LAND USE AND LAND COVER CHANGES AT UPPER NAGWAN WATERSHED USING GIS AND REMOTE SENSING

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Abstract

Hydrological process in a mixed land use watershed are significantly influenced by land use (LU) and land cover(LC) in order to quantity the effect of LU/LC, topography, morphology, runoff and sediment yield of a small multivegetated watershed in a sub-humid sub tropical region in Nagwan watershed, Hazaribagh, India. The sub-watershed with relatively high forest cover showed significantly less runoff and sediment yield, where as a sub-watershed with more area under cultivation produced higher runoff and higher sediment yield. In the watershed comprising areas under cultivation, waste follow and eroded land, forest and bushes. Remote sensing has emerged as a powerful tool for cost effective data acquisition in a short time at periodic intervals (temporal), different wave length lands (speotral) and covering large area (spatial). The availability computing facilities makes it possible to overcome many difficulties and limitations and to develop distributed continuous models, based on available regional information.

Introduction

Water is essential for life. However, availability of fresh water is scarce and has become a prime concern over the last decades. Demand and competition for water continue to grow almost everywhere. The main reason can be explained by the increase of the world population leading to higher demand on water in many activities such as agriculture industry due to such activities make this resource limited and now a days is considered as water crisis.

Catchment models are in general designed to meet two primary objectives. The first is to gain a better understanding of the hydrologic behaviors and the second objective is the generation of synthetic hydrologic data for the catchment. They are also providing valuable information for studying the potential impacts of changes in land use of climate. In catchment modeling, water quantity and water availability are considered traditionally by simulating the relation between precipitation and discharge at the river outlet. Rainfall – runoff modeling is a major part of this job. Therefore, rainfall – runoff modeling is considered as standard tool routinely used today for the investigation and application in catchment hydrology. However due to catchment heterogeneity, dynamic and non-linear hydrologic behavior, it is not easy to quantity the runoff of the system adequately. Appropriate modeling requires a certain level of understanding of the physical characteristics. It becomes even more difficult if data from the catchment is not available, commonly referred as an ungauged catchment.

Precipitation is the most essential process for the generation of runoff at a catchment scale. The distribution of Precipitation varies spatially and temporally in the nature. Due to vegetation, part of rainfall is intercepted by vegetation canopy. Interception is known as a loss function to catchment runoff depending on vegetation type, vegetation density. Rainfall remains at the land surface as depression storage and either evaporates, infiltrates or is discharged as overland flow. Basically, the runoff generation at a catchment scale in general includes two main components: (1) surface runoff (2) subsurface runoff.

Study area

The Nagwan watershed is located at Upper Siwane river of Damodar-Barakar basin in the Hazaribagh District of Jharkhand, India, and lies between 85.25º to 85.43º E longitudes and 23.99º to 24.12º N latitude. The location and topographic map of Nagwan watershed is shown in Figure 1. The catchment is rectangular in shape with an area of 92.46 sq km and length-width (L/W) ratio as 2.7. The maximum and minimum elevation in the catchment is 640 m and 550 m respectively above mean sea level. The catchment has very undulating and irregular slope varying from 1 to 25%. The climate of watershed is sub-tropical with three distinct seasons viz. winter (October to February), summer (March to May) and monsoon (June to September).

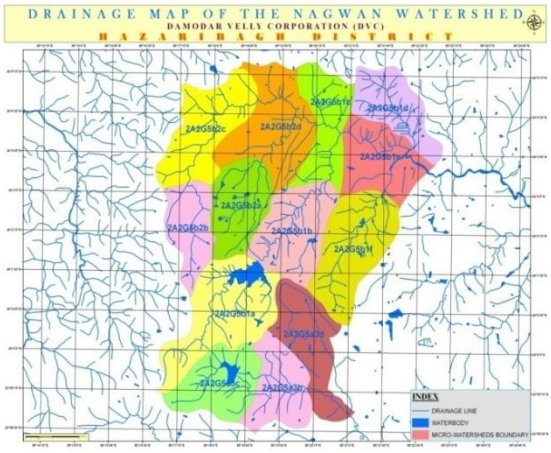

Fig.1:-Drainage map of Nagwan watershed.

