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Assessment of Land Use /Land Cover Change in Wular Catchment Using Remote Sensing and GIS

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Abstract

An improved understanding of land use and cover change is considered to be a requirement for the global assessment of landscape dynamics. It is essential for the development of management strategies and policies to prevent further decline in the environmental value. A watershed is an ideal unit for management of natural resources and mitigation of impacts. The present study is an attempt to determine the spatio-temporal land use/land cover change in Wular Catchment and to find out the major factors causing the change. The Datasets used for present study consist of SOI toposheets, 1961 of 1:50000 scale and IRS IC LISS III, Oct 2004 imagery with a resolution of 23.5 meters. On screen digitization and supervised classification approaches were used for the assessment of changes in land use/land cover. The results indicate that Dense Forest has drastically decreased by 16.2% of the total Catchment from 1961 to 2004. Agriculture and Built up area have been extended on 5.2% and 3.0% of the total area, while as 3.0% of the land has been rendered barren. *Thus erosion and other degradation process induced by human intervention is an imminent threat to the fertility and stability of the mountainous landscape of the study area.*

Introduction

For centuries, man's interaction with his environment has been undergoing change and adoptation. But today, the increasing scale and rate of changes threaten to exceed the present adaptive capacities of many individual societies, particularly in the fragile and finite areas like high altitude zones. Human induced activities stand out as a large force causing land use/land cover changes (Nunes and Auge, 1999). Land use and land cover change are the most pernicious impacts of humans on natural ecosystems, and they have cascading effects on atmospheric, hydrologic, and biogeochemical cycles at local, regional, and global scales (National Research Council 1993; Vitousek, 1994). Intensification of food production is a key activity in the development of modern society. The use of fertilizers, machinery and fossil fuel made it possible to increase the productivity. However, increasing agricultural exploitation of landscapes and associated land use changes have often led to soil quality degradation and loss of soil by erosion. The forest cover protects the environment by regulating soil-water relation, habitat for wild life biodiversity,

carbon fixing (UNEP, 1992), and provides other numerous natural resources.

An improved understanding of land use and cover change is considered to be a requirement for the global assessment of landscape dynamics with reference to their various functions like biodiversity, aesthetics, cultural heritage, and production levels. Thus, it will be able to contribute to the development of management strategies and policies to prevent further decline in the environmental value. A watershed is an ideal unit for management of natural resources and mitigation of impacts. Applications of Remote Sensing and GIS are the most advanced and recent tools for watershed development and management. Change detection can be done accurately using Remote sensing data and GIS, allows overlaying of two or more maps with ease (Lo and Shipman, 1990).

The main objective of the present study is to determine the spatio-temporal land use/ land cover change and to find out the major factors causing these changes.

Study Area

The study area falls in the three tehsils namely Sopore, Bandipore and Sonawari of Kashmir Valley. It has an area of 1200.36 km^2 and accounts for 7.6% of the total area of Kashmir valley. The study area lies between 34°12' 24.67" and 34°36' 26.26" N latitude and 74°26' 41.42" and 74°56' 02.90" E longitude. The altitudinal range of the study area is from 1580 meters near Wular Lake to about 4500 meters in Harmukh range. The location map of the study area is given in Fig.1. The major rivers apart from Jhelum in the study area are Madhmatti and Erin.

The landscape is mountainous and rugged in the north-eastern side, while it is mostly plain in south-western side. Two world famous freshwater lakes namely Wular and Mansbal fall in the study area. The major crops grown in the study area are Paddy and Maize (*kharif*) and Sarson (*rabi*). Fish and water nuts are an important produce of these lakes. The Wular Catchment has got a great tourist potential, in terms of its virgin landscapes, lakes and historical places. It is one of the most enchanting and picturesque resort of Kashmir Valley.

