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ResearchArticle

LAND USE/LAND COVER CHANGE IN NORTH KASHMIR RIVER CATCHMENT REGION USING REMOTE SENSING AND GIS

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ABSTRACT

With the dawn of civilization, humankind has been able to change landscapes in order to improve the amount, quality and security of natural resources critical to its well-being, such as food, freshwater, fiber and medicinal products. Through the increased levels of innovation, human population has, slowly at first, and at increasingly rapid pace later on, increased its ability to exploit resources from the environment, and expand its territory. The present paper aims at quantifying the land transformation in North Kashmir River catchment region. Since the study area is entirely mountainous, maximum change has occurred in the forest cover. The dense forests have shrunk by 112 $Km^2$from 1992 to 2013. Horticulture and agricultural plantation are the fast changing land use classes as minimum land is available for agriculture.

INTRODUCTION

Ecosystem conditions have a close functional relationship with the land use/land cover. Any subtle changes in the landscape in its land use/land cover characteristics have a profound impact on many ecosystem functions like hydrology, climate and biogeochemical cycles and create environmental concerns (Bonetemps *et al*., 2008, Skole *et al*., 1997). Land use/land cover change is a dynamic process operating at larger scales continuously. The changes in land use/land cover are attributed to both natural factors and human activities (Sarma *et al*., 2008) which in turn induces changes that would have serious consequences on natural ecosystems (Moshen, 1999; Luna and Robles, 2003).

During the last 300 years, the intensity of human activities and the subsequent impact on Earth's land surface has increased manifold. More land was brought to human use than before, and already converted land was managed more intensively to increase the yields of agricultural and forest products. LULC change and land management has principally resulted in deforestation, biodiversity loss, global warming and increase in natural disasters (Mas *et al*., 2004; Zhao *et al*., 2004; Dwivedi*et al*., 2005).As early as 1864, George Perkins Marsh in his book *Man and Nature*, documented his observations of landscape changes resulting from human activities. More forests were cleared off the land surface between 1950 and 1980 than in the early 18th and 19th centuries combined (Richards 1990). Such alarming land use changes have resulted in serious local and global environmental problems.

Agriculture has been the most dominant force of land transformation on earth's surface. Approximately, a third of the Earth's land surface is currently being used for cultivating crops or grazing cattle (FAO 2004). The expansion in agricultural land area has been at the cost of natural forests, grasslands and wetlands that provide valuable habitats for species and important services to humankind (Millennium Ecosystem Assessment 2003).Extensive research on land-use changes in tropical Asia is available for the period 1880-1980 (Flint and Richards 1991). This involves an area of 8 million km^2 and 13 countries (India, Sri Lanka, Bangladesh, Myanmar, Thailand, Laos, Cambodia, Vietnam, Malaysia, Brunei, Singapore, Indonesia and the Philippines). With the recognition that land use is an important driver of global environment change, numerous studies in the last two decades have estimated the rates of tropical deforestation and other kinds of land-cover change around the world. Remote sensing has

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played a critical role in documenting these changes (Mollicone *et al*. 2003), and there are multiple examples of studies and resultant databases of rapid land-cover change and ecosystem disturbances in important regions of the world: deforestation in the pan-tropical forest belt; snapshots of land cover in European Russia, continental U.S. and Canada; fire frequency globally and regionally in South America, Southern Africa, and parts of Russia; and the influence of urbanization in selected cities around the world. While most studies were at the local-to-regional scales, global land-cover data sets were developed, using different methodologies, for the early 1990s using AVHRR satellite data (Loveland *et al*. 2000) and 2000-2001 using MODIS satellite data (Friedl *et al*. 2002) and SPOT VGT data. It is estimated that nearly half of the original forests (ca. 8000 years ago) have been lost (Billington *et al*. 1996). Despite the plethora of land-cover change studies and global remote sensing observations, a systematic, global synthesis and review of the major trends in land-cover change was not conducted until recently. The Millennium Ecosystem Assessment, in collaboration with LUCC, recently undertook a synthesis of the regions undergoing rapid land-cover change around the world (Lepers *et al*. 2005). The general pattern of transformation of forests into other forms of land management is a peculiar feature of mountainous landscapes. These changes have been observed in the Himalayan region in the past few decades (Rai *et al*., 1994; Singh *et al*., 1983). The underlying causes for this change have been primarily attributed to the ever increasing population andnon-availability of optimum productive agricultural land (Rai & Sharma 1998).

