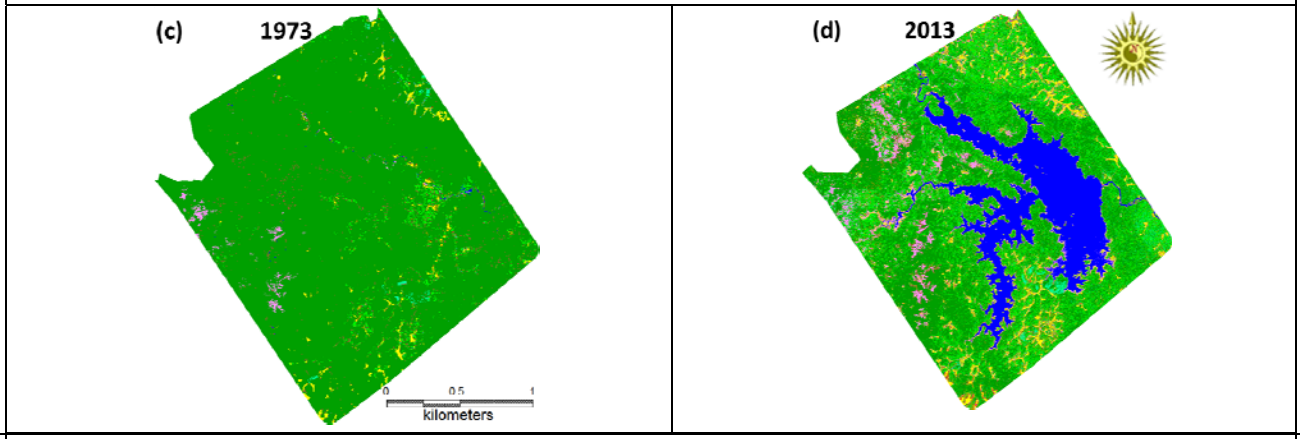


Figure 3 (c, d): Supa dam with 1km buffer



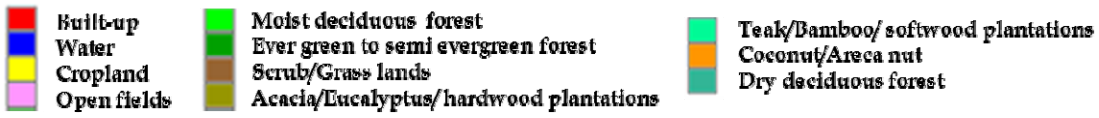


Figure 4: the location of Upper Kaneri dam as shown in Google Earth

Figure 5 (a, b): Kanei dam Project area

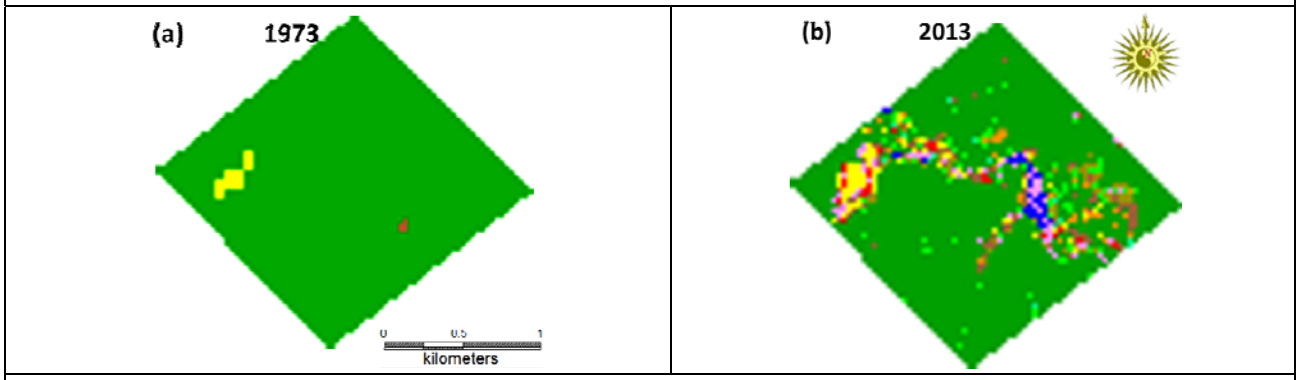


