FOREST-PLUS: FOREST FOR WATER AND PROSPERITY (FOREST-PLUS 2.0)

Ecosystem Services Valuation Methods Strategy Paper

SEPTEMBER 2019

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Cover photo: Indian Peafowl (*Pavocristatus*) in Pocharam Wildlife Sanctuary in the Medak landscape.

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ECOSYSTEM SERVICES VALUATION METHODS STRATEGY PAPER

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ACRONYMS AND ABBREVIATIONS

CBA	Cost Benefit Analysis
CBD	Convention on Biological Diversity
CO_2	Carbon Dioxide
C-stock	Carbon Stock
CVM	Contingent Valuation Method
DBC	Deer Breeding Center
ED	Ecosystem Dependency Index
ES	Ecosystem Services
FAO	United Nations Food and Agriculture Organization
FHH	Female Headed Household
Forest-PLUS 2.0	Forest-PLUS: Forest for Water and Prosperity
FSI	Forest Survey of India
GDP	Gross Domestic Product
GIS	Geographic Information System
GoI	Government of India
ICFRE	Indian Council of Forestry Research and Extension
InVEST	Integrated Valuation of Ecosystem Services and Tradeoffs
MEA	Millennium Ecosystem Assessment
MoEFCC	Ministry of Environment, Forest and Climate Change
NOx	Nitrogen Oxide
NTFP	Non-Timber Forest Product
PES	Payment for Environmental Services
RS	Remote Sensing
SO_2	Sulfur Dioxide
SOC	Soil Organic Carbon
TAL	Terai Arc Landscape
TCM	Travel Cost Method
TEEB	The Economics of Ecosystems and Biodiversity

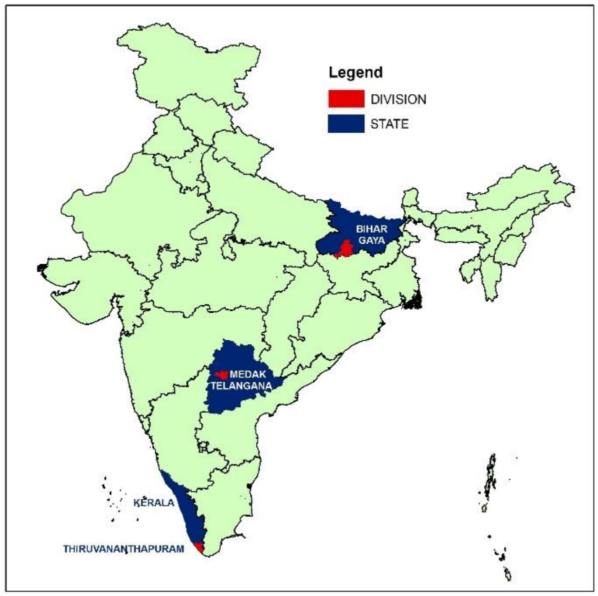
TEV	Total Economic Value
TOF	Trees Outside Forest
TTR	Thiruvananthapuram Territorial
TWL	Thiruvananthapuram Wildlife
USAID	United States Agency for International Development
VER	Verified Emission Reductions
VMP	Value of Marginal Product
WLS	Wildlife Sanctuary
WTA	Willingness to Accept
WTP	Willingness to Pay

1.0 INTRODUCTION

The purpose of the Forest-Plus: forest for water and prosperity (Forest-PLUS 2.0) program is to provide technical assistance that supports the Government of India and other stakeholders to manage forests as important components of broad-based, inclusive, and sustainable economic growth that meet local needs and addresses global environmental challenges.

In order to achieve the goal of this program—**improved management of targeted forest landscapes in India for enhanced ecosystem services and increased inclusive economic opportunities**—Forest-PLUS 2.0 will utilize an ecosystem-based forest management approach. The program relies on close coordination and cooperation among Forest-PLUS 2.0 implementing partners, State Forest Departments in targeted states, academic and research institutions, private sector entities, and forest-dependent communities.

FIGURE 1-1: PROJECT LANDSCAPES



Forest-PLUS 2.0's three objectives around which key tasks and activities are organized are:

- To strengthen ecosystem-based management of forest landscapes;
- To factor ecosystem services into management of forest landscapes; and
- To increase economic opportunities from improved landscape management.

To help meet these objectives, the program is identifying ecosystem services and defining their value to support management planning for forests inside and outside recorded areas. Valuation will also be used to develop incentive-based mechanisms between stakeholders within a landscape, leading to sustainable eco-friendly practices.

Forest-PLUS 2.0 is working in three landscapes: the Gaya Forest Division in Bihar, the Medak Forest Division in Telangana, and the Thiruvananthapuram Forest Division in Kerala.

2.0 ECOSYSTEM SERVICES VALUATION

2.1 BRIEF HISTORY OF ECOSYSTEM VALUATION

Communities dwelling in and around a natural environmental tend to have a high degree of dependency on those ecosystems. Even those communities who live further away from natural environments are dependent on the critical services provided by them through supply chains (Millennium Ecosystem Assessment [MEA], 2005). Similarly, businesses often fail to recognize that their existence and continued prosperity are reliant on the natural ecosystems. Generally speaking, businesses view biodiversity conservation is an "ethical" concern making it part of their corporate social responsibility initiatives and not core to their business (Porter and Kramer, 2006 and 2011; Krehmeyer et al., 2010; Ghosh, 2018).

Since the 1980s, increasing knowledge and better scientific understanding regarding the interface between nature, the economy, and society started changing perceptions in the developed world about the critical roles that natural ecosystems play in human endeavors. One of the earlier influences of this thinking came from the Club of Rome's apocalyptic predictions in its "The Limits to Growth" thesis (Meadows et al., 1972). It hit like a shock wave on the status quo. The response to this "approaching doomsday" was defined by extensive research and increasing knowledge of ecosystems, largely through global assessments and conventions (Ghosh, 2018). Countries that participated in the Earth Summit of 1992 eventually adopted the Brundtland Commission Report's definition of "sustainable development, "and the Convention on Biological Diversity (CBD) came into force in December 1993. With the CBD, international laws came to reflect the fact that conservation of biological diversity is integral to economic development. On the academic front, Pearce and Turner's 1989*Circular Economy* chartered a departure from the very reductionist linear growth model of "take, make, dispose" to a more holistic paradigm that conceives of the economy as being embedded in the ecosystem (Pearce and Turner 1989). This further helped to understand the bi-directional causality between economy and ecosystem.

The first publication to describe ecosystems providing "services" to human society was *Man's Impact on the Global Environment* by the Study of Critical Environmental Problems in 1970, which included a descriptive list of "environmental services." The list was later expanded by Holdren and Ehrlich (1974) to include more services. In subsequent publications, these services were referred to as "public services of the global ecosystem" and "nature's services"—finally coined as "ecosystem services" by Ehrlich and Ehrlich (1981).

The most comprehensive piece on the role of ecosystems in human societies and the classifications of the services provided by them appeared in the MEA of 2005. The assessment highlighted the fact that ecosystems function in their own inimitable ways to provide ecosystem services (benefits) to humans in the form of provisioning services (goods provided by the ecosystems in quantities), regulating services (the organic regulation aspect of the ecosystem through its natural functioning, e.g., pollution control), cultural services (tourism, religious, etc.), and above all, supporting services (umbrella services necessary for production of all other ecosystem services such as soil formation). The linkage between economy and ecosystems became much clearer with better delineation of ecosystem services.

The need to value ecosystem services was evident. Valuation exercises are driven by the objective that in order to understand and influence people and policy makers on the importance of goods and services provided by the ecosystem, it is important to place monetary values on them. One of the first attempts to place an economic value on ecosystem services was found in the USA in the 1950 report titled *Proposed Practices for Economic Analysis of River Basin Projects*, submitted to the **Federal Inter-Agency**

Committee on Water Resources by the **Sub-Committee on Evaluation Standards.** The Report was further modified and published in 1958. This drafting Sub-Committee was a multi-disciplinary one with expertise from Department of Commerce, Department of Health, Education and Welfare, Bureau of Reclamation of the Department of Interior, Chief of the Bureau of River Basins of the Federal Power Commission, Office of the Chief of the Engineers of Department of Army, and the Farm Economics Research Division of the Department of Agriculture. Efforts for valuation of ecosystem services continued throughout the following decades, although research and attention were expanded by two publications that helped the subject gain popularity. The first was N*ature's Services: Societal Dependence on Natural Ecosystems*, edited by Daily (1997) that discusses ecosystem services and their valuation and provides several case studies. The second was a paper by Costanza et al. (1997), "The Value of the World's Ecosystem Services and Natural Capital," that calculated the value of global ecosystem services at $33 trillion. Though their methods and result were often criticized, their papers served the purpose of bringing attention to and provoking discussion on ecosystem services valuation.

This paper proposes a framework valuing ecosystem services of three specific forest landscapes. The paper also presents the concept of ecosystem services, its classifications in terms of recent literature, a review of existing literature, possible ecosystem services of the three landscapes, methods of valuation, and the ecological economic rationales of choices of services and valuation methods.

Forest-PLUS 2.0 conducted an exhaustive literature survey to track the body of work on valuing forest ecosystem services to document best practices, what assumptions have been made, the strengths and limitations of the methods applied, and rationalize the proposed framework and choice of methods based on these. The survey is presented under two sections: (i) valuation studies in the global context, and (ii) valuation studies in the Indian context.

2.2 VALUATION STUDIES IN THE GLOBAL CONTEXT

Valuation studies on ecosystem services of forests have been conducted across the world. Pioneers in the last century such as Gray (1914), Hotelling (1934), and Lotka (1956) talked about valuation of natural resources. Lotka's study of biological species, Gray's scarcity rent of exhaustible resources, and Hotelling's work on the effects of depleting forests on welfare and the link between the values of natural resources with discount rates greatly influenced national income accounting (Kadekodi, 2001). Krutilla (1967) provided the first formal arguments for including existence value in benefit estimates of forests. Hanemann (1984) showed the relationship between the option value and the quasi option value. El Serafy (1989) argued for rules for charging rent for exploitation of resources. Cummings et al. (1986) supported the validity of the Contingent Valuation Methods. A variety of motivations for existence value have been proposed in the literature by Randall and Stol (1983), Boyle and Bishop (1985), Brookshire et al. (1986), and McConnell (1997).

Kramer et al. (1992 and 1995) studied alternative land uses of the Mantadia National Park in eastern Madagascar and looked at the options for land use including shifting cultivation, fuel wood production, and non-timber product collection by forest fringe communities, as well as tourism by foreigners. They also estimated the direct and indirect use and non-use values associated with the creation of the Mantadia National Park. Bennett and Reynolds (1993) undertook a financial cost benefit analysis (CBA) to rationalize between maintaining Sarawak Mangrove Forest Reserve, Malaysia, vis-à-vis its conversion for oil plantation and prawn ponds. Alumeida and Uhl (1995) studied the sustainable planning and use of reserves in the Brazilian Amazon by looking at the comparative CBA of logging, ranching, and rain fed crop production in Northeastern Brazil. Howard (1995) conducted a cost benefit analysis for Uganda's protected area system, including national protected areas, game reserves and forest reserves, and the estimated carbon sequestration option value of future spending by pharmaceutical and agrochemical companies for the use of protected genetic raw material, by applying net present value criterion.

Barbier (1992) distinguished among direct use values, indirect use values, and non-use values. With substantial development of literature on ecosystem service valuation, deforestation in tropical regions became widely acknowledged as a global threat (Barbier et al., 1994; Brown and Pearce, 1994; Dudley et al., 1995; and Sharma, 1992). Lesser known secondary forests in temperate regions were increasingly found to have a profound effect on the global supply of forest goods and services (Arnold, 1991; Sedjo and Lyon, 1990). The Centre for Social and Economic Research on the Global Environment (1992) estimated the values associated with forest conservation and management in monetary terms. The study generated estimates of option and existence values, potential value, implicit prices from conservation funding, use value (tourism and recreational values of protected and non-protected areas, non-timber forest products [NTFPs]) and some functional values (carbon sequestration and storage watershed protection).

Kumari (1995) used the total economic value (TEV) approach to study sustainable forest management for peat swamp forests in the Malaysian state of Selangor and inferred that carbon stock and timber comprised about 20 percent and 70 percent of total economic value, respectively. This study also pointed out uncertainties of economic valuation. Sedjo and Ley (1995) examined the use of forest as a sink of sequestered carbon in Argentina. They suggested that the benefits of carbon sequestration must be borne at a global level. Richard and O'Doherty (1995) defines benefit transfer in various valuation methods and shows that this can be supplemented for additional reliability by using the contingent valuation method (CVM). Garrod and Willis (1995), Whitehead (1995), and Holmes and Kramer (1995) have all written about the use of CVM in different ways.

Carson (1995) estimated the benefits of restricting the use of desert land by using dichotomous choice CVM and found that California residents are willing to pay $177 million to $448 million per year to enact desert protection legislation. Ready et al. (1995) attempted to resolve the ambivalence of respondents to contingent valuation over trade-off between money and changes in the levels of environmental amenities. Li and Mattison (1995) tried to estimate the value with discrete choice contingent valuation method and extended the theoretical framework developed by Hanemann (1984) and Cameron (1988) by introducing uncertainty with individual respondents and estimating forest value using survey data.

A host of studies ensued in the wake of the millennium (e.g., Ferraro and Simpson, 2002; Adamowicz, 2003; Pagiola et al., 2004; Garnett et al., 2007; and Bernard et al., 2009). These studies generally attempted to use methodologies to consider the stock and flows to the communities with an economic valuation of the ecological services it provides. The publication of the Millennium Ecosystem Assessment (MEA, 2005) reinvigorated studies on valuing ecosystem services by providing a framework to understand the classifications of ecosystem services and the existing forward and backward causalities.

Stedman et al. (2005) researched the relationship between forest dependency and community well-being. Mbairamadji (2009) inferred that forest ecosystems not only impact the economic endeavors of the dependent communities but also exert significant influence on their social structures and relations. Czajkowski et al. (2009) talked about valuing changes in forest diversity. Farley and Costanza (2010) extended the framework of valuation and explained its use in developing institutional mechanisms such as like Payment for Environmental Services (PES). In a study in Ethiopia, Tessemaet et al. (2010) found positive attitudes within communities toward wildlife and nearby forests due to their attraction for tourists and their value for future generations. Ojea et al. (2012) evaluated the role of forest in provisioning of water. Tao et al. (2012) estimated the value of forest ecosystem services of the afforested area of the Heshui watershed in Jiangxi province through a contingent valuation survey in 200 households in three counties. Mulenga et al. (2012) estimated the incomes from NTFPs using household survey data in Zambia. Lindemann-Matthies et al. (2013) found a community preference for high biodiversity value in China from the perspective of provisioning services. Ghosh and Uddhammar (2013) talked of evaluation of institutional processes of forest governance through enhanced cultural services (tourism) in cross-country studies conducted in Corbett Tiger Reserve (India) and east African forests of Serengeti-Ngorongoro and Masai Mara.

