International Journal of Ecology and Environmental Sciences 50: 929-939, 2024
ISSN: 2320-5199 (Online); https://doi.org/10.55863/ijees.2024.0330

Quantification of Ecosystem Services of the Melghat Tiger Reserve, Maharashtra, India

LALJI SINGH[1,*], SAIPUN I. SHAIKH[2], SHALINI TOPPO[1], J.S. SINGH[3] AND EKTA SINGH[1]
[1]*Department of Forestry, College of Agriculture, IGKV, Raipur, 492012, India*
[2]*Dy. Conservator of Forests, Land Records WR, Panvel, 410206, Maharshtra, India*
[3]*Department of Botany, Banaras Hindu University, Varanasi, 221005, India*
E-mail: lalji.singh2@gmail.com, shaikhsiforest@rediffmail.com, topposhalini201@gmail.com, singh.js1@gmail.com, ektasingh.95@gmail.com
***Corresponding author**

ABSTRACT
The present study was an attempt to quantify the direct as well as indirect ecosystem services from forest ecosystems in the Melghat area, which were undervalued in economic terms as compared to other developmental projects. The valuation of growing stock in the Melghat Tiger Reserve (MTR) was estimated to be IRs 80,221 crores (equal to 9,600 million US $). While the carbon sequestration potential of the system was estimated to be IRs 9,291 crores, the value of non-timber forest products (NTFP), a part of the provisioning service, was IRs 3.92 crore. The Forest land itself is valued at IRs 66,874 crores using the current land costs in the region for non-forest uses. Recreation benefits are estimated to be IRs 30.94 crores which is more than the user fee collections at entry points. The contribution value of biodiversity and other ecosystem services for the entire Melghat landscape was IRs 2,156 crore. Timber and carbon sequestration loss due to land distributed under forest rights was IRs 447.23 crore, while gains from agricultural use of that land by farmers was merely IRs 7.07 crore. Thus, the land conversion resulted in 63 times higher loss in the total ecosystem services than the gains from the subsistence-level farming practice for provisioning service alone. The total economic value of the Melghat landscape was estimated at IRs 1,69,853 crore, equalling to IRs 57.20 lakh per ha. The Net Present Value (NPV) of IRs 7.5 lakh per ha for protected areas such as the MTR prescribed by the Ministry of Environment, Forests and Climate Change, Government of India is much lower than the estimated value, emphasizing the need to revise NPV using appropriate valuation methodology.

Key words: Carbon sequestration, Ecosystem services, Ecotourism, Forest right act, Forest valuation, Growing stock, Non-timber forest products, Recreation benefits

INTRODUCTION

Conventionally, forests are valued for the tangible benefits, mainly for timber and non-timber forest produce. Non-tangible benefits of forests, for example, soil and watershed protection, climate moderation, nutrient cycling, etc., are ignored because these indirect benefits are not traded in the conventional markets or have proved to be tricky to value (Ninan and Kontolean 2016). Only a few studies attempted to estimate the economic value of the forest ecosystem services in India (Ninan and Kontolean 2016). Developmental priorities in India are forcing the administration to relax forest laws, and this resulted in diversion of existing forests to non-forest uses. Due to the increasing pressure on natural resources, there is a need to undertake valuation of the ecosystem services, particularly with regard to the non-tangible benefits, so that appropriate policies can be formulated. While the need for comprehensive assessment of the total economic value of the biodiversity-rich ecosystems is always there, only a few studies provided the estimates for the 'total net' economic value of the ecosystem services of any biodiversity-rich area.

While the need for land diversion for development works is increasing pressure on the existing protected area networks, the non-availability of opportunity costs for long-term conservation and not implementing the green accounting with integrated environmental costs into the estimated costs of the development alternatives seems to be the principle reason for the land diversions from the protected areas in a country like India. Thus, one must also examine as to how the aggregate economic value of the ecosystem services compares with the opportunity costs of the land to the other land uses. Policymakers always need such information in order

to gain support for conservation funding, involve stakeholders, and for designing the market-based instruments for conservation (Mullan and Kontoleon 2008, Madsen et al. 2011, Mullan 2014, Carrasco et al. 2014). Researchers and policymakers may find such assessments of the total economic value of the ecosystem services of any forest dominated landscape useful.

This study attempted to answer some of the research gaps by quantifying (i) the direct benefits such as, timber, NTFP. etc., and the land value of the Melghat landscape, to represent the provisioning services; (ii) the non-tangible benefits such as carbon sequestration, soil-water conservation, biodiversity, which encompasses the regulating and supporting services; (iii) the benefits of eco-tourism, emphasizing the cultural services provided by the Melghat landscape, and (iv) the effect of forest rights on the overall value of the forest ecosystem, offering insights into policy and management strategies.

MATERIALS AND METHODS

Study area

The Melghat landscape is located in the northern part of the Amravati District of Maharashtra, India. It is situated in the south-western Satpura mountain ranges, shares the border of Madhya Pradesh (Shaikh et al. 2019a) and stretches about 65 km between latitudes 21°11' and 21°46' N and 100 km between longitudes 76°38' and 77°34' E. While the soils on the hills and slopes are shallow to medium in depth, the low-lying areas and river valleys have deep soils due to the accumulation of deposits coming from the hills (Anonymous 1999).

