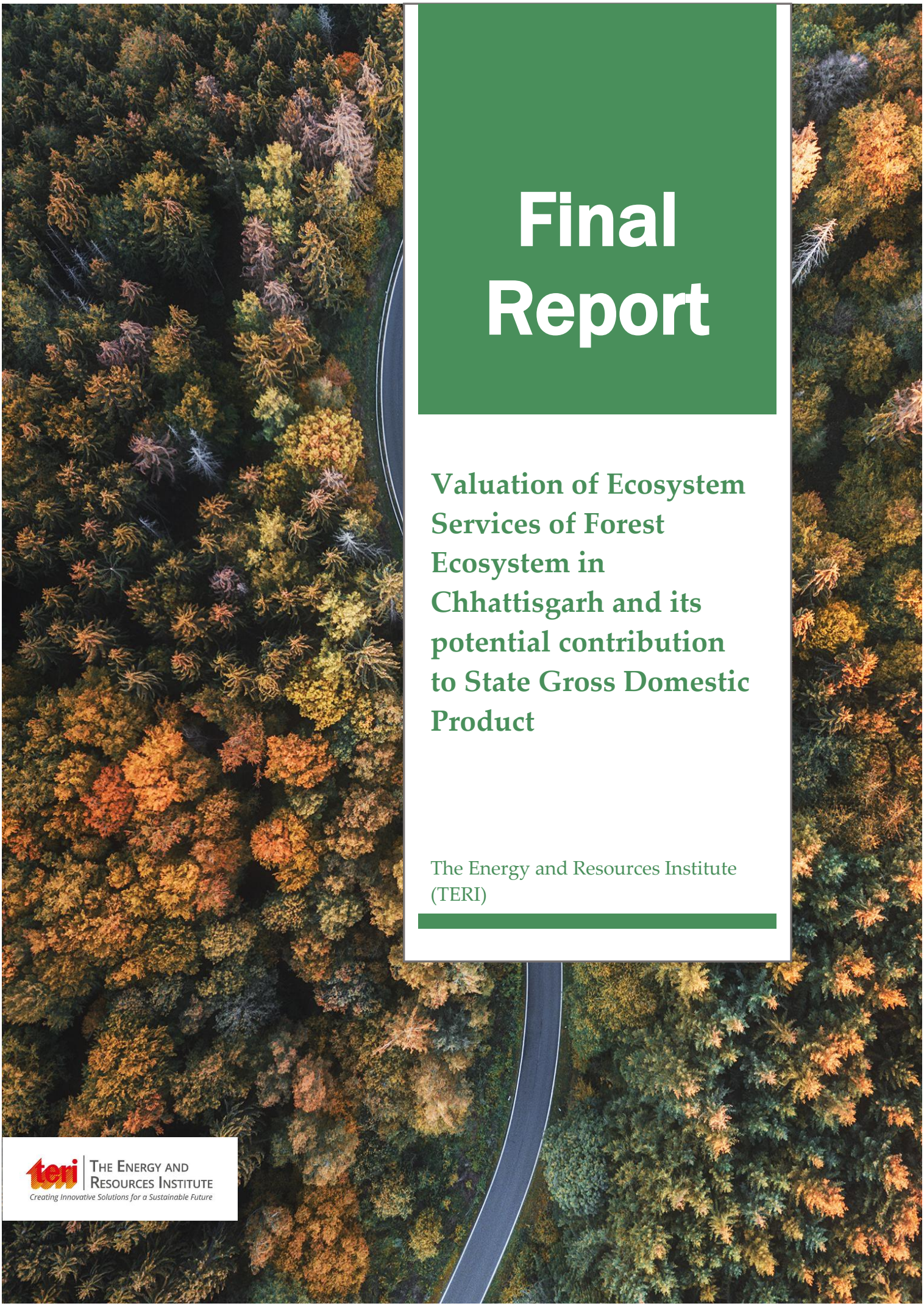

Final Report

Valuation of Ecosystem Services of Forest Ecosystem in Chhattisgarh and its potential contribution to State Gross Domestic Product

The Energy and Resources Institute (TERI)

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VALUATION OF ECOSYSTEM SERVICES OF FOREST ECOSYSTEM IN CHHATTISGARH AND ITS POTENTIAL CONTRIBUTION TO STATE GROSS DOMESTIC PRODUCT

Prepared by –

The Energy and Resources Institute, TERI (2026)

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LIST OF ABBREVIATIONS

AGB	Above Ground Biomass
BGB	Below Ground Biomass
CVM	Contingency Valuation Method
CWRD	Chhattisgarh Water Resource Department
DFO	Divisional Forest Officer
ESIP	Ecosystem Services Improvement Project
ES	Ecosystem Services
ESV	Ecosystem Service Valuation
ESVD	Ecosystem Services Valuation Database
EV	Economic Valuation
FFV	Forest Fringe Villages
FGD	Focus Group Discussions
FMIS	Forest Management Information System
FSI	Forest Survey of India
GDP	Gross Domestic Product
GVA	Gross Value Added
GIS	Geographic information system
GSDP	Gross State Domestic Product
InVEST	Integrated Valuation of Ecosystem Services and Trade-offs
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IWC	Improvement Working Circle
JFM	Joint Forest Management
LULC	land use/land cover
MEA	Millenium Ecosystem Assessment
MFP	Minor Forest Produce
MSP	Minimum Support Price
NCA	Natural Capital Accounts
NCAVES	Natural Capital Accounting and Valuation of Ecosystem Services
NDVI	Normalized Difference Vegetation Index
NPV	Net Present Value
PAGE	Pilot Analysis of Global Ecosystems
PF	Protected Forests

PlWC	Plantation working Circle
PWC	Protection Working Circle
RF	Reserved Forest
RWC	Rehabilitation Working Circle
SCI	Selection cum Improvement
SEEA	System of Environmental-Economic Accounting
SDG	Sustainable Development Goals
SDP	State Domestic Product
SMC	Soil Moisture Content
SNA	System of National Accounts
SOC	Soil Organic Carbon
TCM	Travel Cost Method
TEEB	The Economics of Ecosystem and Biodiversity
TEV	Toal Economic Value
UNSD	United Nation Statistics Division
WAVES	Wealth Accounting and the Valuation of Ecosystem Services

DEFINITIONS

Above Ground Biomass	The total mass of living plant material above the soil surface, including stems, branches, and leaves, used for estimating carbon storage and productivity.
Below Ground Biomass	Biomass of roots and other living components below the soil surface
Biodiversity	The variety and variability of life forms within an ecosystem, including genetic, species, and ecosystem diversity.
Carbon Sequestration	The process by which ecosystems absorb and store carbon dioxide from the atmosphere, primarily through vegetation and soils.
Contingent Valuation Method	A stated-preference survey technique that asks respondents their willingness to pay for specific ecosystem benefits or to avoid losses
Cultural Ecosystem Services	Non-material benefits derived from ecosystems, such as recreation, aesthetic enjoyment, spiritual values, education, and research opportunities.
Discount Rate	The rate used to convert future values into present values in economic assessments.
Ecosystem Assets	Defined as the different components of the ecosystem services that are taken for evaluation. Example timber, fuelwood, carbon sequestration, biodiversity conservation, tourism etc.
Ecosystem Degradation	The reduction in an ecosystem's capacity to provide services due to human-induced or natural disturbances.
Ecosystem Functions	The biological, geochemical, and physical processes that occur within ecosystems and support service provision.
Ecosystem Services	The benefits that humans obtain from ecosystems, including provisioning, regulating, supporting, and cultural services.
Ecosystem Service Cascade	The linkages of each component of ecosystem services with social value bridging the gap between natural science and social science.
Ecosystem Services Valuation	The process of identifying, quantifying and, where appropriate, monetising benefits humans obtain from ecosystems.

Ecosystem Services Valuation Database	A compiled database of monetary welfare values and related studies used as a reference for plausible value ranges
Existence Value	The value people place on knowing that a particular ecosystem or species exists, even if they never use it directly.
Focus Group Discussions	A primary data collection method used in the study to capture stakeholder perceptions
Forest Cover	The proportion of land area occupied by forests, typically classified based on canopy density.
Forest Degradation	A reduction in forest quality, structure, or function, leading to a decline in ecosystem services.
Forest Fringe Villages	Villages located up to a defined buffer (ex- 5 km) from forest boundaries whose livelihoods often depend on forest services)
Forest Management Information System	An integrated digital platform that combines GIS, remote sensing, database management, and decision-support tools to facilitate comprehensive forest planning, monitoring, inventory management, and sustainable operations across administrative levels.
Forest Survey of India	A premier national organization under MoEFCC, GoI. FSI conducts periodic, scientifically robust assessments of the country's forest resources through satellite remote sensing, ground inventories, and GIS mapping, producing the authoritative India State of Forest Report (ISFR) biennially.
Green Accounting	An approach to national accounting that incorporates environmental assets and ecosystem services into economic systems.
Gross Domestic Product	Measures the total monetary value of all final goods and services produced within a country's geographical borders during a specific period, typically one year. It serves as the primary indicator of economic activity and national economic health.
Gross State Domestic Product	Represents the equivalent of GDP but at the state level within India, capturing the total value of goods and services produced within a particular state's boundaries over a financial year. GSDP reflects state-level economic performance and is used for federal fiscal transfers, planning, and comparing regional development;

Indirect Use Value	The value derived from ecosystem services that support or protect economic activities, such as flood regulation or climate control.
Integrated Valuation of Ecosystem Services and Trade-offs	A comprehensive, spatially explicit modeling framework that quantifies and maps multiple ecosystem services from land- and seascapes, revealing synergies and trade-offs among them. Developed by the Natural Capital Project, InVEST uses ecological production functions to generate biophysical outputs
Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services	IPBES is an independent intergovernmental body established in 2012 that strengthens the science-policy interface on biodiversity and ecosystem services for conservation and sustainable use. Functioning like the IPCC for climate but focused on nature.
Intrinsic Value	The inherent worth of nature, independent of its utility to humans.
Minor Forest Produce	A category of forest goods (tendu, mahua, honey, medicinal plants etc (included under provisioning services)
Natural Capital	The stock of natural assets, including soil, water, air, flora, and fauna, that yield ecosystem services.
Natural Capital Accounting and Valuation of Ecosystem Services	A standardized framework that systematically measures, records, and values the stocks of natural capital (ecosystems, biodiversity, resources) and the flows of ecosystem services they provide, integrating these into national economic accounts like GDP/GSDP calculations. Adopted by UN SEEA Ecosystem Accounting (2021), NCAVES quantifies how nature contributes to economic welfare beyond market transactions, enabling policymakers to track depletion vs. regeneration of natural assets.
Natural Capital Accounts	Natural Capital Accounts are structured balance sheets that systematically measure and record the stocks (extent and condition) of natural assets and the flows of ecosystem services they generate, expressed in both physical units and monetary terms.
Natural Resource Depletion	The consumption or degradation of natural resources faster than they can be replenished.
Net Present Value	Discounted sum of future net benefits/costs; used in some valuation approaches referenced in the report
Non-Market Valuation	Methods used to estimate the value of ecosystem services that are not traded in conventional markets.

Non-Timber Forest Produce	See MFP (used interchangeably in Indian context)
Non-Use Value	The value people place on ecosystems even if they never directly or indirectly use them (includes existence and bequest values).
Normalized Difference Vegetation Index	Quantifies vegetation health and density from satellite imagery by comparing near-infrared (NIR) light reflectance (strongly reflected by healthy plants) against red light absorption (used for photosynthesis).
Opportunity Cost	The value of the next best alternative foregone when a resource allocation decision is made under conditions of scarcity. It represents the economic benefits sacrificed—not just explicit monetary costs—when choosing one option over mutually exclusive alternatives.
Option Value	The value placed on preserving ecosystems for potential future use.
Provisioning Services	Ecosystem services that provide tangible goods such as timber, fuelwood, food, water, and medicinal plants.
Recorded Forest Area	Recorded Forest Area (RFA) refers to all geographical areas recorded as 'forests' in government records, primarily comprising Reserved Forests (RF), Protected Forests (PF), and unclassed forests constituted under the Indian Forest Act, 1927
Recreation Value	Refers to the economic benefits people derive from leisure, tourism, and outdoor activities enabled by natural ecosystems
Regulating Services	Benefits obtained from the regulation of ecosystem processes, including climate regulation, flood control, water purification, and carbon sequestration.
Replacement Cost Method	A valuation approach that estimates the cost of replacing an ecosystem service with a man-made alternative.
Resilience	The ability of an ecosystem to absorb disturbances and recover while maintaining its functions and structure.
Resource Scarcity	A condition in which natural resources become limited due to overexploitation or environmental degradation.
Revealed Preference Methods	Valuation techniques that infer the value people place on non-market environmental goods (like ecosystem services) by observing their actual behavior and choices in related real-world markets.

Soil Organic Carbon	The carbon stored in soil organic matter, an important component of carbon stocks.
State Domestic Product	Often used interchangeably with GSDP in Indian economic reporting, It refers to the gross value of output from all economic activities (agriculture, industry, services) within a state before depreciation.
Stated Preference Methods	Valuation techniques based on surveys that ask people their willingness to pay for specific environmental benefits.
Supporting Services	Ecosystem services that underpin all other services, such as nutrient cycling, soil formation, and primary production.
Sustainability	The capacity to meet present needs without compromising the ability of future generations to meet their own needs.
System of Environmental-Economic Accounting	Internationally agreed statistical standard that integrates environmental data with economic accounts from the System of National Accounts (SNA), enabling measurement of natural capital stocks, ecosystem service flows, and their economic contributions to GDP/GSDP. SEEA provides standardized concepts, definitions, classifications, and accounting tables for comparable environmental-economic statistics across countries.
System of National Accounts	Internationally agreed conceptual framework and standardized accounting system for measuring the economic activity of a nation, providing a comprehensive, integrated picture of production, consumption, investment, income distribution, saving, and accumulation of assets.
The Economics of Ecosystems and Biodiversity	A global initiative to make nature's values visible in economic decision-making, demonstrating the economic benefits of biodiversity and ecosystem services while highlighting the growing costs of their loss.
Total Economic Value	A framework that captures the full range of values associated with ecosystems. It an aggregate value capturing use (direct/indirect) plus non-use (existence, bequest) values of ecosystem services
Trade-offs	Situations where enhancing one ecosystem service leads to the reduction of another.
Travel Cost Method	A revealed preference valuation technique that estimates ecosystem service value based on travel and time expenses incurred by visitors.

Use Value	The value derived from direct or indirect use of ecosystem services.
Valuation	The process of assigning economic value to ecosystem goods and services.
Wealth Accounting and the Valuation of Ecosystem Services	WAVES is a World Bank-led global partnership that promotes sustainable development by integrating natural capital accounting into national development planning and economic accounts.
Well-being	A state in which human needs are met, xand individuals can pursue fulfilling lives, supported by ecosystem services.
Willingness to Pay	The maximum amount an individual is willing to pay to obtain or preserve an ecosystem service.

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EXECUTIVE SUMMARY

This Executive Summary presents key findings of the study "Ecosystem Services of Forest Ecosystem in Chhattisgarh and its potential contribution to State Gross Domestic Product GDP", undertaken by The Energy and Resources Institute (TERI) for Chhattisgarh Forest Department, using robust methodologies based on internationally accepted green accounting frameworks.

Introduction

Forests provide a wide range of ecosystem services; however, it is inherently challenging to place a monetary value on many of these. As a result, the full contribution of forests to the economy is not accounted for, and decisions around allocation of financial resources are based on the values of only those forest services that have a clear price tag. It is important therefore to undertake a comprehensive valuation of the ecosystem services of forests and feed results of such an exercise to planners and policymakers.

Such an exercise is particularly significant for forest-rich states of India like Chhattisgarh, with nearly 41 percent of its geographical area under forest cover. This extensive forest cover makes the state a critical area of biodiversity and a key regulator of ecological balance in India. Over the past decade, Chhattisgarh has not only maintained a substantial forest cover but has also registered an increase of 199 Sq.km between 2013 and 2023, as reported in successive India State of Forest Reports. These forests are also central to the lives and livelihoods of tribal and rural communities, who depend on them for a wide range of forest resources for their livelihood and sustenance.

Approach and methods

This study adopts the System of Environmental-Economic Accounting (SEEA) framework, a globally recognized standard by the United Nations for measuring these services in economic terms. It standardizes valuation methods for integration into national accounts like GDP, allowing policymakers to track forest contributions alongside other sectors in a consistent manner. Under SEEA, services are classified into three main categories - provisioning (material outputs like timber and fodder), regulating & supporting (maintenance processes like carbon sequestration and biodiversity conservation), and cultural (non-material benefits like recreation and education), to enable consistent valuation and policy integration. The table below provides a snapshot of valuation methods – as applicable to this study.

Table 1: Valuation method used for ecosystem service valuation

Ecosystem service type	Valuation method	Applicability
Provisioning (Timber, Fuelwood, MFPs)	Market price method	The market price method is best suited for provisioning services that enter established markets.

Regulating (Carbon sequestration)	Modelling based method (InVEST)	A modelling-based method such as InVEST is well-suited for estimating regulating services in landscape-level assessments.
Regulating and Supporting (Air purification, Soil conservation, Pollination)	Replacement cost method	This method is suitable when the ecosystem service does not have a direct market price but has a close substitute can be directly valued. *The replacement cost method estimates the value of ecosystem services by calculating the costs associated with replacing tho se services with human-made alternatives.*
Cultural (Recreation, Ecotourism)	Travel cost method (TCM)	TCM is used to estimate the value of recreational sites based on the costs incurred by visitors to access them.
Regulating (Biodiversity conservation)	Benefit transfer and proxy methods	These methods are used when direct measurement is challenging and current literature provides estimates that are transferable across contexts.

Economic Values of ecosystem services

The table below presents estimates of the annual Economic Values (EV) of key ecosystem services of the forests of Chhattisgarh, based on application of the methods mentioned above and drawing from both official data and a primary survey covering 1200 households selected through a stratified sampling approach

Table 2: Total Economic Value (TEV) of ecosystem services

S.No.	Description	Annual EV (in Rs crore)
1	Timber*	318
2	Fuelwood*	1,857
3	Small Timber*	641
4	Bamboo*	20
5	Fodder*	6,197
6	Minor Forest Produce (MFP)*	9,561
	Provisioning	18,594
8	Carbon Sequestration*	13,394
9	Water Purification and Availability*	20,825
10	Air Purification	269
11	Soil Conservation	693
12	Pollination	13,727
	Regulating	48,908
13	Biodiversity Conservation	41,111

14	Nutrient Cycle	15,211
	Supporting	56,321
15	Recreation*	13,645
16	Education, Science	3,916
	Cultural	17,560
	Total Economic Value (TEV)	**1,41,383**
**Denotes the services accounted as use values*		

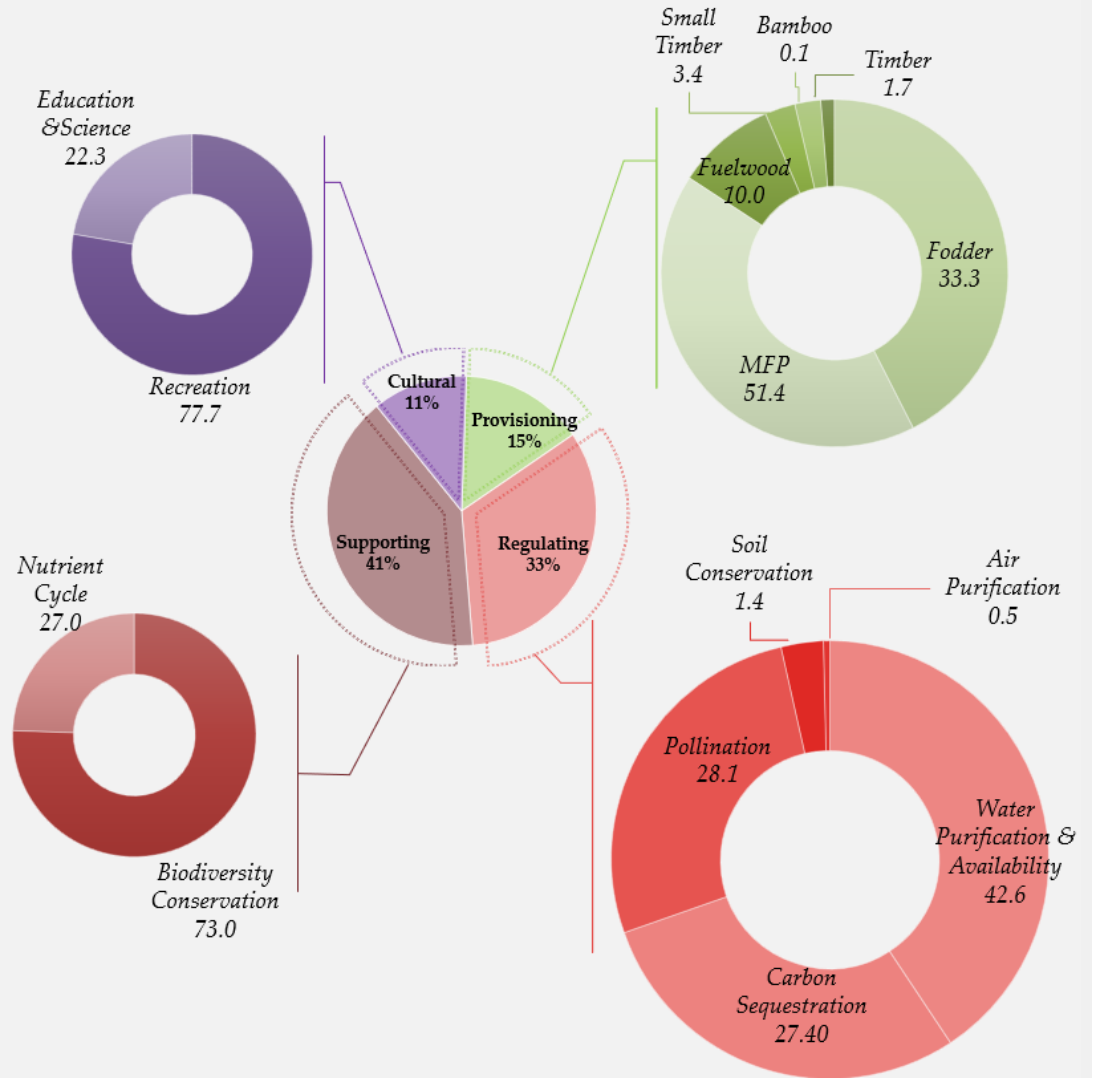

Figure 1: Percentage contribution of services towards TEV

In terms of the spread of values across categories of services, supporting and regulating services clearly dominate. Significantly, these account for about three-fourth of the Total Economic Value, indicating the critical role played by forests in maintaining vital ecosystem functions in the long run beyond being a source of provisioning services. Likewise, cultural values, especially those attributed to recreational benefits, remain significant.

Among provisioning services, the values of fodder and MFP dominate while among regulating services, water availability/ purification, carbon sequestration and pollination rank among the dominant services.

These benefits split into use values totalling Rs. 0.66 lakh crore (47% of TEV), covering direct and indirect benefits (e.g., provisioning services, water availability and purification, recreation) and non-use values (nutrient cycle, soil conservation, pollination, education) at Rs. 0.75 lakh crore (53% of TEV).

It may be noted that the above categorisation of ecosystem services is not exhaustive. Forests, for instance, also generate religious and spiritual values which are of an intangible nature, and cannot be meaningfully monetised. These services are left out of the purview of quantitative assessment in this study.

Contribution to the state's economy

The contribution of the forestry sector to the state's economy is captured through the lens of Gross Value Added (GVA) which calculates the state's income through the 'supply side' at base prices (excluding taxes and subsidies). GVA is ideally suited for sectoral analysis (that is, comparison of sectoral contributions to the economy). The study attempts to position the value of the forestry sector's contribution to the economy within the context of other sectors such as agriculture, mining and manufacturing (that are fully monetised).

This approach reveals a transformative shift when comparing forests' contribution to Chhattisgarh's economy with and without the adjustment for ecosystem services, fundamentally reshaping perceptions of the sector's importance. In the current scenario, official GVA data shows forestry and logging contributing a modest Rs. 18,462 crore (3.5% of total GVA) within a state economy of Rs. 5,33,255 crores, which reflects only recorded timber revenues and ignores the vast unmonetized forest benefits. However, incorporating use values of ecosystem services elevates the contribution of forests to Rs. 66,458 crore (11.4% of total GVA), expanding the overall economy to Rs. 5,81,252 crores. This dramatic leap repositions forestry as the third-largest sector, surpassing mining and manufacturing.

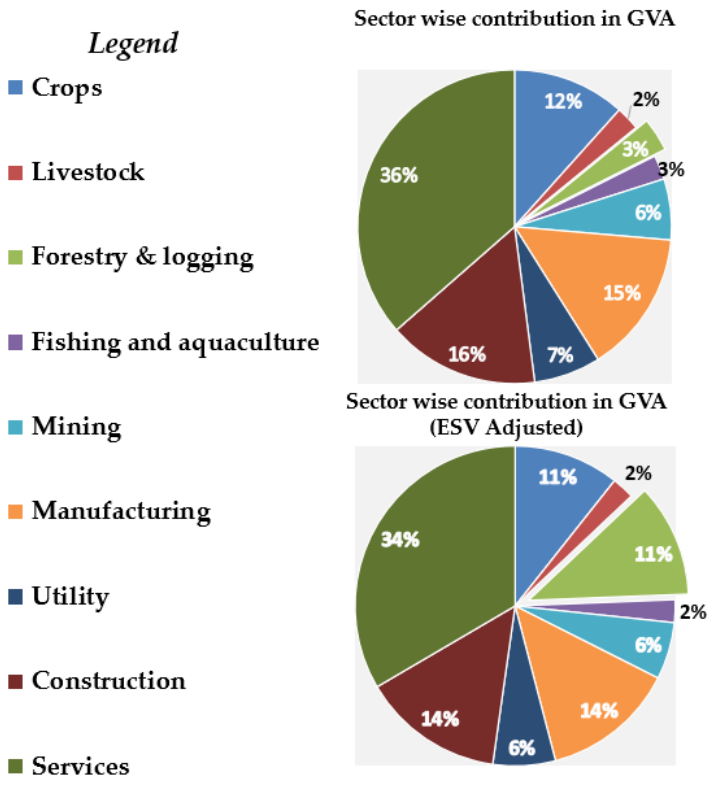

Figure 2: Contribution of Forestry in GVA with and without ESV adjustment

It may be noted that using the GDP approach will slightly elevate the size of the total economy when adjustments are made for taxes (net of subsidies). However, if the adjustments are made consistently

across sectors, the percentage contribution to the economy either in GVA or GDP terms will remain identical (11.4%) and therefore will not alter the overall narrative.

This shows that correctly reflecting just the use values of forests (within the spectrum of ecosystem services) creates a new policy perspective. We note here that this would still represent a conservative estimate of the contribution of the forestry sector to the economy – and if the non-use values are also incorporated within accounting systems, the potential importance of this sector will further go up.

Forests and climate change

Chhattisgarh has achieved the highest national forest cover gain (684 square kilometre from 2021–2023) though growing stock has plummeted from 74.42 m^3/ha (1997) to 55.69 m^3/ha (2019), a 25% loss, creating a 22 m^3/ha deficit against ICFRE's 1 m^3/ha/year Mean Annual Increment (MAI) standard. This could signal stalled regeneration and climate-induced stress (droughts, heat).

The decline in growing stock directly undermines Chhattisgarh's carbon sequestration capacity, a critical regulating ecosystem service valued at Rs. 14,770 crores annually estimated by integrating state-level assessments of carbon stocks, InVEST modelling and carbon market pricing (TERI, 2025; FSI, 2023; MoSPI, 2022). Each cubic meter of wood contains approximately 0.5 tonnes of carbon, following standard wood density conversions for tropical hardwoods like sal and teak dominant in the region. Correcting for the observed 22 m^3/ha growing stock deficit, rather than the referenced 37 m^3/ha, this equates to 11 tC/ha foregone, or 40.3 tCO_2e/ha when applying the IPCC Tier 1 factor of 3.67. Scaled across Chhattisgarh's 4.24 million hectares of forest cover inside RFA, this translates to 171 $MtCO_2e$ of unrealized annual carbon storage capacity.

Policy Implications

It is evident that forests provide a wide range of ecosystem services which when fully valued would significantly increase the sector's contribution to the state's income. Moreover, many of the benefits of forests transcend state boundaries; for instance, the carbon sequestration functions of forests constitute a global service though the state must bear the costs associated with forest management and conservation.

There is therefore a case for states with rich forest cover to be reasonably and fairly compensated for the ecosystem services their forests provide – through appropriate Environmental Fiscal Transfer (EFT) mechanisms. In India, successive Finance Commissions have accepted the principles underlying these mechanisms. The 12th Finance Commission introduced forestry grants using geographical area (7.5% weight), followed by forest cover inclusion in the 13th and 14th Commissions (7.5% weight), and enhancement to "forest and ecology" in the 15th Commission (10% weight) (15th Finance Commission Report).

The 15th Finance Commission provides Chhattisgarh Rs. 2,077 crore annually (2021-26), with approximately 10% (Rs. 208 crore/year) supporting forestry (15th Finance Commission Report Vol. II). Across the state's 59,816 km^2 Recorded Forest Area, this equals Rs. 34,729 per hectare annually. By contrast, the use values of ecosystem services of forests amount to Rs. 1,11,104 per hectare annually, implying that Finance Commission allocations account for less than a fifth of the contribution of forests to the economy even if only the use values are considered.

Besides, these funds remain untied, often redirected by states to other priorities rather than forestry, despite Chhattisgarh achieving the highest national forest cover gain of 684 km^2 (2021-23) (FSI 2023). Results from this study can therefore help build a case of enhancing allocations to the forest sector

of the state. Notably, Chhattisgarh's forests demonstrate significant growth potential that targeted investments could unlock. The state leads nationally in forest cover expansion, yet growing stock stands at 55.69 m^3/ha against a potential of 74.42 m^3/ha observed in earlier assessments. This 22 m^3/ha opportunity, aligned with ICFRE's 1 m^3/ha/year increment standard, could yield 171 $MtCO_2e$ additional carbon storage annually across RFA (40.3 tCO_2e/ha using IPCC factors) (FSI 2023).