Methodology and Database

The study area is covered in the SOI toposheets 43 J/7, 43 J/8, 43 J/10, 43 J/11, 43J/12, 43 J/14 and 43J/15, of 1:50000 scale. These toposheets of 1961 and IRS 1C LISS III with 23.5 meter resolution acquired in October 2004 were used to derive land use/ land cover maps. The scheme adopted for land use/land cover classification is the level I, II and III of NRSA with local modification. The Wular Catchment was accordingly divided into nine classes namely, Dense Forest, Sparse Forest, Barren land, Forest Plantation, Built up land, Agriculture, Water Bodies, Wetland, Snow/Glacier. The study area was divided into nineteen watersheds, Wular Periphery and Wular Lake using AIS & LUS codification modified by Kango

Table 1: Watershed Level Codification Scheme of Wular Catchment

S.No.	Catchment		Sub Catchment	Watershed
1	Wular I	1EW	W1 (Nagmarg) M 2 (Zaingir)	W1a, W1b, W2a, W2b
2	Madhmatti	1EM	M 1 (Tragbal) M 2 (Bodnar)	M1a, M1b, M2a, M2b, M2c
3	Erin	1EE	E 1 (Erin Nar) E2 (Astar Nar)	E1a, E1b, E1c, E2a, E2b, E2c
4	Wular II	1EO	Oa (Dudh. Nar) Ob (Rang Nar)	Oa1, Oa2, Ob1, Ob2
5			-	Wular Lake
6			-	Wular periphery

Source: Adopted from Kango and Qadri, 1982.

