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LAND USE CHANGES IN ASHWANI KHAD WATERSHED USING GIS TECHNIQUES

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Since long, natural resources are being degraded due to population explosion and poor management of land use. The National Forest Policy (1988), envisages bringing one-third of the geographic area of the country under forest cover to maintain ecological balance and environmental stability. The forest cover of the country has been estimated to be 637.3 km^2 about 19.39% of the geographic area of the country. Agriculture is the most dominant land use followed by forest. Forestry and agriculture are two important land use, the latter competing with the former under relentless pressure of an ever increasing population which has grown from 361 million in 1951 to 955 million in 1997. To meet the requirement of food production, besides enhancing the productivity, the area under agriculture has increased from 118 million ha in 1951 to 142 million ha in 1997. Knowledge of extent of land utilization is essential for any land use planning to avoid any adverse consequences in future. Such planning also requires the knowledge of land diversion over a period of time to judge the priority of the area.

The Geographical Information System (GIS) and Remote Sensing (RS) techniques have recently been widely applied to study land use/land cover changes. The urban land use change of North Bhubanswer, Orissa was analysed by Mohanty (1994) using aerial photographs and satellite data. Ghosh *et al.* (1996) studied the land use/land cover change in a mountainous region of Himalayas using GIS and RS. MENRIS (1997) case study on land use changes in Pranmati watershed Garhwal Himalayas using IRS-1B inferred that cultivated land increased significantly at the expense of forests and pasture land. Jaiswal *et al.* (1999) and Minakshi *et al.* (1999) have studied the land use/land cover changes over a period of 30 years in a part of Gohparu block, Shahdol district of Madhya Pradesh and Dehlon block of Ludhiana district of Punjab respectively using GIS and RS. Brahmabhatt *et al.* (2000) studied the land use/land cover changes for period 1988 to 1997 in command area in Kheda district of Gujarat state using multi-temporal satellite data. Mahajan *et al.* (2001) studied the land use status of Ashwani khad watershed using IRS-ID satellite data and

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carried out topographic analysis using GIS techniques to show that altitude, aspect and slope exhibit marked affect on land utilization. Using multidate satellite imagery, Sarma *et al.* (2001) found changes in area under intensive agriculture, wetland and seasonal fallow during the period 1973-1999. Chauhan *et al.* (2003) used aerial photographs of 1976 and IRS-1C LISS III satellite data of 1999 to carry out change detection in Sal forest of Dehradun Forest Division. Joshi and Gairola (2004) studied land cover dynamics along the topography in Balkhila sub watershed situated in Garhwal Himalayas using GIS and RS. In the present study, an effort was made to use these techniques to detect the land use changes of a watershed over a period of twenty years.

Study area, located in mid hill zone of Himachal Pradesh, is geographically situated between $30^0 52'$ to $30^0 58'$ N latitude and $77^0 05'$ to $77^0 13'$ E longitude with an altitudinal range of 900 m to 2200 m above mean sea level. The area drains out in the Ashwani Khad Watershed situated in Solan District of Himachal Pradesh. The average annual rainfall is about 1000 mm. The entire watershed area is rural comprising of 126 thinly populated revenue villages spread over most of the area. Toposheets on 1:25,000 scale (No.53F/1/NW, 53F/1/NE) and on 1:50,000 scale (No.53F/1) obtained from Survey of India (SOI), Dehradun for the year 1979 were used for preparing base map for digitizing contour and land use coverages. The geocoded and geometrically corrected IRS-1D merged PAN-C/D (Path 95, Row 49) of 14 Feb, 1999 plus LISS III (Path 95, Row 49) of 11 March, 1999 on 1:25,000 scale False Colour Composite (FCC) procured from National Remote Sensing Agency (NRSA) Hyderabad duly supported by intensive ground truthing was visually interpreted to obtain land use status for the year 1999. All lands other than agriculture and forest were grouped under wasteland.

