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Full Length Research Paper

How Significant is Valuation of Ecosystem Services?

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ABSTRACT

Clean air and water are two important life lines on this earth. When we are infected due to contaminated water or air, we will pay for cure for sure. Higher the infection, more we pay. Ironically, there is no value for clean air and water provided by nature. As these natural services are considered to be "free and for all", they have been used indiscriminately. So is the case with many such ecosystem services provided by nature. Kyoto Protocol is one such mechanism where the ecosystem service (carbon sequestration) is being paid. It is time to have proper accountability for all the ecosystem services in order, so that they are used conservatively, else our future generation may loose some of these vital services. In this study we have made an attempt to value some of the ecosystem services that we derive from tree based land use systems. Further, the value of the ecosystem services needs to be accounted appropriately in the Gross Domestic Product (GDP), which will not only help in improving our lively hood but also help in using the natural resources respectfully.

Key words: Land use systems, Carbon sequestration, Kyoto Protocol, Sacred groves, Coffee plantations.

INTRODUCTION

The ability to meet our needs without jeopardizing that of our future generation has become one of the major causes of concern. This is true in case of many ecosystem services we derive from natural forests and various tree based land use systems. These services include micro-climate modification functions that may result from carbon uptake and storage (Annonymus, 1998), water and soil protection, biological diversity of various life forms, wildlife habitat protection and recreational use opportunities. From ages these profound ecological services have been used indiscriminately. However, studies done in the recent past have clear indications to show that, natural resources are not eternal and need to be conserved and used in sustainable manner. One of the major reasons that natural resources have been thoroughly exploited or even abused is because of no proper accountability of these resources. In this regard, United Nations initiative in the form of Convention of Conference on Environment and Development, has developed a concept of accounting the Natural resources and termed it as "Green accounting" under System of National Account (SNA) (Haripriya *et al.,* 2005). In doing so, the natural resources can be duly accounted and incorporated into the Gross Domestic Product (GDP). Because, GDP is generally used as an indicator of growth, development and wealth of Nation. Therefore, it is opined that GDP will be misleading when all the wealth of the Nation is not completely accounted (Kumar *et al.,* 2006 and Elourd, 2000). The accounting of natural resources not only reflect in economic terms, the depletion of natural resources but can also have serious impact on poverty alleviation by providing income opportunities and livelihood security for the poor. SNA is utilized by most countries in compiling data for macroeconomic policy analysis. Hence, a greater emphasis is now on land use and land use systems that can be effectively utilized for sustained use of natural resources. With such change in knowledge and gain in wisdom, there has been increased demand for new economic policy analysis data and methods for a country to find balancing points between the ecological, socio-cultural and economic matters in the late twentieth century. In order to adequately address these issues, national economic policy analysis would need revised conceptual models and new numerical foundations specially, in tree based land use sector analysis.

In the light of the above, a study was conducted to assess the ecosystem services derived from three land use systems namely coffee based agro-forestry system, natural forest (dry deciduous type) and sacred groves in the Kodagu district of Karnataka, India.

Land use systems studied

District has witnessed a rapid expansion of plantation crops, mainly Coffee under the impact of immigration and increased profitability but, without total deforestation. Kodagu has been able to preserve some of its forest cover and its original floristic richness, partly because of growing trees in coffee plantations for shade purpose. This can also be attributed to the land tenure system specific to the district (Uthappa, 2004) especially un-redeemed lands. Because of these reasons nearly 74 per cent of the geographical area of the district is under tree cover. Coffee cultivation occupy an area of 1197 km^2 out of 1437 km^2 cultivable land area accounting for 83 per cent of the total cultivable land area in the district (Elourd, 2000).

The second land use system studied was natural forest. Almost 45 per cent of the area of the district is occupied by natural forest (out of 4106 km^2 of the total area, 1841 km^2 is covered by natural forest). It has a wide variety of forest types from scrub, dry deciduous type to wet evergreen forests (Elourd, 2000). Such diversity in natural forest is responsible for providing habitat for a wide range of biodiversity in this region. This region is part of the Western Ghats, which is considered as one of the IUCN recognized hot spots of the biodiversity in the world (Mayers *et al.*, 2000).

