ASSESSING FOREST TRANSITION BEYOND THE METROPOLITAN FRINGE OF BANGLORE USING GEOSPATIAL TOOLS

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Abstract

Over the years, forestland around Bangalore City, which provides ecological, economical and social benefits to the society, is under transition. This study on forest transition from 2001 to 2011 using Remote sensing and Geographic Information System (GIS) revealed an increase in built up by 2% and decrease in cropland by -0.2 % resulting 2.57% forest transition around Bangalore city. Bangalore Rural and the adjacent Ramanagara district show highest builtup of 50.8Ha and cropland area 241.5Ha respectively. Whereas the combined forest transition is seen more in Bangalore rural district (4.05%) followed by Bangalore Urban District (3.10%). 1.21% of the forest transition is seen in vegetated forest area which includes more of forest plantation. The forest-type wise transition is seen more in Eucalyptus forest type (0.49%) followed by mixed forest plantation (0.47%) and scrub forest (0.21%). In a scenario where in urban expansion takes place at an unregulated pace invading pressure on forest, it becomes important to execute strict landuse and forest policies avoiding further transition in the forest area.
Key words: Bangalore, Forest, Builtup, Cropland, Classification, Transition, Forest type.

Introduction

The total forest cover of India is 6,92,027 km² accounting for 21.05 % of the total geographic area of the country [1]. Forests are the large green spaces which serve many ecosystem services at a higher level and provide habitat for wildlife [2 & 3]. Forests are also heavily relied upon for fuel wood, fodder, non timber forest products (NTFP's), food and medicine by rural and tribal communities; in addition it also provides income to the State [4].

Forest's have been declining due to increased population growth, industrialization and urbanization [5]. The population growth from the cities into suburban and peri-urban areas have either permanently replaced the forest by other land uses or degraded it to varying degrees. The unsustainable forestry practices combined with forest fragmentation, monoculture plantations of exotics [6] have resulted in loss or change in forest composition and native biodiversity. The forest change studies in Western Ghat area reveal agriculture expansion as the main cause for forest transition [7].

Bangalore the sixth largest city in India, grew in population by 35.09% in 1991-2001 to 47.18% in 2001- 2011 [8]. The population growth has resulted in the expansion of city from 220 km² in 1972 to 800 km² in 2007, which has lead to the decline in green belt area around the city by 30.5% [9]. The studies on urban expansion reveal an overall decline in vegetation for the greater Bangalore area [10], [11], [12] but not for defined landuse category within vegetation. Through this study we intend to assess the transition particularly in the forest area beyond the metropolitan fringe of Bangalore city using geospatial tools.

Study Area
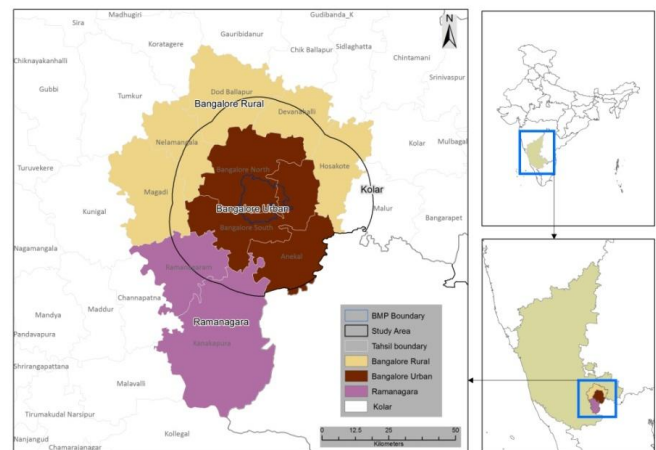
Figure 1: Study area Map

The study area (Figure 1) includes the forests that fall within and 20 km beyond the Greater Bangalore (Bruhath Bangalore Mahanagara Palike (BBMP)) area. Bangalore urban, Bangalore rural, Ramanagara and Kolar district accounts for an area of 377914.5 ha including entire Banneraghatta National park and Savandurga state forest boundary. The study area lies between longitude of 12° 34' to 13° 21' N and latitude of 77° 16' to 77° 67' E. The temperature ranges from 15^0c to 36^0c with the rainfall varying from 800 to 1000 mm.