Nagwan Watershed:

Name of watershed	Nagwan
Name of the RVP/FPR Project	D.V.C.
Name of sub-watershed	U/SEWANI
Year of starting of observation	Since 1959-CONT.

Location

1) Longitude	85^0 16' 52" E to 85^0 22' 50" E
2) Latitude	23^0 58'25" N to 24^0 5' 36" N
3) Stream	U/SEWANI
4) Basin	Damodar Basin

Physiographic details:

1) Watershed area	9246 ha
2) Shape of watershed	Rectangular
3) Soil type	Red loam soil and loam
4) General slop of land	1-5%
5) Land use practices	Sheet to gully
6) Type of vegetation	P.C., U.C., G.L.

Method of measurement

1) Rainfall	Standard rain gauge
2) Runoff	Velocity area method
3) Watershed treatment	U.S.D.H.-48 sampling

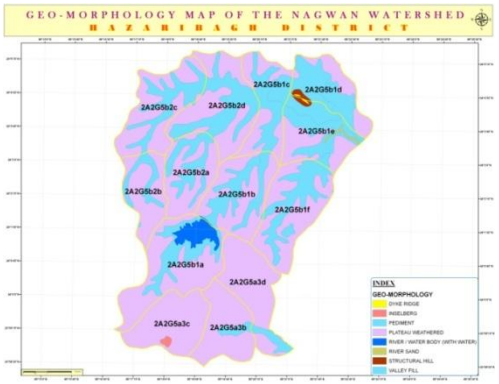

Fig.2:-Geo-Morphology Map of the Nagwan Watershed.

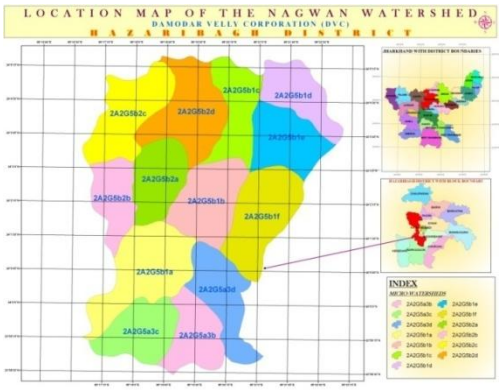

Fig.3:-Location Map of the Nagwan Watershed.

Data availability

The soil data and related maps (1:25,000 scale) were collected from All India Soil and Land Use Survey, Department of Agricultural and Cooperation, Government of India, Kolkata. Topographic maps (1:25,00 scale) were collected from the Survey of India (SOI), Kolkata. Digital data (IRS-ID LISS-III pertaining to February,2005, Feb 2009 and Feb 2011 were obtained from the National Remote Sensing Agency, Government of India, Hyderabad.

Satellite Data

The Landsat 7ETM+ images February, 2005 was downloaded for the full scene of the path and row 143/43 from global land cover facility site. The raw images acquired had file formats as TIF. Pre-processing such as geometric, radiometric and atmospheric corrections which are a prerequisite for analysis of land cover parameters were done. All the operation from importing the data to analysis of the data was carried out in the GIS & RS software ILWIS (Integrated Land Water Information System).

The Enhanced Thematic Mapper Plus (ETM+) is multispectral scanning radiometer carried on board of Landsat 7 satellite. The sensor has provided nearly continuous acquisitions since July 1999, with a 21-day repeat cycle. It has an advantage as compared to the other sensors in respect to measurement precision and spatial resolution. The sensor provides 8 bands with three different resolutions, over a swath width of 183 km. Table 1 gives the sensor characteristics of ETM+sensor

