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Study of land use/land cover dynamics through classification algorithms for Harangi catchment area, Karnataka State, INDIA

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Abstract

Industrialization and urbanization are mainly responsible for the conversion of significant amount of vegetation rich lands such as forests and wetlands into agricultural lands and human settlements. This land use and land cover change in turn has influence on various hydrological processes such as soil erosion rate, sediment deposition in rivers and dams and also stream flow pattern in a catchment. Qualitative and quantitative analysis of Land use and Land cover (LU/LC) changes is necessary to assess the impacts of change in the pattern of natural vegetation on the earth's environment. Satellite images can provide useful information regarding spatial and temporal variation of LU/LC in an area. The purpose of this paper is to analyse the dynamics of LU/LC changes using LISS-III data for the years 2007, 2010 and 2013 of Harangi catchment, Coorg District, Karnataka State, India. Also, study compares three classification techniques such as Parallelepiped Algorithm, Minimum Distance to Mean Algorithm and Maximum Likelihood Algorithm based on the value of overall accuracy and kappa coefficient to check the reliability of the methods in classifying images. The overall accuracy and kappa coefficient obtained by using Parellelepiped, Minimum distance to mean and Maximum likelihood algorithm for the year 2013 are 81.47% & 0.71, 78.67 & 0.68 and 89.36% & 0.81 respectively. Based on these results, it can be concluded that, among all the three techniques, the Maximum Likelihood Algorithm gave higher accuracy with high kappa coefficient and Minimum Distance to Mean Algorithm gave lower accuracy. The LU/LC change detection results between years 2007 and 2013 indicated a drastic change in forest area, plantation and waste land among all other classes. The forest area decreased dramatically from 183.12 sq. km to 131.02 sq. km. Also, fallow land and water body are decreased from 68.89 sq. km to 42.63 sq. km and 6.71 sq. km to 3.82 sq. km respectively. In contrast, the plantation and waterlogged area are observed to have an increasing trend of about 56.07 sq. km to 146.55 sq. km and 17.99 sq. km to 23.81 sq. km. The urban area has been increased from 13.06 sq. km to 13.72 sq. km. The urbanization and agricultural activities are the major reasons for increase in plantation and urban area in an expense of decrease in forest area.

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Keywords: land use and land cover; Maximum Likelihood Algorithm; catchment; satellite images

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1. Introduction

Land is the most important natural resource, which comprises of soil, water and the associated flora and fauna, thus involving the total ecosystem. As a result of economic development in terms of increase in industrialization, urbanization and forest to agricultural land conversions, the land resources have exploited to a greater extent leading to land degradation (Ganasri et al. 2013). The Land Use and Land Cover (LU/LC) change pattern is one of the important parameters which depict this change (Jayakumar and Arockiasamy 2003). Land use can be defined as the use of land by humans, usually with emphasis on the functional role of land in economic activities. In contrast, land cover, in its narrowest sense, often designates only the vegetation that is either natural or man-made on the earth's surface. Land cover is the observed bio-physical features on the earth's surface (Lillesand et al. 2004). Knowledge of the distribution of land use and land cover is essential for planning and management activities (Chauhan and Nayak 2005; Papastergiadou et al. 2007; Lin et al. 2009). Land use patterns reflect the character of a society's interaction with its physical environment, a fact that becomes obvious when it is possible to see different economic and social systems occupying the similar environments (Verburg et al. 1999, 2004, 2006; Liu et al. 2009; Changhong et al. 2011). LU/LC changes are major issues of global environment change. Many a civilization has perished in the past when its people misused and over exploited the land and interfered with the environment (Miao et al. 2011).

