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Impact of land use/land cover dynamics on himalayan wetland ecosystem

Akhtar Alam[1*], S.M. Rashid[2], M. Sultan Bhat[1] and Ashaq Hussain Sheikh[3]

[1]Department of Geography and Regional Development, University of Kashmir, India; [2]Department of Geography, Jamia Millia Islamia, New Delhi, India; [3]Department of Remote Sensing and Geoinformatics, M.D.S. University, India

Abstract

Wetland ecosystems integrate many upstream processes and the differential contributions of spatially distributed controlling factors, especially land use / land cover. In view of the significant importance of wetlands in the ecosystem and regional economy, an attempt has been made to analyze the impact of land use / land cover dynamics on spatial status of Hokar Sar wetland, a Ramsar Site located in Kashmir Himalayas. The impact assessment has been carried out by analyzing the multi-temporal (1986, 1995, 2005) changes in the upstream land use / land cover characteristics of wetland watershed, by using remote sensing data of SPOT HRV-I, Landsat-ETM and IRS-LISS-III, respectively. The multi-temporal land use / land cover statistics revealed that significant changes have taken place from 1986 to 2005 in the watershed. And in response to these upstream watershed changes, the Hokar Sar wetland has exhibited changes in spatial extension, structure and hydrological characteristics. As a consequence of continuous inflow of sediment load and nutrients from the upper catchment due to changing land use, the wetland has fragmented into various spatial zones with varying physicochemical characteristics. Average water depth of the wetland has reduced significantly, wetland has attained eutrophication condition and the overall ecosystem of the wetland has been found to be degraded.

Keywords: Dynamics, Ecosystem, Land use/Land cover, Response, Wetland

Introduction

Among number of anthropogenic factors contributing towards the changing status of wetlands, land use / land cover change (particularly expansion of urbanization and increasing agricultural activities) has been identified among dominant causes leading to degradation of wetlands as reported in number of studies worldwide. Wetlands are of enormous value for the supply of goods and services to society (Begg 1987; Kotze and Breen 1994; Mitsch and Gosselink 2000), but they are threatened globally (Maltby 1991). Land use / land cover change by humans from last few decades is one of primary factors responsible for wetland degradation. The rates and temporal variation of delivery of water, sediment, and nutrients from land surfaces into the aquatic ecosystems varies geographically. The structure and function of stream ecosystems are inextricably linked to the status and condition of their surrounding watershed (Wallace et al. 1999). Changes in land use / land cover generate great spatial heterogeneity in the structure and function of the wetlands. The impacts of anthropogenic nutrient enrichment on the biota and biochemistry of aquatic systems and wetland ecosystems are an important global issue (National Research Council 1992; Carpenter et al. 1998; Downing et al. 1999; Howarth et al. 2000). Anthropogenic activities often generate effects, which also interfere in the ecosystem functioning (Campesan et al. 1981; Sorokin et al. 1996; Collavini et al. 2001).Water quality is significantly related to land use (Benoit and Fizaine 1999; Cuffney et al. 2000; Berka et al. 2001). There is convincing evidence that watershed dominated by agriculture and/or human settlement have significantly higher river, stream and lake nutrient levels (McFarland and Hauck 1999; Cuffney et al. 2000; Berka et al. 2001; Wang 2001). As reported in various studies, urbanization has been identified as one of the leading threats to biodiversity worldwide. Urban areas may threaten ecosystems through direct habitat conversion (e.g., Clergeau et al. 1998, Blair 1999, McKinney 2002) and through various indirect effects of dense human population such as resource use, habitat fragmentation, waste generation, and freshwater cooption (e.g., Mikusinski and Angelstam 1998). Agriculture is another, perhaps even greater, global threat to biodiversity. Similarly to urbanization, agriculture presents both direct problems of habitat conversion and indirect effects of chemical pollution and disturbance of water and nutrient cycles (Pimentel et al. 1992, Vitousek et al. 1997). Such environmental degradation has typically resulted in a decrease in biodiversity and a reduction in the quality of natural services various ecosystems provide (clean water, fresh air, esthetics, recreation) (Conroy et al., 2003). Better understanding of wetland characteristics and potential impacts allow policy makers and wetland users to devise and implement policies, legislation and management practices leading to suitable use of wetland resources for economic gains while preserving their biodiversity. Such interventions require improved knowledge on the processes influencing the physical, chemical and biological characteristics of the wetlands and ongoing changes due to land use practices in the proximity of sensitive wetlands (Piyankarage et al. 2004).

