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IMPACT OF TEMPORAL CHANGE IN LANDUSE CHARACTERISTICS OF URBAN WATERSHED ON HYDROLOGY

RAVIKUMAR B. CHOODEGOWDA, MURUKANNAPPA, CHANDANKUMAR K. S & CHALAPATHI R

Department of Agricultural Engineering, University of Agricultural Sciences, Bangalore, Karnataka, India

ABSTRACT

Changing native land use system due to urbanization influence hydrological behavior of the catchment. Scientific study on assessing the impact of city expansion found necessary to understand its effect on hydrology. To investigate the impact of temporal change in land use system on a watershed, present study was conducted at a microwatershed located in the northern part of Bengaluru city, Karnataka, India. Temporal change in land use system during 1975 and 2014 was investigated. ArcInfo and ERDAS Imagine a GIS and Image processing software respectively were used for spatial data analysis and satellite image processing respectively. Runoff was estimated using NRCS curve number method. Results of the study indicated that, the habitation/human settlement increased from 193.31 ha to 831.00 ha, agricultural land area was reduced from 963.31 ha to 369.07 ha between the years1975 and 2014 respectively, plantation area was reduced by 23% and there was negligible change in area of the water body. Run off curve numbers value was increased from 78.17 to 84.92 indicated that, more runoff from a small storm event leading to flood due to changed land use in the watershed.

KEYWORDS: ERDAS, Hydrology, NRCS, Curve Number, and GIS

INTRODUCTION

More people are migrating to city in search of jobs and better civic amenities led to unplanned city expansion. This urbanization over the period of time changes native land use system leads to hydrological changes. Scientific study on assessing the impact of city expansion is needed to understand its effect on hydrology helps administrators for better city planning. Considering the limitations of the techniques and practices currently available for evaluating land Use/land cover impacts on the hydrology, there is a strong need to explore alternative approaches. This involves use of Geographic Information Systems(GIS) and Remote Sensing (RS) to evaluate the response of the hydrologic regime, in a given watershed, to different land use changes over a period of time. Present remote sensing technology provides for understanding, monitoring and in some cases quantifying these natural and management induced predictions such as runoff, soil loss, changes in vegetative cover, and the consequences of habitat disturbance. Due to city expansion in urbanized watersheds potential of increasing storm runoff rates, and therefore increasing the risk of flooding. To investigate the temporal change in land use/land cover system, and assess its impact on hydrology, present study was taken up at a microwatershed located at northern part of Bengaluru city, Karnataka state, India. Bengaluru is fast growing city in India converting land used for agriculture and other purposes to residential layouts, malls, to address the following objectives.

- To investigate temporal change in watershed characteristics during years 1975 and 2014
- To assess the impact of change in land use / land cover condition on hydrology.

MATERIALS

Site Location

In this study, spatial data of land use system during 1975 and 2014 were collected, analysed and compared to assess the impact of temporal changes of the microwatershed. The selected microwatershed is located in the northern part of Bengaluru city, Bengaluru north district of Karnataka state, India spreads on an area of 1414 hectares. It is in the eastern dry zone of Karnataka state agro-climatic zone classification having majority of red sandy loam soil receiving average annual rainfall 780.0 mm more from south west monsoon. It is located at an altitude of 930 m from MSL with annual mean maximum and minimum temperature 29.2^0 C and 17.8^0 C, Relative humidity of 84% and 48% respectively, mean annual evaporation of 5.6 mm and PET 4.2 mm (all weather data is average of 40 years since 1972, source; GKVK, UAS Bangalore weather data) (Figure 1).

Toposheet no.57G/12/SW with scale of 1:25,000 was procured from Survey of India to collect land use details during the year 1975 and Cartosat imagery was used to assess the 2014 land use pattern of the selected watershed. To scan the toposheet, Context Puma G600, A0 size color scanner was used. Calcomp thermal color printer was used to print the scanned image. Arc Info GIS software developed by ESRI was extensively used for development of geodatabase, delineation of microwatershed boundary, preparation of different thematic maps and other spatial analysis. ERDAS Imagine 2014 digital image analysis software developed by Integraph was used for supervised classification of the land use.