The vegetation cover is one of the important factors which partitions the rainfall into various hydrologic components such as surface runoff, base flow, ground water flow, evapotranspiration etc., Therefore, the land use change pattern studies plays a paramount role in watershed management and hydrological modelling (Lin et al. 2008; Wijesekara et al. 2012; Warburton et al. 2012). The land use change is a dynamic process, as it involves rapid spatial and temporal pattern change (Veldkamp et al. 2001; Huigen 2004; Gumageri et al. 2011; Ganasri and Dwarakish 2014). The analysis of LU/LC change pattern and identifying its causes are recognized as a current research frontier in both landscape and ecosystem studies (Verburg et al. 1999, 2006; Niehoff et al. 2002; Campbell et al. 2005; YueChen and ChunYang 2008; Arunachalam et al. 2011). An accurate and up-to-date land cover change information is necessary to understand and assess the environmental consequences of such changes (Giri et al. 2005).The satellite remote sensing data helps in quantification of LU/LC patterns and determines their changes with time (Shamsudheen et al. 2005; Binh et al. 2005; Dewan and Yamaguchi 2009; Vanum and Hadgu 2012; Zheng et al. 2012). The Geographic Information System is used as an effective tool for managing secondary data necessary to analyse and document the spatial changes (Prakasam 2010; Rao et al. 2011). Over the years, remote sensing has been used for land use/land cover mapping in different parts of India (Gautam and Narayanan, 1983; Kachhwala 1985; Brahabhatt et al., 2000; Chilar 2000; Nagamani and Ramachandran 2003). In recent times, the land use change models are used as tools to support the analysis of the causes and consequences of land use change in order to better understand the functioning of the land use system and to support land use planning and policy (Lin et al. 2009; Wang et al. 2011; Yu et al. 2011; Zheng et al. 2012). Furthermore, models can support the exploration of future land use changes under different scenarios (Verburg et al. 2004). Modeling land-use change as a function of biophysical and socio-economic driving factors is one technique for unravelling the complex relationships in land-use change systems and provides insights into the extent and location of land-use change (Zheng et al. 2012).

The present study has been taken up with a view of understanding the changes in land use/land cover in Harangi catchment, Kodagu district during the years 2007, 2010 and 2013. This area is known for its extensive plantation activity in recent times. It is believed that aggressive exploitation of the land in this area might have affected the land use pattern. The major objectives of the study are: a) to classify the LISS-III satellite image to analyse the dynamics of land use change and to identify the reasons for the land use changes and b) to compare the accuracy of different classification algorithms in classifying satellite images.

2. Study Area

Harangi river is a major tributary to river Cauvery and has its origin in Pushpagiri Hills, Coorg District situated on its western part and separated from Bhagamandala, the source of Cauvery. The study area geographically lies between 75^0 38′ E and 75^0 55′ E longitude and 12^0 24′ N and 12^0 40′ N latitude, with the catchment area of 417.54 km^2 (Figure 1). Harangi catchment is blessed with bountiful rainfall in the upper reaches and has important tributaries like Madapura and Hotti hole. Heavy rainfall, steep valleys and absence of any storage reservoirs has led to the practice of irrigation in patches in some valleys mostly depending on rains during Southwest monsoon. The climate is characterized by high humidity and mild temperature. The temperature generally varies from 10^0 C to 12.8^0 C in December to about 32^0 C to 35^0 C in the summer months of April and May. The highest and lowest reliefs are formed at 1525 m and 884 m respectively above the mean sea level and the mean annual rainfall is 2332.59 mm.

3. Methodology

The study involves the LU/LC change analysis in Harangi catchment by considering different land use classes. The two major tools used for getting land use/land cover information from satellite imagery are visual interpretation and digital image processing. Visual interpretation uses various scene elements like size, shape, tone, texture and association etc., to identify and delineate objects. In contrast, Digital Image Classification is the process of assigning pixels to respective classes. Usually each pixel is treated as an individual unit composed of values in several spectral bands (Lillisand et al. 2004).

The study made use of ERDAS IMAGINE 9.1, a image processing software to accomplish the objectives. The overall methodology adopted for the present study is as shown in Fig. 2. The base map (Fig. 1) of the study area was delineated from Survey of India (SOI) toposheet of 1:50000 scale using ArcGIS 9.3 software. The satellite images of IRS-P6, LISS III multispectral sensor were obtained from National Remote Sensing Centre (NRSC), Hyderabad, India for the years 2007, 2010 and 2013. The satellite images were geo-referenced with respect to coordinate system of toposheet by using image-to-image transformation. Further, the satellite images of the study area were extracted for the above mentioned years. The seven LU/LC classes considered during classification of images were urban area, forest area, water body, water logged area, plantation, fallow land and waste land. The classification was done by using three different methods such as, the Maximum Likelihood algorithm, Minimum Distance to Mean algorithm and Parallelepiped algorithm (Gao 2009).