Study Area

Hokar Sar wetland is located in the Doodhganga watershed of western Himalayas in the extreme northern part of India. The wetland is also a wildlife reserve and was declared as *Ramsar Site* in 2005. It is located at an altitude of 1584 meters above mean sea level on Srinagar – Baramulla National Highway, J&K, (Fig.1).

* *Corresponding Author, Email: alamwani@gmail.com*

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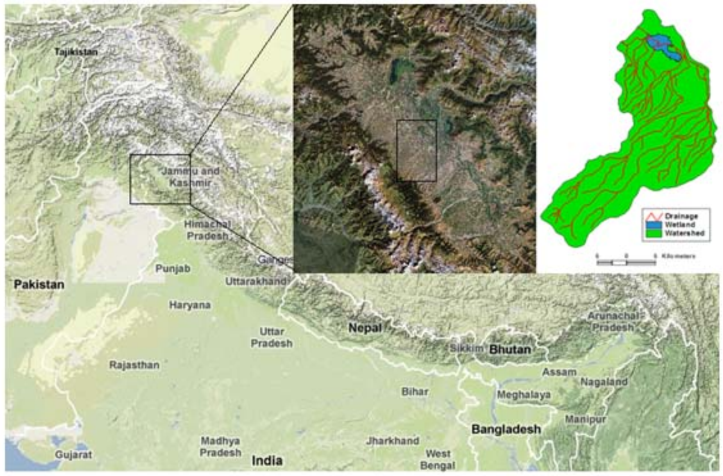
Fig. 1 Location of the study Area



Material and Methods

Remote Sensing data and Geographical Information System (GIS) techniques were used for spatiotemporal assessment of the Doodhganga watershed and Hokar Sar wetland. Supplemented with ground validation multi-temporal land use / land cover mapping and change detection was performed using digital datasets of SPOT-HRV-1 (1986), Landsat-TM (1995) and IRS LISS-III (2005).

Results and Discussion

Land use/ Land cover Analysis

Land use/ land cover mapping of Doodhganga watershed was carried out using satellite data of the year 1986, 1995, and 2005. Supervised classification helped in the identifying, delineating and mapping of the land use/land cover into several classes. The classes identified include settlements, agricultural land, cultivable waste, natural vegetation, plantation, grass land, water bodies, marshy land, waste land, and snow cover areas, fig.2. The changes in the land use/land cover classes were mapped, quantified and accuracy assessment was done for all the three dates

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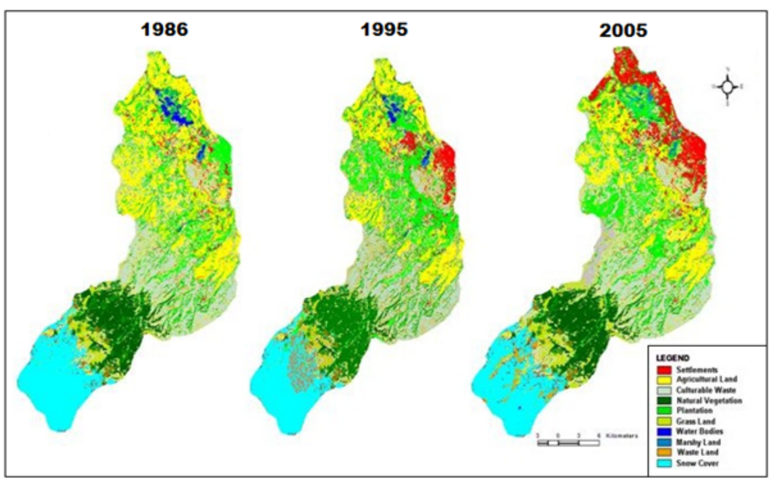
Fig. 2 Multi-temporal Land use/ Land cover of Dooddhganga Watershed