Povazan et al. (2015) and Rambonilaza et al. (2015) have made recent applications of non-market valuation methods in valuing protected areas in Eastern Europe. Pechanec et al. (2017) applied the PES principles for the monetary valuation of natural forest habitats, which were mapped in the Czech Republic in order to create the Natura 2000 European network. More recently, Strand et al. (2018) estimated spatially explicit values over a range of ecosystem services provided by the Brazilian Amazon forest. The services include food production (Brazil nut), raw material provision (rubber and timber), greenhouse gas mitigation (carbon dioxide [CO_2] emissions) and climate regulation. Highest values range from US$56.72 ± 10 ha/year to US$737 ± 134 ha/year but are restricted to only 12 percent of the remaining forest. Liu et al. (2019) estimated values of ecosystem services of a protected rainforest (Mengyang Reserve) in China, and the effectiveness of valuation of ecosystem services in the conservation of tropical reserves. Simon et al. (2019) estimated the perceptions of stakeholders regarding ecosystem services provided by tropical forests in south-eastern Cameroon through a survey and found that communities valued cultural and amenity services but were less aware of regulating services.

Ecosystem valuation efforts have sometimes created controversy, which has ultimately enriched the overall debate. For example, high values have been derived from tropical forests such as the economic values of Amazon forest. (e.g., Guiterrez and, Pearce 1992). Despite the valuation exercises, concerns have been expressed repeatedly that unrealistic numbers undermine the credibility of forest valuation in general. The most vocal criticism has been found against the CVM, where it has often been expressed that "stated preference" approaches are arbitrary (Hutchinson et al., 1995). Yet Anderson and Bojö (1992) felt that the case for sustainable use of forest resources cannot be served by resorting to improper use of the replacement cost method. Carrasco et al. (2014) also expressed that the existing methods of ecosystem service valuation fail to capture biodiversity value.

2.3 VALUATION STUDIES IN INDIA

According to the Indian Ministry of Statistics and Programme Implementation, the contribution of ecosystem services from forests to the Gross Domestic Product (GDP) of India is 1.23 percent. Studies conducted on valuation of forests in India highlight the deep-rooted inextricable linkages between forests and human livelihoods. Chaturvedi (1992) estimated the water supply benefits of Almora forests in one of the initial studies on valuation. Brandon and Hommann (1995) had earlier presented an estimate of the economic costs associated with environmental degradation in India, while James and Murty (1999) developed an approach to arrive at the same estimate using factor cost.

Hadker et al. (1997) studied the willingness to pay of residents of Bombay for conservation of Borivilli National Protected Area. Chopra and Kadekodi (1997) valued the ecosystem services of the Yamuna Basin using the contingent valuation method. Kadekodi and Ravindranath (1997) evaluated the value of carbon storage of forests at a national level. Chopra (1998) estimated the value of tourism and recreation of the Keoladeo National Park using the travel cost method. Haripriya (1999) also estimated the value of carbon storage services provided by Indian forests, using miscellaneous forest inventory data. A study by Haripriya (1999) of the Indira Gandhi Institute of Development Research on forest resources accounts revealed that if all direct benefits are accounted for, forest resources contribute around 2.9 percent to the Adjusted Net Domestic product of the country. Manoharan (2000) suggested economic values of different forest types in India after accounting for selected tangible and intangible benefits. Verma (2000) examined the contribution of forests in Himachal Pradesh in sustaining rural livelihoods and provisions for urban markets in terms of direct consumption and non-consumptive benefits. Hirway and Goswami (2004) estimated values of mangroves, including the replacement cost/value of mangroves in Gujarat. Different direct use and non-use values of mangroves at different levels were also estimated including the potential value of mangroves. Badola and Hussain (2005) provided an estimate of the values of services provided by the Bhitarkanika mangrove ecosystem in India and estimated cyclone damage avoided in three selected villages, taking the cyclone of 1999 as a reference point. The values were reached at by assessing the socio-economic status of the villages; the cyclone damage to houses, livestock, fisheries, trees, and other assets owned by the people; and the level and duration of flooding. Verma and Kumar (2006) conducted natural resource accounting for the forest and land sectors in Madhya Pradesh and Himachal Pradesh.

Badola et al. (2010) estimated the ecosystem services of Corbett Tiger Reserve in a comprehensive study. Vandermeulen et al. (2011) used 53 economic valuation methods to generate public support for green infrastructural investments in urban areas. World Bank (2013) used economic valuation for biodiversity at the national level. Bahuguna and Bisht (2013) estimated the value of ecosystem goods and services of the Indian forests. Vermaet al. (2013) also estimated the cost of forest diversion for non-forestry uses. In a much-highlighted report, Verma et al. (2015) estimated the values of 25 ecosystem services from six different landscapes in India. Brij Gopal and Dinesh Marothia's TEEB-India study on the economic analyses of Ken-Betwa link was on Panna Tiger Reserve valuation, but it entailed very sketchy account of taking averages of values of two forests from Verma (2015), namely, Kanha and Ranthambor. While Gopal and Marothia (2015) have come out with valid and credible inferences on Ken-Betwa link based on the exercise, from a forest valuation perspective, the question that is raised is whether benefit transfer approaches can be used at such large scales for all the ecosystem services considered in a forest as this leads to gross approximation. Ninan and Kontoleon (2016) conducted valuation of forest ecosystem services for Nagarhole National Park in Karnataka. Chaudhry (2016) estimated forest ecosystem services for Pakke Tiger Reserve in Arunachal Pradesh. Ghosh et al. (2016) calculated the landscape-level value of ecosystem services for Terai Arc Landscape (TAL) in Uttarakhand and emerged with an estimate of US$ 6 billion for the landscape in 2015-16. A recent survey paper prepared by Vermaet al. (2018) presented a review of existing ecosystem accounting initiatives and literature in India.

3.0 ECOSYSTEM SERVICES

3.1 CLASSIFICATION OF ECOSYSTEM SERVICES

Ecosystems provide various goods and services to society. These goods and services, rendered free of cost, enhance well-being directly and indirectly. The supply of these goods and services are often not registered by humans, though their role in the economy and society in general is vital and pervasive across the economy. The direct and indirect benefits obtained from ecosystems are defined as "ecosystem services" (ES) (Costanza et al., 1997; MEA, 2005; TEEB, 2011), and this concept addresses the critical linkage between ecosystems and human social welfare (Fisher et al., 2008). Ecosystem services play a crucial role in the overall well-being of humans and are vital to quality of life. They also carry significant cultural, aesthetic, and economic value.

The MEA defined ecosystem services as "*the benefits people obtain from ecosystems*" and assigns them into four different categories (Table 3-1):

TABLE 3-1: TYPES OF ECOSYSTEM SERVICES

Type of Ecosystem Services	Description
Regulating Services	Services obtained due to the regulation of natural processes and the control or modification of biotic and abiotic factors (e.g., air quality maintenance, climate regulation, water regulation, and erosion control).
Provisioning Services	Direct material resources such as food, freshwater, fuelwood, etc. obtained from the ecosystem.
Cultural Services	Intangible, non-material benefits obtained by the people in the form of spiritual and religious enrichment or recreation, etc., such as sacred groves, forest-based art and culture, and satisfaction derived from the way of life.
Supporting Services	Services that serve as basic necessities for the production of all other ecosystem services (e.g., primary production, and soil fertility).

While the above table presents the MEA classifications, the more recent assessments in TEEB (2011) outlines supporting services as "habitat services" while keeping aside some as ecosystem functions that support the services. In this context, it is important to define two more concepts: "ecosystem functions" and "natural capital" and their relations with ecosystem services. Costanzaet al. (1997, p. 254) define ecosystem functions as "... the habitat, biological, or system properties or processes of ecosystems." In other words, functions encompass the biological, geochemical, and physical processes and components organically occurring within an ecosystem. These functions, while relating to the broader ecosystem structures (e.g., vegetation, water, soil, atmosphere, and biota), emanate from interactive forces within and across ecosystems. Due to this interactivity from within and across ecosystems, ecosystem functions are also called "ecological processes."

However, Scott et al. (1998) provide further distinctions between processes and functions. According to them, processes are "interactions among elements of the ecosystem," functions are "aspects of the processes that affect humans or key aspects of the ecosystem itself … the purposes of the processes," while services are "attributes of ecological functions that are valued by humans" (p. 50). One may infer that functions occur biologically and chemically in ecosystems, regardless of human presence. Services are the benefits humans derive from the functions, where functions also encompass processes (Ghosh and Bandyopadhyay, 2009).

This study follows the MEA classification that is more broadly accepted and forms the basis of all global ecosystem assessments and valuation studies, while avoiding the double counting as noted by TEEB.

3.2 ECOSYSTEM SERVICES IN FOREST-PLUS 2.0 LANDSCAPES

The Forest-PLUS 2.0 program landscape selection process included a literature survey; an analysis of physiographic, ecological, and socio-cultural aspects for each landscape within the nominated states; and discussions with the Ministry of Environment, Forest, and Climate Change (MoEFCC); State Forest Departments; and other important stakeholders (state biodiversity boards, land boards, agriculture departments, horticulture departments, nongovernmental organizations, and civil society organizations) active in natural resource management in the landscapes. Selection criteria and considerations included:

- MoEFCC priorities;
- State Forest Departments' willingness to partner with Forest-PLUS 2.0;
- Ecoregion diversity;
- Forest cover;
- Potential for improving forest cover outside of recorded forest areas;
- Potential for enhanced ecosystem services delivery;
- Status of working plans;
- Socio-economic considerations;
- Potential for developing natural resources-based value chains (beyond subsistence); and
- Potential for replication.

Since Forest-PLUS 2.0 places emphasis on ecosystem services, especially water from forests, the team paid particular attention to water bodies in each landscape to understand better their management and that of stakeholders over water and associated beneficiaries. The team discussed their observations and information from the field visits with senior officers of the respective states, and the MoEFCC made the final decision. Table 3-2 below provides a snapshot of the three landscapes.

TABLE 3-2: SALIENT ASPECTS OF FOREST-PLUS 2.0 LANDSCAPES

Name of the Landscape	Wildlife Sanctuaries Included	Major Water Bodies	Total Area (in ha)	Total Forest Area (in ha)	Forest Area (percent)	Population (2011 Census)
Gaya	Gautam Buddha	Falgu River, 34 tanks (artificial)	65,4500	60,500	9.2	4,391,418
Thiruvananthapuram (Thiruvananthapuram Territorial [TTR] and Thiruvananthapuram Wildlife [TWL])	Neyyar, Peppara Wildlife Sanctuary (WLS), and Shendurney	Neyyar River, Neyyar Reservoir, Karamana River, Peppara Reservoir, Vamanapuram River, Kallada River, Kallada Reservoir, Shendurney River, Kazhuthurutty River, and Kulathupuzha River and tributaries	27,4831	58,134	21.1	3,301,427

Name of the Landscape	Wildlife Sanctuaries Included	Major Water Bodies	Total Area (in ha)	Total Forest Area (in ha)	Forest Area (percent)	Population (2011 Census)
Medak	Pocharam	130 tanks (5 natural; 125 artificial), Pocharam Reservoir, and Manjira Canal	205,100	75,000	36.5	3,033,288

The site selection process revealed two interesting facts. First, the three landscapes reflect forests in three zones on the Indian map: the Gaya landscape reflects an ecosystem in the Gangetic Plains of the north; the Medak landscape represents the south-central part of India; and the Thiruvananthapuram landscape represents the extreme south of the country. The landscape regimes and forest types allow a comparative analysis across ecosystems with different socio-economic-ecological characteristics. Second, in terms of economic assessments or importance in public and policy spaces, all three landscapes have been studied less than their counterparts in their respective regions.

An overview of the most salient ecosystem services provided within the selected landscapes is presented below:

3.2.1 MEDAK LANDSCAPE

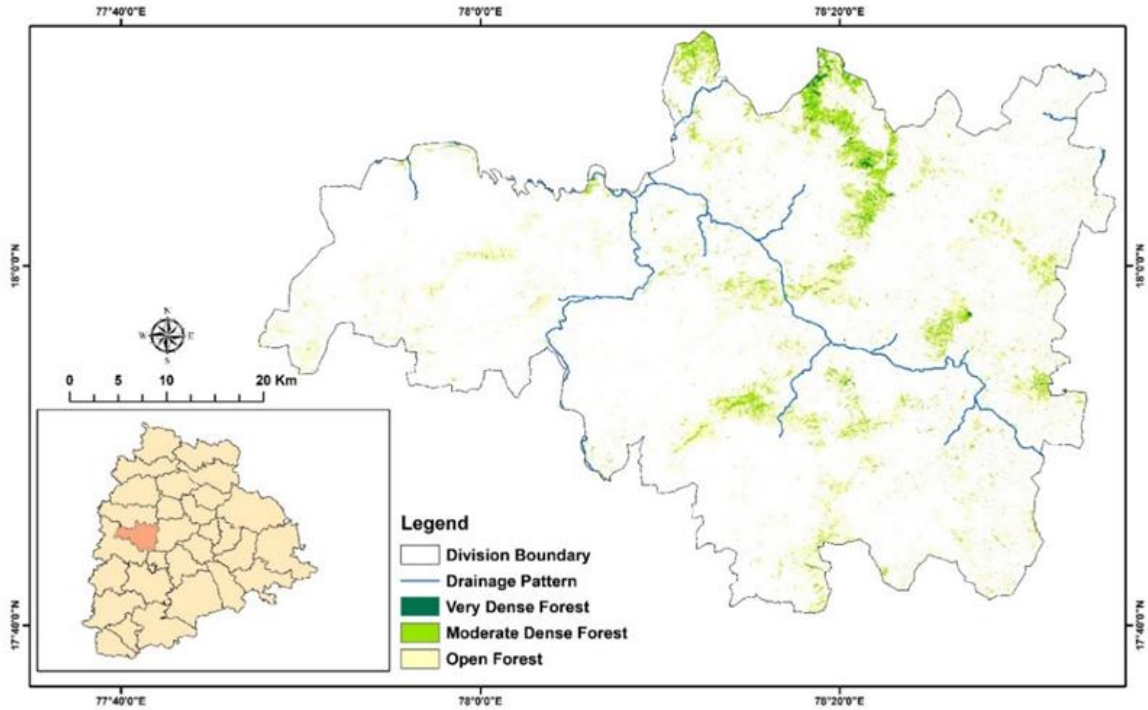
The Medak Forest Division is located in the central-west part of Telangana State. It has a semi-arid, hot, and dry climate. The forest division and administrative district boundaries are coterminous and form part of the Deccan Plateau, with undulating terrain. Major crops grown are paddy rice, maize, jowar, castor, sunflower, chilies, and pulses. The Manjira River, a tributary of the Godavari River, flows through the district and is the main source of water for the twin cities of Hyderabad and Secunderabad. The river supplies irrigation within and adjoining the landscape.