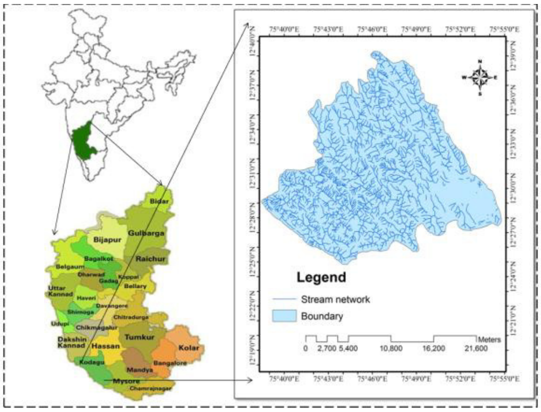

Fig. 1. Location map of Harangi catchment

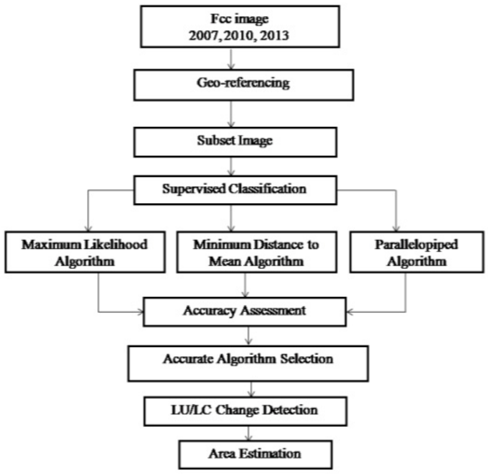

Fig. 2. The flow chart of methodology for detection of LU/LC change

3.1. *Maximum Likelihood Algorithm*

The maximum likelihood method takes advantage of the probability of a pixel being a member of an information class in its decision making. This algorithm relies on the second-order statistics of the Gaussian probability density function model for each class. The basic discriminate function for pixel X is

$$X \in C_j \text{ if } p(C_j/X) = \max[p(C_1/X), p(C_2/X), \ldots, p(C_m/X)] \quad (1)$$

Where max $[p(C_1/X), p(C_2/X), \ldots, p(C_m/X)]$ is a function that returns the largest probability among those inside the bracket.

3.2. Minimum Distance to Mean Algorithm

The decision rule in the minimum-distance-to-mean algorithm is based on the relativity among the spectral distances between the pixel in question and the center (mean) of all information classes that have been derived from the training samples. The decision rule behind this classifier takes the following form:

$$\text{Pixel X} \in C_j \text{ if } d(C_j) = \min[d(C_1), d(C_2), ..., d(C_m)] \quad (2)$$

Where min $[d(C_1), d(C_2), ..., d(C_m)]$ is a function for identifying the smallest distance among all.

3.3. Parallelepiped Algorithm

The parallelepiped algorithm assigns a pixel into one of the predefined information classes in terms of its value in relation to the DN range of each class in the same band. This comparison is expressed mathematically as

$$\text{Pixel X} \in C_j \text{ if } \min DN_j \leq DN_x \leq \max DN_j \quad (3)$$

The decision rule states that pixel X under consideration is a member of information class C_j if and only if its value falls inside the DN range of this class in the same band.

After obtaining classification results, it is necessary to check its accuracy. Assessment of the thematic accuracy of the classification results is defined as the verification of the labeled pixel identity against the ground truth at the time of sensing at representative sample points (Lillesand et al. 2004). Therefore, accuracy assessment has been carried out and the kappa coefficient was calculated for all the three methods in order to select best classification algorithm among them. During this process, around 40 ground truth points were chosen within the study area which includes sample points in all LU/LC classes. Based on the results of accuracy assessment, best classification algorithm was identified and its results were utilized for the process of change detection. LU/LC maps were composed using ArcGIS 9.3 software and map to map comparison was used for change detection.

