Economic valuation of forest soils

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Quantifying the cost associated with forest activities is an effective way of managing and maintaining forests. This can be achieved by the economic valuation of our forest resources in terms of cost–benefit analysis (CBA). However, such studies on economic valuation of forest soils in India are sparse. The present work on environmental accounting of forest soils of Halol Range, Gujarat highlights the cost and benefit related to the resources. The work reflects the real contribution of different forest restoration activities carried out in this area. It has brought out the precise amount of economic loss or economic benefit due to changes in soil nutrient status. Multitemporal analysis of the soils with respect to changes in the soil fertility status (i.e. 1997–2009) and economic valuation for the resulting changes based on nutrient replacement cost have been done. Though the 1997 analysis showed overall economic loss, the restoration activities by the Forest Department (FD) had not only overcome this loss, but brought in economic benefits of about Rs 388.13/ha in 2009. Though many a times the indirect benefits of the FD activities are not visualized, such indirect CBA of forest resources highlights the benefits of these activities.

Keywords: Cost–benefit analysis, economic valuation, forest soils, soil fertility, use value.

FORESTS have both direct and indirect use values[1]. The emphasis on using forests only for wood production has changed in recent decades. Greater emphasis has been laid on the forests as supplier of a wider range of goods (non-wood forest products) and services, including environmental roles such as land and water protection, aesthetics, biological diversity, influence on the biosphere, etc.[2]. Realization of the indirect benefits of forests to mankind, including improvement in the quality of forest ecosystem, has increased nowadays. Forests play a key role in the livelihoods of the local people, but their status is deteriorating over the last few decades. Underestimation of the contribution of forests or absence of valuation of forest products and services is one of the essential factors leading to forest degradation[3,4]. Estimating the values of forests, i.e. economic valuation and understanding how different components of this ecosystem interact with the income and welfare of rural households is a key step towards sustainable use and management of forests[5].

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The principal motivation for economic valuation of the environment is to make it possible to include environmental impacts in terms of cost–benefit analysis (CBA)[6]. In the case of forests, the economic valuation of this resource can enable decision-makers to include the impact of restoration activities in terms of CBA. In other words, in carrying out forest conservation activities, organizations can accurately identify and measure investments and costs related to such activities, and can also prepare and analyse the data generated. With better insight into the potential benefit of these investments and costs, they cannot only improve the efficiency of their activities, but can also play an important role in supporting rational decision-making[7].

Soil in the forest ecosystem plays an important role by performing key ecological functions. Any conservation activities when implemented in the forests will have some impact on the forest soil. Realizing the importance of forest soils, the present study was designed to determine the effect of conservation activities carried out in the forests on soil fertility status and calculate the precise amount of economic loss or benefit due to such changes in soil nutrient status. The study area is located in Halol Range, Panchmahal District, Gujarat, stretching between long. 22°25′41″N and 22°29′06″N, and lat. 73°31′23″E and 73°35′35″E. Preservation plots present in the study area were selected for our current study.

For the present study, soil samples were collected in 2009 from different forest sites (which are at present established as forest preservation plots and in the past were open forest area) in the Halol Range, viz. CSO Plot, Semialata Plot with lac, Semialata Plot without lac, Pavagadh P.P. Plot (lower part) and Pavagadh P.P. Plot (middle part). The soil nutrient data for 1997 were acquired from the Forest Department (FD).

The soil samples thus collected were dried and sieved using a 2 mm sieve. Soil parameters like pH, electrical conductivity (ECe), carbon (C), nitrogen (N), phosphorus (P) and potassium (K) were tested following standard methods of analysis[8,9].

The fertility of the soils was measured based on the NPK content, ECe and pH value of the soil, and any change in the soil fertility status of the different sites was calculated based on the replacement value method of NPK[10]. The replacement cost technique is a valuation method based on cost estimates. The cost of a man-made substitute that provides the same service as the ecosystem, is estimated to derive the economic value of that ecosystem service[11].

