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Carbon stock estimation in the catchment of Kotli Bhel 1A hydroelectric reservoir, Uttarakhand, India

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ABSTRACT

Constructions of dams/reservoirs all over the world are reported to emit significant amount of greenhouse gases (GHGs) and are considered as environmental polluters. Organic carbon is contributed by the forest in the catchment, part of soil organic carbon is transported through the runoffs to the reservoir and undergoes aerobic and anaerobic degradation with time to release GHGs to the atmosphere. Literature reveals that no work is available on the estimation of 'C' stock of trees of forest catchment for assessing/predicting the GHGs emissions from the reservoirs to atmosphere. To assess the GHGs emission potential of the reservoir, an attempt is made in the study to estimate the 'C' stock in the forest catchment of Kotli Bhel 1A hydroelectric reservoir located in Tehri Garhwal district of Uttarakhand, India. For this purpose, the selected area was categorized into the site-I, II and III along the Bhagirathi River based on type of forest available in the catchment. The total carbon density (TCD) of tree species of different forest types was calculated using diameter at breast height (dbh) and trees height. The results found that the TCD of forest catchment was found 76.96 Mg C ha^{-1} as the highest at the site-II and 29.93 Mg C ha^{-1} as lowest at site-I with mean of 51.50 Mg C ha^{-1}. The estimated forest 'C' stock shall be used to know the amount of carbon present before and after construction of the dam and to predict net GHGs emissions. The results may be helpful to study the potential of a given reservoir to release GHG and its subsequent impacts on global warming/climate challenges.

1. Introduction

Forests, the largest carbon pool on earth, acts as a major sources and sinks of carbon in nature. Thus, it is the chief component in the mitigation of global warming and for adaptation to climate change. The climate changes are caused by increasing GHGs which will lead to rise in global mean temperature from 3.7 to 4.8 °C by the year 2100 (IPCC, 2014). The increasing GHGs levels and associated climate change will have both positive and negative impact. On the positive side, due to increase in temperature and increased concentrations of CO_2, the productivity of crops increases. On the negative side, climate change will bring in temperature, precipitation, and heavy rainfall thereby resulting in natural calamities like drought, flooding, storms, rise in sea level and other effects like environmental health risks and the overall impact on agriculture (Kumar and Sharma, 2015b). Forests store more carbon than other terrestrial ecosystems (Gibbs et al., 2007). The major C pool in forests is equal to plant biomass (above- and below-ground), coarse woody debris, litter and soil (IPCC, 2003; Richards and Evans, 2004) which increases over the life cycle of a forest to a state of equilibrium when respiration by plants and soils decomposition of biomass becomes equal to the rate of growth (Acker et al., 2002; Smithwick et al., 2002). Estimation of forest carbon stocks enables one to assess the carbon losses during deforestation. Since 1990s, hydroelectric reservoirs are identified as being potential contributor of significant gross emissions, mainly carbon dioxide (CO_2) and methane (CH_4) (Tremblay et al., 2004; Giles, 2006). However, net GHG "footprint" of these reservoirs is still the subject of much debate (Galy-Lacaux et al., 1997; Fearnside, 2005; Dos Santos et al., 2006).

Uncertainties and variability (Dos Santos et al., 2006) in the data are the major reasons behind this scientific debate on net GHG emissions by tropical reservoirs. Uncertainties are related to the initial organic carbon stocks available in the area prior to impoundment. Since the forests are contributing to the largest 'C' stocks on forest land, deforestation is becoming the primary focus of the emissions associated with land-use changes (IPCC, 2006). Fearnside (2008) developed an explicit model of carbon stocks and its degradation to assess the GHG emissions from hydroelectric reservoirs. A precise estimation of carbon stock is very important as most of the GHGs emitted from reservoirs during the first few years after the impoundment, are due to decomposition of the

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flooded organic carbon contained by both biomass and soils (Giles, 2006) depending on the local environmental conditions such as hydrodynamics, latitude, reservoir age, water quality, temperature, bacteriology, labile organic carbon etc (Barros et al., 2011; Kumar and Sharma, 2012, 2014a, 2014b). The deforestation coupled with developmental activities like contribution of dam, roads, industries and agriculture and urban settlements are likely to increase the concentration of GHGs in the atmosphere. For the reservoirs, 54% of the emissions are due to release of carbon stock, 36% due to loss of carbon sink and 10% due to inundation of the reservoir (Laura, 2005). The literature reveals that no reports are available on forest C stock estimation in the catchment of hydroelectric reservoirs for the purpose of predicting GHG emitted from the hydroelectric reservoirs, which were considered till last decade as environment friendly.