The forest area of Melghat Tiger Reserve (MTR) is dry deciduous and dominated by teak (*Tectona grandis*) and the associated vegetation dominated by trees of *Haldina cordifolia*, *Lannea grandis*, *Boswellia serrata*, *Butea monosperma*, *Anogeissus pendula*, *Wrightia tinctoria*. This area was notified as a tiger reserve in 1974 with a total area of 1815 km^2 (https://amravati.gov.in/tourism-melghat), managed by the Wildlife Division of the Forest Department, Government of Maharashtra. The total area of forests in the Melghat region, including territorial and wildlife section, is 2969 km^2 covering 1293 compartments. During the study period, the Melghat Forest was reorganized into Melghat territorial and Melghat buffer divisions (Table 1).

Table 1. Detials of Melghat landscape area

Name of division	No!	Area (in km^2)			
		RF*	PF*	UF*	Total
East Melghat (T.)	261	560.76	0.21	0.00	560.97
West Melghat (T.)	247	578.84	14.78	0.02	593.64
Total Territorial	508	1,139.60	14.99	0.02	1,154.61
Sipna Wildlife	372	793.45	0.00	0.00	793.45
Gugamal Wildlife	263	611.24	0.00	1.36	612.60
Akot Wildlife	150	402.87	0.00	5.82	408.69
Total	785	1,807.56	0.00	7.18	1,814.74
Grand total	1,293	2,947.16	14.99	7.20	2,969.35

* = RF, PF & UF are reserve forest, protected forest and UN-classed forest, respectively; ! = number of compartments

Valuation of ecosystem services

Provisioning services

Considering differences in the growing stock among different working circles, the FRS (Forest Resource Survey) data from the study area have been stratified working circle wise. The status of growing stock of Melghat landscape is given in Table 2. The total growing stock was valued at market rate of the timber as per forest department records available in the office of the territorial CCF (Chief Conservator of Forests) Amravati. For valuation purposes, the timber

Table 2. Status of growing stock of Melghat forest.

Name of division	Total growing stock (m^3)			
	*SCI/ TPWC	*PrWC	*IWC/ SWC	Total
East Melghat (T.)	2,17,1748	8,98,586	6,34,881	37,05,215
West Melghat (T.)	24,49,002	-	10,86,208	35,35,210
Total Territorial	67,92,497	17,97,173	23,55,971	7,24,0425
MTR	1,54,18,031			1,54,18,031
Total Wildlife	1,54,18,031	0	0	1,54,18,031
Grand Total	2,22,10,528	17,97,173	23,55,971	2,26,58,456 i.e., 227 lakh m^3

* = SCI, TPWC, PrWC, IWC, and SWC represent selection cum improvement, teak plantation working circle, protection working circle, improvement working circle, and selection working circle, respectively

Table 3. Value of growing stock as per market rates

Tree species	Rate (IRs/m^3)	Volume of GS (m^3)	Value (crore IRs)
Teak*	46,715	1,49,54,581	69,860
Important non-teak timber species	24,794	24,92,430	6,180
Other species	8,022	52,11,445	4,181
Total		2,26,58,456	80,221 i.e., IRs 27 lakhs/ha

* = Market rates based on last 3 years auction data

Table 4. Zone-wise valuation of forest lands

Land zone	Area (ha)	Average market rate/ha (in lakhs)	Value of land in each zone (in lakhs)
Zone I	18,600	72	13,39,200
Zone II	91,300	34	31,04,200
Zone III	1,97,000	12	22,44,000
Total	2,96,900	—	66,87,400 i.e., 66,874 crore IRs

is classified into three categories, namely, (i) teak (more than 66% volume of GS was teak); (ii) important non-teak timbers like *Haldina cordifolia, Pterocarpus marsupium, Dalbergia paniculata,* etc., and (iii) other less important trees. The valuation of growing stock as per market rate is given in Table 3. The value of NTFP was calculated from the sale proceeds of the forest department. The MTR area does not have any revenue from NTFP, hence the revenue value for territorial area was used to derive the total value. The GS volume data for the NTFP species like *Diospyros melanoxylon*, *Hardwickia binata*, *Boswellia serrata*, *Acacia catechu*, *Cassia fistula*, *Feronia limonia*, *Semecarpus anacardeum*, *Buchanania lanzan, Madhuca indica, Butea monosperma, Carrya arborea* are available, but the sale data are available only for *Diospyros melanoxylon* and Bamboo (*Dendrocalamus* spp.), which are auctioned regularly.

Verma and Kumar (2006) elaborated a socio-economic methodology for calculating the value of NTFP usage as local consumption. They provided an approach to estimate the internal consumption value of NTFPs. To estimate the internal consumption value of NTFPs, data from forest-dependent villages were analyzed. In some villages, the value of NTFP was reported at IRs 1,86,120/- and 2,31,950/-, representing 16.77 and 15.9% of the net village product per year, respectively. The average of these values was IRs 2,09,020 per village per year. Joint forest management records indicated that there are 143 forest-dependent villages in the study area.

