Green Accounting of Forest Resources, Framework for Other Natural Resources and Index for Sustainable Environmental Performance for Uttarakhand State

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GREEN ACCOUNTING OF FOREST RESOURCES, FRAMEWORK FOR OTHER NATURAL RESOURCES AND INDEX FOR SUSTAINABLE ENVIRONMENTAL PERFORMANCE FOR UTTARAKHAND STATE

STUDY EXECUTION TEAM

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support extended by Mr. Rajesh Kumar, Joint Director, Mr. Prakash Lakhchaura, Deputy Director and Mr. H.K Tripathi in facilitating data provisioning to us in the desired formats.

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Message

Uttarakhand, "The Abode of Gods," is one of the mega-diverse Himalayan states of India. Uttarakhand's forests provide a number of key ecosystem services to all the citizens of our country, including the origin of our rivers, biodiversity, etc. The state of Uttarakhand is also prone to multiple natural hazards. A large percentage of mountain communities are dependent on forest produce and owing to their low adaptation capacity to climate change, these communities are most vulnerable and likely to be affected by it.

With more than 70 percent of area under forests, Uttarakhand offers a rich natural base which provides many benefits not only to the state but to the entire country and the rest of the world. Maintaining large forest areas not only benefits the state in terms of benefits related to microclimate regulation, tourism and forest products, livelihood to mountainous communities, achieving SDGs but also results in a significant quantum of positive externalities through benefits related to water that are largely accrued to downstream states.

These advantages, a major proportion of which are accrued to other states, are however realized through costs borne by Uttarakhand in terms of opportunity cost of not being able to use the forest land for other purposes. The current study estimates the economic value of the state's natural resources and contribution which will eventually help develop a strong case for Uttarakhand's demand for Green Bonus from the central government.

I congratulate the whole team associated with the study, especially the team from the Directorate of Economics and Statistics, Department of Planning, Indian Institute of Forest Management Bhopal and IORA Ecological Solutions for the efforts made and my best wishes for release of the study report. I believe that such reports will help in inculcating an appreciation for the benefits from the forest area of Uttarakhand and will also provide much needed information to our conservationists, economists, academia and other stakeholders.

(Trivendra Singh Rawat)
Chief Minister, Uttarakhand

उत्पल कुमार सिंह
Utpal Kumar Singh

मुख्य सचिव
Chief Secretary

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Foreword

Uttarakhand, as indeed the nation, witnessed rapid economic growth in the past two decades, which has helped to push a very large number of people out of poverty. However, this rapid development has come at a cost in terms of the immense pressure that has been created on our natural resources leading to challenges related to air and water quality, solid waste management, forest degradation and climate change.

Uttarakhand's large forest area, biodiversity and unique climate have acted as a counterfoil to some of the maladies described above and have made a significant contribution towards meeting the national and international environmental commitments of India towards maintenance of forest cover and carbon sequestration, providing livelihood, timber, fodder, clean air, water to our population and achievement of SDGs. The forests of Uttarakhand are also critical for the sustainability of the source and upper reaches of some of the most important river systems of the Country. It is therefore imperative that the value of huge potential of forests and natural resources in the state be assessed in a systematic fashion.

The current study is an attempt by the Indian Institute of Forest Management and IORA Ecological Solutions to help estimate the worth of natural resources of the state and the contribution of the wealth to the state's GDP through an understanding of the ecosystem service production functions. The study also highlights the importance of monitoring the health of the natural resources of the state by devising Sustainable Environment Performance Index (SEPI).

I congratulate the team from the Directorate of Economics and Statistics for the initiative and the team led by Dr. Madhu Verma for bringing out this report. I am sure that the study report will help to develop a better undrstanding of the ecosystem services and its role in policy and decision-making.

(Utpal Kumar Singh)
Chief Secretary

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Preface

Uttarakhand is endowed with many life-sustaining natural resources such as glaciers, forests, rivers and minerals. Natural resources are an integral part of national wealth, providing critical ecosystem services and goods to our vast population extending beyond the state of Uttarakhand. Maintaining such large forest areas benefits not only Uttarakhand but also results in a significant quantum of positive externalities such as benefits related to water that are largely accrued to downstream states. These benefits are however realized through costs borne by Uttarakhand in terms of opportunity cost of not being able to use the forest land for other purposes. Thus, public investment by Uttarakhand in maintaining large areas under forests benefits several downstream states.