The major streams flowing in the study area are Arkavathi originating from Nandi Hills and Suvarnamukhi originating at Bannerghatta National Park joins Vrishabhvathi, with its origins from the centre of Bangalore city.

Out of 22779 ha of forest area coming in the study area 5580 ha of forest falls in Bangalore urban, 3855 ha in Bangalore Rural and 12487 ha, 857 ha in Ramanagara and Kolar district respectively. Except Banneraghatta National Park, which falls in both Bangalore Urban and Ramanagara District all other forests are categorized as Reserve forests. The forests are of scrub and dry deciduous type with thorny undergrowth [13]. The major species found in the area are *Albizzia amara, Acacia nilotica, Anogeissus latifolia, Albizzia lebbek, Albizzia odoratissima, Pterocarpus marsupium, Terminalia alata, Terminalia paniculata, Terminalia bellerica, Terminalia chebula, Zizyphus jujube.* The major NTFP's in the forest are *Tamarindus indica, Feronia limosa, Emblica officinalis* etc. The vegetation does not attain any great size in many of the places owing to scanty rainfall and damages caused by biotic factors such as repeated hacking, fire and browsing [14], [15].

Methodology

Study area map was developed using the Survey of India (SOI) topo sheets of 57g/7, 57g/11, 57g/12, 57g/16, 57h/5, 57h/6, 57h/9, 57h/11, 57h/12, 57h/13 and 57h/14 of 1:50.000 scale by georeferencing for further analysis. The forest boundaries were delineated using the SOI toposheets. Cloud free multi-spectral images of Landsat 7 ETM+ and Landsat 5 TM acquired on 10th November 2011 and 29th October 2001 were selected for the study. The 2011 image had Scan Line error; with the aid of Frame and Fill software developed by *National Aeronautics and Space Administration (NASA)*, it was corrected with another image from January 2009.

Image classification for 2001 and 2011 was done for built up and cropland categories considering them as the main contributor for forest transition. The classification was done using supervised classification. A set of homogenous pixels of land cover were selected and algorithm was trained to classify the data based on such 'training sets'. Size, shape, location, number of pixels, number of training sets for a particular class, placement, and uniformity were some of the characteristics considered while assigning the training sets. As many training sets as possible were thus selected. The algorithm groups similarly occurring pixels based on feature signatures from the 'training sets' are selected and assigned to a particular class. Some small errors of misclassification were rectified by manually re-coding the classes after comparison with Google Earth imagery of the same date, wherever it was available. The final results of the classified image data were processed using ERDAS (version 9.2) and ARC GIS (version 10).

Forest type loss assessment was done mainly using the Karnataka Forest Department's forest type classification data. The satellite imageries with Survey of India topo maps, French Institute forest maps and forest department working plan maps were also utilized followed by ground verification. All these information were converted into digital database using GIS technique for easy reference. Field visits and data collection confirmed the forest transitions.

Results and discussion

Forest transition:

The image classification (Figure 2) results for 2001 and 2011 reveal increased in builtup area from 25.6 Ha to 76.3 Ha, showing 2% change, whereas the cropland area shows a decrease from 1483.7 Ha to 508.2 Ha with -0.7% change (Table 1). The forest transition due to built up and cropland change is 0.34% and 2.23% respectively. The overall forest transition across the years is 2.57%.