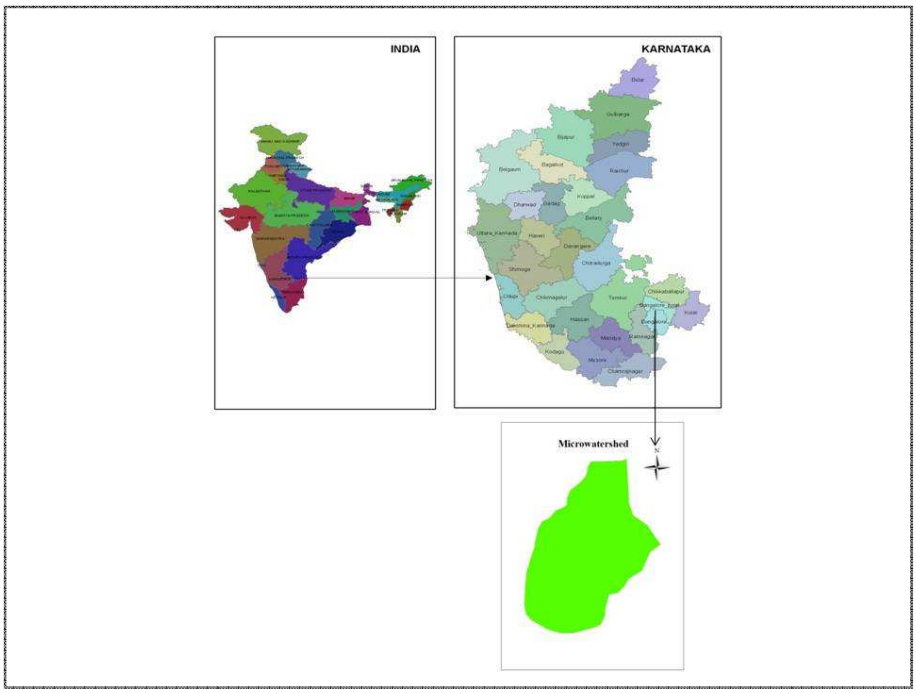

Figure 1: Location Index Map of the Microwatershed

METHODOLOGY

Generation of Land Use Land Cover Map of the Year 1975

Microwatershed boundary was first delineated on the tracing paper using the procured topsheet. While delineating the boundary, ridge line of the watershed was carefully traced looking in to the contours of the toposheet and inspecting the site to confirm the accuracy of the delineation. Further, correctness of the work was cross verified with the delination of the catchment using Digital Elevation Model (DEM) using ArcGis software. The DEM was procured from the Bhuvan online portal of National Remote Sensing Center(NRSC), Hyderabad, India. Depending on the information printed on the toposheet, the microwatershed was classified into four land use classes they were, habitation (human settlement included roads, buildings, and other facilities), agricultural land (included cultivable, grass land and open shrubs), plantations and waterbody. The same land use classes were traced on the tracing paper. The traced toposheet was scanned using Contex Puma G600 color scanner – A0 size. The scanned toposheet is then brought to GIS framework by creating a personal geodatabase and feature classes. The scanned raster was then georeferenced and microwatershed polygon was digitized using ArcGIS software. Similarly, four land use polygons were also digitized (figure 2).

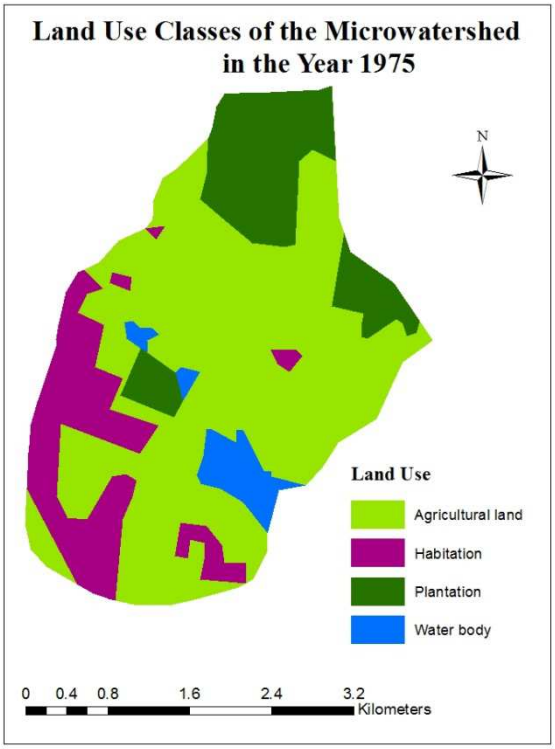

Figure 2: Land Use Classes of the Microwatershed During 1975

Generation of Land Use Land Cover Map of the Year 2014

Land use characteristics of microwatershed for the year 2014 was done using remote sensing satellite imagery procured from National Remote Sensing Center, Hyderabad (Cartosat, LISS 3 Image). The raster of the image was clipped using vector polygon of the microwatershed already developed. Land use and land cover was classified using ERDAS IMAGINE software then to confirm the classification, site was visited and supervised the classification (figure 3).

Estimation of Curve Numbers

To assess the impact of changed land use characteristics on runoff, National Resource Conservation Society Curve Number method curve numbers have been developed for both 1974 and 2014 scenario. Curve numbers have been assigned to the different land use system using standard procedure. User can select any storm event to obtain runoff of the microwatershed for that particular storm event.