The land use pertaining to the year 1979 and 1999 are shown in (Figs. 1 and 2), respectively and the area under different land uses are given in Table 1. It was estimated that in the year 1979, the watershed was having 60.09 km^2 area under wasteland followed by 13.23 km^2 under agriculture and 11.98 km^2 under forest. The wasteland constitutes approximately 70% of the geographical area of the watershed and remaining 30% is almost equally shared by agriculture and forest. In the year 1999, the agricultural area increased to 28.62 km^2 whereas both wasteland and forest area decreased to 46.51 km^2 and 10.17 km^2, respectively. The land use changes derived over a period of 1979 to 1999 are shown in (Fig. 3 and Table 2). In general, it was observed that in a span of 20 years, out of the total 85.30 km^2 area, 57.81 km^2 area remained unchanged which is 67.78% of the total watershed area. 6.05 km^2 of agriculture land was converted to wasteland and 19.63 km^2 of wasteland was put to agriculture use. Only 1.81 km^2 of forest was encroached and used for agriculture.

Table 1: Land use in Ashwani Khad Watershed

Landuse Type	Landuse 1979		Landuse 1999	
	Area (km^2)	% of Total Area	Area (km^2)	% of Total Area
Agriculture	13.23	15.51	28.62	33.55
Forest	11.98	14.04	10.17	11.92
Wasteland	60.09	70.45	46.51	54.53
Total	**85.30**	**100.00**	**85.30**	**100.00**

Table 2: Land use Changes in Ashwani Khad Watershed 1979-1999

Changes in Landuse	Area (km^2)	% of Total Area
Unchanged	57.81	67.78
Agriculture to Wasteland	6.05	7.09
Forest to Agriculture	1.81	2.12
Wasteland to Agriculture	19.63	23.01
Total	**85.30**	**100.00**

Table 3 shows changes in land use in different altitudinal zone. The data reveal that in general agriculture area in all the altitudinal zones has increased. However, the maximum area which was brought under agriculture was 6.46 km^2 in altitude 1300-1500 m followed by 3.20 km^2 in 1100-1300 m, 2.22 km^2 in 1500-1700 m altitude zones. The least area brought under agriculture was 0.06 km^2 in altitudinal zone of 2100 m and above. Thus in totality, 15.39 km^2 of agriculture area increased in a span of 20 years. The forest as well as wasteland

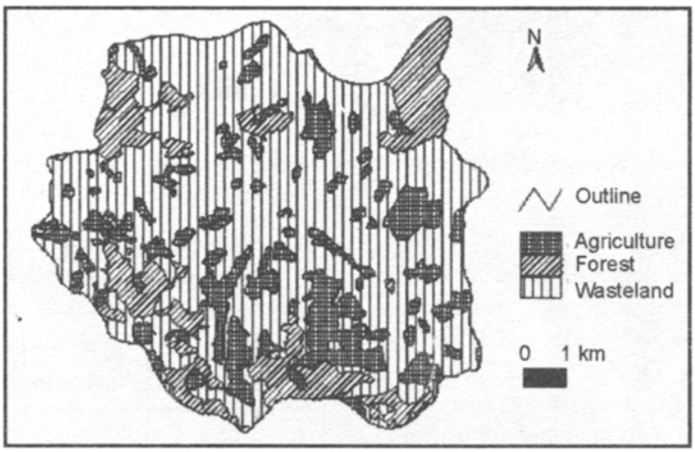

Fig. 1. Land use in Ashwani Khad Watershed (1979)

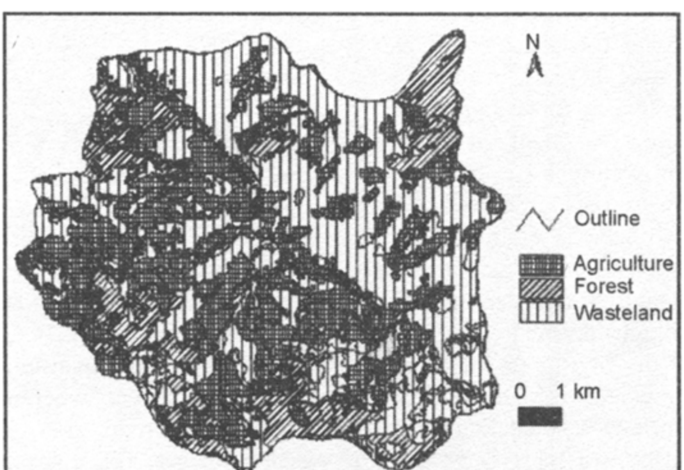

Fig. 2. Land use in Ashwani Khad Watershed (1999)

