Title of the Paper:

Economic Assessment of Forest Ecosystem Services Damages and Compensation for Ecological Restoration

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Theme of the Paper:

Issues in ecosystem accounting and forest accounts

Introduction

The forest ecosystem services play an important role in human welfare. Examples of forest ecosystem services include provisioning services (food, water and energy); regulating services (climate regulation, air purification, water conservation) and cultural services (aesthetic, recreation and tourism), sometimes collectively referred to as natural capital. Therefore, a healthy forest and ecosystem have been maintained for a sustainable climate and livelihood for human beings as well as rejuvenation of nature. Yet, continuing human activities and natural calamities often reduce the stock and flow of the forest ecosystem (Whitehead et al., 2017). If the forest ecosystem goods and services fall below a certain threshold level, the natural capital stock and flow of services will change to a less favourable or non-functional state. Even a relatively small decline or damage to 'forest assets may add up to a significant loss across the landscape. The value of degradation or loss to the forest ecosystem services is often ignored in the economic decision-making process (Reid et al., 2005). One of the main reasons is that most of the economic calculation is based on market prices. However, a few provisioning ecosystem goods and services selling in the market are incomplete (or) missing markets for regulating and cultural services. The reason for market failure is that most of the cultural services have public good characteristics (non-rival and non-excludability). Therefore, economic decision-makers have paid little attention to the value of forest ecosystem services. Hence, with a better understanding of the economic value generated by forest ecosystem services, effective policies can be framed for sustainable forest management at the local level.

Karnataka is endowed with a huge wealth of natural resources and biodiversity and is one of the most ecologically rich states in the Western Ghats region. Forests are a very important natural resource of the state covering an area of 38,575 sq km which is 20.11% of the state's geographical area (FSI, 2019). Karnataka forests provide several benefits to human beings. The direct tangible benefit includes non-timber forest produce and other life support ecosystem services. It also includes non-tangible benefits, for instance, many regulating ecosystem services like fresh air, water and pollination services for agriculture production. In addition, climate regulation services, prevention of soil erosion, water conservation, disease regulation, pest regulation, natural hazard regulation, are of most importance for human survival and ecological sustainability. However, these aspects are often ignored in routine

economic decision-making (Kumar P and Michal D Wood 2012; Costanza et al 2014; Balasubramanian 2019).

According to the Karnataka State Disaster Management Authority (KSDM), the frequencies of climate-related events like floods/heavy rainfall, landslides forest fires, are frequent. The landslides and floods in Kodagu were due to heavy rainfall received during August 15-21, 2018, in the three taluks namely, Virajpet, Somwarpet and Madikeri. The rain received in these areas was more than 22%, 28% and 32% respectively, of the average. Bandipur forest fire destroyed an area of 10,920 acres during Feb 21-25. 2019. In addition, the 2019 floods in Karnataka affected 22 districts and caused immense damage to all sectors like agriculture, livestock and forests. Therefore, during the last five years, there have been more disturbances to the forest ecosystem in the Karnataka state. In addition, forest land has been converted for non-forest purposes in Karnataka under the Forest Conservation Act 1980. The agencies that have converted forest land for various purposes are Central/State government agencies/departments, institutions, companies and others including private individuals in Karnataka.

Loss and degradation of forest ecosystem services have an immediate impact on human well-being. The MEA (2005) framework offers a multi-dimensional perspective of human well-being, i.e freedom and choice, necessities for leading a good life, health, good social relations; security and concerning four ecosystem services categories like provisioning, regulating, cultural and supporting services (Balasubramanian and Sangha, 2021). Ecosystem services offer an integrated socio-economic and ecological view for better understanding the role of nature in human well-being (Gruz-Garicia et al., 2017). The loss and degradation of forest ecosystem services will negatively affect the poor who are most vulnerable in society, for example, subsistence farmers, the rural poor, and traditional societies. These groups face the immediate risks of any biodiversity and ecosystem services loss (Diaz et al 2006).

However, to consistently monitor an assessment is needed for better management of natural capital through the System of Environmental-Economic Accounting (SEEA) framework. It will help to calculate the loss and damages related to the ecosystem goods and services for maintaining the stock of forest and natural capital assets (Garibaldi et al., 2013). So far, economic estimation of the loss and damage has focused only on the primary level in Karnataka. Therefore, this study will calculate the climate stress on the effects on forest ecosystem services and possible correlations and implications on the societal losses and damages based on existing secondary data from various line departments of Karnataka. Compensation to make good the loss and damages are one of the major policies and a promising tool by the local governments. Environmental compensation focuses on the resource itself, i.e., compensation is “paid” to the public in the context of environmental and forest resources management. In practice, compensation can take the form of projects that restores and improves forest areas by way of habitat restoration to offset the impact of ecological damages (Lipton et al., 2018). There are several evidence of climate change in Karnataka, but still, very few works of literature on loss and damages to forest and ecosystem services from climate change exist. This little attention will give more insight into the human economic loss in the future. Therefore, an urgent assessment and calculation of loss and damages for natural capital and forest ecosystem services in Karnataka is needed to better understand and sustain forest management at the local level.