Funding should extend beyond forest protection to address root causes of degradation, particularly supporting forest-fringe communities. Approximately 12.77 million forest-dependent people generate Rs. 20,000-50,000 annually from Minor Forest Produce, yet face constraints in health, sanitation, and education (Household survey, TERI, 2025). Forest development must be viewed as an integrated policy objective, combining sustainable forest management with livelihood enhancement, including improved access to health, sanitation, and education services for forest-dependent communities. This integrated strategy aligns with national objectives under the Green India Mission, translating ecosystem values into tangible socio-economic gains. Ecosystem service valuation provides the essential evidence base for securing these resources. Demonstrating forests' substantial economic contributions makes a compelling case for prioritizing the sector in state planning.

Conclusion

This study demonstrates that Chhattisgarh's forests constitute vital economic assets generating a total value of Rs. 1.41 lakh crore / year in ecosystem services (of which Rs 0.66 lakh crore comprise use values elevating contribution of forestry sector to 11.4% in the state's income), while confronting degradation pressures that demand urgent action. Current funding is based on a relatively narrow estimate of a part of the use value of forests and constrains the realisation of the state's remarkable growth potential, including 171 $MtCO_2e$ additional carbon storage capacity. Enhanced budgetary allocations to the forestry sector, for example through scaling up Finance Commission allocations will help unlock this potential while delivering climate resilience, community prosperity, and establish Chhattisgarh as a thought leader in green economy initiatives. Ecosystem service valuation provides the evidence base to transform forests from undervalued land banks. into a crucial pillar of sustainable development.

Sustainable forest management must prioritize the upliftment of forest-fringe communities through employment generation and improved health, sanitation, and education; however, current budgetary allocations to the forestry sector are inadequate. The economic value of forests highlighted in this study highlights the need for increased budgetary support to strengthen forest conservation while enhancing livelihoods of forest-dependent communities.

1. INTRODUCTION

Ecosystem services refer to the wide array of benefits that humans derive from natural ecosystems and are fundamental to human well-being, economic development and environmental sustainability. These are services that are derived directly from nature without the need of significant capital-intensive transformation. A large share of ecosystem services at the global scale is provided by forest biomes that comprise a third of the world's land area. Forests provide several provisioning services such as timber, fuelwood, Minor Forest Produce (MFP), fodder, and bamboo. In addition, they deliver vital regulating and supporting services by moderating local and global climate, enhancing soil stability and water quality, supporting pollination, reducing the impacts of natural hazards, maintain natural habitats and sustaining biodiversity. Forests also offer important cultural services leading to the realisation of recreational, aesthetic and spiritual values. Together, these services form a vital foundation for human well-being, livelihoods and sustainable growth **(Chiabai et al., 2011; Bravo-Oviedo et al., 2014; Brander, 2023; Ramachandra et al., 2024).**

However, the full range of ecosystem services is not captured in mainstream economic accounting frameworks, often resulting in inadequate consideration of these services in planning decisions. In particular, the significant amount of regulating and supporting services gets left out – as they remain outside the purview of market transactions and hence do have a well-defined market price. However, they make critical contributions to the functioning of the market economy which, though notionally recognised, do not get formally recorded and reported within accounting systems. At the same time, the relentless pursuit of growth-based development models, tends to overlook the environmental losses caused by unsustainable industrial development since the losses in ecosystem services resulting therefrom do not get formally captured in monetary terms. In other words, the negative externalities of industrial development often remain outside decision-making frameworks, compromising the long-term flow of ecosystem services. At a practical level, forest ecosystems therefore risk degradation due to anthropogenic pressures which directly diminish the flow of ecosystem services such as carbon sequestration, water regulation, soil conservation, and biodiversity support. This is compounded further by climate change impacts that exacerbate this degradation by altering temperature and precipitation regimes, increasing the frequency of extreme events, and reducing ecosystem resilience.

> ***"IT IS IMPOSSIBLE TO PUT A PRICE TAG ON NATURE"***
>
> *Society at large understands economic language, so economists have devised methodologies to **"estimate"** economic value of tangible and intangible benefits of nature.*

Consequently, ecosystem services have largely been taken for granted and overexploited, primarily because they are not transacted in conventional markets. In a world where economic decision-making is predominantly driven by monetary metrics, the benefits provided by forests remain undervalued, as their worth is not readily comparable to financial returns from other forms of capital. The lack of integration of ecosystem services within formal market structures, has meant that their true economic contributions remain invisible in traditional indicators such as the Gross Domestic Product (GDP) **(Vatn & Bromley, 1994; Sukhdev, 2009)**.

At present, the conventional GDP does not account for ecosystem services or the depreciation of natural capital, leading to a distorted picture of economic growth that overlooks environmental degradation. As a result, decision-making processes often prioritize short-term financial gains at the expense of long-term ecological sustainability, leading to overextraction, degradation and biodiversity loss.

Valuation of ecosystem services provided by forests attempts to bridge this gap by systematically identifying, quantifying, and where appropriate, monetising the contributions of forests to human society, thereby translating the benefits of ecological functions into a language understood by policymakers and planners. It provides the much-needed evidence base to inform policy decisions by highlighting trade-offs between conservation and development, and by demonstrating the economic costs of ecosystem degradation and the benefits of sustainable management. When integrated into planning and budgeting processes, ecosystem services valuation can support more informed and rational allocation of public resources, justify increased investments in forest conservation and restoration, and mainstream environmental considerations into sectoral and fiscal policies. In this way, valuation serves as a critical tool for aligning economic development objectives with ecological sustainability.

The Total Economic Value of forests, in its true sense, should reflect the full contribution of goods and services to human well-being, including benefits derived from the natural environment or "natural capital" **(Pearce & Atkinson, 1993)**. For conventional goods and services traded in markets, this can be inferred from observable market prices and quantities. In contrast, most ecosystem services such as biodiversity conservation, climate regulation, and carbon sequestration are not traded in markets and therefore lack explicit (market) price signals. As a result, their economic significance is often overlooked in decision-making related to resource use and conservation, leading to sub-optimal outcomes for both the environment and society.

It may be noted that successive Finance Commissions have recommended the inclusion of environmental considerations within India's tax devolution mechanisms; for example, by assigning weightage to the forest cover of states to compensate for fiscal disabilities and promote ecological benefits. Likewise, the computation of the Net Present Value (NPV) of forests for the purpose of determining payments for forest land diversion takes into consideration the values several, though not all, ecosystem services that forests provide.

However, mainstream income accounts of India, at this time, remain restricted to a relatively narrow set of economic activities in the context of forests, covering (a) major products comprising industrial wood (timber, round wood, match and pulpwood) and fuel wood (firewood and charcoal wood) and (b) minor products comprising a large number of wild growing forest material such as bamboo, fodder, lac, sandalwood, honey, resin, gum, tendu leaves, cork, balsams, vegetable hair, eelgrass, acorns, horse chestnuts, mosses, lichens etc **(MoSPI, 2007)**. These are largely products that are traded and distributed through government channels and/or have a discernible market price.

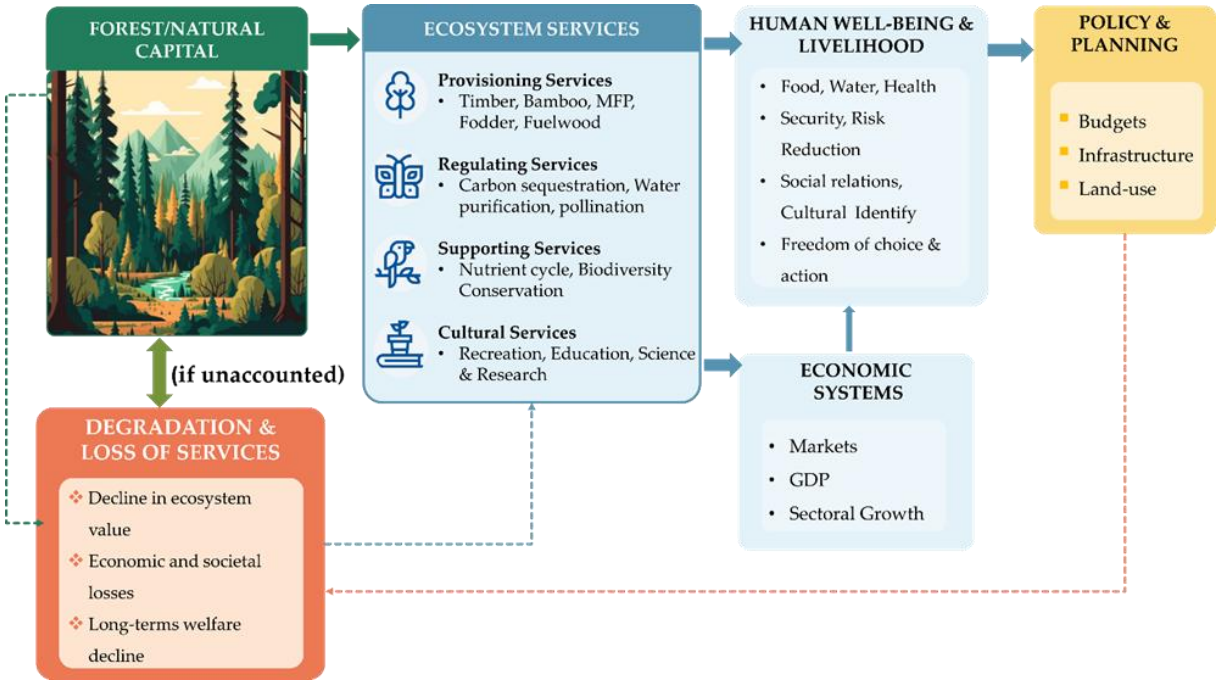

Figure 3: Conceptual linkages between forest ecosystem, ecosystem services, human well-being and economic systems

Recognizing this gap, the Chhattisgarh Forest Department (ChFD) has launched a transformative initiative to identify, map, and evaluate the economic contribution of forest ecosystem services and explore their integration into the State Domestic Product (SDP). This effort represents an important step toward ensuring that ecological sustainability and economic development are pursued in tandem. The project aims to:

1. Select a suitable framework for assessment.
2. Identify and quantify different categories of ecosystem services provided by forests (provisioning, regulating, supporting, and cultural).
3. Prepare environmental accounts based on the System of Environmental-Economic Accounting (SEEA), and
4. Develop training programs and manuals to build institutional capacity for ecosystem service valuation across the forest department and allied agencies.

This approach will enable policymakers to conduct robust economic analyses of development interventions, assess trade-offs between conservation and development, and ensure that long term ecological benefits are fully factored into planning decisions. Such information could also aid the process of internalising environmental externalities by informing the setting of appropriate fees or levies for damage to natural capital, determining compensation for communities and stakeholders affected by the loss of ecosystem services, and optimising mitigation and management strategies in developmental works by prioritising the protection of high-value ecosystem services.

2. SCOPE OF WORK

The assignment for the valuation of ecosystem services for natural forests ecosystem of Chhattisgarh and understanding the potential contribution to state's GDP has the following objectives:

1. Conduct a desktop review of inventories, existing studies, reports, literatures and documents on ecosystem valuation for natural ecosystem in Chhattisgarh. The study will also review existing national financial policy and guidelines, accounting and budgeting system of the state.
2. Review existing nationally and/or international accepted frameworks for valuation of ecosystem services and select the most appropriate framework for assessment.
3. Select most appropriate economic valuation methods. The methods should be repeatable and replicable so that follow-up valuations can be conducted to monitor social and economic changes in ecosystem values over time.
4. Based on selected framework, identify, map, and quantify ecosystem service being provided by forest ecosystem of Chhattisgarh. Apply best available tools to arrive at GEP and prepare Environmental Accounts.
5. Undertake field-level survey (using appropriate statistical methods) based on the approved framework/ protocol for the collection of data for evaluating ecosystem services.
6. The processing and analyzing of collected data to show current or baseline value of the identified ecosystem service and shall be disaggregated according to the different beneficiary groups, sectors and scales if possible.
7. To assess the potential impacts of climate change on the ecosystem services in Chhattisgarh and evaluate the costs and benefits of adaptation measures.
8. Assessing the value of ecosystem services and the potential contribution of Chhattisgarh Forests to the states GDP.
9. Development of training manual based on the material reviewed, methods, and approaches adapted for the valuation of ecosystem services and conduct training and capacity building of the forest department and other stakeholders on ecosystem service valuation.
10. Use estimate of the value of services to evaluate potential policy recommendations for enhancing the resilience and sustainability of the forest ecosystem services.

3. STUDY AREA

This study was conducted in the forests of Chhattisgarh, a state located in the central India. Geographically, Chhattisgarh lies between latitudes 17°46' N to 24°06' N and longitudes 80°15' E to 84°51' E. Covering a total area of 135,191 sq.km, the state constitutes 4.1% of India's total geographical area **(CGFD, 2025)**. The total population of Chhattisgarh is 2.56 crore of which 76.76 % resides in rural areas **(Census of India, 2011)**. The state's total Gross State Domestic Product (GSDP) at current prices is projected to reach Rs. 5.61 trillion (US$ 67.27 billion) in 2024-25 **(IBEF, 2025)**.

Chhattisgarh is endowed with some of the country's most pristine and plentiful natural resources. Its topography is made up of mountains, plateaus and plains. The state's forests, lush, green, and untouched, serve as the source for significant rivers such as the Mahanadi, Narmada, and Indravati. These forests are home to a remarkable variety of flora and fauna, making them a vital ecological treasure of the region **(CGSCCC, 2025)**.

Forests of Chhattisgarh

The forest cover of Chhattisgarh is 55,811.75 sq.km, representing 41.28% of its geographical area. It consists of 5.49% very dense forest (7,416.57 sq.km), 23.65% moderately dense forest (31,983.80 sq.km) and 12.14 % open forest (16,411.38 sq.km). Additionally, scrubland covers 610.41 sq.km, accounting for 0.45%. **Figure 1** depicts the forest cover map of the state **(FSI, 2023)**.

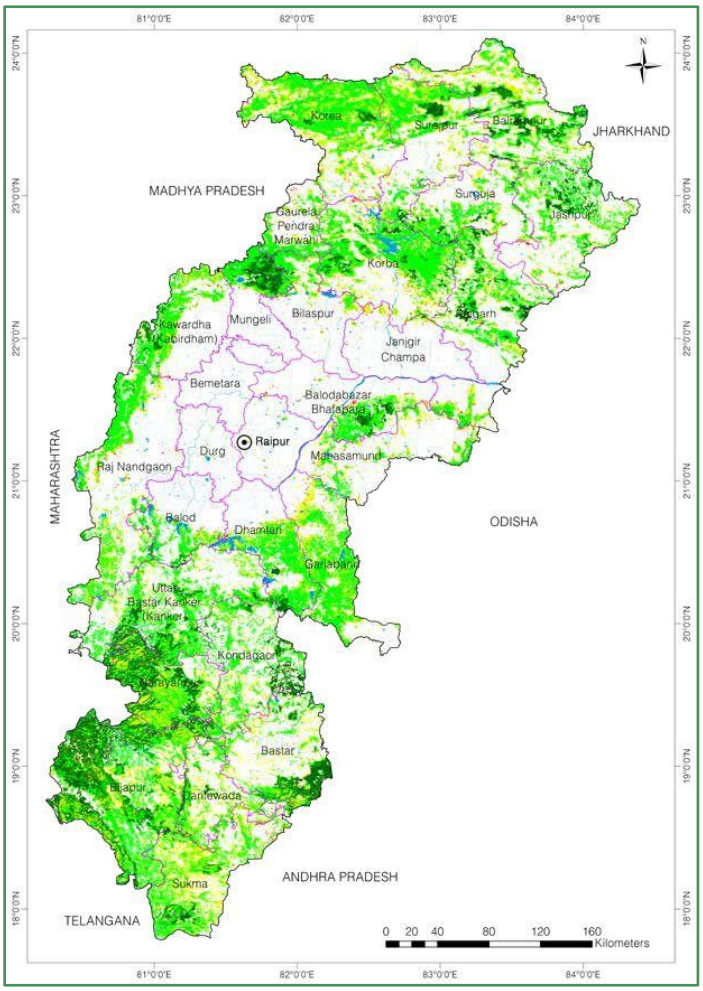

Figure 4: Forest Cover of Chhattisgarh

Source: India State of Forest Report, 2023

According to ISFR 2023, Chhattisgarh has the maximum positive change of 702.75 sq.km of forest cover as compared to other states. The growing stock of Chhattisgarh is 398.54 M m^3 while the carbon stock is 505 Mt **(FSI, 2023)**.

The total Recorded Forest Area (RFA) of Chhattisgarh is 66,074.30 sq.km, which represents 46.89% of the total area. The State has 2 National Parks, 8 Wildlife Sanctuaries, 3 Tiger reserves and 1 Bio-sphere Reserve. The RFA is divided into a total of 6 forest circles, each consisting of several divisions. The Durg circle includes 6 divisions, the Jagdalpur circle has 5 divisions, the Bilaspur circle consists of 10 divisions, the Kanker circle contains 6 divisions, the Sarguja circle has 6 divisions, and the Raipur circle is made up of 5 divisions. These circles constitute the administrative basis for the management and conservation of the state's forest resources **(CGFD, 2025)**.

The area under different Forest Types in Chhattisgarh (**as per the Champion & Seth Forest Classification, 1968)** based on the Forest Cover Map, ISFR-2023, is presented in **Table 3** below.

Table 3: Forest Types of Chhattisgarh

S. No	Forest Type	Area (km^2)	% of the total mapped area
1	3B/C1c Slightly moist teak forest	3,716.66	6.59
2	3B/C2 Southern moist mixed deciduous forest	8,755.37	15.52
3	3C/C2e (i) Moist peninsular high-level Sal	832.76	1.48
4	3C/C2e (ii) Moist peninsular low-level Sal	9,296.76	16.48

5	3/E1 Terminalia tomentosa forest	18.97	0.03
6	3/2S1 Dry bamboo brakes	3.77	0.01
7	5A/C1b Dry teak forest	284.98	0.51
8	5A/C3 Southern dry mixed deciduous forest	15,384.67	27.26
9	5B/C1c Dry peninsular Sal Forest	8,692.08	15.40
10	5B/C2 Northern dry mixed deciduous forest	7,387.48	13.09
11	5/DS1 Dry deciduous scrub	610.41	1.08
12	5/E9 Dry bamboo brakes	828.94	1.47
Sub Total		**55,812.85**	**98.92**
13	TOF/Plantation	609.31	1.08
Total (Forest Cover & Scrub)		**56,422.16**	**100.00**

Source: India State of Forest Report, 2023

Biogeographic Features of Chhattisgarh

CLIMATE

Chhattisgarh has a tropical climate, characterized by hot and humid conditions due to its proximity to the Tropic of Cancer and reliance on the monsoons for rainfall. Summer temperatures range between 30°C and 47°C while winter temperatures vary from 5°C to 25°C. The state receives an average of 1,292 millimetres (50.9 inches) of rainfall **(CGSCCC, 2025)**.

TOPOGRAPHY

Chhattisgarh's topography consists of a variety of landforms, including mountain ranges, plateau regions, and plains. The central region of Chhattisgarh is home to a river basin, which is divided into the undulating Rimland and the flat plains of Chhattisgarh. The gradient of the Chhattisgarh Plain is mostly flat, with its elevation ranging between 250 metre and 330 metre.

The Maikal Range extends as part of the Satpuda-Maikal landscape for about 500 kms. On one side of this stretch lies Chhattisgarh's Achanakmar Wildlife Sanctuary, and on the other side is the Melghat Tiger Reserve in Maharashtra. This landscape extends through both the Satpuda and Maikal ranges in Chhattisgarh.

The Satpura Range, which stretches across Madhya Pradesh, Maharashtra and Chhattisgarh, spans about 900 kms. The Satpura Range serves as a natural divider, separating the Deccan Plateau in the south from the Indo-Gangetic Plain in the north. The rivers Mahanadi, Tapti, and Godavari flow through the hilly regions of Chhattisgarh **(Maps of India, 2025)**.

SOIL

A large portion of Chhattisgarh is covered by red and yellow soil. While there are several soil types, four major ones—Kanhar, Matasi, Dorsa, and Bhata—occupy a significant area of the land.

Table 4: Type of Soil in Chhattisgarh

Name	Type	Description
Kanhar	Clayey	A low-lying deep bluish black soil with high moisture retention capacity. It is well suited for rabi crops, particularly wheat.
Matasi	Sandy loamy	This is a yellow sandy soil, with an admixture of clay. It has limited moisture retention capacity, often used for paddy cultivation.
Dorsa	Clay-loam	This type of soil is intermediate in terms of soil moisture retention between kanhar and matasi. This is best described as loamy and is a colour between brown and yellow.
Bhata	Laterite	This soil is a coarse-textured, red sandy-gravelly soil, found on upland tops. It is deficient in minerals and other productivity enhancing nutrients

Source: Bano, 2018

WATER RESOURCES

Chhattisgarh is divided into five river basins. The Mahanadi Basin drains an area of 77,302 sq.km the Godavari Basin covers 38,361 sq.km, the Ganga Basin drains 18,865 sq.km, the Brahmani Basin spans 1,316 sq.km, and the Narmada Basin drains 2,113 sq.km of catchment area in the state **(CGSCCC, 2025)**.

The Mahanadi River, which drains the vast central region of Chhattisgarh, is the largest and most significant water body in the state. This river system collects nearly all the rainfall from the basin and channels it to the Bay of Bengal. The Chhattisgarh Basin, formed by the Mahanadi and its main tributary Seonath, drains the central districts of Rajnandgaon, Durg, Raipur, and southern Bilaspur. It is the most extensive and agriculturally fertile region in the state, often called the "rice bowl" of India, supporting a large portion of the state's population.

The estimated surface water flowing through rivers in Chhattisgarh is 48,296 million cubic meters. However, due to various geographical and interstate constraints, the usable surface water in the state is limited to 41,720 million cubic meters. Currently, only about 18,249 million cubic meters of surface water is being utilized. The estimated groundwater in the state is 14,548 million cubic meters, with current exploration accounting for approximately 18.31% **(CGWRD)**.

Chapter 4 Methodology

4.METHODOLOGY

The methodology presented here is dictated by the understanding that if the full value of the ecosystem services of forests is not estimated and accounted for, forest resources may get over exploited or degraded, and the wider values of forests may not get recognised in decisions around land-use planning and resource management. The methodology draws upon a literature review on relevant frameworks and valuation methods.

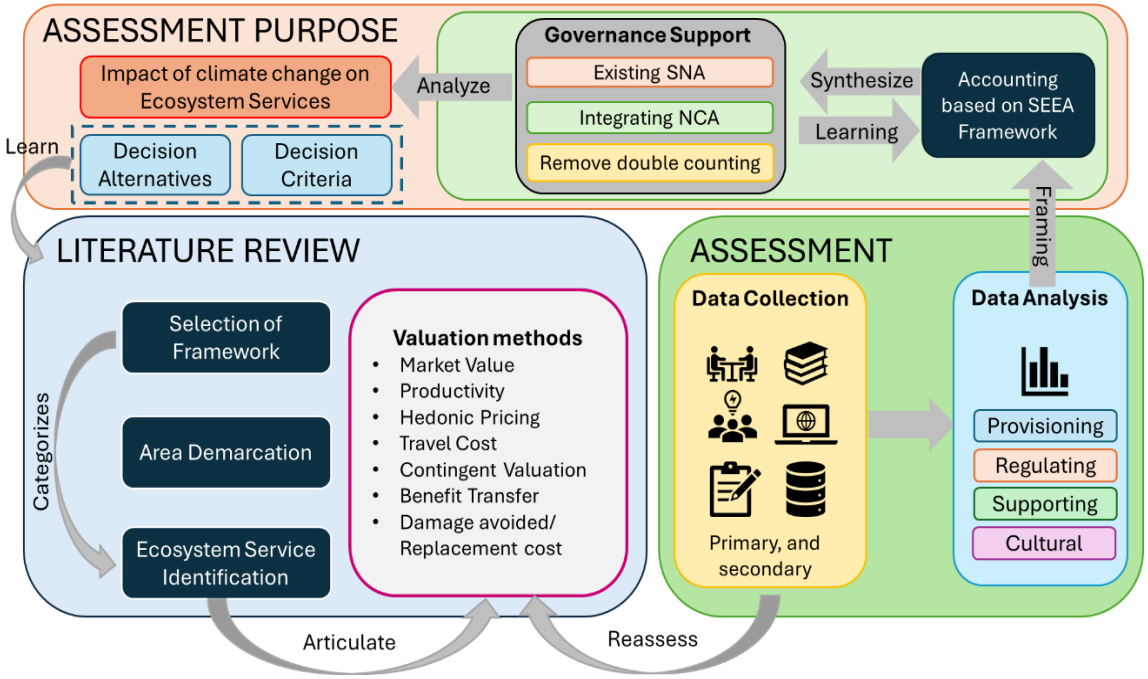

Figure 5: Overview of globally adopted methodology

The Ecosystem Services (ES) valuation process follows a structured, evidence-based methodology which commences with a comprehensive literature review to identify and select an appropriate valuation framework, priority ES relevant to the region's forests, and a suitable method for each ES.

Building on this foundation, the core assessment phase involves targeted data collection from credible sources (primary and secondary) and rigorous quantitative analysis. This yield estimates of ES values in monetary terms, and their aggregate contribution to Gross Domestic Product (GDP). The detailed workflow is outlined below:

4.1. LITERATURE REVIEW

A detailed literature review was undertaken to assess the various components, processes, and frameworks relevant to conducting an Ecosystem Service Valuation (ESV) for Chhattisgarh's forests. A comprehensive desk review of national and international studies was carried out to develop an understanding of ecosystem services, ESV frameworks, valuation approaches, and key economic concepts such as GDP calculation, Natural Capital Accounts (NCA), the System of National Accounts (SNA) and Net Present Value (NPV).

A wide range of research papers, books, and project reports were consulted, including studies under the Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES) project, the Ecosystem Services Valuation Database (ESVD), ecosystem service valuation studies conducted in Himachal Pradesh and tiger reserves across India, and NPV studies by Madhu Verma **(Verma et al., 2013; 2016 & 2017)**. In particular, the study *Valuation of Ecosystem Services of Karnataka State, India under the NCAVES Project* **(Ramachandra et al., 2022)** was referred to, as the valuation framework adopted for Karnataka provides a replicable approach for other Indian states and can support conservation planning and ecosystem-based management at the national scale.

Similar valuation studies undertaken in tiger reserves and forest landscapes of Himachal Pradesh and other regions were reviewed to gain insights into the frameworks applied, ecosystem services identified, valuation methods used, and the range of values estimated. These studies served as important references for identifying appropriate services and valuation techniques for the forests of Chhattisgarh.

The ESVD was also referred to as a supporting resource. The ESVD has been developed with the objective of providing robust and easily accessible information on the economic benefits of ecosystems and biodiversity, as well as the costs associated with their degradation and loss. It compiles monetary welfare values related to ecosystem services and currently includes 12,390 value records drawn from over 1,100 studies across different biomes, ecosystem services, and geographic regions. The ESVD was used to understand the probability ranges of ecosystem service values that could be expected while valuing forest ecosystem services in Chhattisgarh.

Data sources corresponding to different variables used for valuing individual ecosystem services were drawn from multiple references, details of which are provided in the subsequent sections. Based on the literature review, the framework adopted for the study, the ecosystem services identified, and the valuation methods proposed for estimating the economic value of forests in Chhattisgarh are described in the following section.

4.1.1. ECOSYSTEM SERVICE VALUATION FRAMEWORK

Several established ESV frameworks relevant to this study were reviewed and comparatively evaluated, ultimately selecting the most appropriate one based on criteria such as ES and process covered, measurement, transdisciplinary implementation, economic value, measurement, etc. A discussion of these frameworks is provided below.

MILLENNIUM ASSESSMENT (MA) REPORT

It was launched in 2001, and the principal report was published in 2005. The proposal for Millennium Assessment arose during a meeting held at World Resources Institute (WRI) on 17 May 1998 to discuss plans for biennial world resources **(MEA, 2003)**. The meeting concluded with a proposal for a set of activities to create a new international assessment process, which includes the following:

a) Conducting a 'Pilot Analysis of Global Ecosystems' (PAGE).
b) Focusing world resources from 2000-2001 on the condition of global ecosystem
c) Establishing a consultative process that could lead to creation of a full international science assessment.

The studies under Millennium Assessment (MA) Report underline how humans have changed the environment and the consequences of changing environment on human well-being. The findings are compiled in five technical volumes and six synthesis reports, which

provide information to decision-makers to manage ecosystems in more sustainable manner that maintain biodiversity and ecosystem. MA doesn't generate new primary knowledge, instead it adds value to existing information by clarifying how ecosystems, human wellbeing and intrinsic values in nature are intimately connected **(MEA, 2005)**.

THE ECONOMICS OF ECOSYSTEMS AND BIODIVERSITY (TEEB)

This project started in 2007 by the group of Environment Ministers of G8+ 5 countries (which involves the group of leaders from G8 nations and Heads of Government of 5 leading emerging economies). It highlighted the urgent need of improving knowledge and awareness about the loss of biodiversity and helps policy makers in decision-making on nature conservation and sustainable economic development **(TEEB, 2010, TEEB, 2010a; TEEB, 2010b)**. To achieve this goal, a structured approach was implemented for valuation of benefits provided by biodiversity and ecosystems to demonstrate their value in economic terms, and wherever possible capture the monetary value in decision making process **(TEEB)**.

SYSTEM FOR ENVIRONMENTAL ECONOMIC ACCOUNTING (SEEA)

System of Environmental-Economic Accounting (SEEA), for development planning, policy analysis, and to promote adoption of NCA beyond Wealth Accounting and Valuation of Ecosystem Services (WAVES) partner countries. WAVES has supported the development of 32 natural capital accounts (across seven domains = water, land, forest, energy, minerals, ecosystem, others) contributing to the monitoring of 11 Sustainable Development Goals (SDGs) and assisted in institutionalization of NCA in 10 countries. It has also helped in making 52 informed decisions across different policy making (including designing, implementing, monitoring and reforming) (SEEA, 2012; SEEA 2021).

