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Impact of Land use and Land Cover Changes at Upper Betwa Region, using SWAT

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***Abstract* -Hydrological processes in a mixed land use watershed are significantly influenced by land use (LU) and land cover (LC). In order to quantify the effect of LU/ LC, topography, and morphology, runoff and sediment yield of a small multi vegetated watershed in a sub-humid subtropical region in India were simulated by the Soil and Water Assessment Tool (SWAT) model and were compared with measured values. The Betwa River originates from Barkhera, Raisen district, Madhya Pradesh which lies between 22^{0}54' to 26^{0}00' N latitudes and 77^{0}10' E to 80^{0}20' E longitudes. It is a southern tributary of Yamuna River which in turn is a tributary of Ganga River. The region, though historically important, continues to be highly underdeveloped due to poor management of irrigation facilities. The rainfall is scanty, uncertain and unevenly distributed; land degradation has taken place and may further increase due to continuing deforestation. After upper betwa basin soil classification are Loamly 26.65%, Fine loam 3.01%, Fine 69.09% and Clay 1.26%. Land use /land cover classification are Agricultural 41.6%, Water 1.58%, Forest 28.33%, Urban land. 14.48%, Waste / barrier land 7.45% and Scrub land 6.54% of 2002.**

Keywords:-Hydrological modeling Arc-SWAT model, Remote sensing and GIS, Catchment.

INTRODUCTION

Land use/ cover change (LUCC) has important impacts on the functioning of socio- economic and environmental systems with important tradeoffs for sustainability, food security, biodiversity and the vulnerability of people and ecosystem to global change impacts (Lesschen *et al.*, 2005). Land cover change refers to the complete replacement of one cover type by another, for example deforestation. Land use change includes the modification of land cover types, for example intensification of agricultural management or other changes in the farming system. Land use and types, for example intensification of agricultural management or other changes in the farming system. Land use and land cover changes are the results of the interplay between socio–economics, institutional and environmental factors (Lesschen *et al.*, 2005). As estimated 175 million hectare of land in India constituting about 53% of the total geographical area (329 million hectare), surface from deleterious effect of soil erosion and other forms of land degradation. Active erosion caused by water and wind alone accounts for 150 million hectare of land, which amounts to a loss of about 5.3 million tonnes of sub- soil per year. In addition, remaining 25 million hectare land have been degraded due to ravine, gullies, shifting cultivation, salinity, alkalinity, and water (Reddy,1999) .

Impact assessment of land use change, population growth and watershed development to soil loss, water quality and quantity is one of the most important topics in a watershed. The rapid increase of population and the driving force of economic growth further accelerate the need for various land uses within the watershed. To contemplate the scope of such problems, as experienced in many other developing countries, the efforts of pursuing integrated optimal planning to achieve the sustainable uses of these watershed resources becomes critical. Many studies have been made of multi-objective land-use planning under various conditions, such as those applied in an industrial complex, a watershed, a river basin. However, very few of them focus on the evaluation of the optimal balance between economic development and environmental quality within a watershed.
Watershed characteristics, such as land use/land cover, slope, and soil attributes, affect hydrologic and water quality processes and hence regulate sediment and chemical concentration (Basnyat *et al.* 2000). Knowledge of the basic hydrologic processes occurring in watershed give a better understanding of land use impacts on soil and water resources. Change in land use/land cover is considered as an important hydrologic factor affecting storm runoff generation and sediment yield (Calder 1992; Naef *et al*. 2002; Bakker *et al.* 2005).
The remote Sensing technology has been found applicable to different aspects such as surface water mapping, watershed surveys groundwater mapping land use / land cover mapping, environmental studies, forest mapping, water quality, structural mapping, etc.(Trivedi, *et al.* 2006). Various studies revealed that remotely sensed databases in combination with GIS can perform efficient management of land and water resources in irrigated agriculture which requires comprehensive knowledge on many variables including climate, soil land use. Crops, water availability, water distribution network, management practices, etc. (Su and Wen 2001 ; Bioggio and Ding, 2001; Kjelds and Storm, 2001).

MATERIALS AND METHODS

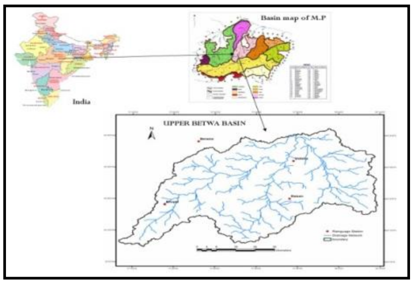

Figure 1: Location Map of Upper Betwa Basin

Study Area

The study area is located in Betwa sub-basin falling between Bhopal and Vidisha in Madhya Pradesh (India), which covers a catchment area of 46580 km^2 out of the total catchment area 4122 sq.km area is taken in the present study. Betwa river rises in the Raisen district of Madhya Pradesh near village Barkhare, south west of Bhopal at an elevation of about 576 m above mean sea level and flows in a north-easterly direction for 232 km through Madhya Pradesh and enters the Jhansi district of Uttar Pradesh. After running for a further distance of about 261 km. in Jhansi, Jalaun, and Hamirpur districts of Uttar Pradesh, it joins river Yamuna near Hamirpur at about 106 m above mean sea level. The total length of the river from its origin to its confluence with the Yamuna is about 590 km, about 232 km in Madhya Pradesh and the balance in Uttar Pradesh.