Valuation studies have been carried out for a single parameter, i.e. change in soil fertility. The replacement cost technique was used to estimate the cost of nutrients in the selected sites. The economic valuation of benefit from the surplus amount of nutrients or losses from the low nutrients was accomplished indirectly from the cost; the FD will have to pay to retain soil fertility. Thus economic

Table 1. Soil nutrient status of different sites in 1997 and 2009

	pH		EC (dSm^{-1})		Total nitrogen (kg ha^{-1})		Available phosphorus (kg ha^{-1})		Available potassium (kg ha^{-1})	
Plot	1997	2009	1997	2009	1997	2009	1997	2009	1997	2009
CSO Plot	7.1	6.3	0.13	0.18	733.73	486.56	38.3	113.92	420.07	546.03
Semialata Plot with lac	6.9	6.6	0.14	0.13	772.35	874.52	48.18	104.80	395.36	422.33
Semialata Plot without lac	6.9	7.2	0.18	0.45	810.96	1826.44	43.74	402.73	415.13	1429.43
Pavagadh P.P. Plot (lower part)	7.4	6.9	0.22	0.17	579.26	76.49	49.91	77.56	395.36	301.13
Pavagadh P.P. Plot (middle part)	7.3	7.3	0.18	0.20	675.80	120.72	60.54	75.33	358.3	382.35

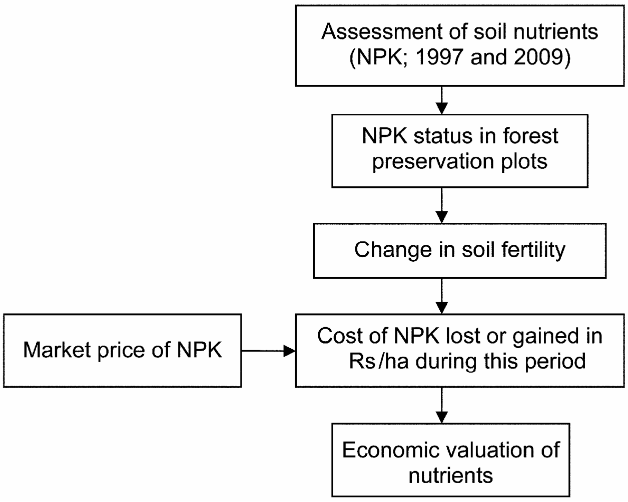

Figure 1. Methodology for economic valuation of NPK.

value was assessed on the basis of the amount required for replacing nutrients which are deficient in the soil or the amount that is saved where nutrients are retained in the soil. Thus the amount of N, P and K, lost from the soil or retained in the soil was estimated, and then subjected to economic valuation based on the market cost of the equivalent fertilizers during the respective years. Figure 1 depicts the entire methodology of economic valuation.

The results showed changes in soil fertility status and variation in the nutrient status of the selected forest sites during a span of 12 years showed. The soil quality gradually changed with increase or decrease in different nutrients, specifically NPK, pH and ECe (Table 1). No significant changes in pH and ECe values of the soil during this period were observed. Soils had normal pH and ECe, except for the CSO Plot where the soil became acidic[12]. N content decreased from 1997 to 2009, except for two plots, Semialata Plot with lac, Semialata Plot without lac, where it increased. P and K increased in the soil when compared to N, except for one plot, Pavagadh P.P. Plot (lower part), where potassium content decreased. The reason for such a decreased status of nutrients in CSO Pavagadh and Semialata plots could be the short duration for their recovery. Restoration activities in the Pavagadh P.P. plots have been initiated in 2003, whereas in the case of CSO and Semialata plots, it started in 2008. In addition, Pavagadh P.P. plots have undulating topography and hard, rocky terrain with shallow, medium black soil. The soil in this area is subjected to constant erosion due to lack of vegetation cover. Thus non-retention and washing away of the nutrients due to run-off during the rainy season must have brought about a deficit.

Economic valuation of any resource can be expressed in terms of direct or indirect economic benefit or loss in rupees generated by that resource. The valuation of benefit or loss in rupees is in terms of the amount saved due to increased nutrient status or amount to be incurred for increasing the nutrient status respectively. The present work which focused on assessment of the economic loss or benefit due to changes in soil nutrient status of forest soil showed variations with respect to single nutrients, but in totality there was benefit to some extent.

The decrease or increase in nutrient status, i.e. NPK affects the fertility status of any area, which was calculated based on the NPK content in the soil. Accounting of each nutrient has been assessed separately for different years for different nutrients (Table 2). This was based on the cost of fertilizers like urea, super phosphate and muriate of potash for N, P and K respectively. In the case of N, accounting of nutrients showed that a cost input of Rs 12,285.01/ha needed to be incurred in 1997. In 2009, this amount increased to Rs 13,233.3/ha. It is the minimum amount which is essential for bringing back the optimal level of N in the soil. The assessment of P and K showed no decrease in their levels and hence the amount to be incurred was saved. The total amount saved in 1997 and 2009 for both the nutrients, i.e. P and K amounted to Rs 6385.11/ha and Rs 13,621.38/ha respectively.

