LAND-USE/COVER CHANGE AND CARBON FLUX IN A HIMALAYAN WATERSHED

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ABSTRACT

Based on satellite imagery for the 1988s and 2001s, land-use/cover change and associated carbon stock and flux as a result of changes were estimated in Mamlay watershed of Sikkim Himalaya, India. The total area of forest was decreased by 28%, whereas open cropped area increased by more than 100%. The conversion of forests into other land-uses resulted in a remarkable decline in the C densities. Across the land-use/cover, total mean C densities ranged from 46 t ha^{-1} in open cropped area temperate to a high of 669 t ha^{-1} in temperate natural dense forest. The heavily converted areas lost an estimated 55% of their total 1988 C pools, whereas the low impacted area lost only 0.12%. Changes in land-use released 7.78 tC ha^{-1} yr^{-1}, demonstrating that land-use changes significantly affected C flux. Therefore, the conversion of forest to agriculture land should be reversed.

INTRODUCTION

Land-use/cover change has emerged as a central issue within the scientific community concerned with global environmental change [*Kumar and Turner*, 1994]. One-third to one-half of the earth's land surface has been transformed by human action [*Vitousek, et al*., 1997]. The land-use change from forest to other usage has been quite conspicuous in the last few decades in the Himalayan region [*Rai*, 1995]. The forest-dominated watersheds are consequently converted into agrarian watersheds which lead to a considerable loss of carbon and disrupted the hydrological cycle.

The present study was carried out in Mamlay watershed, which is located in the southern part of Sikkim state in the eastern Himalayan biogeographic zone. The present data are the result of two consecutive years of study of three sites of each land-use/cover. The watershed lies entirely in the mountainous zone and has an elevational range of 300-2650 m asl, with a total area of 3014 ha encompassing nine revenue blocks including 34 settlements.

RESULTS

The land-use pattern in the watershed as a whole showed about 14% and 31% area under agricultural practices in 1988 and 2001, respectively. The agroforestry practices in the watershed are traditional and about 4% area came under these practices in both the years. The total forest land in the watershed accounted for 69% and 49% of the total area and wasteland covered about 11% and 15% in 1988 and 2001, respectively. During the 13-years period, the open cropped area increased by more than 100%, while wasteland increased by about 149%. The total forest cover decreased by 28% during 1988 to 2001.
The total mean C densities varied more than fifteen fold between the land-use/cover classes, from a low of around 46 t ha^{-1} in Open cropped area temperate to a high of 669 t ha^{-1} in Temperate natural forest dense. Area-weighted standing crop values for vegetation, litter, humus and soil were calculated on each land-use/cover class for the entire watershed. Total stand carbon in the studies watershed area (3014 ha) was 624×10^3 tC, total C stored in the soil to a 1-m depth was 456×10^3 t. Total vegetation C was 161×10^3 t, litter C 5.33×10^3 t and humus C 1.44×10^3 t in the whole watershed.

The net carbon fixed by different land-use/covers ranged between 3 to 7.43 tC ha^{-1} yr^{-1} (mean= 4.88). Carbon flux in different land-use/covers indicates maximum emission of carbon through soil respiration in all the land-uses. The carbon emission through soil respiration is highest in agricultural soils (21.28 tC ha^{-1}) and lowest in wasteland (12.67 tC ha^{-1}). Land conversion during the past 13 years (1988-2001)

resulted into a net release of 119×10^3 t vegetation C and 183×10^3 t soil C. This translates into release of 7.78 tC ha^{-1} yr^{-1} from the entire watershed due to land-cover change. Differences in carbon mass in different land-use/covers support the hypothesis that land-use transformation from forest to agriculture and other usage causes tremendous losses of terrestrial carbon that reduce the land sustenance potentials. Therefore, efforts should be made to allow carbon sequestration under the Kyoto Protocol. The watershed has 458 ha of wastelands. If these wastelands are allowed for afforestation, it may sequester 25.7×10^4 t more carbon over the next few decades.

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