From Forest-PLUS 2.0 meetings with the Forest, Agriculture, Rural Development, and Revenue Departments, the team observed that many schemes are already working toward the goal of "greening the landscape" (generally referring to increasing biomass). Medak has large tracts of contiguous forest and has a high potential for planning trees outside forest (TOF). For example, the Telangana Government began implementing the Telanganaku Haritha Haram Program in 2015 to increase the green cover of the state from 24 percent in 2015 to 33 percent in 2020. The program envisages planting 2.3 billion trees, including 1 billion within forest areas over four years with help from different government departments and other stakeholders. The tree planting target for 2019-20 is 30 million, with 20 million to be planted in forest areas. With 14 million plants planted in 2018-19, the district administration has supported each Gram Panchayat to set up a nursery to raise 100,000 saplings.

The Pocharam WLS is located about 100 km from Hyderabad and 18 km from Medak. The sanctuary is 130 km^2: 80 km^2 in Kamareddy District and 50 km^2 in Medak District (Medak Forest Division). Two deer breeding centers (DBCs) have been established in Pocharam WLS. Tourists from Hyderabad and neighboring areas regularly visit the DBCs for animal safaris. Common animals include deer, dilgai, sambar, wild boars, and peacocks.

The Manjira WLS is a 20-km stretch of the Manjira River with 500 meters on either side of the river set aside to protect the more than 200 crocodiles that live there.

FIGURE 3-1: MEDAK LANDSCAPE



Ecosystem Services in Medak

Provisioning Services. The Medak Forest Division is a source of fruits, seeds, and medicinal plants for the local population. The main resources collected include teak, neem, mahua, sal, beedi leaves, and grass. Fruits such as sitaphal, chironji seeds, and medicinal herbs are also sourced from the forest. There are 216 forest fringe villages in the division out of a total of 469 villages. Large portions of recorded forest area are open forest, shrub forest, and areas devoid of trees. The availability of NTFPs is quite low. Beedi leaf (used for wrapping traditional cigarettes), Mahua flower and seed, custard apple, chironji, and marking nut are the important NTFPs available in the forest division. Both men and women collect these NTFPs from the forest and sell them in the local market. Beedi leaf is sold to the forest department. Women generally sell custard apple in the retail market. Some medicinal plants are extracted from the forest, especially in the Narsapur area, and sold to traders in Hyderabad and other locations. No value addition is done to the NTFPs.

The villagers also collect fiber and fuelwood from the forest, but the availability of alternatives has reduced collection. The local population, especially the indigenous population, rely on the natural medicines and pharmaceuticals for their livelihood and health.

Regulating Services. The Medak Forest provides key regulating services in terms of air quality regulation, climate regulation, water regulation (water conservation, water quality and health maintenance), carbon sequestration, and regulation of natural hazards (storms, flooding, etc.). Farmers and forest-based communities benefit from the enhanced forest and food productivity, pest and disease regulation as well as from erosion regulation that protects the vegetation cover and topsoil. The high magnitude of pollination benefits everyone locally as well as regionally by maintaining the richness of biodiversity.

Cultural Services. The Medak landscape forests provide the local population with avenues for eco-tourism, as well as spiritual and religious tourism. The landscape contains sacred groves that are protected and worshipped by the communities.

Supporting Services. The community receives various benefits from the supporting services that occur in the Medak landscape. These mainly include provision of biodiversity, soil formation, primary production, and nutrient cycling.

3.2.2 GAYA LANDSCAPE

The Gaya Forest Division, in the south of Bihar and bordering Jharkhand, is an important cultural heritage site. Buddha is believed to have attained enlightenment at Bodh Gaya, making it an important Buddhist pilgrimage site. There are other places in the landscape of religious significance to Hindus and Jains. The landscape is densely populated, with agriculture being the primary occupation.

The forest cover in the division is sparse, though there is significant potential for TOF in the area. To combat the declining state of the resource base, the state has created schemes to promote plantations, set up nurseries, and incentivize farmers to ensure the survival of plants. The state government is implementing an agroforestry scheme based on poplars wherein planting material is given for free to farmers to plant trees on their farms. Based on the survival, the government provides incentives to the farmers. The state has set a target of reaching 17 percent tree cover by 2022, from 7.75 percent as of 2017. The Hariyali Mission scheme, launched in 2012 under the Government of Bihar's Department of Environment, Forest, and Climate Change, has been working toward this target. The local government has prepared a State Policy on Agroforestry in 2018 to create dedicated institutional and collaborative mechanism to work on agroforestry. The Falgu/Phalgu River, a tributary of the Ganga, serves Gaya Town and District and runs south to north in the division. Formed by the confluence of two streams (Lilajan and Mohana), this non-perennial river's flow increases largely during the rainy season.

The Gautam Buddha WLS is an important part of the landscape, covering 259 km^2 and located on the hills and undulating tracts north of hilly terrain that is an extension of the Chhotanagpur Plateau. Among the wildlife found in the sanctuary are tigers, leopards, hyenas, sloth bears, wolves, wild dogs, wild boars, sambhars, spotted deer, and nilgai.

Ecosystem Services in Gaya

Provisioning Services. Water provisioning is among the most important ecosystem services of the Gaya landscape. The area is crisscrossed by the traditional Ahar Pyne (irrigation canal and storage tank) system as irrigation takes place mainly through these channels. Nearly all the villages have access to drinking water, but only 1 percent of households in rural areas have access to piped water. Water quality problems exist in the district due to fluoride contamination from mining and fertilizer run-off.

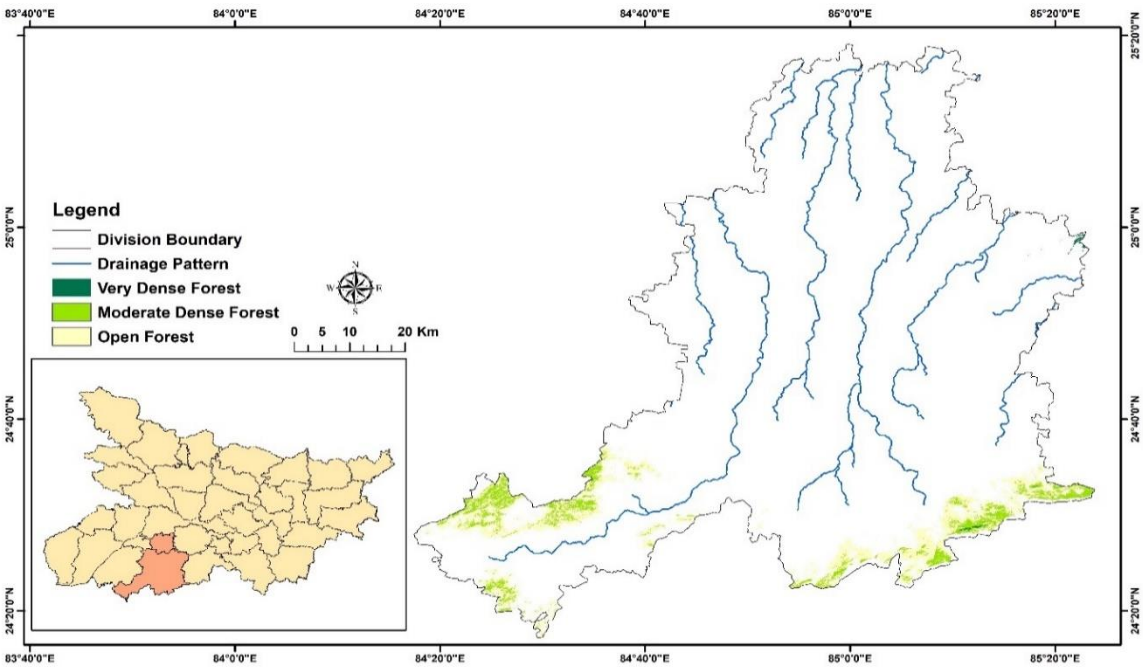
The Gautam Buddha WLS provides the forest fringe villages with fuelwood, fodder, and other minor products (e.g., bael, mahua, and beedi leaves). However, collection and use of these products are predominantly for subsistence, with only nominal selling of fuelwood and seasonal fruits in the local market. The district is characterized by high dependence on natural resources, which puts heavy pressure on the already degraded forest.

Regulating Services. In addition to water, fuel, and food, the forest ecosystem plays a role in regulating air quality and climate, natural hazard and pest regulation, and carbon sequestration. The forest is the origin of many small seasonal streams that feed into the irrigation system, and it regulates by filtering sub-surface and surface water flows. Associated services of erosion control, pollination, and water purification/waste treatment from the forest benefit everyone.

Cultural Services. Beyond aesthetics, tourists and the local population benefit from the region's cultural heritage, spiritual and religious tourism, ecotourism, and art, folklore, and architecture that are sources of recreation and livelihoods.

Supporting Services. Farmers and the local population benefit from soil formation, primary production, nutrient cycling, and provision of habitat.

FIGURE 3-2:GAYA LANDSCAPE

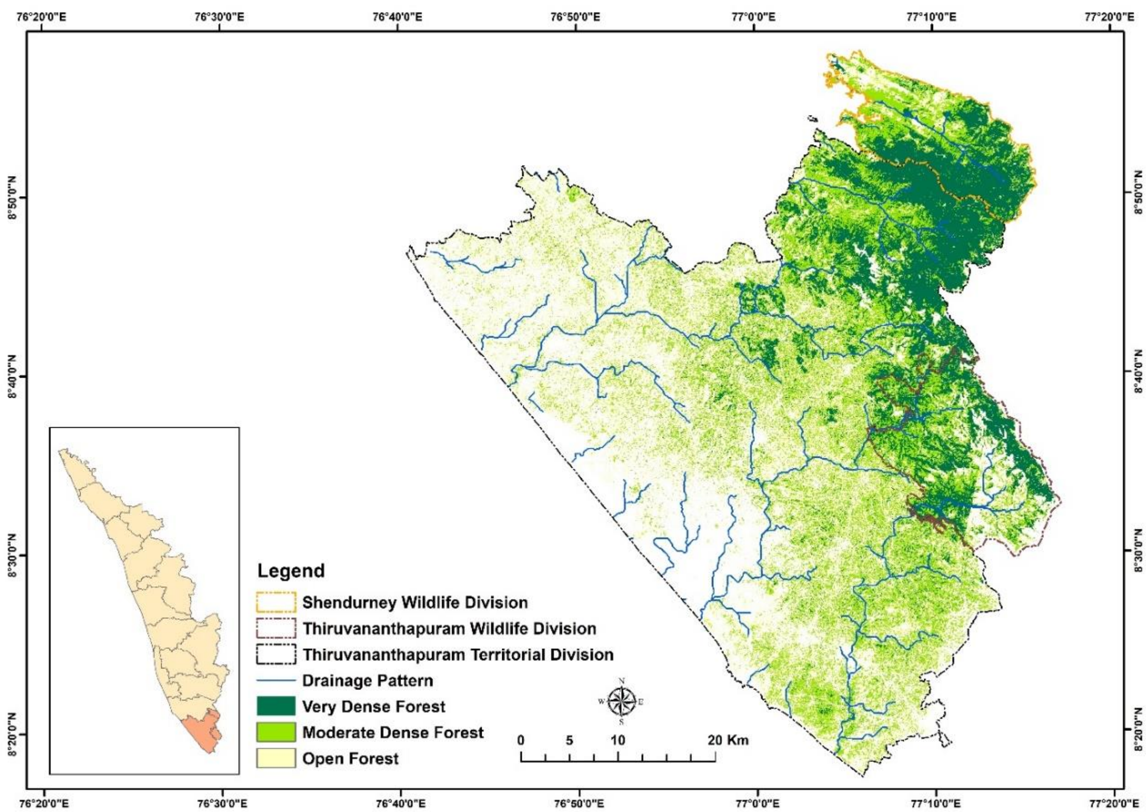


3.2.3 THIRUVANANTHAPURAM LANDSCAPE

The Thiruvananthapuram landscape at the southern tip of Kerala encompasses two divisions: Thiruvananthapuram Territorial (TTR) and Thiruvananthapuram Wildlife (TWL) divisions with headquarters in Thiruvananthapuram City (and State Forest Department headquarters). This area is rich in biodiversity, both terrestrial and aquatic. With picturesque undulating terrain and water bodies, it is ideal for ecotourism. Though there is an ecotourism infrastructure in the terrain, there is scope for much more. The communities utilize the natural resources for both subsistence and commercial purposes. Vanasree, a community-owned enterprise, produces and sells value-added forest products through a chain of retail outlets. The landscape is densely populated, with Thiruvananthapuram being the largest urban center in the state.

The landscape includes 108 small sacred groves primarily located in the lowland and midland regions. Most of the groves are associated with temples, while some of them are privately held. The Karamana and Neyyar are the two major rivers crossing the landscape, originating from Chemunji Mottai and Agasthyarkoodam mountains in the Western Ghats. The river basins exhibit major land use and land cover change with encroachments along flood plains and within riverbeds, indiscriminate dumping of waste and sewage, and construction of buildings and houses right up to the river front that impact fluvial function negatively. The major reservoirs of Aruvikara, Peppara, and Karamana and the Neyyar Dam on the Neyyar River cater to the water supply of Thiruvananthapuram and the adjoining areas. The Peppara Reservoir is the main water source for Thiruvananthapuram City, and the Neyyar Reservoir is the main source of water for five other Gram Panchayatsin the landscape. The watershed of both these reservoirs falls within the TWL division. The reservoirs' capacities are decreasing due to increased siltation caused by degradation of the hill slopes surrounding the reservoirs.