The third land use system studied is the sacred groves. Small patches of forests with a deity in it, is called as sacred grove (Kalam, 2000). The sacred groves are considered to be very divine and have very high religious sentiments among the natives. This traditional culture has helped in conserving small patches of forests over generations. Such a tradition is in practice in many parts of the world apart from India (Burman, 1998 and Basu, 2000). Kodagu district has nearly 1241 sacred groves of various sizes, occupying an area of nearly 2550 ha (Kushalappa and Kushalappa, 1996). These patches of forests were found to house many rare and endangered species. In these three land use systems some of the indicators of ecosystem services were measured to assess the value of some of the ecosystem services a tree based land use system can provide.

METHODOLOGY FOLLOWED

Study was conducted in Kodagu district located between 75º 25˙- 76º 14˙ E and 12º 15˙- 12º 45˙ N which is a part of the Western Ghats. Soil is mainly lateritic in nature and temperature ranges between 23 to 35° C and mean annual rainfall is 1200 to 2000 mm. One of the major land use system of the district is Coffee cultivation. Both *Coffea arabica* and *Coffea robusta* are grown here, each occupying an area of 26,100 and 56,250 ha respectively (Anonymous, 2006). An area of approximately 50 ha of each land use system was earmarked as study area. Among the large number of sacred groves of different dimensions present in this district, one of the largest sacred groves was selected for the study. Coffee plantation having a tree cover comprising both indigenous as well as exotic species was selected.

Stratified random sampling was followed where, as many quadrants of size 20 m x 20 m were laid in each of the land use systems to cover 10 per cent of the study area. All the tree species in sampled area were identified and for assessing floristic diversity, Shannon diversity indexes as well as Richness Index were derived. Clear bole height and diameter at breast height (DBH) were recorded for all the trees above 10 cm DBH. This was used for volume of wood, biomass and carbon content estimations. For regeneration assessment, four plots of 4 m x 4 m were laid within each 20 m x 20 m plot and plants up to 10 cm GBH were enumerated. Soil samples were collected randomly from the entire study area at the rate of approximately one sample per hectare and were used for Organic Carbon, Nitrogen, Phosphorus and Potassium estimations following standard protocols (MacDickens, 1997 and Walkley and Black, 1934). Valuation of various ecosystem services were derived as explained in the monograph (Haripriya *et al.*, 2005 and Kumar *et al.*, 2006).

RESULTS, DISCUSSION AND WHAT IT MEANS

Among the various ecosystem services, biological diversity is an important component. In this study, the numbers of tree species were found to be 22, 18 and 16 in Sacred Groves, Natural Forest and Coffee based agro-forestry system respectively (Table 1). In coffee based agro-forestry systems diversity was found to be least because, tree species are selectively planted compared to sacred groves or natural forests, where species are naturally distributed, regenerated and most importantly not regulated. The simple measure of species diversity is Shannon's diversity index. In the present investigation, the value of Shannon's diversity index were found to be 2.90, 2.50 and 2.37 in Sacred Groves, Natural Forest and Coffee based agro-forestry system respectively. Species richness was highest in sacred groves because, this ecosystem is least disturbed and also protected by local community against disturbances such as fire, animal and anthropogenic pressures and therefore, provide better opportunity for both regeneration and survival of plants in this ecosystem. Sacred groves are found to be a better land use system that can help in protecting the biodiversity, especially of those species which are under various levels of threats. Natural forests in principle are protected and subject to less disturbance. However, in reality, since there is human habitation close to the forest all around, it is likely to experience pressure from the surrounding inhabitants and their animals. This can influence the diversity as well as regeneration to a great extent. Hence, both species richness as well as regeneration (Table 1&2) was found to be less compared to sacred groves.