Study Area

Spatially, the North Kashmir River Catchment Region lies between 34º 12 09 to 34º 41 55 north latitude and 73º 54 37 to 75º 35 10 east longitude as shown in the figure 1.The study area forms a part Western Himalayan region. The eastern part is an abode of few important glaciers which play a crucial role in the hydrology of river Sind.

The central and western catchments are rain-fed, thus, having a strong seasonal effect on the water flow. The North Kashmir Rivers have carved their valleys draining the southern slopes of North Kashmir Himalaya which is a massive topographic barrier. It encloses the Kashmir valley on north and north-east.

Datasets and methodology

The present study is the combined implementation of GIS and remote sensing techniques. The methodology adopted for the study is shown by the figure 2.The satellite imageries acquired for the present study areLandsat5TM (1992) and Landsat OLI and TIRS sensor (2013).The land use/land cover statistics obtained from the attributes tool of raster module of the software were analysed to draw certain inferences.

The absolute change in land use/ land cover of the two dates was obtained by the difference of the values of different dates of the same category while percentage change was calculated by dividing it with the total area and multiplying by hundred.

$$Percentage\ change = \frac{Absolute\ change}{Total\ area} \times 100$$

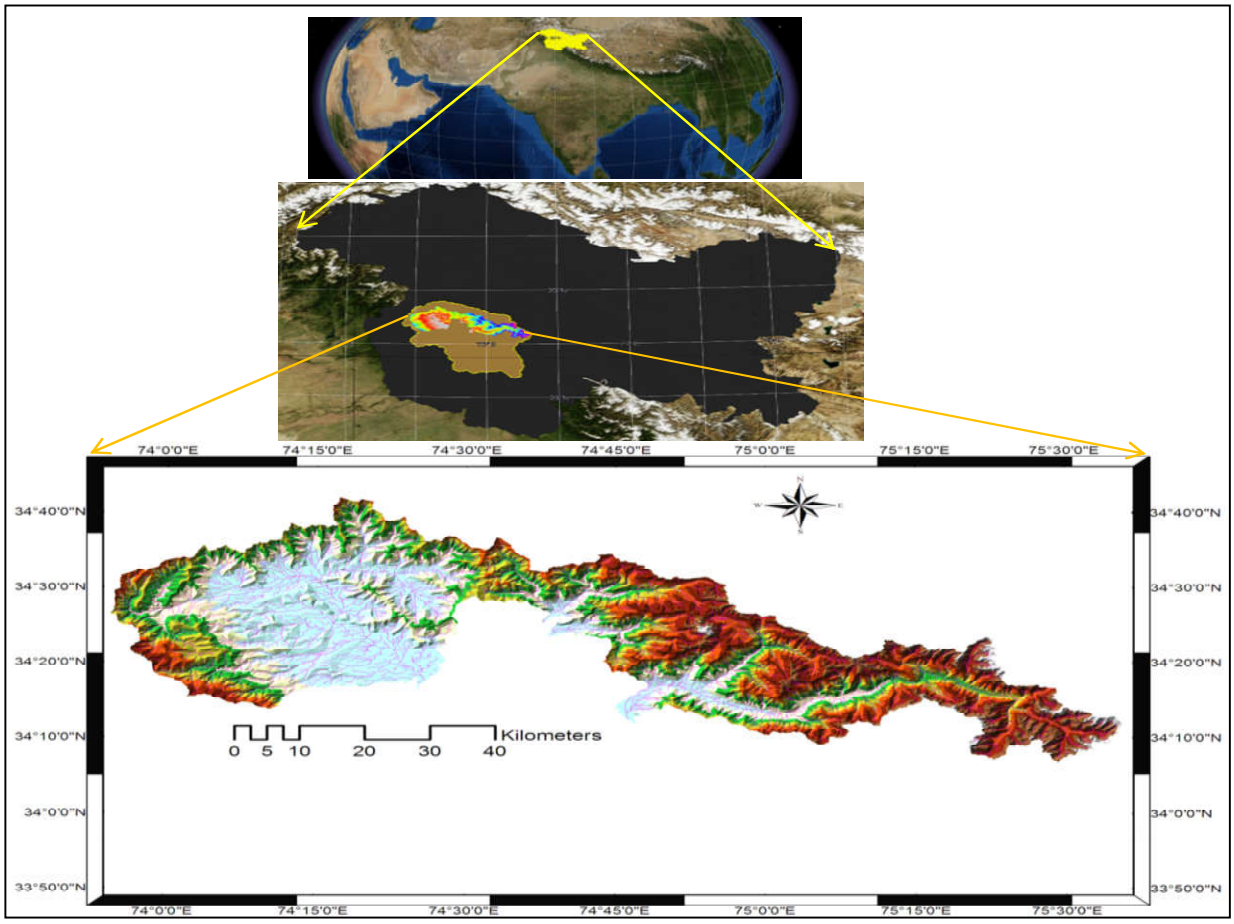

Fig. 1

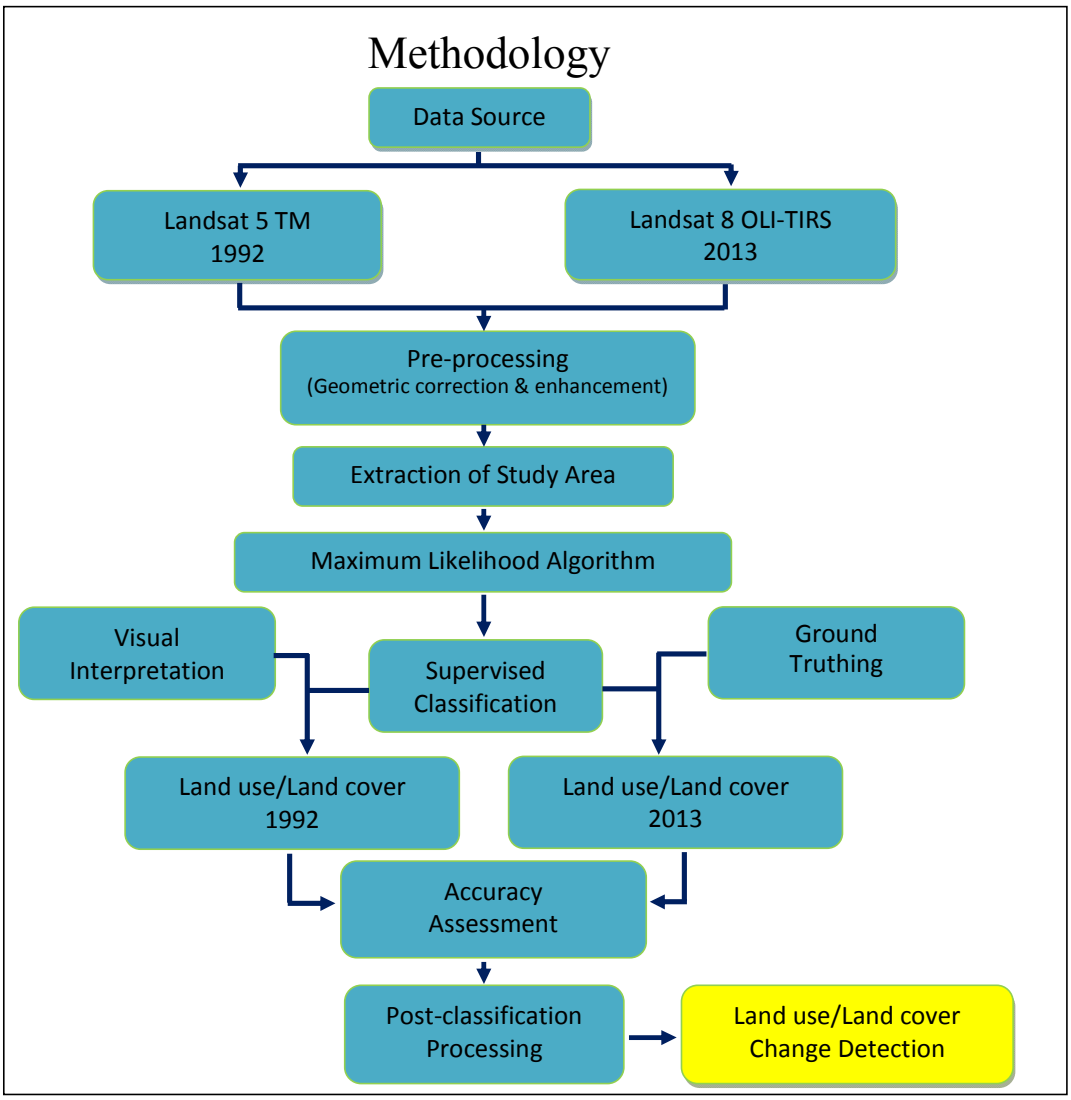

Fig.2

RESULTS AND DISCUSSION

Land use/ Land cover of North Kashmir River Catchments (1992)

The land use/land cover statistics of 1992 in North Kashmir River Catchments is given in the table1. Since the study area is a mountainous region, forests are the dominant land cover category.