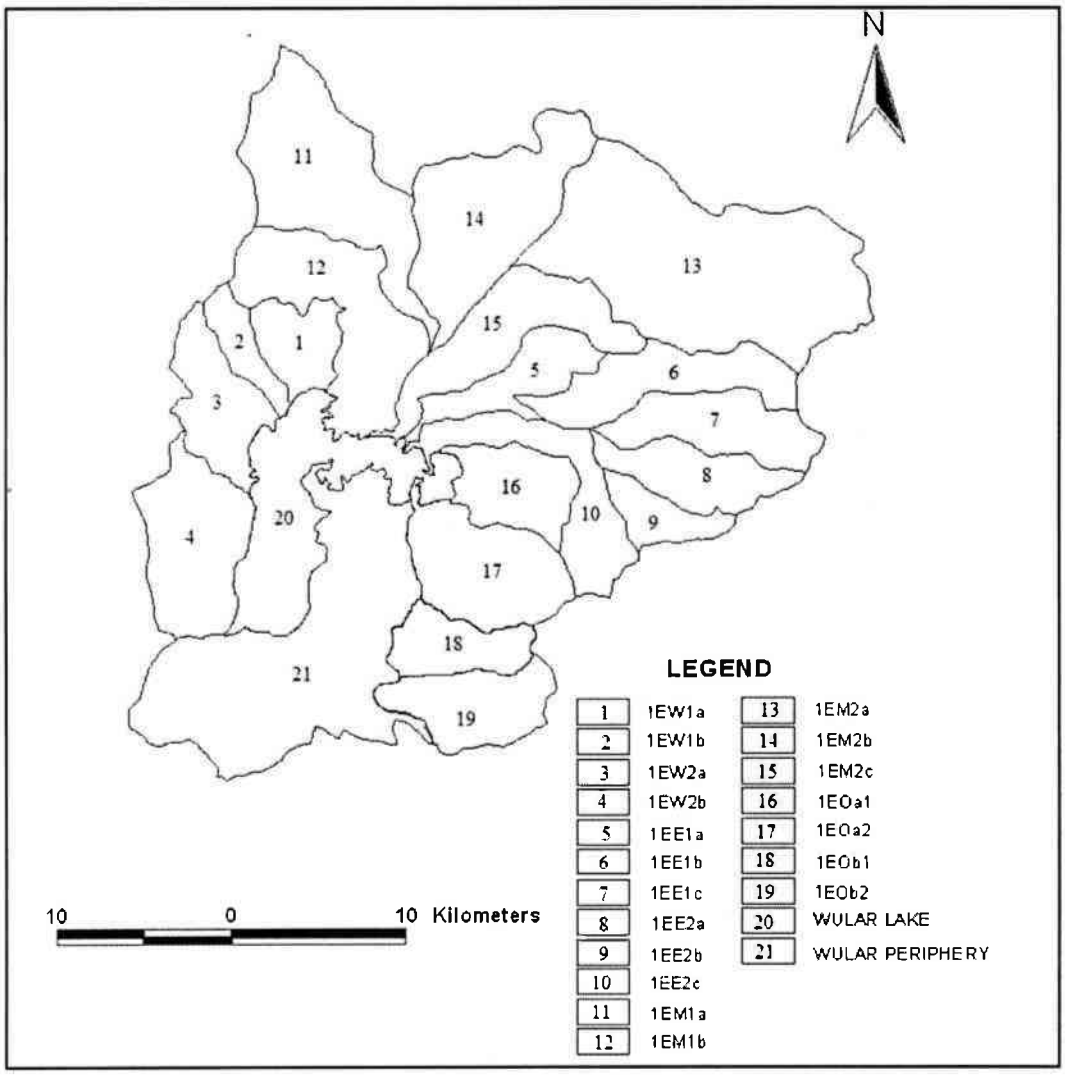


Fig. 2: Watershed Map-Wular Catchment.

and Qadri (1982), given in Table 1.1 and depicted in fig.2.

Pentium IV processor and aided by Erdas Imagine 8.4 and Arc View 3.2a were used to carry out the tasks of digital processing and analysis. The steps of methodology are given in fig.1.3. The toposheets and the imagery were registered to UTM WGS 84 (43 North); by map to map and map to image geo-referencing. On screen digitization and supervised classification approaches were used. In supervised classification the training sets were assigned on the basis of Ground Truth. The Maximum Likelihood classifier has been used in the classification procedure of remotely sensed digital data (Foody *et al.,* 1995).

Analysis

Results and Discussion 1

The watershed wise land use/land cover change of 1961 and 2004 is given in table 1.2. The land use/land cover of 1961 and 2004 is depicted in fig. 4 and 5 respectively. The percentage wise land use and land cover is presented in fig. 6 (1961) and fig. 7 (2004). The data revealed that Wular Catchment has shown significant decrease of 19407 hectares in Dense Forest which amounts to 16.2% of the total Catchment. Sparse Forest has also been reduced by 7%. Water Bodies and Wetland have shrunk by 4% and 0.9% respectively. Agricultural Land has increased by 6167 hectares which amounts to 5.2%. Both Built up land and Barren land have increased by 3.0% while as Forest Plantation has shown an increase of 2.7% of the total Catchment. The inclusion of snow cover in the satellite imagery (Oct, 2004) has led to the increase of 14% in the Snow/ Glacier category, since the toposheet (1961) depicts only the glacial extent.

Thus human economic activity shifted 9689 hectares of land from various covers to agriculture and settlement. This unrelenting, long term process noticeably depleted the natural resources of the area and left a vast area into unproductive barren land. In the past 43 years, the Forests, Scrublands and other Grasslands, Wetlands and Water bodies shrank from 73.9% to 48.6% of the total Catchment; while as the area which has been rendered Barren in these four decades is 3645 hectares.

The watershed wise land use/land cover of 1961 and 2004 is given in fig. 6 and 7 respectively. It is revealed that Dense Forest has shown a drastic decrease in almost all watersheds. Highest decrease has been shown by 1EM2b (37.4%), 1EM1a (34%), 1EE2c (31.2%), 1EW2a (30.9%), 1EW1b (30%). Sparse Forest has shown a significant decrease in majority of watersheds while in few watersheds it has increased. Major negative changes in Sparse Forest have occurred in 1EM2a (42.05%), 1EE1c (35.6%), 1EOb2 (26.3%), while as major positive changes have occurred in 1EM1a (16.6%), 1EW1b (15.1%). The degradation of the forests is mainly a result of clearance for agriculture, fuel wood and timber extraction as well as the growing frequency and severity of forest fires. Access