4. Results and Discussion

A spatio-temporal quantification of changes in the land use pattern of Harangi catchment during 2007-2013 was performed and the LU/LC maps and graphical representation of area changes for the years 2007, 2010, and 2013 are as shown in Figure 3 and 4 respectively. The classification was carried out by using three different methods such as Maximum Likelihood Algorithm, Minimum Distance to Mean Algorithm and Parallelopiped Algorithm and the classified area of different LU/LC classes is given in Table 3. The accuracy of the classified maps was analysed by estimating the Kappa value and overall accuracy. The result of accuracy assessment is as given in Table 1. It is observed that Kappa value with respect to the Maximum Likelihood Algorithm is 0.81 which is the highest compared to parallelepiped (0.71) and minimum distance to mean algorithm (0.68). A Kappa value of 0.75 or greater indicates a good degree of classification.

There is no simple way to evaluate the errors in the classification associated with change detection. In addition to the errors generated in the classification of single date satellite image, the analyst must contend with the propagation of errors in the classification of second-date satellite image, the change-detection algorithm, registration and radiometric differences between the images of different dates. In the present study, the accuracy has been assessed based on overall accuracy and Kappa coefficient. Overall accuracy refers to the proportion of agreement between a classification result and the reference data at certain specific locations. Kappa coefficient is a more discerning statistical parameter for comparing the accuracy of different classifiers and offers better interclass discrimination than the overall accuracy measure. The results of accuracy assessment process shows that, the overall accuracy and kappa coefficient for Maximum Likelihood Algorithm, Parallelepiped Algorithm and Minimum Distance to Mean Algorithm are 89.36% and 0.81, 81.47% and 0.71, 78.67% and 0.68 respectively. The graphical representation of the results for three classification algorithm shows that the area distribution under different land use categories varies drastically from one algorithm to another algorithm (Figure 4 a, b and c). Hence, accuracy assessment process has been used to take decision regarding the selection of efficient classification algorithm. Results indicate a decrease in Kappa value from the Maximum Likelihood Algorithm to the Parallelepiped Algorithm, and from the

Parallelepiped Algorithm to the Minimum Distance to Mean Algorithm. This general trend tells that the Maximum Likelihood Algorithm is the most accurate, followed by the Parallelepiped Algorithm and the least accurate method would be the Minimum Distance to Mean Algorithm.

Minimum distance to mean algorithm provided less accurate classification results. Because, it has misclassified four LU/LC classes such as urban area, plantation, fallow land and forest area. It can be observed clearly in the LU/LC maps and graph of Minimum Distance to Mean Algorithm (Figure 3 (C)). The result of Parallelepiped Algorithm also shows less efficiency compared to Maximum Likelihood Algorithm, because of misclassification of three land use classes such as urban area, plantation and forest area (Figure 3 (B)). Even though Maximum Likelihood Algorithm provided classified LU/LC maps with 89.36 % accuracy, it has failed to represent spatial distribution of urban area and it has misclassified waste land and fallow land as urban area (Figure 3 (A)). All the three algorithms have come across confusion while classifying waste land, urban area, fallow land and waterlogged area. The major reason for misclassification that has been done by these algorithms is due to poor performance of algorithms in distinguishing waste land, fallow land and urban area. Since, these three classes are characterized by more or less similar signatures. Similarly, algorithms failed to distinguish between forest area and plantation as they are represented by similar tones of red in False Colour Composite (FCC) image. The accuracy of classification can be improved by including more number of representative signatures for each class, using high resolution satellite images, using secondary data such as study area knowledge from field survey and Google Earth maps etc.,

Table 1: Kappa Values and Overall Classification Accuracy of three different classification algorithms for the LU/LC maps of the year 2013.

2013 LU/LC map / Methods	Kappa Value	Overall Classification Accuracy [%]
Maximum Likelihood Algorithm	0.81	89.36
Parallelepiped Algorithm	0.71	81.47
Minimum Distance to Mean Algorithm	0.68	78.67

Table 2: Results of change detection between 2007 and 2013 in Harangi catchment using Maximum likelihood algorithm

Sl. No	**LU/LC Class Name**	**% area**			**Changes in area (%)**		
		2007	2010	2013	2007-2010	2010-2013	2007-2013
1	Urban Area	3.12	3.19	3.28	0.07	0.09	0.16
2	Fallow Land	16.45	14.90	10.18	-1.56	-4.72	-6.27
3	Plantation	13.39	21.23	35.00	7.84	13.77	21.61
4	Forest Area	43.73	38.54	31.29	-5.19	-7.25	-12.44
5	Waste land	17.40	14.81	13.65	-2.59	-1.16	-3.75
6	Water Logged area	4.30	5.39	5.69	1.09	0.30	1.39
7	Water Body	1.60	1.94	0.91	0.34	-1.03	-0.69
	Total	100	100	100	0	0	0

