LANDUSE/LANDCOVER CHANGES AND ESTIMATION OF SURFACE RUNOFF OF KRS CATCHMENT: CAUVERY BASIN, KARNATAKA.

Sakthivel M.,* Hiazeule, Raghav M.S.*****
*Associate Professor, Department of Geography,University of Madras
**M.Sc Applied Geography,Department of Geography,Universityof Madras
***M.TechGeoinformatics,Department of Geography,University of Madras

Abstract
The availability of the water resource in a catchment depends upon the integrity of the land use, terrain and meteorological parameters such as rainfall, temperature, etc. KRS Catchment in the Cauvery basin covers an area of 10,957 Km2 was taken up for the study. The study was conducted in order to understand the changes of Landuse /Landcover and their impacts on the watershed and to estimates the runoff calculation using SCS-CN method, which is mainly used for estimating infiltration characteristics of the watershed, based on the land use property and soil property and it is widely used as a simple method for predicting direct runoff volume for a given rainfall event.In the present study, the methodology for assessing the landuse/ landcoverchanges and determination of runoff for KRS Catchment using Remote Sensing, GIS and SCS method was described.Analysis of the landuse/landcover revealed the changes taken part from 2006 to 2017. Major changes were from forest and barren land to agriculture, built up and water bodies.The SW Monsoon rainfall and landuse data were used along with the experimental data of soil classification for the estimation of the runoff for the study area. The result shows excess runoff and low infiltration take places mostly in the month of July followed by June, august and lowest runoff on the month of September.This will help for watersheds planning of various conservations measures.

Keywords: *KRS Catchment, Runoff, SCS Curve Number, GIS, Remote Sensing.*

Introduction

Water is the most abundant substance on Earth and is the principal constituent of all living things. In the atmosphere, water plays a major role in maintaining a habitable environment for human life. At the present time, rising populations and improving living standards are placing increasing pressures on available water resources.

Land use/cover change detection is very essential for better understanding of landscape dynamic during a known period of time having sustainable management. Land cover changes within a watershed areal so recognized as an important factor affecting hydrological processes and water resources. The change in Landuse adversely affects the catchment dynamics in maintaining the hydrologic conditions. Application of remotely sensed data made possible to study the changes in land cover in less time, at low cost and with better accuracy (Kachhwala, 1985) in association with GIS that provides suitable platform for data analysis, update and retrieval (Chilar, 2000).

The Soil Conservation Service-Curve Number (SCSCN) method developed by National Resources Conservation Service (NRSC), United States Department of Agriculture (USDA) in 1969, is simple, predictable and stable conceptual method for estimation of direct runoff depth based on storm rainfall depth. This model is a widely used hydrological model for estimating runoff using runoff and curve number (CN). The CN is an index that represents the watershed runoff potential (Ishtiyaq, Vivek, and Mukesh, 2015). It is reliance an only one parameter and its responsiveness to four important catchment properties, i.e. soil type, land use, surface condition, and antecedent moisture condition, increased its popularity. It is a versatile and widely used procedure for runoff estimation. The requirements for this method are low, rainfall amount and curve number. The curve number is based on the areas hydrologic soil group, land use treatment and hydrologic condition.

Aim and objectives

The main aim of the study is to assess and analyze landuse/landcover change detection and to calculate the Surface Runoff of KRS (Krishna Raja Sagar) Catchment, Cauvery basin.
To assess the Landuse/ Landcover changes in the catchment area and their impacts on the Watershed. To calculate the surface Runoff using SCS-CN Method.

Study area

The study area covers five districts of Karnataka namely Chimagalur, Hassan, Kodagu, Mysore and Mandya. The study area covers an area of 10,957 Km2. The basin receives rainfall mainly from the S-W Monsoon and partially from N-E Monsoon in the Karnataka. The climate at the basin level generally remains dry except for monsoon months. There is a considerable variation in the mean daily maximum and minimum temperatures across the catchment. Quantifying the total rainfall in the basin across the year; about 68% is received during the south-west monsoon, about 17 % in the northeast monsoon, 15% in the pre monsoons and the rest in the winter months.

