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Research Article

STUDIES ON LAND USE AND LAND COVER OF LOWER SONE BASIN USING REMOTE SENSING AND GIS

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Abstract- Land use/ land cover is an important component in understanding the interactions of the human activities with the environment and thus it is necessary to monitor and detect the changes to maintain a sustainable environment. The Landsat-8 satellite system has long term data archives and can be used to assess the land cover changes in the landscape to provide information to support future urban planning. In this paper an attempt has been made to studies on land use and land cover of lower Sone basin. The study was carried out through Remote Sensing and GIS. Landsat-8 imagery of 2015. The value of elevation varies from 17–599 m in the study area. In the present study, threshold values of 10% for Land use class, 10% for Soil class and 10% for Slope class are considered, resulting in formation of 158 HRUs in the study area spread over 37 subbasins. The study area was classified water (0.58%), Forest-mixed (5.50%), Sugarcane (5.41%), Rice (79.69%), Tomato (6.23%), Corn (1.53%) and Pine (1.06%). The soil of the study area is divided into sandy- clay- loam (4.34%), sandy- loam (9.91%) and loam (85.75%) on the basis of soil texture. GIS software is used to prepare the thematic maps and ground truth observations were also performed to check the accuracy of the classification. It does not indicate any significant environmental impact on the study area. However, it is necessary to closely monitor the land use/land cover changes for maintaining a sustainable environment.

Keywords- Remote Sensing, Geographical Information System, Land Use, Land Cover.

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Introduction

Remote Sensing (RS) and Geographic Information System (GIS) are now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of Earth – system function, patterning and change at local, regional andglobal scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity [1]. Remote Sensing data has been the most important data source for environment change studies and a large collection of Remote Sensing images has made it possible to analyse Spatio–temporal patterns of environmental elements and impact of human activities. Remote Sensing has been widely reported to be used for change detection and monitoring [2]. An understanding of the pattern, causes and both the social and ecological consequences of historical changes will enhance our capability to predict future landscape dynamics and devise more effective landscape management strategies. The present study combines the scientific research techniques of GIS and RS as mapping tools, accompanied by ground observations. Geographic Information System (GIS) is an information technology that has been used in public policy-making for environmental and forest planning and decision-making over the past two decades [3].GIS and related technologies provide foresters with powerful tools for record keeping, analysis and decision making.

Automatic inference of land use information from land cover is problematic given the complex area-specific relationship between land cover and land use. Satellite RS, used alone, currently offers limited possibilities for routinely providing comprehensive agricultural land use information, including important land management aspects. This is the manner in which human beings employ land and its resources. Land use includes agricultural land, built–up land, recreational area, wildlife management area etc. Land use is defined as the arrangement activities and inputs people undertake in a certain type to produce, change or maintain it. This definition of land use establishes a direct link between Land cover and the action of people in their environment [4]. Land use includes agricultural land, urban development, grazing, mining, recreation area, wildlife management and area which include land for economic activities. Land cover refers to the physical characteristics of earth's surface in the distribution of vegetation, water, soils, and other physical features of the land including those created solely by human activities, e.g., settlement. Land cover plays a pivotal role in impacting many parts of the human and physical environment [5]. Human intervention and natural phenomena cause change in land cover day by day. Land cover change give important information about a number of applications like agriculture, hydrology, forestry and ecology, grass land, bare soils etc. For example, in a forestation programme, we need to know the areas where forests are degrading or areas with less forest, etc. Land cover implies the physical or natural state of the earth's surface. It can be covered by the various physical features like vegetation, wetland roads, grassland, water body and hill etc. RS has an important role in the analysis of land use and land cover of area. In order to use land optimally it is necessary to have information of existing land cover/ land use and the capability to monitor the dynamics of land use resulting out of newer demands of increasing population and changed lifestyles. The developments in computing technology and recent advances in the availability of digital datasets and the use of geographic information systems (GIS) for water resources management have revolutionized the study of hydrologic systems.

Study Area

The river Sone is an important right bank tributary of the river Ganga. It originates from Amarkantak high lands in hills of Maikala range in Bilaspur district of Chhattisgarh at an elevation of 640 m and latitude 20°44' N and longitude 82°4'E. The river outfalls into the Ganga at about 16 km. upstream of Patna at latitude 25°14' N and longitude 84°42' E. The total length of the river is 881 km. The total catchment area of river system is 70,055 sq.km.