With such a high endowment of natural forests, a case can be argued for Uttarakhand to receive a "Green Bonus" for meeting expenditure on preserving and regenerating degraded natural forests and environmental resources. The current study is a stepping stone to provide scientific justification for such claims.

The study estimates the economic value of the state's forest resources and its contribution to the state's GDP which will help businesses understand and manage the potential quid pro quo between traditional economic and environmental goals. In addition, the study has also developed a Sustainable Environmental Performance Index and Natural Resource Accounting Framework for Uttarakhand to monitoring its environmental performance and the state of its natural resources. Finally, capacity building of departmental personnel on the above has been carried out through workshops and exposure visits.

Altogether, the study presents much needed information for policy makers, conservationists, economists, academia and other stakeholders which would help in inculcating an appreciation for the benefits from the forest area of Uttarakhand and acknowledging their varied contributions to diverse ecological and economic systems. I compliment Dr. Manoj Kumar Pant Nodal Officer of SSS project DES Uttarakhand who initiated the study under SSS project. I also appreciate Dr. Madhu Verma and her whole team from IIFM and IORA Ecological Solutions for this sincere and timely effort and extend my best wishes on the release of the study report. I am confident that the report will be useful for all stakeholders involved in and committed to the conservation of forests and other natural resources.

(Amit Singh Negi)
Secretary
Government of Uttarakhand

FOREWORD

It gives me great pleasure to introduce the report by the Indian Institute of Forest Management, Bhopal on 'Green Accounting of Forest Resources, Framework for Other Natural Resources and Index for Sustainable Environmental Performance for Uttarakhand State and Capacity Building on Environmental Statistics and Green Accounting' funded for this study by the Directorate of Economics and Statistics, Government of Uttarakhand.

The current study attempts to provide estimates of the value of natural capital stored in the forest area of Uttarakhand but its value has not been recognized in our accounting system. Recognition of benefits is likely to create an evidence base which will pave the way for a strong "Green Bonus" for the state and enhanced investment in these repositories of genetic information. Study findings also indicate that a large proportion of flow benefits (as well as stock) are intangible, and hence often unaccounted for in market transactions.

The study has made a pioneering attempt to develop a "Sustainable Environment Performance Index" for the state of Uttarakhand. The index measures the current state of the environment and resource extraction on ecosystem and human health

and measures it on an annual basis to give significant changes in the index.

At the end, the study also provides a framework for Gross Environmental Product (GEP) in line with the international system for collecting relevant data on different sectors, e.g. Land, Water, Energy, etc. in order to meet the need for preparing GEP to eventually reflect the economic value of all natural resources of the state.

I take this opportunity to thank the Directorate of Economics and Statistics, Dehradun for assigning this study to Dr. (Mrs.) Madhu Verma, Professor, Environment and Developmental Economics and Coordinator, CESM at IIFM in collaboration with IORA Ecological Solutions and compliment her for her best endeavours along with her support team in bringing out this report. I am also thankful to the full-fledged support extended by the Forest Survey of India, Forest Department and Planning Department as without their help this study could not have been actuated. I hope the findings of this report will further help in strengthening the policies related to Environment, Forests and Climate Change for sustainable management of natural resources and landscapes of Uttarakhand.

(Pankaj Srivastava)