Figure 5 (c, d): Kaneri dam with 1km buffer

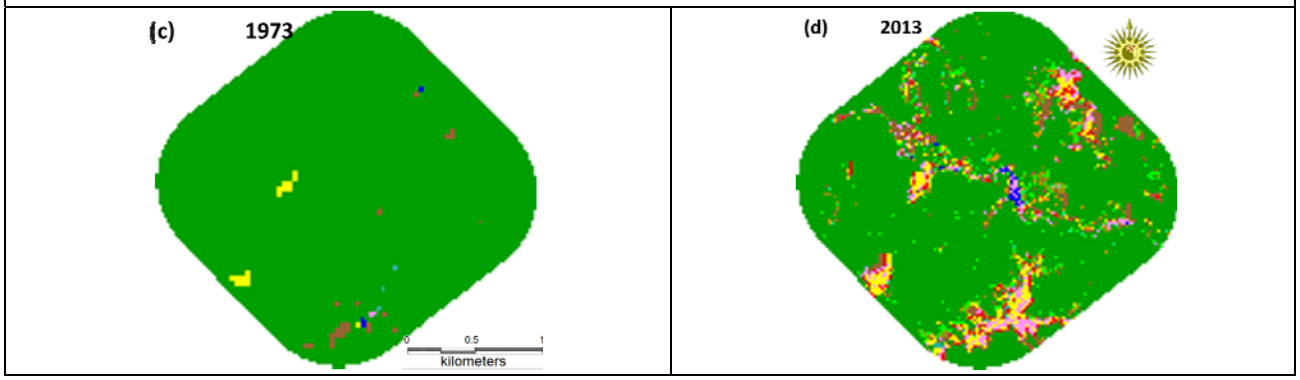
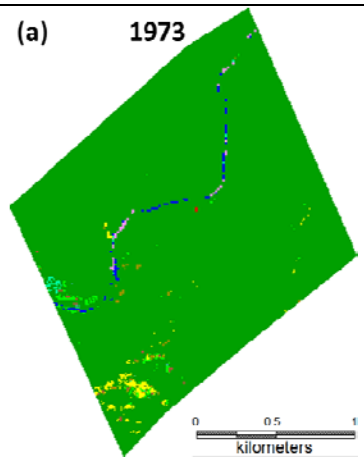


Figure 6: the location of Kodasalli dam as shown in Google Earth

Figure 7(a, b): Kodasalli dam Project area



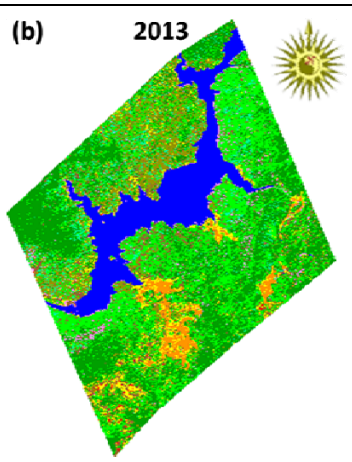
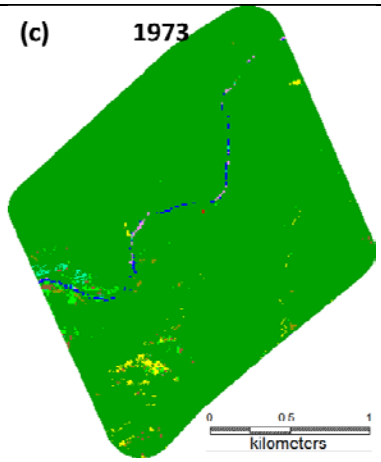