FIGURE 3-3: THIRUVANANTHAPURAM LANDSCAPE



Ecosystem Services in Thiruvananthapuram

Provisioning Services. The Thiruvananthapuram landscape supports a large tract of forest land that provides fresh water for irrigation and drinking. The forest also accounts for diverse NTFPs collected and used by communities for food, medicine, and commercial purposes. There are at present 41 collection centers and 11 value addition centers located in the state's forest areas that are linked to the state-run Vanasree initiative. Through these collection centers, forest protection committees and eco-development committees purchase NTFPs including medicinal plants from the tribal communities, provide value addition and sell the products in Vanasree outlets. The products include honey; oils produced from lemongrass, sandalwood, and eucalyptus; sandalwood soap; and spices.

Regulating Services. In terms of regulating services, the forest aids in air quality and climate regulation, water flow regulation, and natural hazard regulation. Carbon sequestration is also an important regulating service.

Cultural Services. Thiruvananthapuram has seven ecotourism destinations visited by about 840,000 people annually. The sacred groves and temples together provide cultural services, beyond their intrinsic aesthetic value, to locals and tourists.

Supporting Services. Supporting services present in Thiruvananthapuram landscape include nutrient cycling, soil formation, primary production, and provision of habitat.

4.0 VALUATION METHODS

This section reviews existing valuation techniques and links ecosystem services to the techniques most appropriate for valuation.

4.1 DESCRIPTION OF VALUATION TECHNIQUES

At the highest level, valuation of ecosystem services can be conceptualized as the:

1) Value of the good or service in the consumer's utility bundle; or
2) Value of the good or service as an input in the production function.

The first option entails, in some form or the other, a delineation of a utility/demand function. The second option is a production function approach. One of the subsections below describes the production function approach in further details.

Generally, the valuation techniques with utility function-based approaches are further classified as:

1) Stated preference approaches, which use contingent valuation method, contingent ranking, or conjoint analysis; or
2) Revealed preference approaches, which are based on the actual market behavior of agents and use surrogate market approaches (travel cost and hedonic pricing methods) and conventional market approaches such as dose-response and replacement costs.

Another approach is the benefit transfer method which is widely used for valuation of ecosystem services under conditions of non-viability of an original valuation study, usually due to data, budget, or time constraints. This approach uses a value estimated from a different study as a proxy.

4.1.1 STATED PREFERENCE APPROACHES

Stated preference valuation techniques are usually based on questionnaire survey, where people are asked directly to state their willingness to pay (or accept) or ranking for an improvement (or decline) in the quantity or quality of an ecosystem service. In the process of delineating alternative scenarios, a hypothetical market is created for the respondent to state their preferences. The three techniques under stated preference are discussed below:

Contingent Valuation Method

The CVM, originally proposed by Davis (1963), entails asking respondents about their willingness-to-pay or accept (WTP/WTA) for any specified environmental good/service quantity/quality improvement. This technique has six stages:

- Setting up a hypothetical market;
- Obtaining bids;
- Estimating mean WTP and/or WTA;
- Estimating bid curves;

- Aggregating the data; and
- Evaluating the Contingent Value.

While CVM has been widely used for estimating both use and non-use values (as stated in the literature survey), the major criticism against this method arises due to potential response biases that exist in the form of:

1) Strategic bias, which arises if respondents intentionally give responses that do not reflect their true values; and

2) Hypothetical Bias, which arises because respondents are not making real transactions (Kriström 1997)

Contingent Ranking Approach

The contingent ranking approach involves asking respondents to rank a large number of alternatives of various combinations of non-marketed ecosystem goods and services. The shortcoming of this method is that it is difficult to find a complete ranking and may not yield specific monetary values of the ecosystem services valued.

Conjoint Analysis

Under conjoint analysis, a respondent is faced with a large number of ranking tasks and each following ranking task involves a smaller number of alternatives. It is different from contingent valuation and contingent ranking where large number of individuals are asked about their stated preferences for one set of alternatives. Although conjoint analysis has its applications in psychology, marketing, and behavioral sciences, conjoint analysis gives unstable results from the perspective of individual choice theory (Marder, 1999).

4.1.2 REVEALED PREFERENCE APPROACHES

Revealed preference approaches attempt to determine the preferences from actual, observed market behavior of individuals. Revealed preference approaches include:

Surrogate Market Approach

This approach entails analyzing the existing markets for goods and services that are intricately linked with non-marketed ecosystem services. In this situation, individuals reveal their preferences for the market services when they purchase the market goods through their actual behavior. The various methods used under this are:

1) *Hedonic Pricing of Ecosystem Services*: The hedonic price method is based on the premise that the attributes of a good or service can be defined as a bundle and the price is defined by the forces of demand and supply in the goods market. The hedonic pricing approach applies econometric techniques to data on private good characteristics and prices to derive estimates of the implicit prices for environmental quality. This method is widely used to study the implicit prices of changes in air quality, noise, and proximity to waste sites (Smith and Huang, 1995 and Farber, 1998). It has, however, limited applications in developing nations like India, where ecological considerations have so far hardly been found to be a determinant behind consumption decisions or property choices.

2) *Travel Cost Method (TCM)*: TCM values a recreational site by using the value of time and other costs incurred in visiting the site as a proxy for what a visitor would be willing to pay to visit the

site. The most basic version of TCM is a continuous demand model for a single site to generate the individual's demand function for the site, from which consumer surplus can be calculated and aggregated across the individuals. According to Pearce and Moran (1994) the following are the main steps in TCM:

a) Site selection;

b) Zoning of the site;

c) Survey of representative sample of individuals visiting the site;

d) Obtainment of the visitation rates for each zone;

e) Estimation of travel cost;

f) Derivation and statistical regression;

g) Construction of demand curve;

h) Estimation of consumer surplus; and

i) Estimation of the benefits of environmental improvement.

3) *Averting Behavior Method*: In this approach, market prices of substitutes for non-marketed ecosystem services are used to value the latter. This is achieved by estimating the marginal rate of substitution between the environmental goods and substitute private goods and ultimately the calculation of the value per unit change of the environmental good. Although this method is apparently robust, it is hardly used, primarily because such substitutability might be rare to find.

Conventional Market Approaches

Any loss of ecosystem goods and services leads to reduction in individual well-being. This can be estimated through losses in productive assets or earning power. An individual may be compensated to maintain or restore the well-being at their initial state in terms of money or other goods by the amount of loss. This mode of estimating non-market environmental services is known as conventional market approach or damage function approach. The approach is applied in either the dose-response approach or replacement cost approach.

1) *Dose Response Approach:* This method attempts to establish a relationship between environmental damage (response) and some cause of the damage such as pollution (dose) (Pearce and Moran, 1994). Cause of damage is correlated with the change in output, which can be valued by the market using revealed/inferred or shadow prices.

2) *Replacement or Avoided Cost Approach:* This approach looks at the cost of replacing or restoring the damaged asset to its original state and use this avoided cost as a measure of the benefit of restoration (Ghosh, 2018).

Generally, revealed preference approaches are based on actual market behavior, and are considered to be more authentic than the stated preference approached. The arbitrariness in estimates in stated preference approaches have often been criticized, therefore the authors try to apply revealed preference approaches as much as possible.

4.1.3 BENEFIT TRANSFER

When the data on environmental values of a specific site are not available due to limited resources, budget, or time, estimates from previous studies on similar ecosystem services are used as a proxy. Since the estimates of economic benefits are "transferred" from a site where the study has already been conducted to the newly selected site, the approach is known as benefit transfer. Benefit transfer generally takes place in the following ways:

- Transferring average benefit estimates;
- Transferring adjusted average benefit values; and
- Transferring benefit functions.

The simplest way to transfer benefit is to use the unit day approach. This entails valuing the same activity at alternate sites with existing values for activity days. The "unit day values" are adjusted to fit into the study site. That said, a benefit function transfer entails a more rigorous approach. A benefit function may statistically relate respondents' WTP to ecosystem services. The transfer of a benefit function will incorporate the adjustments with respect to the characteristics of the study site (Barbera, 2010). Generally, a meta-analysis is conducted to arrive at the figures.

4.1.4 PRODUCTION FUNCTION APPROACH

From an economic theory point of view, production function approach is the most robust approach of estimation because it values the contribution of an ecosystem service in the production of a marketed good. This entails mathematical optimization and econometric techniques and has been discussed in detail while discussing valuation of agricultural waters. This also has its applications in resource economics for estimation of scarcity value of a resource (Ghosh and Bandyopadhyay, 2009).

Table 4-1 summarizes the advantages and disadvantages of using the approaches described above:

TABLE 4-1: VALUATION TECHNIQUES AND THEIR ADVANTAGES/DISADVANTAGES

Valuation Approach	Method	Advantages	Disadvantages
Stated Preference	Contingent Valuation Method	• For non-market goods such as environmental services, CVM (if properly employed) can provide a fairly accurate assessment of individual preferences. • Estimated WTP values can be incorporated into monetary based cost-benefit analyses. • Helps create a basis of valuation of changes in amenities that are not physically present, through hypothetical scenarios.	• Difficult to administer. • Strategic bias arises if respondents intentionally give responses that do not reflect their true values. • Hypothetical bias arises because respondents are actually not making real transactions.

Valuation Approach	Method	Advantages	Disadvantages
	Contingent Ranking	• Helps in ranking and understanding individual preferences.	• Doesn't aid monetary valuation; only helps in ordinal measurements. • Difficult to find a complete ranking.
	Conjoint Analysis	• Has wide applications in psychology, marketing, and behavioral sciences. • Helps in product positioning in markets.	• Prone to provide very unstable results due to sampling and measurement errors.
Revealed Preference – Surrogate Markets	Hedonic Pricing	• Market based and therefore provides actual market behaviors. • Applies rigorous econometric techniques to data on private good characteristics and prices to derive estimates of the implicit prices for environmental quality. • Widely used to study the implicit prices of changes in air quality, noise, and proximity to waste sites.	• Has potentially limited application in spaces where ecological considerations have infrequently been found to be a determinant behind consumption decisions or property choices.
	Travel Cost Method	• Market based and therefore captures actual market behaviors. • Applies rigorous econometric techniques to data on private good characteristics and prices to derive estimates of the implicit prices for environmental quality. • Sound theoretical economic background supports this method.	• Costly to administer. • Limited application for valuing "cultural services" only.
	Averting Behavior Method	• Based on estimating the marginal rate of substitution between the environmental goods and substitute private goods and ultimately the calculation of the value per unit change of the environmental good. • This method is apparently robust.	• It is hardly used, primarily because such substitutability might be rare to find.

Valuation Approach	Method	Advantages	Disadvantages
Revealed Preference – Conventional Markets	Dose Response Method	• Attempts to establish a relationship between environmental damage (response) and some cause of the damage such as pollution (dose). Cause of damage is correlated with the change in output, which is valued by the market using revealed/inferred or shadow prices. Understanding of the causal relation leading to valuation is a strength of this analysis.	• In cases of ecosystem services, it has often been difficult to obtain the causal relation between changes in ecosystem structure, functions, and eventually services. Hence, this approach may fail under such circumstances.
	Replacement Cost Method	• Market-based and easy to administer.	• From an ecosystem service perspective, under conditions of irreplaceability and non-substitutability of ecosystems, there remain questions on the use of this technique.
Benefit Transfer		• Easy to administer. • Inexpensive. • Less time-consuming. • Helpful in situations where a host of ecosystem services are to be included to estimate the total economic values of ecosystem services.	• May result in arbitrariness. • May not capture the true nature of the ecosystem structure and services.
Production Function Approach		• Highly rigorous approach from an economic and econometric perspective.	• Application is confined to situations where ecosystem services could be linked to production processes (not consumption).

4.2 PROPOSED METHODS OF VALUATION FOR FOREST-PLUS 2.0

This section proposes the methods to be used for valuation of different ecosystem services in the Forest-PLUS 2.0 landscapes. Forest-PLUS 2.0 proposes to take up valuation of 22 selected ecosystem services that occur under the four classifications:

1) Provisioning services such as water for agriculture, water for urban-industrial use, food, medicinal plants, timber stock, timber flow, fuel, fodder, other NTFPs, and soil fertility;

2) Regulating services such as water conservation, water purification, biological control, flood regulation, moderating extreme events, carbon sequestration, air pollution control, and erosion control;

3) Supporting services such as gene-pool protection, pollination, and habitat services of biodiversity; and

4) Cultural services such as tourism and recreational values and cultural and spiritual values.

As stated in Section 1, Forest-PLUS 2.0 will not combine values of the supporting services with the other three to avoid the possibility of any form of double counting.

For each ecosystem service, the authors considered the appropriateness of all the valuation techniques explained in the section above, their merits and demerits, and advantages and disadvantages (stated above); availability of data to perform the valuation exercise; and the studies that have been done from the literature (please see section on past valuation studies).Other factors include feasibility issues such as the time frame for data collection and the cost of doing the entire exercise. Based on this Forest-PLUS 2.0 proposes the following valuation methods to be applied to the ecosystem services that have been identified for valuation.

4.2.1 WATER FOR AGRICULTURE: PRODUCTION FUNCTION APPROACH

One form of the multifunctional attributes of water is its application in agriculture. The production function approach will be considered for obtaining the estimate of the value of water in agriculture. The value of marginal product (VMP) of water is multiplied with the total water use to obtain the value of its contribution, e.g., the water provisioned for agriculture. From an ecosystem service perspective, nature provides water through various sources (meteorological, hydrological, and hydro-geological, among others). The marginal product of water is essentially reflected properly only when one takes the total water use, and not merely irrigation water. This model does not consider impacts of return flows, as it is irrelevant from the perspective of total value of water provisioning service. It is assumed in this framework that all water is provisioned from nature and reflects on the provisioning service.

$$Y_{ist} = \lambda . W_{ist}{}^{\alpha} \ldots (1)$$

Y_{ist} = production of the ith crop for season s in year t;

W_{ist} = Water use for the ith crop for season s in year t;

λ and α are the parameters.

Further, $W_{ist} = \omega_i . A_{ist} \ldots (2)$

ω_i = Crop - Water Requirement for ith crop;

A_{ist} = Area under the ith crop for season s in year t;

The log - linear format of the production function is

$$\ln Y_{ist} = \ln \lambda + \alpha . \ln W_{ist} \ldots (3)$$

$$or, \frac{\partial Y_{ist}}{\partial W_{ist}} = \alpha . \frac{Y_{ist}}{W_{ist}} = \frac{\alpha}{\omega} . \frac{Y_{ist}}{A_{ist}} \ldots (4)$$

Estimate α from time - series data or through benefit transfer.

$$\text{Value of irrigation water will be} = \sum_i P_i . W_i . \frac{\partial Y_i}{\partial W_i} \ldots (5)$$

The mathematical framework is as follows:

The coefficients of slope and the intercept of the log-linear model will be estimated through an econometric model with fixed-effects panel data regression. The data considered will be at the district level. Water-use estimates will be arrived at by multiplying area with crop-water requirement. This exercise will largely be based on secondary data from the *Season and Crop Report* and Departments of Economics and Statistics of each state. Once the coefficients are obtained, the slope coefficient of the log-linear model will be multiplied with the average product of water to obtain the marginal product of water. This will require taking data for the necessary econometric framework.