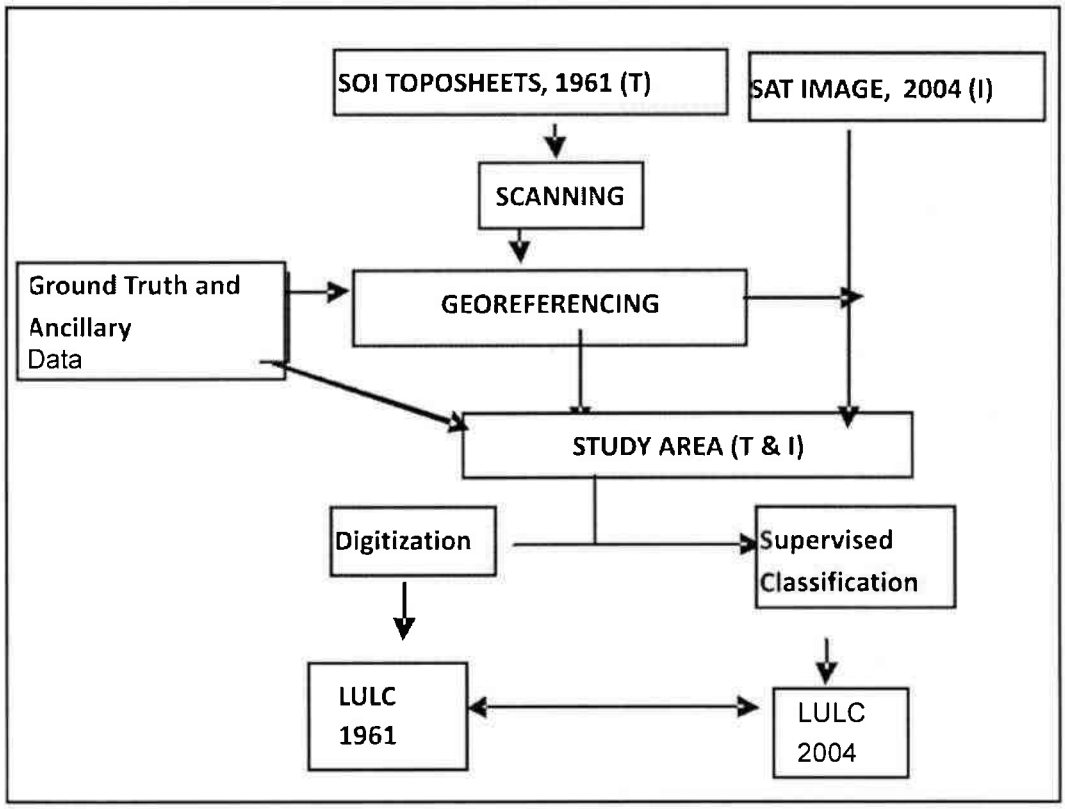


Fig. 3: Steps of Methodology

to markets and efficient transportation has increased commercial exploitation of timber while over utilization of forests in terms of fuel wood, animal feed and construction material are mostly due to socio economic backwardness of the adjoining villages. Fire, is traditionally used practice to eliminate woody vegetation and land clearance for agriculture. The incidence of fire has also been for other reasons in the study area like the increased military movement in last 20 years. The deforestation in the study area is generally a two step process, conversion of Dense Forest to Sparse by logging and then the removal of Sparse Forest by the expansion of agriculture and settlements. Thus, the increase of Sparse Forest in few watersheds is due to the conversion of Dense Forest into the Sparse. Moreover, the drastic decrease of Sparse Forest in some watersheds, even if the human interference is negligible is attributed to the increased Snow Cover on these watersheds at the time of satellite over pass. Built up land has increased significantly in 1EOb1 (7.2%), 1EE1a (6.9%), 1EM2c (6.3%). Agriculture has also shown a significant increase in 1EW2a (18.6%), 1EOa1 (16.5%), 1EW1a (12.2%). The watersheds in which the Barren land has drastically increased include