Figure 2: Forest transition map for the year 2001-2011
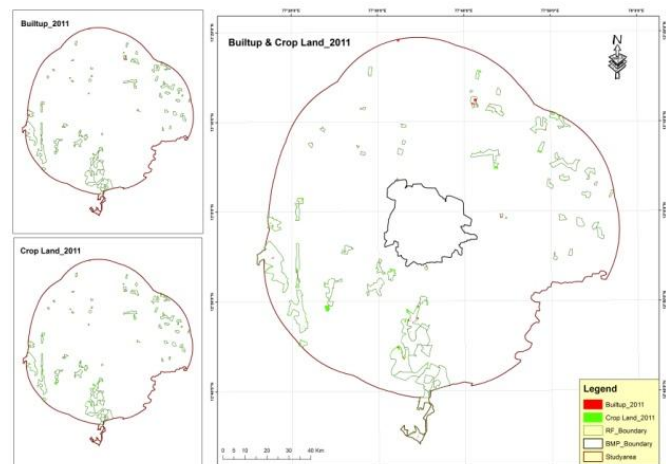
The district wise analysis (Table 2) shows major forest transition of 1.32% in the Bangalore Rural area compared to other districts due to builtup change. The change in the district is in Devanahalli region (Yartiganahalli Reserve forest), where the forestland has been used for establishing the International airport. In both Bangalore rural and urban district the built up change is more in 2011. There is Zero builtup in Kolar district. The overall forest transition due to builtup is 0.34%. Ramanagara District shows major cropland in the Basvantara state forest area and also the major decline in cropland area from 2001 to 2011 is also seen in the same district. With the ground verification and interaction with people it revealed that the proximity of Bangalore city has made rural people shift their livelihoods from agriculture to other works like labour, private factories etc. Even some of

the forest villages (not in revenue records) have stopped cultivating because of increased human wildlife conflict across the years, especially in and around the Banneraghatta National Park area. Here people cannot claim compensation since they don't have rights on the land from revenue department; once they get the rights they would start cultivating again. Now the lands have been left fallow.

The forest transition due to cropland is seen more in Bangalore Urban District (2.85%) followed by Bangalore rural (2.73%) and Ramanagara District (1.93%). The forest transition due to cropland change is 2.23%. The builtup and cropland change together contributed to 2.57% transition in the forest area. The combined forest transition from builtup and cropland is seen more in Bangalore Rural (4.05%) and Bangalore Urban Districts (3.10%) followed by Ramanagara (2.02 %) and Kolar (0.30 %) revealing gradual increase of pressure on forest from urban expansion. Human influenced ecosystem transition is common in an urbanizing landscape [16], which account for 2% of the Earth's surface [17]. The urbanizing landscapes have disrupted the preexisting land uses and altered the larger-scale habitat attributes such as the composition of native vegetation in the landscape [18],[19],[20],[21],[22].

Transition in Forest types

The forest transition from builtup and cropland change has resulted in altering the species composition and forest types. The transition in forest type due to builtup and cropland change was studied by classifying the entire forest area in to vegetated forest area and other forest area. Vegetated forest area (Figure 3) consists of Dry deciduous forest, Scrub forest, Grass land, *Acacia* plantation, *Eucalyptus* plantation and mixed forest plantation. The other forest area includes previously converted builtup & cropland, agricultural plantation, abandoned land/ forest blank, water bodies, waterlogged areas, mining area and rock.

The entire forest area has 18331 (80%) of Vegetated forest area and 4448 Ha (20%) of other forest area (Table 3). In 2011 classification out of 76.32 Ha builtup change 53.82 Ha (73.1%) is seen in Vegetated forest area and 22.5 Ha (26.9%) in the other forest area. Similarly out of 508.21Ha of crop land change 222.48 Ha (36.8%) is in the Vegetated forest area and 285.74 Ha (63.2%) in the other forest area. This reveals that out of 2.57% forest transition 1.21% of transition as happened in the vegetated area where as 1.35% in the other forest area

Table 1: Forest transition for the year 2001-2011

Year	Total Forest area (Ha)	Builtup (Ha)	Builtup Change 2001-2011		Forest transition (%)	Cropland (Ha)	Cropland Change 2001-2011		Forest transition (%)	Total change (Ha)	Total forest transition (%)
			(Ha)	(%)			(Ha)	(%)			
2001	22779	25.63	50.7	2.0	0.34	1483.67	-975.5	-0.7	2.23	1509.29	2.57
2011		76.32				508.21				584.54	