4.2.2 FOOD AND MEDICINAL PLANTS

Under the head of food, produced/harvested fruits, NTFPs, and other forest-based resources will be considered. The data will be obtained from questionnaire surveys. The market prices of these food items or their substitutes (surrogate markets) will be considered and multiplied with the quantities to obtain the values of the various food items.

Even in the case of medicinal plants that are accessed free of cost by the communities, the same approach of valuation will be considered through surrogate market approaches.

4.2.3 TIMBER FLOW AND TIMBER STOCK

The value of timber through licensed felling will be estimated with the local market price of timber by adjusting for management and transportation costs. Further, the standing timber biomass represents the stock benefits. The same method of using the market prices and multiplying that by the quantity will give us the value of the timber stock.

4.2.4 WATER FOR URBAN-INDUSTRIAL USE

Since the authors will primarily consider municipal water use, municipal operations and maintenance costs will be considered and the economic cost of procurement and distribution per unit and the environmental costs through benefit transfer approaches added. Further, Forest-PLUS 2.0 proposes to obtain the value of consumer surplus from past demand estimations for urban-industrial water as another application of benefit transfer, make the necessary adjustments with respect to the price subsidies offered by the municipality, and add the consumer surplus accordingly to the marginal costs (that are supposed to reflect the prices). The costs need to be adjusted with the Wholesale Price Index to arrive at the value of urban-industrial water.

4.2.5 FUEL, FODDER, AND OTHER NTFPS

Primary data on quantities will be collected through unstructured interviews and questionnaire surveys. In case they are marketed, the market price will be multiplied with the quantity, and if not marketed, surrogate market methods will be used to arrive at the values.

4.2.6 WATER CONSERVATION

Water conservation can be stated to be a regulating service of the ecosystem which reduces surface run-off. The value will be estimated through a combination of benefit transfer and surrogate market or alternative cost methods. While the amount of water conserved will be taken from past estimates in related sites, the economic cost of storage will be considered from alternative storage mechanisms that will include the capital expenditure and the operations and maintenance costs.

4.2.7 GENE-POOL PROTECTION

Gene-pool protection is a critical supporting service of the ecosystem. A meta-analysis will be conducted to obtain the value per area and will be multiplied by the total landscape area to arrive at this value.

4.2.8 WATER PURIFICATION

Water purification is a regulating service of the ecosystem. This value will be obtained through estimation of water-use by obtaining population data from Census 2011, and making necessary projections, and then multiplying the population by average per capita water use in adjoining areas with data from municipality and local governments. If certain data are not available, average water per capita water consumption estimates from other studies conducted in India will be used. These figures will be multiplied with the cost of water treatment, as available from the market.

4.2.9 BIOLOGICAL CONTROL

Biological control is a very important regulating service of the natural ecosystems. They moderate the risk of spread of infectious diseases by regulating the populations of disease organisms and agents that cause such diseases. Since site-specific studies for estimating the economic values are not available, the only option will be benefit transfer mechanisms. The unit area values will be arrived at by deriving a mean value from other similar studies through a meta-analysis and will be multiplied by the total area to obtain the ecosystem service values.

4.2.10 POLLINATION

The role of forests in pollination as a supporting service of the ecosystem can be evaluated through meta-analysis only. This will entail obtaining means of estimates of the amount of pollination, getting alternate markets prices of creating pollinators, and multiplying them. The other way is through surrogate market methods, where one looks at alternate ways of increasing the quantity and quality of pollinator-dependent crops in absence of pollinators, such as pollination by hand, and then apply the costs of the alternative methods. This will be decided in due course while conducting the exercise.

4.2.11 FLOOD REGULATION AND MODERATING EXTREME EVENTS

Forests help in regulating flood damages by retaining excess rainwater and preventing extreme run-offs. For estimating these, as stated earlier in Section 5, the avoided costs of losses to property will be considered by taking the estimates of water retention capacity of the landscape and possible flooding scenarios without the forests. This has previously been conducted by Ghosh et al. (2016) in other circumstances.

4.2.12 CARBON SEQUESTRATION

Carbon stock will be estimated with Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) or alternately in the ways as stated in Section 4.1.2. The quantity will be multiplied with the price of carbon credits in voluntary markets or with Verified Emission Reductions (VER) credits. Although an underestimate (as explained later in this paper), this will shed light on the importance of carbon sequestration of these landscapes to humanity.

4.2.13 AIR POLLUTION CONTROL

This is another regulating service of the ecosystem. This study will consider sulfur dioxide ($SO_{2)}$ and nitrogen oxide (NO_X), and past estimates on the control of pollutants, and multiply them with prevailing prices of pollution control. This is similar to the surrogate market approach.

4.2.14 SOIL FERTILITY

Forest vegetation increases the fertility of the land by adding nutrients. The impact is felt in agriculture. The total fertility enhancement will be determined by considering the total area and possible fertility enhancement capacity of the forest from existing estimates. This will be multiplied by the unit price of fertilizer to arrive at an estimate.

4.2.15 TOURISM AND OTHER RECREATIONAL VALUES

Travel cost method is proposed to be used here. A questionnaire survey will be used to derive a tourism demand function. The sum of the average tourist spending and the consumer surplus will give us the value of the landscape from the perspective of tourism. If tourism purposes are found to be different for different respondents, multiple demand functions will be developed and multiple values will be taken.

4.2.16 BIODIVERSITY AS A HABITAT FOR SPECIES

In a recent estimate by Costanza et al. (2014), the value of habitat services has been considered. Here, the authors will consider the benefit transfer approach, consider per unit value from existing literature base and multiply it with the area of the landscapes.

4.2.17 EROSION CONTROL

Forests help in control of soil erosion. Had the forest not been there, basic erosion prevention techniques with plantations, shrubs, grass, or mulch would have been put in place for controlling erosion, and costs would have been incurred. The cost that would have been incurred in the process will be estimated and presented as the value of erosion control through the avoided cost approach because of the existence of the ecosystem.

4.2.18 CULTURAL AND SPIRITUAL VALUES

Often these services are difficult to be monetarily valued. The difficulty arises as respondents feel that such services are irreplaceable and not substitutable. However, a "willingness-to-accept" measure for the loss of this service will be applied.

TABLE 4-2: A SUMMARY OF THE METHODOLOGICAL APPROACH TO VALUATION OF THE ECOSYSTEM SERVICES IN THE THREE FOREST LANDSCAPE

ES Classification	Type of Ecosystem Service	Valuation Approach	Methodology	Data Sources
Provisioning Services	Water for agriculture	Production function approach	The VMP of water is multiplied with the total water use to obtain the value of its contribution	Area and production data will be obtained from the Season and Crop Report and Department of Economics and Statistics of each state.
	Food and medicinal plants	Market price method	Market prices of the food and medicinal plant items or their substitutes (surrogate markets) will be considered and multiplied with the quantities to obtain the values of the various food items.	The data will be obtained from questionnaire surveys.
	Timber flow and timber stock	Market price method	The market prices will be multiplied with the quantity of the stock and flow.	The data will be obtained from Forest Department offices.
	Water for urban-industrial use	Combination of market prices and benefit transfer method	The municipal operations and maintenance costs will be used and the economic cost of procurement and distribution per unit and the environmental costs will be added. Value of consumer surplus will be obtained from past demand estimations and added. The costs need to be adjusted with the Wholesale Price Index to arrive at the value of urban-industrial water.	Data will be obtained from Municipal corporation, past estimates, and the Reserve Bank of India databases (for WPI).
	Fuel, fodder, and other NTFPs	Market price and surrogate market methods.	In case they are marketed, the market price will be multiplied with the quantity, and if not marketed, surrogate market methods will be used to arrive at the values.	For each of the services like fuel, fodder, and various NTFPs primary data on quantities through unstructured interviews and questionnaire surveys will be obtained.
Supporting Services	Gene-pool protection	Benefit transfer	A meta-analysis will be conducted to obtain the value per area and will be multiplied by the total landscape area to arrive at this value.	Data will be obtained from past estimates.
	Pollination	Benefit transfer/alternate cost (to be decided during the study)	This will entail obtaining means of estimates of the amount of pollination, getting alternate market prices of creating pollinators, and multiplying them.	Data will be obtained from meta-analysis, and/ or from markets.

ES Classification	Type of Ecosystem Service	Valuation Approach	Methodology	Data Sources
			The other way is through surrogate market methods, where the authors look at alternate ways of increasing the yields from pollinator-dependent crops, and then quantify those costs.	
Regulating Services	Water purification	Market price	This value will be obtained by estimating water-use by using population data from Census 2011 and making necessary projections. In case data are not available, the average per capita water consumption estimates from various India-wide studies will be used. The water use data will then be multiplied by the population. These figures will then be multiplied by the cost of water treatment, from market prices.	Data will be obtained from the municipality and local governments and water treatment plants.
	Biological control	Benefit transfer	The unit area values will be determined by deriving a mean value of various studies obtained through a meta-analysis and will be multiplied by the total area to obtain the ecosystem service values.	Data will be obtained from meta-analysis.
	Flood regulation and moderating extreme events	Avoided cost	Avoided costs of losses to property will be determined by taking the estimates of water retention capacity of the landscape and possible flooding scenarios without the forests.	Primary and secondary data on property prices from local agents and local government will be obtained.
	Carbon sequestration	Through InVEST and market prices	Carbon stock will be estimated with InVEST or the quantity will be multiplied with the price of carbon credits in voluntary markets or with VER credits.	Data will be obtained from the Forest Department and voluntary carbon markets.
	Air pollution control	Surrogate market approach	SO_2 and NO_X will be considered, along with past estimates on the control of pollutants, and the same multiplied with prevailing prices of pollution control.	Data will be obtained from past estimates
	Soil fertility	Market price method	Total fertility enhancement will be determined by considering the total area, and possible fertility enhancement capacity of the forest from existing estimates. This will be multiplied by the unit price of fertilizer to arrive at an estimate.	Data will be obtained from the past estimates and Forest Department.
	Water conservation	The value will be estimated through a combination of benefit transfer and surrogate	Taking the alternate cost of creating a storage.	Water volumes will be estimated by extrapolating from similar sites in India. Storage costs will be calculated

ES Classification	Type of Ecosystem Service	Valuation Approach	Methodology	Data Sources
		market or alternative cost methods.		based on required capital expenditures, plus operation and maintenance costs.
	Biodiversity as a habitat for species	Benefit transfer	Product of per unit value and the area of the landscape.	Meta-analysis.
	Erosion control	Avoided cost approach	Estimate the cost of erosion prevention techniques, and present that as the value of erosion control through the avoided cost approach because of the existence of the forest.	Data on cost incurred will be taken from sites that have placed basic erosion prevention techniques with plantations, shrubs, grass, and mulch, among others.
Cultural Services	Tourism and other recreational values	Travel Cost Method	A questionnaire survey, as proposed earlier, will be used to derive a tourism demand function. The sum of the average tourist spending and the consumer surplus will give us the value of the landscape from the perspective of tourism. If tourism purposes are found to be different for different respondents, multiple demand functions will be developed, and multiple values will be taken.	Data will be obtained from the past estimates, Forest Department, and questionnaire survey.
	Cultural and spiritual values	Willingness to accept	measure for the loss of this service	Data will be obtained from questionnaire survey.

5.0 ASSESSMENT APPROACHES

Forest-PLUS 2.0 will be working closely with an external agency to conduct baseline assessment across three landscapes. The focus of the baseline assessment will be to collect information on existing flow of ecosystem services from the forest landscapes and the level of economic benefits of households in targeted landscapes. The assessment will cover hydrological services, carbon, biodiversity and others. This exercise is linked to the data requirements of the valuation study and will be conducted as a physical assessment and socio-economic assessment.

5.1 PHYSICAL ASSESSMENT (GIS/RS)

In order to collect the information needed to conduct the valuation exercise, certain assessment of physical parameters have to be assessed such as water flows from different sources (rivers, streams, springs, tanks) and carbon stock in the above ground and below ground biomass and soil carbon. The authors propose assessment techniques which use a combination of latest geographic information system (GIS)/remote sensing (RS) tools available and scientifically tested methods used by Indian Council of Forestry Research and Education (ICFRE) institutions. These techniques are described below.

5.1.1 MAPPING OF WATER RESOURCES USING RS/GIS

A GIS application tool will be used to map the uses of ecosystem services of water by a diverse group of stakeholders. The focus of the geospatial analysis will be on river waters, lakes, ponds, and tanks (e.g., Ahar Pynes). The landscape or catchment (based on the topographical analysis) will be the appropriate scale for quantifying processes related to the water cycle and the alteration of ecosystem functions under different stressors. The assessment will use time series data to identify trends and degradation of services, test the effectiveness of existing policies, and conduct scenario analysis.

The following steps outline the methodology.

- *Step 1: Scoping Study:* The ecosystem services of water emanate from interaction of water and land in forests, agricultural lands, riparian areas, wetlands, and water bodies. A comprehensive list of the availability of water from each of these sources will be prepared based on consultations with stakeholders and beneficiaries.
- *Step 2: Mapping and Assessment of Water Resources and Beneficiaries:* Since the three landscapes lie in different physiographic zones, the types of aquatic ecosystem will vary accordingly. Based on the scoping study and stakeholder consultations, each landscape will be spatially mapped using high-resolution satellite data to generate thematic information about the aquatic ecosystem in each landscape. Simultaneously, based on the list of beneficiaries assessed through surveys, the information will be transferred to the geospatial platform to generate a spatially explicit linkage between the aquatic ecosystem service and beneficiaries.
- *Step 3: Biophysical Mapping and Assessment:* The biophysical methods will include assessment of biophysical characters that include geospatial analysis of land use and land cover, mapping and assessment of water quantity and quality, and the water-related ecosystem services that will be impacted by the complex interactions of climate, topography and geology, land cover and management, and other anthropogenic modifications of the landscape. Hydrological models will assess the dynamics of the river basin (resilience) and the temporal (lagtime) and spatial distance between beneficiaries and impacts. This can be used in scenario analysis of multiple stressors and prediction for water-related ecosystem services. Assessment of biophysical characters

integrated with hydrological modelling will also establish relationships among stressors, status, and services.