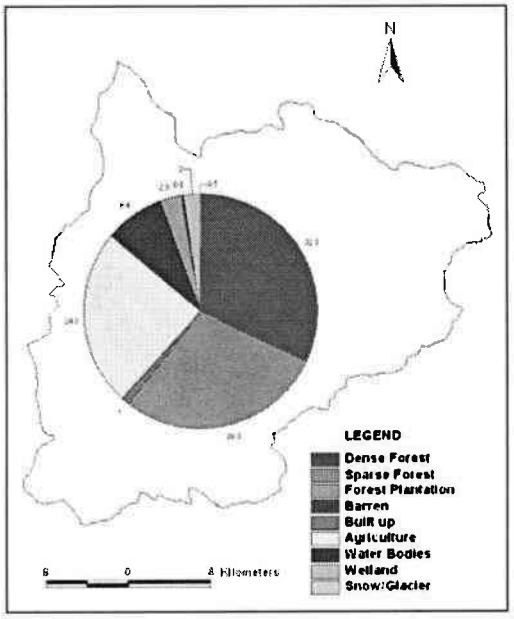
Table 2: Land Use / Land Cover Change – Wular Catchment, 1961 and 2004

Unit: hectares and percentage in brackets '( )'.

S.No.	Watershed Code	Dense Forest	Sparse Forest	Built up	Agriculture	Barren	Water Bodies	Wetland	Forest Plantation	Snow /Glacier
1	1EW1a	-561 (-22.8)	-69 (-2.8)	+128 (+5.3)	+297 (+12.2)	+205 (+8.3)	0	0	0	0
2	1EW1b	-461 (-30)	+233 (+15.1)	+56 (+3.7)	+83 (+5.4)	+89 (+5.8)	0	0	0	0
3	1EW2a	-1157 (-30.9)	+171 (+4.6)	+144 (+3.7)	+696 (+18.6)	+90 (+2.5)	0	0	+56 (+1.5)	0
4	1EW2b	-180 (-3.1)	-197 (-3.4)	+348 (+6.0)	+263 (+4.6)	+101 (+1.7)	0	-348 (-6)	+13 (+0.2)	0
5	1EM1a	-2850 (-34)	+1386 (+16.6)	+55 (+0.7)	+151 (+1.8)	+516 (+6.2)	-34 (-0.5)	0	0	+776 (+9.2)
6	1EM1b	-1677 (-22.9)	+634 (+8.7)	+456 (+6.15)	+362 (+4.9)	+234 (+3.2)	0	-16 (-0.2)	+3 (+0.1)	+4 (+0.05)
7	1EM2a	-2247 (-13.7)	-6945 (-42.05)	+7 (+0.04)	+319 (+1.9)	+236 (+1.41)	-17 (-0.1)	0	0	+8647 (+52.5)
8	1EM2b	-2894 (-37.4)	+707 (+8.9)	+121 (+1.5)	+533 (+6.7)	+272 (+3.4)	-36 (-0.4)	0	0	+1387 (+17.3)
9	1EM2c	-1160 (-21.3)	+419 (+7.6)	+340 (+6.3)	+141 (+2.7)	+59 (+1.1)	-160 (-3.0)	0	(+57) (+1)	+304 (+5.6)
10	1EE1a	-637 (-21)	-35 (-1.3)	+208 (+6.9)	+219 (+7.2)	+134 (+4.5)	-6 (-0.2)	0	+15 (+0.5)	+103 (+3.4)
11	1EE1b	-1037 (-22.6)	-615 (-13.4)	+190 (+4.2)	+454 (+9.9)	+175 (+3.8)	-69 (-1.5)	0	0	+902 (+19.6)
12	1EE1c	-724 (-17.8)	-1445 (-35.6)	+9 (+0.25)	+46 (+1.1)	+14 (+0.35)	-10 (-0.3)	0	0	+2110 (+52)
13	1EE2a	-762 (-22.8)	-853 (-25.5)	+1 (+0.03)	+32 (+0.97)	-10 (-0.27)	+9 (+0.27)	0	0	+1583 (+47.3)
14	1EE2b	-393 (-21.9)	-362 (-20.1)	0	0	+95 (+5.3)	0	0	0	+660 (+36.7)
15	1EE2c	-1381 (-31.2)	+359 (+8.1)	+195 (+4.4)	+309 (+7)	+98 (+2.2)	-31 (-0.7)	0	+5 (+0.1)	+446 (+10.1)
16	1EOa1	-324 (-9.4)	-482 (-14)	+169 (+5)	+574 (+16.5)	+39 (+1.1)	0	0	0	+24 (+0.8)
17	1EOa2	-818 (-14.4)	+60 (+1)	+192 (+3.4)	+535 (+9.5)	+32 (+0.6)	-3 (-0.1)	-73 (-1.3)	+22 (+0.4)	+53 (+0.9)
18	1EOb1	-104 (-3.8)	-558 (-20.8)	+193 (+7.2)	+121 (+4.5)	+519 (+19.3)	0	-171 (-6.4)	0	0
19	1EOb2	0	-1026 (-26.3)	+228 (+5.8)	+162 (+4.2)	+747 (+19.1)	-93 (-2.4)	-18 (-0.4)	0	0
21	Wular Lake	0	0	+1 (+0.01)	+208 (+2.6)	0	-3649 (-45.3)	0	+3440 (+42.69)	0
22	Wular Periphery	0	+223 (+1.4)	+481 (+3.1)	+785 (+5)	0	-690 (-4.4)	-443 (-2.9)	-356 (-2.2)	0
23	Wular Catchment	-19407 (-16.2)	-8323 (-7)	+3522 (+3.0)	+6167 (+5.2)	+3645 (+3.0)	-4789 (-4)	-1069 (-0.9)	+3255 (+2.7)	+16999 (+14.2)