Date: April 24, 2019

Place: Bhopal

KEY MESSAGES

- The current study attempts to provide estimates of the value of natural capital stored in the selected forest area of Uttarakhand. Recognition of benefits is likely to create an evidence base which will pave the way for a strong "Green Bonus" and enhanced investment in these repositories of genetic information.
- Study findings also indicate that a large proportion of flow benefits (as well as stock benefits) are intangible, and hence often unaccounted for in the market transaction.
- Acknowledging the fact, our limited understanding of natural processes and their associated values, the study uses a VALUE+ approach. The 'VALUE' represents all benefits for which monetary economic valuation is possible and conducted, while the '+' represents all those benefits for which economic valuation is currently not possible either on account of lack of accepted methodologies, knowledge and/ or understanding. The economic values derived in the study are thus conservative.
- The study has also attempted to prepare forest resources accounts as per the System of Environmental-Economic Accounting (SEEA). The SEEA provides the internationally agreed framework for providing indicators that directly respond to the demand of integrated policy-making, reversing the historical 'information silo' approach to statistics.
- The study provides economic estimates for as many as 21 ecosystem services from the forest area of Uttarakhand.
- The study findings indicate that the monetary value of flow benefits emanating from the Uttarakhand forest is approximately Rs. 95,112 crores (lower bound estimates) annually. This equivalent to an annual flow value of Rs. 3,88,085 per hectare of forest in Uttarakhand. In addition, the Uttarakhand forest protect and conserve stock comprising the value of land, timber stock and carbon storage is valued at Rs. 14,13,676 crores.
- The study also demonstrates available tools for biophysical assessment and application of InVEST – a suite of tools used for mapping ecosystem services. The results indicate potential use of InVEST in identifying ecosystem service hotspots and providing valuable management prescriptions for forest managers.
- The study has also made a pioneering attempt to develop a "Sustainable Environment Performance Index" (SEPI) for the state of Uttarakhand. The index measures the current state of the environment and resource extraction on ecosystem and human health; and compares it on an annual basis to give significant changes in the index.
- At the end, the study also provides a framework for Gross Environmental Product (GEP) and tables in line with the international system for collecting relevant data on different sectors, e.g. land, water, energy etc. in order to suffice the need for preparing GEP to eventually reflect the economic value of all natural resources of the state.

EXECUTIVE SUMMARY

Uttarakhand is endowed with many life-sustaining natural resources such as glaciers, forests, rivers and minerals. Natural resources are an integral part of national wealth, providing critical ecosystem services and goods to our vast population extending beyond just the state of Uttarakhand.

As per the Forest Survey of India, Uttarakhand has a total Recorded Forest Area of 38,000 km², almost 71 percent of its total geographical area. Despite this rich natural base which provides enormous contributions to people, the current recorded contribution of forestry in the Gross State Domestic Product (GSDP) of Uttarakhand (2015-16) is reflected as 2.08 per cent only. This under representation of forest in the state's economy is due to the limitation of the current accounting system owing to which the true contribution of forests does not get reflected in the state's GDP.

Since nature's contribution to people through various goods and services are often not monetized in the market, it may lead to their overexploitation and degradation of the natural assets they flow from. This degradation results in poor quality of life for all our citizens, but the impacts are particularly pronounced on the poor and vulnerable groups suffering the most from degraded access to clean water, air and sanitation, as well as from climate shocks.

At the same time, maintaining such large forest areas benefits not only Uttarakhand but also results in a significant quantum of positive externalities such as benefits related to water that are largely accrued to downstream states. These benefits are however realized through costs borne by Uttarakhand in terms of opportunity cost of not being able to use the forest land for other purposes. Thus, public investment by Uttarakhand in maintaining large areas under forests benefits several downstream states.

With such a high endowment of natural forests, a case can be argued for Uttarakhand to receive a "Green Bonus" for meeting expenditure on preserving and regenerating degraded natural forests and environmental resources. The current study is a stepping stone to provide scientific justification for such claims.

The study estimates the economic value of the state's forest resources and its contribution to the state's GDP. In addition, the study has also developed a Sustainable Environmental Performance Index and Natural Resource Accounting Framework for Uttarakhand to monitoring its environmental performance and the state of its natural resources. Finally, capacity building of departmental personnel on the above has been carried out through workshops and exposure visits.

METHODOLOGY

Acknowledging the fact that our understanding of natural processes and their associated values is limited, the study uses a VALUE+ approach. The 'VALUE' represents all benefits for which monetary economic valuation is possible and conducted, while the '+' represents all those benefits for which economic valuation is currently not possible either on account of lack of accepted methodologies, knowledge and/or understanding. The economic values derived in the study are thus conservative.

Valuation took into consideration varied approaches depending on the ecosystem goods and services in question. The study has used a multiplicity of frameworks including Total Economic Value; Millennium Ecosystem Assessment; Stock and Flow; Tangible and Intangible Benefits; EPA benefits categories; Investment Multiplier; Human Values and Ecosystem Assets; and Health Benefits to communicate the diverse values embedded and emanating from the forests of Uttarakhand.

VALUATION OF FOREST ECOSYSTEM SERVICES

The study provides economic estimates for as many as 21 ecosystem services from the forest area of Uttarakhand. Efforts were made to arrive at district level estimates as per the extent of data availablility within the state.

