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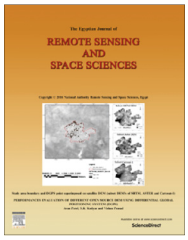

RESEARCH PAPER

Stimulus of developmental projects to landscape dynamics in Uttara Kannada, Central Western Ghats

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Abstract Unplanned large scale developmental projects in recent times have been causing alterations in land use land cover [LULC] at spatial and temporal scales with the substantial changes in the landscape. Uttara Kannada district has the distinction of having highest forest cover in India. Forest ecosystems in the district have witnessed major transformations due to industrialization during the post-independence. Impact of developmental activities during the post-independence era, is evident from barren hill tops due to deforestation. The analysis of temporal spatial data acquired through space borne sensors highlights the decline of evergreen-semi evergreen forest cover from 67.73% (1973) to 32.08% (2013). The ad-hoc approaches adopted in the implementation of developmental projects in the ecologically sensitive regions has impaired the ecosystem services affecting the people's livelihood. The changes in the landscape structure with LULC changes have altered the functional abilities of an ecosystem evident from lowered hydrological yield, disappearing perennial streams, higher instances of human–animal conflicts, declined ecosystem goods, etc. About 64355 Ha of forest land is diverted for various non-forestry activities during the last four decades by the government apart from encroachment of 7072 Ha of forest area for agriculture, horticulture activities, etc. Encroachment of forest land has resulted in the land degradation leading to reduced productivity. Alterations in bio-geo chemical and hydrological cycles have necessitated the restoration of native forests in the region to ensure water and food security, and

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livelihood of the local people. Monitoring and visualization of landscape dynamics helps in evolving appropriate management strategies. LULC dynamics analyses considering agents (developmental projects) through fuzzy analytic hierarchy process (AHP) integrated with Markov cellular automata (CA) indicate the developmental projects such as West Coast Paper Mill (WCPM) and Kaiga Nuclear Power House (KNPH) will lead to further fragmentation of forests with spurt in urbanization by 2022. This necessitates framing appropriate policy measures to sustain natural resources focusing on the landscape's ecological, hydrological, economic and social factors.

1. Introduction

Forests are integral part in the socio-economic, ecological, and cultural fabric of tropical regions (Mbuvi and Boon, 2008). Humans depend either directly or indirectly on forests to an extent of 80% in developing world (FAO, 1997; Ahenkan and Boon, 2008). Livelihood of the local people is sustained by both aquatic and terrestrial ecosystems, the extent of support depends on the health of the respective ecosystems. Altering the ecological integrity would impact the ecological goods and services affecting the livelihood of the dependent population. Development approaches for improving the quality of dependent populations towards the economic advancement needs to consider social, ecological, psychological and political processes (World Bank, 2006). Unplanned developmental activities though provided employment and resources to the handful influential sections but have deprived majority of native population of natural resources. The adverse effects of the unplanned 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. due to changes in vegetation structure, growth, biomass and food productivity (Daigle, 2010; Rawat et al., 2013; El Baroudy and Moghanm, 2014). Many countries have overexploited the forests, fisheries, and mineral wealth by polluting water, air to accelerate economic growth (Prizzia, 2002; Barnett and Pauling, 2005). Deforestation in Asia, estimated at between 0.9% and 2.1% per annum has direct and profound impacts such as lowered ecological flows in rivers, flash floods, etc. The ever increasing demand of resources has led to fragmentation of forests and deforestation endangering highly productive ecosystems with changes in climate and other stressors. The cumulative effects of developmental activities are evident from the extent of fragmentation of forests, which is the manifestation of the changes in landscape patterns (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 (Apps and McLellan, 2006). Construction of dams (Fu et al., 1998; Ramachandra et al., 2010), river diversions and linear projects (road and rail network) have impacted on hydrologic regime, aquatic habitat, the extinction of species, etc. (Rosenberg et al., 1997; Renofalt et al., 2010). Now there is an increasing concern of the potential impact of hydrologic alterations on biodiversity, and studies have begun to focus on the environmental and social consequences of large scale developmental projects (Rosenberg et al., 2000; Ramachandra et al., 2000; Qi and Ruan, 2005) in ecologically sensitive regions.

Ecosystem degradation due to the unplanned developmental activities trigger adverse impact on natural resources evident from barren hill tops, decreased water flow in streams, etc. Developmental activities impose direct costs to the dependent communities due to the loss of goods and services and indirect costs in terms of loss of rural lands (Dasgupta and Shaw, 2016). Conversion of forests for agriculture expansion, human settlements, infrastructure, mining, etc. is rampant in recent times. Illegal and unscientific human alteration of land use pattern is referred as encroachments (National Commission on Agriculture, 1976). This situation is a consequence of increase in demands for food, rising market prices for commodities (Kunwar et al., 2009), and also due to the lack of enforceable ownership rights to forest property. The slash and burn cultivation practiced predominantly earlier is banned in India due to proven ecological consequences. Recent forest clearances for agriculture and horticulture purposes are noticed in forest areas with good drainage network and soil fertility (Kanninen et al., 2007; Stickler et al., 2007) by market forces (Scoones et al., 1992; Neumann and Hirsch, 2000). Unplanned developmental activities coupled with widespread encroachments have affected the goods and services of forests. These areas are abandoned in recent times due to lack of productivities with the mismanagement of natural resources and economic pressures. The restoration on these lands can offer greater potential for biodiversity recovery, carbon sequestration and enhanced ecosystem services (Omeja et al., 2012). This requires inventorying, mapping and periodical monitoring to assess the agents of changes for mitigating deforestation apart from assessing the efficacy of forest protection, regeneration and utilization of resources (Suwanwerakamtorn et al., 2011; Ramachandra et al., 2014).

Data acquired remotely through space borne sensors at regular intervals and analysis using GIS with GPS (Global Positioning System) has aided in the estimation of biophysical characteristics of land surfaces and dynamics for the

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sustainable management of a landscape (Ramachandra et al., 2012). The knowledge of spatio-temporal LULC changes and visualization of future growth is essential for natural resources planning and also to overcome the problems associated with the haphazard and uncontrolled land cover changes (Bharath et al., 2014). There have been a number of modelling approaches through multi criteria analysis in decision making (MCADM) such as Markov-CA, AHP, artificial neural network (ANN) etc., which are either used independently or combined in hybrid models (Keshtkar and Voigt, 2016) to forecast changes (Taha and Rostam, 2011; Bharath and Ramachandra, 2016) and for sustainable management of natural resources (Belton and Stewart, 2002; Kazemi et al., 2016). Fuzzy AHP proved appropriate in fuzzy environments for MCADM, for modelling landscape dynamics in recent years (Saaty, 1988; Mendoza and Martins, 2006; Bharath and Ramachandra, 2016). The uncertainty in MCADM can be explained through fuzzy AHP that provides visualization of transitions for immediate judgments. Integration of fuzzy AHP with CA helps in prioritization and quantifying the role of drivers involved in the landscape conversion. The fuzzy-AHP-CA aids in deriving the weights from fuzzy pairwise comparison matrices using change of relational measurement indicators by a set of fuzzy weights, which are useful for decision making through multiple criteria. Knowledge of landscape dynamics and visualization of likely LULC transitions would help in taking location specific ecosystem approaches of conservation measures by involving all stakeholders help in the management of natural resources. The ecosystem approach accounts ecologically sensitive areas, habitats of endangered (threatened) species, rare and "keystone" (ecologically important) species and also likely threats to the biodiversity. Main objective of the current work is to,

(1) Quantification of land use changes during 1973–2013.
(2) Assessment of the role of agents such as developmental projects in LULC dynamics during 1973–2013.
(3) Visualization of landscape dynamics and likely land use in 2022 using multi criteria decision making.
(4) Measuring the impact of local agents (such as encroachments) role in deforestation, using geo-informatics.

2. Study area

The Uttara Kannada district (13.92°–15.53° North and 74.09°–75.09° East) has the distinction of having highest forest cover in the state of Karnataka, India. The district has a tropical climate with the mean annual rainfall of 4237 mm and elevation ranges from 0 to 1050 m. The district has five forest divisions and one wildlife division (Fig. 1) covering 11 taluks (local revenue administrative division). The region is the repository of exceptional biodiversity with higher endemism, which is due to the humid tropical climate, topographical and geological characteristics, and geographical isolation (Arabian Sea to the west and the semiarid Deccan Plateau to the east). The region is part of the Western Ghats, one among 34 global hotspots of biodiversity. The total population of the district is 1,502,454 (as per 2011 census) with population density of 146 persons per sq.km. The coast and plains have been expressing higher population presence while Sahyadri'regions with moderate pressures. The district has 140 km coastal line and the west flowing rivers (Kali, Bedthi, Aganashini, Sharavathi, Venkatapur) break the shoreline of Uttara Kannada by deep and wide mouthed estuaries, larger creeks with ample biodiversity (Mesta et al., 2014). However, due to lack of environmental accounting of natural resources, the 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 on ad-hoc basis and impacts of these decisions are evident from barren hill tops, lowered quantity and duration of stream flow, etc. Large reservoirs on Kali and Sharavathi, for hydroelectricity generation have submerged vast tracts of natural forest and displaced a large number of families. The region has witnessed large scale migrations, encroachment of forest lands and conversion to agricultural lands (with the implementation of project due to water availability). This has 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. Encroachment of forest lands, conversion of natural forests to monoculture plantations of exotic species, etc. have resulted in the fragmentation of forests and animal habitats resulting in higher instances of human-animal conflicts. Cumulative impacts of all these activities are evident from the disappearance of endemic species and erosion of biodiversity in the region. Annexure A lists the land allotments made for various developmental activities by the State government since 1956.