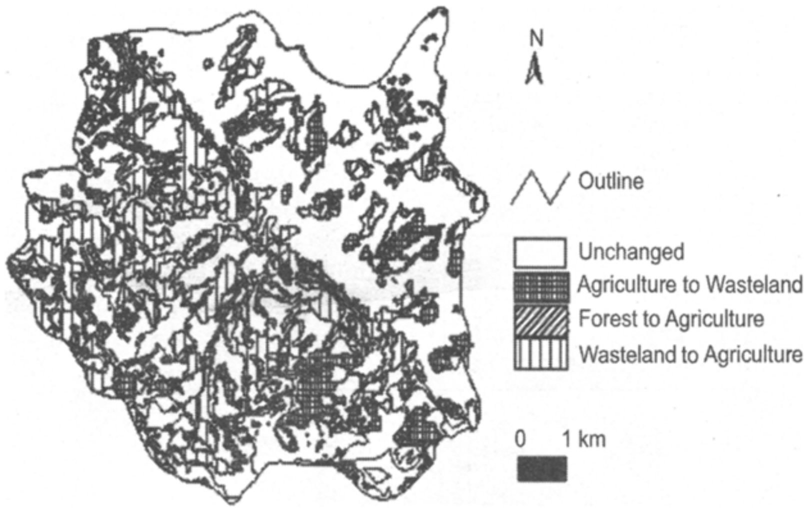

Fig. 3. Land use changes in Ashwani Khad Watershed (1979-1999)

area on the other hand decreased after 20 years of observations. Maximum decrease in the forest area was 0.59 km^2 in 1700-1900 m followed by a decrease of 0.50 km^2 in 1300-1500 m altitude zone. Forest area showed no variation in altitude zone of 2100 m and above. In totality, 1.81 km^2 of forest was encroached in the watershed. A positive trend of utilizing wasteland area was observed. Maximum wasteland to an extent of 5.96 km^2 changed to agriculture in 1300-1500 m altitude zone followed by 3.02 km^2 in 1100-1300 m altitudinal zone. The least, 0.06 km^2 area of wasteland was put to agriculture use in altitudinal zone of 2100 m and above where forest area showed no changes. The possible reason of increase in agricultural land in the watershed is due to an increase in population of the watershed. This increase in agriculture area is at the cost of encroachment of the forest area and utilization of the wasteland, which is evident from their decrease. The decrease in forest and wasteland were higher in mid altitudes (1300-1900 m) owing to maximum settlements of human population (Mahajan *et al.*, 2001) in these zones. Nearly 16% population growth over a period 1981 to 1991 was observed in the watershed with maximum growth in the mid altitudes.

Table 3: Land use changes in different altitudinal zones 1979-1999

Altitude (meters)	Area (km^2)		
	Agriculture	Forest	Wasteland
900-1100	1.68	-0.03	-1.65
1100-1300	3.20	-0.18	-3.02
1300-1500	6.46	-0.50	-5.96
1500-1700	2.22	-0.36	-1.86
1700-1900	1.27	-0.59	-0.68
1900-2100	0.50	-0.15	-0.35
2100 and above	0.06	0	-0.06
Total	**15.39**	**-1.81**	**-13.58**

Over a period of 20 years, the maximum increase in agriculture area has been found to be 7.01 km^2 in flat lands followed by 2.36 km^2 in northern aspect (Table 4). The least expansion (0.40 km^2) was found in southeast aspect, whereas, in western aspect agriculture area reduced in 1999 as compared to its extent in the year 1979. The decrease observed was 0.53 km^2. Forest area showed increase in two aspects (0.40 km^2 in northwest and 0.16 km^2 in flat lands) whereas in rest of the aspects it decreased. The highest decrease of 1.13 km^2 was noticed in western aspect followed by 0.36 km^2 in northern aspect. In southern aspect minimum decrease of 0.07 km^2 in forest cover was observed. Wasteland area increased by 0.44 km^2 only in flat lands whereas it decreased in rest of the aspects. Maximum utilization of wasteland was 2.70 km^2 in northern aspect followed by 2.27 km^2 in western aspect and 0.99 km^2 in southwest aspect. Maximum increase of agriculture in flat land as well as northern aspect is due to availability of plenty of water for irrigation purpose, which is generally scarce in southern aspects. The decrease in forest area and utilization of wasteland of the watershed is attributed to the increase in settlements in the northern aspect. Wasteland area in flat land has increased because the Giri river changes its course every year. Thus, the area, which it leaves behind becomes waste and natural regeneration of such area takes time.