The value of the forest land was calculated by dividing Melghat landscape in different zones based on market value for alternate land use. Hence as per market rates of land, the Melghat area is divided in to three zones viz.; zone I, zone II and zone III. Zone I includes forest lands near Chikhaldara town where land values are high due to cool climate and hill tourism destination. Zone II is downhill area of semi-urban blocks of Paratwada (Achalpur) and Dharani. Paratwada is entry point of Melghat landscape and Dharani is the exit point toward Burhanpur (Madhya Pradesh). Zone III includes rural and least accessible remote areas, which is a major part of Melghat landscape. The forest land management units were classified into urban, rural and interior land compartments and the market value of the adjoining land assigned to them was used as a surrogate price for valuation (Table 4).

Cultural services

The recreation benefits were initially computed based on the actual tourism revenue of Forest Department and MTR. The data from tourism entry points as well as forest field offices were collected and the travel cost method as recommended by Czajkowski et al. (2019) along with benefit transfer approach was used. The economic worth of recreation was taken as a reference from the Pench Tiger Reserve (PTR) from the earlier studies. The final set of usable responses were recorded based on visitors' appreciations in a 24 unit field questionnaire to document consumer responses during visits in April 2005 for the purpose. This method uses survey data based on individual visitor feedback, for further statistical scoring analysis. The demand function for the estimation of consumer surplus of the visitors to the reserve was calculated using standard methods (Verma and Kumar 2006).

Regulating services

The carbon sequestration valuation was done as per

the recommended methods of the Intergovernmental Panel on Climate Change guidelines (Anonymous 2006). The inclusion of below-ground biomass (BGB) further enhanced the estimation of carbon sequestration. The carbon rate, i.e., 79$ per tonne was derived from the Edinburgh Forestry Commission report (Anonymous 2011), which was used for the present study. NPV calculations were applied using a discount rate of 6.5% to determine the current monetary value of carbon sequestration in the Melghat forests. Soil water conservation and biodiversity values were calculated following Ninan and Kontolean (2016). The water balance model was used to estimate water conservation value using the value of ET+R as 38.75% based on Krishnaswamy et al. (2012). Water being potable, the municipal water supply rates for kilo-liter were applied.

For soil conservation value, opportunity cost approach was used as prescribed by Ninan and Kontolean (2016). This required a comparative study of soil erosion in woody and non-woody lands. Secondary references from similar landscapes, such as Nagarhole National Park, were utilized to calculate the soil conservation benefits (Ninan and Kontolean 2016).

Supporting services

Other values like biodiversity and nutrient availability, etc., were added to the total value following Karanth et al. (2004). The concept of Possession Value, equal to market value of adjoining land is incorporated in revised document (Anonymous 2019) issued by the Ministry of Environment Forests and Climate Change (Government of India), on the same lines as proposed in the present study.

Quantifying the effect of forest right act

The Forest Rights Act (FRA), 2006 has significant impact on forests of Maharashtra State, as it facilitates the recognition of rights to forest dwellers over forest resources including land and minor forest produce (Sharma et al. 2015). The data regarding land allotted to individuals and community forests rights conferred by the district level committee after scrutinizing claims of applicants were collected from the Tribal Development Department, Revenue Department and Forest Department, Government of Maharashtra for this study (Shaikh 2019b). Value of landscape per ha was worked out to obtain the tangible benefits and quantification of the non-tangible benefits. The livelihood benefits are derived from the agricultural productivity reports of Agriculture Department Statistics for the Amravati District, Maharashtra.

RESULTS AND DISCUSSION

Provisioning services

Growing stock

The Forest Resource Surveys (FRS) are periodic survey measurements of growing stock in forest areas under Forest Department's administration. However, the Melghat Tiger Reserve (MTR) area was not enumerated due to conservation restrictions. In the territorial divisions of Melghat, out of 115461 ha only 248.40 ha area was enumerated. The growing stock (GS) volumes with respect to the technical prescriptions corresponding to Working Circles (WC) reveal the availability of a substantial quantity of growing stock in the Melghat landscape. The MTR area not thinned due to management prescriptions of wildlife is likely to experience a loss in volume increment due to stagnation in growing stock. Tewari (2017) elaborated the effect of thinning on the composition of growing stock. In his comparative evaluation of thinned and unthinned forests, it was observed that the growing stock volume of the thinned forests was 223.81 m^3, whereas the unthinned forests had a growing stock volume of only 73.69 m^3. This indicates that the unthinned forests experience about a 67% loss in growing stock increment compared to thinned forests. These findings underscore the importance of regular thinning to promote healthy forest growth and to increase timber volume. Without thinning, forests can become overcrowded, leading to competition for resources among trees, which can inhibit growth and result in a decline in forest vitality.In the present study, we observed the overgrown and unexploited elite growing stock of MTR is vulnerable to illicit felling as there are indications of poaching for wood/ fuelwood. Therefore, implementing, at least, salvage felling in protected areas is recommended to mitigate this risk. Such interventions should be carried out carefully to avoid disturbing the habitat and biodiversity. Balancing wildlife conservation with

sustainable forestry practices could ensure both biodiversity preservation and economic benefits from the forest resources.

Economic valuation of GS revealed that teak alone accounts for 87% of the total value due to its high market price. Finished teak logs in square form fetch a value exceeding IRs. 62,287 per m^3. There is scope to improve the value of other species by considering their medicinal as well as NTFP values. The total estimated value of the Melghat GS is IRs. 80,221 crores, equivalent to approximately 962 crore US $ (Table 11)

NTFP benefits

The GS volume data for *Diospyros melanoxylon* and Bamboo, major components of NTFP, were obtained from the forest department records with sale proceeds data. The internal consumption value of NTFPs for the 143 forest-dependent villages was IRs 298.87 lakhs which reflects the significant reliance on NTFPs within these villages. The total benefit value was IRs 391.87 lakhs which demonstrates the substantial economic contribution of NTFPs to the local communities, highlighting the importance of sustainable management and utilization of these forest resources (Table 5).