Table 3: Results of LU/LC classification using Maximum likelihood, Parallelepiped and Minimum distance to mean algorithm

Methods & Year / LU/LC Classes	Maximum Likelihood Algorithm (km^2)			Parallelepiped Algorithm (km^2)			Minimum Distance to Mean Algorithm (km^2)		
	2007	2010	2013	2007	2010	2013	2007	2010	2013
Urban Area	13.07	13.35	13.72	9.39	5.76	6.15	95.07	18.59	54.92
Fallow Land	68.90	62.38	42.63	37.38	37.19	36.49	37.14	46.95	17.16
Plantation	56.07	88.91	146.55	65.34	75.64	144.11	54.92	41.50	158.16
Forest Area	183.12	161.37	131.02	184.77	186.48	140.53	186.98	222.81	99.95
Waste land	72.86	62.00	57.15	97.00	82.41	63.07	22.77	59.35	61.28
Water Logged area	17.99	22.56	23.81	18.72	22.37	23.93	15.70	21.36	23.21
Water Body	6.71	8.14	3.83	6.11	8.86	4.43	6.14	8.16	4.03
Total	418.71	418.71	418.71	418.71	418.71	418.71	418.71	418.71	418.71

4.1. Change detection analysis during 2007-2013

The postclassification change detection technique has been adopted to analyse the LU/LC change between the years 2007 and 2013 (Table 2 and Table 3). Based on the results of accuracy assessment process, the LU/LC statistics obtained using Maximum Likelihood Classifier, which gave better accuracy with 0.81 Kappa value, has been utilized for studying the change. The forest land, fallow land and plantation are the land cover types occupying highest percentage of area in the study region, covering about 70% of the total area.

LU/LC change during 2007 - 2010

The results show that, mainly the plantation, water logged area, urban area and water body are increased from 56.07 sq.km to 88.91 sq.km, 17.98 sq. km to 22.56 sq.km, 13.06 to 13.35 sq. km and 6.71sq. km to 8.14 sq. km respectively. The forest area, fallow land and waste land have been reduced from 183.12 sq.km to 161.36 sq.km, 68.89 sq.km to 62.37 sq.km and 72.85 sq. km to 62 sq.km respectively.

LU/LC change during 2010 - 2013

The notable change has been observed under classes such as plantation, forest area, fallow land and waste land. In particular, a drastic increase in plantation from 88.91 sq.km to 146.55 sq.km is observed. In contrast, the forest area, waste land and fallow land have shown a decreasing trend of 161.36 sq. km to 131.02 sq. km, 62 sq. km to 57.14 sq. km and 62.37 sq. km to 42.63 sq. km. There is a slight variation in the water logged area and urban area of about 22.56 sq.km and 23.81 sq.km and 13.35 sq. km to 13.72 sq. km respectively.

LU/LC change during 2007 - 2013

The LU/LC change detection results for the years 2007 and 2013 indicated a drastic change in forest area, plantation and waste land among all other classes (Table 3). The forest area decreased dramatically from 183.12 sq. km to 131.02 sq. km. The waste land is decreased from 72.85 sq. km to 57.14 sq. km. Also, fallow land and water body are decreased from 68.89 sq. km to 42.63 sq. km and 6.71 sq. km to 3.82 sq. km respectively. In contrast, plantation and waterlogged area are observed to have an increasing trend of about 56.07 sq. km to 146.55 sq. km and 17.99 sq. km to 23.81 sq. km. The urban area has been increased from 13.06 sq. km to 13.72 sq. km.

The results indicate that increase in urban area and plantation from year 2007 to 2013 because of improved living style of people in this region. As study area is a rural catchment, the main occupation is agriculture. Hence, it is observed that forest area and waste land has been decreased drastically, which might have been utilized for agricultural activity. Also, there is a fluctuation in the water body and waterlogged area because of change in water level from year to year in the Harangi reservoir. Harangi reservoir is one of the important water sources for drinking and agricultural activity in the region. Overall, there is a drastic change in all LU/LC classes of the study area.