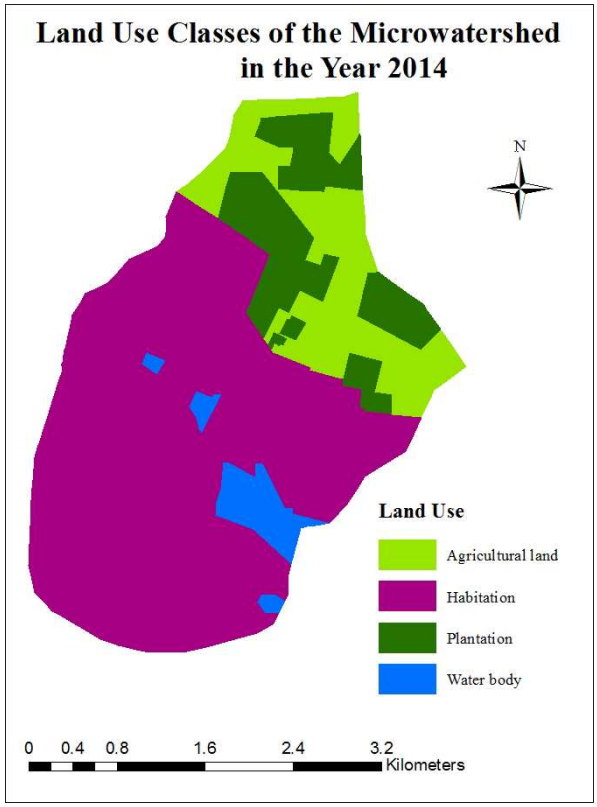

Figure 3: Land Use Classes of the Microwatershed During 2014

RESULTS

Results of the present study indicated that, the habitation/human settlement increased from 193.31 ha during 1975 to 831.00 ha during 2014. There was 330% increase in the area of habitation over a period of 39 years whereas, drastic decrease in agricultural land was observed. 963.31 ha of Agricultural land during 1975 was reduced to 369.07 ha during 2014. Reduction of Agricultural land area amount to be 62%. It was also observed that, the plantation area was reduced by 23% and there was negligible change in area of the water body (figures 4, 5 and 6). Results of runoff estimation by NRCS curve number method showed a drastic reduction in curve numbers for Agricultural land use and increase in habitation land use systems between two study period. Weighted average of the curve number of all the land use system together during 1974 was 78.17 and during 2014 was 84.92 (table1and table 2).