Valuation of forest land

In the present study, forest lands were valued by comparing market values of land adjoining forest compartments. There is variation in market prices of land in tourist area of Chikhaldara town, adjoining Paratwada town on highway, and the land in remote localities. Applying the market value for different zones, the forest land value worked out to IRs 66874 crores (Table 11).

Table 5. Valuation of NTFP benefit in Melghat

Source	Revenue (lakh IRs)	Remarks
Tendu	49.47	Data on PESA area not available
Bamboo	21.73	
Other NTFP	02.45	Domestic consumption not included
Grass and fuelwood	19.35	As per available records. Unlicensed grazing not included.
Add value of NTFP local consumption	298.87	Verma and Kumar (2006)
Total NTFP	391.87	i.e., 3.92 crores IRs

Considering the hedonic pricing trend in Chikhaldara, a new location for hill station, Makhla village which is hardly 10 km from Semadoh entry point of MTR also has high market value similar to Makhla village which is on high elevation and close to safari point and Paratwada-Burhanpur road. Thus, hedonic pricing advantage can be taken to increase future value of landscape. The Hedonic Pricing technique was employed to evaluate Chikhaldara because of its unique attributes. Surrounded by forests, this area benefits from a cooler climate, making it an attractive tourist destination. Its appeal is further enhanced by its historical significance, marked by the remains of ancient forts. The Hedonic Pricing method quantifies the value of environmental attributes by attributing weight to the existing market value. In essence, clean, green environments with scenic value leads to higher land prices.

Ying et al. (2011) elaborated the importance of forest land in forest valuation, along with timber, other forest produce, and environmental services. Valuing forest land is crucial to avoid underestimating the gross value of forest resources. Chan (2014) used Faustmann formula to calculate the value of forest land based on the quality of the growing stock (GS), the Land Expectation Value (LEV). However, it can be argued that forest land should be treated like normal land, with GS as an additional product.

Land values vary based on location, with forest land near municipal areas being more valuable than that in rural fringes, regardless of GS production. For instance, forest land in Greater Mumbai is valued in crores of rupees, while in Bhamragad, it is valued in lakhs of rupees. Thus, the standing timber adds only a marginal input to the total cost of forest land, highlighting the significant impact of locality on land valuation.

The value of forest landscapes, as per the Ministry of Environment, Forest and Climate Change (MoEFCC) notification under the Forest Conservation Act (FCA), is quantified as Net Present Value (NPV), which ranges between IRs 5.8 to 9.2 lakhs/ha for various canopy densities (Shaikh et al. 2019a). If valuation is improved based on the quantification of indirect forest services, the resulting value will be much more informative (Shaikh et al. 2019a). Currently, due to the low Net Present Value,

alternative land uses such as dams, reservoirs, highways, and habitation projects are often valued much higher compared to forest land use.

Regulating services

Carbon sequestration

The carbon sequestration benefits of Melghat forests were calculated based on the growing stock (GS) data given in Table 3. Initially, the GS volume of 2,26,58,456 m^3 was converted to carbon sequestration in tonnes using a wood density factor of 0.6 and a carbon factor of 0.47, resulting in 63,89,685 tonnes of carbon sequestered. After accounting for the below-ground biomass (BGB) with a factor of 0.235, the total carbon sequestration increased to 78,91,261 tonnes.

Using an average carbon rate of $79 per tonne from the Forestry Commission, Edinburgh report-2011 (adjusted for 2019 values), and converting this rate to Indian Rupees at an exchange rate of IRs = 70/$, the carbon value was estimated at IRs 43,63,86,70,675 (IRs 43,640 crores in 2007). Applying a net present value (NPV) discount rate of 6.5%, the current valuation of carbon sequestration in Melghat forests was determined to be IRs 9,291 crores (Table 6).

This value represents approximately 11.58% of the GS value, highlighting the significant economic contribution of carbon trapped in the forest ecosystem, which persists even after the conversion of GS into wood products. It is important to mention that a Tree Credit bill by Government of India which was proposed to compensate the tree growers who contribute to carbon sequestration through tree planting has been proposed. This lucrative scheme, if implemented, will encourage tree planting campaign.