SEEA emerged from ongoing discussions on assessing and measuring the concept of sustainable development. It was adopted as an international standard by UN Statistical Commission at its 43rd session in March 2012 and became the first international statistical standard for environmental-economic accounting.

INTERGOVERNMENTAL SCIENCE-POLICY PLATFORM ON BIODIVERSITY AND ECOSYSTEM SERVICES (IPBES)

IPBES is an independent intergovernmental body established by the member Governments in 2012. The aim is to provide policymakers with the scientific assessment, knowledge and state of the planet's ecosystem, biodiversity, and the contribution they make towards people. It provides options and actions to conserve and sustainably use vital natural resources. The IPBES global assessment of Biodiversity and Ecosystem Services is the first critical assessment of status, trends, social implications of these trends, their direct and indirect causes and the actions to be undertaken to ensure a better future for all (IPBES, 2019). The framework set out includes three interlinked elements:

a) Nature
b) Nature's contribution to people
c) Good quality of life

Other elements acting on the above-mentioned elements include anthropogenic assets, direct drivers of change, and institution, governance and other indirect drivers.

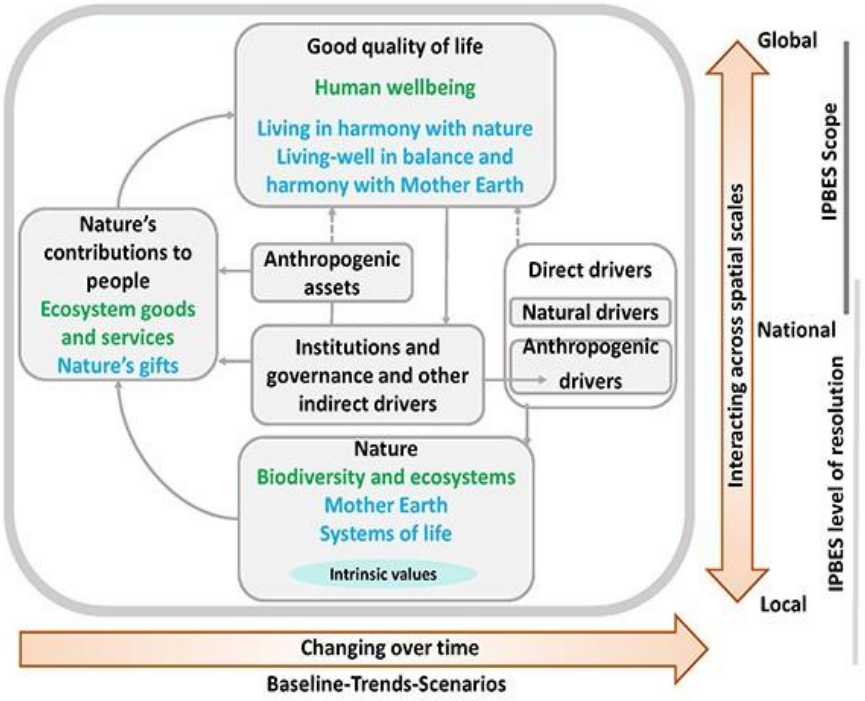

Figure 6: PBES Conceptual Framework

Source: Diaz et al., 2015

COMPARATIVE ASSESSMENT OF FRAMEWORKS

The four frameworks in are compared based on 16 criteria such as defining ecosystem service, ecosystem, ecosystem processes, transdisciplinary implementation, adaptability, concepts of framework, ecosystem service cascade, measurement of services, decision context, standard outputs of the framework, trade-offs dashboard, critical natural capital, long time frame, economic, existence, and transformative value to human beings **(Brodt & Saner, 2018)**.

The table highlighting the criteria addressed by different frameworks and the extent of addressing the criteria is given below:

Table 5: Review of Ecosystem Services Framework by applying 16 criteria

	Millennium Ecosystem Assessment (MEA)	The Economics of Ecosystems and Biodiversity (TEEB)	The System of Environmental-Economic Accounting (SEEA)	Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES)
Ecosystem Services				
Ecosystem				
Ecosystem Processes				

Transdisciplinary Implementation				
Adaptability				
Concepts				
Ecosystem Service Cascade				
Measurement				
Decision Context				
Standard Outputs				
Trade-Offs,				
Critical Natural Capital				
Long time frame				
Economic value				
Existence value				
Transformative value				

Fully addressed

Moderately addressed

Not addressed

4.1.2. ECOSYSTEM SERVICES

Forests offer a diverse range of benefits, directly supporting nearby communities and directly or indirectly benefiting all of humanity. They provide natural resources utilized by local industries and corporations, contributing to employment generation and essential services that enhance the nation's quality of life. However, despite their acknowledged significance, the benefits derived from many natural ecosystems remain inadequately understood and measured **(Negi and Agrawal, 2006)**.

Categorization of ecosystem services is a precondition for any attempt to measure, map, or value ecosystem services and to communicate the findings transparently (Groot et al., 2017). The MA describes ecosystem services as the advantages that humans derive from ecosystems. These services include provisioning services such as food and water, regulating services such as flood and disease control, cultural services including spiritual, recreational,

and cultural benefits, and supporting services such as nutrient cycling, which sustain the Earth's life-supporting conditions **(MEA, 2003)**.

Though the concept of ecosystem services is now well understood, the full significance of these services is not always recognized for policymaking. Assessing and being aware of the benefits of ecosystem service is essential to understanding the importance of ecosystem services for improving and continuing human wellbeing and for sustainable management of the ecosystem **(Costanza et al., 2014)**. Furthermore, information on ecosystem services is important for decision-makers to understand the dependency of local communities on ecosystem services, incorporate stakeholders' perceptions, and come up with better land-use policies **(Forster et al., 2015)**.

Figure 7: Types of ecosystem services

Source: MEA, 2005

Classification of Ecosystem Services by SEEA:

The SEEA framework uses the Common International Classification of Ecosystem Services to group ecosystem services. The details of all the ecosystem services included in the SEEA framework are provided in the following sections.

1. PROVISIONING SERVICES

Provisioning services are the material and direct benefits that are obtained from the forests. These include timber, fuelwood, fodder, bamboo and other NTFP (*Referred to as MFP in this study as per Indian context*).

Table 6: Provisioning Services identified by SEEA Framework

S. No.	Ecosystem service	Sub service	Description
a)	Biomass	Crop	It is the contribution of the ecosystem to the growth of cultivated plants that are harvested by economic units for various uses including food and fibre production, fodder, and energy.
		Grazed biomass	It is the contribution of the ecosystem to the growth of grazed biomass that is an input to the growth of cultivated livestock. This excludes the contributions to the growth of crops used to produce fodder for livestock like hay and soybean meal as they are included in crop provisioning services.

		Livestock	This is the contribution of the ecosystem to the growth of cultivated livestock and livestock products like meat, milk, egg, wool, and leather that are used by economic units for various uses, mainly food production.
		Aquaculture	It is the ecosystem contribution to the growth of animals andplants like fish, shellfish and seaweed in aquaculture facilities which are harvested by economic units for various uses.
		Wood	This is the ecosystem contribution to the growth of trees and other woody biomass which are harvested for various uses including timber production and energy.
		Wild fish andother natural aquatic biomass	These services are the ecosystem contributions to the growth of fish and other aquatic biomass which are reproduced in uncultivated production for various uses, mainly food production.
		Wild animals, plants, and another biomass	It is the contribution of the ecosystem to the growth of wild animals, plants and other biomass which are reproduced and harvested for various usesIt also includes services related to hunting, trapping and Bioprospecting activities; but excludes wild fish and other natural aquatic species.
	Water supply		It reflects the combined ecosystem contributions of water purification, water flow regulation and other services to the supply of water of appropriate quality to users for various uses including household consumption.

Source: SEEA EEA Framework

2. REGULATING AND SUPPORTING SERVICES

Regulating and supporting ecosystem services can be regarded as classes of ecological processes and functions that intangibly contribute to human welfare **(Costanza et al., 2017)**. They serve as the underlying support for human safety, biosphere integrity, and the functioning of most other ecosystem services, such as provisioning and cultural services **(Sutherland et al., 2018)**. Some of the regulatory services provided by ecosystems include pollination, disease, and flood management, and maintaining the quality of the air and soil.

However, these services are often overlooked and undervalued as tracking the benefits of these services is complex and their accounting often leads to double counting **(Sutherland et al., 2018)**. The regulating and supporting services are grouped into four categories which are further divided into 11 groups. The details of the services are provided in the **Table 7** below.

Table 7: Reference list of regulating and supporting ecosystem services

Division	Group	Examples of ecosystem services	Examples of benefits derived
Remediation and regulation of biophysical environment	Bioremediation	Chemical detoxification/ breakdown of pollutants by plants, algae, microorganisms and animals	Reduced level of pollutants/ contaminants in soil and groundwater
	Dilution, filtration, and sequestration ofpollutants	Removal of organic materials and nutrients from wastewater by biogeochemicalprocess, filtration of particulates and aerosols, sequestration of nutrients andpollutants in organic sediments, removal of odours	Cleaner air, water, andsoil
Flow regulation	Air flow regulat ion	Natural or planted vegetation that serves as shelter belts, air ventilation services	Dust storm mitigation, heat mitigation in urban areas
	Water flow regulation	Regulation of timing and magnitude of water run-off, flooding, and aquifer recharge	Prevention of flood damage, recharge of water into surface water and groundwater, reduceddamage from high water levels
	Mass flow regulation	Stabilization of soil and mudflows	Prevention of soil erosion, avalanches and mudflows
Regulation of physic-chemical environment	Atmospheric regulation	Capture of carbon dioxide, climate regulation, maintenance of urban climate and regional precipitation patterns	Reduced amount of GHGs in the atmosphere, reducedimpact of climate change, improvement of climate conditions
	Water regulation	Oxygenation of water, retention, and translocation of	Improvement of water quality

		nutrients in water	
	Pedogenesis andsoil cycle regulation	Maintenance of soil fertility and structure in the cultivated system	Improvement of soilfertility and productivity in the cultivated system
	Noise regulation	Natural buffering and screening	Reduction of noise level
Regulation of biotic environment	Life-cycle maintenance, andhabitat and gene pool protection	Pollination, seed dispersal, maintenance of habitat nursery population and habitats	Improvement of productivity of crops,habitats conservation
	Pest and disease	Control of pathogens	Reduced hazard level to crops, human health and the environment

Source: SEEA EEA Framework

3. CULTURAL SERVICES

Cultural services are the non-material benefits people obtain from the ecosystems. The services include tourism; recreation and physical/ mental health; aesthetic appreciation and inspiration for culture, art, and design; spiritual experience and sense of place; and education, research, and scientific values. These allow urbanites to reconnect with the nature.

Table 8: Five Cultural Services identified in SEEA framework

S. No.	Ecosystem service	Description
a)	Recreation	Through the biophysical characteristics and qualities of ecosystems, these contributions enable people to use and enjoy the environment through direct interactions with the environment. It includes services for both locals and non-locals i.e., visitors, including tourists. These may also be realized by those undertaking recreational fishing and hunting.
b)	Visual amenity	The ecosystem contributes to local living conditions, mainly through the biophysical characteristics and qualities of ecosystem which provides sensory benefits, especially visual, and combines with other ecosystem services, including recreation-related services and noise attenuation services to underpin amenity values.

c)	Education, science and research	It is the contribution of the ecosystem through the biophysical characteristics and qualities of ecosystem which enables people to usethe environment through intellectual interactions.
d)	Spiritual, artistic and symbolic	These services are the ecosystem contributions through the biophysical characteristics and qualities of ecosystem which are recognized by people for their cultural, historical, aesthetic spiritual or religious significance. These may underpin people's cultural identity and can inspire people to express themselves via various artistic means.

Source: SEEA EEA Framework

4.1.3. VALUATION METHODS

There are three different ways to assess the value of ecosystem services: qualitative analysis, quantitative analysis, and monetary analysis **(TEEB, 2011)**. According to **Kettunen et al. (2012)**, qualitative analysis focuses on non-numerical indicators of the value such as benefits to mental and physical health, and social benefits from recreation. Quantitative analysis focuses on numerical data such as the quantity of sequestered carbon, quality of water, etc. The monetary analysis focuses on translating the qualitative and quantitative aspects into a particular currency. Monetary valuation of ecosystem services is the most widely applied approach **(Christie et al., 2012)**, as it is often deemed to be the most pragmatic language when it comes to communication with political and business institutions **(Spash, 2013)**.

Ecosystem service valuation utilizes various methods and approaches to estimate the value of ecosystem services **(Liu et al., 2010)**. These methods include direct market valuation methods (market price–based method, cost-based valuation methods, and production function approaches), indirect market valuation methods or revealed preferences (travel cost method and hedonic pricing method), and non–market valuation methods or stated preference (contingent valuation methods, Choice modelling methods, and group deliberation) **(Koetse et al., 2015)**. Importantly, no single valuation method can capture all dimensions of ecosystem value. Multiple methods may be applicable to the same ecosystem service, but the best-fit approach must be selected based on the nature of the service, availability of data, socio-economic context, and the objective of the valuation. For example, the value of timber extraction from forests can be reliably estimated using market prices, whereas recreational or cultural benefits may require methods based on visitor behavior or stated preferences.

Why Method Selection Matters

Ecosystem services can often be valued using more than one method. However, the most appropriate method depends on the local context, including nature of the service, site conditions, availability of data, and the purpose of valuation. Therefore, professional judgement plays a key role in selecting the method that can best capture the realistic value of a service.

Example: Valuation of Recreational (Ecotourism) Services

- ✓ **Scenario A: Easily accessible ecotourism site -** If a forest ecotourism site is located close to settlement areas, has good road connectivity, and receives a high number of visitors, its recreational value can be reliably estimated using the Travel Cost Method. In such cases, visitors' actual travel expenses (transport costs, time spent, accommodation, and entry fees) reflect how much they are willing to pay. Since people actively visit the site, their observed behaviour provides a realistic estimate of its use value.
- ✓ **Scenario B: Remote or poorly accessible ecotourism site** - If a forest site is remotely located or has very low visitor numbers due to poor infrastructure or access restrictions, the Travel Cost Method may underestimate its true value. People may still care about the site's conservation, beauty, or future tourism potential even if they do not currently visit it. In such situations, the Contingent Valuation Method is more appropriate, as it captures people's stated preferences for protecting or improving access to the site.

The key valuation methods relevant to forest ecosystem services in Chhattisgarh are described below, along with their context-specific applicability.

A.MARKET VALUE

The market price method estimates the value of ecosystem services using actual market transactions. It is applied to ecosystem goods that are directly bought and sold, such as timber, fuelwood, fish, and other forest and aquatic products **(TEEB, 2010)**. The method relies on observed market prices and the quantities traded to calculate the economic value generated by the ecosystem.

In practice, the value of an ecosystem good is estimated by multiplying the market price by the quantity produced. This approach assumes that the good is traded in a reasonably competitive market, where prices reflect users' willingness to pay for the ecosystem-derived product **(Arias-Arévalo et al., 2018)**.

The market price method is best suited for provisioning services that enter established markets, including timber, agricultural produce, fish, and non-timber forest products. It is relatively simple to apply where reliable data on prices and quantities are available and has the advantage of being transparent and easily understood by decision-makers.

NOTE: This method cannot be used to value non-marketed ecosystem services, such as recreation, biodiversity conservation, or cultural values. In addition, its accuracy may be affected where markets are distorted by subsidies, informal trade, or regulatory controls, which can lead to over- or under-estimation of true ecosystem value (Arias-Arévalo et al., 2018).

B. CONTINGENCY VALUATION METHOD (CVM)

CVM is a survey-based technique for valuation of resources and services that do not have established markets, typically environmental attributes, and amenities **(Alberini & Kahn, 2006; Cho et al., 2008)**. It uses a hypothetical market approach to appraise consumer preferences by directly asking their willingness to pay for changes in the level of environmental goods or services **(Carson & Hanemann, 2005)**. It is "contingent", because people are asked to state their willingness to pay, contingent on a specific hypothetical scenario and description of the environmental service. This method is now ubiquitous, and it has received increasing attention to estimate option and existence values **(Haab & McConnell, 2002)**. Stated-preference methods like CVM (or choice experiments) are used when the service is non-marketed and other meaningful proxies are unavailable

One service and multiple valuation approaches

Example: Valuation of Carbon Sequestration Services

- **Scenario A: Availability of spatial and land-use data** -When LULC data are available, and the objective is to assess carbon storage and sequestration across large forest areas, biophysical models such as InVEST are most suitable. These models estimate the amount of carbon stored and sequestered and can then convert this into monetary values.
- **Scenario B: Limited data or time constraints** -When detailed spatial data are not available, or when a rapid estimate is needed, the Benefit Transfer Method may be more practical.

C. AVOIDED COST METHOD/ REPLACEMENT COST METHOD

This method estimates the cost of replacing a specific ecosystem service by some other similar resource that provides the same benefits. The value of a similar resource or substitute used is based on its associated market prices. The assumption while using this method is that, if people incur cost to replace the ecosystem service, then those services must at least be worth the price paid to replace them.

D. TRAVEL COST METHOD (TCM)

It is a Surrogate Market Approach technique that uses the price people pay to visit an ecosystem as a measure of its recreational value when valuing ecosystems or natural resources. TCM calculates the benefits of an ecosystem service that results from people using them for leisure activities. It can also be used to assess how a nature park's visitor counts, and overall entrance fee revenue would change in the event of a higher entrance cost.

TCM assumes that travel costs represent the price of access to a recreational site. People's willingness to pay to visit a site is thus estimated based on the number of trips they make at different travel costs. This is called a revealed preference technique because it reveals willingness to pay based on consumption behaviour of visitors.

E. SOFTWARE BASED MODELLING

Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) is a suite of models used to map and value ecosystem services. InVEST includes a set of GIS-based modules (e.g. for carbon, water, habitat, pollination) that map how services flow across a landscape.

It helps explore how changes in ecosystems can lead to changes in the flow of many different benefits to people. InVEST provides results in either biophysical terms (e.g., tons of carbon sequestered) or economic terms (e.g., the net present value of that sequestered carbon). Carbon sequestration service value is calculated by considering the social cost of carbon per tonne.

Carbon storage capacity of the forest ecosystem is estimated using the InVEST Carbon storage and Carbon sequestration model. This model evaluates the amount of carbon stored each year and the amount of carbon sequestered over a period. It aggregates the biophysical amount of carbon stored in four carbon pools (aboveground living biomass, belowground living biomass, soil, and dead organic matter) based on land use/land cover (LULC) maps. The LULC maps are generated using Landsat Data and are utilized for change detection and to calculate the conversion of classes between the years. The model considers inputs as land use maps and a CSV file containing the values of carbon above ground, carbon below ground, soil carbon, and dead carbon concerning each land-use class.

Using data on the social cost of carbon, its annual rate change, and a discount rate, the model provides a value for carbon sequestered over time expressed as a monetary value. The model provides outcome in form of:

1. Amount of carbon fixed in each carbon pool in Mg/ha
2. Net amount of carbon stored over the years in all pools of carbon

InVEST is well-suited for regulating and supporting services (carbon storage, water purification, pollination, soil retention, etc.) in landscape-level assessments. It is especially useful when mapping spatial patterns of services under different management scenarios.

Note: This method relies heavily on GIS data (land cover, climate) and its application needs a high degree of technical expertise. This method is therefore feasible only when its intensive data requirements and processing capabilities can be achieved.

F. BENEFIT TRANSFER METHOD

The benefit transfer method estimates values by adapting results from existing valuation studies. Instead of collecting new field data, one takes published economic values (from literature or databases) for similar ecosystem services and transfers them to the target site. For example, if studies have estimated a WTP of $10/day for recreational fishing in one region of the world, that value (possibly adjusted) can be applied to another similar lake. The basic idea is to find "benefit transfer functions" or unit values from analogous contexts and apply them to the site of interest **(Ecosystem Valuation)**.

Benefit transfer is most useful when time or resources are too limited for a meaningful primary study, and an economic estimate is needed. It works best when the original study's context closely matches the new site (similar ecosystems, demographics, income, etc.). The main limitation of the method is its accuracy as the results are only as reliable as the underlying studies, and differences in context must be adjusted carefully.

Example 3 - Valuing Biodiversity Conservation

Biodiversity conservation provides multiple benefits (habitat protection, genetic resources, ecosystem stability), however, most of these benefits do not have market prices, which makes valuation challenging. As a result, different valuation methods may be appropriate depending on the context and purpose of the study.

Scenario A: Biodiversity valued for its existence and conservation importance

Suppose a forest area in Chhattisgarh supports rare or endemic species that are not directly used by people (e.g., rare birds, medicinal plants, or threatened mammals). Many people may never visit this site, but they still value its protection. In this case, the Contingent Valuation Method (CVM) is suitable. This method uses surveys to ask people how much they would be willing to pay to conserve the species or prevent biodiversity loss. It captures non-use values such as existence value and bequest value (value for future generations).

Scenario 2: Cost of replacing lost biodiversity functions

Suppose forest degradation leads to the decline of wild pollinator species such as bees, butterflies, and birds. These pollinators play a crucial role in supporting nearby agricultural systems by enabling crop reproduction. If these species disappear, farmers may be forced to rely on costly alternatives such as manual pollination, managed commercial pollinators, or large-scale habitat restoration programs.

In this case, the cost of hiring labour for manual pollination, establishing artificial pollination systems, or restoring degraded forest patches to bring back pollinators can be used as a proxy for the value of the biodiversity service. These expenses represent what society must pay to compensate for the loss of a naturally provided service. In such situations, the Replacement Cost Method can be used to estimate the value of biodiversity conservation.

4.2. DATA COLLECTION

Robust data collection forms the foundation of ecosystem services valuation and directly influences the accuracy, reliability, and policy relevance of the results. For accurate valuation of ecosystem services, it is essential to use data from authentic sources only as this enhances the validity and appropriateness of the estimated values. Given the diversity of ecosystem functions and spatial variability across landscapes, a structured and systematic data collection approach is required. Accordingly, the data collection exercise has been designed to capture information at appropriate scales ensuring consistency, transparency, and alignment with established valuation frameworks.

The data collection exercise is categorized into 3 tiers based on the approach of conducting the exercise. Tier 2 and Tier 3 are often referred to as "higher tier" methods and are generally considered more accurate than Tier 1 i.e. default values, as they are more specific to the areas in which they are used. The methods are described in the **Table 9** below:

Table 9: Three tiers of data collection

Tier 1	Tier 2	Tier 3
Simplest approach using global default values	National, or region-specific default values are used	Higher order data collection approach having detailed modelling or inventory measurement system
Suitable for large scale approaches for eco-regions	Suitable for large scale approaches for national, state, regional, landscape, and/or project level	Suitable for small approaches for project level
Least accurate	Moderately accurate	Most accurate
Less time consuming	Less time consuming	Very time consuming
High uncertainty	Moderate uncertainty	Least uncertainty
Example: Using global default values for calculation of emission factor, BEF etc.	Example: Using national level data or using region specific research studies for taking value of parameters such as carbon stock, forest area etc.	Example: Conducting a primary survey for getting values of the parameters involved such as tree height, and girth, household-based questionnaires, KPI with experts etc.

The choice of data collection approach depends on the valuation method adopted, the extent to which primary/ secondary data is available (or can be sourced) and the identification of relevant target groups who access or benefit from specific ecosystem services. Accordingly, a combination of approaches has been applied to this study.

Both qualitative and quantitative data were collected to comprehensively assess the economic value of ecosystem services. The data were validated through an extensive review of literature, stakeholder consultations and GIS-based analysis, where possible. Data collection was undertaken through two modes:

PRIMARY DATA SOURCES included household surveys, tourist surveys, and school surveys. In addition, focus group discussions were conducted to capture in-depth insights, perceptions, and experiential knowledge related to specific ecosystem services such as minor forest produce and spiritual services. Field visits were also undertaken to assess forest conditions, ecosystem impacts, interactions with local communities, and potential losses to ecosystem services.

SECONDARY DATA SOURCES comprised published literature, government and commercial databases, and web-based resources.

The study adopted a mixed-methods approach, integrating both primary and secondary data sources. Relevant stakeholders were identified, and structured discussions were conducted to collect and validate data for cost estimation. The Chhattisgarh Forest Department was a key stakeholder and was consulted at every stage of the study. Key informant interviews were conducted with officials of the Forest Department and other relevant Departments to obtain expert inputs. These qualitative insights and shared datasets were used both for estimating economic values and for validating the valuation results.

4.2.1. PRIMARY SOURCES

The primary sources include household survey, tourist survey, school survey and focus group discussions (the questionnaire of surveys is provided in Annexure I).

- **Household Survey**

A household level survey was conducted as part of this study to gather micro-level information on key ecosystem goods and services in Forest Fringe Villages and to validate some of the secondary or aggregative data, as was needed. The study adopted a sampling approach to ensure comprehensive and representative data collection across varied ecological and administrative categories. A stratified sampling approach in the context of environmental and socio-economic helped to capture the heterogeneity present in large and diverse regions by dividing the study area into relatively homogeneous sub-groups (strata) based on relevant ecological and administrative criteria.

In this context, the sampling framework was designed to reflect the variation in agroclimatic, forest, and socio-economic conditions influencing vegetation, forest resource use, and community interactions with forest ecosystems.

For the household survey the sampling design followed a two-tier stratification, where the study area was divided into:

1. Agroclimatic zone
2. Forest Division

Strata 1: Agroclimatic zone

The agroclimatic zones served as the first level of stratification as they are defined by variations in climate, topography, and soil type, which collectively influence the type, composition, and density of vegetation. Similar agroclimatic conditions generally harbour similar vegetation types, forest composition, and ecosystem processes. By stratifying the sample based on agroclimatic zones, the study ensured representation of the ecological variability across the state. The first level of stratification was based on the agroclimatic zone, namely:

- Northern Hill
- Chhattisgarh Plain
- Bastar Plateau

Strata 2: Forest Division

Forest Divisions represent administrative and management units that vary in forest type, resource distribution, and intensity of human interaction. Stratifying by Division allows for inclusion of management-related differences and ensures operational feasibility by aligning field activities with existing administrative boundaries. Within each agroclimatic zone, forest divisions serve as the second level of stratification. The selection of forest divisions is based on:

- Forest Circle (administrative demarcation for management efficiency) – The sampling covered all the Forest Circles in Chhattisgarh
- Forest cover extent and condition within each circle (using forest cover data from Forest Survey of India) – Within each circle the division with relatively high and low

forest cover were selected. This assumes that forest cover is related with the amount of forest resources that are extracted.

- Expert recommendations from forest officials (especially Divisional Forest Officers), who provided insights on the presence of significant forest resources, extraction pressures, and ecological importance.

Selection of villages and households

Within each selected forest division, villages and households were chosen purposively in consultation with the Divisional Forest Officer (DFO) to ensure logistical feasibility, accessibility, and relevance for the study.

Sample Size

The sample size was calculated based on the total number of households present in the Forest Fringe Villages (FFV) in Chhattisgarh i.e., 29,02,273 **(FSI, 2020; Census of India, 2011)** using Cochran formula for large population:

STEP 1: Calculation for Infinite population

$$S = Z^2 \times P \times \frac{(1-P)}{M^2}$$

S	**Sample Size for Infinite Population**	**1,172**
Z	Z-Score	2.05
P	Population Proportion	0.5
M	Margin of Error	0.03

STEP 2: Calculation of Sample size

$$\text{Sample Size} = \frac{(S)}{1 + \frac{(S-1)}{\text{Population}}}$$

N	**Total household**	**29,02,273**
N	**Sample Size or Number of Sample**	**1,171**

Rounding off we have taken **1200** as the sample household size.

The distribution of the sample in different strata is as below:

Table 10: Distribution of sample in different strata

Agro-climatic zone	Forest Division	Number of Villages	Number of Households
Chhattisgarh Plains	Raipur Circle 1. Balodabazar 2. Mahasamund 3. Dhamtari Durg Circle 1. Kawardha 2. Khairagarh 3. Mohla-Manpur	10	400
Northern Hills	Bilaspur Circle 1. Mungeli 2. Korba 3. Raigarh 4. Sarangarh-Bilaigarh Sarguja Circle 1. Sarguja 2. Balrampur	10	400
Bastar Plateau	Kanker Circle 1. Kanker 2. South Kondagaon Jagdalpur Circle 1. Bastar 2. Dantewada	10	400
Total		**30**	**1,200**

Table 11: Summary of the Sample distribution

Category	Number
Village	30
Forest Circle	6
Forest Division	12
Household	1,200
Household per village	40

➢ **Tourist Survey**

A tourist survey was conducted to assess the recreation services of forests in Chhattisgarh. The survey sites have been finalized in consultation with Shri. Gurananthan N **(Conservator of Forest; Land Management)** and the Wildlife Wing, based on tourist footfall and the ecotourism potential of each site.

The sites selected for tourist survey are as follows:

Table 12: Tourist Spots selected for survey

Tourist Spot	Forest Division
Mangata Wildlife Park, Rajnandgaon	Rajnandgaon
Lamni Park, Bastar	Bastar
Tatamari Hill Station, kondagaon	Keshkal
Eco Camp Kadar (Kadar Dam), Mahasamund	Mahasamund
Resort Nature Camp, Jatmai, Raipur	Gariyaband
Amcho sargi Nature Park, Kondagaon	South Kondagaon
Buka Lake, Korba	Katghora
Bilasa Taal, Bilaspur	Bilaspur

The questionnaires for household survey, tourist survey and school survey are available in the Annexure I.

- **School Survey**

A school survey was conducted to assess the education, science, and research services provided by forests. The survey covered 10 schools across Chhattisgarh, selected randomly in consultation with the Chhattisgarh Forest Department and the Chhattisgarh Biodiversity Board, to estimate the expenditure incurred on forest and biodiversity-related education.

- **Focus Group Discussions (FGDs)**

Focus Group Discussions were conducted to assess the extent of resource dependency among forest fringe communities. Local community members were engaged in discussions regarding the types of resources they extract from the forest, including fuelwood, fodder, and primarily MFP. Participants were also asked about the quantity of fuelwood and MFP collected, sources of household income, livestock ownership, and average grazing duration. The questionnaire of Focus Group Discussion is provided in the Annexure.