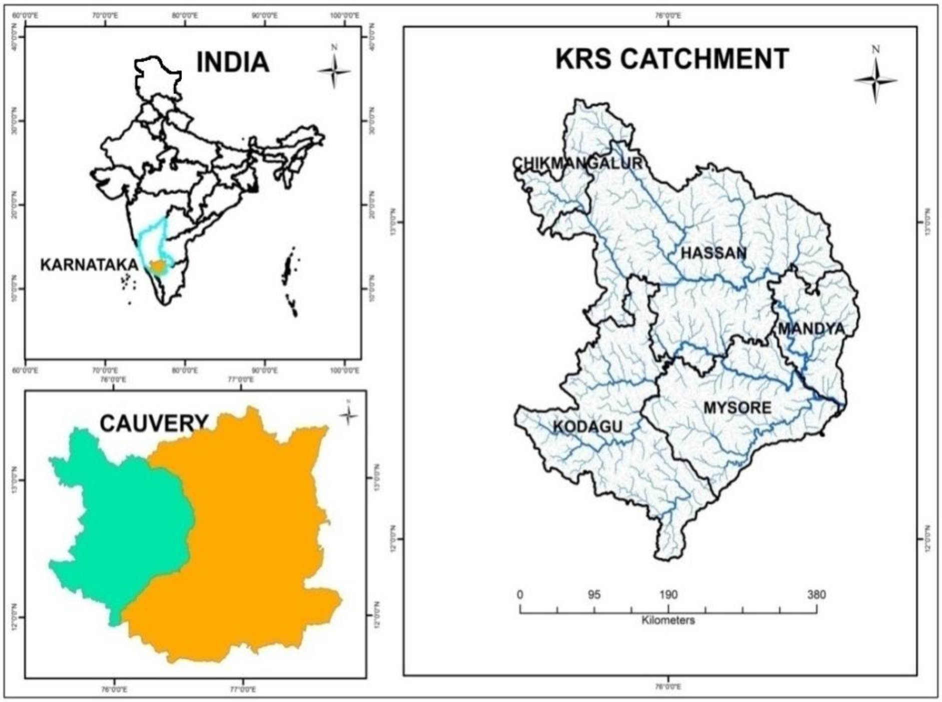

Figure 1. Base Map of the Study Area

Methodology

AWIFS and LANDSAT 8 satellite images of 2006, 2012 & 2017 were downloaded, preprocessed and mosaicked to create an image of the Catchment area. Digital classification using ERDAS Imagine was performed to identify categories of land use& land cover based on spectral characteristics using supervised classification technique and visual interpretation was done from the Google earth. CARTOSAT DEM of 30 meter resolution along with a daily report of SW Monsoon rainfall data of Gram Panchayat of the year 2016 was used and the soil data was collected from NBSS & LUP (National Bureau of Soil Survey and Land use Planning, Nagpur) at the scale of 1:50,000 and Land use/Land cover of the year 2017(February) was also used for the analysis. Soil classes are used in the preparation of hydrological soil-cover complex, which in turn are used in estimating direct runoff.

Results and discussion

Land use and Land cover changes detection

Comparison of LU/LC in 2006, 2012and 2017 derived satellite imagery interpretation indicates that the built-up areas is largely broadened from 998km2 (2006) to 2450 km2(2017).This is due to urban expansion and population increase in this study area. The study area witnessed large amount of agriculture land converted into settlements and other urban development activities. Forest cover comprising all land with tree cover of canopy density is significantly declined from 2006 (5907 km2) to 2017 (3871 km2).Water spread area, both man-made and natural water features such as rivers/streams, tanks, and reservoirs, also decreased from 531 km2 (2006) to 210 km2 (2017). Water spread area decrease is occurred due to the gradual conversion of water spread area into built-up area or human developmental area as the population increased significantly during the past decades.

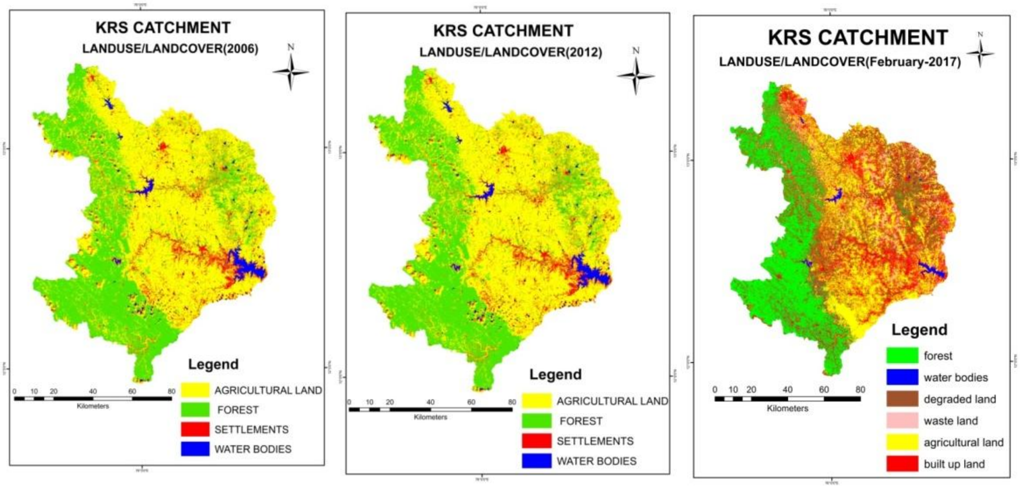

Figure 4. Landuse/ Landcover Map for the year 2006, 2012 & 2017.