Data acquisition

Hydro-meteorological data

Daily data for 10 years (1993-2002) were collected from IMD-Pune, for rainfall. Maximum and minimum air temperature, solar radiation, relative humidity and wind speed.

Topographic, soil and land Use/cover data

The Upper Betwa basin is covered in the topographic maps no 54L10, 54L6, 54L9 and 54L11 on 1:250,000 scale, which was collected for use from the Survey of India. Soil map and soil resources data were collected from the NBSSLUP Nagpur and Land Use/Cover map were collected from Geological Survey of India, Bhopal. The procedure for preparation of soil texture map and Land Use/Cover map is described in 2 and 3.

Satellite data

The cloud free digital LANDSAT data which covers the study area was downloaded by Global Land Cover Facility site. Satellite data of autumn season for the year 2000 was used to generate the land use/cover map of the study watershed. The satellite data were in three electromagnetic spectral bands (band 1: 0.63-0.69 μm, band 2: 0.75-0.90 μm and band 3: 1.55-2.35 μm). Its sensor provided the data with 30 m spatial resolution.

Data processing for the model

Hydrological data

The hydrological data shall be processed using statistical and graphical procedures. Observed rainfall data of Upper Betwa Basin were used to prepare input file for model. Similarly daily temperature data file was also prepared and given to the model as input.

Map registration and digitisation

ERDAS 9.3, the image processing package and a GIS (Arc GIS 9.3) software package were used to process the data as per the need in the input files of the SWAT model. All the maps including topographic and soil texture were traced carefully and scanned with 300 dpi (dots per square inch). The scanned maps were saved in TIFF format and imported to the ERDAS for further processing. The latitude and longitude of the ground control points were converted to actual ground co-ordinate. The boundary of the Upper Betwa Basin was carefully digitised.

Extraction of basin characteristics

Advanced Space-borne Thermal Emission and Reflection (ASTER), elevation data was used for preparing digital elevation model and drainage network using ARC-GIS software. Flow accumulation and flow direction theme were also developed. Based on soil and land use classes Hydrologic Response Units (HRUs) were generated for the whole basin using ArcSWAT model.

Soil map

The soil map of the basin was carefully traced, scanned and exported to the ArcGIS. Map to map registration was performed using the registered topographic maps. Different soils were carefully traced and the polygons representing various soils were then flood filled with different colours for proper identification. The areas under different soils were identified and presented in figure 2.

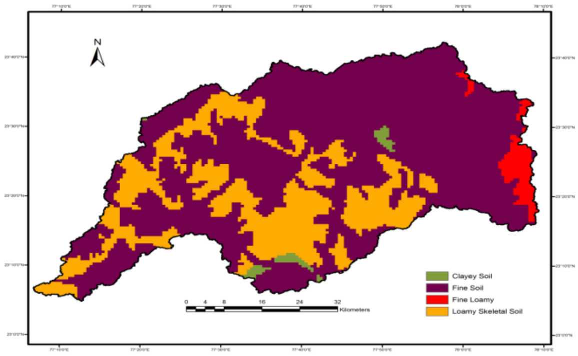

Figure 2. Soil map of Betwa Basin

The soil distributed in the Betwa river are classified into Clayey Soil,Fine Soil,Fine Loamy, and Lomey Skeletal Soil types (Figure 2). All of those soils are fine textured (clay to silt clay) and their soil fertility is generally poor, being susceptible to soil erosion. Among them, Clayey Soil and Fine Soil are categorized as highly fragile to surface soil erosion.

Land use/land cover classification

The supervised classification has been used in this study for classification of satellite data.\ Maximum Likelihood Classifier (MLC) module was used for classifying the land uses. The classification was done by the Ground Control Points (GCPs). These GCPs were taken with the help of Hand Held GPS during field visit of basin. Each pixel in the image data set was then categorised into the land use class it most closely resembles. The land use/cover classes were cropland, fallow land, scrub, barren land, water body and settlements. Areas occupied by each land use for each sub-watershed were determined in figure 3.