Figure 7(c, d): Kodaslli dam with 1km buffer



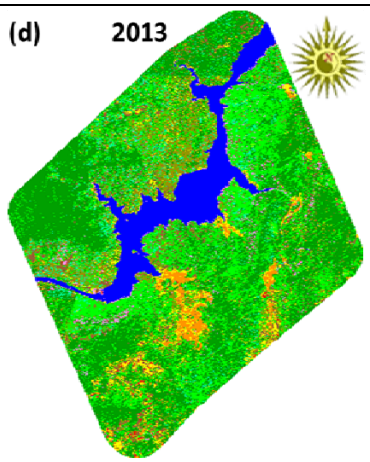


Figure 8: the location of Kadra dam as shown in Google Earth

Figure 9 (a, b): Kadra dam Project area

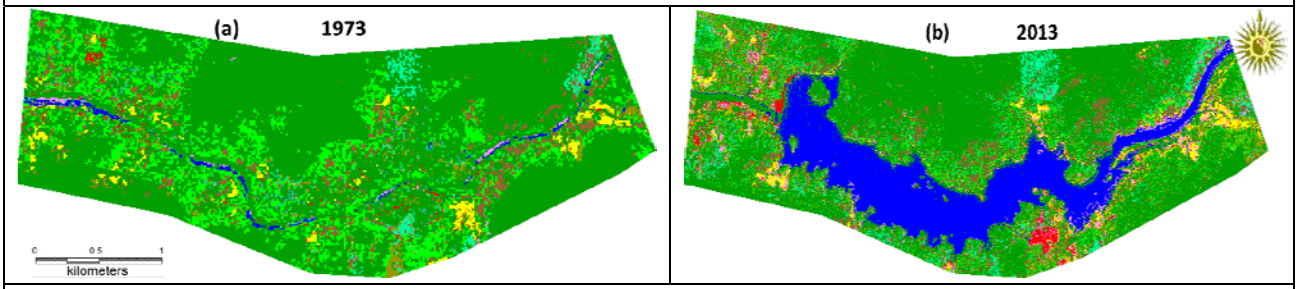


Figure 9 (c, d): Kadra dam with 1km buffer

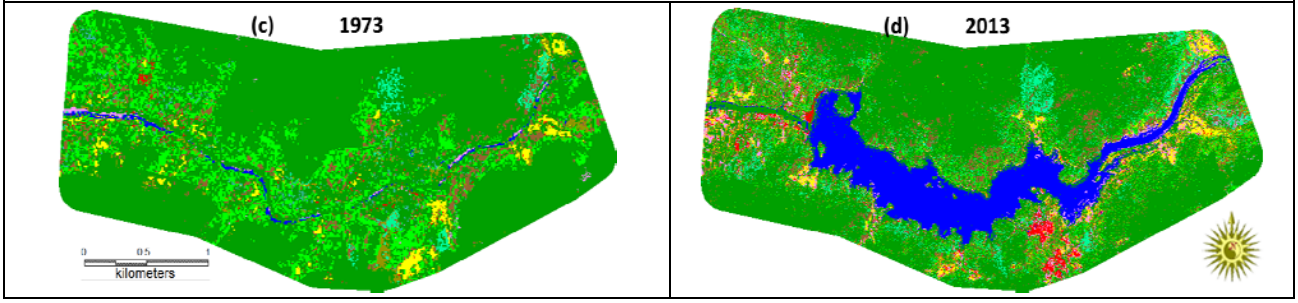
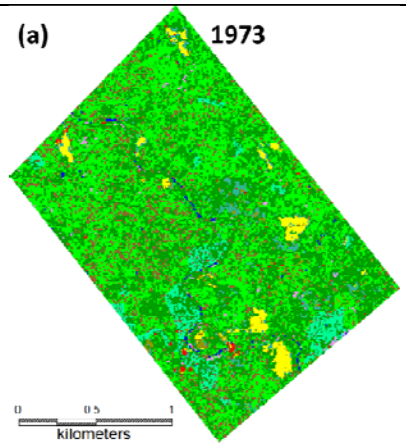


Figure 10: the location of Bommanalli reservoir as shown in Google Earth

Figure 11: Bommanalli reservoir Project area (a, b)



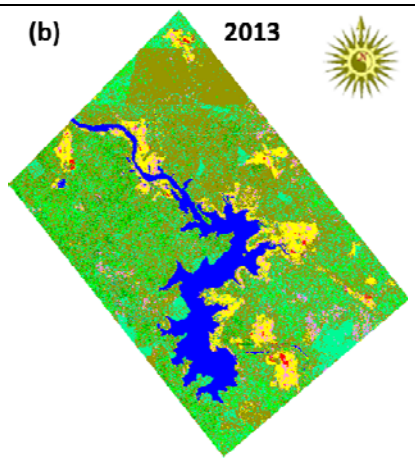
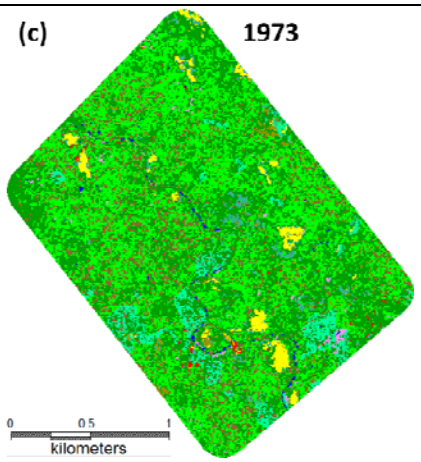