Table 1 Land use/ Land cover of North Kashmir River Catchments (1992)

LULC Category	Area in KM^2	Percentage to the total area
Waterbody	44	1.12
Grassland	72	1.84
Sparse Forest	885	22.79
Built up	18	0.47
Agricultural Land	491	12.63
Horticultural Plantation	115	2.95
Agricultural/Forest Plantation	79	2.04
Snow/Glacier	581	14.95
Wasteland	262	6.75
Dense Forest	1339	34.45
Total	3886	100.00

Source: Computed from Landsat Imagery of October, 1992

Dense forest occupied 1339 sq. kms of North Kashmir River Catchments in 1992 which constitutes 34.45 percent of the study area followed by sparse forests which is the second largest land cover category in the study area.

The total area under this category in 1992 is 885 sq. kms constituting 22.79 percent of the study area. A good proportion of the study area is under glacier and snow. There is a general decrease in altitude from east to west as a result the snow/glacier cover decreases significantly from east to west. More than 90 percent of snow/glacier cover is found in Sind and Erin catchments(fig 4). A little bit of snow/glacier is also found on the western margins of North Kashmir River Catchments. Snow/glacier covered 581 sq. kms of area in North Kashmir River Catchments which constitutes 14.95 percent of the total area. Agricultural land also occupies a significant proportion of the total area. This land cover category is extended over an area of 491 sq. kms which is 12.63 percent of the study area. Mountain peaks and rocky outcrops have been categorized as wasteland and it occupies an area of 262 sq. kms which constitutes 6.75 percent of the total area. Horticultural and agricultural plantation are other major land use/cover categories spread over an area of 115 and 79 sq.

kms and constituting 2.95 and 2.02 percent of the study area, respectively.

Waterbody, grassland and built-up are the other land use/cover categories which occupy very insignificant proportion of area in the North Kashmir River Catchments as given in table 1 and fig. 3.The study area has a very rugged topography with a very little plain area. The rugged nature of the landscape leaves almost no scope for the built-up to spread. Built-up covers 18 sq. kms which is just 0.47 percent of the total area. Waterbody and grassland occupy 44 and 72 sq. kms of area which constitutes 1.12 and 1.84 percent of the total area, respectively.

Land use/ Land cover of North Kashmir River Catchments (2013)

The table 2 and fig. 5 shows the land use/cover statistics of 2013 in North Kashmir River Catchments. The table shows that dense forest is the most dominant and widespread land cover category in the study area with a total areal coverage of 1227 sq. kms which constitutes 31.569 percent of the study area.