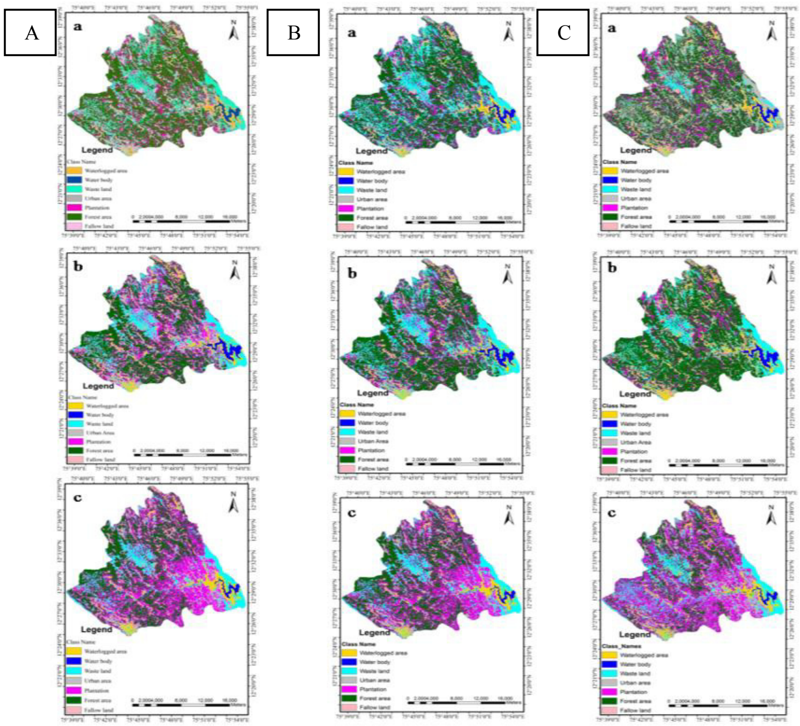

Fig 3. Classified images of Harangi catchment for years a) 2007, b) 2010 and c) 2013 using A. Maximum Likelihood Algorithm, B. Parallelepiped Algorithm, C. Minimum Distance to Mean Algorithm

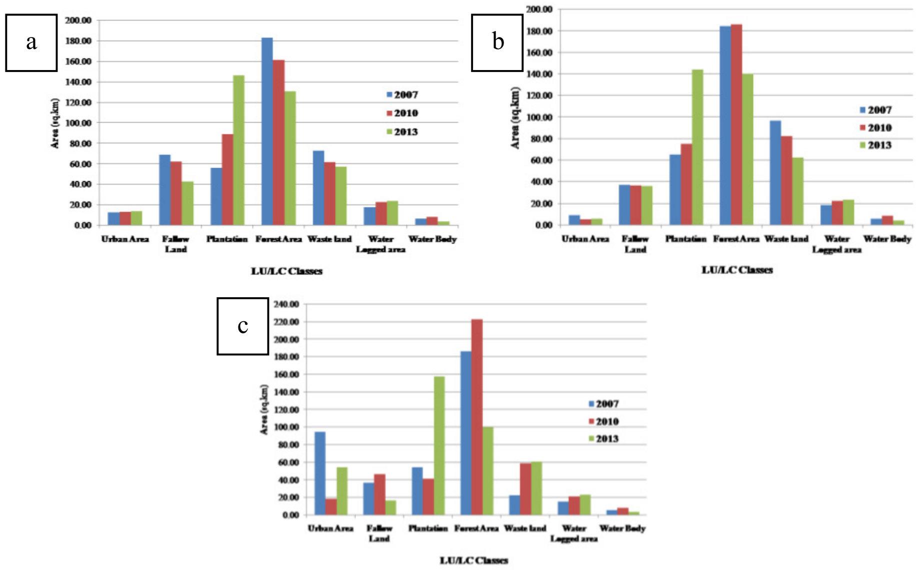

Fig 4. Graph of LU/LC change for years 2007, 2010 and 2013 in Harangi catchment using a) Maximum Likelihood Algorithm b) Parallelepiped Algorithm, c) Minimum Distance to Mean Algorithm