3. Materials and method

The method followed for the current study (Fig. 2) involves preprocessing of data, land use analysis and mapping of encroachments using forest administrative boundaries. LULC changes in Uttara Kannada district is analysed using temporal remote sensing data (1973, 1989 and 2013) with ancillary data and field data. The remote sensing data (RS) used in the study are Landsat MSS (25/01/1973), Landsat TM (03/01/1989), Landsat ETM^{+} (06/01/2004; 29/1/2013) and Google Earth (http://earth.google.com). Landsat data were downloaded from public archive (http://landsat.gsfc.nasa.gov). Ancillary data include cadastral revenue maps (1:6000), the Survey of India (SOI) topographic maps (1:50,000 and 1:250,000 scales), vegetation map of South India developed by French Institute (1986) of scale 1:250,000 (http://www.ifpindia.org). The forest boundaries of each division representing different forest types, revenue land information are collected from state forest department (http://www.aranya.gov.in). Topographic maps provided ground control points (GCP's) to rectify remote sensing data and scanned paper maps. Vegetation map of South India (1986) of scale 1:250,000 (Pascal, 1986) was digitized to identify various forest cover types and classify RS data of

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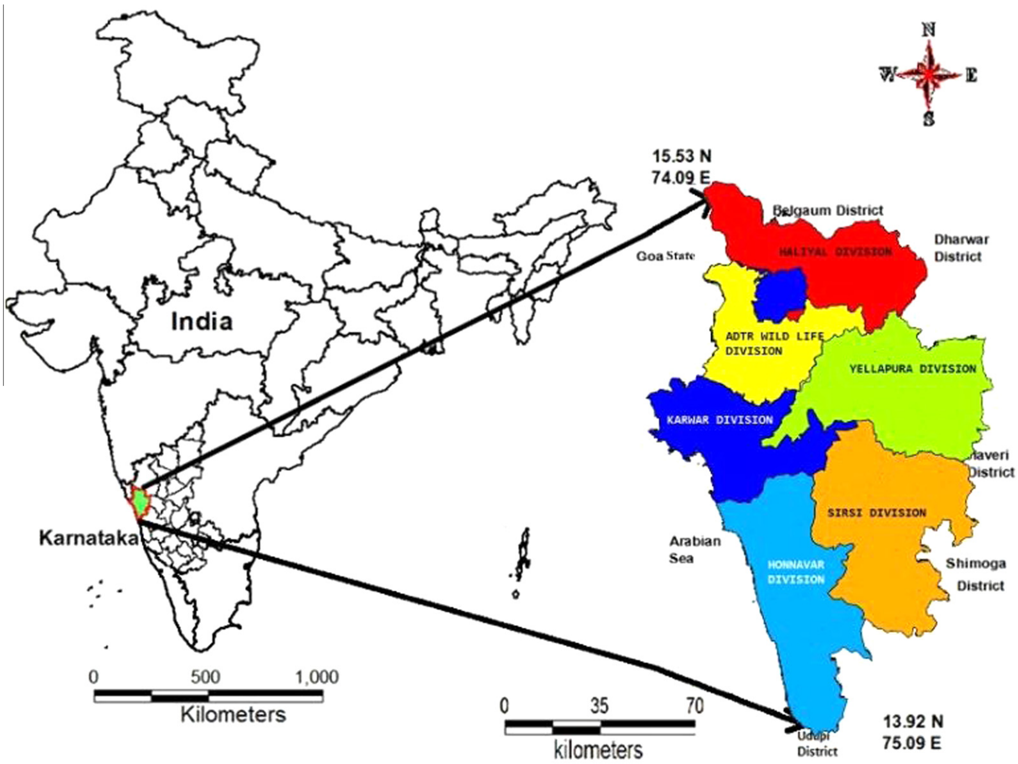

Figure 1 Study area-Uttara Kannada district, India.

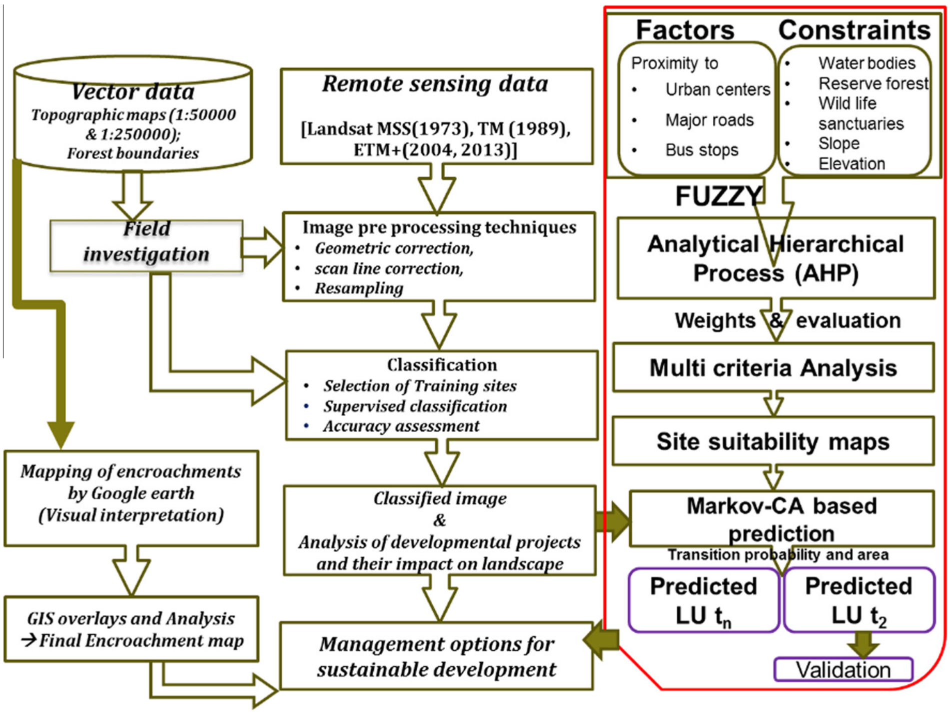

Figure 2 Method followed in the analysis.

1980's. Other ancillary data includes land cover maps, administration boundary data, transportation data (road network), etc. Pre-calibrated GPS (Global Positioning System – Garmin GPS units) were used for field data collection, which were used for RS data classification as well as for validation. Remote sensing data obtained were geo-referenced, rectified and cropped corresponding to the study area. Geo-registration of remote sensing data (Landsat data) has been done using

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ground control points collected from the field using pre calibrated GPS (Global Positioning System) and also from known points (such as road intersections, etc.) collected from geo-referenced topographic maps published by the Survey of India (http://www.surveyofindia.gov.in).

The Landsat satellite 1973 images of spatial resolution 57.5 m × 57.5 m (nominal resolution), were resampled to 30 m × 30 m comparable to the 1989 and 2013 data. Landsat ETM+ bands of 2013 were corrected for the SLC-off through image enhancement techniques, followed by nearest-neighbour interpolation. Land use analysis involved (i) generation of False Colour Composite (FCC) of remote sensing data (bands – green, red and NIR). This composite image helps in locating heterogeneous patches in the landscape, (ii) selection of training polygons by covering 15% of the study area (polygons are uniformly distributed over the entire study area) (iii) loading these training polygons co-ordinates into GPS, (iv) collection of the corresponding attribute data (land use types) for these polygons from the field, (v) supplementing this information with Google Earth and (vi) 60% of the training data has been used for classification, while the balance is used for validation or accuracy assessment. The land use analysis was done using supervised classification technique based on Gaussian maximum likelihood (GML) algorithm with multi-temporal "ground truth" information (collected from field using GPS). GML Classification of remote sensing data is based on Bayes' theorem through the selection of the largest posterior probability rather than the minimum distance and for each training site the complete distribution of values is retained by generating a histogram. The number of occurrences in each histogram bin relative to the total number of occurrences determines the conditional probability distribution (Atkinson and Lewis, 2000) based on the spectral signature defined in the training set to determine each class. Mean and covariance matrix were computed using estimate of maximum likelihood estimator. This technique is proved to be a superior classifier as it uses various classification decisions using probability and cost functions (Ramachandra et al., 2012). GRASS GIS (*Geographical Resources Analysis Support System*) – software is used for the analysis, which is a free and open source software (http://wgbis.ces.iisc.ernet.in/grass/index.php) having the robust support for processing both vector and raster files. Accuracy assessments were performed to decide the quality of the information derived from RS data considering reference pixels. These test samples are then used to create error matrix (also referred as confusion matrix) kappa (κ) statistics and overall (producer's and user's) accuracies to assess the classification accuracies.