Figure 11 (c, d): Bommanahalli reservoir with 1km buffer



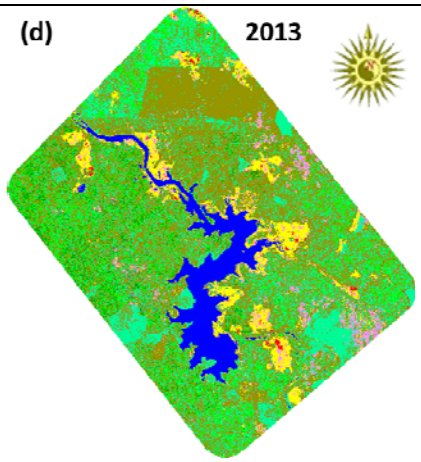


Figure 12: the location of Tattihalla reservoir as shown in Google Earth

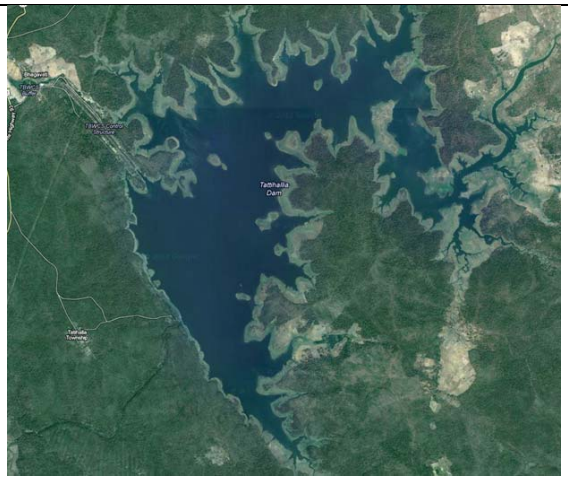
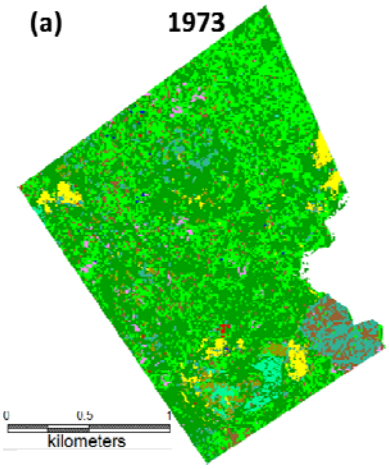


Figure 13: Tattihalla reservoir Project area (a, b)



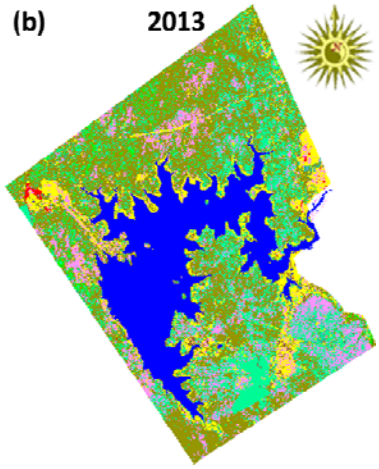
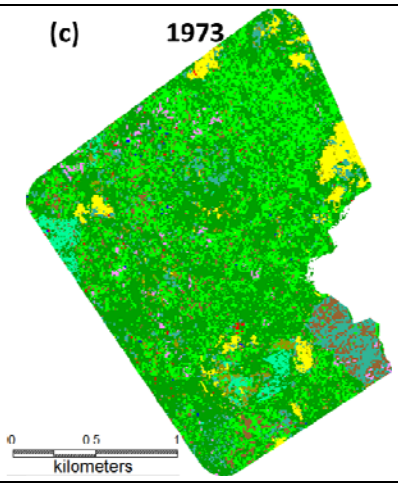


Figure 13 (c, d): Tattihalla reservoir with 1km buffer



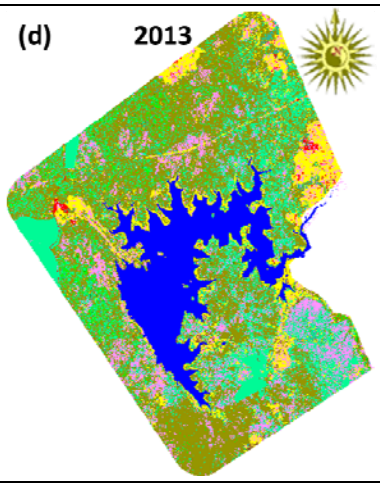


Figure 14: the location of Gerusoppa dam as shown in Google Earth

Figure 15: Gerusoppa dam Project area (a, b);