Based on discussions with Shri Sunil Kumar Mishra **(Additional Principal Chief Conservator of Forests; Land Management, Forest Conservation Act and Climate Change)** and Shri Gurunathan N **(Conservator of Forest; Land Management)**, the field plan for conducting Focus Group Discussions (FGDs) was finalized. Subsequently, FGDs were carried out in selected villages of North Chhattisgarh. A total of four FGDs were conducted at the following locations:

1. Puta Village, Ambikapur District
2. Talapar Village, Korba District
3. Bhudbhud Village, Korba District
4. Balrampur District (with participants from Sonhara, Shankarpur, and Girwarganj villages

Chhattisgarh hosts a wide variety of sacred groves, which play a significant role in forest conservation and the protection of biodiversity, while also contributing to the cultural ecosystem services provided by forests. To further highlight the importance of sacred groves, a field visit was conducted to Kotumsar village in Kanger Valley National Park. The visit aimed to engage with the Dhurva tribal community residing in the area and to understand their religious beliefs and traditional practices associated with forest conservation.

The details of FGDs are provided in Annexure I.

4.2.2. SECONDARY SOURCES

Secondary sources used for the study included official documents and data from relevant websites. In addition, a workshop was conducted wherein the data requirements were explained to the Forest Department and based on their suggestions, different stakeholders were identified, After this, various meetings were held with representatives from different wings of the Forest Department such as wildlife, biodiversity, production, development, monitoring, and evaluation to gather specific data essential for the valuation of various ecosystem services. During the key personnel interviews, specific data requirements were discussed with the concerned authorities (Details of the Key Informant Interviews are provided in Annexure II). Along with the data received from various departments and divisions, other sources such as Water Board, Ministry of Statistics and Programme Implementation, and Forest Survey of India were also referred to. The details of the data sources used in the study are presented in the table below:

Table 13: Secondary sources used for the study

Source of data	Data Required	Source
Forest Department **Monitoring and Evaluation** **Budget, Finance and Audit**	Annual extraction of forest resources such as timber, bamboo, fuelwood, and other wood. Per unit cost of each forest resource or total revenue generated from the annual extraction	
Forest Department -Budget, Finance and Audit	Annual Administrative Report 2024-2025, Nistar Patrika 2024, Budget Book 2024-25, Budget Book 2023-24	
Forest Department - Development and Planning Division	Annual tourist footfall and revenue generated Operation season of each site Per hectare cost of plantation activities undertaken	
Forest Department - Forest Management Information System (FMIS) Division	Shape files for the Soil Moisture Content (SMC) activities Shape file of NDVI assessment	

	Shape file of soil type map Shape file of forest type map Updated shape file of Reserved Forest, Protected Forest, and orange area List of Forest Fringe villages (FFV) upto 5 km from the boundary of RFA	
Forest Department - Wildlife Division	Annual tourist footfall and revenue generated Operation season of each site Annual budget allocated to wildlife wing Annual number of crimes/ offences	
Forest Department - Protection Division	Annual number of crimes/ offences	
Chhattisgarh Biodiversity Board	List of research collaborations with other institutes and the budget sanctioned in these studies for the past 3 years, Chhattisgarh Biodiversity Assessment Report, Sacred grove studies, Jungle safari report, Past 3-year budget allocated for different activities/ initiatives conducted by State Biodiversity Boards, Suggestion of some schools, Institutes/ Universities where we can reach out to conduct a short survey	
Chhattisgarh State Minor Forest Produce (Trading & Development) Co-operative Federation Limited	Comprehensive list of MFPs Quantity of MFPs Minimum Support Price (MSP) provided by the federation for each MFP List of value-added products derived from MFPs and their corresponding market prices MFP-wise annual revenue generated by the federation for the past three years Annual Reports of the Federation for the last five financial years	

	Report on the Hatt Bazaar Survey conducted by the federation in 2019	
Forest Development Corporation	Annual timber production Average market prices of timbre sold by corporation Annual Revenue generated Cost break-up across different timber classes and diameter categories	
Forest Survey of India	FFV Population Annual Extraction of Fuelwood, Fodder, Other Wood and Bamboo Unit cost of Fuelwood, Fodder, Other Wood and Bamboo Adult cattle unit conversion factors Cattle Population	.
Published Literature	Fraction of Dry Matter available for grazing	Roberts O & Grieve B (2025). All about Pasture utilization
Forest Survey of India	Per ha sequestration in five pools of carbon (AGB, BGB, Deadwood, Litter and SOC)	India State of Forest Report 2021 and 2023
Ministry of Statistics and Programme Implementation	Social Cost of Carbon	Envistat Volume II
Chhattisgarh Water Resources Department	Per litre cost of water for purpose such as drinking, agriculture and other household purposes.	Chhattisgarh Water Resource Department
Longva, T., Eide, M. S., Endresen, Ø., Sekkesæter, Ø., Helgesen, H., & Rivedal, N. H. (2024). Marginal abatement cost curves for CO2 emission reduction from shipping to 2050. *Maritime Transport Research*, *6*, 100112.	Marginal abatement cost of per tonne of pollutant gases	
MoEFCC and FSI	Percentage of regeneration attributed to pollination	Revision of rates of NPV applicable for different class/ category of forests

CAMPA	Per ha plantation cost	
Convention on Biological Diversity	Social Cost of Faunal Biodiversity	Secretariat of the Convention on Biological Diversity (2001). The Value of Forest Ecosystems
Ministry of Chemicals and Fertilizers Department of Fertilizers	Per kg cost of nutrient (N) Per kg cost of nutrient (P) Per kg cost of nutrient (K)	Ministry of Chemicals and Fertilizers, Department of Fertilizers
Department of School Education	Total number of schools in Chhattisgarh Total number of teachers in Chhattisgarh	Department Of School Education, School Education Portal

4.3. DATA ANALYSIS

Analysis in this report is based on parameters and data from primary surveys (including households, schools, and tourists), key informants relevant to the study, secondary sources (such as FSI, Forest Department, Chhattisgarh MFP Federation, Chhattisgarh Water Resource Department etc), and relevant scientific literature. Relevant software and other tools have been used wherever necessary to analyse the data.

ECOSYSTEM SUPPLY IN PHYSICAL TERMS

Ecosystem supply in physical terms systematically quantifies all identified services through standardized biophysical metrics encompassing extraction volumes for direct flows, areal extents for spatially distributed intangibles, and capacity measures for regulatory processes. Examples:

- ✓ Provisioning services that provide tangible benefits such as timber, bamboo, small timber, fuelwood, MFP, and fodder are presented in physical terms as per the quantity of the individual resource extracted from the forests.
- ✓ Services such as carbon sequestration are measured as total carbon stored from all five pools of carbon including Above Ground Biomass (AGB), Below Ground Biomass (BGB), deadwood, leaf litter, and Soil Organic Carbon (SOC) yielding aggregate tCO_2e/ha.
- ✓ Other regulating services such as water purification is quantified by consumption capacity in volumes, such as litres of water used by the downstream community (i.e., FFV).
- ✓ Supporting and cultural services such as soil conservation, air purification, nutrient cycling, pollination, recreation, and biodiversity conservation are measured by areal extent (hectares of forest area covered) capturing spatial influence where volumetric metrics are infeasible.

ECOSYSTEM SERVICES IN MONETARY TERMS

Building on physical supply accounts, ecosystem supply in monetary terms, translates biophysical flows into monetary units (Rupees). Valuation employs internationally accepted and SEEA referenced methods such as market price for traded ecosystem services such as timber, fuelwood, fodder, etc.; avoided/ replacement cost for regulating and supporting such as water treatment equivalents, Soil Moisture Conservation (SMC) costs, afforestation costs etc.; proxy costs based on net benefit or expenditures for services such as recreation, and biodiversity conservation Unit rates are taken from different sources as outlined in **Section 4.2.1** and **4.2.2.**

Thus, monetization principles mirror physical metrics, for example:

For provisioning services and water purification the ecosystem service monetary accounts is estimated as:

$$EV = Extracted\ quantity\ (in\ kg/\ litres) \times market\ price$$

For regulating and cultural services such as carbon sequestration, air quality the monetary accounts is estimated as:

$$E_j = Quantity\ of\ services\ (tCO_2\ eq/\ concentration\ of\ pollutants) \times Social/\ abatement\ cost\ or\ proxy\ costs$$

For cultural services such as recreation, and education, science and research the monetary accounts are prepared by understanding the benefits availed by people and the amount they are willing to spend (expenditure) for availing these benefits; for example visiting a National Park/ Wildlife Sanctuary/ or organizing a field visit in areas with rich forest for education and scientific researches.

The Toal Economic Value (TEV) from the forests of Chhattisgarh is estimated by aggregating all the ecosystem service values and is given in the formula below:

$$TEV = Economic\ Value\ of\ Provisioning\ Services + Economic\ Value\ of\ Regulating\ and\ Supporting\ Services + Economic\ Value\ of\ Cultural\ Services$$

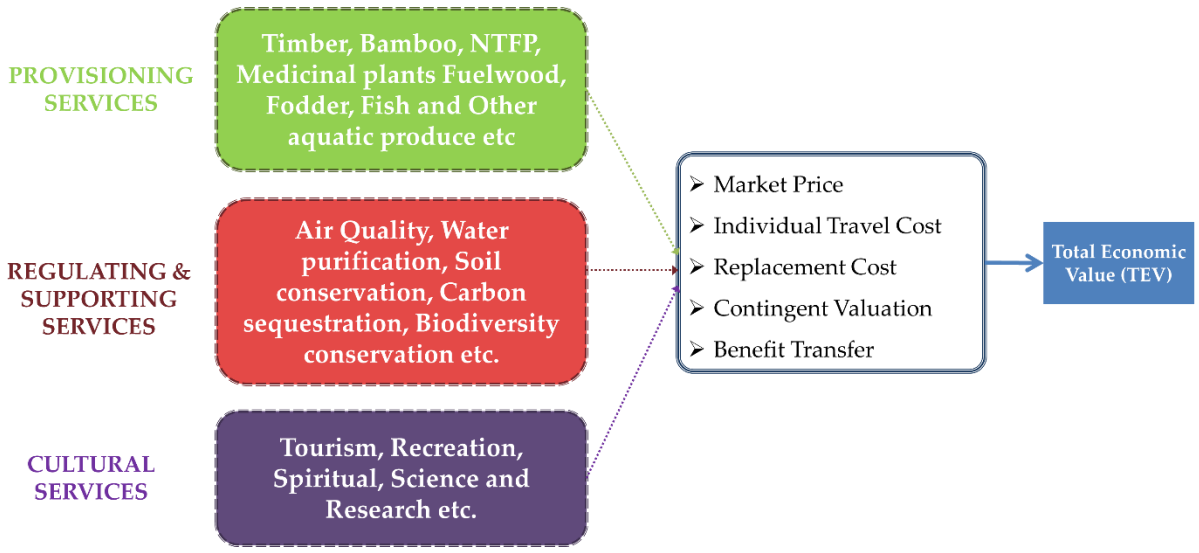

Figure 8: Total Economic Value (TEV)

VALUATION AND NATIONAL INCOME ADJUSTMENT

Forests interact with the economy in many ways. This means that a system of economic accounts must make multiple adjustments related to them to account for the ecosystem services of forests.

As per the UN Division of Statistics **(UNSD 2003)**, forest resource accounting may be defined as a process of identifying and measuring various benefits and costs of forest, putting value tags on them, and recording them in appropriate sets of accounts/statements. It comprises both physical and monetary accounts and their integration with national accounts.

It is important to mention here that monetary estimates particularly for use values and defensive expenditures may already be included in the traditional income accounts. There is thus a significant risk of double counting if adjustments are not made carefully. While a standalone estimate may not have any issue for capturing and presenting all these values, however, when it comes to adjustment with the national accounts, one has to exercise caution to ensure that there is no duplication while making necessary adjustments in the national income accounts.

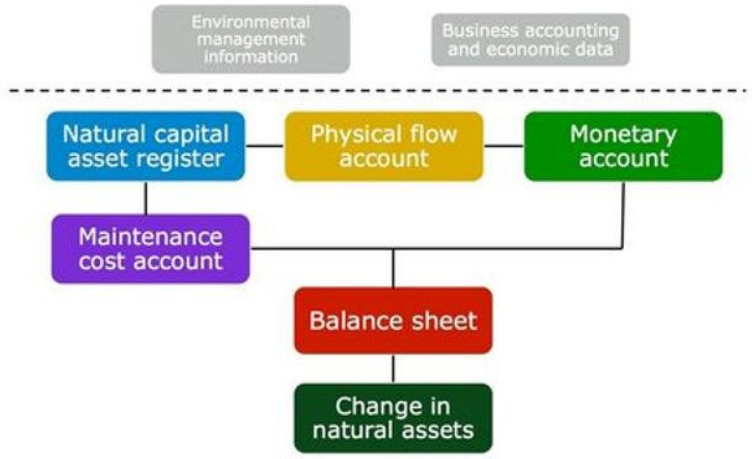

Figure 9: Incorporating TEV to GDP of the State

A caveat is that the valuation process is context specific, depending on the "demand of the people" and "supply of the ecosystem service", therefore it varies greatly across locations and beneficiaries. Furthermore, the valuation of the ecosystem services and its contribution to the GDP requires a detailed understanding of the supply chain of the forest resources and its impact pathways. Thus, an exercise of this nature needs to be carried out in close collaboration with all relevant government departments.

Chapter 5 Valuation of Ecosystem Services

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5.4. Cultural Services

5.4.1. Recreation

5.4.2. Education, Science and Research

5. VALUATION OF ECOSYSTEM SERVICES

The valuation of the ecosystem services is built upon:

1. A valuation framework i.e., SEEA in this study
2. Careful selection of ecosystem services to be valued and respective valuation methods

SELECTION OF VALUATION FRAMEWORK

SEEA is selected as the framework for this study on the valuation of ecosystem services based on the result of the comparison of different frameworks **(Section 4.1.1 - Comparative assessment of frameworks)**. The details of SEEA are provided in the **Annexure III**. The advantages and suitability of SEEA in context of Chhattisgarh is as follows:

- It is a framework that attempts to establish links between the environment and the economy.
- The aim of SEEA is to incorporate natural capital into the country's accounting system and thus takes a macro-economic approach
- It goes beyond SNA by including natural capital and its benefit from ecosystem services while following a structure similar to the SNA, thus facilitating smooth integration in economic statistics.
- It is an international statistical standard that rests upon internationally agreed concepts and definitions for environment-economic accounting.

SELECTION OF ECOSYSTEM SERVICE

The selection of ecosystem services for valuation of Chhattisgarh Forest was guided by a multi-criteria approach to ensure ecological relevance, economic significance, data robustness, and stakeholder alignment. The criteria adopted are described below:

- **Ecological Significance:** Priority was given to ecosystem services that play a critical role in maintaining forest ecosystem integrity and functionality. These include services that contribute to biodiversity conservation, habitat provision, climate regulation, soil and water conservation, and overall ecosystem resilience.
- **Economic and Social Relevance:** Ecosystem services that have direct or indirect economic value and are closely linked to human well-being were prioritised. This includes provisioning services such as timber, fuelwood, MFPs, and fodder, as well as regulating and cultural services that support livelihoods, industries, and public welfare. Special emphasis was placed on services that are actively utilised by local communities, the Forest Department, and forest-based industries, thereby contributing to income generation, employment, and regional economic development.
- **Data Availability and Feasibility of Valuation:** Only those services for which reliable and credible data could be sourced were selected. Data availability from secondary literature, government records, project reports, and stakeholder consultations was a key consideration. In addition, the feasibility of applying established valuation methods such as market price, avoided cost, replacement cost etc was assessed to ensure that the valuation results are methodologically sound.

- **Stakeholder Perception and Prioritisation:** Stakeholder perspectives were integrated into the service selection process through FGDs, interviews with key stakeholders, and consultations with local communities and forest officials. Services perceived as highly important by stakeholders, particularly those influencing livelihoods, forest management decisions, and community dependence on forests, were prioritised to ensure policy relevance and local acceptance of valuation outcomes.
- **Literature Review:** A review of national and state-level studies on ecosystem service valuation was undertaken to identify commonly valued services and methodological best practices. Literature focusing on ecosystem services in India and comparable regions provided a reference for service selection, ensuring consistency with existing valuation studies and enhancing the comparability of results across states and forest types.

As per the above-mentioned criteria, the following ecosystem services provided by the forest ecosystems of Chhattisgarh were identified and selected for inclusion in the present study.

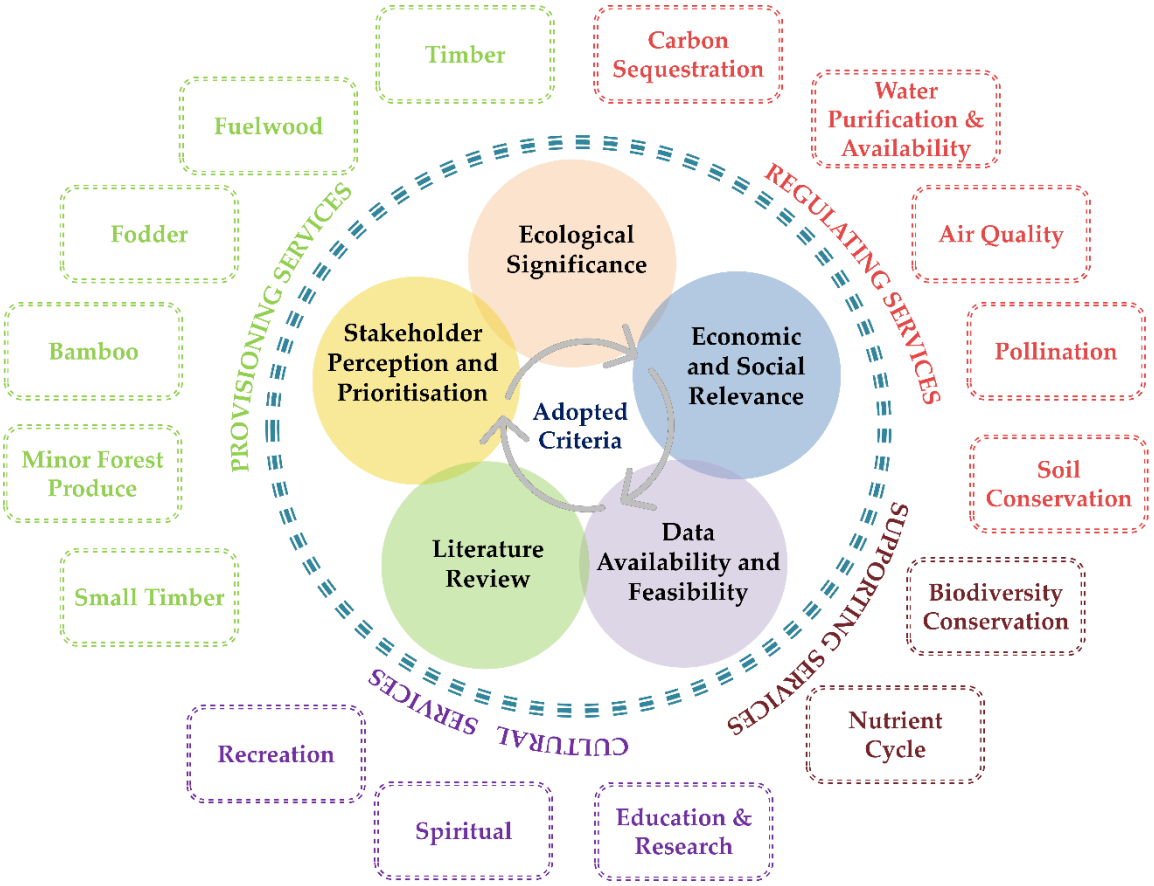

Figure 10: Selected ecosystem services

5.1. Provisioning Services

Chhattisgarh, home to 20,335 villages, of which 9,657 (47.49%) FFVs lies within 5 km from RFA (FSI, 2020). The estimated population in FFV is approximately 12.77 million **(FSI, 2020)**. These FFVs are heavily reliant on the natural resources such as small timber, fuelwood, fodder, and bamboo **(FSI, 2020)**. Communities residing near the forests of Chhattisgarh also depend on different MFPs such as medicinal plants, honey, fruits, and tendu leaves.

5.1.1. TIMBER

Timber represents a major provisioning ecosystem service provided by forest ecosystems, supplying essential raw material for construction, furniture, paper, fuelwood, and other economic activities. The availability of timber is determined by long-term ecological processes such as tree growth, nutrient cycling, and climatic regulation. Consequently, timber production is intrinsically linked to the overall health and resilience of forest ecosystems. In addition to timber, forests provide several other wood products such as *dengri* and *ballis*, which contribute significantly to forest-based provisioning services.

The ecosystem service being considered here, i.e. timber production, refers to the contribution of RFA to supply wood. The use of timber may imply small scale extraction for building material, or alternatively large-scale commercial use by national or international logging interests. Where timber is marketed, the economic value should be readily apparent. In Chhattisgarh major timber species includes Teak (*Tectona grandis*), *Melia dubia, Eucalyptus,* Mahua *(Madhuca longifolia)* **(ICFRE, 2020)**.

The valuation of timber is particularly important due to its direct and observable market value, which allows it to be readily incorporated into economic analyses and policy decision-making. Market-based valuation approaches such as the direct market price method, stumpage value, and NPV analysis are commonly employed, as they account for harvesting costs, rotation periods, and prevailing market conditions.

Overall, the valuation of timber enhances recognition of forests as renewable economic assets while reinforcing the need to balance economic returns with ecological sustainability.

Valuation Method: Market Price Method

The Market Price Method has been used to estimate the value of timber extracted from forests.

Data Collection:

Mode: Secondary sources

The data has been collected through meetings with the Forest Development Corporation, Monitoring and Evaluation Wing and the Production Wing of the Forest department.

The annual quantity of timber extracted was calculated by aggregating timber volumes obtained from the following sources:

- ✓ Timber harvested and sold by the Forest Department
- ✓ Timber harvested and sold by the Forest Development Corporation
- ✓ Timber sold through *nistar* depots

- ✓ Timber confiscated by the Forest Department
- ✓ *Balli* harvested and sold by the Forest Department
- ✓ *Dengri* harvested and sold by the Forest Department
- ✓ *Dengri* distributed through nistar depots

The quantities of *balli* and *dengri* is 3,91,603 (in nos.), and 2,36,148 (in nos.) respectively **(Chhattisgarh Forest Department)**. The standard unit of conversion used for nos. to cum for *balli* and *dengri* is 0.02 and 0.01 respectively **(Chhattisgarh Forest Department)**.

Quantity of Timber:

Category	Annual quantity (lakh cum)
Timber from Forest Development Corporation (FDC)	0.26
Timber from Production division	1.04
Timber confiscated	0.02
Balli from Forest Department	0.08
Balli (Nistar)	0.004
Dengri (Forest Department)	0.03
Total Timber Extracted	**1.44**

The total timber extraction from the forest during the assessment period (2025-26).

Based on the quantity of timber extracted (0.26 cum) and the revenue generated (Rs. 5,776.73) for all species by Forest Development Corporation. The per cubic meter price for timber is estimated as Rs. 22,102 per cum.

Formula:

$$EV_{timber} = Market\ Price\ (Rs/cum) \times Quantity\ of\ Timber\ Extracted\ (lakh\ cum)$$

EV_{timber} = Rs 22,102 x 1.44

= Rs. 318 crores

5.1.2. SMALL TIMBER

In addition to timber and small timber, forests provide small timber which contribute significantly to local livelihoods. These are extracted by forest fringe villages for their household purposes (such as for making agricultural equipment's, utensils, fencing etc), and forest department.

Valuation Method: Market Price Method

The Market Price Method is used to estimate the economic value of small timber resources extracted from forests in Chhattisgarh.

Data Collection

Mode: Secondary sources

The total quantity of small timber extracted by the FFV has been sourced from the Forest Survey of India. **(FSI, 2020)**.

The market price of small timber was taken as Rs. 7,518 per cubic metre **(FSI, 2020)**.

Quantity Extracted

Category	Annual quantity (lakh cum)
Small Timber (FFVs)	8.52

Formula

The economic value was calculated using the following formula:

$$EV_{SmallTimber} = Quantity\ Extracted\ (lakh\ cum) \times Market\ price\ (Rs/cum)$$

$EV_{SmallTimber}$ = 8.52 × 7,518

= Rs 641 crores

5.1.3. FUELWOOD

Fuelwood is a dominant source of energy in Chhattisgarh, particularly in rural and tribal areas, where a large proportion of households depend on forests to meet their daily cooking and heating needs. Fuelwood is primarily collected from forestlands in the form of fallen wood and dry branches and is used both for domestic purposes and for commercial and industrial activities such as jaggery preparation, bakeries, and cremation.

According to the Census of India (2011), 91% of households in Chhattisgarh rely on fuelwood and dung cakes as their primary cooking fuel. Nearly 98% of the fuelwood consumed in the state is sourced from forests, indicating a high level of dependence of local communities on forest ecosystems **(ICFRE, 2020)**. Commonly used fuelwood species include *Terminalia tomentosa* (saja), *Lagerstroemia parviflora* (sena), *Boswellia serrata* (saliha/salhe), *Anogeissus latifolia* (dharwa), *Buchnania lanzan* (char), *Madhuca indica* (mahua), *Schleichera oleosa* (kusum), *Pterocarpus marsupium* (beeja), and *Semecarpus anacardium* (bhilwa) **(ICFRE, 2020)**.

Valuation Method: Market Price Method

The Market Price Method was adopted to estimate the economic value of fuelwood, as fuelwood in Chhattisgarh has a well-defined market price whether it is directly purchased, collected by households, harvested by the Forest Department, or distributed through nistar depots. The total value of fuelwood includes its use for household cooking and water heating as well as for commercial and institutional purposes.

Data Sources

The data for valuation of fuelwood was done through both primary and secondary sources.

Mode: Secondary Sources

- The quantity of fuelwood extracted from Department is sourced from Forest Department, Forest Development Corporation (including nistar depots).
- The market price of fuelwood was estimated at Rs 4.46 per kg **(FSI, 2020)**.
- The total population of the FFV is taken as 12.77 million **(FSI, 2020)**

Mode: Primary Sources

- Household survey was conducted to estimate the per capita extraction of fuelwood (369.76 kg) from the RFA of Chhattisgarh and its prevailing market prices. To ensure robustness and avoid underestimation, survey findings were validated using secondary data from the Forest Survey of India **(FSI, 2020)**.
- The percentage dependency of the FFV on fuelwood (90%) is estimated from the household survey.

Formula

The quantity of fuelwood extracted from the RFA of Chhattisgarh is estimated understanding the per capita requirement of FFV from the sampled population adjusted to the population of FFV in Chhattisgarh and direct consumption by Department. The total quantity of fuelwood extracted is estimated as per the formula below:

Annual quantity of fuelwood extracted = Fuelwood (survey based) + Fuelwood (Department)

Fuelwood (survey based) = Dependency × Per capita consumption × Total FFV population

Where,

Per capita consumption (in tonne) = Quantity extracted by households (in tonne) / population of FFV

Quantity extracted by households (in tonne) = Daily extraction (in kg) x frequency of extraction in a month (in nos. of days) x frequency of extraction in a year (in no. of months) x 1000

Quantity Extracted

Primary Source	Annual quantity (lakh tonne)
Household survey (Chhattisgarh)	41.55
Secondary Source	**Annual quantity (lakh tonne)**
Forest Development Corporation	0.055
Forest Department	0.021
Nistar depots	0.006
Total Annual Fuelwood Extracted	**41.63**

The economic value (EV) of fuelwood was calculated as:

$$EV_{fuelwood} = Total\ Quantity\ Extracted\ (lakh\ tonne) \times Market\ Price\ (Rs/tonne)$$

$EV_{fuelwood}$ = 41.63 x 4.46 x 1000

= Rs 1,857 crores

5.1.4. FODDER

Forests constitute an important source of fodder and play a critical role in sustaining the livestock population of Chhattisgarh, particularly in rural areas. According to the 19th Livestock Census (2012), Chhattisgarh has a total livestock population of 15.04 million (excluding 0.038 million stray cattle). Cattle form the largest share of livestock (65.24%), followed by goats (21.44%), buffaloes (9.24%), and sheep (1.12%). Livestock fodder requirements are primarily met from agricultural fields and adjoining forest areas, highlighting the dependence of the livestock sector on forest ecosystems.

Valuation Method: Market Price Method

The Market Price Method was adopted to estimate the economic value of fodder obtained from forests. This method values ecosystem services based on the quantity consumed and prevailing market prices.

Data Sources:

Mode: Primary Source

The data is obtained from the following sources:

- A household survey was conducted to estimate the number of sampled livestock and their consumption requirements. To ensure robustness and avoid underestimation, the survey results were validated using secondary data from the Forest Survey of India (FSI).