Materials and Methods

Karnataka's forest ecosystem provides an important diverse service and values to human society. Healthy forest ecosystems produce and conserve soil. They also regulate water flow in streams besides preventing water runoff averting land degradation and desertification by reducing the risks of climate-related events such as drought, floods and landslides. However, the lack of proper forest ecosystem services impacts Karnataka negatively disrupting the livelihood of a large population as these forest ecosystem services continue to be undervalued, or not valued at all. Therefore, the continuing loss and degradation of forest resources lead to loss of watershed values, loss of employment and economic opportunities, loss of biodiversity and ultimately, continue to cause air pollution and climate change in the future. Therefore, the present study has estimated the loss value of forest ecosystem services based on per hectare value through the various environmental valuation methods of Karnataka.

Table 1: Methodology (Types of Ecosystem Services and Data sources of the study)

Types of Ecosystem Services	**Data sources**
Timber production	i) Annual Reports (2015-16, 2016-17, 2017-18, 2018-19, 2019-20 and 2020-21), Forest Department, Govt of Karnataka
Growing stock	ii) State Forest Report 2015, 2017, 2019 and 2021
Afforestation	i) Annual Reports (2015-16, 2016-17, 2017-18, 2018-19, 2019-20 and 2020-21),, Forest Department, Govt of Karnataka ii) State Forest Report 2015, 2017, 2019 and 2021
Forest conversion to non-Forest purpose	i) Annual Reports (2015-16, 2016-17, 2017-18, 2018-19, 2019-20 and 2020-21),, Forest Department, Govt of Karnataka ii) Forest clearance, Ministry of Environment Forest and Climate Change
Forest Fire	i) Forest Department, Govt of Karnataka (2015, 2016, 2017, 2018, 2019, 2020 and 2021). ii) Karnataka State Disaster Management Authority (KSDMA), Govt of Karnataka
Timber loss	i) DCF, Madikeri
Carbon stock	i) State Forest Report 2015, 2017, 2019 and 2021 ii) Above Ground level biomass (2015-16, 33.41; 2016-17, 33.41; 2017-18, 34.1; 2018-19, 34.11; 2019-20, 33.41; 2020-21, 31.69) iii) Soil Organic Carbon (2015-16, 53.2; 2016-17, 53.2; 2017-18, 77.14; 2018-19, 77.14; 2019-20, 53.2; 2020-21, 53.6)
Air Purification	i) Annual Reports (2015-16, 2016-17, 2017-18, 2018-19, 2019-20 and 2020-21),, Forest Department, Govt of Karnataka ii) State Forest Report 2015, 2017, 2019 and 2021 iii) Forest Department, Govt of Karnataka iv) Karnataka State Disaster Management Authority (KSDMA), Govt of Karnataka v) Ninan and Kontoleon (2016); Balasubramanian (2021); Xi (2009) vi) Sulphur Dioxide annual absorption rate (SO_2 10.8kg) and (NO_2 15.6)

	vii) viii)	Abatement Cost of SO_2 (Rs 40305) Abatement Cost of NO_2 (Rs 88580)
Soil Erosion Prevention	i) ii) iii) iv) v)	Annual Reports (2015-16, 2016-17, 2017-18, 2018-19, 2019-20 and 2020-21),, Forest Department, Govt of Karnataka State Forest Report 2015, 2017, 2019 and 2021 Forest Department, Govt of Karnataka Karnataka State Disaster Management Authority (KSDMA), Govt of Karnataka Ninan and Kontoleon (2016); Balasubramanian (2021); Xi (2009) Per hectare value of soil erosion prevention Rs 126019
Social Cost of Carbon	i)	Ricke et al (2018) Rs 5313 per tonnes of carbon damages
Non-Timber Forest Products	i) ii)	Annual Reports (2015-16, 2016-17, 2017-18, 2018-19, 2019-20 and 2020-21), Forest Department, Govt of Karnataka Per hectare value of Non-timber forest products Rs 1671.54 Karnataka (Chopra 2006)
Household collection of NTFPs	i)	Household income from NTFPs Rs 12000 Karnataka Balasubramanian (2020)
Pollination Services	i)	Per hectare value of pollination services Rs 23377.42 (Ninan and Kontoleon, 2016).

