INNOVATIVE ENERGY TECHNOLOGY SYSTEMS AND ENVIRONMENTAL CONCERNS: A SUSTAINABLE APPROACH
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Impact of Land Use Change on Water Resources

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Abstract

Land use changes are altering the hydrologic system and have potentially large impacts on water resources. Land use and water resources are unequivocally linked. The type of land and the intensity of its use will have a strong influence on the receiving water resource. Whether the source is natural or comes from a human activity, the impact of any land use practice on either the quantity or quality of water can be substantial. Large-scale increases in some rural land uses can change the way water moves through the landscape by intercepting water before it reaches waterways, reservoirs and aquifers or using water drawing water directly from shallow aquifers. This can reduce the amount of water available for other water users and the environment. This is particularly true for changes to deeper-rooted vegetation. In India, there has been significant land use change over the past 20 years. Over the past two decades, the understanding of land use changes in different parts of India and their impacts on water resources has improved. Many studies have been conducted to estimate: changes in water use (that is, evapo transpiration) and the impacts of those changes on stream flow and groundwater levels. Rapid socio-economic development drives land use change. This is particularly true in the case of the rapidly developing cites of India. However, an increasing population, developmental pressures, absence of land use planning, and competition for water resources, continually contribute to the degradation of water resources. Changes in land use have potentially large impacts on water resources, yet quantifying these impacts remain among the more challenging problems in hydrology.
The relationship between land change and hydrology is complex, with linkages existing at a wide variety of spatial and temporal scales; however, land change unquestionably has a strong influence on global water yield. Land cover and use directly impact the amount of evaporation, groundwater infiltration and overland runoff that occurs during and after precipitation events. These factors control the water yields of surface streams and groundwater aquifers and thus the amount of water available for both ecosystem function and human use.

Keywords-Land use, hydrology, water resources, infiltration, runoff

Introduction

Changes in land cover and use alter both runoff behavior and the balance that exists between evaporation, groundwater recharge and stream discharge in specific areas and in entire watersheds, with considerable consequence for all water users. (Sahin & Hall, 1996; DeFries

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& Eshleman, 2004). River discharge worldwide has increased noticeably since 1900, and studies suggest that land change may be directly responsible for as much as 50% of this increase (Piao, et al., 2007).

Land use and land cover have a direct relationship with environmental characteristics and processes, including the productivity of the land, species diversity, climate, biogeochemistry and the hydrologic cycle. The characteristics of land cover and use have an impact on the climate, biogeochemistry, hydrology, and the diversity and abundance of terrestrial species.

Land use refers to the human purposes that are associated with the land cover (e.g. raising cattle, recreation, or urban living and relates to human activities on the land. A single category of land use may be associated with a variety of land covers. Similarly, a single land cover may support multiple uses. For example, residential land use may have tree cover, grass cover, road cover, and roof cover while a forest may be used for timber production, recreation, or wildlife preservation.

Land use change may involve either a shift to a different use, such as agricultural land changing to residential, or an intensification of the existing use, such as from light to heavy industry. The dual role of human activity in contributing to the causes and experiencing the effects of global change processes brought about by land use changes emphasizes the need for better understanding of the interaction between humans and the environment. This need becomes more imperative as changes in land use become more rapid.

In the past 50 years, India has experienced large land-use changes including deforestation, overgrazing and land reclamation. Land use change may have both immediate and long-lasting impacts on hydrological processes and the local and regional water balance. With the ongoing population growth and socio-economic problems in the region this land use change trend will continue or even aggravate in future. Therefore an assessment of the impact of future land use change on the hydrological process is of utmost importance, especially in combination with climate change impact studies. A prerequisite for this assessment is that the hydrologic processes in the region have to be understood in detail. Humans have exerted large-scale changes on the terrestrial biosphere, primarily through agriculture; however, the impacts of such changes on the hydrologic cycle are poorly understood. The purpose of this study was to test the hypothesis that the conversion of natural rangeland ecosystems to agricultural ecosystems impacts the subsurface portion of the hydrologic cycle by changing groundwater recharge and flushing salts to underlying aquifers.

Status of land Use Changes –

While land change is clearly a forcing factor in water supply, it is also an important driver of human water demand and overall water quality (DeFries & Eshleman, 2004). The conversion of native land cover to irrigated agriculture has been a critical factor in our ability to feed a human population growing at an exponential rate. By some estimates, 40% of the world's population relies on irrigated crops (Vorosmarty, *et al*., 2000) and irrigation accounts for as much as two-thirds of all human water usage (Malmqvist & Rundle, 2002). Deforestation, afforestation, and urban development have lesser though not insubstantial effects on water demand and supply as well. The consequences of all of types of land changes have profound impacts on water quality. Sewage and industrial pollution are widespread in most urban areas, and agricultural runoff almost universally results in elevated nitrate levels in both surface and groundwater supplies. By one estimate, a mere 10% of the world's rivers can be considered 'pristine' (Malmqvist & Rundle, 2002).