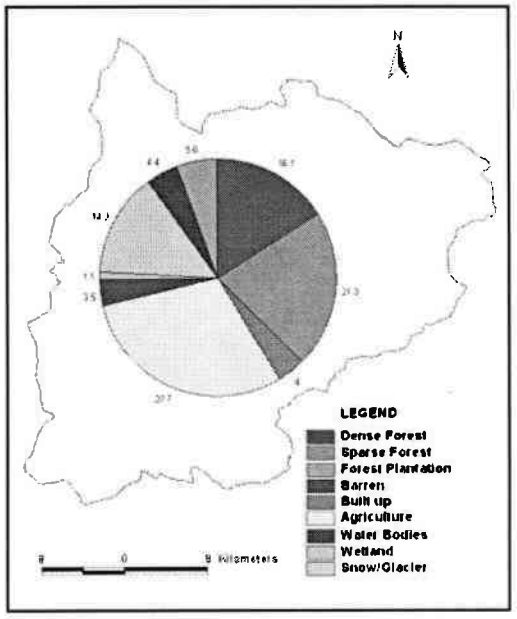
Source: Computed from SOI toposheets, 1961 and IRS LISS III, 2004

Fig.4: Land use/land cover – Wular Catchment, 1961



Source: Computed from SOI toposheets, 1961

Fig.5: Land use/land cover – Wular Catchment, 2004

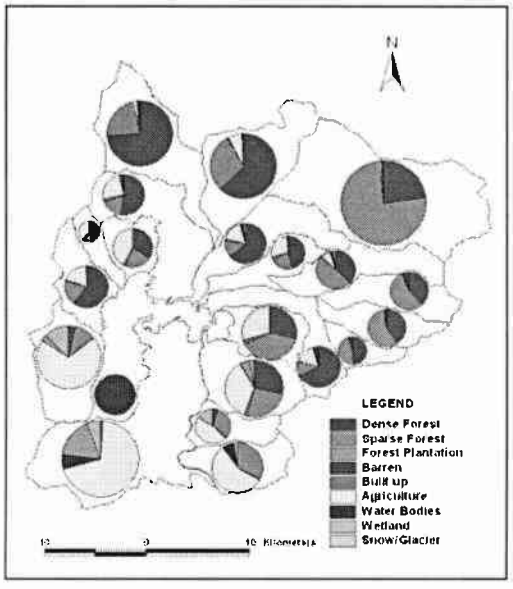


Source: Computed from IRS 1C LISS III, 2004

1EOb1 (19.3%), 1EOb2 (19.1%). The most important and direct indicators of human impact on any region is the expansion of Agriculture and Built up land and conversion of productive lands into Barren land. The increase of Agricultural land by 6167 hectares from 1961 to 2004 in all watersheds and mostly on the fragile lands and areas under ecological stress has lead to accelerated soil erosion and excessive land degradation. The pressure to increase rice production to meet food needs has induced land degradation with larger areas of dry lands (uplands) being used to produce rice through clearance of Forest and other natural vegetation. The increase in Built up can be judged by the urban expansion of Bandipore town from 5.56 km^2 in 1971 to 13.4 km^2 in 2001 (Census of India, 2001). It is expanding fast at the expense of either fertile lands or fragile mountains.