In the study, the Kotli Bhel 1A hydroelectric project (under construction since 2013) is selected and located in the Tehri Garhwal division of Uttarakhand, India. The catchment area was divided into 3 sites and total carbon density was assessed using different forest species. The estimated forest 'C' stock shall be used to know the amount of carbon present before and after construction of the dam and to predict net GHGs emissions from the reservoirs.

2. Material and methods

2.1. Sampling site

The Uttarakhand State situated in the northern part of India has an area of 53,483 km^2 and lies between latitude 28°43′–31°28′N and longitude 77°34′–81°30′E. The recorded forest area of the State is 34,691 km^2, which is 64.79% of its geographical area (FSI, 2009). The hilly area has temperate climate whereas the plain area is tropical. The average annual rainfall is about 1550 mm and temperature ranges from sub-zero to 43 °C (FSI, 2009). The area receives moderate to high snowfall from December to February on higher elevations. In the study area, the year is represented by

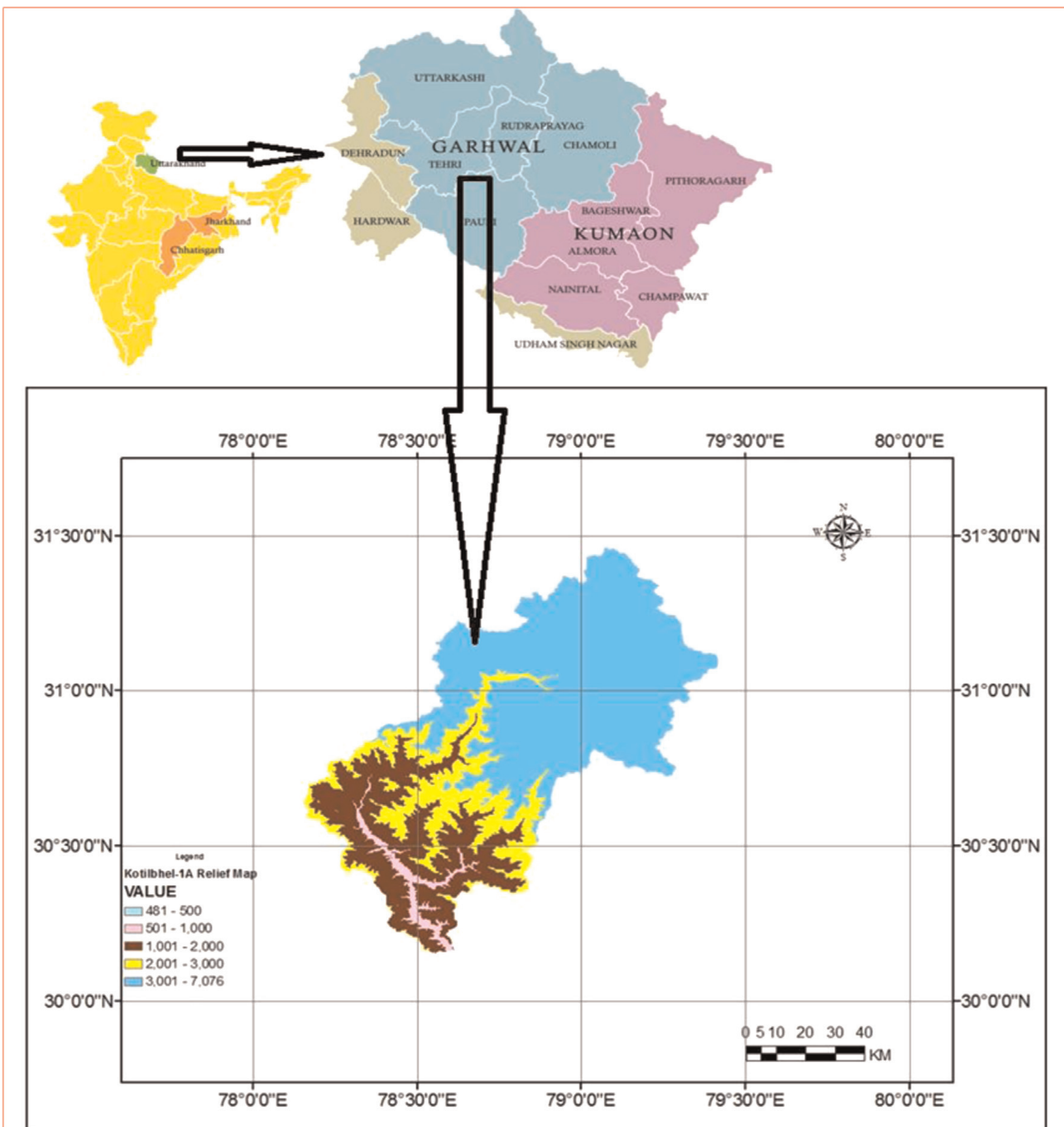

Fig. 1. Catchment area of Kotli Bhel 1A hydroelectric reservoirs with altitudes.

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