

## **Land Use Changes and Conservation of Water Resources in Himalayan Headwaters**

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In Himalaya, nature of terrain and climate impose severe limitations on the scale of productive activities as well as on efficiency of infrastructural facilities. As a result, biomass-based subsistence agriculture constitutes the main source of rural livelihood, and more than 75 % of population depend on traditional agriculture even though the availability of arable land is severely limited and productivity is poor. During recent years, a variety of changes have emerged in the traditional resource-use structure in Himalaya, mainly in response to population growth, and the resultant increased demand of natural resources. Moreover, global climate changes have already stressed natural ecosystem through higher mean annual temperatures, altered precipitation patterns, more frequent and extreme weather events, and forest fires in Himalaya. These are intensifying land use and exerting sharply accentuated pressure on natural resource base of headwaters, which constitute crucial areas for the conservation of water resources. As a result, critical natural resources, such as land, water, forests, biodiversity, etc., have depleted steadily and significantly, leading to their conversion into degraded and non-productive wastelands, reducing groundwater recharge, and disrupting the hydrological regime of Himalayan headwaters. Hence, the regime of water resources in Himalaya is changing rapidly, with respect to water discharge, volume and availability.

The main objective of the paper is to interpret the trends and magnitude of land use changes in ecological and socio-economic backdrops and to assess their impact on water resources, and to evolve an integrated land and water management framework with a case illustration of Kosi Headwater in Kumaon Lesser Himalaya, Uttarakhand, India. The paper attempts to bring out: (i) a detailed analysis and appraisal of land and water resources, using satellite data and Geographic Information System (GIS); (ii) interpretation of community resource utilization patterns in varying ecological and socio-economic situations through conducting comprehensive socio-economic surveys using exclusively designed schedules and questionnaires; (iii) monitoring land use dynamics using multi-date satellite data; (iv) analysis of land use and water interactions using field survey and mapping techniques, hydrological monitoring and integrating data in Geographic Information System (GIS); and (v) evolving an inclusive, adaptive and participatory land and water resource management framework.

The study revealed that out of total area (107.94 km<sup>2</sup>) of the headwater 7.81 % has changed from one land use to other between 1978 and 2008. Cultivated land has increased by 14.33%, forests have declined by 4.36 %, and barren and degraded land has increased by 2.14 % during last 30 years. It was investigated that the amount of surface run-off from cultivated (80 %) and barren lands (85 %) is much higher compared to that of forests (25 %). Consequently, ground water recharge has reduced drastically mainly due to a decrease in forest area. These hydrological disruptions are now clearly discernible in (i) long-term decreasing trend of stream discharge, (ii) diminishing discharge and drying of springs, and (iii) biotic impact on surface run-off flow system and channel network capacity. Nearly 33 % of natural springs have dried out, 11 % of springs have become seasonal, and a stream-length of 736 km has dried. More than 61 % villages of the watershed are facing great scarcity of water for all purposes. All this undermines livelihood and food securities of both highland and lowland population dependent primarily on subsistence agriculture.

Consequently, supply of biomass to agriculture has declined (41 %), irrigation potential has reduced (18 %) and food productivity has decreased (25 %), increasing deficit levels in food, fodder and fuel-wood respectively by 32 %, 20 % and 27 %. Integrated land and water management framework which evolved for the region is based on terrain and hydrological characteristics, and developmental needs and priorities of local people. It makes provisions for water-conserving forestry and horticultural practices, rainwater harvesting schemes, livelihood improvement through cultivation of less water requiring and drought resistant food as well as cash crops, and enhancing resilience of both natural and human systems to long-term impacts of climate change based on local knowledge and in agreement with local communities and government agencies.

Further Reading:

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