The statistical analysis of the multi-temporal land use/land cover maps of the Doodhganga watershed reveal that significant changes have taken place from 1986 to 2005. Table: 1.0 provides changes of Land use/land cover in Doodhganga Watershed during 1986, 1995 and 2005. Land use/ land cover in the Doodhganga watershed and in the environs of the Hokar Sar wetland has marked significant changes. Land use change over time, based on human needs has modified the physical environment in the area. The growing population has significantly altered the natural landscape. There has been loss in natural vegetation, agricultural lands, water bodies and open space particularly due to increasing residential and commercial land uses. The conversion of land from one use to other has put a wide range of negative effects as far as overall health of the watershed is concerned. The changes in land use / land cover are the consequence of many activities and it is summarized that settlement area has increased (4.98% to 15.75%), waste land has decreased (4.60% to 1.92%), plantation area has increased (7.69% to 21.27%), agricultural land has decreased (31.21% to 14.87%), culturable waste has decreased (16.46% to 1.69%), grass land area has increased (8.50% to 22.90%) , marshy land has decreased (1.96% to 1.65%), natural vegetation has decreased (11.62% to 11.46%), water bodies have decreased (1.47% to 0.24%) and snow cover has decreased also (11.47% to 8.20%).

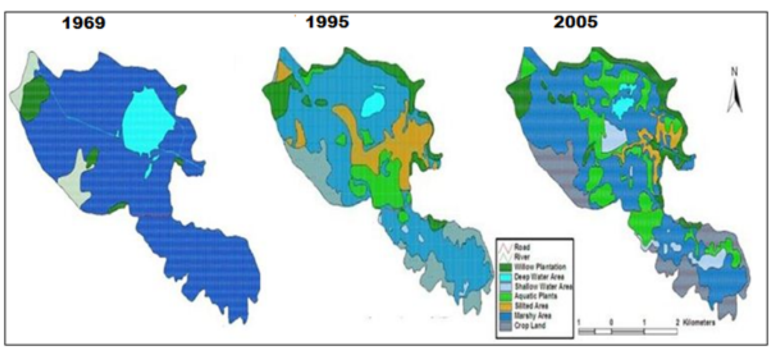
Table: 1.0 Change Detection Statistics of Land use /Land cover (1986-2005)

Class Name (LULC)	Area (Hectares) 1986	Area Percent (%)	Area (Hectares) 1995	Area Percent (%)	Area (Hectares) 2005	Area Percent (%)	Total Change (Hectares) 1986-2005
Settlements	3049	4.98	6037	9.87	9633	15.75	6584
Waste land	2814	4.60	2731	4.46	1179	1.92	-1638
Plantation	4702	7.69	9172	15.00	13004	21.27	4470
Agricultural land	19082	31.21	18901	30.91	9092	14.87	-9990
Cultivable Waste	10064	16.46	1134	1.85	1039	1.69	-9025
Grass land	5198	8.50	7508	12.28	14001	22.90	8803
Marshy land	1201	1.96	1103	1.80	1009	1.65	-192
Natural vegetation	7108	11.62	7059	11.54	7011	11.46	-97
Water bodies	903	1.47	510	0.83	150	0.24	-753
Snow cover	7016	11.47	6982	11.42	5019	8.20	-1997
Total	61137	100	61137	100	61137	100	

Spatio-temporal Assessment of the Hokar Sar Wetland

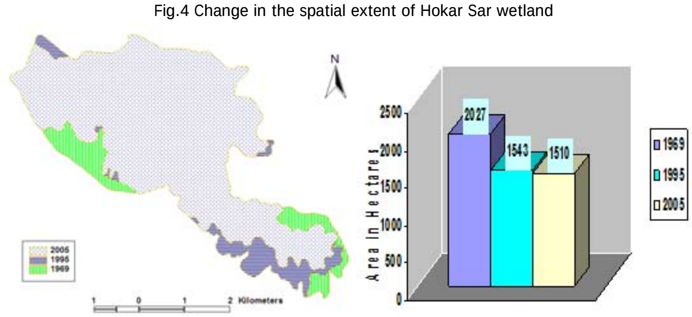
Doodhganga river after traversing through the upper catchment ultimately enters the Hokar Sar wetland, thus acting as a carrier of alien material from upper catchment into the wetland. It has been observed that land use/land cover changes in the Doodghganga watershed has resulted in the degradation of the wetland. The upstream watershed changes have affected the spatial extension, flora and fauna and hydrological characteristics of the Hokar Sar wetland. The water covered area of the wetland which was 169 hectares in 1969 has reduced to 60 hectares and 45 in the years 1995 and 2005 respectively, registering net annual loss of 3.4 hectares. Marshy area has noticed reduction from 1691 hectares in 1969 to 1212 hectares in 2005. Significant increase has been observed in plantation area (79 hectares in 1969 to 163 hectares in 2005).