Mode: Secondary Source

- The Adult Cattle Unit (ACU) conversion factors for cow, buffalo, sheep, goat, and other livestock were taken as 1, 1.38, 0.15, 0.15. and 0.15 respectively **(FSI,2020)**.
- The average grazing hours for cow, buffalo, sheep, goat, and other livestock were taken as 6.47, 6.67, 6.78, 6.79, and 6.63 respectively (household survey).
- The per ACU dry matter requirement is taken as 2-3% of average body weight of 350 kg **(Chand et al., 2013)**
- Fraction of dry matter available for consumption by livestock is taken as 0.75 **(Roberts & Grieve, 2025)**.
- Dry to green ration is taken as 0.25 i.e., 25% **(Roberts & Grieve, 2025)**
- The prevailing market price of fodder was estimated at Rs. 5.84 per kg based on the household survey.
- Population of livestock as per FSI 2020 is as below:

Livestock	Population (in lakhs)
Cow	58.01
Buffalo	9.94
Sheep	0.15
Goat	23.73

Bull	34.85
Donkey	0.18
Horse	0.18
Total Livestock Population	**127.04**

Formula:

The quantity of fodder consumed by different livestock is estimated by understanding the per fodder requirement from the sampled population adjusted to the population of livestock in FFV in Chhattisgarh. The formula used is as below:

Annual Fodder requirement (in kg) = Per capita consumption × Total livestock population in FFV

Where,

Per capita consumption (in tonne) = Quantity consumed by livestock (in kg)/ population of FFV x Dependency x 1000

Quantity consumed by livestock (in kg) = Sampled livestock (in nos.) x ACU factor x DM_{req} *x PF x frequency of grazing in a month (in nos. of days) x frequency of grazing in a year (in no. of months)*

DM_{req} *= Dry Matter requirement per ACU; (2.5% of 350 kg = 8.75 kg)*

PF = Pasture Fraction = (Fraction of dry matter available x (Grazing hours in a day / total grazing hours in a day)

Average annual fodder consumption per animal (tonne):

- Cow: 0.84

  Per capita consumption of cow (in tonne) = ((6,921 x 1 x 8.75 x (0.75 x (6.47/8)) x 28 x 6)/6,921) x 0.94

  = 0.84

- Buffalo: 1.19

  Per capita consumption of cow (in tonne) = ((619 x 1.38 x 8.75 x (0.75 x (6.67/8)) x 28 x 6)/619) x 0.94

  = 1.19

- Sheep: 0.13

  Per capita consumption of cow (in tonne) = ((118 x 0.15 x 8.75 x (0.75 x (6.78/8)) x 28 x 6)/118) x 0.94

  = 0.13

- Goat: 0.15

  Per capita consumption of cow (in tonne) = ((1,636 x 0.15 x 8.75 x (0.75 x (6.79/8)) x 28 x 7)/1,636) x 0.94

  = 0.15

The per capita consumption of Bull, Donkey, and Horse is taken same as Buffalo, Goat, and Cow respectively as their ACU is same.

Annual Fodder requirement (in tonnes) = $\sum$ (Per capita consumption$_i$ (in tonne) x Population$_i$ (in lakhs)) all animals

= (0.84 x 58.01) + (1.19 x 9.94) + (0.13 x 0.15) + (0.15 x 23.73) + (1.19 x 34.85) + (0.15 x 0.18) + (0.84 x 0.18)

= 106.12

Where,

Per capita consumption$_i$ = Per capita consumption of all animals

Population$_i$ = Population of all animals

The economic value (EV) of fodder was calculated as:

$$EV_{fodder} = Total\ Quantity\ of\ Fodder\ (tonne) \times Market\ Price\ (Rs/tonne)$$

EV$_{fodder}$ = 106.12 x 5.84 x 1000

= Rs 6,197 crores

5.1.5. BAMBOO

Bamboo, one of the most important plant groups within the grass family, is a fast-growing perennial species widely distributed across tropical, subtropical, and temperate regions. In Chhattisgarh, bamboo plays a significant role in ecological sustainability as well as in the cultural and socio-economic development of the state. A large proportion of forest-dependent and tribal communities rely on bamboo as a natural and renewable resource for livelihood and subsistence. Owing to its strength, flexibility, and rapid regeneration, bamboo is extensively used as a construction material and as an alternative to tropical hardwoods. Its versatility supports a wide range of uses, including baskets, mats, handicrafts, ladders, scaffolding, fishing rods, window blinds, flutes, carving, veneer, and paper production.

Thus, bamboo constitutes an important forest provisioning resource, contributing to income generation, traditional craftsmanship, and sustainable forest-based industries in Chhattisgarh.

Valuation Method: Market Price Method

The Market Price Method was adopted to estimate the economic value of bamboos as it is directly purchased, collected by households, harvested by the Forest Department, or distributed through nistar depots. The total value of bamboo includes its use for household uses as well as for commercial and industrial purposes.

Data Sources

Mode: Secondary sources

- The quantity of bamboo extracted from Department is sourced from Forest Department, Forest Development Corporation (including nistar depots).
- The market price of bamboo was estimated at Rs 6.65 per kg **(FSI, 2020)**

- The total population of the FFV is taken as 12.77 million **(FSI, 2020)**

Mode: Primary sources

- Household survey was conducted to estimate the per capita extraction of bamboo (53.44 kg) from the RFA of Chhattisgarh and its prevailing market prices. To ensure robustness and avoid underestimation, survey findings were validated using secondary data from the Forest Survey of India **(FSI, 2020)**.
- The percentage dependency of the FFV on bamboo (24%) is estimated from the household survey.

Formula

The quantity of bamboo extracted from the RFA of Chhattisgarh is estimated understanding the per capita requirement of FFV from the sampled population adjusted to the population of FFV in Chhattisgarh and direct consumption by Department. The total quantity of bamboo extracted is estimated as per the formula below:

Annual quantity of bamboo extracted = Bamboo (survey based) + Bamboo (Department)

Bamboo (survey based) = Dependency × Per capita consumption × Total FFV population

Where,

Per capita consumption (in tonne) = (Quantity extracted by households (in kg) / (1000 x population of FFV)

Quantity extracted by households = Daily extraction (in kg) x frequency of extraction in a month (in nos. of days) x frequency of extraction in a year (in no. of months)

This was supplemented with official extraction data from the Forest Department and Forest Development Corporation, resulting in the following totals:

Primary Source	Annual quantity (lakh tonne)
Household survey (Chhattisgarh)	50.14
Secondary Source	**Annual quantity (lakh tonne)**
Forest Development Corporation	0.009
Forest Department	0.15
Total Bamboo Extracted (kg)	**0.30**

The economic value (EV) of fuelwood was calculated as:

$$EV_{Bamboo} = Total\ Quantity\ Extracted\ (lakh\ tonne) \times Market\ Price\ (Rs/tonne)$$

EV_{Bamboo} **= 0.30 x 6.65 x 1000**

= Rs. 20 crores

5.1.6. MINOR FOREST PRODUCE

Minor Forest Produce (MFP) comprises a wide range of non-timber forest resources obtained from forests, including edible products, medicinal plants, resins, gums, fibres, and other biologically derived materials. MFPs constitute a critical provisioning ecosystem service, particularly in forest-dependent regions such as Chhattisgarh, where they play a vital role in food security, subsistence, and income generation for under-privileged and forest-dependent communities.

In Chhattisgarh, the collection and trade of MFPs have been formally recognised and institutionalised through state legislation. Several MFPs such as tendu leaves (*Diospyros melanoxylon*), sal seed (*Shorea robusta*), harra (*Terminalia chebula*), gums (khair, dhawara, kullu, babool), tamarind, chironji, mahua seed (*Madhuca indica*), and lac have been nationalised. To support sustainable harvesting, fair pricing, and livelihood enhancement of MFP collectors, the Chhattisgarh State Minor Forest Produce (Trading & Development) Co-operative Federation Ltd. **(CGMFP Federation)** was established. The Federation functions as a nodal agency to regulate procurement, processing, value addition, and marketing of MFPs in the interest of primary collectors **(Churpal et al., 2021).**

The valuation of MFPs as a forest ecosystem service is essential because these products represent a direct and tangible benefit derived from forest ecosystems. Unlike many regulating or cultural services, MFPs have observable market transactions, making their economic value more readily quantifiable. Explicit valuation helps capture the contribution of forests to rural livelihoods, subsistence security, and local economies benefits that are often underestimated in conventional forest accounting and land-use decision-making.

Valuation Method: Market Price Method

The Market Price Method has been adopted to estimate the economic value of MFPs, as most MFPs collected in Chhattisgarh are either consumed at the household level or sold through formal and informal markets. This method values ecosystem services based on prevailing market prices, adjusted for quantities harvested.

Data Sources

The data for valuation of fuelwood was done through both primary and secondary sources.

Mode: Secondary sources

- The revenue generated from sale of MFPs sourced from Chhattisgarh State Minor Forest Produce Federation **(CGMFPF)**
- Minimum Support Price (MSP) of each MFPs sourced from Chhattisgarh State Minor Forest Produce Federation **(CGMFPF).**
- The total population of the FFV is taken as 12.77 million **(FSI, 2020)**

Mode: Primary Sources

- Primary data were collected through a household survey to estimate per capita consumption and sale of MFPs, along with prevailing market prices for individual commodities. The survey captured information on 21 different MFPs. To ensure robustness and avoid underestimation, the survey results were validated with secondary data obtained from the Chhattisgarh State Minor Forest Produce Federation.

- The percentage dependency of the FFV on fuelwood (92%) is estimated from the household survey.

Formula

$$EV_{MFP} = EV_{MFPsurvey} + EV_{MFPCMFPF}$$

Where,

$EV_{MFPsurvey}$ = Economic valuation of MFP from survey

$EV_{MFPCMFPF}$ = Economic valuation of MFP from revenue by CMFPF

For MFPs covered under household Survey, the economic value of was estimated by scaling household-level extraction to the broader forest area and applying prevailing market prices, as follows:

$EV_{MFPsurvey}$ = *(Per capita consumption (in kg)/1000) x total FFV population x (Market Price (in Rs/kg)/1000) x Dependency*

Where,

Per capita consumption = Quantity extracted by households (in kg) / population of FFV

Quantity extracted by households = Daily extraction (in kg) x frequency of extraction in a month (in nos. of days) x frequency of extraction in a year (in no. of months)

Quantity Extracted as per Primary Survey

Since the market price and per capita consumption of each MFP is different, the economic value of each MFP is calculated in the table below.

S.No.	MFP Name	Annual Qty Extracted (lakh tonne)	Avg. Price per unit	Unit	Per capita extraction (in kg)	EV (Rs. crore)
1	Mahua	4.89	57	Kg	38.30	2,770
2	Tendu Leaves	0.04	5,500	Std. Bag	0.32	2,275
3	Harra/Bahe da	0.45	70	Kg	3.55	317
4	Char	0.11	246	Kg	0.87	272
5	Dori	0.13	65	Kg	1.03	84
6	Aam (Mango)	0.79	156	Kg	6.20	1,236
7	Mushroom	0.06	801	Kg	0.45	463
8	Amchur	0.41	164	Kg	3.21	670

9	Tendu Fruit	0.53	100	Kg	4.15	529
10	Karil	0.63	149	Kg	4.92	938
11	Jamun	0.15	97	Kg	1.15	142
14	Ginger	0.22	50	Kg	1.70	108
15	Turmeric	0.005	90	Kg	0.04	4
16	Amla	0.20	57	Kg	1.58	114
17	Giloy Dry	0.02	140	Kg	0.14	25
18	Tog	0.004	30	Kg	0.03	1
19	Imli	0.09	29	Kg	0.74	27
20	Tora	0.04	255	Kg	0.30	97
Sum of Economic Value (EV) of all MFPs (Household Survey)						**10,072**

$EV_{MFPsurvey}$ = Rs 10,072 crores *(Sum of EV of all MFPs in household survey)*

Quantity Extracted as per Secondary data

For MFPs not covered under the household survey, quantity and price information for an additional 20 MFPs were obtained from CGMFP Federation. The price of each MFP recorded from the household survey was also compared with the MSP. This combined approach ensured a comprehensive assessment of MFP extraction and value across the state.

S.NO.	MFP	Revenue Generated (Rs)
1	Nagarmotha	16,200
2	Honey	64,74,000
3	Shikakai	7,500
4	Bel	1,07,300
5	Kaju	8,40,000
6	Sal seed	99,94,97,400
7	Mahul Patta	1,20,000
8	Kalmegh	6,73,000
9	Charota seed	4,000
10	Bhelwa	1,200
11	Rally kosa	1,40,04,000

12	Rally kosa (Poli)	78,000
13	Palash	1,75,000
14	Ragi	89,22,000
15	Kodo	7,70,53,000
16	Kutki (Black)	19,76,000
17	Kutki (Brown)	31,62,000
18	Tikhur Kand	3,32,000
19	Safed musli	7,13,000
20	Sawai grass	36,000
21	Chironji	2,92,13,000
22	Tamarind	1,80,00,01,908
23	Lac Rangeeni	26,26,470
24	Lan Kusumi	23,39,505
25	Bael Dry	1,03,400
26	Kaju Guthli	26,31,825
27	Jamun pulp	18,85,445.00
	Total	**2,95,29,93,153**

$EV_{MFPCMFPF}$ = Rs 295 crores *(Sum of revenue for all MFPs from Chhattisgarh MFP Federation except for those covered in survey)*

Valuation Formula:

EV_{MFP} = Sum of Economic Value of each MFP (Household Survey) x dependency + Sum of Revenue generated from each MFPs (CGMFPF) (Rs)

EV_{MFP} = 10,072 x 0.92 + 295

= Rs 9,561 crores

5.2. REGULATING SERVICES

5.2.1. CARBON SEQUESTRATION

One of the most important roles of forests is to store and sequester carbon and therefore mitigate climate change. Forests sequester carbon from the atmosphere by accumulating Carbon dioxide (CO_2) and transforming it into stored carbon via photosynthesis. The carbon accumulated is sequestered in the form of living biomass (i.e., Above Ground wood and non-woody biomass), deadwood, leaf litter, and soil contributing to forest carbon stock **(FSI, 2023)**.

Valuation Method: Software Based Modelling

The InVEST carbon sequestration model estimates the quantity of carbon sequestered from a landscape and values the amount of sequestered carbon over time. It aggregates the biophysical amount of carbon stored in four carbon pools (aboveground living biomass, belowground living biomass, soil, and dead organic matter) based on land use/land cover (LULC) maps. The model considers inputs as land use maps and a CSV file containing the values of carbon above ground, carbon below ground, soil carbon, and dead carbon concerning each land-use class. InVEST also tries to quantify projected sequestration with the input for future land use.

Data Sources

Mode: Secondary Data

The valuation of carbon sequestration was done through secondary sources. Carbon stock data for the forests of Chhattisgarh were obtained from the India State of Forest Report (ISFR) 2021 and 2023. Carbon stocks across five pools—above-ground biomass (AGB), below-ground biomass (BGB), deadwood, leaf litter, and soil organic carbon (SOC) were compiled for both years. Annual carbon sequestration was estimated from inter-temporal changes in these pools and converted to CO_2 equivalents using the standard factor of 3.67.

Carbon pool Data	Carbon Stock (tC/ha) 2021	Carbon Stock (tC/ha) 2023
AGB	27.41	27.78
BGB	8.78	8.86
Deadwood	1.97	23.6
SOC	50.93	51.42

Land-use maps were used as supporting spatial inputs.

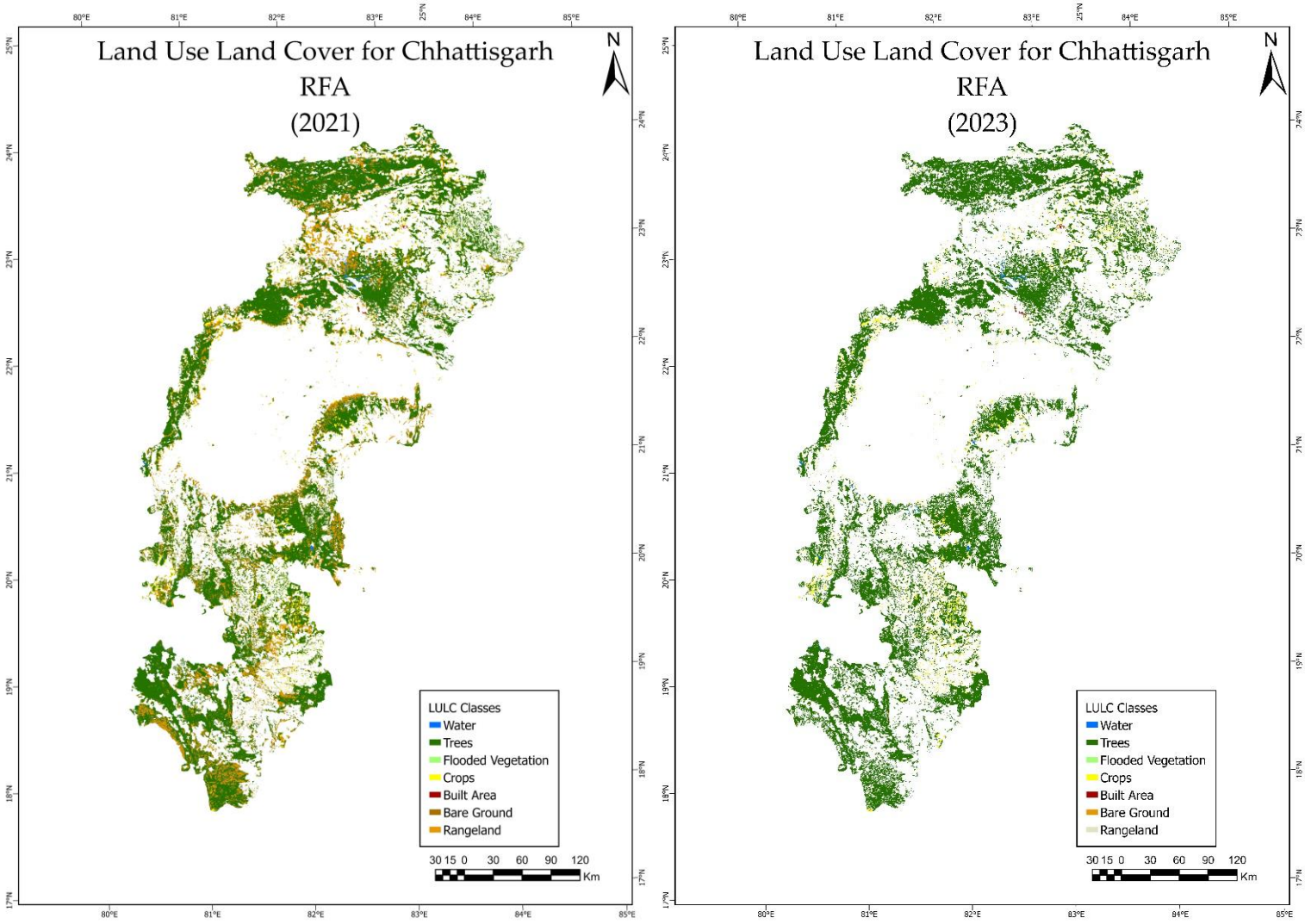

Figure 11: Land Use Land Cover maps for Chhattisgarh Recorded Forest Area (RFA), 2021 (Left) and 2023 (Right)

The economic value of carbon sequestration was estimated by applying the **Social Cost of Carbon (SCC)**, taken as **USD 91 per tCO_2e** **(MoSPI,2022)** The SCC was converted to Indian Rupees using an exchange rate of Rs **89.97 per USD (XE Currency)**.

Social Cost of Carbon

The social cost of carbon (SCC) has been taken as USD 91 per tonne of CO_2eq. (MoSPI,2022). For policy-oriented studies, the SCC is preferred over the prevailing market price of carbon credits because it represents a comprehensive estimate of the total economic damages caused by the emission of one tonne of CO_2, including impacts on human health, property, ecosystems, and the climate system. In contrast, the carbon credit price reflects only the current market cost of offsetting or reducing one tonne of CO_2 within a specific regulatory or voluntary market and does not capture the broader societal and environmental damages associated with carbon emissions.

Valuation:

The carbon stock data were processed using the InVEST Carbon model, which estimated total carbon storage of 33,49,63,276 tCO_2e for 2023 and 33,00,47,837 tCO_2e for 2021. The annual carbon sequestration was derived from the net change between the two periods and converted to CO_2 equivalents, resulting in an annual sequestration of 1,80,39,661 tCO_2e.

Economic Value Estimation

$$EV_{carbon\ sequestration} = Annual\ Carbon\ Sequestration\ (tCO_2e) \times SCC\ (USD) \times Exchange\ Rate\ (USD\ to\ Rs)$$

$EV_{carbon\ sequestration}$ = 1,63,59,831 x 91 x 89.97

= Rs. 13,394 crores

5.2.2. AIR QUALITY REGULATION

Forests play a critical role in maintaining and improving air quality by acting as natural sinks for atmospheric pollutants. Through photosynthesis, forests absorb carbon dioxide (CO_2) and release oxygen, thereby enhancing ambient air quality. In addition, forest vegetation captures and retains air pollutants such as carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulate matter, and other airborne toxins. By functioning as natural buffers against emissions from urban and industrial sources, forests significantly reduce pollutant concentrations, contributing to improved public health and mitigation of climate change and air pollution impacts

Valuation Method: Avoided Cost Method

The air purification service provided by forests was valued using the Avoided Cost Method, which estimates the costs that would be incurred if forests did not provide this service naturally. In the absence of forests, pollutant reduction would require technological interventions or changes in industrial processes, both of which involve additional expenditure. Industries often undertake such measures to comply with emission standards, and the associated costs are reflected as marginal abatement costs (MAC). These MAC values were used as proxies to assign a monetary value to the air purification services rendered by forests.

Data Sources

Mode: Primary Source

The valuation of air quality regulation was done through secondary sources. It is based on the following datasets:

- Concentration of CO, NO_2, and SO_2 within forest areas and in non-forest areas within a 20 km buffer, derived using remote sensing data.
- Difference in pollutant concentrations between forested and non-forested areas, converted to tonnes per square kilometre.

Remote sensing analysis indicates lower concentrations of CO, NO_2, and SO_2 in forested areas compared to non-forested areas, highlighting the role of forests in pollutant absorption which is highlighted in the table below:

Conc. CO (near Forest) in mol/m2	**0.0390000**
Conc. of NO_2 (near Forest) in mol/ m2	0.0000470
Conc. of SO_2 (near Forest) in mol/m2	0.0001900
Conc. of CO (away from Forest) in mol/m2	0.0430000
Conc. of NO_2 (away from Forest) in mol/m2	0.0000970
Conc. of SO_2 (away from Forest) in mol/m2	0.0004700

The difference in concentration thus obtained is as follows:

	mol/m2	g/m2	t/km2
Conc. Diff CO	0.004	0.112	0.112
Conc. Diff NO_2	0.00005	0.0224	0.0224
Conc. Diff SO_2	0.00028	0.01792	0.01792

Mode: Secondary Source

- Marginal abatement costs for each pollutant **(Longva et al., 2024)**
- Area of abatement, defined as the total geographical area minus recorded forest area, amounting to 75,376 sq. km.

The marginal abatement cost of the pollutants is provided below as per exchange rate of 89.97 (XE Currency):

	USD per t	Rs. per t
Marginal abatement cost of CO	330	29,690
Marginal abatement cost of NO_2	10,300	9,26,691
Marginal abatement cost of SO_2	7,158	6,43,996

Valuation:

The economic value of air purification was estimated by multiplying the reduction in pollutant concentration (in t/km²) by the respective marginal abatement cost (Rs. per tonne) for each pollutant. The aggregated value was then scaled by the total area of abatement.

$$EV_{air\ quality\ regulation} = (\Delta CO \times MAC_{CO} + \Delta NO_2 \times MAC_{NO2} + \Delta SO_2 \times MAC_{SO2}) \times Area\ of\ Abatement\ (in\ sq.km)$$

$$EV_{air\ quality\ regulation} = (0.112 \times 29{,}690 + 0.0224 \times 9{,}26{,}691 + 0.01792 \times 6{,}43{,}996) \times 75{,}376$$

= Rs. 269 crores

5.2.3. WATER AVAILABILITY AND PURIFICATION

Forests play a crucial role in maintaining water quality by removing pollutants, sediments, and excess nutrients through natural processes such as filtration, absorption, and microbial activity. Tree root systems slow surface runoff, enhance groundwater recharge, and reduce soil erosion, thereby minimizing the transport of contaminants into water bodies. These functions are vital for safeguarding aquatic ecosystems and ensuring safe water supplies for human use.

India is the largest user of groundwater globally **(World Bank, 2012)**, and Chhattisgarh accounts for 14,548 MCM of groundwater, representing 3.17% of India's total groundwater resources **(CGWRD)**. Several hydrological studies indicate that forested catchments generate runoff with significantly lower levels of suspended solids and pollutants compared to other land-use systems **(Bruijnzeel, 2004; Auquilla et al., 2005; Varanka & Luoto, 2012)**. Improved water quality reduces the operational costs of water treatment plants, highlighting the linkage between forest cover and reduced water treatment expenditure **(Alvsilver et al., n.d.)**.

Forests regulate hydrological processes such as runoff, recharge, and precipitation, thereby influencing both the accessibility and quality of water resources **(Ramachandra et al., 2020)**. Forest soils, native vegetation, and associated microorganisms filter contaminants and bacteria from precipitation-derived water. Water originating from forested landscapes is often valued for its mineral richness, purity, and medicinal properties **(Chatterjee, 2011; Terrado et al., 2014; Zawadzka et al., 2019)**. Soil and water conservation and water purification are therefore interlinked ecosystem services provided by forests.

Valuation Method: Market Price Method

Market Price Method was used to estimate the economic value of water availability and purification services provided by forests in Chhattisgarh.

Data Sources:

The valuation of water availability was done through primary sources. A household survey was conducted to assess water consumption for drinking, agriculture, household use, and other purposes. The consumption values of the sampled households were extrapolated to the forest-fringe village (FFV) population of Chhattisgarh **(1,27,70,000).**

Description	Total consumption (lakh litres)	Price (per litre)
Annual drinking water	1,50,645	5
Annual agricultural consumption	11,62,424	0.01
Annual household survey consumption	44,62,994	0.29
Other Purposes	12,195	0.29

The price/ per litres consumption for agriculture, and other household purposes is sourced from Chhattisgarh Water Resource Department.

Whereas, the price/ per litres consumption of drinking water is taken considering Chhattisgarh Water Resource Department, household survey, and FGDs.

Valuation:

The total annual water consumption for each use category was multiplied by the respective market price per litre. The economic value (EV) was calculated as:

$$EV_{water\ availability\ and\ purification} = (Drinking\ water\ consumption\ (in\ lakh\ litres) \times price\ (Rs\ /\ litres)) + (Agricultural\ consumption\ (in\ lakh\ litres) \times price\ (Rs\ /\ litres)) + (Household\ consumption\ (in\ lakh\ litres) \times price\ (Rs\ /\ litres)) + (Other\ uses\ (in\ lakh\ litres) \times price\ (Rs\ /\ litres))$$

$\mathbf{EV_{water\ availability\ and\ purification}}$ = (1,50,645 x 5) + (11,62,424 x 0.0117) + (44,62,994 x 0.294) + (12,195 x 0.294)

= Rs. 20,825 crores

5.2.4. SOIL CONSERVATION

Forests play a vital role in maintaining soil fertility and stability through litter decomposition and humus formation. Forest vegetation reduces soil erosion by protecting the soil surface from direct rainfall impact, intercepting sediments, and slowing surface runoff. These functions help prevent floods and landslides while sustaining ecosystem integrity. Forests also enhance soil moisture retention, promote groundwater infiltration, and delay high-intensity precipitation, thereby moderating extreme hydrological events.

The extensive underground root systems of forest vegetation improve both the physical and chemical properties of soil by enhancing soil structure, increasing organic matter content, and facilitating nutrient cycling. Through these mechanisms, forests regulate soil fertility and contribute significantly to long-term land productivity. Forest ecosystems are therefore critical in reducing soil and splash erosion, retaining rainwater, maintaining soil moisture, dispersing runoff, and protecting surface soils **(Ma et al., 2019)**.

Valuation Method: Avoided Cost Method

Avoided Damage Cost Method was applied to estimate the economic value of soil conservation services provided by forests in Chhattisgarh.

Forests reduce sediment generation and transport, thereby avoiding downstream damages such as reservoir sedimentation and the associated costs of soil and water conservation (SMC) measures. The **InVEST Sediment Retention Model** was used to estimate the sediment retention capacity of forested landscapes. The model assesses sediment retention based on geomorphology, climate, land-use/land-cover, vegetation characteristics, and management practices. Inputs include estimated soil loss and sediment transport, while outputs represent avoided sedimentation.

The model also enables valuation of soil conservation benefits in terms of avoided costs related to sediment removal and water quality maintenance and helps assess the impacts of land-use change on sediment management costs.

Data Sources:

Mode: Secondary Source

The valuation of soil conservation was done through secondary sources.

- InVEST Sediment Delivery Ratio (SDR) Model inputs:
  - Raster layers of rainfall erosivity (R-factor) and soil erodibility (K-factor)
  - Digital Elevation Model (DEM), land-use/land-cover (LULC), and watershed maps
  - LS factor (slope length and steepness derived from DEM)
  - Root zone depth by vegetation type
  - Conservation Practice Factor (CPF)
  - Land Cover Factor (LCF)
  - Borselli parameter
- The per-hectare cost of soil and moisture conservation (SMC) measures was estimated by analysing the cost incurred by department (Rs. 1,322.96 crores) in SMC treatment area of 25,03,000 ha.
- The catchment area of rivers in the Recorded Forest Area of Chhattisgarh is approximately 60,00,000 hectares (Chhattisgarh Forest Department)

Valuation:

The per-hectare SMC cost was calculated as follows:

SMC cost (in Rs/ ha) = 13,22,96,00,000/ 25,03,000

= 5,285

The **Sediment Delivery Ratio (SDR)** estimated using the InVEST model was **0.2185 per ha**.

The economic value (EV) of soil conservation services was calculated using the formula:

$$EV_{soil\ conservation} = SDR \times Total\ catchment\ area\ (in\ ha) \times Per\text{-}hectare\ SMC\ cost\ (in\ Rs)$$

$\mathbf{EV_{soil\ conservation}}$ = 0.2185 × 60,00,000 × 5,285

= Rs 693 crores

5.2.5. POLLINATION

Forests deliver vital pollination and seed dispersal services through natural processes driven by diverse biotic agents, including insects (e.g., bees, butterflies), birds, bats, and mammals. These services underpin forest regeneration, fruiting, and food production across landscapes by enabling the transfer of pollen between flowers and the transport of seeds to suitable germination sites. Pollination, in particular, is a cornerstone ecosystem service that sustains biological productivity and biodiversity: approximately 78% of flowering plants including many forest species rely on animal pollinators for reproduction and survival **(Ollerton et al., 2011)**.

Enhanced pollinator abundance boosts ecosystem service supply by elevating production levels, improving fruit and seed quality (e.g., size, nutritional content, and appearance), and supporting higher yields **(Balachandran et al., 2017)**. These contributions extend to seed dispersal, which facilitates gene flow, forest succession, and resilience against disturbances. Together, they directly bolster human food security by supporting wild food sources and adjacent agricultural systems **(Hipólito et al., 2019)**.

Valuation Method: Replacement cost method

We have valued pollination (including seed dispersal) using the replacement cost method, which estimates the expense of artificially replicating natural forest regeneration (e.g., via plantations or assisted reproduction) in the absence of biotic agents. This involves comparing:

- Costs of natural regeneration in protected forest patches (fenced against grazing, fire, or human pressures) **(Balachandran et al., 2017; Ray et al., 2015)**.
- Afforestation costs for equivalent artificial planting.