- *Step 4: Framework – Linking Pressures, Ecological Status and Ecosystem Services:* A conceptual framework shall be developed for the integrated assessment of water-related services. The framework will identify the main pressures affecting aquatic ecosystems and the possible links to the alteration of the ecosystem/hydrological attributes: 1) water quantity (including seasonality); 2) water quality; 3) biological quality elements; and 4) hydro-morphological and physical structure. This will also incorporate ecological and economic aspects using established models such as InVEST[1].

5.1.2 CARBON STOCK ESTIMATION

Primary data collection on carbon reference levels in the selected landscapes shall be based on forest inventory to be prepared by the team in select landscapes. The teams will lay a statistically relevant number of sampling plots in the forest land, crop land, settlement, and grassland, among others, to prepare an inventory of biomass stock and soil organic carbon in as many pools as possible, including above ground biomass, below ground biomass, and soil organic carbon (SOC). Based on the inventory, the team will estimate the net carbon stock of the various strata and eventually sum it up for measuring the net carbon stock (C-stock) of the forest. Data from tiers 3, 2, and 1 will be applied in that order. Sampling plot design will follow the prescriptions of Forest Survey of India. Primary data collection will include diameter at breast height, height, collection of soil samples, and litter (if applicable and not considered insignificant). Volumetric and allometric equations will be the ones used by Forest Survey of India (FSI) in the latest India State of Forest Report or published by FSI or ICFRE. Estimation of SOC shall be done in a Government approved lab. In the absence of any primary data, secondary data will be used to estimate the C-stock. The approved working plans are considered to be authentic documents to source C-stock information. In the absence of this, data in expired working plans will be used along with FSI reports to estimate the C-stock at the divisional level. While the forest mensuration equipment are many, the primary tools are densiometers, GPS devices, and measuring tapes. However, if C-stock will not be measured, use of secondary sources will be considered instead of primary sources. INVEST provides an estimate once sufficient input data is provided. If sufficient input data is not available, we will sort to benefit transfer methods through meta-analysis.

5.1.3 BIODIVERSITY

Biodiversity will be estimated through an avoided cost approach through benefit transfer from a meta-analysis. The avoided cost may arise through the cost per unit area that needs to be incurred for creating an alternate habitat. This may be arrived at through a meta-analysis. Then, we transfer the benefit in terms of avoided cost per unit area and multiply it by total area. This will give us the total value of the habitat services.

The benefit transfer method is used to estimate economic values for ecosystem services by transferring available information from studies already completed in another location where the characteristics are comparable. It is important to make sure that the quality of the study is adequate before using benefit transfer. The final step is to adjust the existing values to better reflect the values for the site under consideration. Such adjustments may be based on demographic characteristics or other parameters that are unique to the habitat, as determined by biodiversity surveys of the landscape.

[1] InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) is a suite of models developed in Stanford University under the Natural Capital Project to map and quantify ecosystem services. In the process, it helps in understanding how changes in ecosystem structures and processes can alter the flows of ecosystem services. For details, see https://naturalcapitalproject.stanford.edu/software/invest.

5.2 SOCIO-ECONOMIC ASSESSMENTS

The socio-economic assessments will be carried out primarily through surveys, focused group discussions, participant observations, and data obtained from secondary sources. Forest-PLUS 2.0 will engage local organizations whenever possible. Here, a two-stage approach is proposed.

1) Focused group discussions at sample villages with local stakeholders with the help of Gram Panchayats (local governments) will be conducted to understand the local use of forest resources for domestic and commercial purposes. No less than 15 percent of villages in each landscape will be chosen through a stratified random sample. Villages will be chosen using a gradient of distances from the forest. The stakeholders will also be asked to place their own ranking of ecosystem services.

2) Questionnaire surveys will be conducted across households in each landscape. It is intended to survey a statistically critical yet manageable size of sampling data after looking at the sampling frame during the time of the work. The questions will be on the quantum of goods and services (mostly marketed and direct use provisioning services) and socio-economic variables such as income, consumption, expenditure, age of the main earning member, education, distance of the household from the forest, gender of the decision-maker/head of the family, gender of the concerned individual who accesses and uses the local level NTFPs, number of domestic animals, and benefits from domestic animals (such as milk or ploughing). Further enquiry will be made on the property prices of the households.

5.2.1 FUELWOOD, TIMBER, FODDER, AND NTFPS

The first step of the socio-economic survey will be to identify the services and classify the beneficiaries utilizing fuelwood/timber from ES boundary into either domestic or commercial. The data will then be gathered on quantity of fuelwood/timber extracted based on user category and on market prices of fuelwood/timber. If direct market price is not available, then close substitutes will be used as a proxy. The data of the quantum of provisions will be gathered through questionnaires and prices obtained from primary and/or secondary sources at various markets (local to global, if commercially marketed).

5.2.2 WATER PROVISIONING DUE TO FOREST COVER

The role of forests in augmenting water flow is widely acknowledged. The presence or absence of forests has a profound impact on the hydrological processes at the watershed level. Here, water values will be determined by their use. Uses will vary depending on whether the water is for agricultural, industrial, and domestic purposes. For agriculture, the water consumption will be estimated from the gross cropped area of various crops, and their crop-water ratios. For urban water uses, information from local municipality will be obtained. For drinking water, secondary information or benefit transfer information will be used.

5.2.3 REGULATING SERVICES: MODERATION OF EXTREME EVENTS

A questionnaire survey will be used for assessing the property prices of various sites. This will be further verified from unstructured interviews with local governments or property dealers. Information will also be collected on the prices of domestic animals. This becomes important as an avoided cost approach will be needed for valuing nature's services in moderation of extreme events.

5.2.4 GENDER DIMENSION IN THE DISCOURSE

There is a gender dimension to the access and use of local-level provisioning services. This dimension must be identified at the first stage and incorporated as a critical variable throughout the exercise. Three crucial questions will be investigated:

- Do women have better access and make more use of the direct provisioning services at the local levels than men?
- Do women-led households extract more value from the use of direct provisioning services than men-led households?
- Do women-led households have a higher ecosystem dependency in terms of local use than men-led households?

While data about these will emerge from the questionnaire surveys, the analytical methods are explained in the next section.

5.2.5 INCOME CLASSES, DISTANCE FROM THE FOREST AND ECOSYSTEM SERVICES

The authors intend to map the role of ecosystem services across various income classes based on the information from the questionnaire in order to analyze the hypothesis on:

- Whether the lowest income groups in the regions have higher ecosystem dependency than others; and
- Whether the distance from the forest plays a role in ecosystem dependency.

6.0 DISCUSSION AND IMPLICATIONS FOR FOREST-PLUS 2.0

6.1 MONETARY VALUES

Interpreting the monetary values of the ecosystem services is a challenging task. It is important to understand that the various services considered occur at various scales. Some of the services occur at very local levels and have direct bearing on local livelihoods. These services are primarily provisioning in nature. This is especially true for food, fodder, medicinal plants, and various NTFPs that are used for direct consumption. On the other hand, there are others that have market and trade linkages, while services like carbon sequestration are "global common goods." The scales of operation of these services get reflected in values and that makes interpreting the values difficult.

Another important point to note is that the estimates of value in this exercise will be conservative. The reasons for doing a conservative estimate are:

1. The analysis will be confined to a select set of ecosystem services, as the authors often exclude values of services that have not been discovered or understood.
2. It is difficult to track the supply-chain of some of the ecosystem services and the scale at which they benefit human communities (e.g., how flood regulation service of forests can help a business in the city).
3. There remains the problem of double counting while considering the supporting services of the ecosystem and adding them up to estimate the total economic value. This is more so because in many cases there is a forward causal linkage of the supporting services with other services. Sufficient caution has to be taken to avoid any form of double counting. In such situations, this study will estimate the values of the supporting services but report them separately, without integrating them with other forms of services.
4. It is difficult to list all forms of cultural services or value them. Forests often have very specific cultural values that may be individual-specific. Nature tourism will be considered through travel cost methods for the forest zone and the buffer and adjoining areas where tourism has developed. But it will be implausible to bring religious values in the framework of markets due to existence of "income effects" (Milgrom and Roberts 1992:19).
5. The value of benefits obtained by communities downstream will be covered only up to a limited extent to keep the scope of the study within manageable proportions.
6. Value of carbon sequestration will always be an underestimate as the authors are compelled to rely on the value of the carbon credits in the voluntary markets, which, by no means, reflects the true benefits that nature provides humans with. Ecological sciences are yet to quantify the exact nature and causality between total human benefits and carbon sequestration. As argued by Ghosh (2014), the price reflected by the carbon market always remains lower than the actual value of carbon sequestered. The sequestered CO_2 is a global common good, and it brings with itself benefits like diminishing morbidity, lowering health costs, enhancing productivity and these are not reflected in the market. The price of carbon credit depends more on the economic activities and the associated market dynamics and has less to do with service provision.

However, in absence of any other alternate pricing mechanism, this study will report the underestimated value of sequestered carbon.

Given all these limitations, it is prudent to interpret the values as a reflection of the cost of inaction if adequate protection and right governance of existing forests are not in place. Conservative estimates are preferred to over-estimates and it can create a stronger case for conservation. The "strength" of conservative estimates in policy making and public awareness becomes apparent when one looks at the two notions, "GDP of the poor" and "ecosystem dependency index," as discussed in the next sub-section.

6.2 ECOSYSTEM SERVICES AS "GDP OF THE POOR"

The increasing popularity of the concept of ES has helped create a strong case for environmental conservation and forms an input towards development of interventions. The critical role of ecosystem services in the lives of the poor in the underdeveloped regions of the developing world was recognized by the Millennium Ecosystem Assessment. There is no doubt that the poor depends on a wide range of ecosystem services and are therefore more vulnerable to biodiversity loss or land-use change than economically well-to-do groups (MEA, 2005). The dependence of the urban rich on the ecosystem services is substantially lower. Billé et al. (2012) feel that biodiversity is tantamount to biological insurance for the poor (MEA, 2005). Along these lines, Daw et al. (2011), in a compelling argument to link ecosystem services to poverty alleviation, has been critical of the much emerging ES literature that adopts an aggregated perspective of humans and their well-being, with almost no acknowledgement of the role of ecosystem services in poverty alleviation.

The role of natural capital and ecosystem services do not feature in the national income accounts or in GDP estimates, though their roles in the economy are fundamental. Quite evidently, the costs of depletion of natural capital and consequent ecosystem services are also not considered to be part of the GDP. Sukhdev (2009) argued in favor of estimating the values of the ecosystem services to assess their roles in livelihoods and termed ecosystem services as "GDP of the poor" and placed the hypothesis that the rural poor people make more direct use of the services provided by the ecosystem. Sukhdev's paper therefore states that while the value of most of the provisioning services of the forest was only around 7 percent of India's GDP (when it was given a monetary value) on an aggregate, it was estimated to be around 57 percent of the income of India's rural poor.

6.3 DEVELOPING THE ECOSYSTEM DEPENDENCY INDEX

In order to understand the ecosystem dependency, the ecosystem dependency index is developed. It is the ratio of the direct use values in the form of some important provisioning services to the total income of households. Therefore, if *ED* is the Ecosystem Dependency Index, then

$$ED = \frac{ESV}{Y}$$

Where *ESV* is the value of the ecosystem services, and *Y* denotes household income.

According to this definition, the higher the *ED*, higher is the dependence on the ecosystem. In previous exercises at the micro-level, it has often been found that in poorer regions, the value of ecosystem services at local levels exceed incomes (Ghosh et al., 2016; Ghosh, 2018). Ghosh (2018) in an application for Kunnigal wetlands in Karnataka, has estimated the *ED* as 1.24, implying that the value obtained by the poor from the wetlands are higher than the average incomes of the households. This creates a clear case for conservation, as the community at the local and meso levels would lose 24 percent more than their annual income if the water body is lost. The loss will be even more if one considers the global benefit of carbon sequestration. In another instance, Ghosh et al. (2016), while estimating the values of ecosystem services of the Terai Arc Landscape (TAL)in Uttarakhand, infer that "…more than half the population in the TAL – Uttarakhand is living below poverty levels and an earning member of a household earns as little as US$ 1.9/day. The ecosystem dependency of these households is higher than those earning average per capita incomes." There is therefore no doubt that any policy and action leading to land use change needs to take into consideration the impacts on poor households, especially in cases where social security provisions are inadequate.

The case is stronger with the argument that even "conservative" estimates of values of ecosystem services exceed the incomes of the poor who are reliant on these services for their living.