Table 2: District wise Builtup and cropland change for 2001-2011

| District	Forest area (Ha)	Builtup 2001 (Ha)	Builtup 2011 (Ha)	Forest transition (%)	Cropland 2001 (Ha)	Cropland 2011 (Ha)	Forest transition (%)	Total Forest transition (%)
Bangalore Urban District	5580	3.6	14.4	0.26	350.0	158.8	2.85	3.10
Bangalore Rural District	3855	12.1	50.8	1.32	368.9	105.4	2.73	4.05
Kolar Distrct	857	0.0	0.0	0.00	2.5	2.5	0.30	0.30
Ramanagara District	12487	9.9	11.1	0.09	762.2	241.5	1.93	2.02
Total	22779	25.6	76.3	0.34	1483.7	508.2	2.23	2.57
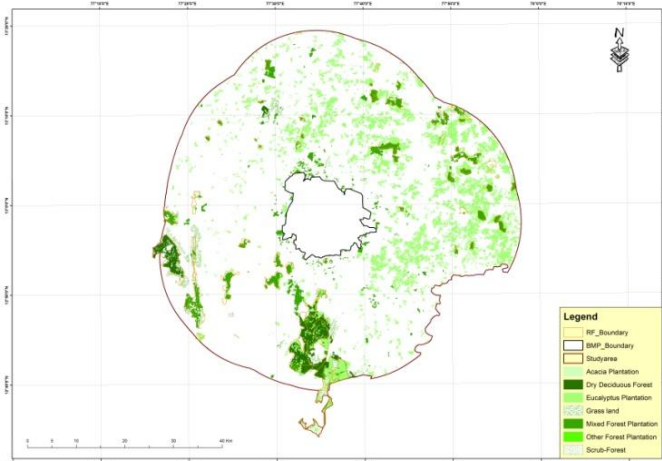
Figure 3: Forest type map for the study area (Karnataka Forest Department, 2007)

Forest plantation dominates the 18331Ha forest area followed by Dry deciduous and scrub forest. Vegetated forest area constitutes 77% of plantation of which 56% is Eucalyptus plantation, 42% is mixed forest and 2% is Acacia plantation. The native forest is only 23% with 45% Dry deciduous, 39% Scrub forest and 16% of Grassland area (Table 4).

Majority of the forest type-wise transition due to builtup is seen in the mixed forest plantation, whereas the transition due to cropland seen is 0.45 % in Eucalyptus plantation followed by 0.30% and 0.20% in mixed forest plantation and scrub forest respectively. The Forest area in Bangalore Urban, Rural, Kolar Districts majorly constitutes only plantation. The dry deciduous and scrub forest is majorly seen in Bannerghatta National Park and Savandurga state forest of Ramanagara District (Table 5).

Table 3: Forest transition for the year 2011

	Area (Ha)	%	Builtup 2011 (Ha)	%	Cropland 2011 (Ha)	%	Combined transition (Ha)	%
Vegetated forest area	18331	80	53.82	0.24	222.48	0.98	276.30	1.21
Other forest area	4448	20	22.5	0.10	285.74	1.25	308.24	1.35
Total forest area	22779	100	76.32	0.34	508.21	2.23	584.54	2.57

Table 4: Forest type - wise transition for the year 2011

Forest Type	Forest area (Ha)	%	Builtup 2011 (Ha)	Transition %	Cropland 2011 (Ha)	Transition %	Combined transition (Ha)	Combined transition (%)
Acacia Plantation	255	1.1	0.39	0.00	2.10	0.01	2.49	0.01
Dry Deciduous Forest	1824	8.0	0.98	0.00	2.09	0.01	3.08	0.01
Eucalyptus Plantation	7970	35.0	10.89	0.05	101.77	0.45	112.65	0.49
Grass land	678	3.0	0.00	0.00	3.22	0.01	3.22	0.01
Mixed Forest Plantation	6030	26.5	39.61	0.17	67.53	0.30	107.14	0.47
Scrub-Forest	1574	6.9	1.95	0.01	45.76	0.20	47.72	0.21
Other forest area	4448	19.5	22.50	0.10	285.74	1.25	308.24	1.35
Total	22779	100.0	76.32	0.34	508.21	2.23	584.54	2.57