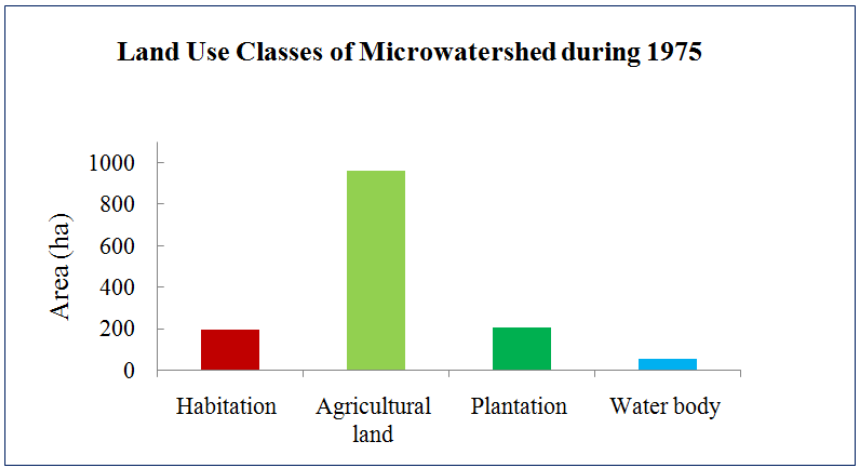

Figure 4: Land Use Distribution in the Microwatershed During 1975

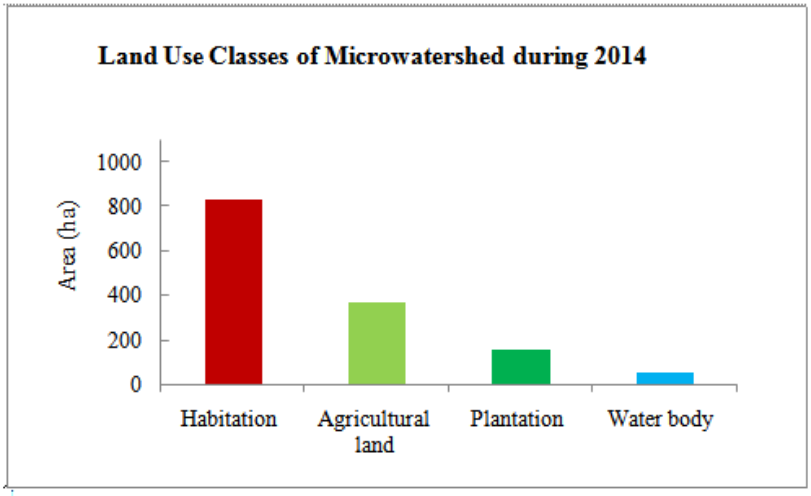

Figure 5: Land Use Distribution in the Microwatershed During 2014

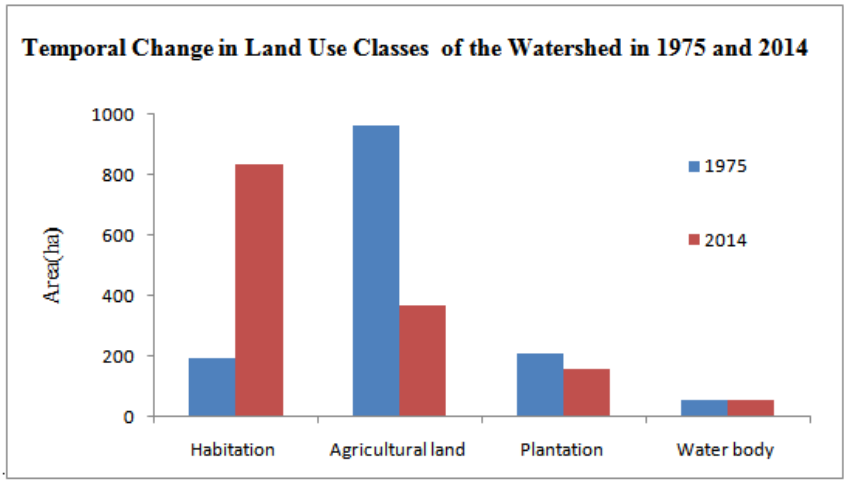

Figure 6: Temporal Change in Land Use Classes in the Microwatershed during 1975 and 2014

Table 1: Curve Number Estimation for the Land Use Classes of the Microwatershed During 1975

Land Use	Hydrological Soil Group	Area(Ha)	Curve Number	Area*Curve Number
Agricultural land	A	192.66	65	12523.04
	B	577.99	75	43348.99
	C	96.33	82	7899.15
	D	96.33	86	8284.47
Plantation	B	51.34	71	3644.81
	C	133.47	78	10410.80
	D	20.53	81	1663.26
Habitation	C	135.32	91	12313.84
	D	57.99	93	5393.35
Water body	D	52.40	97	5082.45
	Total area	1414.36		110564.18
	Weighted Curve number			78.17

Table 2: Curve Number Estimation for the Land Use Classes of the Microwatershed During 2014

Land Use	Hydrological Soil Group	Area(Ha)	Curve Number	Area*Curve Number
Agriculture land	A	147.63	65	9595.82
	B	73.81	75	5536.05
	C	110.72	82	9079.12
	D	36.91	85	3137.10
Plantation	A	15.83	32	506.46
	B	47.48	58	2753.90
	C	79.14	72	5697.72
	D	15.83	79	1250.33
Habitation	C	83.10	91	7562.10
	D	747.90	93	69554.70
Water body	D	56.02	97	5434.27
	Total Area	1414.36		120107.57
	Weighted average curve number			84.92

DISCUSSIONS

Results of the study temporal change in land use characteristics between 1975 and 2014 of the selected watershed located in the northern part of a fast growing cosmopolitan city Bengaluru, showed drastic change in the land use system. There was a significant increase in habitation/ human settlement over the periods of 39 years since1975. 330% (637 ha) of native land used for agriculture purpose like crop cultivation, grazing, orchard and open shrub belonged to different hydrologic soil group was converted in to residential parcels, roads, parking lots and other civic amenities. The changed scenario resulted in sealing open land and restricting water to infiltrate and causing flood even during less intensified storm events. Estimated curve numbers to calculate runoff for a particular storm event is the evident for the changed conditions. Increased weighted average curve numbers in 2014 compared to 1975 attributed to more runoff from less intensified storm event. It clearly indicates that, there is less scope for infiltration of water and ground water recharge. It also resulted in depletion of ground water in the study area.

CONCLUSIONS

The present study clearly indicated that, the city expansion converted the native land used for agriculture, silviculture and other crop and animal husbandry purpose in to construction of buildings, roads, and other civic facilities. This changed land use system attributed to more runoff from the catchment lead to sudden flood. Urbanization without proper planning giving less scope for construction of water storage structures, sufficient drainages facilities for safe disposal of excess runoff. The sealed soil surface restricts water to infiltrate lead to less ground water recharge and depletion of ground water table.

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