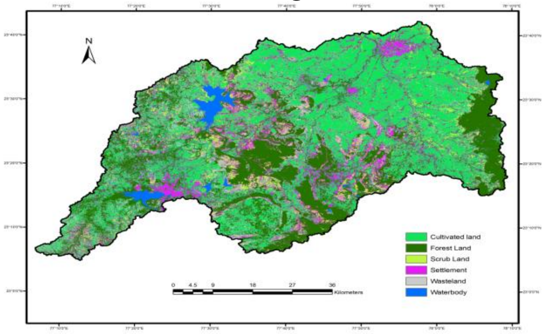

Figure 3. Land use map of Betwa basin

Land use and soil Characterization

Soil and vegetation cover plays a significant role in the water movement process. Since the infiltration capacity of soil depends on the soil texture the highest infiltration rates are observed in sandy soils. This indicate that surface runoff is highest in clay or loamy soils which has low infiltration rates. Vegetation on the other hand acts as a barrier to flow of water. Dense vegetation covers the soil from raindrop impact and reduces the problems of erosion.

In the present study the prepared land use and soil maps were converted into ArcInfo Grid format using ERDAS Imagine software and was imported in the AVSWAT model. Both the land use and soil map were made to overlay and was they subdivided into hydrologic response units (HRU) based on the land use and soil types Subdividing the areas into areas into hydrologic response units enables the model to reflect the evapotranspiration and other hydrologic conditions for different landcover/ crops and soil (Neitsch, 2002).

RESULTS AND DISCUSSION

Table 1 Catchment wise land use / land cover pattern of upper Betwa basin in 1992

Land use / land cover	Area under different land use and land cover (sq km)					
	Vidisha	Raisen	Bhopal	Rajgarh	Total	% Area
Agricultural land	4864.876	5350.51	15.38.46	1138.49	12892.32	51.06
Water land	387.71	99.05	74.28	3.07	564.13	2.27
Forest	884.52	1854.05	371.44	1975.43	5085.46	20.53
Urban land	265.35	491.02	158.00	941.56	1855.92	7.49
Waste / barrier land	162.16	330.17	526.68	1520.65	2539.66	10.25
Scrub land	803.43	287.84	623.97	1162.49	2877.75	11.62
Total Geographical	7371	8466	2772	6154	24763	

Table1 presents the land use data of 1992 collected from Commissioner of Land Records Madhya radish, Gwalior. It is well evident from the data that there was reasonable change is land use in the Betwa basin.

Land use /land cover distribution

The land use land cover distributions for year 2002 as derived from the maps are presented in the table below:-

Table 2 Land use / land cover distribution of upper Betwa Basin (2002)

Land use / land cover categories	Land use area in 2002	
	Square km	Area Percentage
Agricultural land	10301.40	41.6%
Water land	391.25	1.58%
Forest land	7015.33	28.33%
Urban land	3585.68	14.48%
Waste / barrier land	1844.84	7.45%
Scrub land	16196.50	6.54%

The remote sensing image analysis of land use pattern at Betwa basin presented in table 2. which represents the static area of each land use land cover category for the year 2002.Less than 15% area under built up land / village category depicts the natural of social structure of the study area in the year 2002. More than 40% of agriculture land show the dependency of the population on agriculture for livelihood. The total forest cover (both dense and degraded) of is about 28% which shows the presence of good natural habitat. Also the water land was less (<7.45%). Water bodies covered around 1.58% of the total areas. The soil distributed in the upper Betwa basin are classified into clayey soil 1.26%, fine soil 69.09%, fine loamy soil 3.01%, Loamy skeletal soil 26.65%, all of the those soils are fine textured (clay to silt clay) and their soil fertility is generally poor, being susceptible to soil erosion. Among, clayey soil and fine soil are categorized highly fragile to surface soil erosion.

The result derived from the remaining land use in table 1 imply that between 1992-2002 forest area was increased about 7 percent of the scrub area and 7 percent urban area increased while the other classes were decreased. The largest increased category was urban /settlement because the upland of upper Betwa basin has been place suffered as rapid increase in population as well as due to the rise semi-urban and urban centers in Berasia and Raisen which are the result of industrial development of upper betwa basin.

CONCLUSION

The soil distributed in the Betwa river are classified into Clayey Soil,Fine Soil,Fine Loamy, and Lomey Skeletal Soil types . All of those soils are fine textured (clay to silt clay) and their soil fertility is generally poor, being susceptible to soil erosion. Among them, Clayey Soil and Fine Soil are categorized as highly fragile to surface soil erosion.. Low-lying flat lands in the Betwa Basin have been widely developed for paddy cultivation. Upland fields with an elevation of 200-1000 m have been also developed for agricultural uses. Since the completion the Betwa Basin, forest areas have drastically decreased and upland field have been increased. It is considered that such changes of land uses in the basin might be one of main causes for the drastic increase of soil erosion within the basin.

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