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Impact of Urbanization on water resources

Though conversion to urban land use comprises a relatively small amount of total land area, the hydrologic effects of urbanization can affect a considerable number of people and may range far beyond the boundaries of the urban area. These effects tend to fall within one of three main categories: adjustment and interruption of local groundwater supplies, pollution of local groundwater and downstream surface water, and the artificial adjustment of watershed yield via trans-basin diversion. Hydrologically-speaking, the most important impact of urbanization is the increase of impervious surfaces within the watershed. Impervious surfaces prohibit infiltration of water to the soil during precipitation events, thus inhibiting groundwater recharge and increasing overland runoff during precipitation events (Mustard & Fisher, 2004; Shanahan & Jacobs, 2007)

Impact of Deforestation/A forestation on water resources

The amount and type of vegetative land cover is one determinant of the water yield of a drainage basin. Forests produce higher rates of evapotranspiration and interception (the storage of water on leaf surfaces) than do grass or shrublands, all of which influence the amount of water that is available for direct drainage into streams or for aquifer recharge (Farley, *et al*., 2005). The adjustment in evapotranspiration in deforestation/afforestation land change is particularly acute. Trees generally have lower surface albedo, higher surface aerodynamic roughness, higher leaf surface area, and deeper roots than other types of vegetation, with each characteristic tending towards an increase in evapotranspiration of water and a decrease in streamflow discharge (Costa, *et al*., 2003).

Impact of agriculture / irrigation on water resources

The conversion of native ecosystems to irrigated agricultural production is one of the most widespread land change processes and is one with profound hydrologic impacts of its own. Some researchers have estimated that irrigated land coverage has increased worldwide from 100, 000 km2 in 1800 to 2, 700, 000 km2 in 2000. The rate of conversion is accelerating to match exponential population growth, with a doubling of the amount of irrigated land in just the past 50 years (Mustard & Fisher, 2004). Unfortunately, irrigation is one of the least efficient water uses, at least in terms of sustaining resources within a watershed. Research indicates that anywhere from 2400 to 3500 km3 of water is irretrievably lost each year worldwide (meaning it cannot be returned in fluid form to the watershed from which it was obtained), with irrigation accounting from 85-90% of this total. This represents 9.5% of all of the earth's total annual fresh water supply and 30% of the fresh water than is accessible (Vorosmarty & Sahagian, 2000). Results show that recharge is related to land use as follows: discharge through evapotranspiration (i.e., no recharge; upward fluxes 0.1mmyr1) in natural rangeland ecosystems (low matric potentials; high chloride and nitrate concentrations);moderate-to-high recharge in irrigated agricultural ecosystems (high matric potentials; low-to-moderate chloride and nitrate concentrations) (AD recharge: 130–640mmyr1); and moderate recharge in nonirrigated (dryland) agricultural ecosystems (high matricpotentials; low chloride and nitrate concentrations, and increasing groundwater levels). Agricultural conversion alters key vegetation parameters that affect recharge, including fractional vegetation coverage, wilting point, and rooting depth. Reducing fractional vegetationcoverage to zero during fallow periods between crop rotations can increase recharge.

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Discussion and Conclusion

Variations in recharge associated with land use changes can have negative impacts on groundwater quality because thick unsaturated zones in semiarid and arid regions contain a reservoir of salts that accumulated over thousands of years (Allisonet al., 1990;) The general result of this study is that groundwater recharge is related to land use changes is as follows-

- Recharge is negligible beneath semiarid and arid rangeland ecosystems, where total-potential gradients are upward, metric potentials and water contents are low, and chloride and other salts have been building up in the unsaturated zone for thousands of years.
- Recharge is moderate-to-high beneath irrigated agricultural ecosystems (e.g., 130–640 mm yr 1 at the AD site). Total-potential gradients are down-ward, metric potentials and water contents are high, and chloride levels in unsaturated-zone pore water are low to moderate.
- Recharge is low to moderate beneath dry land agricultural ecosystems (e.g., 9–32 mm yr 1 at the HP3 site). Total-potential gradients are downward, metric potentials and water contents are high, and chloride levels in unsaturated-zone pore water are low
- Increased recharge associated with dryland as well as irrigated agriculture can lead to degradation of ground-water quality because of leaching of salts that have been accumulating in the unsaturated zone for thousands of years prior to cultivation, because of application of fertilizers, and, in irrigated areas, because of evapo-concentration of applied groundwater.
- The strong correlation between recharge and land use shown in this study suggests that managed changes in land use can be used to control groundwater recharge and groundwater quality.

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