Table 6. Valuation of carbon sequestration benefits

Particulars	Calculations	Remarks
GS (m^3)	2,26,58,456	
C sequestration in AGB (t of C)	63,89,685	
C sequestration including BGB (t of C)	78,91,261	
Average carbon rate (US $/tonne)	79	
Carbon rate US$	5,530	Average rate IRs 70/$
Gross carbon value (IRs)	43,63,86,70,675	
Value in year 2007	i.e., 4,364 crores	Rounded up
Value as on 2024	9,291 crores	NPV at 6.5 % interest

Table 7. Quantification of soil and water conservation value

Particulars	Calculations	Comments
Chikhaldara block	1,407.21 mm	Average rainfall
Dharani block	873.67 mm	Average rainfall
Average in Melghat landscape	1,140.44 mm	
ET + R @ 38.70%	441.92 mm	
Water conserved	698 mm	i.e., 0.6 m
Total water conserved in Melghat landscape	2,07,55,75,750 m^3 or Klio-litres	
Rate of potable water	36.30 IRs/Kl	
Value of water conserved	7,534 crore IRs	
Total area of MTR (ha)	2,96,935	
Economic value of soil protection (IRs/ha)	1,26,019	
Value of soil protection function	3,742 crore IRs	

Soil water conservation

The Melghat landscape was identified as part of Chikhaldara and Dharani blocks within Amravati District, Maharashtra. According to data sourced from the Amravati District NIC (National Informatics Centre), the annual rainfall in these two blocks was recorded at 1,407.21 and 873.67 mm, respectively. The average annual rainfall for the entire Melghat landscape was calculated to be 1,140.44 mm. After accounting for ET and R losses, 698 mm (~0.7 m) of water per m^2 was estimated to be conserved annually. This resulted in a total water conservation of 2,07,55,75,750 m^3 or kilo litre (kl) in the Melghat landscape (Table 7).

The economic value of soil protection function was estimated at IRs 1,26,019/ha. Considering total area of 2,96,935 ha, the soil conservation value for Melghat is worth IRs 3,742 crores (Table 7). The high soil conservation value signifies the importance of forests in soil conservation.

The combined value of soil and water conservation is thus IRs 11,276 crore (Table 11), which highlights the importance of forests in soil-water conservation. Again, this value is merely for a year, if we work out value on cumulative basis; we

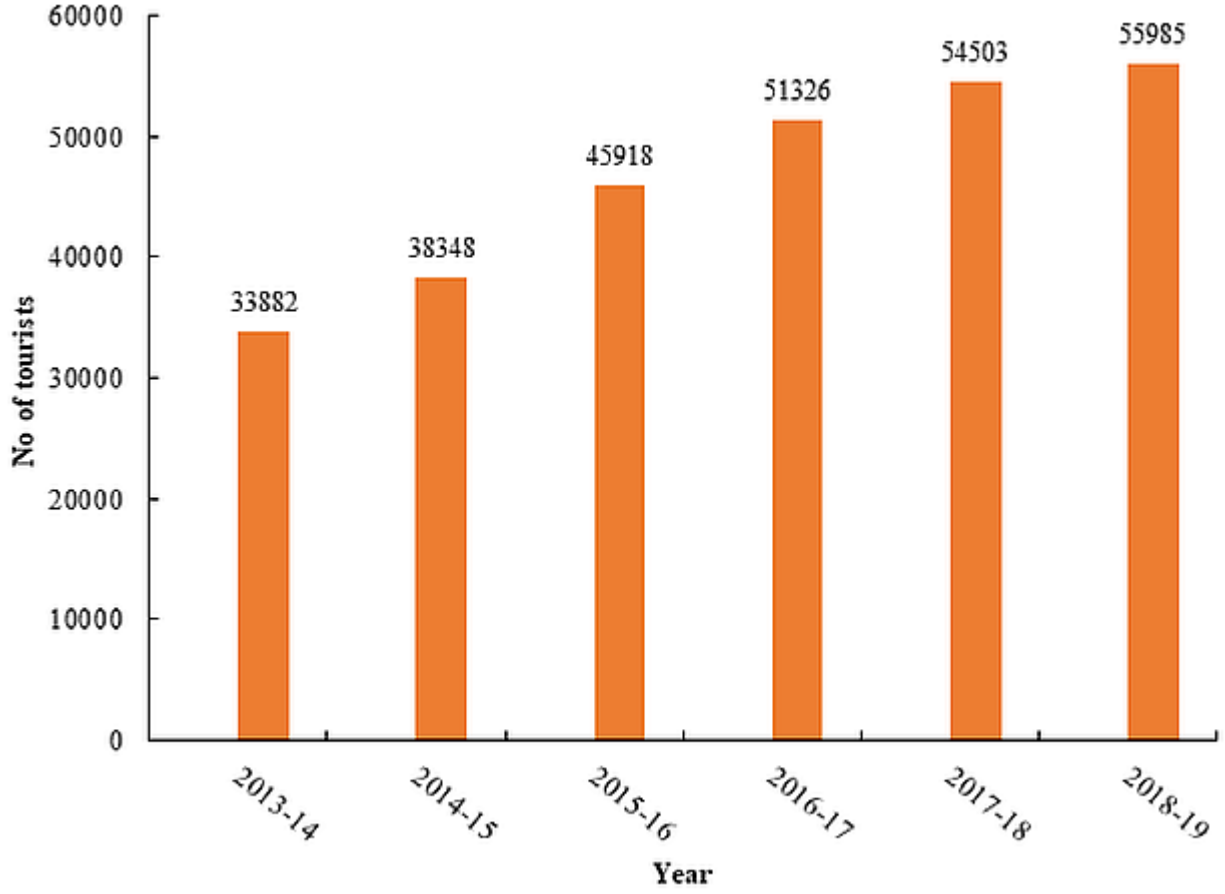

Figure 1. Pattern of tourist visits in Melghat Tiger Resrve during 2013-14 to 2018-19 (Singh et al. 2020)

find infinite benefits by conserving forest. Further research is required to ascertain the purity of water in wild streams vis a vis mineral water bottle which may add value to forest landscape.