The catchment of the whole river system is surrounded by the Vindhachal range in the North, the Punpun river system and the Chotanagpur plateau on the East, the Baghelkh and plateau and the Mahadeva hills on the South and the forest clad Maikal and Bhamver ranges on the West . After flowing a distance of 655 km.through the states of Chhattisgarh, Madhya Pradesh and Uttar Pradesh, the river Sone enters in Jharkhand. Its important tributaries lying in their states of Chhattisgarh, Madhya Pradesh, Uttar Pradesh and Jharkhand are Johilla, Mahanadi, Banas, Gopad, Rihand, Ghagher, Kanhar and North Koel. The river Kanhar which flows South to North and in the downstream reach forms boundaries between Jharkhand and Madhya Pradesh. After meeting with the river Kanhar, the river Sone enters Jharkhand and joined by the river North Koel on its right bank. The river, thereafter, takes a sharp North-East turn and finally joins the river Ganga. But my study area focus on catchment area 135700.11 hectare from Arwal, Aurangabad, Arrah, Bhabua, Buxar, Jahanabad, Rohtas and Patna district in Bihar state, Garhwa and Palamu district in Jharkhand.

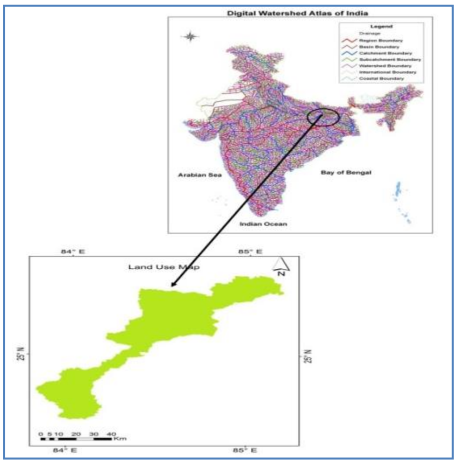

Fig-1 Location of study area

Material and Methods

INPUT DATA

A. Digital Elevation Model (DEM)

The DEM is the raster data consisting of sampled array of pixels containing elevation values representing ground positions at regularly spaced intervals. It is used for watershed and stream network delineation and the computation of several geomorphological parameters of the catchment including slope for HRUs. The Shuttle Radar Topography Mission (SRTM) obtained elevation data on a near-global scale to generate the most complete high-resolution digital topographic database of Earth. For the present analysis projected DEM to WGS_1984_UTM_Zone_44N coordinate system is used in ArcSWAT Watershed Delineator for watershed delineation.

B. Landuse /Land Cover

The land use / land cover data of the study area is required for HRU definition and subsequently for assigning the Curve Numbers (CN) to the land areas for runoff computations and hydrological analysis. The land use of an area is one of the most important factors that affect surface erosion, runoff, and evapotranspiration in a watershed during simulation. Land use/Land cover classified data of Landsat-8 of USGS-U.S Geological Survey for this study.

C. Soil Map

The soil map of the study area has been obtained from digital soil data of Food and Agriculture Organization (FAO). The soil is classified into different categories on the basis of USDA taxonomy *viz*., Typic Paleustalfs, Aeric Ochraqualfs, Vertic Ustochrepts, Typic Haplustalfs, Typic Haplaquepts, Typic Ustochrepts, Typic Ustifluvents, Typic Ochraqualfs, Aquic Ustipsamments, Lithic Ustorthents, Aeric Haplaquepts, Vertic Ochraqualfs, Typic Haplaquents and Fluventic Ustochrepts.

D. Watershed delineation by SWAT.

Watershed delineation tool is used to delineate sub-watersheds based on an automatic procedure using the DEM of the area. The basin has to be delineated into an adequate number of hydrologic response units which will take account of changes in climate, land use and soil types. Accordingly, the basin is divided into 37 sub-basins. The Hydrological analysis in SWAT is carried out at Hydrologic Response Unit (HRU) level, on daily time step. HRUs are lumped land areas within each subbasin with unique land cover, slope, soil and management combinations. Runoff is calculated for each HRU separately and routed to obtain the total runoff. The land use/land cover map, soil map and slope maps of the study area have been overlaid to demarket HRUs. Area below the given respective threshold values are ignored while delineating the HRUs. In the present study, threshold values of 10% for Land use class, 10% for Soil class and 10% for Slope class are considered, resulting in formation of 158 HRUs in the study area spread over 37 subbasins.

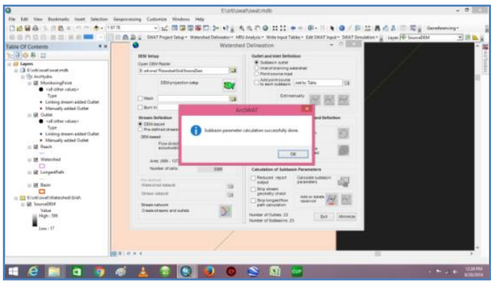

Fig-2 Watershed Delineation

Result and Discussion

DEM

The general topography of the catchments was studied through the digital elevation model generated from SRTM data. Elevation was considered as one of the important variables for the assessing runoff. During the monsoon season, the area with high elevation having steep slope causes more discharge in lowland areas [6]. The value of elevation varies from 17–599 m in the study area. The elevation value of the study area, where construction of Greater Kaimur range is going on, is equal to 599 m and where the link will finish, near Palamu, is equal to 518 m. So this shows the alignment of Sone river is appropriate [Fig-3]. Low elevated areas are the places to be inundated first during flood, therefore, were given higher rank. Higher elevation and steep slope cause quicker depletion of storage, which results as larger peak discharge in the downstream reaches, especially close to the proposed dam; therefore, high elevated area was given higher rank for erosional hazard.