Any restoration activity on the forest land if justified in terms of the cost–benefit that has occurred from that activity for a specific resource will have more weightage. In case of forest soil, the actual amount required to be incurred due to reduction in nutrient status for any nutrient is given in terms of total replacement value of NPK. The total replacement cost of NPK in all the sites exhibited higher values in 2009 compared to 1997. The increase in replacement cost of NPK in 2009 is mainly due to high replacement cost of N during that year. The

Table 2. Accounting (cost–benefit/loss) in Rs/ha of nutrients for different sites for 1997 and 2009

Plot	For N* (Rs/ha)		For P** (Rs/ha)		For K*** (Rs/ha)	
	1997	2009	1997	2009	1997	2009
CSO Plot	(–) 2359.30	(–) 3610.01	(+) 40.99	(+) 341.96	(+) 1305.13	(+) 1892.09
Semialata Plot with lac	(–) 2163.89	(–) 1646.93	(+) 80.33	(+) 305.66	(+) 1189.98	(+) 1315.66
Semialata Plot without lac	(–) 1968.49	(+) 3169.79	(+) 62.63	(+) 1491.43	(+) 1282.09	(+) 6008.74
Pavagadh P.P. Plot (lower part)	(–) 3140.92	(–) 5684.96	(+) 87.22	(+) 197.25	(+) 1189.98	(+) 750.87
Pavagadh P.P. Plot (middle part)	(–) 2652.41	(–) 5461.16	(+) 129.51	(+) 188.37	(+) 1017.25	(+) 1129.35
Total value	(–) 12285.01	(–) 13233.3	(+) 400.68	(+) 2524.67	(+) 5984.43	(+) 11096.71

Cost of fertilizer in 1997: *Rs 4.6/kg; **Rs 2.5/kg; ***Rs 4.225/kg.
Cost of fertilizer in 2009: *Rs 5.06/kg; **Rs 3.98/kg; ***Rs 4.66/kg.

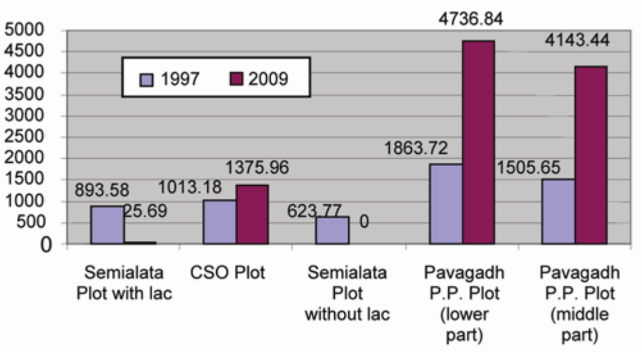

Figure 2. Replacement cost of NPK (Rs/ha) for different sites in 1997 and 2009.

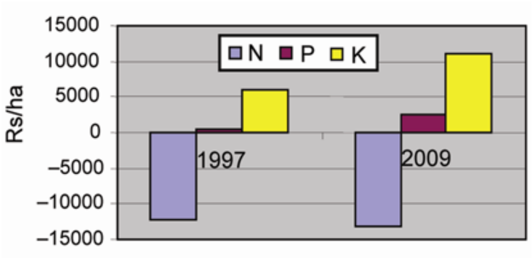

Figure 3. Economic valuation of N, P and K in 1997 and 2009.

overall economic benefit was Rs 388.13/ha in 2009, in comparison to the loss of Rs 5899.89/ha in 1997. Figure 2 shows the site-wise replacement value of NPK for 1997 and 2009. Among all the sites, the replacement cost of Pavagadh P.P. Plot (lower part) in 1997 was found to be the highest and it further increased in 2009. The decrease in N content in soils of this site has mainly contributed to this high replacement cost.

Economic valuation of a resource can be given in terms of direct or indirect economic benefit, or economic loss generated due to the resource. The economic benefit is either in terms of saving the amount to be incurred for its restoration activities or in terms of the benefits to the resource.

The CBA of forest soils of the Halol Range as a result of changes in soil fertility status over period of 12 years has highlighted the importance of restoration activities of the FD. Economic valuation of a single nutrient showed that there was economic loss of Rs 948.29/ha in case of N and economic benefit of Rs 2123.99/ha and Rs 5112.28/ha in case of P and K respectively (during a period of 12 years). Thus economic valuation of a single nutrient during both 1997 and 2009 respectively, highlights the benefit occurred due to P and K and loss due to N (Figure 3). These facts have again brought out the positive implication of the FD activities.

