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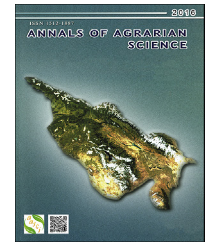

Assessment of carbon dioxide sequestration service: Case study of Ijevan state sanctuary (Tavush' region of Republic of Armenia)

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ABSTRACT

The article presents the study results of the carbon dioxide sequestration and emission reduction ecosystem services in the newly formed Ijevan state sanctuary, located in the Tavush region of Republic of Armenia (RA). As an outcome of study we got that forest ecosystems of Ijevan state sanctuary sequestrated 440,7 metric t carbon and reduced 1568,27 metric t CO_2 emission annually. It turns out that the value of carbon sequestration service by forest ecosystems equal to US $ 4407000 annually. With the removal of illegal logging the amount of sequestered of carbon can be increased by 10,95 metric tons. As an outcome the amount of carbon dioxide in the atmosphere will be reduced by 39.07 metric tons. The economic benefit will be an annual US $ 109.500 surplus of service.

Introduction

The forest ecosystems are the source of many benefits and services, most of which are difficult to calculate and evaluate. The Forest ecosystems global service value, evaluated by Costanza et al. was 4,7 trillion US $ which is very modest assessment [1]. In subsequent years, the services provided by forest ecosystems essentially were valuated.

The goods derived from the basic services of forest ecosystems are divided into direct use, non-wood forest products use and indirect use. Direct use and non-wood forests products use values are comparatively easily subjected to an economic assessment and valuation [2]. Whereas indirect use values, including carbon sequestration and emission reduction shall be made on the basis of indirect methodological approaches. Professor (Institute of Geography of the Russian Federation) A.A. Tishkov did comprehensive study on the biosphere and ecosystems services in specially protected areas, where it was emphasized the importance of air quality regulation, climate and surface flow regulation, improving the food chain, soil formation, and evaluation methodology [3].

According to the TEEB (The Economics of Ecosystems and Biodiversity, http://www.teebweb.org/ [4]) methodology, forest ecosystem services are classified into four categories:

1. Resources provision services, ecosystem services, which are describing material and energetic outputs of ecosystems activities.
2. Regulatory services, ecosystem services, when ecosystems act as regulators.

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3. Cultural (spiritual) services, includes non-material esthetic, spiritual and physiological benefits, those populations get from ecosystems or by being in touch with ecosystems.
4. Supportive services, those services are necessary for functioning of ecosystems' other services (provision, assurance).

Carbon dioxide gas absorption (climate change mitigation) service evaluation is considered to be one of the important regulatory services for forests. Forest ecosystems during their lifetime are absorbing carbon dioxide from atmosphere and store carbon in their tissues. Although from one side increase of usage of mineral fuels and from the other side deforestation, are leading to increase of carbon dioxide in the atmosphere [5].

Objectives and methods

In order to calculate the absorption capacity of carbon dioxide, first we need to calculate the average yearly growth of main varieties of trees in the forest in m^3. Thereafter with the help of weighted average method, we should calculate average growth of trees for 1 ha in m^3. Then on the base of several forestry studies should be derived the basic density coefficients of tree species, so the wet mass (biomass) converted into dry material mass (P_0). The derived coefficients of different tree species (the basic wood density) on the base of average weighted is turned into average value. All these coefficients thereafter are input into "the IPCC inventory" software package. This software package enables the collection and calculation of greenhouse gas emissions data. All the carbons in biomass reserves with the help of specific formulas that are converted into carbon dioxide.

The emissions are calculated on the base of biomass loss, based on fuel wood and round wood volume (m^3), after which as of carbon dioxide emission is calculated processed wood (harvested legally or illegally) and destroyed timber volumes as a result of forest fire. The received data with already calculated coefficients (wood base density, quantity of carbon in timber) is introduced in "IPCC inventory" software package. All the carbons in biomass reserves with the help of specific formulas are converted into carbon dioxide [6].