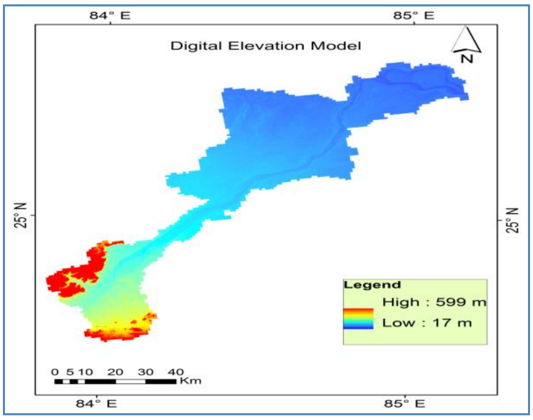

Fig-3 DEM map of study area.

Drainage

Evaluation of the characteristics of the drainage pattern of a river basin using quantitative morphometric analysis provides information about the hydrological nature of the rocks exposed within the drainage area [7]. A drainage map of a river basin provides a reliable index of the permeability of the rocks and also gives information about basin yield [8]. Drainage map of the study area represents the network of main streams in the catchments, followed by the tributaries up to the last order. The drainage map shows the major river Sone, and a large number of other streams draining this study area [9]. The drainage pattern in the area was dendritic, pinnate type [Fig-4]. The southern part of the area, where proposed Sone barrage exists falls into the high drainage density. About 40% of the area upstream of the proposed barrage shows medium drainage density [Fig-4]. The area having higher drainage density causes low infiltration and the movement of the surface runoff is faster therefore it causes more erosion hence was given a higher rank for erosion zonation [10].

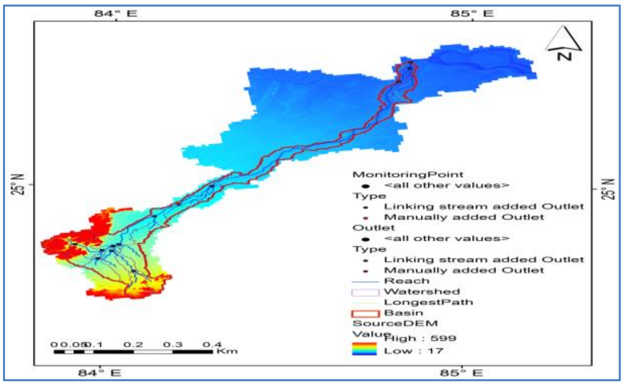

Fig-4 Drainage map of study area.

Land use/Land cover

Various land use/land cover classes were mapped from Landsat data through unsupervised classification [11,12]. Land use/land cover study is useful in assessing impacts of river linking on land resources. Landsat-8 satellite data of year 2015 and topographic maps were used to prepare the land use/land cover map of the area through hybrid image classification technique. The study area was classified into 9 categories *viz.* water, Forest-mixed, Sugarcane, Rice, Tomato, Corn, Pine, Range-Grasses, Italian Ryegrass. The classified image depicting various land use/land cover classes of the study area is shown in [Fig-5]. The land use/land cover statistics of the study area presented in [Table-1] but Range-Grasses and Italian Ryegrass did not found in the study area. Due to seasonal variability in water quantity, some area that was submerged during monsoon season may not have been present on the date the images were taken and therefore not more identified as water in the classification. The characteristics of forested areas also changed dramatically depending on season.

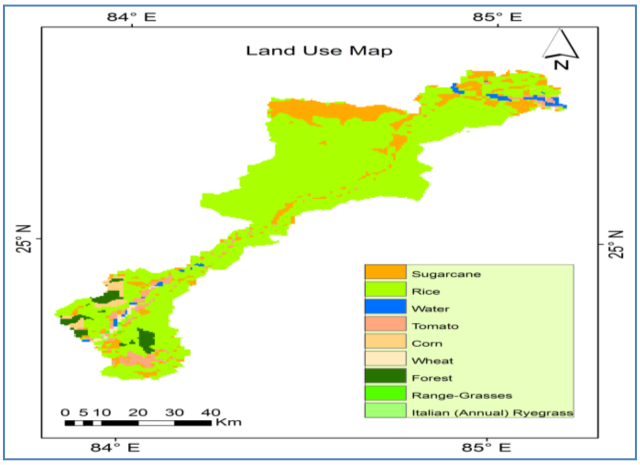

Fig-5 Land use/Land cover map of study area.