Temporal land use analyses for each developmental projects have been done considering the project region and project region with a 1 km buffer for accounting changes in the vicinity due to the implementation of the project. Considering buffer region extended the focus of strategies to measure the land use manifestation due to of economic and workforce development. The major initiation of developmental projects started in mid-1980's and hence 1973 was chosen as a base reference year, while 2013 information represents the current status. Fuzzy clustering technique is performed to group the spatial units of agents into clusters based on their attribute data using evaluation membership functions (sigmoidal monotonic decrease/increase function, linear) and rescale driver maps into the range 0–255, where 0 represents unsuitable sites and 255 represents the most suitable for transition. In the MCDM process, a collection of different factors such as elevation, slope, proximity to urban centres, proximity to roads and constraints such as water bodies, reserve forest, wild life sanctuaries, slopes higher than 20% were considered. Analytical Hierarchal Process (AHP) is then used to assign weights to these spatial units based on expert opinion. The consistency index CI is computed to evaluate consistency of the weightage matrix. Consistency ratio (CR) was evaluated for three regions and acceptable CR from 0.04 to 0.09 is obtained for each land use. The weightage matrix for each developmental project is evaluated separately. For example, WCPM area the consistency values of industries (0.22), major roads (0.09), urban area (0.34) with CR of 0.06. The CR value below 0.1 indicates the model is consistent, obtained by the probability of the random weights from the landscape factors (Saaty, 2008). Then CA is implemented with the help of transition probability matrix, which inherits past states of land use types to predict future state. CA selects the location of pixels which are most likely to be transformed between the time periods. Land use is simulated for the year 2013 based on different conditions (i.e. transition rules, iteration numbers) generated based on land use history of 2004–2012. Simulated land use of 2013 was validated with the actual land use (based on classification of remote sensing data) through kappa indices, as a measure of agreement. Once these data and agents are trained and validated, data are used to model and simulate for future trends (2022). The other major land use change driver is encroachment of forests. The division-wise forest administrative maps were used for spatially quantifying the extent of forest encroachments. These administrative forest boundaries were geometrically corrected with GPS points, topographic maps and overlaid on Google Earth. These administrative boundaries with distinct land survey numbers and other features aided in visual interpretation method by marking unauthorized modifications of land. This is further validated with field data compiled using GPS.

4. Results and discussion

4.1. Land use changes from 1973 to 2013

Temporal remote sensing data were classified into eleven land use categories and Table 1 lists land use details during 1973–2013 and depicted in Fig. 3(a–c). Comparative assessment of land use categories reveals the decline of vegetation cover in the district during 1973–2013. Unplanned developmental activities coupled with the enhanced agriculture and horticultural activities have aided as prime drivers of deforestation. The reduction of area under evergreen forests from 67.73%

Table 1 Land use variation from 1973, 1989 and 2013.

Category	Year								
	1973		1989		2004		2013		Loss/gain in area (1973–2013)
	Ha	%	Ha	%	Ha	%	Ha	%	(Ha)
	Forest								
Moist deciduous forest	**95,357**	**9.27**	143,849	**13.98**	172,667	16.78	**161,996**	**15.74**	66,639
Evergreen to semi evergreen forest	**696,978**	**67.73**	531,872	**51.68**	373,845	36.33	**330,204**	**32.08**	−**366,774**
Scrub/grass land	38,109	3.70	44,123	4.29	22,646	2.20	40,402	3.93	2293
Dry deciduous forest	25,410	2.47	13,848	1.35	7221	0.70	9873	0.96	−15,537
Water	7681	0.75	16,604	1.61	28,625	2.78	28,113	2.73	20,432
	Non-forest								
Built-up	3886	**0.38**	12,982	1.26	28,040	2.72	31,589	**3.07**	27,703
Crop land	71,990	**7.00**	121,167	11.77	150,391	14.61	145,395	14.13	**73,405**
Open fields	14,071	1.37	34,783	3.38	34,432	3.35	37,660	3.66	23,589
Acacia/eucalyptus/hardwood plantations	40,905	**3.97**	55,694	5.41	107,617	10.46	122,927	**11.94**	82,022
Teak/bamboo/softwood plantations	13,997	**1.36**	21,937	2.13	49,072	4.77	67,111	**6.52**	53,114
Coconut/areca nut/cashew plantations	20,702	**2.01**	32,227	3.13	54,530	5.30	53,993	**5.25**	**33,291**
Total	**1,029,086**								

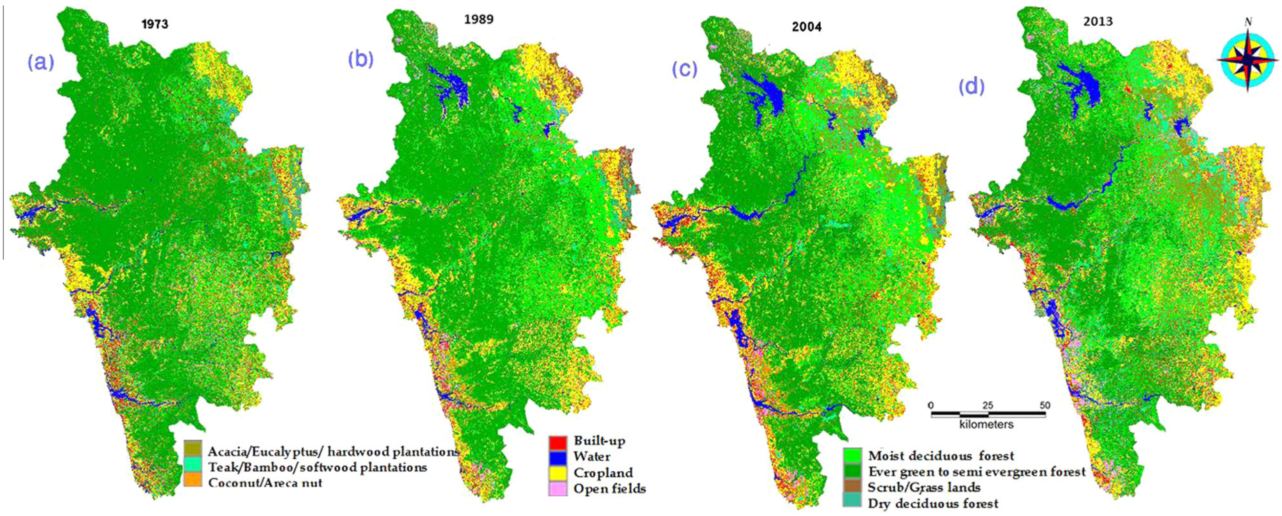

Figure 3 (a–c) Spatiotemporal land use changes for 1973, 1989, 2004 and 2013.

(1973) to 32.09% (2013) due to anthropogenic activities involving the conversion of forest land to agricultural and horticultural activities, monoculture plantations and land releases for developmental projects. Transition of evergreen-semi evergreen forests to moist deciduous forests, and some have been converted into forest plantations (such as Teak, Acacia spp., etc.). Enhanced agricultural activities are evident from the increase in agricultural land use from 7.00% (1973) to 14.13% (2013) and the area under human habitations have increased during the last four decades, evident from the increase in built-up area from 0.38% (1973) to 3.07% (2013). The increase in plantation of exotic species (*Acacia auriculiformis*, *Casuarina equisetifolia*, *Eucalyptus* spp., and *Tectona grandis*) has led to the removal of forest cover and also extinctions of species. The dry deciduous forest cover is very less (0.96%) and is found mainly in the north eastern part of the district in Mundgod taluk and partly Haliyal taluk. The areas of each category were also compared with available administrative reports, statistical department data and forest division annual reports. The accuracy of classifications (Table 2) is verified using field data and online data (Google earth, Bhuvan). Accuracy of the classification ranges as 82.52%, 92.22% and 91.59% with more consistent results.

4.2. Developmental projects and their impacts on the forest ecosystem

The major developmental projects with buffer region in the district are listed in Fig. 4 (marked on Google Earth image of the district) and spatio temporal analysis is done to understand LULC changes with the implementation of developmental projects. District falls into three agro climatic zones namely

Table 2 Accuracy assessment of the study.

Year	Accuracy	Moist deciduous	Ever green to semi	Scrub	Dry deciduous	Built-up	Water	Crop land	Open land	Acacia	Teak	Coconut
1973	PA	82.36	90.24	58.92	92.27	67.61	90.73	83.14	86.54	72.39	74.85	50.16
	UA	81.45	89.82	57.52	91.84	66.69	89.94	79.26	86.42	71.58	78.18	66.02
1989	PA	88.76	94.59	92.28	80.89	98.28	99.62	95.83	91.58	97.44	84.41	38.83
	UA	97	97.84	98.16	70.07	77.6	95.53	87.09	93.84	74.33	59.18	73.75
2004	PA	89.18	91.42	97.58	86.05	99.93	86.49	97.86	90.24	87.04	84.64	83.34
	UA	91.10	92.44	98.46	84.64	96.96	95.26	81.39	89.82	94.33	86.05	89.2
2013	PA	87.92	93.91	93.24	86.78	60.34	99.77	97.49	89.81	92.53	78.68	89.92
	UA	85.54	96.3	85.7	86.85	94.14	99.56	90.11	89.13	90.98	91.1	80.02

Year	Overall accuracy	Kappa
1973	82.52	0.81
1989	92.22	0.89
2004	91.24	0.9
2013	91.51	0.89

*PA – Producer's Accuracy; UA – User's Accuracy.