Table 4: Land use changes in different aspects 1979-1999

Aspects	**Area (km^2)**		
	Agriculture	**Forest**	**Wasteland**
Flat	7.01	0.16	0.44
North	2.36	-0.36	-2.70
Northeast	1.09	-0.35	-1.54
East	0.83	-0.13	-1.24
Southeast	0.40	-0.08	-1.60
South	1.49	-0.07	-1.58
Southwest	0.81	-0.25	-0.99
West	-0.53	-1.13	-2.27
Northwest	1.93	0.40	-2.10
Total	**15.39**	**-1.81**	**-13.58**

Table 5 shows that maximum increase of agriculture area observed was 5.41 km^2 in 26.4-33.0 degree followed by 4.99 km^2 having 0-6.6 degree slope class. However, agriculture area decreased by 1.30 km^2 from 1979 to 1999 in 13.2-19.8 degree slope class. The extent of the forest cover increased by 0.36 km^2, 0.20 km^2 and 0.01 km^2 in 0-6.6 degree, 39.6-46.2 degree and 52.8-59.4 degree slope classes respectively in decreasing order. However, forest cover decreased in rest of the slope classes and maximum decrease of 1.02 km^2 was observed in 13.2-19.8 degree slope class. Area under wasteland increased by 4.75 km^2, 1.11 km^2, 0.63 km^2 and 0.14 km^2 in 26.4-33.0 degree, 0-6.6 degree, 46.2-52.8 degree and 52.8-59.4 degree slope classes respectively. Maximum utilization of wasteland was 7.79 km^2 in area having slope of 13.2-19.8 degree. Since flat lands and moderate slopes are suitable for agriculture, it has resulted in agriculture expansion in these slope classes. Steep slopes on the other hand are not conducive for agriculture hence such slopes remained under forest cover. Only a marginal decrease in forest cover was observed. The decrease in wasteland observed in the moderate slopes was due to its utilization for agricultural purposes. The results are in agreement with those of MENRIS (1997) case study which reported that maximum expanse of agriculture is in the range of 20°-30° slope.

Table 5: Land use changes in different slope classes 1979-1999

Slope (degrees)	**Area (km^2)**		
	Agriculture	**Forest**	**Wasteland**
0-6.6	4.99	0.36	1.11
6.6-13.2	2.01	-0.30	-2.37
13.2-19.8	-1.30	-1.02	-7.79
19.8-26.4	2.40	-0.11	-5.65
26.4-33.0	5.41	-0.16	4.75
33.0-39.6	0.76	-0.72	-4.19
39.6-46.2	0.48	0.20	-0.21
46.2-52.8	0.60	-0.07	0.63
52.8-59.4	0.04	0.01	0.14
Total	**15.39**	**-1.81**	**-13.58**

It is concluded that over a period of 20 years, the agriculture area in the watershed has increased to an extent of 15.39 km^2, whereas the forest area has decreased by 1.81 km^2 and also wasteland area by 13.58 km^2. The decrease in wasteland area indicates proper utilization of these lands for agriculture purposes. However a small decrease in the forest area is of concern and needs attention of the policy planners. The topographic analysis has indicated that the wasteland in mid altitudes and mid slopes suitable for agriculture purposes were brought under cultivation. On the other hand at relatively higher altitudes and moderate slopes, decrease in forest area was observed due to encroachment for settlements and cultivation. Due to availability of water for irrigation purpose, agricultural area increased in flat lands and northern aspect where wasteland has decreased. Expansion of urban settlements in the western aspect resulted in maximum decrease of forest area. It is suggested that to utilize wasteland and protect further depletion of forest of the watershed, improved agricultural practices like contour bunding, terracing, intercropping, agro-forestry and other interventions may be adopted giving due consideration to the topographic features of the area of the watershed.

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