5. Conclusions

The principle objective of this study is to detect, assess and predict the trend in land use and land cover changes in the Harangi catchment of kodagu District, Karnataka. An attempt has been made to capture seven land use and land cover classes accurately, as they change through time. The seven classes were distinctly produced for each study year but with more emphasis on urban area and plantation as it reflect the impact of anthropogenic activities. In achieving this, accuracy assessment using Kappa Coefficient is also introduced into the research work to evaluate the performance of three algorithms. Results indicated that maximum likelihood algorithm produced acceptable LU/LC classification with kappa coefficient of 0.81. This study demonstrates the ability of Remote Sensing and GIS in capturing spatio-temporal changes in LU/LC. This area is situated in fertile plains and is lush with greenery, and is therefore an attractive site for people to relocate to. Due to this there has been a substantial amount of deforestation in the region, which has been identified in terms of reduction in the forest area and waste land. Contrary to, the area under plantation category has been increased remarkably from 2007 to 2013. As study area includes Harangi reservoir, the documentation of change in water body is helpful for taking decisions regarding management of the reservoir performance. This study has provided qualitative and quantitative changes in the land use pattern in the catchment, which becomes very important information for watershed management and planning.

References

Anil, N., Sankar, J G., Rao, J M., Prasad, I., Sailaja, U., 2011. Studies on Land Use/Land Cover and change detection from parts of South West Godavari District, A.P – Using Remote Sensing and GIS Techniques. Journal of Indian Geophysical Union 15, 187-194.

Arunachalam, S., Maharani, K., Chidambaram, S., Prasanna, M V., Manivel, M., Thivya, C., 2011. A study on the Land use pattern change along the coastal region of Nagapattinam, Tamil Nadu. International Journal of Geomatics and Geosciences 1:700-720.

Binh, T., Vromant, N., Hung, T N., Hens, L., Boon, E., 2005. Land cover changes between 1968 and 2003 in Cai Nuoc, Ca Mau Peninsular, Vietnam. Environ. Dev. and Sustain. DOI 10.1007/s10668-004-6001-z, 519-536.

Brahabhatt, V S., Dalwadi, G B., Chhabra, S B., Ray, S S., Dadhwal, V K., 2000. Landuse/landcover changes mapping in Mahi canal command area, Gujarat, using multi-temporal satellite data. Journal of Indian Society of Remote Sensing 28, 221-232.

Campbell, J D., Lusch, P D., Smucker, A T., Wangui, E E., 2005. Multiple Methods in the Study of Driving Forces of Land Use and Land Cover Change: A Case Study of SE Kajiado District, Kenya. Human Ecology 33, 763-791.

Changhong, S., Bojie, F., Yihe, L., Nan, L., Yuan, Z., Anna, H., et al. 2011. Land Use Change and Anthropogenic Driving Forces: A Case Study in Yanhe River Basin. Chinese Geographical Science 21, 587-599.

Chauhan, H B., Nayak, Shailesh., 2005. Land Use/Land Cover changes near Hazira Region, Gujarat using Remote Sensing Satellite data.. Journal of the Indian Society of Remote Sensing 33, 220-227.

Chilar, J., 2000. Land cover mapping of large areas from satellites: Status and research priorities. International Journal of Remote Sensing 21, 1093-1114.

Dewan, M A., Yamaguchi, Y., 2009. Using remote sensing and GIS to detect and monitor land use and land cover change in Dhaka Metropolitan of Bangladesh during 1960–2005. Environmental Monitoring and Assessment. 150, 237-249.

Ganasri, B P., Dwarakish, G S., 2014. Analysis of Land Use/Land Cover distribution using Remote Sensing and GIS: A case study of Mulki river basin, Karnataka. Proceedings of the Fifth Indian National Conference on Harbour and Ocean Engineering, 12-14.

Ganasri, B P., A, Raju., Dwarakish, G S., 2013. Different Approaches for Land Use Land Cover Change Detection: A Review. Research and Reviews: Journal of Engineering and Technology, 2 (3), 44-48.