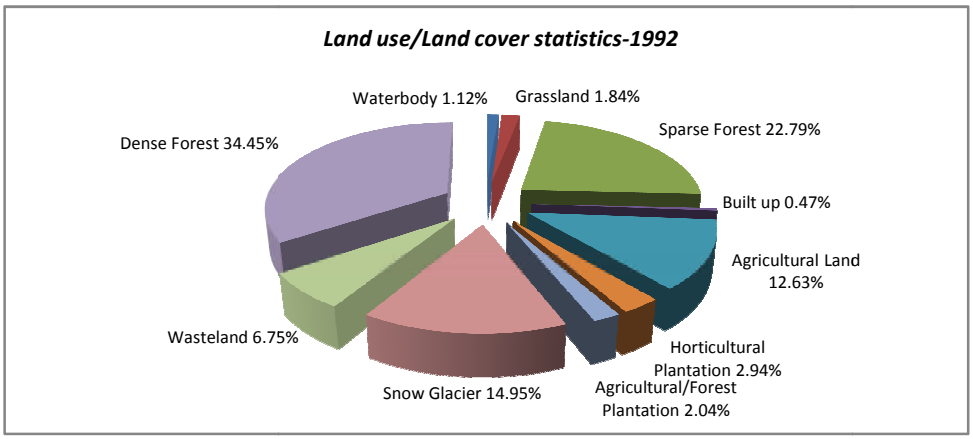

Fig. 3

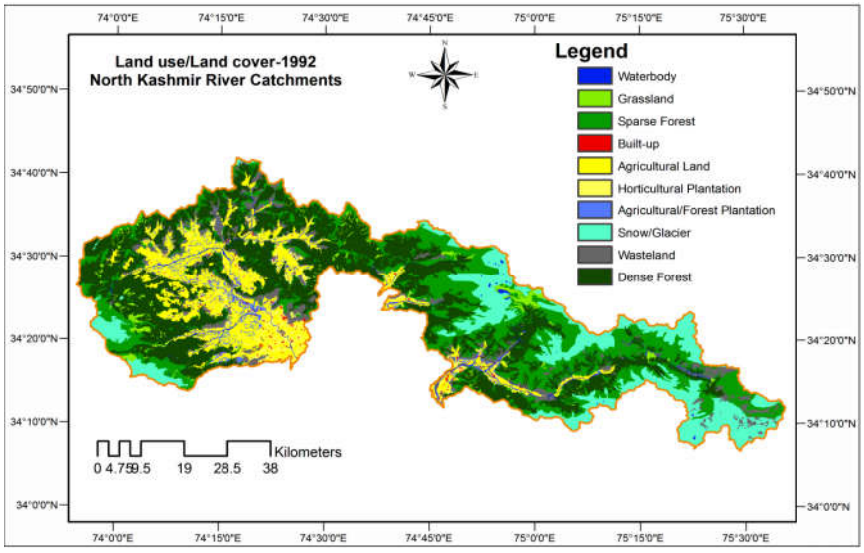

Fig. 4

Source: Generated from Landsat imagery of October, 1992

After dense forests, sparse forest is the major land cover category extended over an area of 1002 sq. kms in North Kashmir River Catchments. Sparse forest constitutes 25.78 percent of the study area. The area under snow/glacier is 537 sq. kms which constitutes 13.81 percent of the total area. Most of the snow/glacier cover is found in Sind and Erin catchments as the altitude starts decreasing substantially while going from east to west (fig 6). This land cover occupies the higher reaches of the study area. A very small proportion of snow/glacier flanks the western margin of the study area. The glaciers are present only in Sind catchment as the altitude is very high.

North Kashmir River Catchment region is a part of north western Himalayas as a result the upper reaches of the study area are perpetually under the snow/glacier cover. Agriculture is the primary occupation of the people in North Kashmir River Catchment region. Agricultural land is spread over an area of 496 sq. kms constituting 12.77 percent of the study area. Being a mountainous region,there are insignificant prospects for agricultural expansion.

The elevated portions of Kashmir valley are generally under plantation crops and North Kashmir River Catchment region is no exception to this. The plantation crops thrive best in the elevated land areas and gives good economic returns.

Nowadays, people are switching from subsistence to commercial farming.