Cultural services

With rising level of income, the tourists in India prefer to explore wilderness as a new trend. The tourism in wild destinations without impacting delicacy of nature and aiming welfare of forest dependent people is what the eco-tourism means. Eco-tourism in Melghat forests has the same essence.

There is increased trend of tourist visits over the years as per office records. The tourist data available as per office records from 2013 to 2019 is given in Figure 1, which indicated an increasing trend. The forest department earns revenue through tourist entry fees, vehicle entry fees, camera charges as well as video shooting fees etc. Safari jeeps are also made available to tourists at a reasonable fees apart from accommodation in tourist camps on optional basis. The revenue earned from all these sources was (tourist entry fees IRs 16,75,511; vehicle entry fees IRs 34,49,614; camera charges IRs 36,24,768; and safari jeeps and accommodation IRs 35,88,842) IRs 1,23,38,681, i.e., 0.15 million US$.

The Travel Cost Method (TCM) is an indirect valuation tool that assesses the intrinsic value of a landscape by estimating consumer surplus. This method calculates the difference between the total expenses a visitor incurs traveling to a tourist site and the maximum amount they are willing to pay for the visit. In estimating the consumer surplus for recreation benefits at Melghat Tiger Reserve, the Benefit Transfer Approach was applied, drawing on data originally derived from the Pench Tiger Reserve. The comparison is made with both direct valuation as well as benefit transfer approach (Singh et al. 2020) and the higher value was taken towards valuation so that the decision makers may not go for the diversion for petty purposes/project.

The decision to apply findings from the Pench

Tiger Reserve (PTR) study to the Melghat Tiger Reserve (MTR) is grounded in the belief that both areas share similar attributes or circumstances. This comparative approach involves evaluating both direct valuation methods and the benefit transfer technique. The preferred valuation for MTR is determined by selecting the higher value derived from either method. This ensures a comprehensive assessment of MTR's economic value, leveraging the most robust estimate available (Verma and Kumar 2006).

According to the FAO valuation manual for ecosystem services (Masiero et al. 2019), findings from one study site with a similar profile, such as the Pench can be transferred to another site like Melghat. The consumer surplus value at PTR was IRs 2,437.45 lakhs. The current discounted market value is taken into account to bring the economic value of different years at par, as the PTR value is for the year 2006. Consequently, the consumer's surplus for the Melghat was determined to be IRs 5,527 lakhs. Furthermore, considering the higher number of tourists visiting the Melghat compared to the Pench (55,985 and 20,805, respectively), the total recreation value for Melghat was IRs 30.94 crore (Shaikh et al. 2019a).

Supporting services

Biodiversity

Apart from the direct use value like medicines, recreation, food web, biodiversity has other non-use values too. The Melghat landscape has floral diversity indices of 91, 109, 450, 84, and 38 for tree species, shrub, herb, grass and climber species, respectively, spread over 2,96,935 ha. Ninan and Kontolean (2016) reported that the biodiversity value of Nagarhole National Park was IRs. 24.17 crore. Corresponding to its area, the biodiversity value of MTR is estimated at IRs 112 crore. Additionally, Melghat is home to significant faunal diversity, including 48 orders, 186 families, 496 genera, and 962 species/sub-species. It was observed that MTR has prey base density of 5.3/km^2. In the MTR 15,736 ungulates exist as tiger prey base. Population values from regular transect surveys are available from MTR office records. Considering Tiger Conservation plan length of 10 years, the annual rates were multiplied and willingness to pay is calculated. Comparative annual rates of adoption for different categories are listed in Table 8.

The faunal biodiversity value of the MTR, based on the 'willingness to pay' method and adoption rates from Mysore and Borivali zoos, was calculated at IRs 102.24 crore. Incorporating the prey base data from Karanth et al. (2004), the faunal biodiversity value increased to IRs 152.57 crore. This valuation excludes the avifauna and other wildlife, suggesting a potentially greater value of biodiversity. Combining the floral and faunal biodiversity values, along with gene pool, habitat, and bio-control values, the total biodiversity value of MTR was estimated at IRs 2156 crore (Table 11).

Other values

The component-wise valuation of other residual services are given in Table 9. Summing all these

Table 8. Quantification of faunal biodiversity utility value

Category	Wild fauna	Population in MTR	Rate for adoption in Mysore Zoo	Rate for adoption in Borivali Zoo
Group C	(I) Tiger	64	1,00,000/-	3,10,000/-
	(II) Leopard,	175	35,000/- for all	1,20,000/-
	Sloth Bear,	290		NA
	Gaur/ Sambar	1,030		NA
Group B	Hyaena, Jackal, Dhole, etc	164	20,000/-	30,000/-
Group C	Rest all wild animals forming prey base	1,442 wild boars + 1,357 other deer/ antelopes	3,500/- 7,500/-	NA 10,000/-