Fig. 3 Spatio-temporal Dynamics of Hokar Sar Wetland



As result of conversion to other land uses (especially conversion to agriculture), the fallow land in the wetland has reduced from 88 hectares in 1969 to 0 hectares in 1995. In response to upstream land use/land cover change significant proportion of sediment load gets settled in the wetland. Silted area has increased from 0 hectares in 1969 to 221 hectares in 1995. It was noticed that there is decrease in silted area from 221 hectares in 1995 to 90 hectares in 2005. The decrease in silted area during this period is the result of emergence of plants over the significant proportion of silted area. The statistical analysis shows that crop land has increased from 0 hectares in 1969 to 484 hectares in 1995 and 517 hectares in 2005. The main reason for increase in the crop land area is the encroachment and conversion of wetland area into agricultural land by the local farmers.

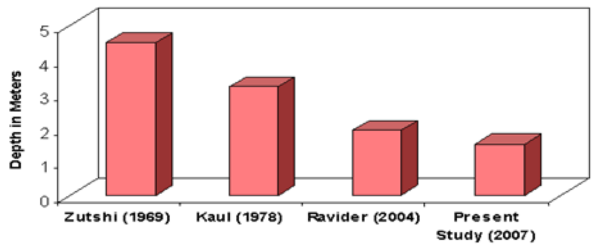
Fig.4 Change in the spatial extent of Hokar Sar wetland



There has been a substantial loss in the areal extent of the wetland as it has decreased from 2027 hectares in 1969 to 1543 hectares in 1995 and 1510 hectares in 2005, registering an annual loss of 14.36 hectares during this period. Land use/land cover changes in the watershed have contributed to the decline of spatial extent and quality of the Hokar Sar Wetland. Considerable area of the wetland has been observed to be lost. Fig.4 highlights the decrease in the total areal extent of the Wetland from 1969 to 2005.

The changes in land use / land cover affect the rate of soil erosion and concentration of sediment load carried by rivers to receiving water bodies. The continued sediment intrusion has altered the average depth of the wetland. It could be inferred on the basis of studies carried out at different time periods that mean water depth of wetland has reduced considerably as displayed in fig.5. The mean water depth of water has decreased from 4.7 meters in 1969 to 1.3 meters in 2007 with 0.08 meters of depth loss annually.

Fig.5 Average water depth of Hokar Sar wetland



Conclusion

Among myriad of factors contributing towards the changing status of the wetlands changes in the upstream land use / land cover characteristics have been identified as dominant factor responsible for degradation of wetland ecosystem in western Himalayas. The assessment reveals that the land use / land cover changes in the upper catchment especially in immediate uplands have adversely affected the Hokar Sar Wetland. The Wetland has suffered serious loss during last few decades as a result of changes in land use / land cover especially unplanned urban sprawl, unregulated agricultural development, inflow of fertilizers, silt, solid waste and pesticides from the catchment into the wetland. The consequences of these problems include reduction in wetland area, decrease in water depth, degradation of water quality and deterioration of natural ecosystem. The wetlands of Kashmir valley play a significant role in overall water cycle of the basin. However, these wetlands have been facing a variety of threats, both anthropogenic and natural. It is found that large areas of wetlands have been degraded and lost in the past as a result of land use/land cover change and unsustainable planning initiatives in the valley. It is further observed that the wetlands have received little attention so far in terms of conservation and management. Hence, there is a need for making scientific assessment of problems and for mitigation of the hazards causing threats to the wetlands. Conservation of these unique spaces needs special efforts by the government. A complete understanding of behavior of wetland ecosystem requires an interdisciplinary, integrated and multi-temporal holistic approach. Although, there is a growing interest in natural resources management among geoscientists and environmentalists, there still exists a wide gap in the understanding of factors associated with changing dynamics of wetland ecosystem. Wetlands, if properly managed can be used profitably for meeting a wide variety of the human requirements and for deriving environmental benefits. The management of these wetlands requires inter-agency cooperation, policy making, capacity building and technology transfer.

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