The study findings indicate that the monetary value of flow benefits emanating from the Uttarakhand forests is approximately Rs. 95,112 crores annually. This is equivalent to an annual flow value of Rs. 3,88,085 per hectare of forest in Uttarakhand. In addition, Uttarakhand forest protect and conserve stock is valued in the range of Rs. 14,13,676 crores annually. Table 1, Table 2, and Table 3 below present Uttarakhand's forest resources using different frameworks.

Table 1: Uttarakhand's Forest Ecosystem Services in the Stock and Flow Value Framework (Lower Bound)

Uttarakhand Forest Ecosystem Services (Stock Values)	Economic Value (INR crores)	Physical Volume
Timber Stock	7,21,101.70	370.65 million m^3
Carbon Stock	2,55,725.50	290.33 million tonnes of carbon
Land Value	4,36,849.0	Total forest area 38,139.18 km^2
Total Stock Value	14,13,676.20	N.A.
Uttarakhand Forest Ecosystem Services (Flow Values)	Economic Value (INR crores)	Physical Volume
Fuelwood	3,395.20	67,90,469 tonnes/year
Fodder	7,776.10	2,59,20,296.47 tonnes/year
Timber	1,243.20	6,38,994 m^3/year
Non-Timber Forest Products	303.7	Multiple units
Employment Generation	300	1 crore man days
Carbon Sequestration	1,482.20	61,760.16 tonnes/year
Water Purification	655.7	12,28,22,047.4 m^3/year
Water Provisioning	745.3	40,43,74,400 m^3/year
Gene-Pool Protection	73,386.50	N.A. as based on BT
Sediment Regulation/Retention	561	2,36,20,000 tonnes of sediments/year
Biological Control	251.7	Benefits Transfer: Rs 660/ha./Year
Pollination	441.1	Benefits Transfer: Rs 1,800/ha./Year for tropical forests
Gas Regulation	176.5	Benefits Transfer: Rs 720/ha./Year for tropical forests
Waste Assimilation	1,764.60	Benefits Transfer: Rs 7,200/ha./Year for tropical forests
Flood Regulation	1,306.50	Benefits Transfer: Rs 540 crores per annum. The value was adjusted for WPI
Recreation/Tourism	9.9	3,22,936 individuals visited various tourist attractions
Habitat for Species	892.5	Total forest area 38,139.18 km^2
Nutrient Cycling/Retention	420.9	NPK present in 2,36,20,000 tonnes of sediments/year
Total Flow Value	95,112.60	NA

Table 2: Uttarakhand's Forest Ecosystem Services in the Millennium Ecosystem Assessment Framework (Lower Bound)

Ecosystem Services	Uttarakhand Forest Ecosystem Service (Flow Values)	Economic Value (INR crores)	Physical Volume
Provisioning Services (A)	Fuelwood	3,395.20	67,90,469 tonnes/year
	Fodder	7,776.10	2,59,20,296.47 tonnes/year
	Timber	1,243.20	6,38,994 m^3/year
	NTFP	303.7	Multiple units
	Employment Generation	300	1 crore man days
	Total	**13,018.20**	
Regulating Services (B)	Carbon Sequestration	1,482.20	61,760.16 tonnes/year
	Water Purification	655.7	12,28,22,047.4 m^3/year
	Water Provisioning	745.3	40,43,74,400 m^3/year
	Gene-Pool Protection	73,386.50	N.A. as based on BT
	Sediment Regulation/ Retention	561	2,36,20,000 tonnes of sediments/year
	Biological Control	251.7	Benefits Transfer: Rs 660/ha./Year
	Pollination	441.1	Benefits Transfer: Rs 1,800/ha./Year for tropical forests
	Gas Regulation	176.5	Benefits Transfer: Rs 720/ha./Year for tropical forests
	Waste Assimilation	1,764.60	Benefits Transfer: Rs 7,200/ha./Year for tropical forests
	Flood Regulation	1,306.50	Benefits Transfer: Rs 540 crores per annum. The value was adjusted for WPI
	Total	**80,771.10**	
Cultural Services (C)	Recreation/Tourism	9.9	3,22,936 individuals visited various tourist attractions
	Total	**9.9**	
Supporting Services (D)	Habitat for Species	892.5	Total forest area 38,139.18 km^2
	Nutrient Cycling/Retention	420.9	NPK present in 2,36,20,000 tonnes of sediments/year
	Total	**1313.4**	
Total Flow Value - Grand Total (A+B+C+D)		**95,112.60**	