Soil Classification

Soil classification deals with the systematic categorization of soils based on distinguishing characteristics as well as criteria that dictate choices in use. The important soil characteristics that influence the hydrological classification of soils are effective depth of soil, average clay content, infiltration characteristics and the permeability.

Four hydrologic soil groups are described below:

Group A (LOW RUNOFF POTENTIAL): Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sand or gravels. These soils have high rate of water transmission.

Group B (MODERATELY LOW RUNOFF POTENTIAL): Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well-drained soil with moderately fine to moderately coarse textures. These soils have moderate rate of water transmission.
Group C (MODERATELY HIGH RUNOFF POTENTIAL): Soils having low infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well-drained soil with moderately fine to moderately coarse textures. These soils have moderate rate of water transmission.
Group D (HIGH RUNOFF POTENTIAL): Soils having low infiltration rates when thoroughly wetted and consisting chiefly of clay soils with high swelling potential, soil with permanent high water table, soils with clay pan or clay layer at or near the surface and shallow soils over nearly impervious material.

Table 1. Classes of Land Use/Cover of the Study Area for the year 2006, 2012 & 2017

Estimation of Surface Runoff

Landuse/Landcover classification for the year 2006	
Name	**Area in km square**
Agricultural land	6790
Built up land	998
Forest	5907
Water bodies	531

Landuse/Landcover classification for the year 2012	
Name	**Area in km square**
Agricultural land	2790
Built up land	738
Forest	2207
Water bodies	201

Landuse/Landcover classification for the year 2017	
Name	**Area in km square**
Agricultural land	2973
Built up land	2450
Forest	3871
Water bodies	210
Waste land	512
Degraded land	2072

Runoff depends to a large extent on the antecedent soil moisture conditions and the intensity of rainfall. Runoff varies widely according to the seasonal distribution of rainfall, catchment characteristics (shape, size, steepness, vegetation type and density).The SCS runoff expressed in unit depth spread over the watershed is given by,

Q = (**P−0.2S**) ^2/ (**P+0.8S**)

Where, Q direct flow volume expressed as a depth in mm; P = precipitation in mm; S = potential maximum retention in mm.
CN curve number value used to estimate potential maximum soil retention (S),

S=25400/CN-254

The standard assumption is that I_a= 0.2S If rainfall is greater than .2 S, then there is a possibility of runoff. Otherwise, if rainfall is less than 0.2S, runoff will be zero. Hence, the rainfall events, which are more than 0.2S, were considered for further runoff estimation.

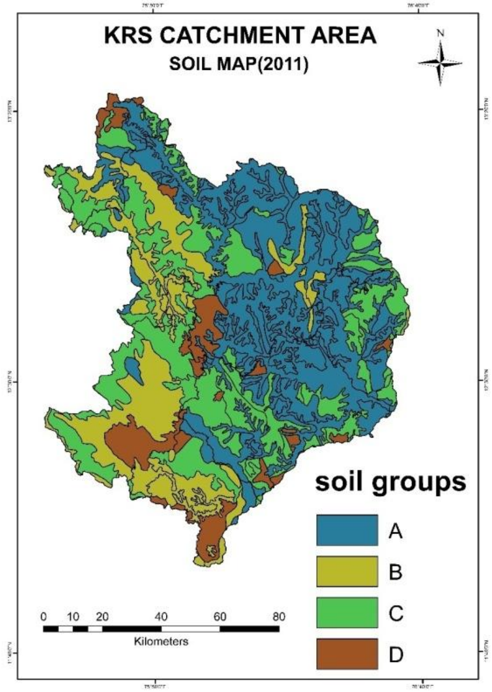

Figure 4. Soil classification Map of the study area.