Table 5: District wise Forest type-wise transition for the year 2001-2011

District	Forest type	Geographic area (Ha)	Forest area (Ha)	Builtup 2001 (Ha)	Builtup 2011 (Ha)	Cropland 2001 (Ha)	Cropland 2011 (Ha)
Bangalore Urban District	Acacia Plantation	194373	71	0.00	0.05	0.00	0.00
	Dry Deciduous Forest		86	0.00	0.00	0.10	0.10
	Eucalyptus Plantation		2434	1.13	4.93	76.18	30.27
	Grass land		11	0.00	0.00	0.00	0.00
	Mixed Forest Planta-tion		1760	0.46	5.43	96.16	38.79
	Scrub Forest		241	0.00	0.00	9.28	4.92
	Non forest area		977	2.04	3.97	168.32	84.73
	Total forest area		5580	3.64	14.38	350.03	158.81
Bangalore Rural District	Acacia Plantation	109331	150	0.00	0.00	0.00	0.00
	Dry Deciduous Forest		0	0.00	0.00	0.00	0.00
	Eucalyptus Plantation		370	0.37	0.47	47.80	26.04
	Grass land		0	0.00	0.00	0.00	0.00
	Mixed Forest Planta-tion		1816	0.00	33.82	27.23	12.76
	Scrub Forest		260	0.00	1.86	62.03	15.47
	Non forest area		1260	11.71	14.67	231.80	51.08
	Total forest area		3855	12.08	50.82	368.85	105.35
Kolar Distrct	Acacia Plantation	19918	11	0.00	0.00	0.00	0.00
	Dry Deciduous Forest		0	0.00	0.00	0.00	0.00
	Eucalyptus Plantation		78	0.00	0.00	0.64	0.64
	Grass land		0	0.00	0.00	0.00	0.00
	Mixed Forest Planta-tion		681	0.00	0.00	1.71	1.71
	Scrub Forest		0	0.00	0.00	0.00	0.00
	Non forest area		87	0.00	0.00	0.18	0.18
	Total forest area		857	0.00	0.00	2.53	2.53
Ramanagara District	Acacia Plantation	101412	22	0.00	0.35	2.79	2.10
	Dry Deciduous Forest		1739	0.46	0.98	2.16	1.99
	Eucalyptus Plantation		5076	0.63	5.48	116.63	44.82
	Grass land		667	0.00	0.00	4.76	3.22
	Mixed Forest Planta-tion		1763	0.25	0.35	66.73	14.27
	Scrub Forest		1073	0.02	0.09	121.94	25.37
	Non forest area		2148	8.55	3.87	447.25	149.75
	Total forest area		12487	9.91	11.12	762.25	241.52

With the expansion of city limit and shrinking of green belt around Bangalore city, the forest patches are becoming more vulnerable to change. The expansion has lead to the extinction and removal of majority of native species [23], [24], [25], [26] and it has replaced natural habitats by weedy flora [27], [28].

The urbanization has even changed the vegetation by increasing exotic plant cover [29] and reducing native plant diversity in patches [25], [30], in turn reducing the biological uniqueness of local ecosystems [31]. The same situation exists even with other taxa [32] other than plants.

Hence it becomes important to conserve the forest patches from transition especially the forests rich in native biota. These forest patches provide habitat to many medicinal

herbs and wildlife species that might vanish unknowingly if the transition of the forest continues. Environmentally sound urban planning [33] and forest conservation policies should be enforced to conserve these remnant forest patches. The forest department should restore the degraded forest patches with native species other than promoting fast growing exotic species. Government should initiate awareness building programs among the people living adjacent to the forest on restoring the abandoned cropland with fast growing native species instead of fast growing exotic species.

Acknowledgement

Reference

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