Table 9. Other residual services

Service	Value in crore from similar landscape	Proportionate value for Melghat	Remarks
Gene pool	1,241	1,800	From Kanha Tiger Reserve (KTR)
Pollination, biological control and habitat refugia	64	92	
Nutrient cycling and air purification	16	23	From KTR
Waste assimilation	98	142	From KTR

values, the total economic value (TEV) of the Melghat landscape comes to IRs 1,69,853 crore (2,038 million US $), which means 57.27 lakh/ha (Table 11) which contain (i) value of tangible benefits like GS, NTFP, and land at IRs 1,47,099 crore (1,759 US $), (ii) ecotourism benefits at IRs 1,23,38,681 (0.15 million US $), (iii) value of indirect benefits, like carbon sequestration, soil water conservation, recreation, biodiversity and other indirect benefits at IRs 22,754 crore (272 US $), (iv) TEV of the Melghat forests at IRs 1,69,853 crore (2039 million US $/ha) which comes to IRs 57.20 lakhs (68,360 US $). It is much higher in comparison to NPV rate of IRs 7.5 lakh/ha, (v) the values of certain benefits like NTFP, recreation, soil water conservation etc. are worked out for the particular year. If these values are taken for a rotation period of 70 years or at least working plan period of 10 years, the landscape value comes much higher.

Quantification of effect of forest right on forest value

The land allotments under FRA in the Melghat forests is given in Table 10. Taking the growing stock value at IRs 27 lakhs/ha obtained earlier, a loss of total growing stock value estimated at IRs 424 crores for the FRA allotment area of 1,570 ha. Using the carbon sequestration value per ha at IRs 147 lakhs/ha the loss for FRA allotted area of 1,570 ha is IRs 23.08 crore. Therefore, the total loss from FRA allotments is reported at IRs 447 crore for the Melghat forests. The loss value may increase once the pending land allotment cases are finalized.

The report of the SDAO (Superintending District Agriculture Officer), Amravati and the District Level Planning Committee, Amravati district, states that, there are 1,40,423 marginal farmers having less than 1 ha land, out of the total 4,15,858 farmers. Marginal farmers form main component of FRA allotments. In Amaravati district the Melghat forests encompass the Dharni and Chikhaldara tehsils. Agriculture in this district includes the cultivation of soyabean, tur/arhar, cotton, moong, urad, rice, jowar etc., is prevalent in the Dharani and Chikhaldara blocks. Farmers, due to high rainfall in Melghat, mainly cultivate rice crop. Crop productivity reported by SDAO for the soybean as 835 kg/ha, arhar 829 kg/ha and moong 429 kg/ha. With this low level of

Table 10. Forest land allotments under individual forest rights and CFR (Shaikh et al. 2019c)

Division	Individual forest rights (ha)	CFR cases in numbers	Remarks
East Melghat	382	35	Pending 88 ha
West Melghat	484	32	Pending 161 ha
Sipna Melghat Tiger Reserve	642	13	Balance evicted
Gugamal Melghat Tiger Reserve	062	02	
Total allotted area	1,570		

*CFR: Community Forest Rights

Table 11. Summary of total economic value of Melghat landscape

Benefits	Valuation component	Value (crore IRs)	Remarks
Tangible benefits	Timber/ GS	80,221	Value of total tangible benefit is IRs 1,47,099
	NWFP	3.92	crore i.e., 175 US$
	Land	66,874	
Indirect benefits	Recreation	30.94	Value of total indirect benefit is IRs 22,754
	Carbon sequestration	9,291	crore i.e., 272 US$
	Water and soil Conservation	11,276	
	Other	2,156	Biodiversity, Air quality etc
TEV		1,69,853 i.e., 2,038 million US$	For entire landscape per ha cost much higher as compared to NPV cost (MoEFCC) 7.5 l/ha i.e., 57.20 lakhs/ha

productivity in above mentioned field crops, the farmers hardly earn IRs 45,000 agricultural income as per market survey. Small Scale Industries Department along with Joint Forest Management Committees and Village Eco-Development Committees in Melghat are trying to improve livelihood through milk processing and honey collection and value addition. While these efforts provide an average income gain of up to IRs 7.05 crores/ha from the Forest Rights Act (FRA) lands, the comparative loss from reduced growing stock is significantly higher at IRs 447 crores. This disparity illustrates that the loss incurred is approximately 63.25 times greater than the gains achieved by farmers through these initiatives. In Gondia district of Maharashtra, 2,181 ha of forest land emitted 5,70,881 tonnes carbon through deforestation (Sharma et al. 2015). Using this study the estimated losses could be IRs 316 crores for carbon sequestration in the MTR (Shaikh et al. 2019c). Considering huge losses, a policy level scrutiny is needed for the Forest Rights Act and policy to shift the FRA land beneficiaries with handsome compensation as per earlier similar schemes. Thus, the FRA land beneficiaries may get better cultivable land in settled villages. Their next generation may get good education, vocational training and better employment opportunities as compared to inhabiting in remote forests. This remedy seems more feasible than allowing them in remote forests (Shaikh et al. 2019c).

CONCLUSIONS

The economic valuation of growing stock, carbon sequestration, non-timber forest product, forest land, recreation benefit, biodiversity and other ecosystem services revealed the economical perspectives for saving valuable forests in developing countries like India which is under great pressure to dilute the forest policies to foster developmental goals.

ACKNOWLEDGEMENTS

Authors are thankful to the authorities of Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India and Panjabrao Deshmukh Krishi Vidyapeeth, Akola Mahaharashtra for the necessary support during research work. The authors are also obliged to Maharashtra Forest Department for grant of necessary permission as and when required during the study period.

Authors' contributions: All authors contributed equally.