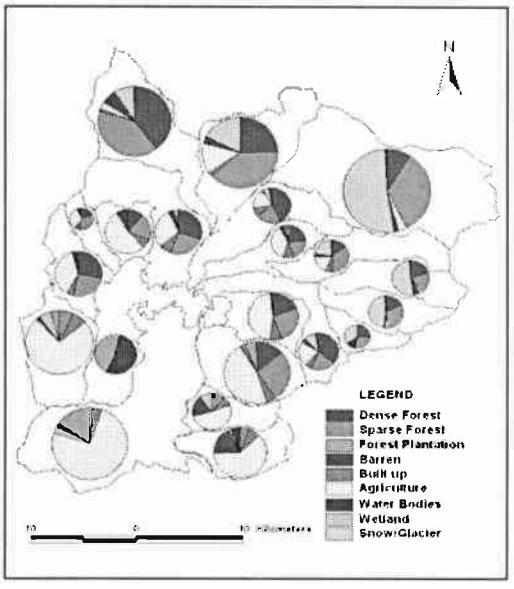
Wetlands have decreased significantly in 1EOb1 (6.4%), 1EW2b (6%). The Water bodies and Wetlands in the study area have lost an area of 5858 hectares to other land uses from 1961 to 2004. The open waters of Wular Lake have been polluted and reduced by an area of 3649 hectares amounting to 45.3%, which has been encroached upon for agriculture and settlements (209 hectares). Willow Plantation and Hydrophytic vegetation have eaten up 3440 hectares of the lake. The trend of encroachment in Wular Lake is construction of bunds or floating gardens on the shallow parts of the lake, planting willow on them and then encroach the whole area by secondary filling. Haigam wetland

Fig. 6: Watershed wise Land use/land cover – Wular Catchment, 1961



Source: Computed from SOI toposheets, 1961

Fig. 7: Watershed wise Land use/land cover – Wular Catchment, 2004



Source: Computed from IRS 1C LISS III, 2004

has lost an area of 443 hectares which has mostly come under agriculture. Thus, the increasing siltation and encroachment of human settlements have contributed significantly to the reduction of Water bodies and Wetlands. The silted parts of Wetlands and Water bodies are being encroached for agriculture. The construction of bunds or embankments has helped to promote agriculture on wetlands. The snowfall in the upper reaches at the time of satellite overpass in oct 2004 has led to the drastic increase in snow/glacier category,* as toposheet, 1961 depicts only the glacial extent.

Conclusion

The changes in land cover and in the way people use the land have become recognized over the last few decades as important global environmental changes. Land is a finite resource while the natural resources it supports can vary over time according to management conditions and uses. Expanding human requirements and economic activities in the study area are placing ever increasing pressure on land resources, creating competition and conflicts resulting in sub optimal use of both land and land resources.

The susceptibility of the Wular Catchment to degradation is high which is highlighted by the rapid increase of Barren land. The Wular Catchment signaled a drastic shift in ecosystems. Varying intensities of change have been registered in different watersheds but the overall trend

of changes is same for all. Several types of phenomena can be suggested to explain the differences in land use/cover change observed between watersheds. The first and foremost reason is the difference in levels of urbanization. Secondly, the inhospitable terrain also plays its part as physical constraints restrict the availability of natural resources. The role of government in the conservation of natural resources like forests is also one of the important determinants in restricting the overexploitation of natural resources. The environmental consequences of these changes were soil erosion and other watershed problems, like changes in hydrology, slope instability etc. The land use/land cover changes took place in almost all the watersheds. Only the high altitudinal zones of certain watersheds remained unaffected. Thus erosion and other degradation process induced by Human intervention is an imminent threat to the fertility and stability of the mountainous landscape of the study area.