In coffee based agro-forestry systems tree species grown for shade is completely regulated, especially in the redeemed plantations. Trees are not only grown for providing shade for coffee plants but are also secondary source of income among small holders, during the lean periods of coffee yields. Therefore, the tree species present in coffee based agro-forestry system, is not a true reflection of different tree species ability to grow or regenerate. However, given the fact that these coffee based agro-forestry systems are established after selective clearing in the natural forests, and trees grown are the native ones, this land use systems can be used for conservation of the diversity. Because, the number of native tree species used as shade trees in the coffee plantations are many. It is only a recent trend to replace them with silver oak (*Grevillea robusta).* If this is slowed down or curbed, it can help in conservation of native floral diversity. It can be made possible, by various means such as; creating awareness and motivating the coffee growers about the importance of biodiversity. Motivation can also be in terms of providing incentives for growing or retaining the native tree species. Hence, all the three land use systems can contribute substantially and should be used in preserving the biological diversity in a more comprehensive manner.

Regeneration of species was significantly different in three land use systems (Table 2). The distribution of different size classes of growing stock in the sacred groves is more evenly distributed compared to natural forests. As the age and size of the growing stock increases, because of the competition, weaker ones get eliminated. This is a natural process seen during the course of forest stand establishment in the natural forests (Smith *et al.*, 1996). Therefore, higher size class of growing stock has reduced gradually in case of sacred groves and is considered to be a desired trend. In natural forest such a distribution of different size classes was not seen. This is an indication of a disturbance factor in play (could be fire, wildlife and anthropogenic factors). Under disturbed conditions an irregular distribution of size, age and species distribution occurs which lead to the formation of a heterogeneous and complex structure of forest (Smith *et al.*, 1996).

The biomass accumulation was highest in coffee plantation compared to other two ecosystems studied (Table 3). This is due to few important factors such as age, density, competition and species composition (Smith *et al.,* 1996). Shade trees are generally planted in the coffee plantation and allowed to grow before the planting of coffee in a more systematic manner compared to other two ecosystems studied here. Healthy and robust seedlings are planted and provided with sufficient care, which results in better and uniform growth. Where as in natural forest or sacred grooves the populations naturally regenerated and therefore their will be lot of variation in the age, size and growth among the trees. The second factor is density. The trees are distributed at uniform distance to provide uniform level of shade to entire coffee plantation. Therefore, trees in the coffee plantation are distributed more evenly. In a natural stand trees are randomly distributed, because the establishment of a tree under natural condition depends largely on extent of competition for natural resources and various types and levels of disturbances. Trees in the coffee plantation have little competition compared to trees grown under natural condition as they get supplementation of water and nutrients along with the coffee crop. Finally, the species composition in a coffee plantation is less diverse compared to a natural stand (Table 1). Fast growing tree species are preferred in coffee plantation, while it is not necessarily so under natural forests and sacred groves. All these factors are responsible for such a large variation in the biomass accumulation in three different land use systems and so also in carbon sequestration occurring through above ground biomass accumulation. For these obvious reasons the biomass accumulation of natural forest was found to be least compared to other land use systems studied. Coffee plantation seems to be a very potential land use system for carbon sequestration.

Carbon sequestration is one of the most important ecosystem services provided by trees. The total carbon sequestered from the standing biomass of the three land use systems was to the tune of 387 t/ha. This is equal to 1419 tonnes of carbon dioxide in the atmosphere being removed per hectare of tree cover. Among the three land use systems, the contribution from coffee plantation was maximum (Table 3). Each ton of carbon sequestered is worth any where between US $ 6 and 20 (Haripriya *et al.,* 2005). Therefore, the total value of the carbon sequestered from three land use systems could be between US $ 2322 to 7740. It is also important to know that, in the process of removing carbon dioxide from the atmosphere through photosynthesis, oxygen is released into the atmosphere, which is the life line of all terrestrial aerobic life forms. Unfortunately we have no value for such an important ecosystem service provided by the trees (Haripriya *et al.,* 2005).