Results and Discussion

The economic value of forest ecosystem services has monitored and documented major forest products based on the market price in Karnataka. However, there is a lack of understanding of the full cost and benefits of forest ecosystem services. This reveals the unsustainable consumption and production of forest goods and services. The value of forest ecosystem goods and services are very critical to human beings as well as nature. Hence, without estimating the benefits or loss of forest ecosystem services may result in inadequate financial resources from the local, national and international levels. This is one of the main reasons why many of the ecosystem goods and services are not properly traded in the market or missing market or market failure. Therefore, the allocation of resources or funds is inadequate for sustainable forest management. In addition, forest ecosystem services are not able to maintain their regeneration capacity which is very important to human consumption and maintenance of the ecological balance of nature itself due to manmade and natural disturbances to the forest ecosystem. Loss and degradation of the forest ecosystem have directly and indirectly affected the economy and society. For example, Karnataka Forest ecosystem services have incurred a loss to the tune of Rs 3831.28 crore during the last five years (see table 2)

Table 2: Economic Loss of Forest Ecosystem Services in Karnataka (Rs in Crore)

Year	Loss of Carbon Sequestration in vegetation	Loss of Soil Organic Carbon	Soil Erosion Prevention	Sulphur Dioxide (So2)	Nitrogen oxide (No2)	Pollination Services	NTFPs	Household Income Loss	Loss of timber
2015-16	4.9	7.8	3.49	1.2	3.82	0.15	0.009	0.3	4.8
2016-17	100.77	160.46	65.79	2.22	7.21	3.05	0.1	6.26	14.5
2017-18	62.11	140.47	41	1.41	4.49	1.89	2.45	3.9	87.2
2018-19	123.02	278.22	77.25	2.66	8.46	3.58	5.86	7.35	174.51
2019-20	363.01	578.04	226.17	7.81	24.8	10.48	0.1	21.53	522.25
2020-21	137.51	232.59	85.77	2.96	9.3	3.97	2.37	8.1	185.47
Total	**791.32**	**1397.58**	**499.47**	**18.26**	**58.08**	**23.12**	**10.889**	**47.44**	**988.73**

Source: Author's estimation based on secondary data

The loss of forest ecosystem services is mainly due to forest land conversion for non-forest purposes followed by forest fires and other natural calamities in Karnataka. Due to forest loss and degradation, the loss value of carbon sequestration is estimated at Rs 1897.05 crore during the assessment period. Loss due to carbon sequestration in vegetation and soil is a major problem for the conservation of ecosystem and biodiversity especially sustainable development, socio-economic impact such as food insecurity, poverty and inequality at the local level. In addition, the average mean temperature will increase depending on the rate of forest loss. Further, forest-dependants' income and livelihood will reduce.

Conclusion and Recommendations

Calculating the loss of forest ecosystem services to better understand the importance of various forest ecosystem services, such as provisioning, regulating and cultural service, will contribute to the state economy. Forest ecosystem services' benefits or loss has not been recorded in the economic calculation, such as the state income account. Economic estimation helps in better resource allocation, especially the budget for forest and biodiversity conservation. Accounting for ecosystem services is also long-term societal welfare in terms of environmental services that play a major role in human well-being. Karnataka is famous for nature-based tourism; therefore, cultural ecosystem services must be linked with tourism and areas identified for implementing revenue streams for ecosystem services in the state. Therefore, Karnataka is one of the important states for implementing the value of ecosystem services and integrating it into the state income calculation which is the stock and changes of stock and flow of environmental goods and services through the System of Environmental Accounting framework. Finally, forest ecosystem accounts can help local policymakers to understand the benefits of forest ecosystem goods and services and their contribution to the economic growth of Karnataka.

The introduction of the eco-budget by Karnataka in 2022-23 could be attributed to national and international commitments in the recent past. India is committed, at the highest level, to meeting its pledges under the Nationally Determined Contributions (NDC) made to the international community under the Paris Agreement of 2015. In a 2019 report, the Ministry of Environment, Forest, and Climate Change (MoEFCC) has identified Karnataka as having the second-highest potential of creating more carbon sink through additional forest and tree cover

by 2030 (Balasubramanian, 2024) further reading https://www.ideasforindia.in/topics/environment/eco-budget-in-karnataka-opportunities-and-challenges.html

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