Conflict of interest: Authors declare no conflict of interest.

REFERENCES

Anonymous.1999. India Sate of Forest Report 1999. Forest Survey of India, Ministry of Environment, Forests and Climate Change, Dehra Dun, India.

Anonymous. 2006. GL, 4(4), Table 4.3. Intergovernmental Pannel on Climate Change, http://www.Intergovernmental Panel on Climate Change-nggip.iges.or.jp /public/2006gl/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf

Anonymous. 2011. Annual Report and Accounts 2011-2012. Forestry Commission, Edinburgh, Great Britain/England.

Anonymous. 2019. Forest (Conservation) Act, Guidelines. Forest conservation division. Ministry of Environment, Forest and Climate Change, New Delhi, India.

Carrasco, L.R., Nghiem, T.P.L., Sunderland, T. and Koh, L.P. 2014. Economic valuation of ecosystem services fails to capture biodiversity value of tropical forests. Biological Conservation, 178, 163-170. https://doi.org/10.1016/j.biocon.2014.08.007

Chan, S.J. 2014. Forest valuation under the generalized Faustmann formula. Canadian Journal of Forest Research, 44, 56-63. https://doi.org/10.1139/cjfr-2013-0298

Czajkowski, M., Giergiczny, M., Kronenberg, J. and Englin, J. 2019. The individual travel cost method with consumer specific values of travel time savings. Environmental and Resource Economics, 74, 961-984. https://doi.org/10.1007/s10640-019- 00355-6

Goslee, K., Walker, S.M., Grais, A., Murray, L., Casarim, F. and Brown, S. 2012. Leaf technical guidance series for development of forests carbon monitoring system for REDD+ : module C-CS calculations for estimating carbon stocks. USAID ASIA.

Karanth, U., James, N.D., Kumar, N.S., William, A.L. and Hines, J.E. 2004. Tigers and their prey: Predicting carnivore densities from prey abundance. Proceedings of the National Academy of Sciences, 101(14), 4854-4858. https://doi.org/10.1073/pnas.0306210101

Krishnaswamy, J., Bonell, M., Venkatesh, B., Purandara, B.K., Rakesh, K.N., Lele, S., Kiran, M.C., Reddy, V. and Badiger, S. 2013. The groundwater recharge response and hydrologic services of tropical humid forest ecosystems to use and reforestation: support for the infiltration-evapotranspiration trade-off hypothesis. Journal of Hydrology, 498, 191-209. https://doi.org/10.1016/j.jhydrol.2013.06.034

Madsen, B., Carroll, N., Kandy, D. and Bennett, G. 2011. Update: State of Biodiversity Markets. Washington, DC: Forest Trends, 2011. Available at: http://www.Ecosystem Market Place.com/reports/2011_update_sbdm

Masiero, M., Pettenella, D., Boscolo, M., Barua, S.K, Animon, I. and Matta, J.R. 2019. Valuing forest ecosystem services: a training manual for planners and project developers. Forestry Working Paper No. 11. Rome, FAO. 216 pages.

Mullan, K. 2014. The Value of Forest Ecosystem Services to Developing Economies. Center for Global Development Working Paper No. 379. Available at SSRN: http://ssrn.com/abstract=2622748 or http://dx.doi.org/10.2139/ssrn.262274.

Mullan, K. and Kontoleon, A. 2008. Benefits and Costs of Forest Biodiversity: Economic Theory and Case Study Evidence, Monograph Report. Published for the European Commission as part of the Potsdam Initiative and TEEB, 167 pages. Available at: http://ec.europa.eu/environment/nature/biodiversity/economics/pdf/scoping.Pdf

Ninan, K.N. and Kontolean, A. 2016. Valuing forest ecosystem services and disservices – Case study of a protected area in India (Nagarhole NP). Ecosystem Services, 20, 1-14. https://doi.org/10.1016/j.ecoser.2016.05.001

Shaikh, S., Choudhary, V. and Singh, L. 2019a. Forest & ecosystem valuation: A case study of Melghat landscape. Journal of Plant Development Research, 11(10), 625-628.

Shaikh, S. Choudhary, V. and Singh, L. 2019b. Comparative study of growing stock of Melghat forests under different silvicultural prescriptions. Tropical Plant Research, 6(3), 521-523. https://doi.org/1022271/tpr.2019.v6.i3.065

Shaikh, S., Singh, L. and Taide, Y. 2019c. Impact of forest rights on value of Melghat landscape. Journal of Plant Development Research, 11(1), 685-687.

Sharma, J.V., Gokhale, Y., Chauhan, S. and Tyagi, A. 2015. Forest right act and climate change vulnerability: Impact on forests and forest dwelling communities in Maharashtra. Indian Forester, 141(12), 1230-1236.

Singh, L., Anurag, Shaikh, S. and Mali, H. 2020. Quantification of direct and indirect recreation benefits of Melghat Forests. RASSA Journal of Science Society, 2(1), 46-49.

Tewari, V.P. 2017. Enhancing carbon retention through improved forest management. Indian Forester, 143 (9), 928-930.

Verma, M. and Kumar, V. 2006. Natural resource accounting of land and forestry sector for the sates of Madhya Pradesh & Himachal Pradesh. IIFM CSO Report, 195-198 & 223-227.

Received: 17th May 2024
Accepted: 24th July 2024