Results and analysis

With this methodology in Tavush region were calculated the carbon dioxide absorption capacity and the economic valuation was made for Ijevan forest state sanctuary. The total area of reserve is 14 thousand ha (Fig. 1), from which forested area is 11,600 ha. The total volume of timber is 1.6 mil m^3 (*Source:* forest inventory data from 2004). To calculate the absorption capacity of forests we need to have volume distribution based on tree species. The dominant variety is beech-59% of total timber volume, then it's oak − 23%, hornbeam −11.5% and other varieties-only 6.5% are (Table 1).

The carbon absorption is calculated for each tree variety. To count the carbon dioxide changes in living biomass, were used revised regional conversion coefficients according to tree species.

Here are calculation results:

Conversion factor is IPCC conversion factor for beech (dominating variety in the region) (0.538 d.m./m3 wet*0.4902 carbon content = 0.264 tC per m^3). When converted to CO_2: 0.264*44/12 = 0.968 tCO_2 per m^3 of wet biomass harvested.

For 944,000 m^3 this is equal 944,000*0,264 = 249,2 metric t C

944,000*0.968 = 913,792 metric tCO_2 avoided per year.

Oak − 0.570 × 0.5016 = 0.286 0.286 × 368,000 = 105.2 metric t C

0.286 × 44/12 = 1.048 × 368,000 = 385.664 metric tCO_2

Hornbeam − 0.640 × 0.5060 = 0.323 0,323 × 184,000 = 59.4 metric t

0,323 × 44/12 = 1.184 × 184,000 = 217.856 metric t CO_2

Other tree species − 0.530 × 0.4900 = 0.259 0,259 × 104,000 = 26.9 metric t C

0,259 × 44/12 = 0.49 × 104,000 = 50.960 metric t CO_2

As a result, we have received 440,7 metric t carbon sequestrated and 1568,27 metric t CO_2 emission reduced on annual bases.

There are a variety of methods to determine the economic value of carbon sequestration. The most common are benefits transfer, defensive expenditure methods. Interesting method was offered by Pimentel [7]. He estimated the value of carbon sequestration services by using estimates of the coastal flood damages that would be avoided if increases in sea levels caused by global warming were prevented. Depending on the chosen method, the economic cost of 1 t of carbon sequestration is different from 5 to 65 US $ [8]. In our work we considered (on the base of calculations) 10 US $ per 1 ton [9]. This mean that the economic value of carbon sequestration service provided by forests of Ijevan state sanctuary equals to 4407000 US $ annually.

Ijevan state sanctuary management plan is in the process of preparation. That plan, after approval, certainly will change the balance of carbon sequestration. In the sanctuary territory will be carried out reforestation activities, that will reduce illegal logging, which in its turn will increase the amount of carbon absorbed by forest ecosystems.

Requirement of firewood per year by 7200 households in 5 villages surrounding the Ijevan state sanctuary is 49 thousand m^3 [10]. This number is 20 times higher than the estimated annual allowable harvesting volume. It's evident that 40 thousand m^3 of firewood is acquired by local population through illegal logging.

Establishment of state sanctuary will change the regime from economic use to protection and this will reduce timber withdrawal at the area conservatively by 40,000 m^3 of wet timber. Considering the distribution of tree species in this volume in the same way as above and making the calculation of absorbed carbon by the same methodology we got the following results:

Beech − 0.538 × 0.4902 = 0.264 × 23,600 = 6.2 metric t C

23,600 × 0.968 = 22.8 metric t CO_2:

Oak − 0.570 × 0.5016 = 0.286 0.286 × 9200 = 2.6 metric t C

0.286 × 44/12 = 1.048 × 9200 = 9.6 metric t CO_2

Hornbeam − 0.640 × 0.5060 = 0.323 0,323 × 4600 = 1.48 metric t C

0,323 × 44/12 = 1.184 × 4600 = 5.4 metric t CO_2

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