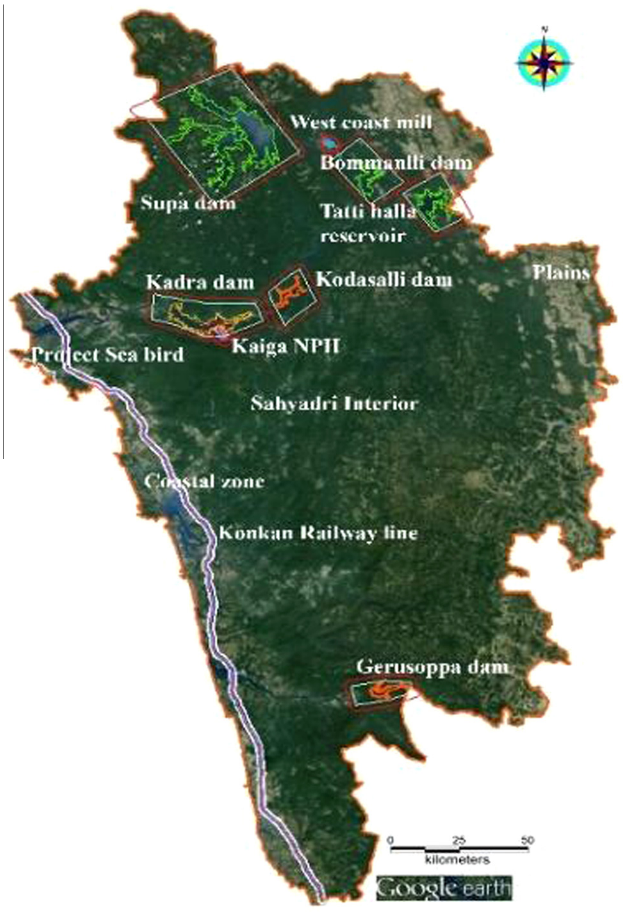

Figure 4 The major developmental projects of Uttara Kannada district.

coast, Sahyadri interior and plains. Specific projects, which are expressive of unplanned implementations in each zone were chosen for the change analysis. Developmental projects include Sea Bird, Gerusoppa dam in the coastal zone, Supa dam, Kadra dam, Kaiga NPH in Sahyadri, West Coast Paper Mill, Tattihalla reservoir in plains. The impacts of these projects are discussed in the next section.

4.2.1. Project Sea Bird

Indian Navy established Asia's largest Naval Base at Karwar, about 120 km south of Goa on the west coast of India under 'Project Seabird' also known as 'INS Kadamba' in 1986, for the creation of infrastructure and facilities for the basing of ships/submarines, with all associated operational/support facilities (http://indiannavy.nic.in). Phase I of Project Seabird has been completed in 2005, spread over an area of 45 square kilometres with a 26 km-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. 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. Project Seabird Phase IIA commissioned in 2011 involved the construction of a wide range of new facilities and augmentation of certain existing facilities which spans 4 km over 50 Ha land. Land use in the project Seabird region (Table 3 and Fig. 5) shows an increase in 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). The rehabilitation of the evacuees brought greater pressure in other coastal villages as well as in the forest areas of hinterland. The built-up area within 1 km buffer constitutes about 21.09% in 2013.

Table 3 Land use analysis of project Sea Bird.

Land use category	Year							
	Project area				Project area with 1 km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
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
Dry deciduous forest	0.00	0.00	0.00	0.00	3.69	0.20	0.45	0.02
Water	**110.16**	**15.26**	**6.77**	**0.94**	**130.15**	**7.15**	**63.94**	**3.51**
Built-up	**12.78**	**1.77**	**231.58**	**32.09**	**52.39**	**2.88**	**383.75**	**21.09**
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
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
Total area	721.71				1819.35			

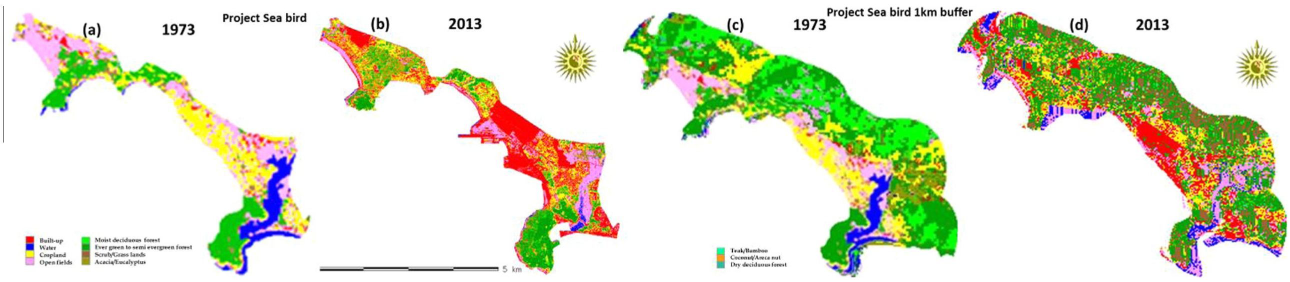

Figure 5 (a–d) Temporal change in land use by Sea Bird project.

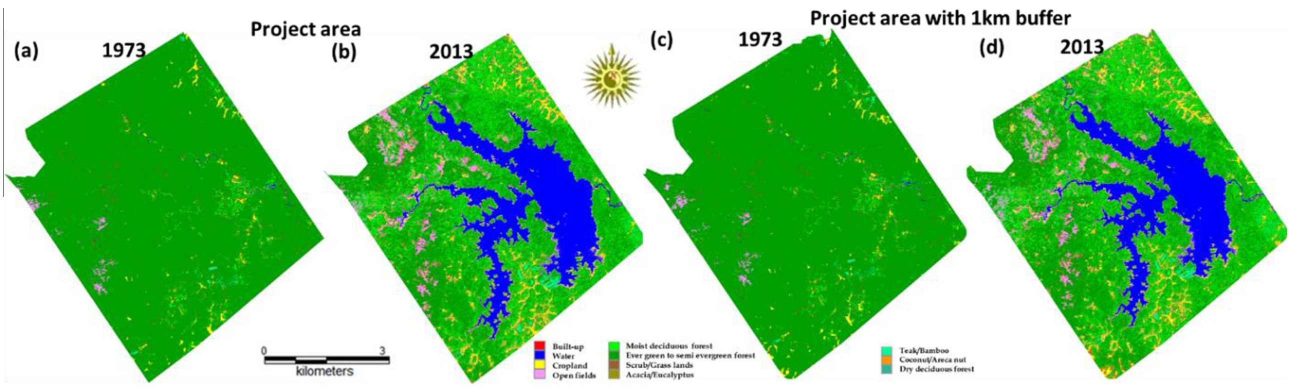

Figure 6 (a–d) Land use analysis of Supa dam from 1973 to 2013.

4.2.2. Supa dam

Supa dam is the second largest dam in the state of Karnataka, built across the Kali river (101 m high and 332 m long concrete gravity dam) in Supa (Joida) taluk for power generation (http://karnatkapower.com/portfolio/supa-dam/). This submerged more than 24 villages with acquisition of 10,692 Ha of forest land, 2248 Ha of private land and 466 Ha of revenue land totalling 13,406 Ha. The construction started in 1974 and ended in 1987 has a catchment area of 1057 km^2 and the live storage-capacity is 145 Tmcft. (Thousand million cubic feet). The power house was commissioned in 1985. Refugee settlement of this project 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 forests, and was taken over for resettlement around 1975. At the time of handing over, the entire vegetation (including fully grown trees) was removed, and the land was allowed to lie fallow without the institution of any soil

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Table 4 Land use at Supa dam region from 1973 to 2013.

Land use category	Year							
	Project area				Project area with 1 km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
Moist deciduous forest	869.27	1.77	9100.07	18.49	992.05	1.72	11127.9	19.33
Evergreen to semi evergreen forest	**46522.1**	**94.7**	**21063.3**	**42.79**	**54426.8**	**94.55**	**25,216**	**43.80**
Scrub/Grass lands	530.09	1.08	1341.39	2.73	608.59	1.06	1466.80	2.55
Dry deciduous forest	87.58	0.18	376.26	0.76	117.65	0.2	392.80	0.68
Water	142.05	0.1	10126.1	20.57	52.48	0.09	10940.1	19.00
Built-up	**15.3**	**0.03**	**60.49**	**0.12**	**20.70**	**0.04**	**163.82**	**0.28**
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
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
Total area	49220.08				57565.45			

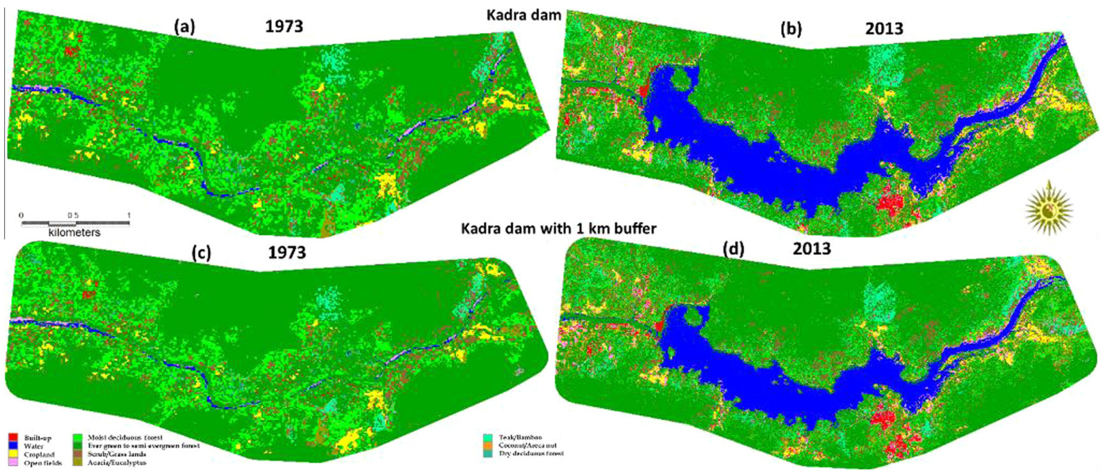

Figure 7 (a–d) Land use analysis for Kadra dam (1973–2013).

Table 5 Land use at Kadra dam region.