Table-1 *Percentage of various land use/land cover classes in the study area*

Sl. No.	Land use		Area		Percentage
	Crop	Code	Acre	Hectare	
1	Sugercane	SUGC	18135.3184	7339.1143	5.41
2	Rice	RICE	267216.4820	108138.8406	79.69
3	Tomato	TOMA	20902.3381	8458.8892	6.23
4	Water	WATR	1952.7965	790.2699	0.58
5	Forest-Mixed	FRST	18434.3247	7460.1180	5.50
6	Cor n	CORN	5138.0736	2079.3078	1.53
7	Pine	PINE	3542.4236	1433.5702	1.06

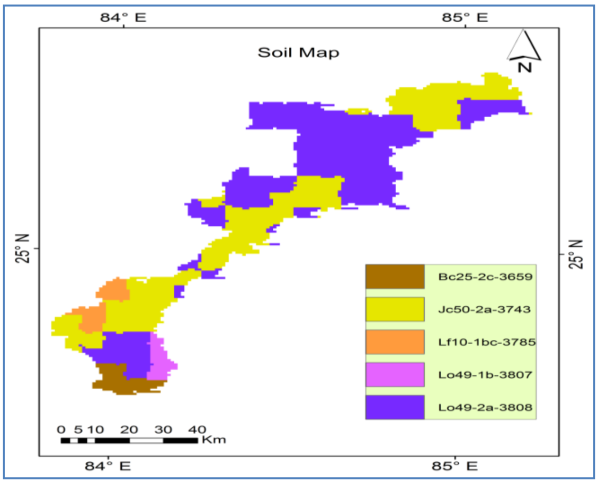

Fig-6 Soil map of study area.

Table-2 *Percentage of various soil classes in the study area*.

Sr. No.	SNAM	SEQN	TEXTURE	Area		Percentage
				Acre	Hectare	
1	Bc25-2c-3659	3659	SANDY_CLAY_LOAM	14551.4900	5888.7882	4.34
2	Jc50-2a-3743	3743	LOAM	172814.4686	69935.6422	51.54
3	Lf10-1bc-3785	3785	SANDY_LOAM	19933.6763	8066.8851	5.94
4	Lo49-1b-3807	3807	SANDY_LOAM	13316.0283	5388.8138	3.97
5	Lo49-2a-3808	3808	LOAM	114706.0935	46419.9808	34.21

Soil map of the study area

The soil of the area is divided into sandy- clay- loam, sandy- loam and loam on the basis of soil texture. Most of the part of study area is covered by loamy soil. Loamy sand soil is present in most of the Patna, Bhojpur, Arwal and, east part of Rohtas district, while west part of Rohtas and Bhabua (Kaimur) district are covered by sandy-loam and Aurangabad district is covered by sandy- clay-loam. Linking canal is covered by loamy soil [Fig-6]. Soil erodibility is a function of several soil properties such as the particle size distribution, organic matter, moisture, top soil shear strength, infiltration capacity, etc.. Soil particle size plays important role in erodibility, like clay particles that cannot be detached easily but can be easily transported, while sand particles are opposite. Loamy sand soil is more predominant in the north-western region of the study area with poor moisture retention causing extensive erosion. On the other hand, sandy- loam and sandy-clay-loam soils, which are present mostly in the south region have higher water retention capacity and therefore are less prone to erosion. Clayed loam soil has given higher rank for inundation because of high storage capacity of soil and loamy sand has given higher rank for erosion because of low storage capacity.

Conclusion

The study clearly established that the satellite remote sensing coupled with GIS can be a powerful tool for mapping and evaluation of land use/land cover classification of lower Sone basin. The significant in the land use/land cover during the classification recorded some interesting observations. During this time span the significant positive observations as per environment is concerned are the natural systems represented by natural drains, mud flats, mangroves and river systems indicated significant. More than 60% of agriculture land shows the dependency of the population on agriculture for livelihood. The total forest cover (both dense and degraded) of is less than 28% which shows the presence of bad natural habitat. Also the water land is less (<7.45%). Water bodies covered around 0.58 % of the total areas. Which shows continuously decrease water body area it is very harmful for the agriculture and livelihood. In general the land use/land cover data during the study of the lower Sone basin indicated certain significant which may not show any significant environmental impact. However, these trends need to be closely monitored for the sustainability of environment in future.

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Author Contributions: All author equally contributed

Abbreviations:
GIS: Geographic Information System
DEM: Digital Elevation Model

Conflict of Interest: None declared

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