Economic values are derived from standardized rates for natural forest regeneration across all forest types, adjusted to align with plantation regeneration benchmarks (Compensatory Afforestation Fund Management and Planning Authority (**Ollerton et al., 2011; Hipólito et al., 2019**). These rates incorporate the Revision of Net Present Value (NPV) rates for different forest classes/categories, as notified by the Ministry of Environment, Forest and Climate Change **(Verma et al., 2013)**.

This valuation conservatively captures only the direct replacement cost of natural regeneration attributable to pollination and seed dispersal, partially accounting for forest succession dynamics. Notable constraints include: (i) Lack of site-specific data: Excludes broader benefits, such as pollination/seed dispersal services to nearby agricultural fields, orchards, or wild food systems; (ii) Attribution fraction: Assumes 50% of natural regeneration stems from biotic agents (insects, birds, mammals), with the remainder due to abiotic factors (e.g., wind, water flow). This is a cautious estimate, given the absence of India-specific quantitative data; (iii) Scope: Focuses solely on forest-internal regeneration; does not quantify off-site spillovers or long-term biodiversity gains.

Despite these limitations, the approach provides a robust, lower-bound estimate of the irreplaceable role of forest pollinators and dispersers in maintaining ecosystem integrity.

Data Sources:

Mode: Secondary Source

The plantation cost per hectare is taken as Rs. 64,717 per hectare adjusted for the plantation cost by CAMPA under different plantation densities i.e., 1000 tree per ha, 1100 tree per ha, 1100 tree per ha, and 2500 tree per ha.

50% of the natural regeneration in forests is attributed to pollination and seed dispersal services by insects, birds and other animals and the remaining is attributed to natural processes such as water flow and wind **(Verma, 2013)**.

Valuation Formula:

$$EV_{pollination} = Afforestation\ cost\ (in\ Rs\ per\ ha)\ x\ Area\ (in\ ha)\ x\ Regeneration\ rate\ attributed\ to\ pollination$$

Where,

Area = Forest cover inside the RFA

$\mathbf{EV_{pollination}}$ = 64,717 x 42,42,039 x 0.5

= Rs. 13,727 crores

5.3. SUPPORTING SERVICES

Forests ecosystems have multifunctional potential in terms of supporting the natural processes responsible for ecosystem services. It includes natural processes that allow ecosystems to continue providing other services. These services maintain fundamental ecosystem processes, such as habitat for flora and fauna, or maintenance of the genetic and biological diversity etc. The supporting ecosystem services considered for Chhattisgarh includes:

5.3.1. NUTRIENT CYCLING

Nutrient cycling represents one of the most critical ecosystem services provided by forests, facilitating the efficient and continuous movement of essential nutrients between the physical environment (soil, water, and atmosphere) and living organisms. This process encompasses the uptake, utilization, transformation, and recycling of nutrients through biological, geological, and chemical pathways. During various biological process such as photosynthesis, respiration, decomposition, and microbial activity nutrients are absorbed, assimilated, and eventually returned to the soil or water, ensuring their availability for future generations of organisms.

Key macronutrients recycled in this process include nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg), which are indispensable for organismal survival, growth, and reproduction. The specific role of each nutrient varies based on the organism's physiological needs, environmental conditions, geological substrate, and prevailing chemical reactions. For instance, autotrophs like trees and plants primarily absorb these nutrients from soil and water via their root systems during growth. As trees mature, they accumulate both mineral (e.g., NPK) and non-mineral nutrients. A portion of these nutrients is naturally recycled back to the soil through litterfall such as fallen leaves, branches, and organic debris which decomposes and replenishes soil fertility. This natural recycling forms the foundation for valuing nutrient cycling as an ecosystem service, as it sustains soil productivity without external inputs **(Jain et al., 2021)**.

Valuation Method: Avoided Cost Method

To quantify the economic value of nutrient cycling in forests, we apply the avoided cost method combined with market price estimation **(Jain et al., 2021)**. This approach calculates the cost society would incur if forests were absent, necessitating artificial replacement of nutrients lost through erosion, leaching, or depletion. In such a scenario, we would need to purchase and apply synthetic fertilizers (e.g., NPK-based products) from the market to maintain equivalent soil fertility and agricultural productivity.

The valuation focuses on nutrient accumulation in forest soils, derived from litterfall and linked to carbon stocks. Specifically:

- Nutrient levels are estimated as the total average NPK content (in tonnes per hectare, t/ha) per tonne of carbon stock in above-ground biomass (AGB).

This is scaled up to the total forest cover within the specified Reference Forest Area (RFA), here representing Chhattisgarh's forests.

Data Sources:

Mode: Secondary Source

- AGB carbon stock: 27.78 tonnes of carbon per hectare (tC/ha) across Chhattisgarh forests **(FSI, 2023)**.
- Average NPK content in forest soil: 0.01644 t/ha per unit of carbon stock **(Jahanifar et al., 2017; Xue et al., 2001)**.
- Total forest cover in RFA (Chhattisgarh): 4,242,039 hectares **(FSI, 2023)**.
- Ideal NPK ratio in forest ecosystems: 4:2:1 (N:P:K), reflecting natural proportions for balanced soil fertility **(Chand & Pavithra, 2015)**.
- Market prices per kg: Nitrogen (Rs 98.02), Phosphorus (Rs 66.93), Potassium (Rs 23.65) **(DOF, 2025)**.

Valuation Formula:

Total NPK content across Chhattisgarh forests:

Total NPK (tonnes) = AGB (tC/ha) × NPK content (t/ha per tC) × Area (ha)

Where,

Area = Forest cover inside the RFA

Total NPK = 1,937,353 tonnes

Distribution by nutrient using 4:2:1 ratio (total parts = 7):

- Nitrogen (N) = 1,107,059 tonnes
- Phosphorus (P) = 553,529 tonnes
- Potassium (K) = 276,765 tonnes

$$EV_{nutrient\ cycle} = [(N\ content\ (in\ kg)\ x\ cost\ of\ N\ based\ fertilizer\ (Rs/\ kg)) + (P\ content\ (in\ kg)\ x\ cost\ of\ P\ based\ fertilizer\ (Rs/kg)) + (K\ content\ (in\ kg)\ x\ cost\ of\ K\ based\ fertilizer\ (Rs/kg))]$$

$\mathbf{EV_{nutrient\ cycle}}$ **=** (1,107,059,000 x 98.02) + (553,529,000 x 66.93) + (276,765 x 23.65)

= Rs. 15,211 crores

5.3.2. BIODIVERSITY CONSERVATION

Biodiversity conservation is a foundational ecosystem service provided by forest ecosystems. By maintaining a wide range of plant and animal species, genetic diversity, and ecological interactions, forests ensure ecosystem stability, resilience, and the continued provision of multiple other services such as carbon sequestration, pollination, soil formation, nutrient cycling, water regulation, and cultural benefits. In this sense, biodiversity conservation does not operate in isolation but underpins the functioning of the entire ecosystem service framework (CGSBB, 2025).

The importance of this service is particularly high in Chhattisgarh, which hosts extensive forest cover, rich floral and faunal diversity, and several ecologically sensitive landscapes. These forests support endemic and threatened species, sustain livelihoods, and contribute to regional ecological balance. However, biodiversity conservation does not have a direct market price, making its valuation challenging but essential. Valuing biodiversity conservation is inherently complex because it generates multiple types of benefits that are not captured by market transactions. Moreover, biodiversity contributes indirectly to many other ecosystem services, making it difficult to isolate its value.

Valuation Methodology

Since biodiversity is deeply interconnected with multiple ecosystem services, estimating its value in isolation is not straightforward. Therefore, the valuation of biodiversity conservation services of forest ecosystems in Chhattisgarh adopts a multi-method approach, combining benefit transfer, public expenditure-based valuation, and adjusted provisioning service values. This study therefore attempts to look at the multiple facets of biodiversity, drawing from a range of available methods. It may be mentioned that these estimates are subject to inherent uncertainties, however, collectively they represent a comprehensive approach to the valuation of biodiversity which, while being a critical ecological service, faces a relatively high risk of being undervalued on account of methodological complexities. Importantly, as the analysis below shows, one needs to estimate benefits of biodiversity both inside and outside Protected Areas to present the full picture rather than restricting analysis to those areas that are likely to have the highest conservation values.

$$EV_{\text{Biodiversity conservation}} = EV_{\text{Benefit transfer}} + EV_{\text{Expenditure}} + EV_{\text{Forest resource conserved}}$$

1. Benefit Transfer

To estimate the societal value associated with biodiversity conservation, a review of existing valuation studies was undertaken. Relevant studies were identified from the TEEB database and other peer-reviewed sources. These studies were conducted across different countries and reports economic estimates for the conservation of wildlife, species diversity, and natural habitats. Such estimates reflect people's willingness to support biodiversity protection and represent the broader social cost of conserving faunal diversity.

The reported values were standardized by adjusting for income differences using GDP per capita and converted into Indian currency using appropriate exchange rates. Based on these adjustments, the average economic value of faunal biodiversity conservation was estimated at Rs. 25,829 per hectare per year **(CBD, 2001)**. This represents the value associated with conservation of wildlife and animal diversity and does not capture the full spectrum of biodiversity, particularly the floral component. The derived per-hectare faunal conservation value was multiplied by the recorded forest area of Chhattisgarh to estimate the total faunal conservation value of its forest ecosystems.

$$EV_{Benefit\ transfer} = Total\ Recorded\ Forest\ area\ (in\ ha) \times Forest\ Conservation\ Average\ value\ (Rs./ha/year)$$

Forest Conservation Average value = Average per-hectare faunal conservation cost (Rs. /ha/year) is adjusted as below:

Where,

Average per-hectare faunal conservation cost = (∑Biodiversity conservation cost (in Rs./ha))/ total number of study regions

= Rs. 25,829 per ha

Biodiversity conservation cost = ∑ (Social value x (GDP_{India}/ GDP_{Region}) x Exchange Rate)

Table 14: Studies referred for the social value of conservation

S.No.	Region	Social value (per ha)	Currency	Per capita GDP	Adjust ment	India GDP per capita (in USD)	Exchange rate (USD to Rs)	Bio. Cons (Rs per ha /year)
1	Atlantic Coast Brazil	619	USD	10,580	0.27	2,820	90	14,844
2	Cape Floristic Province, S.Africa	233	USD	6,670	0.42	2,820	90	8,863
3	Peninsular Malaysia	206	USD	13,900	0.20	2,820	90	3,760
4	Ivory Coast	160	USD	3,020	0.93	2,820	90	13,442
5	Eastern Himalayas	137	USD	2,820	1.00	2,820	90	12,326
6	Colombian Choco	106	USD	8,250	0.34	2,820	90	3,260
7	Central Chile	104	USD	17,180	0.16	2,820	90	1,536
8	Greece	1,243	EUR	27,170	0.10	2,820	105	13,547

9	Western Ecuador	2,888	USD	7,210	0.39	2,820	90	1,01,627
10	Southwestern Sri Lanka	2,357	USD	4,320	0.65	2,820	90	1,38,428
11	New Caledonia	1,739	USD	50,173	0.06	2,820	90	8,794
12	Madagascar	961	USD	6,16,220	0.005	2,820	90	396
13	Western Ghats of India	668	USD	2,820	1.00	2,820	90	60,100
14	Philippines	652	USD	4,320	0.65	2,820	90	38,292
15	Uplands of western Amazonia	363	USD	7,879	0.36	2,820	90	11,689
16	Tanzania	290	USD	1,300	2.17	2,820	90	56,598
17	Southwestern Australia	171	USD	65,950	0.04	2,820	90	658
18	Northern Borneo	138	USD	13,900	0.20	2,820	90	2,519
19	California Floristic Province	29	USD	89,600	0.03	2,820	90	82

Source: (CBD, 2001)

$EV_{Benefit\ transfer}$ = 59,81,600 x 25,829

= **Rs. 15,450 crores**

2. Public Expenditure-Based Valuation for Protected Areas

To capture the value associated with active biodiversity protection, the annual budget allocated by the Forest Department for biodiversity conservation in Protected Areas was incorporated into the valuation. This reflects the amount already spent to protect biodiversity. Since these funds are directly linked to conservation activities such as habitat protection, wildlife monitoring, anti-poaching efforts, and restoration, they serve as a proxy for the value of biodiversity conservation services. The total budget allocated for forest conservation activity is Rs. 1,07,10,62,628 (Chhattisgarh Forest Department).

$EV_{Expenditure}$ = Rs**. 107 crores**

3. Adjusted Valuation for Non-Protected Forest Areas (NPF)

While faunal diversity is a critical component of biodiversity, floral diversity plays an equally important role in maintaining forest structure, ecosystem productivity, and long-term ecological resilience. Plant diversity supports habitat complexity, nutrient cycling, regeneration processes, and species interactions, thereby forming the foundation of forest ecosystems. To capture the conservation value associated with floral diversity, an alternative and complementary approach was adopted.

Chhattisgarh is characterized by ecologically rich and heterogeneous forest ecosystems, with high levels of plant diversity across different forest types. A substantial proportion of these forests resources such as fuelwood, fodder, small timber, bamboo, and MFPs extracted by the FFV are taken from the area outside the Protected Areas and are covered in the provisioning services. However, the Protected Areas that restricts the extraction of these

important forest resources still has these resources but are not extracted. The sustained availability of these goods is intrinsically linked to the biological diversity, regenerative capacity, and ecological health of the forest.

To capture the biodiversity-related contribution of these forest areas, the per-hectare value of provisioning services, derived from household and tourist surveys, was used as a proxy. This value reflects the ecological productivity that depends on the diversity and functional integrity of forest vegetation. The per-hectare value was multiplied by the corresponding forest cover within non-protected forest areas to estimate the associated component of biodiversity conservation value.

FC inside RFA (in ha)	42,42,039
Protected areas (in ha)	24,55,400
RFA (in ha)	59,81,600

Source: FSI, 2023

Only forested land within the non-protected areas of RFA was included in this calculation, while other land-use categories were excluded, as the objective was to assess the biodiversity value specifically associated with forest ecosystems. This approach ensures that the ecological contribution of non-protected forests is not overlooked and that their role in sustaining multiple ecosystem services is explicitly recognized. The aggregation of all these components provides a more holistic estimate of the biodiversity conservation value delivered by the forest ecosystems of Chhattisgarh.

Method

$$EV_{Forest\ resource\ conserved} = Forest\ cover\ in\ non\text{-}protected\ area\ (ha)\ x\ Average\ per\text{-}hectare\ value\ of\ provisioning\ services\ (Rs.\ /ha/year)$$

Where,

Average per-hectare value of provisioning services (Rs. /ha/year) = Per hectare value of (Timber + Bamboo + Fuelwood + Fodder + MFP + small timber)

Forest cover in non-protected area (ha) = Forest cover inside RFA (in ha) – Protected Areas in Chhattisgarh (in ha)

The per hectares values of different forest resources conserved due to the presence of protected areas are:

Timber (Rs/ha)	**1,778**
Bamboo (Rs/ha)	110
MFP (Rs/ha)	53,516
Fuelwood (Rs/ha)	10,393
Fodder (Rs/ha)	54,687
Small timber (Rs/ha)	3,586

Note: The table presents the per hectare basis (Rs/ha) value of provisioning services derived from the study area, based on data obtained from multiple sources such as forest department records, market prices and field level information.

$$EV_{Biodiversity\ conservation} = EV_{Benefit\ transfer} + EV_{Expenditure} + EV_{Forest\ resource\ conserved}$$

$$= 15{,}450 + 107 + 25{,}553$$

= Rs 41,111 crores

5.4. CULTURAL SERVICES

5.4.1. RECREATION

Recreation constitutes an important cultural ecosystem service provided by forest ecosystems, offering aesthetic, and experiential benefits to visitors while supporting conservation and local livelihoods. Forest-based ecotourism sites in Chhattisgarh include national parks, wildlife sanctuaries, and other forest recreation areas attract visitors seeking nature-based experiences such as wildlife viewing, landscape appreciation, and cultural interaction.

The aesthetic beauty, and recreational benefits provided by the forests include trekking, swimming, walking, and sightseeing. The aesthetic beauty of the forests of Chhattisgarh is invaluable; the presence of Kailash and Kotumsar caves, fascinating view of Rocky Mountains in Kanger valley, Chitradhara, Ghatarani, Amrit dhara, Tirathgarh waterfalls adds significantly to the aesthetic value of the state. To promote and protect wildlife in Chhattisgarh 1 Biosphere Reserve **(CGFD, 2025)**, 4 Tiger Reserves, 11 Wildlife Sanctuaries, and 3 National Parks are notified **(ENVIS, 2025)**. These Protected Areas are popular tourist attractions in the state which enable visitors to experience and appreciate the natural beauty of these ecosystems. The forest of Chhattisgarh also offers various adventure tourism options such as rock climbing, water rafting, zip lining, camping, and wildlife spotting for thrill and challenge.

The economic value of ecotourism can be inferred from the time and money that visitors willingly incur for access to these sites. Expenditures on transportation, accommodation,

food, entry fees, and other travel-related costs, along with the opportunity cost of time spent travelling together represent the implicit value of the recreational benefits of forest-based ecotourism.

Valuation Method: Travel Cost Method (TCM)

The Travel Cost Method has been adopted to estimate the recreational value of forest-based ecotourism in Chhattisgarh. This method is widely used for valuing non-market ecosystem services where direct pricing is absent, as it captures visitors revealed preferences through actual travel behaviour and expenditure patterns.

Data Sources:

Modes: Primary Source

Data for the Travel Cost Method were collected through a primary tourist survey conducted at selected ecotourism sites across Chhattisgarh. The sampling strategy and survey design are detailed in the section on Primary Survey, and the structured questionnaire is provided in the Annexure.

The questionnaire was designed to capture key variables required for travel cost estimation, including:

- ✓ Time taken to travel to the ecotourism site
- ✓ Total expenditure incurred during the visit (including transportation, accommodation, food, entrance fees and other expenses)
- ✓ Number of visitors visiting the ecotourism site

The survey data obtained from selected ecotourism locations were subsequently extrapolated to estimate the value of ecotourism services across all forest-based ecotourism sites in Chhattisgarh, including national parks, wildlife sanctuaries, and other designated ecotourism areas. The extrapolation was based on annual visitor statistics and visitation patterns observed during the survey.

Valuation Formula:

The economic value of ecotourism services was estimated by aggregating the average cost incurred per visitor and multiplying it by the average number of tourists visiting forest ecotourism sites annually. The total travel cost incurred by a visitor comprises:

- ✓ Travel time cost, reflecting the opportunity cost of time spent travelling to and from the site
- ✓ Travel distance cost, representing transportation expenses
- ✓ Other miscellaneous cost as a direct payment for accessing forest-based recreational services

The data for valuing the recreation (ecotourism) service was collected through tourist surveys conducted at major ecotourism sites, namely Kanger, Achanakmar, and Gomard. A total of 840 tourists were samples in above mentioned sites. The survey captured information on visitor profiles, travel costs, time spent, income levels, and expenditure patterns.

Mode: Secondary Source

In addition, secondary data on annual tourist inflow at the state level were obtained from official documents. The valuation incorporates both domestic and international tourists.

Calculations:

- **Estimation of Tourist Numbers**

Annual number of tourists (both domestic and international) in Chhattisgarh are **26,115,300** **(Sinha et al., 2025).**

- **Estimation of Annual Tourism costs**

The economic value of recreation was estimated using the Travel Cost Method (TCM), which captures the expenses incurred by tourists to access the site. The cost was calculated as follows:

$$EV_{Recreation} = (\sum \text{Time related cost (Rs.)} + \sum \text{Distance related cost (Rs.)} + \sum \text{Entry fee (Rs)} + \sum \text{Miscellaneous costs (Rs.)}) * \text{No. of visits}$$

Where,

Time related cost = Time taken to reach the site (in hrs.) × Wage rate (Rs. per hr) × total group size (This is an estimate of the opportunity cost of time spent for the visit)

Note: The average wage rate is estimated from the total working tourists (including salaried employees, or students who are provided stipend) who have travelled to the place.

For the people who are travelling in groups time related costs (opportunity costs of time spent in travel) are only considered for only those having a source of income. For others (say students), time related costs are not applicable.

Distance related cost = Sum of transportation cost (in Rs.)

Type of Cost	Annual Cost (Rs.)
Time related costs	17,18,028
Distance	14,12,273
Entry fees	17,398
Miscellaneous (including equipment hiring, food, lodging, tour, and any other additional expenses)	12,41,123
Total Annual Tourism cost	**43,88,822**

- **Estimation of Cost per tourist cost**

The per tourist cost was calculated using the annual tourism cost (Rs. 43,88,822) and total sampled tourists (840 tourists). The cost per tourist thus works out to Rs. 5,225.

- **Valuation Formula**

The economic value of the recreational services was calculated using the following formula:

$$EVRecreation = \text{No. Of Annual Tourists in Chhattisgarh} \times \text{Cost per Tourist (Rs.)}$$

$EV_{Recreation}$ = 2,61,15,300 x 5,225

= Rs. 13,645 crores

5.4.2. EDUCATION, SCIENCE AND RESEARCH

Forests provide important platforms for education, scientific inquiry, and research, contributing significantly to the understanding and conservation of forest ecosystems. Various educational, scientific, and research programmes are conducted by schools, universities, research institutions, and government departments to enhance knowledge of forest ecology, biodiversity, and climate processes.

Outdoor workshops, field-based learning, and nature education programmes enable students to engage directly with forest ecosystems and develop a deeper understanding of ecological principles. In addition, academic and research institutions, environmental organizations, and scientists conduct both short-term and long-term studies to examine species interactions, monitor ecological changes, and develop innovative conservation and management approaches. Several long-term ecological monitoring stations have been established by leading scientific institutions to support sustained forest research.

Valuation Method

A **Market-Based Expenditure Method** was used to estimate the economic value of education, science, and research services provided by forest ecosystems. This method captures actual expenditures incurred on educational and research activities related to forests and biodiversity.

Data Collection

Mode: Secondary Source

- The total number of schools in Chhattisgarh is 56,425 (Department of School Education, Government of Chhattisgarh).
- The total numbers of teachers in Chhattisgarh are 2,20,161 (Department of School Education, Government of Chhattisgarh).

Mode: Primary Source

A school survey was conducted to assess expenditure on environmental education related to forests and biodiversity, focusing on the following components:

- Fees paid by students
- Salaries paid to teachers
- Costs associated with field visits, outdoor workshops, and research activities

The survey covered 10 schools.

Valuation:

Student-Related Costs

- Number of students enrolled in forest and environment-related subjects: 333
- Average monthly student fee: Rs. 525
- Annual student fee expenditure: Rs. 20,97,900

Teacher-Related Costs

- Number of teachers teaching these subjects: 13

- Average monthly teacher salary: Rs. 29,050
- Annual teacher salary expenditure: Rs. 45,31,800

Miscellaneous Costs

- Field trips, workshops, and study materials: Rs. 3,06,500

The total annual expenditure per 10 schools was estimated as:

Total cost (in Rs) = Student fees (in Rs) + Teacher salaries (in Rs) + Miscellaneous costs (in Rs)

= 20,97,900 + 45,31,800 + 3,06,500

= Rs. 69,36,200

This results in an average cost per school of Rs. 6,93,620.

Research Expenditure

Expenditure on forest-related research studies by academic and scientific institutions amounted to Rs. 1,78,00,000.

Economic Valuation

The total economic value of education, science, and research services was calculated as:

$$EV_{Education,\ Science\ \&\ Research} = (Cost\ per\ school\ (in\ Rs) \times Total\ number\ of\ schools) + Research\ expenditure\ (in\ Rs)$$

$EV_{Education,\ Science\ \&\ Research}$ = (6,93,620 × 56,425) + 1,78,00,000

= Rs. 3,916 crores

Spiritual Services

The forests of Chhattisgarh are home to various indigenous communities, each with their own unique culture, language, and customs. The creation of sacred groves, usually dedicated to a deity, is a traditional and cultural part of the forest-dwelling communities since ancient times. These wilderness areas hold deep spiritual and religious value to the local indigenous communities. These spiritual services provided by forests are ecosystem services that cannot always be quantified due to limitations in valuation methods; however, this does not diminish their significance. When quantitative assessment is not feasible, the importance of such services can be effectively highlighted through qualitative descriptions. Spiritual values associated with forests represent one such vital ecosystem service, reflecting deep-rooted beliefs, traditions, and practices that contribute to community well-being and conservation ethics.

Sacred groves can be considered as an ancient equivalent of natural sanctuaries for various plant and animal species, resembling small forests and important sites of worship and community gathering. There are almost 600 sacred groves present in the state of Chhattisgarh (Malhotra et. al., 2001). Some groves although having valuable timber are not harvested due to sacred beliefs of the communities. The presence of Siyadevi temple offering mythological values, and Jatmai temple located between beautiful sight of forest and waterfall are some of the temple groves in Chhattisgarh. Other traditional sacred groves include Phool, Sarhul, Kadamara, Mahadani, Buddhadev, Mandar, Bhimsen Kund, Bhimsen Kund, Sani Dev/Ogan Path, Panch Lingeswar Cave, Latiya Dabara etc (ENVIS, 2024).

One such sacred grove in Kotumsar village in Kanger Valley National Park was visited that explored religious beliefs and traditional forest conservation practices of the Dhurva tribal community (details are provided in the Annexure). The sacred groves are built on a concept of *Matagudi* (village deity) and *Devgudi* (boundary deity), both integral to community well-being and protection. It highlighted how rituals, festivals, and belief systems promote the conservation of ecologically important tree species such as Mahua, Sal, Mango, Tamarind, Peepal, Banyan, and Karaya. Sacred practices ensure protection of trees, wildlife, and surrounding habitats, while traditional institutions involving priests (*pujari*), spiritual mediums (*sirha*), and healers (*guniya*) reinforce social cohesion and ecological stewardship. The presence of sacred groves is an important part of the cultural service provided by the forests which functions as culturally rooted mechanisms for biodiversity conservation and sustainable forest management.

6. TOTAL ECONOMIC VALUE

TEV offers a structured, anthropocentric lens for ecosystem service valuation, systematically capturing human derived benefits from forests to guide policy in the currently undervalued sectors like Chhattisgarh's forestry amid funding shortfalls. This framework reveals why marketed output represents only a fraction of true contributions, urging Green GDP adjustments and periodic reassessments to track degradation from different drivers.

TEV = Use Value (Direct, and indirect) + Non-Use Value

TEV aggregates use values that are derived from actual or potential human utilization and non-use values that stem from intrinsic or future-oriented societal preferences into a total measure of human welfare derived from ecosystem changes. The table below presents values of the provisioning, regulating, supporting, and cultural ecosystem services for the accounting period of 2024-25 (monetary asset accounting) and indicates which of the services have been considered 'use' and 'non-use' values in the context of this study.

Table 15: Economic value of ecosystem services indicating classification of use and non-use values.

S.No	Description	Ecosystem Service	Type of Value	EV (Rs (crore))	EV (in percent)
1	Provisioning Services	Timber	Use	318	0.22
		Fuelwood	Use	1,857	1.31
		Small Timber	Use	641	0.45
		Bamboo	Use	20	0.01
		Fodder	Use	6,197	4.38
		MFP	Use	9,561	6.76
2	Regulating Services	Carbon Sequestration	Use	13,394	9.47
		Water Availability and Purification	Use	20,825	14.73
		Air Purification	Non-use	269	0.19
		Soil Conservation	Non-use	693	0.49
		Pollination	Non-use	13,727	9.71
3	Supporting Services	Biodiversity Conservation	Non-use	41,111	29.08
		Nutrient Cycle	Non-use	15,211	10.76
4		Recreation	Use	13,645	9.65

	Cultural Services	Education, Science & Research	Non-use	3,916	2.77
5	**Total Economic Value (TEV)**			**1,41,343**	**100.00**

Note: Biodiversity conservation represents an 'option value' i.e., the value assigned to preserving the potential future use of resources or services, such as medicinal plants or species. It can be classified as either a use value or a non-use value. Following consultation with the Chhattisgarh Forest Department, we have categorized it as a non-use value for this assessment.

The **Figure 12** clearly shows that supporting and regulating services together account for about three-fourth of the value of ecosystem services. This is on expected lines as these services, though often invisible, contribute to vital ecosystem functions, and hence when valued should legitimately account for the lion's share of the total economic value of ecosystem services. Within regulating services, water availability and purification, carbon sequestration and pollination dominate while within supporting services, biodiversity conservation and nutrient cycling emerge as the services with the highest economic value. As per the SEEA framework, ecosystem services should be represented in both physical and monetary terms; accordingly, their supply in these terms is provided in the **Annexure IV**.

The distribution of values as estimated in this study matches (to a reasonable extent) with those reported in other states. While the numbers themselves are not fully comparable due to differences in the coverage of services and the methodologies adopted, the dominance of regulating and supporting services over provisioning services is a notable pattern. Karnataka shows a somewhat similar distribution (SEEA aligned) with provisioning, regulating & supporting, and cultural services contributing to 11%, 48%, and 41% respectively. Arunachal Pradesh shows similar patterns (MEA aligned) with percentage contribution of provisioning, regulating, and cultural services at 21%, 72%, and 6% respectively. The report on revision of rates of NPV applicable for forests of India, shows percentage contribution of provisioning, regulating, and supporting services as 63%, 23%, and 14% respectively (water here was considered as provisioning, rather than regulating, service, and cultural services were not estimated) **(Verma et al., 2013)**.