The details of soil nutrient status of three land use systems were given in the table 4. This will give the account of major nutrients (Organic Carbon, Nitrogen, Phosphorous and Potassium) present in soils of these three land use systems. The observations shows that the Sacred groove have the highest soil nutrient status compared to Natural forests and coffee plantations.

Soil loss due to change in the land use system is of a serious concern in India, because it causes severe damage to the productivity of the system if neglected. Vegetation cover over soil, specially tree cover play a crucial role in preventing the soil from eroding or run-off due to the action of wind, water and other human created causes. A study conducted with this specific purpose for the country (Haripriya *et al.*, 2005 and Kumar *et al.,* 2006) has shown that, for south Indian conditions the soil loss prevented by the forest is approximately 12.295 tones/ha/annum. A study (Tiwari *et al*., 2005) has estimated the cost of land degradation for 17 major Indian states at Rs. 12,288/ha/annum. According to this, the soil loss prevention benefits from the three land use systems amounts to Rs. 5628 million rupees/yr (Table 5).

When the soil is lost due to erosion, it leads to loss of top soil and also large quantity of nutrients (Brady and Weil, 2002). Here we have taken only the major nutrients loss such as N, P, K, and organic matter. At the present market value of these fertilizers (Fertilizer Association of India, 2004), the economic value of the nutrients amounts to Rs.1206 lakh per annum (Table 5).

Hence, forests in particular and tree based land use systems in general, are non-produce economic assets, which provide economic benefits and also provide various ecosystem services along side. Therefore, more importantly these should be taken into state accounts and integrated into national account which will improve the GDP (Haripriya *et al.,* 2005 and Kumar *et al.,* 2006). It is essential to revalidate our perceptions on these services and assess the value of these services which will help in utilization as well as conservation of natural resources. The scientific wisdom we have gained in the recent past has clear indications to show that these ecosystems need to be conserved, if not, we might loose many of these ecosystem services to the society in the foreseeable future. Hence, accounting the national capital has both immediate and far reaching implications. Immediately it helps in improving our GDP and in the long run to conserve these resources so that we do not live on what does not belongs to us.

Table 1: Tree diversity indices of three different land use systems.

Diversity parameters	Sacred groove	Natural forest	Coffee Plantation
No. of tree species	22	18	16
Shanon's Diversity Index	2.90	2.50	2.37
Richness index	23	20	15

Table 2: Number of regenerates in different regeneration classes found in three Land use systems (No. of regenerates /ha).

Regeneration classes	Sacred groove	Natural forest	Coffee plantation
Class: I	1250	2562	5.0
Class: II	1125	1687	2.0
Class: III	1012	2112	1.0

Note: Class I (1 - 30 cm), II (>30 - 60 cm) & III (>60 -100 cm)

Table 3: Tree biomass and Carbon content of standing trees in three land use systems.

Land use system	Tree Volume (m^3/ha)	Above ground biomass (t/ha)	Carbon content (t/ha)	CO_2 content (t/ha)
Sacred Groves	388	194	97	356
Natural Forest	189	94	47	173
Coffee plantation	936	468	234	858
Total	1513	756	378	1387

Table 4: Soil Nutrient status of three land use systems.

Land use system	Soil organic carbon content (%)	Total nitrogen content (t/ha)	P_2O_5 content (t/ha)	K_2O content (t/ha)
Sacred groove	2.88	595	86	1037
Natural Forest	1.73	141	14	633
Coffee Plantation	1.56	172	29	485

Table 5: Value of the soil and soil nutrients loss prevented due to tree cover in three land use systems.

Land use system	Area (km^2)	Soil loss prevented (t/yr)	Value of soil loss prevented (million Rs/yr)	Value of major nutrients loss prevented (lakh Rs./yr)
Sacred groove	25	30825	30	19
Natural Forest (Moist Deciduous forest)	453	558549	553	340
Coffee Plantation	1129	1392057	5045	847
Total	1607	1981431	5628	1206

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