Land use category	Year							
	Project area				Project area with 1 km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
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
Dry deciduous forest	118.46	1.03	2.79	0.02	137.36	0.83	1.99	0.01
Water	112.16	0.98	2239.28	19.55	124.13	0.75	2961.79	17.81
Built-up	**72.55**	**0.63**	**172.56**	**1.51**	**80.02**	**0.48**	**371.65**	**2.23**
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
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
Total area	11453.66				16631.73			

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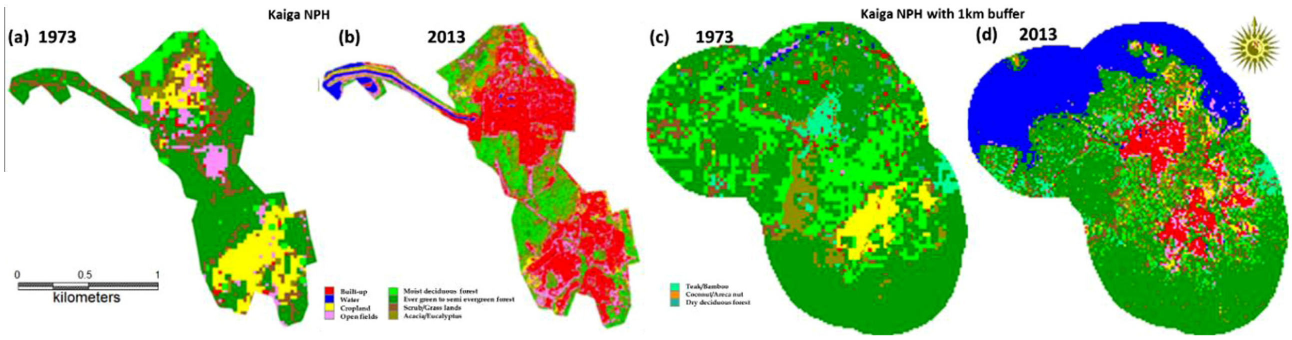

Figure 8 (a–d) Land use analysis for Kaiga NPH.

Table 6 Land use analysis of Kaiga NPH for 1973 and 2013.

Land use category	Year							
	Project area				Project area with 1 km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
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
Dry deciduous forest	0.09	0.00	0.00	0.00	14.76	0.95	0.36	0.01
Water	60.65	3.27	128.77	6.94	115.22	0.33	354.93	6.38
Built-up	**32.50**	**1.75**	**165.41**	**8.91**	**66.02**	**1.03**	**222.86**	**4.01**
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
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
Total area	1856.62				5561.92			

Table 7 Land use analysis of WCPM for 1973 and 2013.

Land use category	Year							
	Project area				Project area with 1 km buffer			
	1973		2013		1973		2013	
	Ha	%	Ha	%	Ha	%	Ha	%
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
Dry deciduous forest	22.95	12.95	0.00	0.00	77.14	7.57	30.60	3.00
Water	2.07	1.17	3.24	1.83	13.32	1.31	27.99	2.75
Built-up	**30.42**	**17.17**	**78.04**	**44.04**	**40.33**	**3.96**	**175.27**	**17.21**
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
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
Total area	177.21				1018.69			

conservation measures at least till 1989. Land use analysis of Supa hydroelectric dam with buffer shows execution of dam has submerged thick evergreen forests which covered 94.7% (1973) of region (Fig. 6 and Table 4) is reduced to 42.79%. The evergreen forest in 1 km 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

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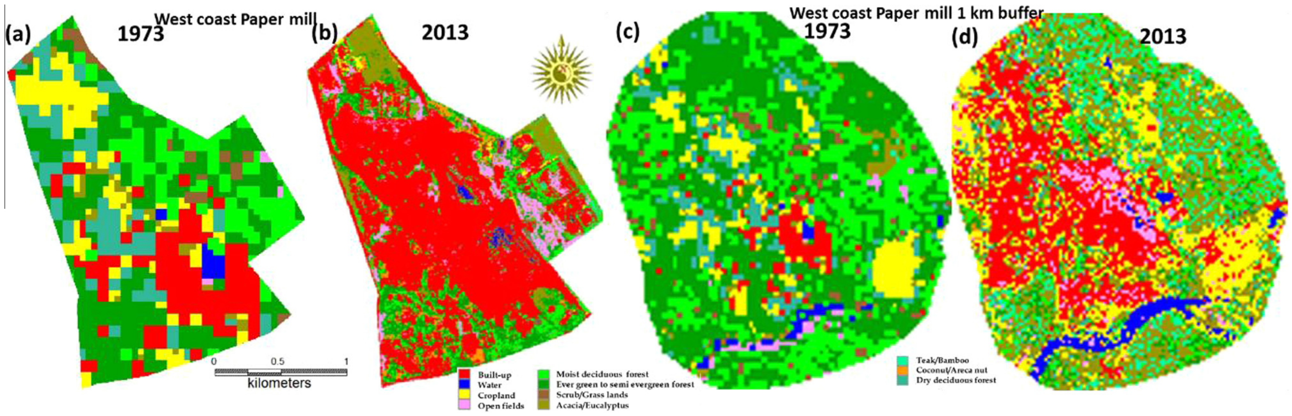

Figure 9 (a–d) Land use transition by WCPM.

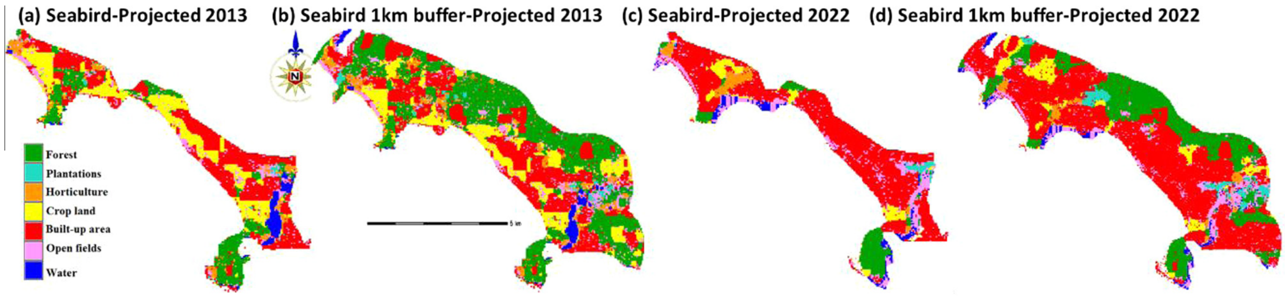

Figure 10 (a–d) Projected land use of Sea Bird project for 2013, 2022.

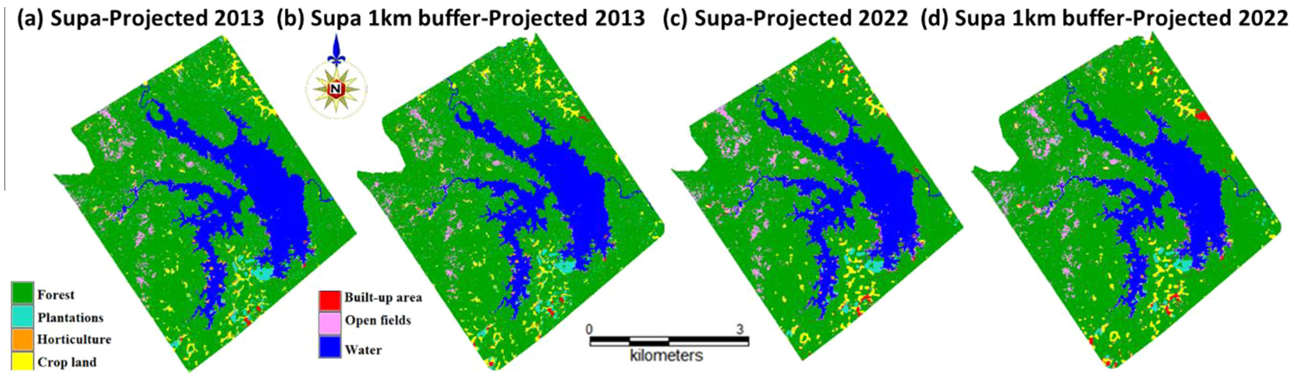

Figure 11 (a–d) Projected land use of Supa dam for 2013, 2022.

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. The agriculture activities in the fringes of the reservoir have increased. The construction of this reservoir has altered the hydrologic regime evident from the conversion of perennial streams to seasonal one affecting the agriculture and horticulture activities.