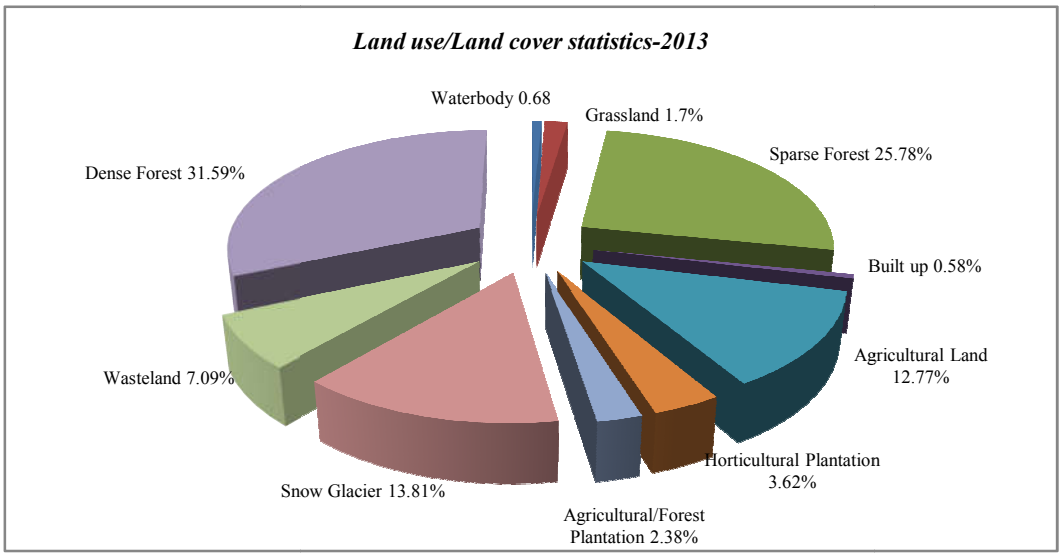

Fig.5

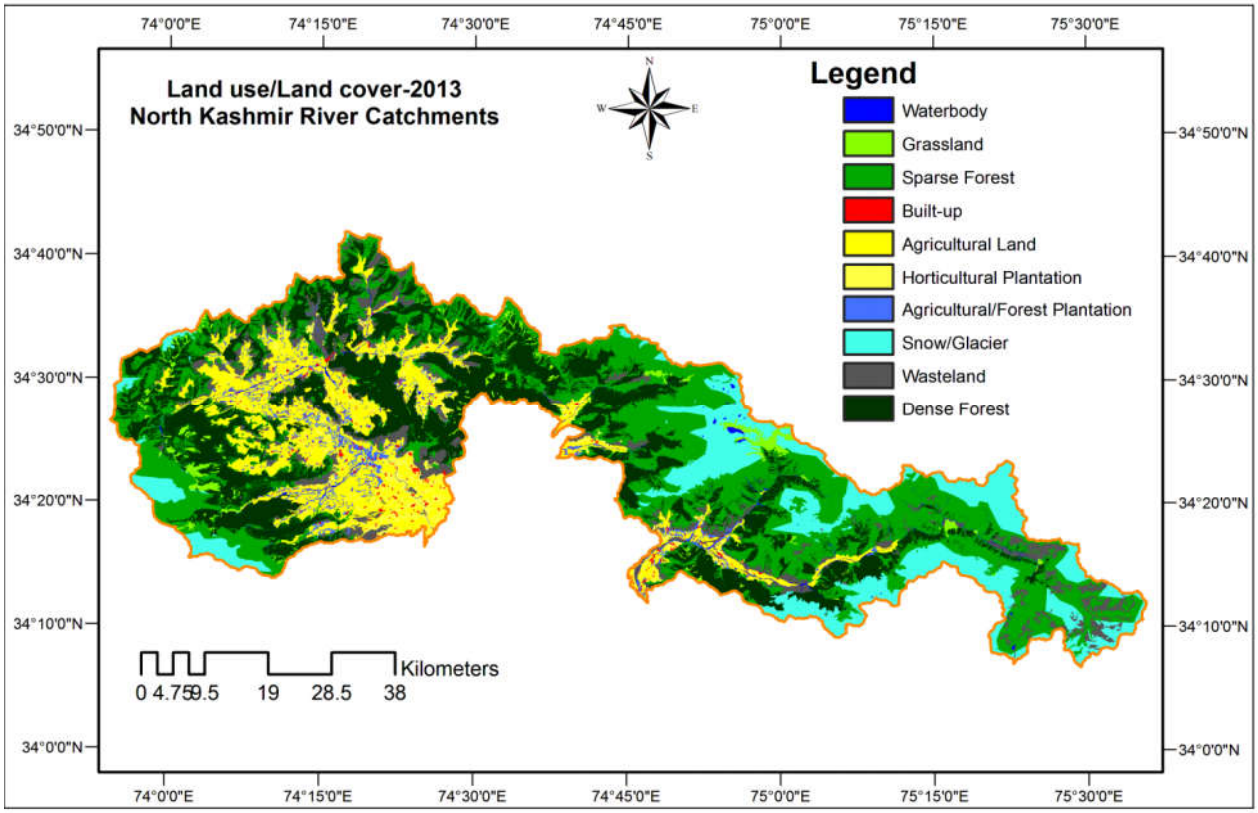

Fig.6

Source: Generated from Landsat imagery of October, 1992

Earlier, the most dominant crop used to be paddy but now plantation agriculture has expanded dramatically at the cost of non-plantation cropland area. The area under horticulture plantation in the study area is 141 sq. kms. which constitutes only 3.62 percent of the study area.

Wasteland is major land cover category in the study area in terms of areal coverage. It is spread over a good proportion of area and includes mostly the mountain peaks and rock outcrops of varying lithology. Wasteland is also found in the vicinity of glacial lands.

It occupies an area of 275 sq. kms which is 7 percent of the study area. Waterbody, grassland, built-up and agricultural/forest plantation are other important land use/cover classes found in the study area but are insignificant in terms of their areal coverage. Among these classes, agricultural/forest plantation is the largest one with an areal extent of 92 sq. kms. It constitutes 2.38 percent of the study area. The agricultural/forest plantation in the study area is found along the banks of major streams and the forest areas. Grassland occupies 66 sq. kms of the study area which is just 1.7 percent of the total area. These are the areas found on the higher

reaches in the form of vast rolling plains or alpine pastures. Waterbody and built-up is spread over an area of 27 and 23 sq. kms of North Kashmir River Catchment region which constitutes 0.68 and 0.58 percent of the study area, respectively.