Table 3: Uttarakhand's Forest Ecosystem Services in the Human Values and Ecosystem Assets Framework

Type of Value	Value (INR Crores)
Adequate Resources	**4,49,567.23**
Timber (Flow), Fuelwood, NTFP, Water Provisioning, Land	
Protection from Disease/Predators/Parasites	**251.7**
Biological Control	
Benign Physical and Chemical Environment	**7,701.0**
Carbon Sequestration, Water Purification, Sediment Retention/ Soil Conservation, Nutrient Retention, Pollination, Gas Regulation, Waste Assimilation, Habitat for Species, Flood Regulation	
Socio-Cultural Fulfilment	**309.9**
Employment Generation, Recreation	
Ecosystem Assets	**10,50,213.70**
Standing Timber, Carbon Storage, Gene-Pool Protection	

FOREST RESOURCE ACCOUNTING FOR UTTARAKHAND

IIED and WCMC (1994) define forest resource accounting (FRA) as a management tool which integrates forest information from many sources and makes it available in forms which are useful for policy-making and planning. An FRA system tracks changes in forests used for both production and protection – especially in their area, legal status, condition and management. It reports these changes in ways which help to improve forest valuation, policy, planning and management, and which help to demonstrate national progress in achieving policy objectives.

Forest Resource Accounting (FRA) provides a realistic estimate of the contribution of forests to the GDP of the economy. When the contributions are recorded through a system of FRA, the contributing stakeholders can also be identified and this would help setting up a compensation payment /incentive-based mechanism to such conservationists. The current study prepared FRA for Uttarakhand uses two approaches - System of Environmental-Economic Accounting (SEEA) and a framework adapted from Xu et al. (1995).

SYSTEM OF ENVIRONMENTAL-ECONOMIC ACCOUNTING (SEEA)

SEEA Central Framework is the international statistical standard for environmental-economic accounting, often described as a satellite system to the United Nations System of National Accounts (SNA). The System of Environmental-Economic Accounting (SEEA) Experimental Ecosystem Accounting (EEA) is an integrated statistical framework for organizing biophysical data, measuring ecosystem services, tracking changes in ecosystem assets and linking this information to economic and other human activity. The work on SEEA EEA was able to take advantage of the more recent developments in the measurement of ecosystem services, such as presented in the Millennium Ecosystem Assessment (MA, 2005) and the original TEEB study (TEEB, 2010). The SEEA EEA represents a synthesis of approaches to the measurement of ecosystems adapted to enable integration with standard national accounting concepts and measurement boundaries. To start with ecosystem accounting it is important to organize data on the extent of different ecosystem types within a study area (Uttarakhand Forest Area) in terms of area. These are indicated in the Tables 4 and 5 below.

Table 4: Physical Asset Account for Recorded Forest Area (in Hectares)

	Opening Stock	Addition to Stock	Reduction to stock	Net Changes in Stock	Closing Stock
Forests and Other Wooded Land	3799960	-	-	-	3799960
Forest Land	2654700	-	-	-	2654700
Primary Forest	2361157.51	-	-	-	2361157.51
Other Natural Regenerated Forest	79834.586	-	6684.096	6684.096	73150.49
Total Natural Forest	2440992.096	-	-		2434308
Planted Forest	139211	12799		12799	152010
Other Wooded Land	-	-	-	-	-
Total Forest Land	2580203.096	12799	6684	6115(+)	2586318

Source: Uttarakhand State Forest Department Report.

Table 5: Area Accounts for Uttarakhand's Forests (in Square Km)

Forests and Other Wooded Land	Opening Stock (2013 ISFR)	Addition to Stock	Reduction to stock	Net Changes in Stock	Closing Stock (2017 ISFR)
Reserve Forest	24643	1904	0	1904	26547
Protected Forest	9885	0	0	0	9885
Unclassed and Vested Forest	123	1445	0	1445	1568
Forest Land (Under Forest Department)	34651	3349	0	3349	38000
Tree Outside Forest and Tree Cover	703	64	0	64	767
Total Forest and Tree Cover	35354	3413	0	3413	38767

Source: Indian State Forest Report 2013 and 2017.