Gao, Jay., 2009. Digital Analysis of Remotely Sensed Imagery. McGraw-Hill Companies, Inc

Gautam, N C., Narayanan, LRA., 1983. Landsat MSS data for land use/land cover inventory and mapping: A case study of Andhra Pradesh, Journal of Indian Society of Remote Sensing 11, 15-28.

Giri, C., Zhu, Z., Reed, B., 2005. Comparative analyses of the Global land Cover 2000 and MODIS land cover data sets. Remote Sensing of Environment 94, 123-132.

Gumageri, Nagaraj., Kumar, K N., Mohan., Dwarakish, G S., 2011. Land Use and Land Cover Changes Around the river mouths of Mangalore, West Coast of India. International Journal of Earth Sciences and Engineering. 4, 346-350.

Huigen, G M., 2004. First principles of the MameLuke multi-actor modelling framework for land use change, illustrated with a Philippine case study. Journal of Environmental Management. 72, 5-21.

Jayakumar, S., Arockiasamy, D I., 2003. Land Use/Land Cover Mapping and Change Detection in part of Eastern Ghats of Tamil Nadu using Remote Sensing and GIS. Journal of the Indian Society of Remote Sensing 31, 70-78.

Kachhwala, T S., 1985. Temporal monitoring of forest land for change detection and forest cover mapping through satellite remote sensing. In: Proceedings of the 6th Asian Conference On Remote Sensing Hyderabad, 77-83.

Lin, Y P., Verburg, H P., Chang, C R., Chen, H Y., Chen, M H., 2009. Developing and comparing optimal and empirical land-use models for the development of an urbanized watershed forest in Taiwan. Landscape and Urban Planning 92, 242-254.

Lin, Y P., Wu, P J., Hong, N M., 2008. The effects of changing the resolution of land-use modeling on simulations of land-use patterns and hydrology for a watershed land-use planning assessment inWu-Tu, Taiwan. Landscape and Urban Planning 87, 54-66.

Liu, M., Hu, Y., Chang, Y., He, X., Zhang, W., 2009. Land Use and Land Cover Change Analysis and Prediction in the Upper Reaches of the Minjiang River, China. Environmental Management 43, 899-907.

Lillisand, M Thomas., Kiefer, W. Ralph., Chipman, W. Jonathan., 2004. Remote sensing and image interpretation. Wiley India.

Miao, LIU., Yuanman, H U., Wei, ZHANG., Junjun, ZHU., Hongwei, CHEN., Fengming, X I., 2011. Application of Land-use Change Model in Guiding Regional Planning: A Case Study in Hun-Taizi River Watershed,Northeast China. Chinese Geographical Science 21, 609-618

Nagamani, K., Ramachandran, S., 2003. Land Use/Land Cover in Pondicherry usingRemote Sensing and GIS, Proceedings of the Third International Conference on Environment and Health, Chennai, India, 15-17.

Niehoff, D., Fritsch, U., Bronstert, A., 2002. Land-use impacts on storm-runoff generation: scenarios of land-usechange and simulation of hydrological response in a meso-scale catchment in SW-Germany. Journal of Hydrology 267, 80-93.

Prakasam, C., 2010. Land use and land cover change detection through remote sensing approach: A case study of Kodaikanaltaluk, Tamil nadu. International Journal of Geomatics and Geosciences 1, 226-233.

Papastergiadou, E S., A, Retalis P., Kalliris, Th, Georgiadis., 2007. Land use changes and associated environmental impacts on the Meditteranean shallow Lake Stymfalia, Greece. Hydrobiologia, 584, 361-372.

Rao, M, Jagannadha., Anil, N C., Sankar, G Jai., Prasad, IVRKV., Sailaja, U., 2011. Studies on Land Use/Land Cover and change detection from parts of South West Godavari District, A.P – Using Remote Sensing and GIS Techniques. Journal of Indian Geophysical Union 15, 187-194

Shamsudheen, M., Dasog, G S., Tejaswini, N B., 2005. Land use/ Land cover mapping in the coastal area of North Karnataka using Remote sensing data. Journal of the Indian Society of Remote Sensing 33, 253-257.

Vanum, G., Hadgu, M K., 2012. Land use/ Land cover changes through the applications of GIS and Remote Sensing and the implications on Sustainable land management. International Journal of Geology, Earth and Environmental Sciences 2, 136-147.