Table 1. Spectral characteristics of Landsat 7 ETM +

Band Number	Wavelength region	Spectral Range (μm)	Resolution (m)	Swath width (km)
1	VIS	0.45-0.52	30	183
2	VIS	0.52-0.60	30	
3	VIS	0.63-0.69	30	
4	NIR	0.76-0.90	30	
5	SWIR	1.55-1.75	30	
6	TIR	10.42.12.50	60	
7	SWIR	2.08-2.35	30	
8	PAN	0.52-0.90	15	

The satellite data would be used for preparing the landuse/landcover map of the study region. Only the first four bands of the ETM+sensor was required for the present study, hence these were downloaded and directly imported into the ILWIS software. A sub-map of the Landsat image consisting the study region was extracted from the single frame and was georeferenced using the Survey of India toposheet of the region. An unsupervised operation was executed to classify the image data. In unsupervised classification image data is grouped into spectral classes based on the statistical properties of all pixel values. It is an automated classification approach with a maximum of four input bands. In the first phase of the operation, a multidimensional histogram of the input bands is calculated. The multidimensional histogram is a representation of the feature space. In the second phase, this feature space is split into several boxes to obtain the desired number of classes. The study region was classified into five groups namely Agricultural, Built-up, Forest, Wasteland and Water bodies land. Figure 4 to 6 shows landuse/landcover classification map for the study region.

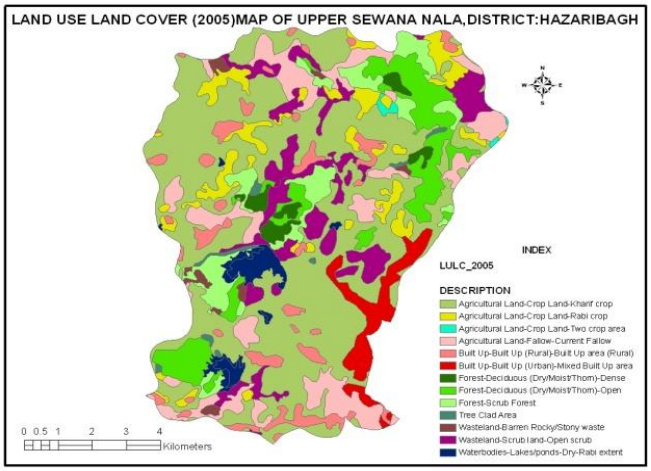

Fig.4:- Land use map of Nagwan watershed, 2005

Table 2 . Land use/land cover pattern of Nagwan watershed, 2005.

YEAR-2005		
SL. NO	TYPE OF LAND USE LAND COVER	AREA (In Ha)
1	Agricultural Land-Crop Land-Kharif crop	4130.2801
2	Agricultural Land-Crop Land-Rabi crop	621.4758
3	Agricultural Land-Crop Land-Two crop area	24.4606
4	Agricultural Land-Fallow-Current Fallow	1035.8452
5	Built Up-Built Up (Rural)-Built Up area (Rural)	486.7641
6	Built Up-Built Up (Urban)-Mixed Built Up area	347.6896
7	Forest-Deciduous (Dry/Moist/Thorn)-Dense	736.8839
8	Forest-Deciduous (Dry/Moist/Thorn)-Open	172.2172
9	Forest-Scrub Forest	611.3552
10	Tree Clad Area	62.6706
11	Wasteland-Barren Rocky/Stony waste	88.0459
12	Wasteland-Scrub land-Open scrub	720.4368
13	Waterbodies-Lakes/ponds-Dry-Kharif extent	207.8750
	TOTAL	**9246.0000**

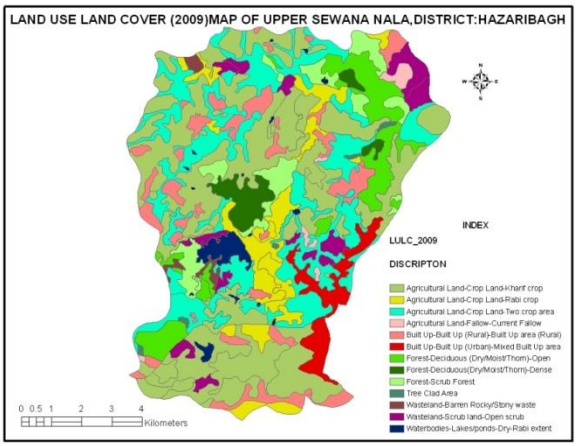

Fig.5:- Land use map of Nagwan watershed, 2009

Table 3 . Land use/land cover pattern of Nagwan watershed,2009.