Table 2 Land use/ Land cover of North Kashmir River Catchments (2013)

LULC Category	Area in KM^2	Percentage of the total area
Waterbody	27	0.68
Grassland	66	1.70
Sparse Forest	1002	25.78
Built up	23	0.58
Agricultural Land	496	12.77
Horticultural Plantation	141	3.62
Agricultural/Forest Plantation	92	2.38
Snow/Glacier	537	13.81
Wasteland	275	7.09
Dense Forest	1227	31.59
Total	**3886**	**100.00**

Source: Computed from Landsat Imagery of October, 2013

Land use/cover Change in North Kashmir River Catchments, 1992- 2013

The land use/land cover change that has occurred in North Kashmir River Catchments from 1992 to 2013 is shown in the table 3. The table clearly reveals that dense forest is the fast changing land cover category in the study area. It has declined from the total area of 1339 sq. kms 1992 to 1227 sq. kms in 2013. The dense forest has decrease by 113 sq. kms within a period of twenty years with an average annual rate of decrease of approximately 6 sq. kms. Multiple reasons could be attributed to this decrease in the forest cover. The rampant deforestation and frequent forest fires have severely reducedthe forest cover in the study area. However, this 113 sq. kms of forest cover has not been cleared off the land completely but has been changed into sparse forest over the period of time. Dense forests constituted 34.45 percent and 31.59 percent of the study area in 1992 and 2013 respectively. It has registered a decrease of 2.86 percent.

Sparse forest, being one of the dominant land cover categories has shown a net increase of 117 sq. kms from 1992 to 2013. It occupied an area of 885 sq. kms in 1992 and 1002 sq. kms in 2013. Sparse forest constituted 22.79 percent of the study area in 1992 but this figure has increased to 25.78 percent in 2013. This land cover category has shown a net increase of 2.99 percent in its areal coverage within a period of twenty years.

Snow/glacier is a temporary land cover that changes with any fluctuations in climatic patterns. Since the study area is entirely mountainous in nature, the higher altitude areas remain snow clad for most part of the year. Snow/glacier has shown a decrease in its areal coverage in North Kashmir River Catchments from 1992 to 2013. A net decrease of 44 sq. kms has occurred in snow/glacier land cover in the study area within a period of twenty years. In 1992, snow/glacier was spread over an area of 581 sq. kms and this figure has gone down to 537 sq. kms in 2013 as is clear from the table 3 and figure 7. This decrease in the areal extent of snow/glacier may be attributed to increasing temperatures from 2000 onwards. As per the WMO Summary Report Published in the year 2013, the decade from 2001 to 2010 has been the warmest decade on record since modern meteorological records began around the year 1850.

Horticulture plantation has shown an increasing trend in the study area. This land use/cover has increased by 0.67 percent from 1992 to 2013. It occupied 2.94 percent of the total area in 1992 and the figure has increased up to 3.62 percent in the year 2013.

Table 3 Land use/cover Change-North Kashmir River Catchments (1992-2013)

Land use/land cover category	Area in km^2 (%age) 1992	Area in km^2 (%age) 2013	Change in area (%age) 1992-2013
Waterbody	44 (1.12)	27 (0.68)	-17 (-0.44)
Grassland	72 (1.84)	66 (1.70)	-6 (-0.14)
Sparse Forest	885 (22.79)	1002 (25.78)	117 (2.99)
Built up	18 (0.47)	23 (0.58)	5 (0.11)
Agricultural Land	491 (12.63)	496 (12.77)	5 (0.14)
Horticultural Plantation	115 (2.94)	141 (3.62)	26 (0.67)
Agricultural/Forest Plantation	79 (2.04)	92 (2.38)	13 (0.34)
Snow/Glacier	581 (14.95)	537 (13.81)	-44 (-1.14)
Wasteland	262 (6.75)	275 (7.09)	13 (0.34)
Dense Forest	1339 (34.45)	1227 (31.59)	-112 (-2.86)
Total	3886 (100)	3886 (100)	0 (0)

There has a general shift in the agricultural practices throughout Kashmir valley. People have moved from subsistence to commercial agriculture in order to fetch more and more economic returns. Moreover, the degrading water resources have further paved way for this transition in the agricultural practices.

Agriculture/forest Plantation has registered a net increase of 0.34 percent from 1992 to 2013. The total area under this land use/cover category was 79 sq. kms in 1992 which has increased to 92 sq. kms in 2013. This plantation is found around the agricultural fields and forest areas.

The mountainous character of the landscape offers a very little scope for the extension of built-up area in North Kashmir River Catchments. There has been an insignificant increase in the built-up area in the study area. It has increased from 18 sq. kms to 23 sq. kms from 1992 to 2013 which is just 0.11 percent of the total area.