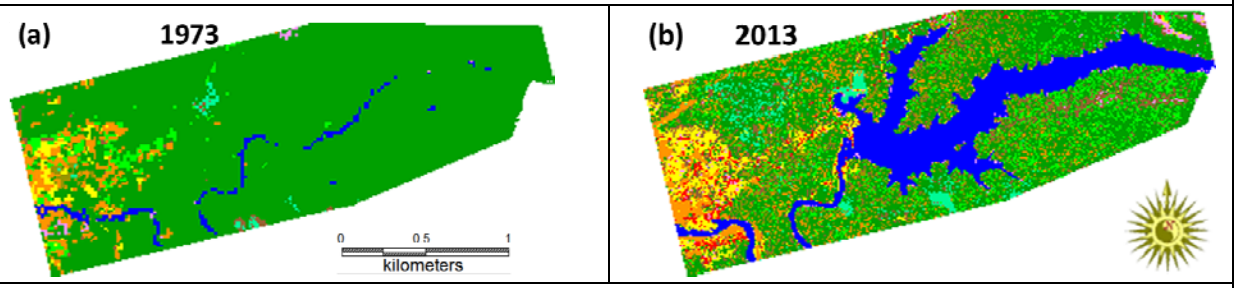


Figure 15(c, d): Gerucoppa dam with 1km buffer

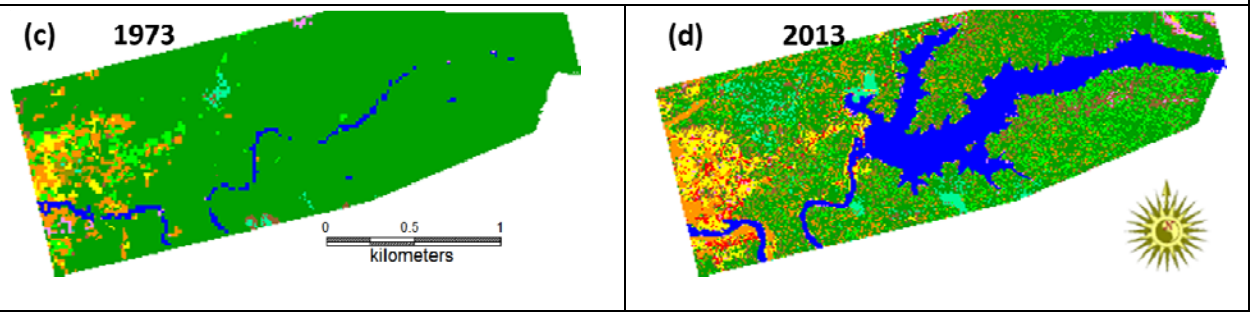
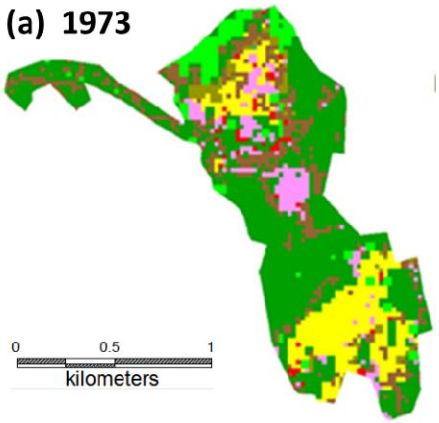


Figure 16: the location of Kaiga NPH as shown in Google Earth

Figure 17: Kaiga NPH Project area (a, b); with 1 km buffer (c, d)



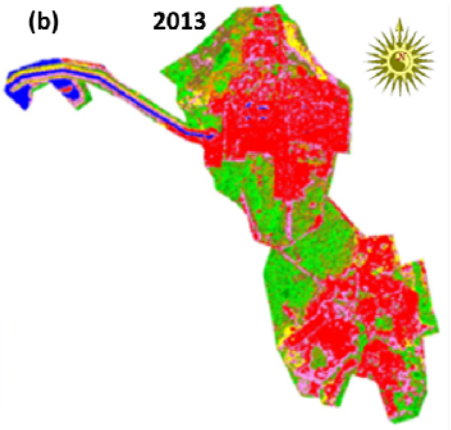
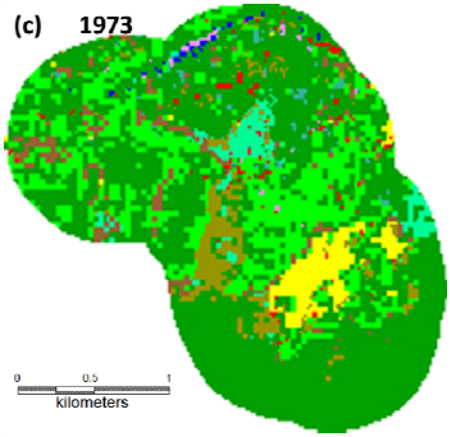