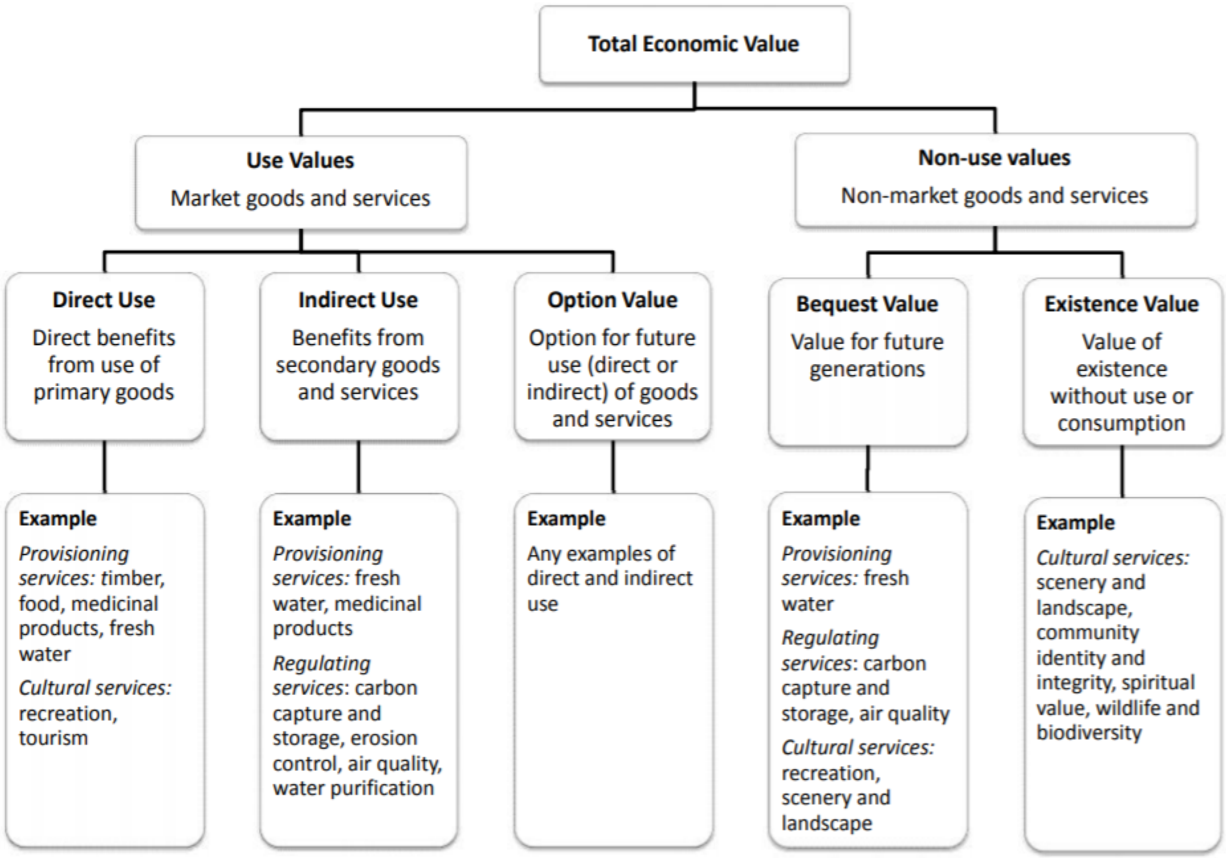
6.4 TOTAL ECONOMIC VALUE

Once classified, the ecosystem services are valued using appropriate techniques and added up to calculate the TEV. Among the numerous services that are provided by ecosystems, a valuation exercise would capture only a sub-set of them. Unless we capture values of *all services, we really do not arrive at the TEV. It is important to note this limitation. The concept of TEV gives us a comparative picture of what we have valued and what we have ignored.*

TEV could be defined as the benefits flowing from a variety of direct and indirect ecosystem services, expressed in monetary terms. Some of these benefits are obtained through market goods and services (used directly or indirectly), while others are non-market goods and services (value for future generations or of purely existential value). TEV is divided into use value and non-use value (see Figure 6-1). Use value is further divided into direct use value and indirect use value and option value. Non-use value is sub divided into bequest value and existence value. Direct use values are derived when an individual makes actual use of a facility, for example visiting a park, or going fishing; indirect use value arises from functional benefits such as forest ecosystem services. Option use value is an individual's WTP for the option of using an asset at some future date. Bequest value is derived from use and non-use values of environmental legacies, and existence value is the value from knowledge of continued existence.

A variety of methods are used to estimate the monetary values of these ecosystem services. Some of these are straightforward to apply such as market price methods for calculating the value of direct use goods like timber; others such as replacement cost methods estimate the 'opportunity benefits' e.g. using the cost of wastewater treatment in the absence of an ecosystem that provides clean water. "Avoided cost" approaches estimate the value on the basis of cost of avoided damages due to presence of the ecosystem such as flood control, storm surge regulation, coastal erosion that would have otherwise been caused due to absence of an ecosystem (e.g., the mangroves). Other methods are the travel cost approach, hedonic pricing method, both of which are based on human behavior in real market situations, and "hypothetical market" approaches that are based on the "stated preference" approach of utility theory in neoclassical economics.

FIGURE 6-1: ECOSYSTEM SERVICES ACCORDING TO THEIR VALUATION TYPE



Source: Adapted from Biodiversity in environmental assessment / Slootweg et al., 2010

6.5 VALUATION RESULTS FOR INFORMED INTEGRATED PLANNING AND DECISION MAKING

The proposed exercise has various policy implications. These implications range from social and economic to ecological, and have bearing on finance, development, judicial proceedings, and institutional and ethical considerations of human endeavors. The proposed valuation exercise will be important from a policy perspective in multiple ways.

6.5.1 TRADE-OFF

Forest landscapes in developing nations are under tremendous pressure due to unbridled human ambitions for development. Myopic visions of economic growth are so overbearing that "costs of growth" are often not acknowledged. Forces of development and urbanization have caused severe land-use change over time, leading to irreparable damages to the ecosystem. Unfortunately, it is not recognized that these ecosystems are irreplaceable, at least in the short and medium term, and so are the ecosystem services. The framework helps illustrate an understanding of the values that ecosystem services yield to human society, and more importantly, it will reflect on the "costs" of development. It will also create an objective mechanism to critically analyze and understand the trade-offs between development and conservation goals. While the benefits from growth are always made visible to the people, it is important that benefits of conservation are also presented side-by-side so that informed choices are made with the holistic picture of both benefits and costs.

6.5.2 FINANCING DECISIONS

This exercise provides key information for rationalization of financing for development. It allows estimation of the "cost of development" which are the losses of values in ecosystem services. This is an important variable in an integrated cost-benefit analysis of development projects. If such costs are factored in, the infrastructure projects (e.g., infringing on protected areas) that are otherwise perceived to be economically and financially viable, might not remain viable any longer. With some further analysis, this valuation exercise could estimate a benchmark figure of the costs of infrastructure intervention in different ecological settings. Linear infrastructure is being thought of in large parts of India as an integral component of its development policy, and with many cases of such planned infrastructure passing through eco-sensitive zones, this exercise will allow the government to note the magnitude of the losses to poor communities who are reliant on ecosystem services that will be lost in the process. Development financial institutions and banks could therefore incorporate these figures in their decision support systems before investing in infrastructure projects.

6.5.3 COMPENSATION FOR ECOSYSTEM SERVICE LOSS

From a normative perspective, this exercise creates a case for compensation mechanism and helps judicial proceedings where one party may be held responsible for losses caused in ecosystem services. Valuation of ecosystem services of the three forest landscapes will also help in understanding the losses that will be incurred in case of land-use changes that are introduced. This exercise can form the basis for appropriate monetary compensation to the ecosystem dependent community.

6.5.4 EQUITY AND TRADE-OFF

The valuation makes us understand that people with relatively lower incomes have higher ecosystem dependency. This is important information for governments and the policy making machinery in particular to devise pro-poor policies while taking into consideration the conservation-development trade-offs. This exercise, therefore, assists in addressing equity and distributive justice.

6.5.6 CONSERVATION AND DEVELOPMENT

Valuation of the ecosystem services in these forest landscapes brings to the surface how conservation goals are embedded in the broader developmental policy. Developmental policies are aimed towards enhancing well-being of communities in these forest landscapes, and the ecosystem service values here will indicate how avoiding ecosystem destroying development would help in actually enhancing net well-being. It brings to the fore that conservation and development have to go hand-in-hand in order to promote sustainability.

6.5.7 RIGHTS AND ECOSYSTEM VALUES

Since the landscapes are spatially dispersed across India, the exercise is expected to yield very different values due to the differences in socio-economic-ecological factors. This offers a scope to analyze the links between access and property rights regimes and ecosystem values (when other variables are similar).

6.5.8 GENDER CONSIDERATIONS

The gender dimension of the conservation-development dynamics will throw critical light on the following:

1) How is gender a factor in terms of accessing ecosystem services?
2) What are the parameters for separate gender-specific policies for community well-being in order to achieve conservation goals?

These questions are very critical from the perspective of equity in livelihood options and also have a significant bearing on design of local level conservation initiatives.

6.5.9 SPATIAL COMPARISON OF INSTITUTIONAL ARRANGEMENTS

With dispersed landscapes across the nation with a variety of local-level norms and existing institutional mechanisms, this exercise can be used to analyze which communities enjoy the maximum benefits and under what institutional arrangements, and whether such arrangements are in consonance with conservation goals. It will allow comparison of different rights and institutional regimes and understand feasible options for meeting both conservation and development goals that may otherwise appear conflicting.

6.5.10 PAYMENT FOR ECOSYSTEM SERVICES

This valuation exercise also provides the key information required to develop market institutions like payment for ecosystem services. In a recent conclave of the Himalayan states at Mussoorie (Uttarakhand), ten states (Jammu and Kashmir, Uttarakhand, Himachal Pradesh, Sikkim, Arunachal Pradesh, Meghalaya, Nagaland, Tripura, Mizoram, and Manipur) have demanded a green bonus from the government for the ecological services being provided by them. Such propositions have also appeared in election manifesto of political parties in India. There has been some debate as to whether a "beneficiaries pay" principle rather than a "state-dictated" fiscal transfer to the biodiversity-rich communities in the Himalayan states would be better suited for sustainable development. This will lead to price discovery of the ecosystem that entail the downstream beneficiaries paying the forest communities for the maintenance of the ecosystem that provides them with the services (such as water provisioning).

However, PES mechanisms have not been uniformly successful across the world. The success story of PES with the Catskill-Delaware watersheds program, where the New York City turned out to be the beneficiary has certain enabling conditions, one of which is the role of the state as an enabling factor. Markets for such ecosystem services sometimes fail due to lack of identification of the marketable ecosystem services, lack of identification of beneficiaries, and the failure of proper valuation of the marketable service. This valuation exercise in the three forest landscapes would provide critical information for the creation of market mechanisms such as PES.

6.5.11 VALUE-CHAIN

This valuation exercise will help us identify the value-chains within the ecosystem services and their potential for enhancement of economic well-being of the community. Value-chains work across some of the marketable provisioning services and can also work for national and international tourism that has been described as components of the global commodity chains (Uddhammar, 2006). After this valuation exercise that will place monetary values to ecosystem services at different levels (local, meso, and global), a natural extension will be to examine the development of the value-chains of the ecosystem services so that better institutional mechanisms like markets can be developed. The valuation exercise will help identify the "low hanging fruits" for which the ecosystem good/ service can be institutionalized and potential beneficiaries and value additions at various levels can be delineated.

6.6 FINAL THOUGHTS

This paper covers identification of ecosystem services in the three Forest-PLUS 2.0 landscapes and proposes a set of methodologies that could be used for valuation of some of the key ecosystem services. Under this program, the valuation results will be used for developing more informed working plans in forest land and management plans in areas outside recorded forest areas. It will also provide important information in the process of developing forest-based value chains. Decision makers linked to all these development efforts require to know how valuable the resource or service is to an individual or community or to an economy, in order to make informed decisions. This valuation exercise will address that crucial information gap.

Going beyond the program, the values of ES will be useful for different public institutions going beyond MoEFCC. Forest-PLUS 2.0 hopes that when this valuation exercise is done, it will provide important information which will have wide range of uses. Some of the potential uses are provided below:

- *Valuation of ecosystem services acts as an objective instrument for decision making.* There is no doubt that numbers speak for themselves. The monetary values of ecosystem services create an objective basis of decision making across multiple options of investment. It removes ambiguity and arbitrary value judgment and helps rationalize preferences from available options. As a policy-making body, the MoEFCC will able to develop more rational approached.

- Valuation of ecosystem services provides a basis for prioritizing investments to meet conservation goals, thereby helping understand the trade-offs between conservation and development (Kinzig et al., 2007). The MoEFCC needs to analyze and evaluate development projects which have an impact on the environment. While there is always a tendency for development decisions to maximize short-term economic gains, valuation of ecosystem services reflect the scarcity value and the true social costs of development in terms of anthropogenic losses to ecosystem services. Valuation provides incentive management and instruments for environmental governance (Panayotou, 1993 and Ghosh, 2014).

- Valuation promotes sustainable development by allowing for efficient and equitable allocation and distribution which leads to social optimality in consumption and production. Social planners face an inherent conflict between efficiency and equity (or a combination of both) in making allocation and distribution decisions while attempting to maximize net social welfare. A comprehensive valuation exercise can help in reconciling social goals that might otherwise appear contradictory (Danda et al., 2019).

- Valuation of ecosystem services can guide legal proceedings for determining damages where a party is held liable for the loss to another party: In legal proceedings, where upstream activity causes losses in ecosystem services downstream or vice versa, there is a need to evaluate the loss (in most cases, in monetary terms) so that the affecter is made to compensate the affected with the value of the damage. Valuation offers a mechanism for strengthening the hands of the judicial system in the country.

- *Valuation helps design efficient management mechanisms (economic instruments, controls, etc.) and institutions (PES).* Incentive schemes negotiated between two ecosystem service users can lead to a win-win situation in addition to enhanced ecosystem health. This is being covered at-length in a different paper.

- Valuation of natural resources helps investment (infrastructure development) decisions that might otherwise ignore the effects on environment: Investment decisions on public goods and utilities (say, dams) in many developing nations often ignore the adverse effects on environment because ecological costs are not considered. The ecological cost might turn out to be large enough to exceed the apparent economic benefits. (Ghosh, 2018).

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ANNEX 1: KEY ECOSYSTEM SERVICES IN MEDAK

Ecosystem Service	Produced or Received on Site	Specify Benefits	List Beneficiary Groups	Magnitude of Benefits L / M / H	Any Substitute Available	Quality of Service	Quantity of Service	Is Associated Ecosystem Threshold Known? (Y/N)	Any Known Risk to ES Threshold
Provisioning									
Water for agriculture and urban-industrial use	Yes	Drinking water, Irrigation, domestic and Industrial purposes	Local Farmers and Urban Residents of Hyderabad and Secunderabad	H	No	NA	NA	NA	NA
Food and medicinal plants (natural medicines, pharmaceuticals)	Yes	Nutrition and source of Livelihood, Health, Prevention of Epidemics	Farmers, Rural Population and Fishermen, Local Population especially the Indigenous population	H	No	NA	NA	NA	NA
Timber flow and timber stock	Yes	Livelihood opportunities	Farmers, villagers	M	Yes	NA	NA	NA	NA
Fuel, Fodder other NTFPs (Ornamental resources)	Yes	Livelihood, cooking, livestock	Rural Population and Indigenous People, Tribal Communities, Artisans and Farmers	M	Yes	NA	NA	NA	NA
Gene-pool protection	Yes	Preservation of the indigenous crops and animal species	Farmers and Tribal Communities	M	Yes	NA	NA	NA	NA
Regulatory Services									
Air Pollution control	Yes	Overall welfare of the local population	Local Population	M	No	Many polluting industries are identified in the location which might	NA	NA	NA