Grasslands are the areas found at very high altitudes. These are actually the alpine pastures located above the tree line. Grasslands occupy a small fraction of the study area which is clear from the table 3. It has recorded a decrease of 6 sq. kms within a period of twenty years. Grasslands occupied 72 sq. kms and 66 sq. kms of the study area in 1992 and 2013 respectively.

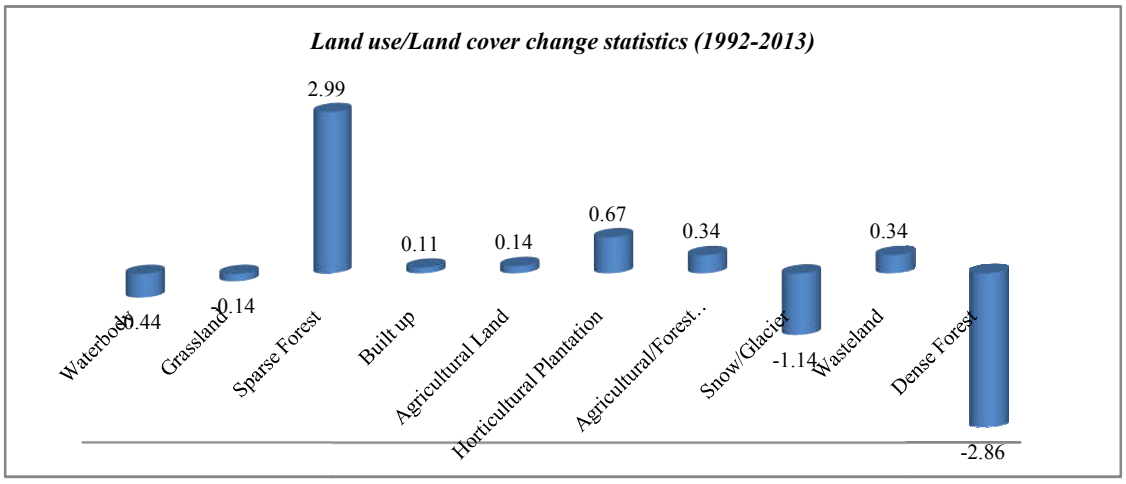

Fig. 7

There has been a slight decrease of 6 sq. kms in the areal extent of grasslands. Grasslands constituted 1.84 percent of the study area in 1992 which has come down to 1.70 percent in 2013. These grasslands have been degraded over the past decades at an alarming rate. As per the experts, these grasslands are now under a constant threat of overgrazing, encroachments, denudation, weeds etc. The call for some scientific steps towards the management of these pastures is the need of the hour else these pastures would be degraded beyond redemption. The alpine pastures in North Western Himalayas are utilized way beyond their carrying capacity.

The channels of various higher order streams and the Sars located in and around the snow clad areas were taken as waterbodies. The waterbodies in the study area have decreased by 17 sq. kms from 1992 to 2013. The Sars on the higher altitudes have remained unchanged as these areas are almost pure natural landscapes devoid of any significant human interference. The channels of the big streams have shrunk in terms of their width. The degrading water resources have caused many streams to dry-up as a result more and more plantation has come up along the banks of these streams. Waterbodies occupied 44 sq. kms of the study area in 1992 and this figure has come down to 27 sq. kms in 2013. The rocky outcrops and bare ground has been included in the category of wasteland. Being a high altitude area in north western Himalayas, the study area has a significant proportion of wasteland. It has registered a net increase of 0.34 percent from 1992 to 2013 (table 3 and fig. 7). Wasteland was spread over an area of 262 sq. kms in 1992 which has increased to 275 sq. kms in 2013. The unchecked deforestation and overgrazing of pastures has rendered many square kilometers of area susceptible to severe erosion and subsequent degradation.

The average land holding size is comparatively small owing to the scarcity of optimum agricultural land available to the people of the region. Moreover, the people in North Kashmir River Catchment Region have switched from subsistence to commercial farming.

Earlier, they use to cultivate crops for family consumption but now these crops have slowly been replaced by the plantation agriculture. This is transformation is more at work in the lower parts of the study area. Agriculture has not shown any recognizable increase in its areal extent over the period of two decades. A total area of 491 sq. kms was under agriculture in 1992 and 495 sq. kms in 2013. Agricultural land constituted 12.63 percent and 12.77 percent of the study area in 1992 and 2013 respectively. Going by the figures, agriculture has recorded an increase of just 0.14 percent within a period of twenty years.

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