Figure 17 (c, d) : with 1 km buffer



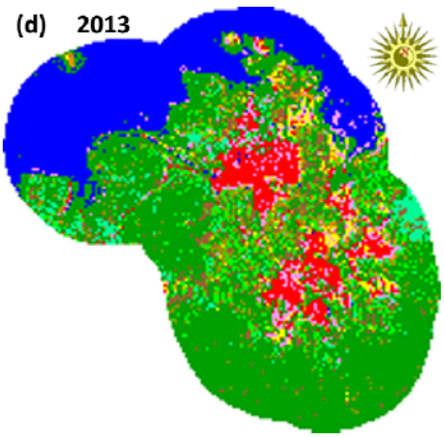


Figure 18: the location of Project seabird as shown in Google Earth and other

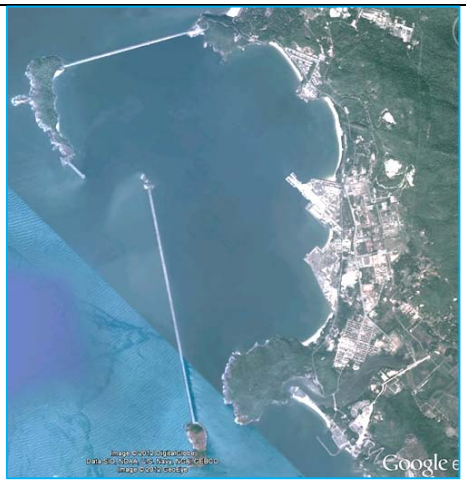
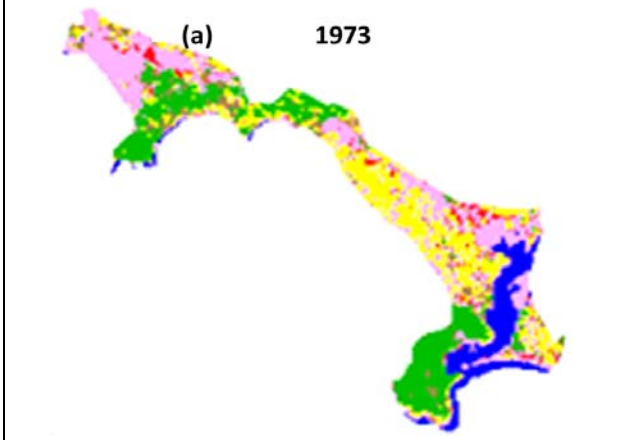


Figure 19: Project seabird area (a, b);



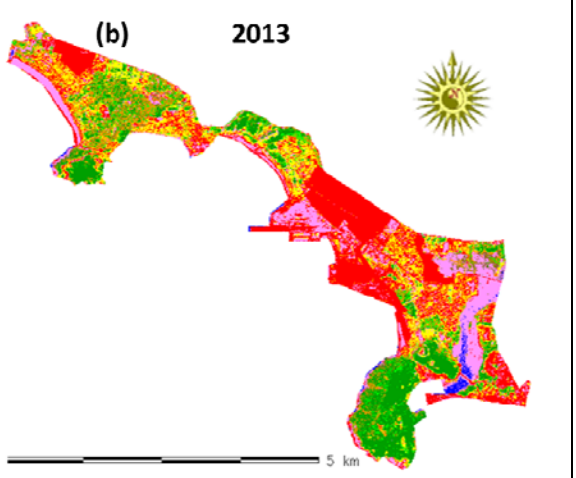
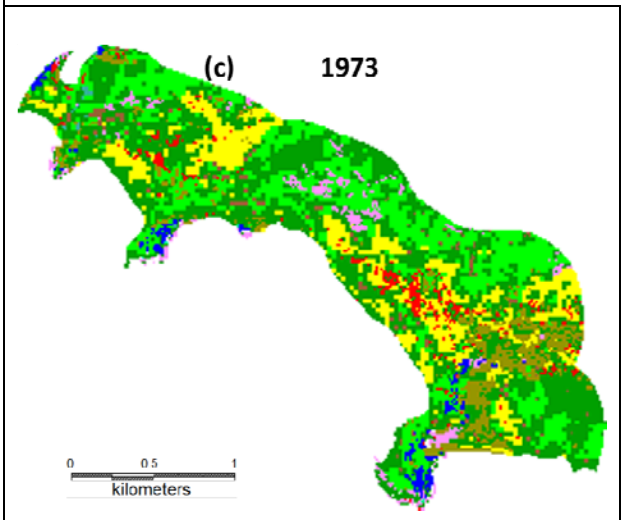


Figure 19 (c, d): project Seabird with 1km buffer



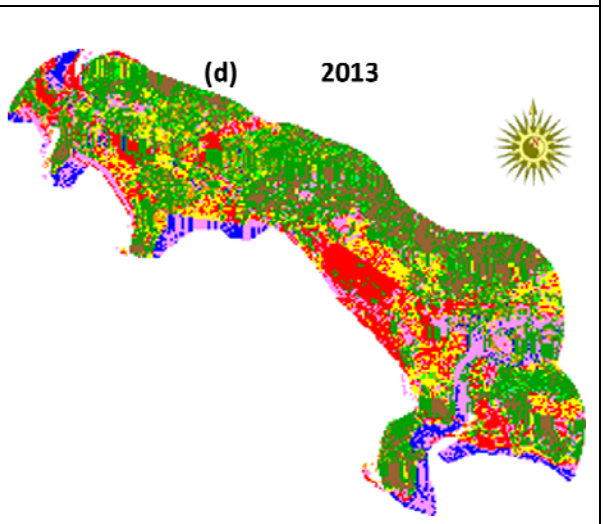


Figure 20: the location of West coast paper mills as shown in Google Earth and project site