YEAR-2009		
SL. NO	TYPE OF LAND USE LAND COVER	AREA (In Ha)
1	Agricultural Land-Crop Land-Kharif crop	3438.2671
2	Agricultural Land-Crop Land-Rabi crop	743.1176
3	Agricultural Land-Crop Land-Two crop area	1693.7748
4	Agricultural Land-Fallow-Current Fallow	82.2118
5	Built Up-Built Up (Rural)-Built Up area (Rural)	753.2446
6	Built Up-Built Up (Urban)-Mixed Built Up area	359.9344

7	Forest-Deciduous (Dry/Moist/Thorn)-Open	710.3935
8	Forest-Deciduous(Dry/Moist/Thorn)-Dense	268.7037
9	Forest-Scrub Forest	519.6005
10	Tree Clad Area	32.3806
11	Wasteland-Barren Rocky/Stony waste	68.9971
12	Wasteland-Scrub land-Open scrub	406.6932
13	Waterbodies-Lakes/ponds-Dry-Rabi extent	168.6811
	TOTAL	**9246.0000**

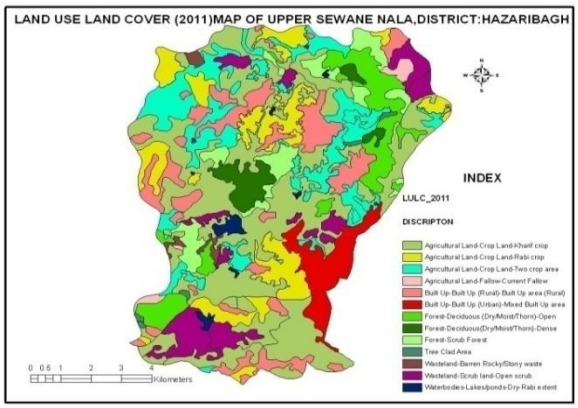

Fig 6. Land use map of Nagwan watershed, 2011

Table 4. Land use/land cover pattern of Nagwan watershed, 2011.

YEAR-2011		
Sl. No	**TYPE OF LAND USE LAND COVER**	**AREA (In Ha)**
1	Agricultural Land-Crop Land-Kharif crop	3133.3202
2	Agricultural Land-Crop Land-Rabi crop	1130.6578
3	Agricultural Land-Crop Land-Two crop area	1300.3878
4	Agricultural Land-Fallow-Current Fallow	77.9863
5	Built Up-Built Up (Rural)-Built Up area (Rural)	1031.0140
6	Built Up-Built Up (Urban)-Mixed Built Up area	462.6970
7	Forest-Deciduous (Dry/Moist/Thorn)-Open	673.2358
8	Forest-Deciduous(Dry/Moist/Thorn)-Dense	270.4914
9	Forest-Scrub Forest	519.2156
10	Tree Clad Area	34.7860
11	Wasteland-Barren Rocky/Stony waste	68.8790
12	Wasteland-Scrub land-Open scrub	449.7349
13	Waterbodies-Lakes/ponds-Dry-Rabi extent	93.5942
	TOTAL	**9246.0000**

RESULTS AND DISCUSSION

After finishing all field, experimental work and preparing the needed maps for the Nagwan watershed. The calculation was done through the map calculator using grid data and ArcGis.9 Spatial Analyst Extension.

Grid system divides the surface on which they are distributed into a matrix of identically squared sized cells. Each cell is filled in with a number that stores the object's attribute value at that location.

There are many things that ArcGis.9 Spatial Analyst can do with grids. It can estimate values for an entire surface from a limited number of measured sample points. This process was used to interpolate the infiltration measurement.