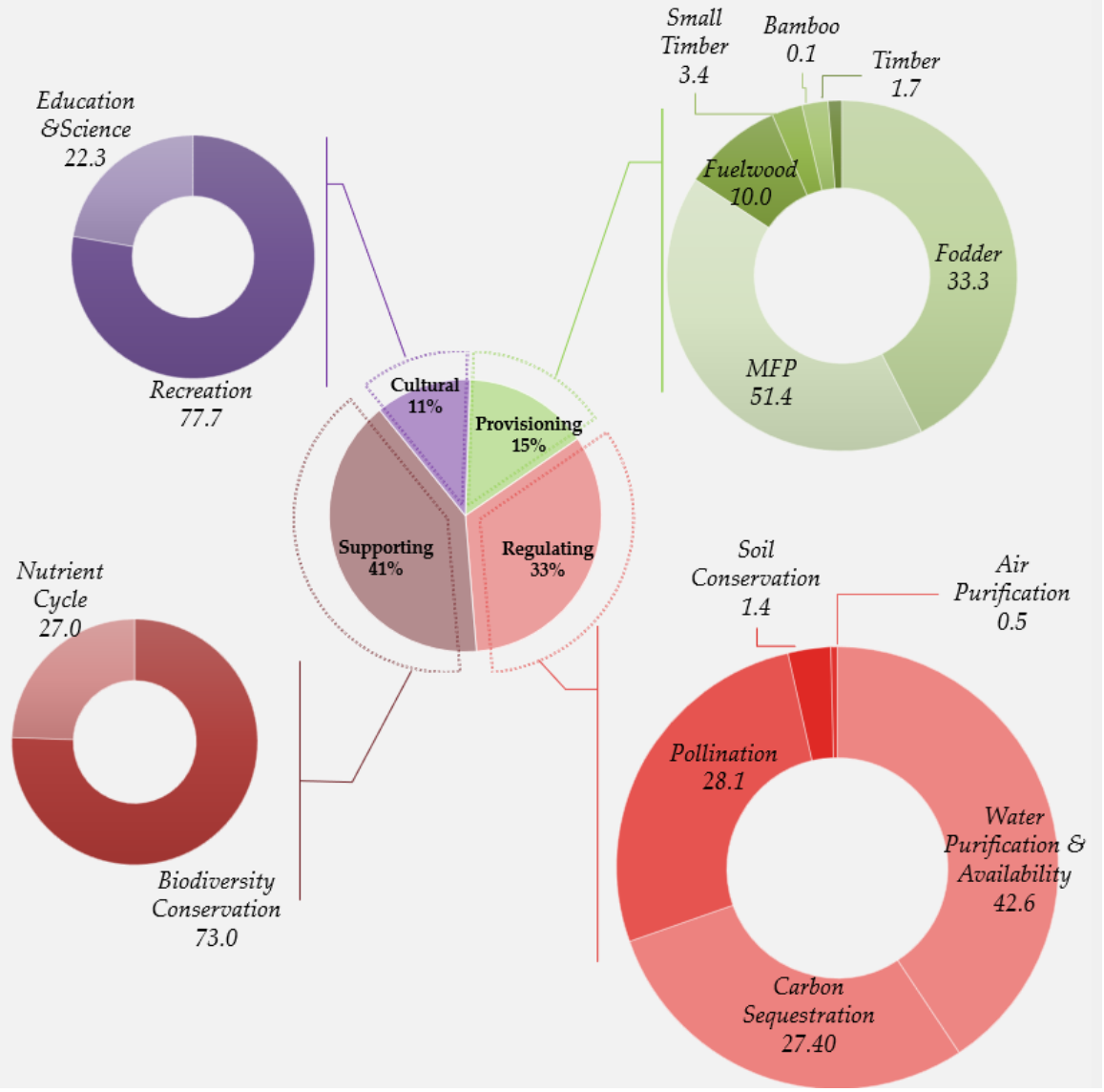

Figure 12: Percentage contribution of different ecosystem services

Net Present Value

The Net Present Value (NPV) of an ecosystem asset is estimated based on the expected income that can be generated by the asset in the future and discounting the future income based on the present accounting period **(SEEA, 2021)**. The net present value is calculated based on the following equation:

$$NPV = \Sigma\ (ES_t/(1+r)\ ^\wedge\ t$$

Where,

t= Number of years ranging between 1 to T

T= Number of years for which the annual benefit from the asset will accrue. This is linked to the length of time needed to regenerate the same type and quality of forests. For this study, this is assumed to be 50 years **(Ramachandran et al., 2020)**.

ES_t= Ecosystem services at time t

r= Social rate of discount. For forest ecosystems, 3% is considered as the discount rate (NCAVES, India) *

S.No.	Description	NPV (in '000 crore rupees)	NPV (in percent)
1	Provisioning Services	4,784	13.15
2	Regulating Services	12,584	34.59
3	Supporting Services	14,491	39.84
4	Cultural Services	4,518	12.42
5	**Total NPV**	**36,378**	**100.00**

**A low discount rate (below the standard market rate) is normally preferred for public investments that yield long term returns. In the context of forestry, ecological benefits that dominate the distribution of TEV (the supporting and regulating services) are essentially long term in nature; a choice of a low discount rate implies that future benefit flows are valued (relatively) more highly in present value terms; this aligns with a long-term sustainability perspective that forest sector investments are expected to embody.*

Mining

Mining represents a critical form of natural capital in forest landscapes, distinct from the provisioning, regulating, supporting, and cultural ecosystem services generated by forest ecosystems themselves. Unlike timber or MFP yields which emerge directly from biotic forest processes or regulating services like carbon sequestration, mineral resources form through abiotic geological formations independent of ongoing forest functionality. Consequently, the SEEA Ecosystem Accounting module (UN 2021) excludes mining from forest ESV asset accounts, classifying it instead under SEEA Central Framework's mineral and energy resources module as separate natural capital stocks.

This separation ensures analytical precision: forests provide habitats and services atop mineral endowments, but extraction depletes finite subsurface assets without regenerating via ecosystem dynamics. In Chhattisgarh, a mineral-rich state where forests cover approximately 44% of land and host major deposits mining drives, approximately 6% of state's GVA **(MoSPI, 2025)**. Operations often overlap forest areas, creating trade-offs in restoration projects, yet contribute disproportionately to state revenues through royalties, employment, and industrial inputs. Treating mining as an add-on component in this study depicts the contribution of mining sector from the forest areas of Chhattisgarh, capturing its standalone economic weight for holistic natural capital accounting.

We thus value mining separately to inform multi-asset project feasibility and policy dialogues by Chhattisgarh Forest department. Data was sourced from the Chhattisgarh Forest Department **(2025 records)**, detailing 91 active mines across key minerals:

Table 16: Distribution of mineral resources, mining area, and economic value within forest areas.

Mineral	Coal	Iron Ore	Bauxite	Total

Number of Mines	59	26	6	91
Total Area (in sq km)	216.58	51.19	19.39	287.16
RFA (in sq km)				59,816
Percent of RFA (in %)				0.48
Total value of mineral (in crore rupees)	33,340	22,359	245	55,944
Value of mineral from forest (in crore rupees)	11,336	12,074	78	23,488

Source: Chhattisgarh Forest Department (2025 records)

7. CONTRIBUTION TO GVA/ GDP

The System of National Accounts (SNA), developed by the United Nations and followed by nearly all countries worldwide, stands as the premier macroeconomic tool for economic analysis and policy design. It employs two primary approaches to national income estimation: the income approach and the production/ output approach. The most common method, the income approach, centres on Gross Value Added (GVA), the value producers add to goods and services within an accounting year before final consumption. In essence, GVA aggregates all value additions along the production consumption value chain.

Contribution to GDP / GVA

Forests deliver both use values (direct market flows and indirect services) and non-use values (existence, bequest, option values for future/intrinsic benefits). Conventional economic structures, including SNA based GDP/ GVA, capture only use values those entering market transactions or proxy-valued via production functions. Non-use values, while vital for welfare (e.g., spiritual, nutrient cycle etc), remain unmonetized in national accounts.

This study thus incorporates the use values from Chhattisgarh's forests, aggregating all provisioning services, carbon sequestration, water availability/ purification, biodiversity conservation, and recreation. Total use value is Rs 0.66 lakh crore annually.

Official forestry sector contribution is as below **(MoSPI, 2025)**:

- GVA: Rs 18,462 crore (3.46% of state Rs 5.33 lakh crore GVA)
- GDP: Rs 19,600 crore (3.46% of state Rs 5.67 lakh crore GDP)

Metric	Total for all sectors (in Rs. crores)	Forestry contribution (in Rs. crores)	Current forest contribution (in %)	EV Use values (in Rs. crores)	EV Adjusted contribution (in %)
GVA	5,33,255	18,462	3.46	66,458	11.43
GDP	5,67,880	19,600	3.46	70,773	11.43

Note: GDP figures are slightly higher than GVA as these are adjusted for taxes (net of subsidies). However, the overall contribution to the economy, whether in GDP or GVA terms remains unchanged as the same adjustments are made for the total and sectoral values.

8. EFFECT OF CLIMATE CHANGE ON ECOSYSTEM SERVICES

India's forests, spanning 21.71% of the country's land area and supporting 18% of the global human population despite occupying just 2.4% of the world's surface **(Shukla et al., 2021; FSI, 2023)**, deliver indispensable ecosystem services. Chhattisgarh, nestled in India's forested heartland, boasts a rich tapestry of sal (*Shorea robusta*), teak (*Tectona grandis*), bamboo, and mixed deciduous forests, supporting exceptional biodiversity **(FSI, 2023)**. Covering 44.37% of its 135,192 Sq.km. area 5.98 million ha of Recorded Forest Area (RFA) these ecosystems sustain 12.77 million FFVs, who derive 20–40% of incomes from forests **(FSI, 2023; FSI, 2020)**.

CRITICAL ROLE OF ECOSYSTEM SERVICES

Chhattisgarh's forests provide multifaceted ecosystem services. These services underpin human wellbeing, providing income between Rs. 20,000–50,000/household/year, food security, and health (herbal remedies amid limited infrastructure) for FFVs **(TERI survey 2025)**.

Sustainable forest maintenance including protection, conservation, and utilization is besieged by drivers eroding structural (biomass, diversity) and functional (productivity, resilience) attributes **(Yan et al., 2025; Cardinale et al., 2012)**.

CASCADING CLIMATE FEEDBACK

Climate change ranks as the paramount threat to the forest ecosystem of Chhattisgarh. It operates in a vicious synergy with drivers of deforestation and degradation, collectively eroding the forest ecosystem services. These drivers fall into two categories, i.e natural disturbances and anthropogenic pressures, each amplified by climate change while in turn exacerbating it, creating self-reinforcing feedback loops that threaten the state's forest cover and its contribution to GDP:

1. Natural Drivers: These are the natural disturbances such as cyclones, floods and droughts. that affects the forest and biodiversity in Chhattisgarh
2. Anthropogenic Drivers: These are the human induced actions that impact on the forest and biodiversity such as forest land diversion for non-forest activities such as mining and unsustainable extraction of timber, fuelwood and minor forest produce.

CHHATTISGARH PRODUCTIVITY PARADOX

Chhattisgarh's forests epitomize climate ecosystem tensions: highest national cover gain (684 Sq.km. from 2021–2023) masks the forest health and quality **(FSI, 2021; 2023)**. Growing stock has plummeted from 74.42 m^3/ha (1997) to 55.69 m^3/ha (2019), a 25% loss, creating a 22 m^3/ha deficit vs. ICFRE's 1 m^3/ha/year Mean Annual Increment (MAI) standard. This signals stalled regeneration and climate induced stress (droughts, heat).

Implications:

- Carbon: 11tC/ha (nearly 40 tCO_2 eq/ha) foregone per year
- Water: Reduced Leaf Area Index (LAI) impairs hydrology
- MFP: Yield crashes resulting in impacts on livelihoods

CARBON SEQUESTRATION

The decline in growing stock directly undermines Chhattisgarh's carbon sequestration capacity, a critical regulating ecosystem service valued at Rs. 14,770 crores annually estimated by integrating state-level assessments of carbon stocks, InVEST modelling and carbon market pricing **(TERI, 2025; FSI, 2023; MoSPI, 2022)**. Each cubic meter of wood contains approximately 0.5 tonnes of carbon, following standard wood density conversions for tropical hardwoods like sal and teak dominant in the region. Correcting for the observed 22 m^3/ha growing stock deficit, rather than the referenced 37 m^3/ha, this equates to 11 tC/ha foregone, or 40.3 tCO_2e/ha when applying the IPCC Tier 1 factor of 3.67. Scaled across Chhattisgarh's 4.24 million hectares of forest cover inside RFA, this translates to 171 $MtCO_2e$ of unrealized annual carbon storage capacity.

CLIMATE CHANGE EXACERBATION PATHWAYS

Climate change intensifies this sequestration crisis through interconnected biophysical mechanisms, pushing forests toward tipping points. Temperatures approaching the 29°C mean annual threshold for tropical moist forests, trigger an 11% decline in net primary productivity (NPP) per 1°C warming, as elevated respiration outpaces photosynthesis **(Nölte et al., 2023).**

WATER REGULATION

Healthy forests in Chhattisgarh regulate critical water cycles through interconnected processes: canopy interception (capturing 20–40% of rainfall), evapotranspiration (releasing 300–600 mm/year vapor to sustain monsoons), and enhanced soil infiltration **(FAO, 2008)**. The observed growing stock decline from 74.42 m^3/ha (1997) to 55.69 m^3/ha (in 2019) directly correlates with reduced LAI, as smaller average tree diameters support less foliage per hectare **(FSI,1997; FSI, 2019)**. This LAI erosion translates to degradation in watershed services, slashing annual water yield regulation and elevating runoff coefficients **(FAO, 2008)**. Beyond the 12.77 million forest fringe villagers (FFVs) reliant on streams for daily needs, this imperils Chhattisgarh's entire population.

Chhattisgarh's characteristic "rainfall at the wrong time" marked by excessive early monsoon deluges followed by prolonged dry spells exacerbates hydrological vulnerabilities, disrupting groundwater recharge cycles that historically sustained the state's aquifers. Forest degradation compounds this: compacted soils in low-density stands reduce infiltration rates, channelling more water as surface runoff and flash floods **(Alaoui et al., 2018)**.

Invasive species like *lantana camara* covering 1,332 Sq.km. worsen impedance through dense, shallow root mats that block macropores, slashing percolation and promoting hydrophobic soils during dry spells **(FSI, 2019; ICFRE, 2022)**. Focus group discussions (FGDs) with FFVs in Puta, Talapar, Bhudbhud, Sonhara, Shankarpur, and Girwarganj villages confirm widespread groundwater declines: pre-monsoon depths have deepened, causing handpump failures in villages **(FGDs TERI, 2025)**.

MFP PROVISION

For Chhattisgarh's 12.77 million FFV population MFPs serve as a lifeline, providing a source of household incomes, supplementing food security, and providing medicinal plants amid limited healthcare access. Household surveys document annual extraction worth Rs. 9,561 crores with Mahua (*Madhuca longifolia*), tendu (*Diospyros melanoxylon*) leaves, harra (*Terminalia chebula*) as major extracted MFPs **(Chhattisgarh MFP Federation; household surveys, TERI 2025)**.

However, growing stock analyses reveal a potential catastrophic regeneration failure in key MFP species, foreshadowing complete livelihood collapse. Climate change disrupts MFP phenology through temperature driven flowering mismatches and reduced fruiting, rendering traditional collection windows increasingly erratic. This shift in fruiting season would desynchronize with

pollinators like bees and bats, whose activity optima now misalign **(CABI, 2022; Dey et al., 2018)**. Household collectors also face acute vulnerability due to narrowed extraction window, and erratic production of MFPs.

These mechanisms spawn negative feedback loops where initial productivity declines reduce forest resilience, amplifying subsequent climate impacts. Low regeneration begets sparse understories, diminishing microhabitat diversity.

9. LIMITATIONS OF THE STUDY

Ecosystem services valuation studies, particularly those focused on natural capital like forests, face inherent challenges due to the complexity and diversity of ecosystems. Forests encompass a wide range of habitats, forest types, and ecological gradients, making comprehensive valuations difficult for large study areas. Thus, such studies are recommended for localized scales, considering homogenous dynamics and spatial variability.

The Ecosystem valuation studies are also highly data-intensive, requiring high-quality, granular data for robust estimates. In the current study, for instance, value of timber (as an ecosystem service) is estimated using total timber volume and revenue generated (provided by Chhattisgarh Forest Department), however this can be refined with species-wise extraction data to capture variations in species specific market values.

Additional limitations include the reliance on secondary data sources for valuation, considering the duration of the study. Despite these limitations, the study has adopted robust methodologies, internationally accepted standardized framework, namely SEEA, and best-suited valuation techniques, yielding the closest possible estimates. These provide valuable insights to inform policy decisions for the forestry sector, including budgetary allocations for conservation and restoration initiatives.

10. CONCLUSION

Estimating the true economic values of ecosystem services (or 'putting a price tag on nature') is always a challenge both due to methodological issues around reliable measurement (and monetization) and the lack of accounting frameworks that can accommodate these challenges. Several of the ecosystem services do not have a clear market price, and therefore one needs to resort to a range of indirect valuation methods, which are, by their very nature, inexact and subject to uncertainties. In a way, this renders some of the values difficult to interpret, especially when comparing them with values of economic output in other sectors (say agriculture or industry). It is in this context that a study of this kind gains great importance. This study employs a suite of direct and indirect methods to present the best possible monetary estimates of the ecosystem services of forests in a manner that makes them reasonably comparable with sectors of the economy that generate directly monetized outputs.

Such an exercise becomes even more critical for states like Chhattisgarh, which, on the one hand. is richly forested, but on the other hand, is undergoing transition to become an industrial hub for the country. Clearly, industrial output is readily measurable, but the ecosystem services of forest are not; as a consequence, macro-economic accounting frameworks may fail to capture the 'true value' of forests in the same way they would take note of industrial output. This would inevitably skew the policy narrative against certain economic sectors – simply because their full value is invisible or not fully captured through market prices.

This study therefore applies a corrective, arguing that if even if a subset of ecosystem services of forests (the 'use values') is provided a monetary value, contribution of forests to the state's income (GDP/ GVA) goes up dramatically to 18.8%, an almost sixfold increase from the value reported in conventional income accounts. This is because the vast range of 'use values' remains unreported either because the products do not enter the market or the accounting systems restrict themselves only to a few products (say timber) that are exchanged in the market. The study also shows that about three-fourth of the economic value of forests is contributed by supporting and regulating services (such as biodiversity, pollination, water availability and purification and carbon sequestration). The values of none of these are captured by direct market prices; nevertheless, these remain the dominate services of forests and need to enter mainstream accounting frameworks so that decisions around planning or land use can be taken based on more rational considerations. It may be added GDP/ GVA contribution as computed above is still a conservative (lower end) estimate; if the non-use values are added, then this percentage will further go up.

At the same time, it may be noted that several of the ecosystem services of forests transcend state boundaries. Some of the services (like carbon sequestration) are global in nature though they are the result of conservation of forest within state boundaries. The principles of Environmental Fiscal Transfer (EFT) constitute clear recognition of this issue. Successive Finance Commissions of India have upheld these principles, linking allocations to the forest cover of states. The current study bolsters this argument by showing that a state's forests generate a range of ecosystem services that go well beyond the ones formally accounted for. By implication, current allocations relate to benefits derived from only a small subset of services and therefore need to go up substantially if the full range of services is recognized.

More broadly, the results of this study indicate that there is an urgent need to enhance budgetary allocations to the forestry sector, given that its true contribution to the state's economy is significantly higher than what is conventionally reported. This should strengthen efforts in forest conservation that will in turn maintain and enhance the dominant supporting and regulating

functions of forests as reported in this study while contributing to the livelihoods of forest-dependent communities, especially those in the forest fringe villages. Principles of Sustainable Forest Management should be invoked here so that extractive use of forests is restricted to sustainable limits while livelihood and employment opportunities in forest fringe villages are stepped up – along with improved education, health and sanitation facilities.

Finally, there is a need to monitor and track the ecosystem services of forests over the long run. A study of this kind presents a useful tool for such monitoring – if the values of the dominant services can be captured in monetary terms, their relative importance within forest management systems will be more clearly visible. This can serve as an important management / planning tool, and if captured in Working Plans (or other management / planning documents), can help the Forest Department (and other agencies) to manage resources in a sustainable manner in the long run, maximizing economic potential without compromising the ecological functions.

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ANNEXURES

ANNEXURE I

Household Survey Questionnaire

Household Survey for Valuation of Ecosystem Services of Forest Ecosystem in Chhattisgarh and its potential contribution to State Gross Domestic Product

HOUSEHOLD SURVEY QUESTIONNAIRE

This survey is taken up as a part of project "Valuation of Ecosystem Services of Forest Ecosystem in Chhattisgarh and its potential contribution to State Gross Domestic Product". The survey is conducted by TERI to evaluate the different ecosystem services, and various parameters associated with the mentioned ecosystem services. Based on the finding's we will be able to estimate the value of the natural capital which can be key contributing factor for improving the GDP of Chhattisgarh. The project developed will help in assessing the contribution of different ecosystem services for better policy making.

Surveyor Code Date
Surveyor Name Time

1. BASIC INFORMATION

Name of the village_____ Union_____
Upzila_____ District_____
GPS Coordinates of Village: Latitude_____ Longitude_____
Name of the Respondent_____ Age_____ Sex_____
Household Size_____ Phone No. of Respondent _____
Level of Education_____
Education Codes: 1= Primary; 2= Secondary; 3= Higher Secondary; 4= Honors; 5= Masters; 6= PhD; 7= Religious Education; 8= Illiterate; 9= Others, please specify
Occupation _____
Occupation codes: 1= Own farm activities; 2= Agricultural Labour; 3= Animal Husbandry; 4= Domestic Work; 5= non-Agricultural labour; 6= Petty Trade; 7= Sale and Collection of NTFP; 8= Tourist Guide; 9= Mason; 10= Driver; 11= Carpenter; 12= Traditional Family Occupation; 13= Government Salaried Employee; 14= Private Salaried Employee; 15= Migrant Worker (Seasonal); 16= Migrant Worker (Whole Year); 17= Not working; 18= Other, Please mention

2. FUELWOOD

2.1. What are the main sources of fuel/energy uses by your household?
- a) Fuelwood
- b) Kerosene
- c) Coal/ Lignite/ Charcoal
- d) Cow dung
- e) LPG
- f) Others, please specify.

2.2. What is the source and quantity of fuelwood collected per household?

Source of fuelwood	Quantity collected per visit (in Kg)	Frequency of collection in a month (in days)	Number of months in a year fuelwood is collected
Forest			
Other lands			
Purchased (Forest Depot, market etc.)			

2.3. What is the purpose of collection of fuelwoods?
- a) Fuelwood for self-consumption (in Kg) _____
- b) Fuelwood for selling in market (in Kg) _____

2.4. What is the present market price of fuelwood per kg (in INR)? _____
2.5. What is your monthly income from all sources (in INR) _____
2.6. What is the number/percentage of village people dependent on wood collected from forest for fuel/ energy?
- a) Number_____
- b) Percentage_____

Household Survey for Valuation of Ecosystem Services of Forest Ecosystem in Chhattisgarh and its potential contribution to State Gross Domestic Product

3. GRAZING

3.1. Livestock details:

S.No.	Livestock Type	Number	Monthly Requirement of Fodder/Feed (In Kg)
1	Cow		
2	Buffalo		
3	Sheep		
4	Goats		
5	Others, please specify		

3.2. Does your cattle graze or do you collect resources for stall feeding or both?

a) Yes b) No

3.3. What is the source of grazing and frequency?

Source of grazing	Grazing hours in a day	Frequency of grazing in a month (in days)	Total months in a year for grazing
Forest			
Other lands			

Source of Stall feeding	Frequency of collection in a month (in days)	Quantity collected per visit (in Kg)	Number of months stall feeding is done.
Forest			
Other lands			
Market			

3.4. What is the purpose of collection of fodder?

a) Fodder for stall feeding (in Kg) _____

b) Fodder for selling in market (in Kg) _____

3.5. What is the present market price of fodder/grass per kg (in INR)? _____

3.6. What is the number/percentage of village people dependent on grazing from forest?

a) Number_____ b) Percentage_____

4. MFP COLLECTION

4.1. MFPs collected from the forest:

S.No.	MFP/NTFP	Quantity collected per visit (in Kg)	Frequency of collection per month (in days)	Number of months NTFP is collected	Market Price per kg (in INR)
1.					
2.					
3.					
4.					
5.					
6.					
7.					

4.2. What is the purpose of collection of MFPs?

a) MFP for self-consumption (in Kg) _____

b) MFP for selling in market (in Kg) _____

4.3. What is the number/percentage of village people dependent on MFP extracted from forest?

a) Number_____ b) Percentage_____

Household Survey for Valuation of Ecosystem Services of Forest Ecosystem in Chhattisgarh and its potential contribution to State Gross Domestic Product

5. Bamboo

5.1. What is the source and quantity of bamboo collected per household?

Source of bamboo	Quantity collected per visit (in Kg)	Frequency of collection in a month (in days)	Number of months in a year bamboo is collected
Forest			
Other lands			
Purchased (Forest Depot, market etc.)			

5.2. What is the purpose of collection of Bamboo?

a) Bamboo for self-consumption (in Kg) _____

b) Bamboo for selling in market (in Kg) _____

5.3. What is the present market price of Bamboo per kg (in INR)? _____

5.4. What is your monthly income from all sources (in INR) _____

5.5. What is the number/percentage of village people dependent on bamboo collected from forest?

a) Number_____

b) Percentage_____

6. WATER PURIFICATION

6.1. What are the main sources of water available for usage? (Can select multiple options)

a) Wells
b) Springs
c) Valleys
d) Desalination
e) Others, please specify.

6.2. What are the uses of water and the respective consumption (in Litres) from various sources?

S.No.	Uses of water	Quantity of consumption (in litres)
1.	Drinking	
2.	Agriculture	
3.	Household purpose	
4.	Others, please specify_____	

6.3. Is there water tariff paid by your household for using water from various sources?

a) Yes
b) No

6.4. If yes, then how much do you pay per month (in INR)? _____

Tourist Survey Questionnaire

Tourist Survey for Valuation of Ecosystem Services of Forest Ecosystem in Chhattisgarh and its potential contribution to State Gross Domestic Product

TOURIST SURVEY QUESTIONNAIRES

This survey is taken up as a part of project "Valuation of Ecosystem Services of Forest Ecosystem in Chhattisgarh and its potential contribution to State Gross Domestic Product". The survey is conducted by TERI to evaluate the different ecosystem services, and various parameters associated with the mentioned ecosystem services. Based on the finding's we will be able to estimate the value of the natural capital which can be key contributing factor for improving the GDP of Chhattisgarh. The project developed will help in assessing the contribution of different ecosystem services for better policy making.

Surveyor Code　　Date
Surveyor Name　　Time

1. BASIC INFORMATION

Name of the Respondent_____ Union_____
Upzila_____ District_____
Age_____ Sex_____Phone No. of Respondent _____
Level of Education_____
Education Codes: 1= Primary; 2= Secondary; 3= Higher Secondary; 4= Honors; 5= Masters; 6= PhD; 7= Religious Education; 8= Illiterate; 9= Others, please specify
Annual Income (in INR) _____
Occupation _____
Occupation codes: 1= Own farm activities; 2= Agricultural Labour; 3= Animal Husbandry; 4= Domestic Work; 5= non-Agricultural labour; 6= Petty Trade; 7= Sale and Collection of NTFP; 8= Tourist Guide; 9= Mason; 10= Driver; 11= Carpenter; 12= Traditional Family Occupation; 13= Government Salaried Employee; 14= Private Salaried Employee; 15= Migrant Worker (Seasonal); 16= Migrant Worker (Whole Year); 17= Not working; 18= Other, Please mention

2. ECOTOURISM

2.1. What was the city and district of departure from which you made this trip to the National Park/ Wildlife Sanctuary/ Reserved Forest?
a) City _____　b) District_____

2.2. Means of transport used to travel to National Park/ Wildlife Sanctuary/ Reserved Forest?
a) Flight
b) Train
c) Bus
d) Auto
e) Own Bike/ Scooter/ Car
f) Hired taxi.
g) On foot
h) Others, please specify.

2.3. How much time did you take to reach National Park/ Wildlife Sanctuary/ Reserved Forest and how far did you come from?
a) Time (in hrs) _____　b) Distance (in Km) _____

2.4. Group details

S.No.	Details of people in your group	No. of people
1.	Friends	
2.	Family	
3.	Colleagues	
4.	Students	
5.	Others, please specify	

2.5. Source of Information about National Park/ Wildlife Sanctuary/ Reserved Forest?
a) Television
b) Internet
c) Newspaper
d) Magazine
e) Friends, family, colleagues
f) Others, please specify.

Tourist Survey for Valuation of Ecosystem Services of Forest Ecosystem in Chhattisgarh and its potential contribution to State Gross Domestic Product

2.6. Costs involved during the visit.

S.No.	Facility	Costs (in INR)
1	Fare for local departure (public transport like flight, bus, train etc)	
2	Fuel expenditure for own vehicle	
3	Hired taxi fare	
4	Auto fare	
5	Rickshaw fare	
6	Entry fee in the National Park/ Wildlife Sanctuary/ Reserved Forest	
7	Equipment charges (binoculars, camera, etc)	
8	Total food expenses (from canteen, local hawkers, restaurants etc)	
9	Ecotourism charges (guide, vehicle, etc.)	
10	Total lodging charges	
11	If taken a tour package	
12	Other expenses, please specify	

2.7. How many trips have you made to National Park/ Wildlife Sanctuary/ Reserved Forest?

a) Once in a year
b) Twice in a year
c) Thrice in a year
d) Others, please specify.

2.8. If you visit more than once, what is the preferred season/ month of the visit? _____

2.9. What is your primary reason to visit National Park/ Wildlife Sanctuary/ Reserved Forest?

a) Watching animals
b) Bird watching
c) Picnic
d) Safari
e) Trekking
f) Camping
g) Sightseeing
h) Research & Education
i) Others, please specify.

2.10. What is your most liked flora or fauna in the National Park/ Wildlife Sanctuary/ Reserved Forest?

S.No.	Type	Names
1	Mammals	
2	Birds	
3	Reptiles	
4	Amphibians	
5	Fishes	
6	Insect	
7	Trees	
8	Shrubs	
9	Grass	

2.11. In your opinion, what improvements need to be made to make the National Park/ Wildlife Sanctuary/ Reserved Forest more attractive and tourist friendly?