4.2.3. Kadra dam

Kadra power house commissioned in 1997, was built on the left bank of the river Kali with an installed capacity of 150 MW. Kadra dam and power house construction work has started in February 1986 and the project was to finish by 1997 but completed in 2000 (http://karnatakapower.com/portfolio/kadra-dam-power-house/). The power house integrates three 50 MW turbines which are coupled to the generating units. The annual generation is 570 MU. The Kadra Dam is an integral part of the Kaiga Nuclear Power House (NPH) project, provides adequate water to meet the total plant water requirement. Due to Kaiga NPH activity this region's aquatic fauna is intensely affected. The plankton diversity showed high sensitivity to elevated temperatures, resulting in decreased diversity and similarity indices near the discharge point (Zargar and Ghosh, 2006). Land use at Kadra dam (Fig. 7 and Table 5) project region and buffer region shows the 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

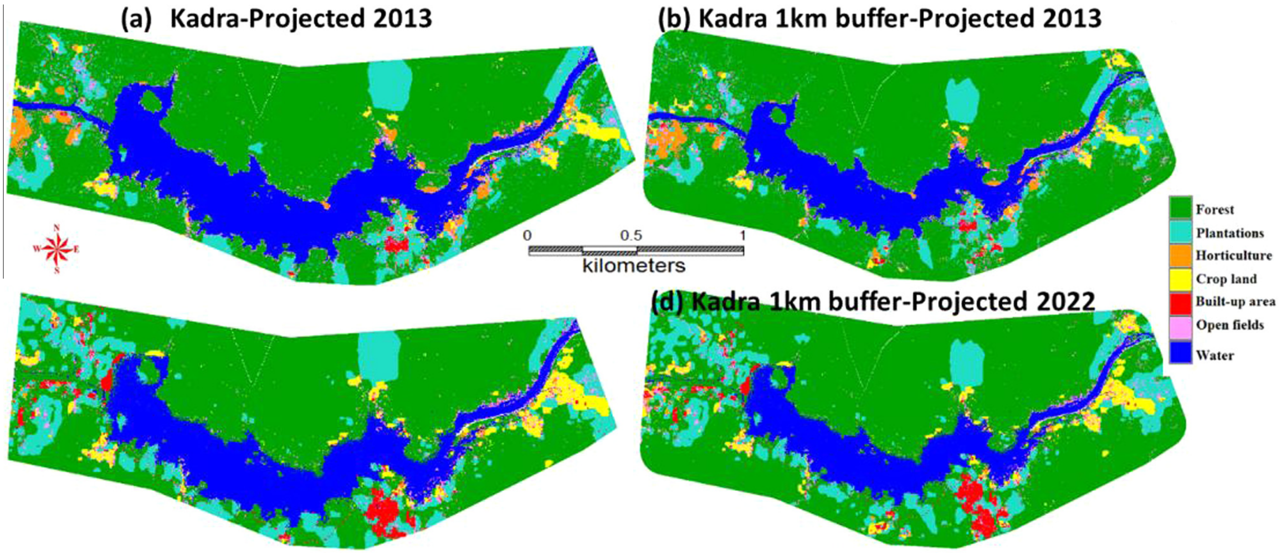

Figure 12 (a–d) Land use of Kadra dam for 2013, 2022.

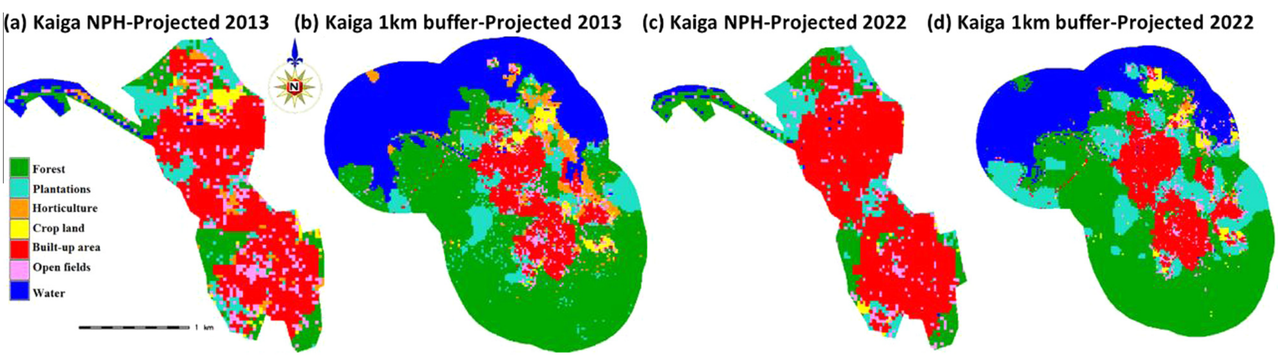

Figure 13 (a–d) projected land use of Kaiga NPH for 2013, 2022.

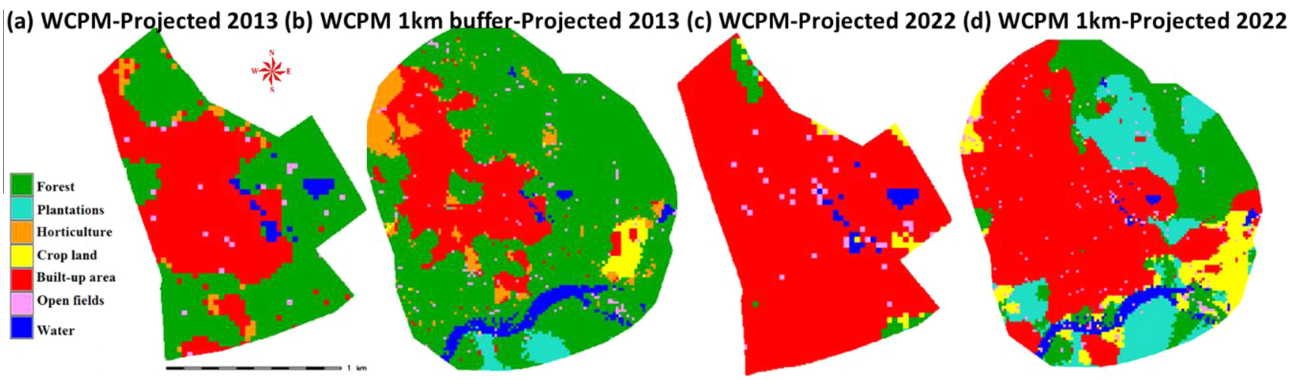

Figure 14 (a–d) Projected land use of WCPM. For 2013, 2022.

noticed in the buffer region due to construction of roads and infrastructure. There are intensive plantation activities observed in 2013 due to higher productivity. The evergreen forest has reached to 47.40% by 2013 at project location with 1 km buffer. The evergreen forests are periodically becoming semi evergreen to moist deciduous in vicinity due to other disturbance regimes. The project is within a 5 km radius of the Anshi-Dandeli Wildlife Sanctuary, and has affected the habitat of fauna such as Black Panther, bear, bison, elephants, deer and tiger.

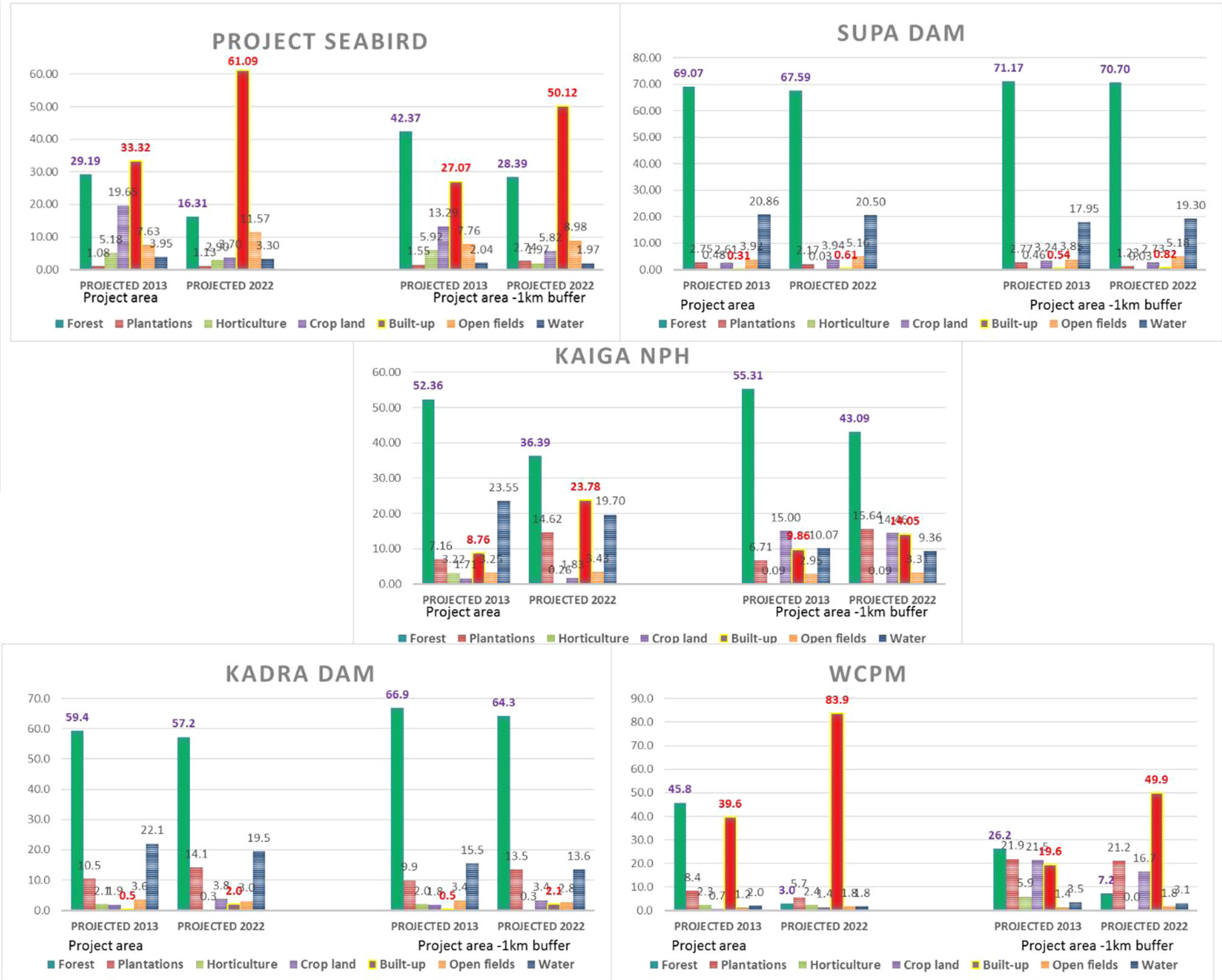

Figure 15 Projected land use of developmental projects and 1 km buffer region for 2013, 2022.