ArcGis.9 spatial analyst deals with a map as matrix, map Algebra is math applied to grid, so it is possible to add, subtract and multiply the maps because grids are geographically referenced array of numbers. By combining and analyzing the land use map with the hydrologic soil group for Nagwan watershed in Hazaribagh were estimated.

Drainage network and surface water bodies

Mapping of depression storage in the form of lakes, ponds and reservoirs using IRS LISS-IV data suggests that the surface storage is distributed throughout the watershed but more number of ponds are found in the upper reaches of the watershed, where the drainage density and pattern are mainly controlled by lithology, minor and major scale fractures (lineaments) as well as slope.

Stream ordering is done for proper planning of conservation measures in terms of storage and capacity. The schematic representation of the drainage network along with stream order is given in figure 1.

Land use

In the present study, the IRS LISS III satellite data of two seasons (representing two cropping seasons) are used for the generation of land use categories. Supervised classification is performed employing the Bayesian Maximum Likelihood Classifier (MLC). MLC, a parametric decision rule, is a well-developed method from statistical decision theory that has been applied to the problem of classifying image data (Settle and Briggs 1987). Information collected from the All India soil and land use survey, Department of Agricultural and Cooperation, Govt. of India, Kolkata. Survey of India (SOI) toposheets were collected from the survey of India (SOI, Kolkata) and personal field visit to the watersheds, it is used to identify the signatures representing various land use classes. They are then evaluated to make sure that, there is suitable discrimination of individual classes. After obtaining a suitable grouping for satisfactory discrimination between the classes

during signature evaluation, the final classification is carried out. The classification accuracy evaluated by confusion or error matrix, showed 92% and 95% accuracy for the producer and the user estimates respectively. In all, five major land use classes namely. Agricultural land (62.86%), Built up area (9.02%), Forest land (17.12%), wasteland 8.74%) and water body (2.24%) are observed in 2005 fig.7, Agricultural land (64.42%), Built up area (12.03%), Forest land (16.55%), wasteland (5.14%) and water body (1.82%) are observed in 2009 fig.9 and Agricultural land (61.02%), Built up area (16.15%), Forest land (16.19%), wasteland (5.60%) and water body (1.01%) are observed in 2011 fig .11. It is evident from the field study that:

- This was concluded from the study that the each land cover/land use studies shows that built up area has been increased to 7% in 6 years and agriculture area has been decreased to 2%.
- Thematic layers derived from high spatial resolution satellite data may further help to increase the accuracy.

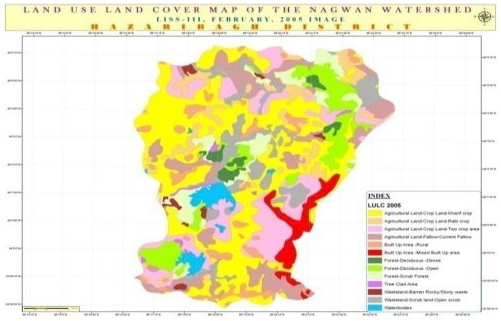

Fig. 7 Land use land cover map of the Nagwan Watershed 2005

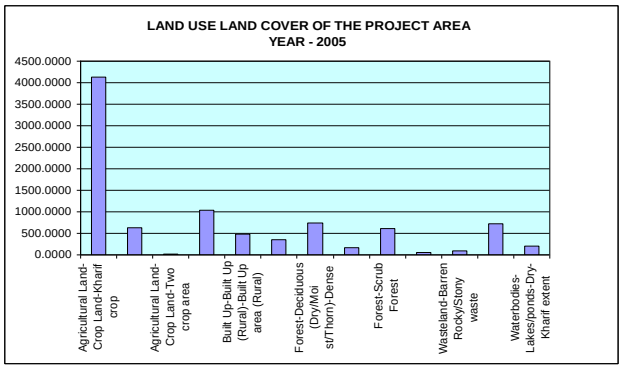

Fig.8 Land use land cover distribution of Nagwan Watershed 2005.