S.No	Improvements	Yes	No
1.	More sit and relax options while moving around		
2.	More Electric Vehicles		
3.	Cleanliness inside the park		
4.	More protection for indigenous species		
5.	Souvenir shops outside the protected area		
6.	Facilities of interpretation centre		
7.	Handy, informative and easy to use guides and pamphlets		
8.	Better signage inside the National Park/ Wildlife Sanctuary/ Reserved Forest		
9.	Others, please specify		

School Survey Questionnaire

School Survey for Valuation of Ecosystem Services of Forest Ecosystem in Chhattisgarh and its potential contribution to State Gross Domestic Product

SCHOOL SURVEY QUESTIONNAIRES

This survey is being conducted as a part of project "Valuation of Ecosystem Services of Forest Ecosystem in Chhattisgarh and its potential contribution to State Gross Domestic Product". The aim of the survey in schools/ University is to understand the extent of forest, biodiversity, and environmental related subjects being taught in the curriculum. This survey aims to assess students' awareness and knowledge of the ecological importance of forests and related environmental issues. The insights gathered will help us identify gaps and opportunities for strengthening environmental education, fostering ecological consciousness among students. This will also help to estimating the contribution of such subjects towards economic value of Chhattisgarh's GDP.

Date: _____ Time: _____

1. BASIC INFORMATION

Name of the Respondent_____ Designation_____
Age_____ Sex_____Phone No. of Respondent _____
Name and address of School _____

2. FOREST, BIODIVERSITY, CLIMATE AND ENVIRONMENT

2.1. What are the total number of forest, biodiversity, climate, and environment related subjects that are being taught in the school/ University?
2.2. Approximate number of students undertaking these subjects?
2.3. Average monthly fees of students (in INR)?
2.4. Number of teachers/ professors available for teaching these subjects?
2.5. Average monthly salary of these teachers/ professors (in INR)?
2.6. Any additional costs incurred by school/ University related to forest, biodiversity, climate, and environment events/ programs throughout the year:

S.No.	Activity	Costs (in INR)
1	Events and/or programs	
2	Field visits	
3	Any other Others	

2.7. How many such programs have been conducted in a year?

Focus Group Discussions

The Focus Group Discussions were conducted to assess the extent of resource dependency among forest fringe communities. Local community members were engaged in discussions regarding the types of resources they extract from the forest, including fuelwood, fodder, and primarily Minor Forest Produce (MFP). Participants were also asked about the quantity of fuelwood and MFP collected, sources of household income, livestock ownership, and average grazing duration. The questionnaire of Focus Group Discussion is provided below.

FGD for Valuation of Ecosystem Services of Forest Ecosystem in Chhattisgarh and its potential contribution to State Gross Domestic Product

FOCUS GROUP DISCUSSION

This discussion is part of the project titled "Valuation of Ecosystem Services of Forest Ecosystem in Chhattisgarh and its Potential Contribution to State Gross Domestic Product". The study is being conducted by TERI to evaluate various ecosystem services provided by forest ecosystems in the state (inside RFA), and to understand the relevance of different forest resources. The findings from this study will help estimate the value of natural capital, which is a potentially significant contributor to Chhattisgarh's Gross Domestic Product (GSDP). The outcomes of the project aim to inform and support better policymaking through evidence-based assessments of ecosystem service contributions.

1. BASIC INFORMATION

Name of the village_____ Gram Panchayat_____
Block_____ District_____
Distance from nearby forest (approx. in kms) _____
GPS Coordinates of Village: Latitude_____ Longitude_____
Total households in the Village: _____

2. FOREST RESOURCE

2.1. What percentage of households in the village collect forest produce (includes MFP, fuelwood, fodder, bamboo, small timber) from the forest?
2.2. Which forest resources are extracted from the forests (RFA)? Please provide a detailed list in case of MFPs.
2.3. What is the frequency of extraction of forest resources? (Collect for each forest resource individually)
  2.3.1. Daily average extraction per visit _____; or
  2.3.2. Monthly average extraction _____; or
  2.3.3. Annual average extraction _____; or
2.4. If extracted daily, then how many days in a month do you collect each forest resource?
2.5. If extracted monthly, then in which months over the course of a year do you collect each forest resource?
2.6. If it is sold in market, at what rates do you sell different forest produce in the local market?
2.7. Is there any noticeable change observed in the presence of forest resource collected from the forest?
2.8. If yes, reason? What was the forest resource extraction last year?

3. WATER CONSUMPTION

3.1. What are the primary sources of water accessible for household or community use? Please mention sources such as wells, tubewells, rivers, handpumps, pipeline or any others.
3.2. What are the primary uses of water and its consumption (in litres):
  3.2.1. Drinking, washing, other household purpose
  3.2.2. Irrigation
3.3. How much agricultural land is available in the village (in hectares)? How much is irrigated, rainfed, and non-irrigated?
3.4. Is there water tariff paid by your household for using water from various sources?
3.5. If yes, then how much do you pay per month (in INR)? _____

Based on discussions with Shri Sunil Kumar Mishra, Principal Chief Conservator of Forest (Land Management) and Shri Gurunathan N, Conservator of Forest (Land Management), the field plan for conducting Focus Group Discussions (FGDs) was finalized. Subsequently, FGDs were carried out in selected villages of Chhattisgarh. A total of four FGDs were conducted at the following locations:

1. Puta Village, Sarguja Division
2. Talapar Village, Korba Division
3. Bhudbhud Village, Korba Division
4. Balrampur Division (with participants from Sonhara, Shankarpur, and Girwarganj villages)

Key Findings of the Focus Group Discussions:

1. Puta Village, Ambikapur District

- The major MFP collected by villagers includes Tendu leaves, Sal seeds, Amla, Harra, Baheda, Kali Haldi, Tikhur, Mahua flowers, and mushrooms.
- Fuelwood consumption is prevalent across 100% of households.
- On each collection trip, villagers typically gather around 50–60 kg of fuelwood, making approximately 7–8 trips per month.
- Every household owns cattle, including cows and goats. Grazing is practiced throughout the day, and fodder is not collected manually as cattle graze freely.
- Bamboo is collected and used to make baskets, which are sold in the local market.
- Small timber is also collected and used to craft furniture, agricultural tools, and household equipment.
- Tendu leaves are sold at Rs. 5.50 per bundle.
- Honey is sold at Rs. 100–150 per kg.
- Char is sold at Rs. 1,000 per kg, although in some cases, villagers sell it to private vendors for Rs. 300 per kg.
- Broom grass is collected for self-consumption.
- Harra is primarily used for making traditional medicines and is not usually sold.
- Mahua seeds are sold at Rs. 50–60 per kg.
- Sal seeds are sold at Rs. 10–20 per kg.
- Baheda is sold at Rs. 15–20 per kg and is also used for household medicinal purposes.
- Seeds of Charota are sold in the range of Rs. 20–50 per kg.
- Kali Haldi is collected for self-use and traditional purposes.
- Every household practices agriculture, with paddy (Dhan) being the primary crop, which is entirely rain-fed.
- Some households also cultivate vegetables, which are sold in the local market.
- The primary source of drinking water in the village is government-installed handpumps.
- Villagers reported that the availability of MFPs has remained consistent over the years, with no major changes observed.

- MFPs are usually collected from forest areas located approximately 1–2 kms from the village.

Figure 13: Focus Group Discussion at Puta Village, District Ambikapur

Following the Focus Group Discussion, a site visit was undertaken to the local ecotourism destination Sitabengra Cave and Jogimara Cave. These caves are of historical and cultural significance, with local narratives linking them to Lord Rama and Sita's stay in the region. A nearby Ram-Janki Temple also attracts a substantial number of visitors.

It was informed that the caves receive an average footfall of 200–300 visitors daily, which rises significantly to nearly 10,000 visitors per day during the Ramgarh Mahotsav. The entry fee structure includes Rs. 50 for four-wheelers, Rs. 20 for two-wheelers, and Rs. 10 per person. Accommodation is available in nearby cottages at a cost of Rs. 1,200 per night.

During the visit, interactions were held with local tourist groups to collect general information regarding travel time, distance covered, place of origin, and total expenditure incurred during their trip. This information was gathered to support the application of the Travel Cost Method for assessing the recreational value of the ecotourism site.

Figure 14: Visit to Local Ecotourism Site - Sitabengra Cave and Jogimara Cave

A visit was also made to Mainpat village, an established tourism site in the region. Key attractions such as the Tibet Temple and Bouncing Land were visited to gain insights into the site's operations and tourist engagement. Popularly known as the "Shimla of Chhattisgarh," Mainpat serves as a hill station and draws a significant number of local tourists. An entry fee of Rs. 20 is charged at the site. The area was observed to be vibrant with local vendors and recreational activities managed by members of the local community.

2. Talapar village, Korba District - 21st June

- The village has a total of 120 households with a population of 1,513.
- The surrounding forest is primarily composed of teak and mixed forest types.
- A majority of households depend heavily on coal for daily activities such as cooking and heating.
- Fuelwood usage is minimal, limited to about 1–2 kg per day, mainly for igniting coal.
- Commonly collected MFP includes Char, Kosam, Mahua, Tendu, Baheda, Dohra, Saja, Harra, and Lac.
- The nearest market for selling MFPs is the Pali Hatt Bazaar.
- An estimated 30–40 households are actively involved in MFP collection.
- Reported prices for select MFPs are: Char – Rs. 80/kg, Lac – Rs. 800–900/kg, Mahua – Rs. 40/kg, Baheda – Rs. 10/kg (collected by only 4–5 households), and Harra – Rs. 20/kg.
- Water is supplied twice daily through coal mine-operated tankers with a capacity of 1,500 litres each.
- Private borewells are present in the village but are rarely used due to contamination from nearby coal mining activities.
- Nearly all households are engaged in agriculture, with 100% dependence on rain-fed farming.
- Since the establishment of coal mines 10 years ago (operational for 5 years), approximately 25% of agricultural land has been lost.
- The nearest sacred/ecotourism site is Chaiturgarh Temple, which villagers typically visit 2–3 times a year; the visit usually takes an entire day, and the entry fee is Rs. 20 (as per villagers).
- A Joint Forest Management (JFM) committee exists in the village, although it is currently inactive.

Figure 15: Focus Group Discussion at Talapar Village, Korba District

3. Bhudbhud village, Korba District

- The village comprises a total of 300 households, and the forest is of mixed type.
- The village is currently undergoing relocation to Sindhpara and Chinpara. Each household has received Rs. 6 lakh as compensation under the relocation package.
- Fuelwood consumption is minimal, primarily due to the proximity of coal mines.
- On average, each household uses approximately 1 *gattha* (25 kg) of fuelwood per week.
- Commonly collected MFP includes Char and Tendu.
- Each household typically collects around 100 *gaddis* of Tendu leaves.
- Approximately 150 households own cattle, with an average of 2 to 15 cattle per household.
- Grazing takes place for 6 to 8 months in a year, typically between 4:00 AM and 8:00 PM.
- Drinking water is provided through tankers operated by the nearby coal mine, each with a capacity of 1,500 litres.
- Between 200 and 250 households are engaged in agricultural activities. All agricultural land in the village is rain-fed.
- Nearby sacred and ecotourism sites as reported by villagers, include Chaiturgarh Temple and Pali Shiv Mandir.

4. Balrampur district comprising participants from 3 villages namely Sonhara, Shankarpur and Girwarganj

- The village consists of 300 households.
- Around 90% of the households extract some form of forest resource, while only 10% do not rely on forest resources.
- Fuelwood is used for cooking, infrastructure construction, and boiling water.
- On average, each household extracts about 25 *gathas* (approximately 625 kg) of fuelwood per week.
- The village has been granted *nistar* rights, allowing the use of forest resources for subsistence.
- MFP collected includes Lac (1 quintal per household per year, sold at Rs. 60–Rs. 100/kg), Tendu leaves (sold at Rs. 5 per bundle), and Mahua (10 quintals per household per year, sold at Rs. 5,600/quintal).
- Other MFPs include Kanda (Rs. 40–Rs. 45/kg), Harra (Rs. 12/kg), Baheda (Rs. 20/kg), Char (Rs. 100/kg), Chironji – unprocessed (Rs. 100/kg), Chironji – processed seeds (Rs. 200/kg) and Sal seeds (Rs. 15/kg)
- Drinking water is accessed from wells, borewells, and privately installed taps. Borewells are approximately 400 feet deep and take around 10 minutes to operate.
- Households pay Rs. 80–Rs. 100 per month in electricity bills, mainly due to the operation of borewells.
- Nearly all households own livestock, typically 3–4 cows and 10–20 goats.
- Grazing takes place throughout the year hence villagers do not collect fodder from the forest.
- A decline in the quantity and quality of Amla has been reported by the community.
- Villagers also noted a reduction in deer sightings, indicating a loss of biodiversity.
- The nearest ecotourism site is Baba Bachraj Kunwar Temple, located about 20 km from the village, with a travel time of approximately 1–2 hours.

- The main crops cultivated in the village are *Dhan* (paddy) and *Gehu* (wheat).

Figure 16: Focus Group Discussion at Balrampur District

Following the Focus Group Discussions, a site visit was conducted to the local ecotourism destination, Baba Bachraj Kunwar Temple. During the visit, information was gathered on visitor footfall and other operational aspects of the site. It was informed that the temple receives approximately 6,000 to 7,000 visitors daily, with the number slightly declining during the monsoon season. The majority of visitors are reported to come from Uttar Pradesh, Jharkhand, and Chhattisgarh.

Figure 17: Visit to local ecotourism site – Baba Bachraj Kunwar Temple

Visit to Sacred Groves

To highlight the importance of sacred groves, a field visit was conducted to Kotumsar village in Kanger Valley National Park. The visit aimed to engage with the Dhurva tribal community residing in the area and to understand their religious beliefs and traditional practices associated with forest conservation. The TERI team was accompanied by a local student, Umesh who facilitated communication by bridging the language barrier and helped introduce the team to local beliefs and customs.

Figure 18: Visit to kotumsar village in Kanger Valley National Park

Mr. Umesh explained the belief systems of the tribal communities associated with Devgudi and Matagudi. Devgudi refers to the deity located at the boundary of a village, believed to protect the village from external threats, while Matagudi is situated within the village and is worshipped for the protection and well-being of its residents. He noted that every village traditionally has both a Devgudi and a Matagudi.

The first visit was made to the *Matagudi* of Kotumsar village, known as *Bairigurhi Pardesin Mata*. The visit was facilitated by a local community member, who explained that the deities and statues were brought to the village by their ancestors when they first settled in the area. These deities are worshipped annually during March–April, along with rituals dedicated to the forest. The worship takes the form of a community festival, marked by celebrations, temporary shops, and collective participation. Offerings typically include the sacrifice of a chicken and a goat, with contributions made by all households in the village. The rituals are conducted by a priest and a Sirha, who is regarded as the living embodiment of the deity during the ceremony.

Mr. Umesh further explained that certain trees are strictly protected due to their religious and cultural significance. Mahua trees are never cut, as their flowers are used to prepare traditional liquor that is offered to the deity. Similarly, mango and tamarind trees are conserved for their fruits. Sal stems and leaves are used for constructing houses and making household utensils. The seeds and leaves of the Mahul tree hold special religious importance; its leaves are offered to the deity, and there is a traditional practice whereby, before sowing the crop, the priest presents the seeds on Mahul leaves as part of the ritual. Mahul leaves are also used in traditional dances and as part of tribal attire and adornment.

In addition, strong religious beliefs are associated with Peepal and Banyan trees, which are revered for their sacred value while simultaneously providing ecological benefits such as habitat for biodiversity and improved air quality. The following photographs document observations from the visit to the *Matagudi* in Kotumsar village.

Figure 19: Visit to Matagudi of Kotumsar Village

The second visit was made to the *Devgudi* of Kotumsar village, known as *Denger Dei.* This sacred site is established around a Karaya tree (*Sterculia urens*) located at the village boundary. The community holds strong religious beliefs associated with this deity, and rituals and offerings are regularly performed on Tuesdays and Saturdays. Owing to the religious significance of the site, the trees around the deity are protected and animals found in the vicinity are also safeguarded.

Mr. Umesh further explained that similar deities exist in other villages and that at the *pargana* level comprising around ten villages, there is an additional deity of collective significance. He noted that each deity is traditionally associated with a *pujari* (priest), a *sirha* (messenger of the deity), and a *guniya* (traditional healer). The guniya is believed to diagnose ailments using rice and provides corresponding Ayurvedic remedies to the community. Deities from surrounding villages are collectively taken to the *Madai* festival, in which approximately 22 neighbouring villages participate. The following photographs document observations from the visit to the *Devgudi* in Kotumsar village

Figure 20: Figure 18: Visit to Devgudi of Kotumsar Village

ANNEXURE II

Key Informant Interviews

Various data were taken from forest department for valuation of services such as timber, MFP extraction, fuelwood, bamboo, etc. A workshop was held and various key informant interviews were held for collection of data. The subsequent paragraphs provide a comprehensive account of the meetings held with each division, along with the specific data requirements discussed.

1. Monitoring and Evaluation

A meeting with Shri Kaushlendra Kumar, Principal Chief Conservator of Forests (Monitoring & Evaluation), was held on 20th June 2025, following the workshop. The discussion focused on timber production in the state in relation to Forest Department operations. Shri Kumar expressed strong interest in the study and assured full support in facilitating data access.

He provided a detailed explanation of the technical aspects of the Working Plan and its relevance for estimating the forest resource values of Chhattisgarh. He elaborated on the different working circles involved in timber production and proposed a template for collecting data. This template includes division-wise information on forest area and the corresponding production of timber, fuelwood, and bamboo.

A follow-up clarification meeting was held on 24th June 2025 to address specific queries regarding forest depots, species-wise timber production, and prevailing market rates. These details were discussed for potential inclusion in the proposed data template.

The specific data requirements, as outlined in the official letter issued, are listed below:

1. Division-wise data on extent of Reserved Forest (RF), Protected Forests (PF), Orange Areas in square kilometres.
2. Division-wise working circle area in square kilometre:
    a. Selection cum Improvement (SCI)
    b. Improvement Working Circle (IWC)
    c. Rehabilitation Working Circle (RWC)
    d. Plantation working Circle (PlWC)
    e. Protection Working Circle (PWC)
3. Year-wise timber, bamboo and fuelwood production in SCI (for past 3 years)
4. Year-wise timber, bamboo, and fuelwood production in IWC (for past 3 years)
5. Year-wise average cost of handling and revenue generated for timber production (for past 3 years)

2. Chhattisgarh Biodiversity Board

Following the workshop, a meeting was held on 20th June 2025 with Ms. Neetu Harmukh, Senior Scientist at the Chhattisgarh Biodiversity Board, who expressed a keen interest in the study. She spoke in detail about the rich and diverse biodiversity of Chhattisgarh and shared several publications and reports related to past biodiversity assessments, highlighting the state's unique flora and fauna. She also offered her support in valuing the spiritual significance of sacred groves, elaborating on their extent and cultural importance to local communities.

A follow-up meeting was conducted on 25th June 2025 to further refine the data requirements. During this meeting, a brief discussion was also held on the educational value of forests, and how schools could be engaged for conducting relevant surveys. Ms. Harmukh provided valuable suggestions on the approach for implementing school-based surveys.

Subsequently, a meeting was held with Shri Rajesh Kumar Chandele, Member Secretary of the Chhattisgarh State Biodiversity Board, during which the discussions with Ms. Harmukh were shared in detail. Based on this interaction, an official letter was issued outlining the following data requirements:

1. List of research collaborations with other institutes and the budget sanctioned in these studies for the past 3 years
2. Chhattisgarh Biodiversity Assessment Report (particularly for biodiversity indices)
3. Sacred grove studies for all over the Chhattisgarh
4. Jungle safari report
5. Past 3-year budget allocated for different activities/ initiatives conducted by State Biodiversity Boards
6. Also, could you suggest some schools, Institutes/ Universities where we can reach out to conduct a short survey (questionnaire for survey is attached for your reference).

3. Budget, Finance and Audit

A meeting with Smt. Sanjeeta Gupta, Additional Principal Chief Conservator of Forests (Budget, Accounts & Audit), was held on 23rd June 2025 to discuss budget allocations under various schemes, market prices of timber and its production, as well as rates related to Soil Moisture Conservation (SMC) and plantation activities in the state. She provided valuable guidance and directed the team to relevant divisions such as the Development Division for scheme-wise budgets, plantation rates, and SMC cost details.

Smt. Gupta also facilitated introductions to departmental officials who shared the latest Annual Report and Nistar Report with the TERI team. Following her recommendation, a meeting was held with Mr. Hemant on 25th June 2025. He offered key insights into the department's budgeting processes and shared recent budget books, while also guiding the team to the official website where budget documents from the past ten years are accessible. Mr. Hemant further clarified that non-plan activities fall under the purview of the Budget and Finance Division, whereas plan activities are managed by the Development Division and the Wildlife Wing.

4. Development and Planning Division

A meeting was held with Shri Arun Kumar Pandey, Principal Chief Conservator of Forests (Development and Planning), on 23rd June 2025 to obtain data related to plantation activities, Soil and Moisture Conservation (SMC) costs, ecotourism sites and budgetary expenditure under various schemes implemented in forest areas. Based on his guidance, a follow-up meeting was conducted with Dr. Devyani Sharma to discuss the data requirements in detail. Following this discussion, a formal list of data requirements was shared with the Development and Planning Division, as outlined below.

1. Scheme-wise budget allocation and expenditure.
2. Ecotourism data related to annual number of tourists in each site, annual revenue generated, and operation season of each site.

3. Per hectare cost of plantation activities undertaken in the respective forest divisions of Chhattisgarh.

5. Forest Management Information System (FMIS) Division

A meeting was held with Smt. Satovisha Samajdar, Deputy Conservator of Forests (FMIS Division) on 23rd June 2025 to discuss the various maps and spatial data that could be provided by the FMIS Division to support the study. She also offered valuable guidance on the valuation of nutrient cycle regulation as an ecosystem service and highlighted how previous studies conducted in Chhattisgarh could contribute to this assessment.

During the meeting, she introduced the team to Mr. Roopnarayan, who provided a detailed overview of a project focused on Soil Moisture Conservation. He explained the project's impact on soil quality and its assessment through remote sensing and GIS techniques. A brief discussion was also held with another expert Mr. Vikram from the division, who provided insights into the availability of spatial datasets and maps, including information on forest fires, forest fringe villages, soil types, forest types, and the shapefile of the Recorded Forest Area (RFA) boundary.

Following these discussions, a formal list of data requirements was shared with the FMIS Division, which included the following details:

1. Shape files for the Soil Moisture Content (SMC) assessment conducted in the following circles Surguja, Bilaspur, Raipur, Kakner, Jagdalpur, and Wildlife (PA). (*Reference study: Change detection of SMC, vegetation cover and water body monitoring using GIS*)
2. Shape file of NDVI assessment (forest density class wise)
3. Shape file of soil type map
4. Shape file of forest type map
5. Shape file of forest fire map (incidence)
6. Updated shape file of Reserved Forest, Protected Forest, and Orange area
7. List of Forest Fringe villages (FFV) upto 5 km from the boundary of RFA

6. Chhattisgarh State Minor Forest Produce (Trading & Development) Co-operative Federation Limited

A meeting was held on 24th June 2025 with Shri Manivasagan, Chief Conservator at the Chhattisgarh State Minor Forest Produce Federation Ltd. ("Van Dhan Bhawan"), to discuss the scale and management of Minor Forest Produce (MFP) in the state. He explained the role of the Federation in uplifting forest-dependent communities by ensuring Minimum Support Prices (MSP) and Support prices for specific MFP species. However, he noted that the Federation currently captures only about 10% of the total MFP extraction occurring in the state.

Following this interaction, further meetings were conducted with Ms. Anuradha and Mr. Shoaib on 25th and 26th June 2025 to gain deeper insights into the procurement processes, value addition mechanisms, and revenue generation from MFPs. It was shared that a total of 67 MFP items are officially recognized, including Tendu, Sal, Mahua, Baheda, Harra, etc.

Based on these discussions, a formal list of data requirements was shared with the Federation, which included the following details:

1. Comprehensive list of MFPs (including medicinal plants) found in the state
2. Quantity of MFPs (including medicinal plants) collected by the federation
3. Minimum Support Price (MSP) provided by the federation for each MFP

4. List of value-added products derived from MFPs and their corresponding market prices (Chhattisgarh Herbal)
5. MFP-wise annual revenue generated by the federation for the past three years
6. Annual Reports of the federation for the last five financial years
7. Report on the Hatt Bazaar Survey conducted by the federation in 2019

7. Forest Development Corporation

A meeting was held with Shri Morice Tushar Nandy, Managing Director, Chhattisgarh Rajya Van Vikas Nigam Limited on 24th June 2025 who directed us to Mr. Singh to gather information regarding timber production and sales under the Forest Development Corporation. During the discussion, it was shared that the Corporation operates primarily through two major circles—Raipur and Bilaspur—which together encompass nine forest divisions engaged in plantation, harvesting, processing, and sale of timber. It was also highlighted that Teak is the principal species managed by the Corporation. Data on annual timber production, prevailing market prices and revenue generated were shared during the meeting. However, detailed information, including cost break-up across different timber classes and diameter categories, has been formally requested through a letter sent to the Corporation.

8. Wildlife Division

A meeting was held on 24th June with Shri Sudhir Kumar Agrawal, Principal Chief Conservator of Forests (Wildlife & Biodiversity Conservation) cum Chief Wildlife Warden, Chhattisgarh, and Shri Alok Kumar Tiwari, Deputy Conservator of Forests (Wildlife), to gather information on ecotourism sites across the state and their operational details. Based on the discussions, the following data was formally requested from the department, as outlined below.

2. Annual number of tourists visiting each ecotourism sites per year (preferable for last 5 years)
3. Annual revenue generated by the Forest Department from these sites per year (including boarding, lodging, safari, and any other miscellaneous revenue) (preferably for last 5 years)
4. Operational season for each ecotourism site in a year (months during which the ecotourism site is open for visitors)
5. Annual number of crimes reported in Protected Areas and respective fines/ penalties/ cost of illegal forest resource confiscated
6. Annual budget allocated to wildlife wing for different activities conducted in all the Protected Areas

9. Protection Division

A meeting was held with Shri Sunil Kumar Mishra, Principal Chief Conservator of Forests (Land Management) on 25th June 2025, during which data pertaining to forest-related offences, particularly those involving illegal extraction, was shared.

ANNEXURE III

System of Environmental Economic Accounting (SEEA)

The System of Environmental-Economic Accounting (SEEA) is a framework that integrates environmental and economic values providing a comprehensive view of interrelations between economy and environment, stocks and changes of environmental assets, and their benefits to the society. It consists of SEEA Central framework (SEEA-CF), a multipurpose framework for understanding interactions between economy and environment, and for describing stocks and changes in stocks of environmental assets which brings together information on water, minerals, energy, timber, fish, soil, land and ecosystems, pollution and waste, production, consumption, and accumulation in a single measurement system (SEEA, 2017; SEEA-EA, 2021). SEEA-CF is complemented by 2 publications:

- **SEEA Experimental Ecosystem Accounting**: This describes the measurement of ecosystem in physical terms and valuation of ecosystems consistent with market principles.
- **SEEA Applications and Extension**s: This presents several monitoring and analytical approaches that could be adopted and describes the way in which SEEA data can be used to inform policy analysis.

Key features of SEEA-CF (SEEA):

1. Relationship of SEEA-CF to the System of Natural Accounting (SNA)

   SNA is a measurement framework that has been evolving since 1950s as a distinguishable approach in the measurement of economic activity, economic wealth, and general structure of economy. SEEA-CF applies accounting concepts, structures, rules, and principles of SNA to environmental information with economic information in a single framework.

2. Combining information in physical and monetary terms

   It has the capacity to organize physical and monetary data classifications into combined presentations (CP). The structure of presentations depends upon topic of measurement (water, energy, air emissions or forest products), the question of interests and availability of data.

3. Flexibility in implementation

   It is a system that emerged as an integrated, internally consistent series of accounts which is designed in such a way that it can be implemented equally well in its totality or partially. Depending upon specific environmental issues faced, countries may choose only a selection of accounts to be implemented in SEEA-CF.

SEEA-CF integrates the information of various stocks and flows of economy and environment in the form of tables and related accounts:

a) Supply and use tables in physical and monetary terms showing flows of natural inputs, products, and residuals.

b) Asset accounts for individual environmental assets in physical and monetary terms showing the stock of environmental assets at the beginning and the end of each accounting period and the changes in stock.

c) A sequence of economic accounts highlighting depletion-adjusted economic aggregates

d) Functional accounts recording transactions and other information about economic activities undertaken for environmental purposes.

The SEEA framework covers the measurement of ecosystem services in three main areas (SEEA):

a) the physical flows of materials and energy within the economy and between the economy and the environment.

b) the stocks of environmental assets and changes in these stocks; and

c) economic activity and transactions related to the environment

ANNEXURE IV

PHYSICAL AND MONETARY USE TABLES

The physical use tables for the ecosystem assets is as below:

S.No.	Description	Physical use
	PROVISIONING SERVICES	
1	Timber (in '000 cum)	143
2	Fuelwood (in million t)	4.16
3	Small Timber (in '000 cum)	852
4	Bamboo (in '000 t)	29.65
5	Fodder (in million t)	10.61
6	*MFP (in million t)	1.2
	REGULATING SERVICES	
7	Carbon Sequestration (in million tCO_2eq)	16.36
8	Water Availability & Purification (in billion litres)	578.83

*MFP physical use represents sum of all the MFPs extracted in kg.

Note: The services such as air purification, soil conservation, pollination, biodiversity conservation, nutrient cycle, recreation, and education, science & research are not represented in physical terms as these represent intangible aspects of ecosystem.

However, their monetary use table is prepared based on the proxy methods and is represented as:

S.No.	Description	Monetary use (crore Rs)
	PROVISIONING	
1	Timber	318
2	Fuelwood	1,857
3	Small Timber	641
4	Bamboo	20
5	Fodder	6,197
6	MFP	9,561
	REGULATING	
7	Carbon Sequestration	13,394
8	Water Availability & Purification	20,825
9	Air Purification	269
10	Soil Conservation	693
11	Pollination	13,727
	SUPPORTING	
12	Biodiversity Conservation	41,111
13	Nutrient Cycle	15,211
	CULTURAL	
14	Recreation	13,645
15	Education, Science	3,916