Analysing economic valuation for any resource is subtle as it requires large, multitemporal data, which are difficult to acquire. Also, it requires a localized approach. However, as a means of quantitatively measuring and assessing the cost and benefit of the different forest conservation activities, economic valuation is necessary. It is an essential factor for achieving greater forest sustainability and management efficiency.

The CBA of changes in fertility of forest soils of the Halol Range can be taken under the category of indirect cost of environmental cost category in the forest management accounting system. However, such studies and the values generated from them can prove to be useful in strategic planning and decision-making processes of FD.

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Occurrence of platinum group minerals in the Western Bastar Craton, Chandrapur District, Maharashtra

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The occurrence of platinum group minerals (PGMs) and gold is reported in association with Fe–Ni–Cu sulphides and chromite in mafic–ultramafic rocks (gabbro–pyroxenite) of Gondpipri area in the Western Bastar Craton. These minerals are mainly moncheite and palladium moncheite and are identified using scanning electron microscope. Chemical analysis of bed-rock samples shows anomalous platinum group element values in which palladium dominates over platinum. This communication highlights the distribution of PGMs and their mineralogical association.

Keywords: Gabbro, gold, platinum group minerals, pyroxenite.

THE importance of platinum group element (PGE) in modern industrial applications gives a new dimension to PGE exploration across the globe. In India, PGE exploration is given more attention not only to reduce the burden on import, but also to meet the growing demand. At present three potential deposits of PGE mineralization have been identified in India, viz. (i) Baula–Nausahi Complex in Orissa, (ii) Sittampundi anorthosite Complex in Tamil Nadu and (iii) mafic–ultramafic Hanumalapur Complex in Karnataka[1,2]. Besides this, PGE occurrences have also been reported from Kondapalli ultramafics of Andhra Pradesh[3], Manipur–Nagaland ophiolites, Nidar ophiolites of Jammu and Kashmir, ophiolites of Andaman and Nicobar Islands, auriferous load in Sakoli fold belt in Maharashtra[4], and Chitradurga schist belt in Karnataka. In this communication, we report PGE–Au–Ni–Cu sulphide mineralization in Bastar Craton[5] from the mafic–ultramafic rocks of Sukma Group around Gondpipri area, though PGE geochemistry has already been studied[6].

The Precambrian craton is bounded by Godavari graben in the south, Eastern Ghats Mobile Belt in the east and Central Indian Suture Zone in the north. The Proterozoic Pakhal Group of rocks, Gondwana sedimentaries and Deccan traps occur to the west of the Bastar Craton. The study area is located about 200 km south of Nagpur in the western part of the Bastar Craton (Figure 1).

In this area, the Archaean to Palaeo-Proterozoic Sukma Group[7,8] comprises of dominantly high-grade metamorphic rocks (charno-enderbite) and gneiss with subordinate mafic–ultramafic rocks, which we will refer to as the Gondpipri complex. This is described as a part of the passive continental margin or back-arc compressional basin setting[7]. The mafic–ultramafic suite occurs as scattered enclaves in the gneissic terrain[9].

The charno-enderbites and the mafic–ultramafic rocks form the basement for the overlying Meso- to Neoproterozoic platformal sediments of Pakhal Group in the western part of the Gondpipri area[10]. The main rock types of the area include charnockite, pyroxenite and gabbro (Figure 1).

The Gondpipri complex consists of several tectonically dismembered gabbro–pyroxenite bodies disposed intermittently in a 10 km long linear belt trending NE–SW. This set-up is more or less similar to the Chennagiri layered complex of Dharwar craton[2].

The mafic–ultramafic rocks show sharp contact with the surrounding charnockite in a few outcrops. However, their exact field relationship could not be convincingly established due to the paucity of outcrops. The length of these lensoidal bodies of gabbro and pyroxenite varies from 10 m to 1 km and the width between < 1 m and about 200 m. These are medium to coarse and exhibit primary magmatic layering defined by parallel arrangement of plagioclase laths and tabular pyroxene at places, without any evidence of recrystallization and post-crystallization deformation. The foliation trends ENE–WSW with moderate dip towards SE.

A majority of these gabbro and pyroxenite bodies are fresh or weakly altered at places. Alteration is manifested

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