4.2.4. Kaiga Nuclear Power House (NPH)

Kaiga NPH generating station located at 14°51′55.16″N 74°26′22.71″E in Kaiga, on the branches of river Kali and the green environs of Western Ghats about 60 km east of the beach town of Karwar (http://www.npcil.nic.in). It was commissioned in March 2000 by the Nuclear Power Corporation limited (NPCIL) of India with annual generation of 2231 GWh. Pressurized Heavy Water Reactor (PHWR) is used for producing saturated steam to drive a double stage Turbo Generator. The natural Uranium bundles are used as fuel for the reactors. 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 have induced radiation doses exposing workers and general public to health hazards (Harrison et al., 2002; Ramana and Ashwin Kumar, 2010). Villagers of Bare, Malavalli, Vajralli and Kalache in Yellapur taluk have reported cancer cases in recent times. 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. Earlier studies have demonstrated adverse effects on aquatic diversity due to water discharge from power plant to Kali river (Zargar and Ghosh, 2006). LULC analyses of the region show (Fig. 8 and Table 6) 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%).

4.2.5. West Coast Paper Mills (WCPMs), Dandeli

WCPM was set up 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. 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 185,000 (MT) per annum (http://www.westcoastpaper.com). The present raw material consumption is 400,000 (MT) per annum of wood.

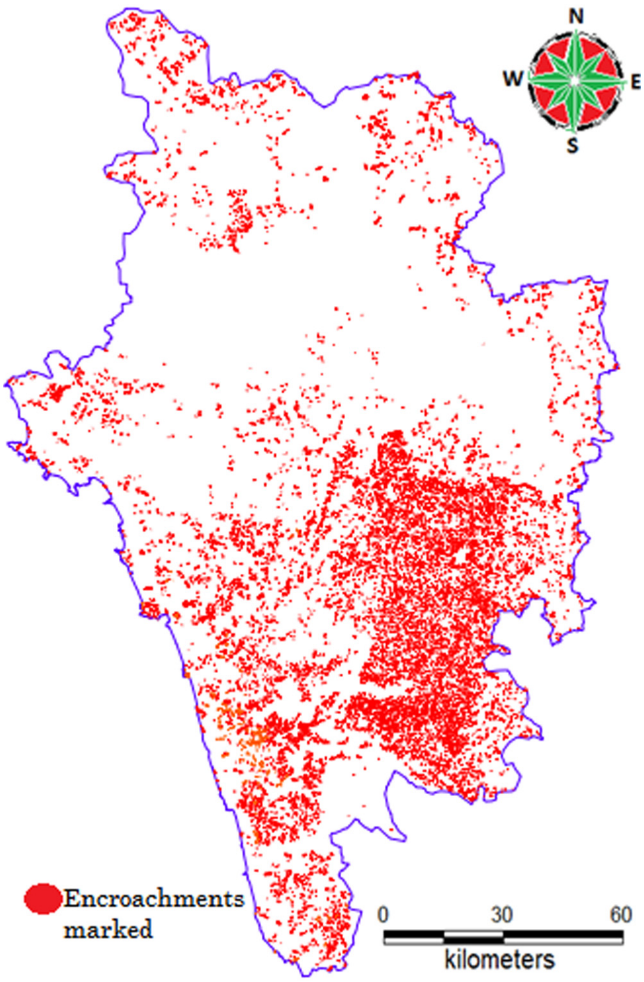

Figure 16 Area encroached in Uttar Kannada district.

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 ("poor man's timber") caused great hardships to basket and mat weavers and rural people. LULC analyses (Table 7 and Fig. 9) of the 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. The mill is promoting eucalyptus plantations in 7689.03 Ha located in nearby plant and villages of Dandeli, which is also evident in land use analysis. Untreated effluents discharged down to Kali river have affected the river, agricultural productivity and groundwater. This is visible as pulp floating in the water and the dark coloured liquid (Krishnamurthy and Bharti, 1994), which is also confirmed by Central Pollution Control Board (CPCB) in 2003 annual report (Ravi Prasad, 2004).

The dominant developmental thrust in the district has traditionally favored industrialization and exploitation of 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 have dramatically altered the structure of fragile ecosystems in the region with long lasting impacts.

4.3. Geo-visualization of land use transitions through fuzzy-AHP-CA

The land use data were classified into 7 categories as forest (evergreen to semi evergreen, moist deciduous forest, dry deciduous forest, scrub/grass lands), plantations (acacia/eucalyptus/hardwood plantations, teak/bamboo/softwood plantations), horticulture (coconut/areca nut/cashew nut plantations), agriculture, open space, built-up and water. Based on land use history during 2004–2012, visualization of land use of 2013 was done on different conditions (i.e. transition rules, iteration numbers). This was validated with the actual land use (based on classification of remote sensing data) through kappa indices. The change trajectories between the observed and simulated land-cover classes for the year 2013 had errors

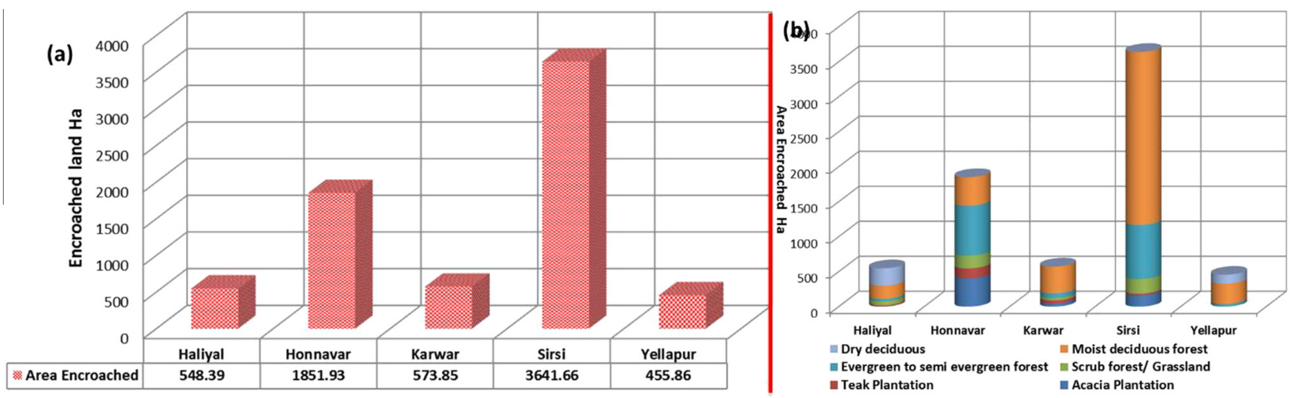

Figure 17 (a, b) Encroachments with respect to forest classes.

lower than 5%. Kno value is a better alternative than Kstandard for assessing the overall accuracy of the model (Pontius, 2000). The Kstandard value of 0.83 highlights the level of modelling accuracy. The model performed very well in its overall ability to predict land-use of 2013 (Kno = 0.88), and the Klocation value of 0.87 indicates that the model provides a reasonable representation of location. Also, visual interpretation of the results shows that there is an evident similarity between the real and simulated maps for the year 2013. The simulated land use Figs. 10–15 shows likely increase in built-up area and loss in forest cover across all the project regions. The process of urbanization is observed to be high in the areas near WCPM, project Sea Bird, Kaiga nuclear power house. The analysis highlighted the decline of forest cover with increase in monoculture plantations and urban areas. The natural vegetation is being replaced by the plantation activities in recent times also indicates their further growth in future years. The WCPM shows increase in built-up area from 39.6% (2013) to 83.9% (2022) due to the influence of Dandeli town located within the project region. The buffer region also had intensification of urban area from 19.6% to 49.9% by 2022. The Seabird region shows increase in urban area from 33.32% (2013) to 42.54% (2022) by losing the forest cover from 29.19% to 21.01% (2022). The moderate changes can be noted in the case of Supa and Kadra dam due to Anshi Dandeli Tiger reserve (ADTR) wild life sanctuary. The region surrounded by development projects witnessed changes within and in the neighbourhood due to rapid land conversion. The cropland intensification also witnessed nearby major reservoirs and huge lakes of Plainer regions. This necessitates comprehensive land use management focusing on restoration of ecosystems to mitigate the impacts further.

4.4. The encroachments as a driver of forest degradation

The forest encroachment is a major driver of forest fragmentation and LULC dynamics. Uttara Kannada district has been experiencing continuous unauthorized land conversions due to fertile forest soil and water availability for cultivation, settlement, construction, grazing cattle and other human activities. The factors responsible are the inducement of market based economic forces, etc. Uttara Kannada district (Fig. 16) forest encroachment map shows an area of 7071.69 Ha is diverted for illegal usages ranging from 1Ha to greater than 10 Ha. Division wise area loss due to encroachments (Fig. 17 (a)) depicts Sirsi and Honnavar divisions with major land encroachments for agriculture, built-up and marked based economic crop cultivation. Serious threats faced swamps in Sirsi, Honnavar divisions, as water drains are diverted to horticulture gardens. The land conversion to built-up environs is common in and around Sirsi, Honnavar, Bhatkal, Kumta town regions. The Haliyal, Yellapur forest divisions are getting affected due to land conversion for agriculture activities. In certain pockets, the existing land owners are converting adjacent forests by clearing and burning. The pattern of illegal forest resource exploitation is found to be the same in all the divisions.