Ecosystem Service	Produced or Received on Site	Specify Benefits	List Beneficiary Groups	Magnitude of Benefits L / M / H	Any Substitute Available	Quality of Service	Quantity of Service	Is Associated Ecosystem Threshold Known? (Y/N)	Any Known Risk to ES Threshold
						affect the overall air quality of the region			
Climate regulation (local temperature/precipitation, etc.)	Yes	Overall welfare, agriculture, provides water etc.,	Local Population	H	No	NA	NA	NA	NA
Carbon Sequestration	Yes	Overall welfare	Local and Global Population	H	No	NA	NA	NA	NA
Water conservation and purification	Yes	Water conservation, Improved Water quality and Health	Local Population	H	No	Effluents from the Industries in the region had impact on the quality of water in the region	NA	NA	NA
Flood Regulation and moderating extreme events	Yes	Protection of life and Property	Local Population	M	No	NA	NA	NA	NA
Pest regulation	Yes	Forest Productivity and Food Productivity	Farmers and Forest Based Communities	M	Yes	NA	NA	NA	NA
Biological Control	Yes	Good Health and Prevention of Epidemics	Local Population	M	Yes	NA	NA	NA	NA
Erosion Control	Yes	Vegetation cover, Prevention of Topsoil and Control of landslides	Local Population	M	Yes	NA	NA	NA	NA
Pollination	Yes	Richness in Biodiversity	Overall everyone both locally and	H	NA	NA	NA	NA	NA

Ecosystem Service	Produced or Received on Site	Specify Benefits	List Beneficiary Groups	Magnitude of Benefits L / M / H	Any Substitute Available	Quality of Service	Quantity of Service	Is Associated Ecosystem Threshold Known? (Y/N)	Any Known Risk to ES Threshold
			regionally						
Cultural Services									
Cultural and Spiritual Values	Yes	Tourism	Tourists	M	NA	NA	NA	NA	NA
Tourism and other recreational values	Yes	Source of Livelihood through tourism and Recreation, Awareness, Source of Livelihood through tourism and Recreation	Tourists and local population	M	NA	NA	NA	NA	NA
Inspiration of art, folklore, architecture, etc.	Yes	Source of Livelihood through tourism and Recreation	Tourists and local population	M	NA	NA	NA	NA	NA
Social relations (e.g. fishing, grazing or cropping communities)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Supporting Services									
Soil fertility	Yes	Agriculture, Vegetation, Moisture conservation and Habitat for living organisms	FarmersLocal Population and Overall everyone both locally and regionally	H	No	NA	NA	NA	NA
Primary production	Yes	Forest Productivity and Ecosystem Stability	FarmersLocal Population and Overall everyone both locally and regionally	H	No	NA	NA	NA	NA

Ecosystem Service	Produced or Received on Site	Specify Benefits	List Beneficiary Groups	Magnitude of Benefits L / M / H	Any Substitute Available	Quality of Service	Quantity of Service	Is Associated Ecosystem Threshold Known? (Y/N)	Any Known Risk to ES Threshold
Nutrient cycling	Yes	Functioning of Ecosystems, Storage of elements and Facilitates the flow of the substances	Overall everyone both locally and regionally	H	No	NA	NA	NA	NA
Photosynthesis (production of atmospheric oxygen)	Yes	Support in regulatory services	Everyone	H	No	NA	NA	NA	NA
Biodiversity as a habitat for species	Yes	Conservation of Flora and Fauna	Overall everyone both locally and regionally	H	No	NA	NA	NA	NA

ANNEX 2:KEY ECOSYSTEM SERVICES IN GAYA

Ecosystem Service	Produced or Received on Site	Specify Benefits	List Beneficiary Groups	Magnitude of Benefits L / M / H	Any Substitute Available	Quality of Service	Quantity of Service	Is Associated Ecosystem Threshold Known? (Y/N)	Any Known Risk to ES Threshold
Provisioning									
Water for agriculture and urban-industrial use	Yes	Drinking, domestic uses, livestock rearing, irrigation	Everyone	H	No	NA	NA	Yes	Nearly all the villages have access to drinking water facilities but only 1 percent of thehouseholds have access to piped water facility in rural area, drinking water quality is a big issue in the district as there is evidence of Fluoride contamination in the drinking water. Agriculture is still largely dependent on rainfall, to cater the needs of irrigation during monsoon season, the district has rivers namely Falgu, Morhar, Niranjana, Gokhle etc. and the Kharif crop is primarily dependent on monsoon as well as irrigation through traditional AharPynes which is damaged over a period of time.
Food and medicinal plants (natural medicines, pharmaceuticals)	Yes	Livelihood, Ayurveda, livelihood Economy, Nutrition	Everyone, Indigenous communities (Viadya)	H	No	NA	NA	Yes	In the field of agriculture, a vast area is available for none arable development projects. A cultivator who grows only cereal crops cannot keep himself engaged throughout the year. Whereas a fruit grower remains engaged throughout the year. There is a huge scope of horticulture development in the

Ecosystem Service	Produced or Received on Site	Specify Benefits	List Beneficiary Groups	Magnitude of Benefits L / M / H	Any Substitute Available	Quality of Service	Quantity of Service	Is Associated Ecosystem Threshold Known? (Y/N)	Any Known Risk to ES Threshold
									district.
Timber flow and timber stock	Yes	Livelihood opportunities	Farmers, villagers	M	Yes	NA	NA	NA	NA
Fuel, Fodder other NTFPs (Ornamental resources)	Yes	Firewood, NTFP, Cottage industry, Local art and craft, Livelihood, Economy	Forest dependent communities, Indigenous communities (Artisans)	M	Yes	NA	NA	Yes	Due to heavy demand of fuel and timber wood the illegal cutting of trees is a problem.
Gene-pool protection	Yes	Seeds storage from mother trees	Farmers, Forest Fringe dwelling communities	M	Yes	NA	NA	Yes	Lack of information and scope for the use of quality seeds of improved varieties in different crops, Productivity can be enhanced through quality seed of improved varieties.
Regulatory Services									
Air Pollution control	Yes	Fresh Atmosphere, Healthy air	Everyone	H	No	NA	NA	NA	NA
Climate regulation (local temperature/precipitation, greenhouse gas sequestration, etc.)	Yes	Sequestered carbon	Everyone, Forest fringe dwelling communities	H	No	NA	NA	NA	NA
Carbon Sequestration	Yes	Overall welfare	Local and Global Population	H	No	NA	NA	NA	NA
Water conservation	Yes	Irrigation, Flood control, Fishing	Everyone	M	No	NA	NA	Yes	More number of low flowing zones will promote ground water exploitation and non-recharging may affect the ground water level.

Ecosystem Service	Produced or Received on Site	Specify Benefits	List Beneficiary Groups	Magnitude of Benefits L / M / H	Any Substitute Available	Quality of Service	Quantity of Service	Is Associated Ecosystem Threshold Known? (Y/N)	Any Known Risk to ES Threshold
Flood Regulation and moderating extreme events	Yes	Controlled erosion, Enhanced green cover	Forest fringe dwelling communities/Rural communities	H	No	NA	NA	Yes	Sometimes high velocity winds (storm) effect the economic back bone (standing crops) of the districts
Pest regulation	Yes	Agricultural crops safety, Genetic diversity of crops	Farmers, Forest Fringe dwelling communities	H	Yes	NA	NA	NA	NA
Biological Control	Yes	Less incidents of critical disease, Fresh environment	Farmers, Forest Fringe dwelling communities	M	Yes	NA	NA	NA	NA
Erosion Control	Yes	Preserved topsoil	Everyone	H	No	NA	NA	Yes	Only healthy soil can produce healthy food material. Erosion of topsoil causes loss in healthy topsoil. Barren and uncultivable land has not been brought under use.
Water purification	Yes	Fresh water availability underground	Everyone	H	Yes	NA	NA	NA	NA
Pollination	Yes	Rich Biodiversity	Everyone	H	No	NA	NA	NA	NA
Cultural Services									
Cultural and Spiritual Values (religious value)	Yes	Tourism, Traditional Knowledge, Traditional Knowledge, Security of local tribes, Research	Stakeholders, Indigenous communities (Homeowners near shrines or heritage sites),	H	No	NA	NA	NA	NA
Tourism and other recreational values	Yes	Economy, Art and culture, Cottage industry, Research	SHGs, Stakeholders, Indigenous communities (Artisans)	H	No	NA	NA	Yes	Tourism has a great potential in the district andcan be developed more by creating proper environment through providing basic infrastructural support.

Ecosystem Service	Produced or Received on Site	Specify Benefits	List Beneficiary Groups	Magnitude of Benefits L / M / H	Any Substitute Available	Quality of Service	Quantity of Service	Is Associated Ecosystem Threshold Known? (Y/N)	Any Known Risk to ES Threshold
									Few places are yet to be connected with telephone/cell phone network.
Aesthetic value	Yes	Tourism	Stakeholders, Leisure travelers and commuters, Indigenous communities (Homeowners near forest)	H	No	NA	NA	NA	NA
Inspiration of art, folklore, architecture, etc.	Yes	Economy, Cottage industry, Tourism, Research	Stakeholders, Indigenouscom munities, SHG's	M	No	NA	NA	Y	Folk music popular in the rural areas of the district are usually presented on important festivals, marriages and on other regional occasions only. Handicrafts like making of baskets with bamboo sticks, Beedii(from tendu leaves), Pattals (Leaf Plates) etc. are the sources of livelihood and lack market linkages.
Social relations (e.g. fishing, grazing or cropping communities)	Yes	Livelihood, Economy, Nutrition	Communities involved	H	Yes	NA	NA	NA	NA
Supporting Services									
Soil fertility	Yes	Fertile soil for forest enrichment and crop production	Everyone	M	Yes	NA	NA	Yes	Most of the land in the district is not leveled hence needs soil & water conservation measures
Primary production	Yes	Carbon sequestration, Support in regulatory services	Everyone	H	No	NA	NA	Yes	Land reclamation such as leveling of land, management of water leased land and reclamation of salinated soil is essential to raise the production and productivity of crops

Ecosystem Service	Produced or Received on Site	Specify Benefits	List Beneficiary Groups	Magnitude of Benefits L / M / H	Any Substitute Available	Quality of Service	Quantity of Service	Is Associated Ecosystem Threshold Known? (Y/N)	Any Known Risk to ES Threshold
Nutrient cycling	Yes	Enhanced Production	Everyone	H	No	NA	NA	NA	NA
Water recycling	Yes	Stable water table	Everyone	H	No	NA	NA	NA	NA
Photosynthesis (production of atmospheric oxygen)	Yes	Carbon sequestration, Support in regulatory services	Everyone	H	No	NA	NA	NA	NA
Biodiversity as a habitat for species	Yes	Biodiversity richness	Everyone	H	No	NA	NA	Yes	Gaya has a substantial forest cover as the plantation along Canal embankment and roads are notified as protected forest under Indian forest Act.

ANNEX 3: KEY ECOSYSTEM SERVICES IN THIRUVANANTHAPURAM

Ecosystem Service	Produced or Received on Site	Specify Benefits	List Beneficiary Groups	Magnitude of Benefits L / M / H	Any Substitute Available	Quality of Service	Quantity of Service	Any Known Risk to ES Threshold
Provisioning								
Water for agriculture and urban-industrial use	Yes	Drinking water, Irrigation	Indigenous communities, rural populations, Urban and sub-urban population of Trivandrum city	H	No	Medium	Medium	NA
Timber flow and timber stock	Yes	Livelihood opportunities	Farmers, villagers	M	Yes	NA	NA	NA
Food and medicinal plants (natural medicines, pharmaceuticals)	Yes	Subsistence, farming, sale, Treating ailments/diseases, sale to locals	Farmers, scientists, forest managers, Indigenous communities, rural populations, forest managers	M	Yes	High	High	
Fuel, Fodder other NTFPs (Ornamental resources)	Yes	Cooking, livestock, livelihoods, Decoration	Indigenous communities, rural population	M	Yes	High	High	NA
Gene-pool protection	Yes	Better crop and plant breeds	Farmers,	L	Yes	Medium	Medium	NA
Regulatory services								
Air Pollution control	Yes	Overall Welfare	Local Population	M	No	Moderate to Heavy Air pollution is experienced in the region	NA	NA
Climate regulation (local temperature/precipitation, etc.)	Yes	Overall welfare, agriculture, Provides Water etc.	Local Population	H	No	NA	NA	NA
Carbon Sequestration	Yes	Overall welfare	Local and Global Population	H	No	NA	NA	NA
Water conservation	Yes	Water conservation, Improved Water quality and Health	Local Population	H	Yes		NA	NA

Ecosystem Service	Produced or Received on Site	Specify Benefits	List Beneficiary Groups	Magnitude of Benefits L / M / H	Any Substitute Available	Quality of Service	Quantity of Service	Any Known Risk to ES Threshold
Flood Regulation and moderating extreme events	Yes	Protection of life and Property	Local Population	M	No	NA	NA	NA
Pest regulation	Yes	Protection of crops and sources of livelihood and also protection of livestock	Farmers, livestock and poultry owners		Yes	NA	NA	NA
Biological Control	Yes	Good Health and Prevention of Endemics	Local Population		Yes	NA	NA	NA
Erosion Control	Yes	Vegetation cover, Prevention of Topsoil and Control of landslides	Local Population		Yes	NA	NA	NA
Pollination	Yes	Species richness, Higher Yield from forest/ Forest Production	Local Population		Yes	NA	NA	NA
Cultural Services								
Cultural and Spiritual Values (religious value)	Yes	Tourism, Religious traditions, spirituality	Govt. Revenue, Rural population, Rural and urban population, tourists	H	No	High	High	NA
Tourism and other recreational values	Yes	Revenue collection, income generation, Recreation	Govt. Revenue, Rural population	H	No	High	Medium	NA
Aesthetic value	Yes	Mental health,	Rural and urban population, tourists	H	No	High	Medium	NA
Inspiration of art, folklore, architecture, etc.	Yes	Recreation, learning	Rural and urban population, tourists	M	No	Medium	Medium	NA
Social relations (e.g. fishing, grazing or cropping communities)	Not found	NA	NA	NA	NA	NA	NA	NA
Supporting Services								
Soil fertility	Yes	Agriculture, Vegetation, Moisture conservation and Habitat for living organisms	FarmersLocal Population and Overall everyone both locally and Regionally	NA	No	NA	NA	NA
Primary production	Yes	Forest Productivity and Ecosystem Stability	FarmersLocal Population and Overall everyone both locally and Regionally	NA	No	NA	NA	NA

Ecosystem Service	Produced or Received on Site	Specify Benefits	List Beneficiary Groups	Magnitude of Benefits L / M / H	Any Substitute Available	Quality of Service	Quantity of Service	Any Known Risk to ES Threshold
Nutrient cycling	Yes	Functioning of Ecosystems, Storage of elements and Facilitates the flow of the substances	Overall everyone both locally and Regionally	NA	No	NA	NA	NA
Photosynthesis (production of atmospheric oxygen)	Yes	Support in regulatory services	Everyone	H	No	NA	NA	NA
Biodiversity as a habitat for species	Yes	Conservation of Flora and Fauna	Overall everyone both locally and Regionally	NA	No	NA	NA	NA

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