*** A note by Editor**

The increase in snow cover/glacier indicated by the authors is their finding based on the analysis of 2004 imagery. The authors have used an imagery from October 2004. The snow cover increase appears to be due to the seasonal snow fall and it may not be a permanent feature. Both the reviewer and Editor express doubt over increased area in the category snow cover/glaciers.

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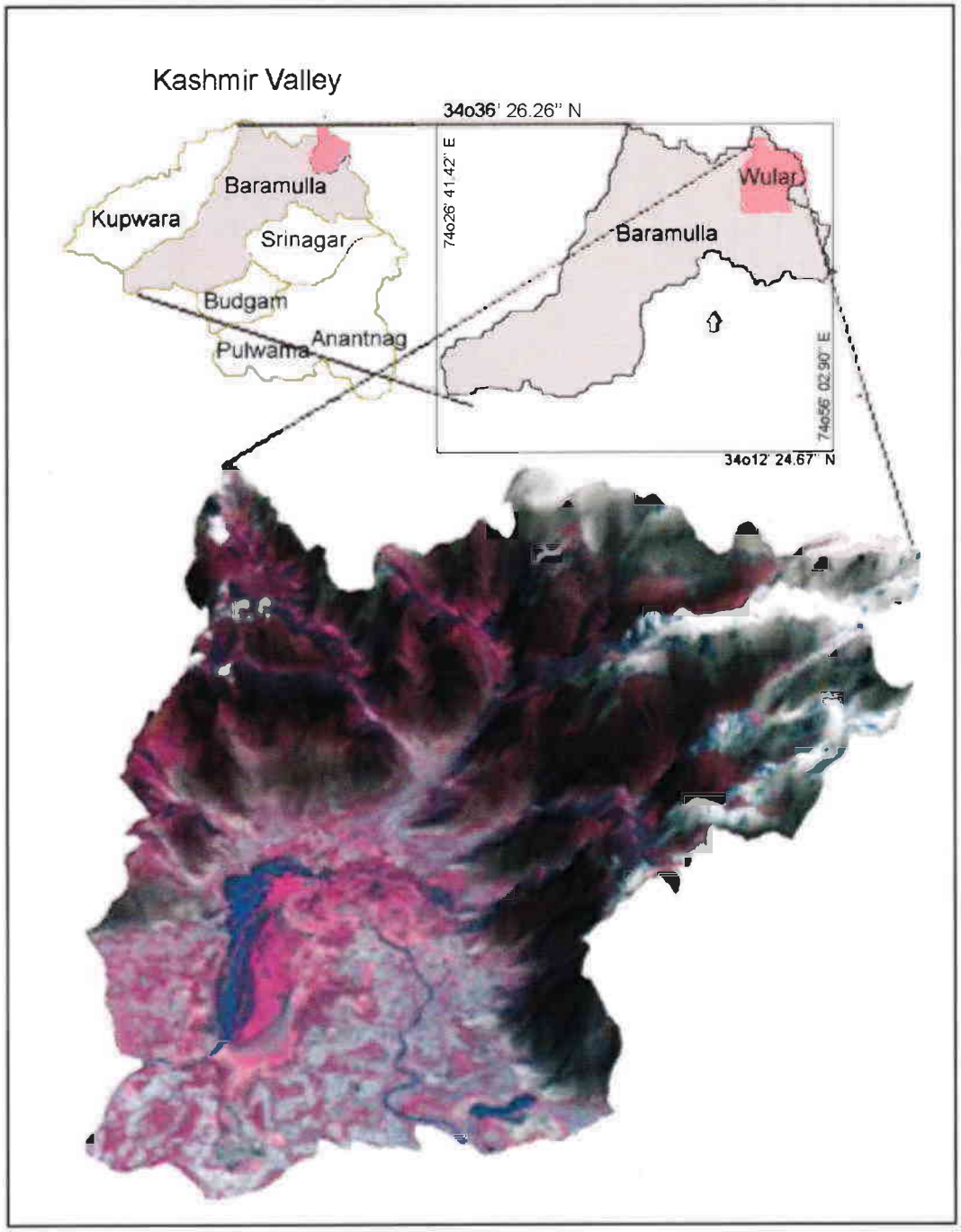

Fig. 1: Location Map - Wular Catchment