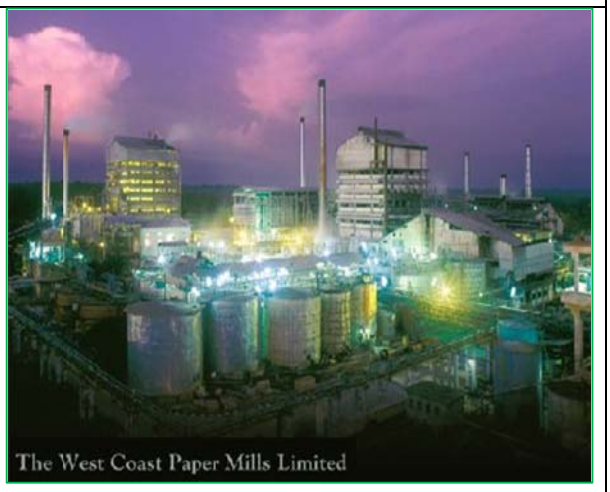
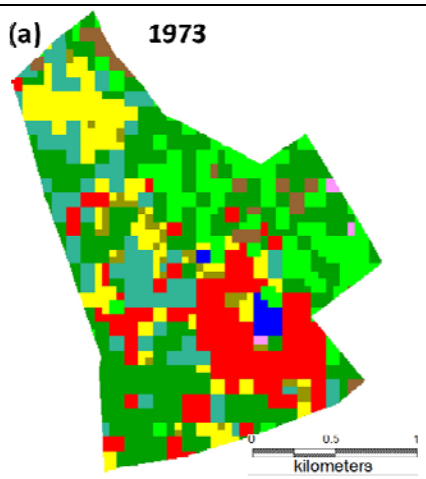


Figure 21: West coast paper mills area (a, b);



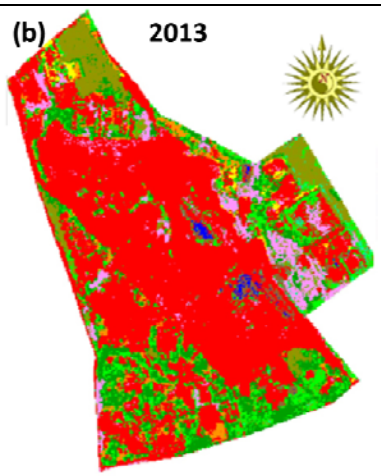
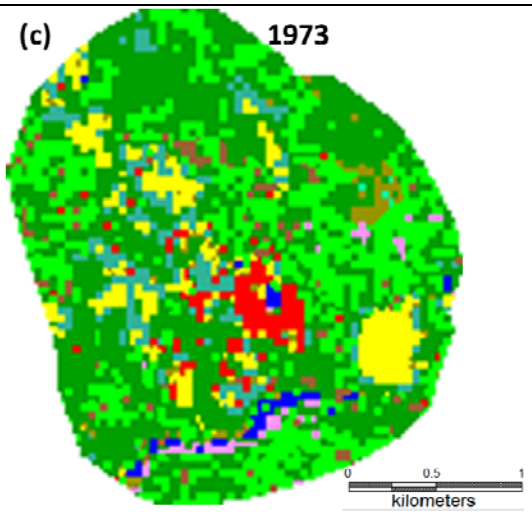