Table 2. CN values for LU/LC classes adopted in this study

LU description	CN for HSG			
	A	**B**	**C**	**D**
Agricultural	64	75	82	85
Forest	30	55	70	77
Waste land	49	69	79	84
Built up land	46	65	77	82
Water body	100	100	100	100

From the below observations the average Curve Number computed is 63 while the specific retention 'S' comes to be equal to 149.17. Runoff coefficient depends amongst other factors on the degree of slope, soil type, vegetation cover, antecedent soil moisture, rainfall intensity and duration. The coefficient ranges usually between 0.1 and 0.5.The above details are useful to identifying runoff potential in KRS catchment and developing appropriate soil and water conservation structures. Excess runoff and low infiltration take places mostly in the month of July followed by June, august and lowest runoff on the month of September. Runoff was estimated by using SCS-CN Method and was analyzed further on monthly basis of SW Monsoon Rainfall.Further graphs were prepared showing linear variation of rainfall-runoff, based on this correlation coefficients were obtained.

Table 3. Runoff estimation for SW monsoon rainfall using hydrological weighted curve numbers

KRS CATCHMENT RAINFALL RUNOFF SW MONSOON 2016				
Month	Average rainfall(mm)	Average CN	Runoff (mm)	Runoff coefficient(mm)
June	212	63	100	0.47
July	214	63	101	0.47
Aug	107	63	26	0.25
Sep	54	63	3	0.06

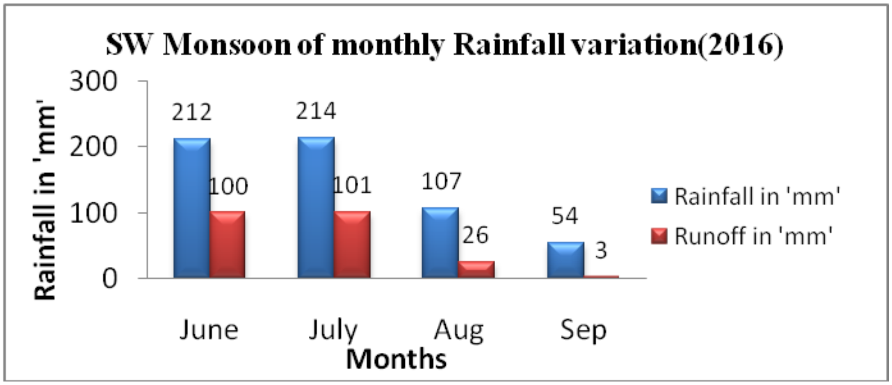

Figure 4. Bar chart showing monthly variation

In the figure shown below on X axis it represents SW Monsoon rainfall data of 2016 of Gram Panchayats under which the respective catchment falls and on Y axis is the respective rainfall-runoff in mm.

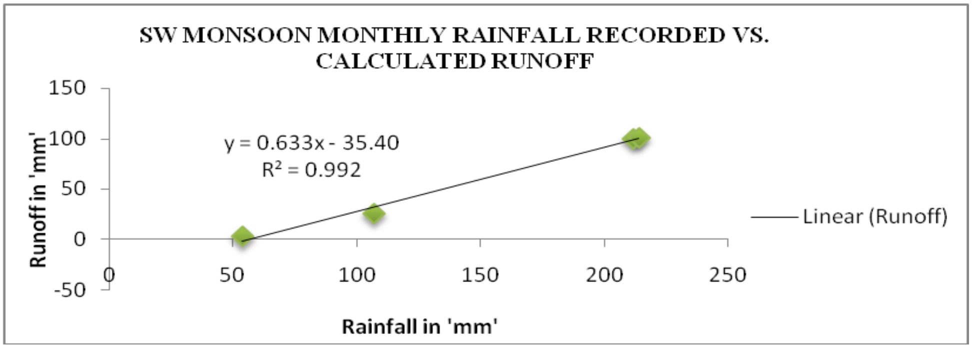

Figure 5. Correlation coefficient for SW Monsoon monthly rainfall-runoff series

The observed correlation between the calculated CN value and the rainfall depth in a watershed can be attributed to the soils and land cover spatial variability of the watershed. This observation may facilitate future studies aiming at the extension of the SCS-CN method documentation for different regions and different soil, land use, and climate conditions.

Conclusion

Results clearly show that LU/LC changes were significant during the period from 2006 to 2017. There is significant expansion of built-up area noticed. On the other hand there is decrease in agricultural area; water spread area, and forest areas. This study clearly indicates the significant impact of population and its development activities on LU/LC change .Increased human interventions have caused rapid transitions in Landcover, adversely affecting the watershed processes and hydrological cycle.LU/LC changes of KRS Catchment area is very useful for environmental management Groups, policy makers and for public to better understand the surrounding.

Further, the runoff mainly depends upon rainfall and soil texture**.**SCS model has been used to estimate runoff. This model gives quick estimate of generated runoff in a particular location with reasonably good accuracy but doesn't take into account flow processes due to topographical variations.

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