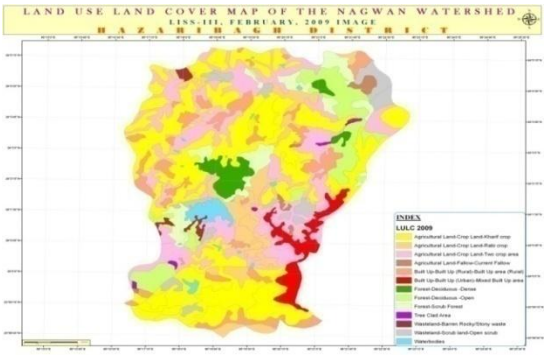

Fig.9. Land use land cover map of the Nagwan Watershed 2009

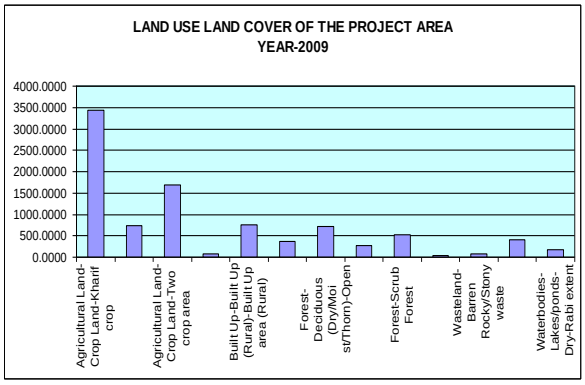

Fig 10. Land use land cover distribution of Nagwan Watershed 2009

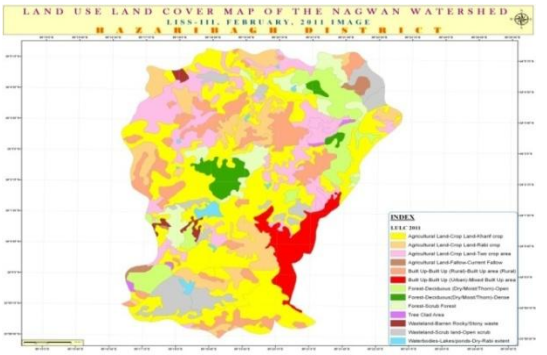

Fig 11. Land use land cover map of the Nagwan Watershed 2011

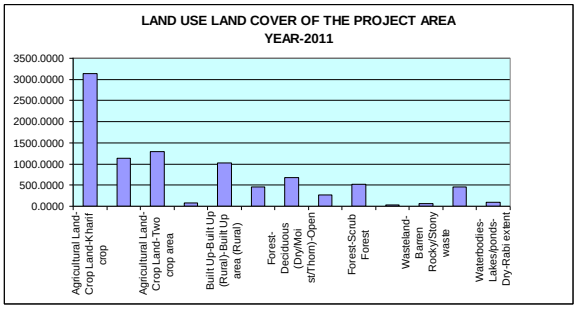

Fig 12. Land use land cover distribution of Nagwan Watershed 2011

Table 5. Land use land cover analysis of Nagwan Watershed.

SL.No	LAND USE LAND COVER(LULC)	Year-2005	year-2009	YEAR-2011
1	Agricultural Land-Crop Land-Kharif crop	4130.2801	3438.2671	3133.3202
2	Agricultural Land-Crop Land-Rabi crop	621.4758	743.1176	1130.6578
3	Agricultural Land-Crop Land-Two crop area	24.4606	1693.7748	1300.3878
4	Agricultural Land-Fallow-Current Fallow	1035.8452	82.2118	77.9863
5	Built Up-Built Up (Rural)-Built Up area (Rural)	486.7641	753.2446	1031.0140
6	Built Up-Built Up (Urban)-Mixed Built Up area	347.6896	359.9344	462.6970
7	Forest-Deciduous (Dry/Moist/Thorn)-Dense	736.8839	710.3935	673.2358
8	Forest-Deciduous (Dry/Moist/Thorn)-Open	172.2172	268.7037	270.4914
9	Forest-Scrub Forest	611.3552	519.6005	519.2156
10	Tree Clad Area	62.6706	32.3806	34.7860
11	Wasteland-Barren Rocky/Stony waste	88.0459	68.9971	68.8790
12	Wasteland-Scrub land-Open scrub	720.4368	406.6932	449.7349
13	Waterbodies-Lakes/ponds-Dry-Kharif extent	207.8750	168.6811	93.5942
		9246.0000	**9246.0000**	**9246.0000**