Major loss was observed in moist deciduous forest cover (3747.89 Ha) followed by evergreen to semi evergreen (1629.16 Ha) (Fig. 17(b) and Table 8). Fig. 18(a) depicts major encroachments in deciduous forest types in eastern side of Haliyal division. Honnavar division (Fig. 18(b)) shows 402.07 Ha of lost in Acacia plantation, because these regions are spatially located very near to agriculture regions. The loss of evergreen forest and swampy areas is due to conversion of areca nut/coconut plantations for getting continuous water supply. Moist deciduous forests (383.71 Ha) mainly cleared for colonization, other associated developments in Karwar division (Fig. 18(c)). The Sirsi division (Fig. 18(d)) has lost major tracts of forests in all categories. The clearing of Betta lands (forest land assigned for leaf manure collection) for other uses such as commercial crop plantations, grazing, poultry etc. are observed in Sirsi division. Yellapura division (Fig. 18(e)) represents a greater loss in moist deciduous forest type comprising 290.07 Ha because these types of forests exist in moderate elevations and are easier to convert to other land use forms. Encroachments in wild life division are not marked due to unavailability of forest administrative boundaries and administrative restrictions.

Verification was done by overlying original reserve forest boundaries (obtained from Karnataka forest department), revenue department records and field data. Field investigations were done to assess the encroachments patterns, including compilation of information such as crop grown, trees removal, period of cultivation and other human induced drivers. The forest land encroachment is the major threat to biodiversity, changes in vegetation type (composition and abundance), destruction of ecosystems/habitats, species extinction, curtailment of natural regeneration, reduction in the total economic value of the forests, increases forest management cost.

Table 8 Area of forest land encroached in different forest categories of five divisions (Ha).

Category	Haliyal	Honnavar	Karwar	Sirsi	Yellapura	Total
Evergreen to semi evergreen forest	31.39	714.22	68.09	**772.48**	33.98	**1620.16**
Moist deciduous forest	190.45	408.23	383.71	**2475.43**	290.07	**3747.89**
Scrub forest/grassland	60.28	182.53	32.18	**208.61**	0.00	483.60
Dry deciduous forest	247.55	0.00	0.00	0.00	128.30	375.85
Acacia plantation	4.59	402.06	45.44	159.52	3.51	615.13
Teak plantation	14.12	144.89	44.43	25.62	0.00	229.06
Total	**548.39**	**1851.93**	**573.85**	**3641.66**	**455.86**	**7071.69**

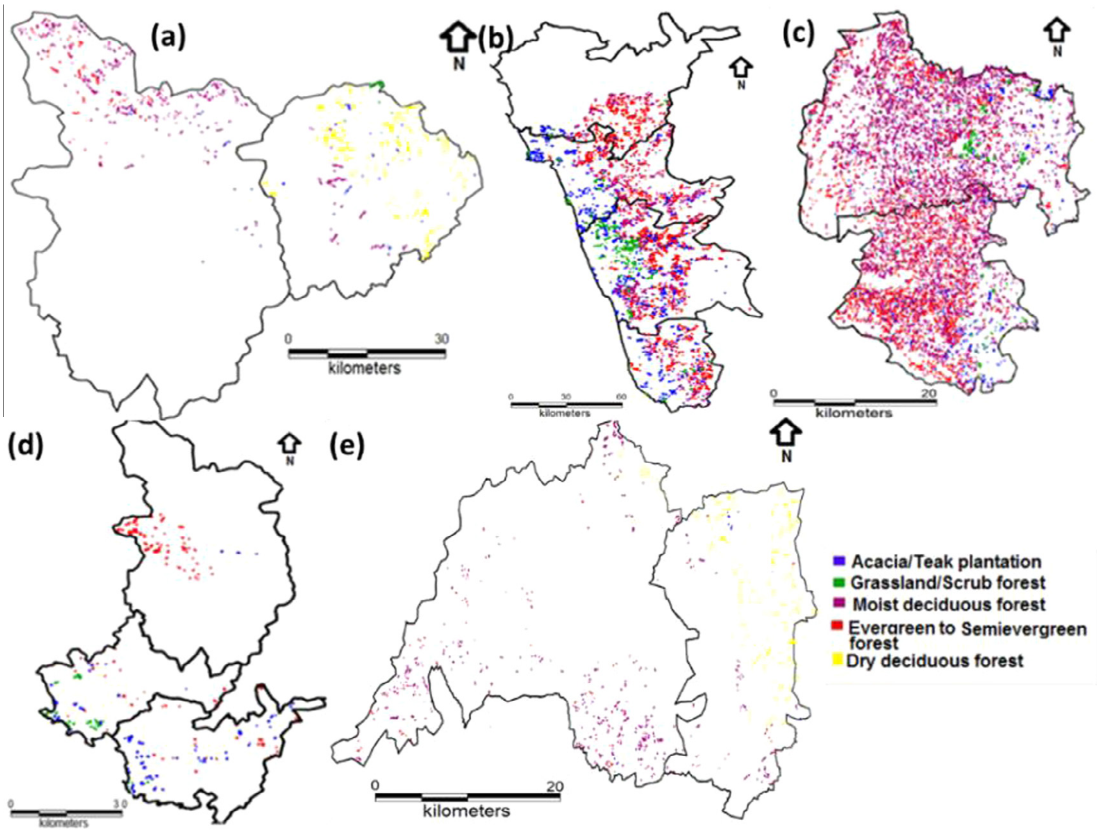

Figure 18 (a–e) Encroachments across all forest divisions.

Effective long-term monitoring (of biological, habitat, and hydrological effects) and mapping of natural resources would help in formulating strategies to mitigate the impact of developmental projects (ex. installation of silt traps or silt screens, waste treatment etc.). Involvement of all stakeholders in the forest management would help in arresting illegal practices of encroachment. Involvement of local forest dwelling communities (tribal societies, self-help groups of women etc.) in forest nurseries activities, afforestation, extraction of non-timber forest products (NTFP) would help in the support of local livelihood and protection of forests. Energy efficient stoves, biogas, solar devices, use of agricultural wastes etc. are to be promoted to minimize the demand of fuel in rural areas. At the same time the provision of adequate fuel wood/or other alternative fuels to cottage industries run by potters, lime makers etc., would help in arresting forest degradation Raising mono cultural/mixed exotic tree plantations has to be site specific such as barren lands, near to pulp based industries. Monitoring involving all stakeholders would ensure post-project environmental monitoring and auditing the compliance and adherence of the environmental norms.

5. Conclusion

Development considering social, ecological, psychological and political processes aids in of improving the quality of human lives with economic advancement. Burgeoning human population, lopsided economic policies at local and global scales have been imposing pressures on forest and other natural resources affecting people's livelihood. The dominant unsustainable developmental thrust in Uttara Kannada region during the last six decades offered essential traditionally protected resources of forest, land, and water at free of cost leading to habitat destruction in ecologically sensitive region, which are long-term and unsustainable. The land use analysis shows major loss of evergreen to semi evergreen forests from 67.73% to 32.08% by 2013. The WCPM shows increase in built-up area from 39.6% (2013) to 83.9% (2022) due to the influence of Dandeli town located within the project region. The forest area encroachment of 7071.69 Ha not only caused the habitat loss of species but also affected people's livelihood due to the devastating effects of forest and habitat fragmentation, alterations in hydrologic regime, etc. Maximum encroachments of forest lands are in Sirsi, Honnavar forest divisions i.e., 3641.66 Ha and 1851.93 Ha respectively. Unplanned developmental activities have given impetus to deforestation resulting in global problems (such as global warming, climate changes, etc.). Other cascaded effects are erosion of productive top soil, enhanced instances of human-animal conflicts, forest fires, declined sustained flow of water in streams. This emphasizes the need for ecosystem approach in the implementation of developmental projects through environmentally sound development. Mitigation measures for ecological impacts are to be considered throughout the project period i.e. planning, designing, construction and operation phase. Land use change monitoring, visualization and forecasting the growth pattern presented here will help the regional administrators to plan future developmental activities more sustainably and cautiously. Ecologically sound developmental projects ensure people's livelihood apart from aiding in the economic development while ensuring sustainability of natural resources and intergeneration equity.

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Annexure

The extent of forest areas released for other purposes from 1956.

S. No.	Particulars of diversion	Area (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 and area actually in operation	1591.250
9	Released to House sites to Houseless (1972–1979)	366.000
10	Rehabilitation of Tibetans displaced riots of Sharavathi, Ghataprabha and Malaprabha, Gowli families etc.	4548.170
11	Area under submersion and other projects.	14602.000
	• Kali hydroelectric project	300.000
	• Bedti project (for colony)	303.365
	• Other irrigation tanks etc.	
12	Released to KSFIC for Napier Hybrid grass cultivation (Sirsi Division)	441.450
13	Released to KAMCO (Dairy and 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 (Phase-I)	2259.000
23	Rehabilitation of Sea Bird out seas	643.720
24	Area released for non-agriculture and other purposes	394.870
25	Konkan Railway project	272.140
26	Area released for improvement and widening of Ankola-Hubli Road	49.431
27	Area released for rehabilitation of displaced persons of KHEP and Kaiga Project	316.410
28	Area released to regularize 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
30	Diversion of forest land for NH-66 (NH-17) (F. No. 8-78/2013-FC. 93.70–283.30 km) in favour of the project Director, National Highways Authority of India	147.04
31	Irrigation tank at Attiveri, Sanavalli and Durgadahalla	60.27
32	Renewal forest land in Dandeli village in favour of M/s. West Coast Paper Mills	80.00
33	Forest land diverted for Project Sea Bird Naval Air Station	246.46
34	Project Sea Bird – Phase II	1000.00
35	Stone Quarrying	7.01
Total		64355.26

*Source. Forest working plan of Uttara Kannada district (Kanara circle (year 2012–13)).

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