Figure 21(c, d): West coast paper mills with 1km buffer



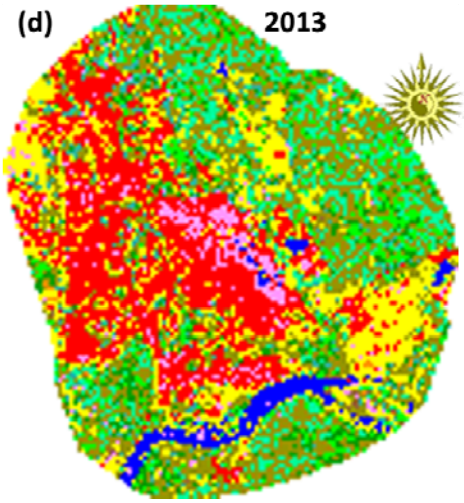
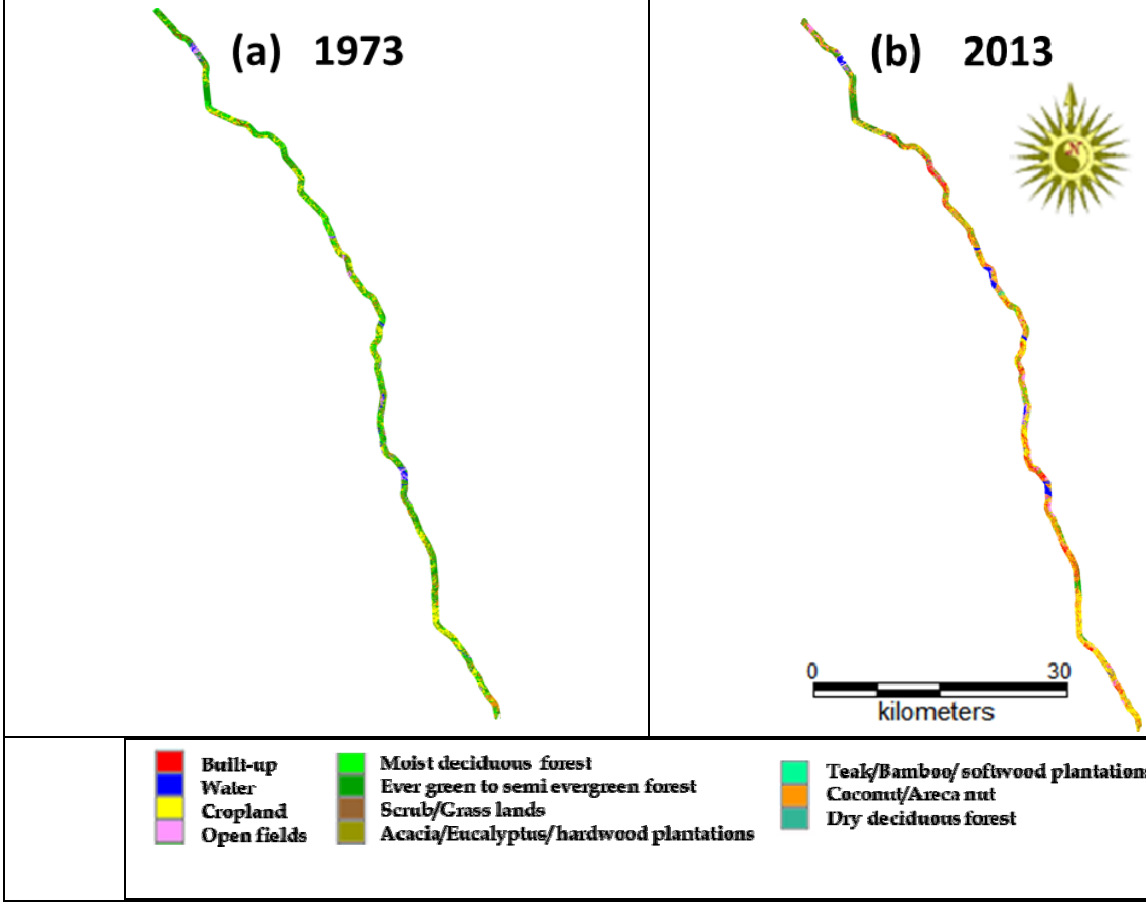


Figure 22: Rail way line of Konkan as seen in Google Earth

Figure 22: Konkan railway area (a, b)



The dominant developmental thrust in U.K. has traditionally favored industrialization and natural resources such as forest, land, water were given at free of cost. Some infrastructure developments include the paper mills, the caustic soda factory, the Kali and Sharavathi Hydel projects, the manganese and limestone mining, establishment of a nuclear plant at Kaiga, establishment of a naval base at Karwar, and the Konkan Railway. Harihar Polyfibres is quite intensively dependent on Uttara Kannada forests for its pulpwood needs. These projects have dramatically altered the structure of fragile ecosystems in the region with sustainable impacts.

Conclusion:

Development is process of improving the quality of all human lives with economic advancement considering social, ecological, psychological and political processes. The rapid development efforts have failed in many ways evident from the enhanced process of deforestation, erosion of productive top soil, enhanced instances of human-animal conflicts, forest fires, declined sustained flow of water in streams. This emphasises the need for development that retains its harmony with nature, by aiming at environmentally sound development. The economically harmonic and sustainable development effort obviously enriches the region. Mitigation measures for ecological impacts are to be considered throughout the project period i.e. planning, designing, construction, operation. There is an urgent need for a strengthening of the interface between science and policy efforts to ensure that scientific findings are implemented towards conserving ecosystems in Western Ghats.

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