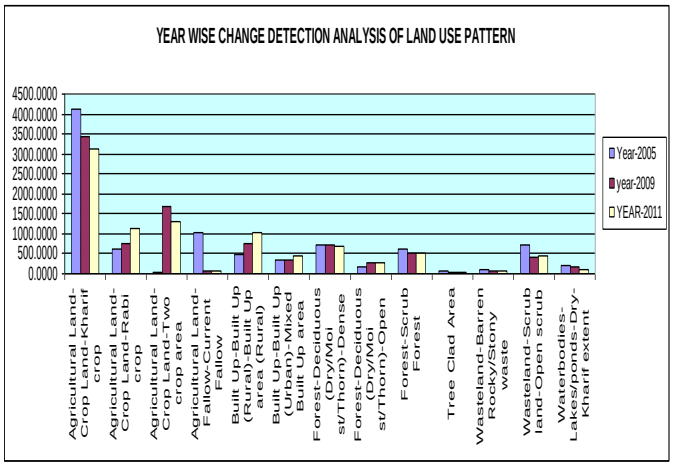

Fig 13. Land use land cover of Nagwan Watershed.

Table 6. Land use land cover(LULC) of Nagwan Watershed of different years.

Land use land cover (LULC)	2005	2009	2011
Agricultural land	5812.0617	5957.3713	5642.3521
Built up area	834.4537	1113.1791	1493.711
Forest land	1583.1269	1531.0783	1497.7288
Wasteland	808.34827	475.6903	518.6139
Water body	207.8750	168.6811	93.5942
Total	**9246.00**	**9246.00**	**9246.00**

Table 7. Land use land cover(LULC) of Nagwan Watershed of different years in percentage.

	2005	2009	2011
Agricultural land	62.8602	64.4210	61.0247
Built up area	9.0250	12.0395	16.1552
Forest land	17.1222	16.5593	16.1986
Wasteland	8.7441	5.1448	5.6090
Water body	2.2482	1.8243	1.0122

Table 8. Land use land cover changing in different years.

	2005-2009	2009-2011	2005-2011
Agricultural land	+1.5608	-3.3963	-1.8355
Built up area	3.0145	4.1557	7.1302
Forest land	-0.5629	-0.3607	-0.9236
Waste land	-3.5993	0.4642	-3.1351
Water body	-0.4239	-0.8121	-1.236

(+) =Increased (-)=Decreased

The remote sensing image analysis of land use pattern at Nagwan Watershed presented in table 5 which represents the static area of each land use land cover category for the year 2005,2009 and 2011. Less than 15% area under built up land / village category depicts the natural of social structure of the study area in the year 2005 and 2009 but in 2011 built upland is more than 15% which shows the presence of not good natural habitat. More than 60% of agriculture land show 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 2.24, 1.82 and 1.01% in 2005, 2009 and 2011 respectively of the total areas. Which shows continuously decrease water body area it is very harmful for the agriculture and livelihood.

The result derived from the remaining land use in table 6 imply that between 2005-2011, forest area was decreased about 0.92 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 Shiwani catchment has been placed suffered as rapid increase in population as well as due to the rise semi-urban and urban centers in Hazaribagh which are the result of industrial development of upper Shiwani catchment after distribution of Bihar and Jharkhand.

SUMMARY AND CONCLUSION

This was concluded from the study that the each land cover/land use studies shows that built up area has been

increased to 7% in 6 years and agriculture area has been decreased to 2%.

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