Next an Ecosystem Condition Account is prepared to reflect the overall quality of an ecosystem asset in terms of its characteristics. In the case of the Forests of Uttarakhand, Ecosystem Condition Account was prepared taking growing stock as the indicator. Opening stock has been estimated in proportion with the forest cover from ISFR 2017 for the state. Mean annual increment has been taken from FAO estimated for India which is 0.5 m3/ / ha. As specific data for each category in Table 6 was not available, figures were equally distributed in proportion with the area each category possesses.

FRAMEWORK ADAPTED FROM Xu et. al. (1995)

The system of Forest Resource Accounting proposed by Xu et al. (1995) discusses the concepts of actual accounts, linkage accounts and potential accounts. Actual accounts measure the flow of goods and services flowing from the forest ecosystem to the economy currently. This flow can be assessed by the construction of Asset Accounts both physical and monetary asset accounts. Potential accounts record the various ecosystem features which determines both the actual and potential flow of benefits of those features, based on various ecosystem quality indices. Linkage Accounts tries to link together the Actual Accounts and Potential Accounts, and consists of estimates of costs of various ecological imperatives required to maintain some ecological indicators at specified level or to avoid losses in the flow of future goods and services (potential benefits). This framework adapted for Uttarakhand is shown in Figure 1.

Figure 1: Forest Resource Account Xu et al. Framework.

Uttarakhand Forest Ecosystem Service (Flow Values)	Economic Value (INR crores)
Fuelwood	3,395.20
Fodder	7,776.10
Timber	1,243.20
Non-Timber Forest Products	303.7
Employment Generation	300
Carbon Sequestration	1,482.20
Water Purification	655.7
Water Provisioning	745.3
Gene-Pool Protection	73,386.50
Sediment Regulation/Retention	561
Biological Control	251.7
Pollination	441.1
Gas Regulation	176.5
Waste Assimilation	1,764.60
Flood Regulation	1,306.50
Recreation/Tourism	9.9
Habitat for Species	892.5
Nutrient Cycling/Retention	420.9
Total	95,112.60

Expenditure Heads	Outlay Budget 2017-2018
Administration and Capacity Building	448.76
Forestation and Conservation	152.68
Forest Protection	135.45
Ecotourism	5.67
Wildlife Management, Parks & Bird Sanctuaries Management	36.91
Infrastructure Development (Building and Roads)	9.20
Strengthening of Forest Panchayats	1.45
Research and Technology	1.39
Rehabilitation and development Program	18.68
Biodiversity Coservation and Rural Livelihood Improvement Project (BCARLIP)	11.50
Uttarakhand Forest Resource Management Program (JICA)	123.00
Total	822.83

Uttarakhand Forest Ecosystem Service (Stock Values)	Economic Value (INR crores)
Timber Stock	7,21,101.70
Carbon Stock	2,55,725.50
Land Value	4,36,849.00
Total	14,13,676.2

Table 6: 8 Physical Accounts for Growing Stock

<table>
<tr><th></th><th colspan="2">Opening Stock (Growing Stock) (cubic metres)</th><th colspan="3">Addition to Stock (cubic metres)</th><th colspan="7">Reduction to stock (cubic metres)</th><th>Net Changes in Stock</th><th>Closing Stock</th></tr>
<tr><th>Type of Timber Resources</th><th>Area Coverage in Hectares</th><th>Volume in Cubic Metres</th><th>Natural Growth</th><th>Reclassification</th><th>Total Addition</th><th>Removals</th><th>Felling Residual</th><th>Losses</th><th>Cata-strophic Losses</th><th>Reclass-ification</th><th>Others (Overall reduction observed from 2015 to 2017)</th><th>(cubic metres)</th><th>(cubic metres)</th></tr>
<tr><td>Mainly Natural Regeneration</td><td>838,597</td><td>97,252,092</td><td>419,298</td><td>0</td><td>419,298</td><td rowspan="8">308885 (Timber) + 83063 (Firewood) = 391948</td><td rowspan="8">10 % of the Total Removals = 39194.8</td><td rowspan="8">Forest Fire (55914.59</td><td rowspan="8">Losses Due to Disease or Other Reasons</td><td rowspan="8">Forest Diversion (22968.37)</td><td>3329230</td><td>-3075303</td><td>94176789</td></tr>
<tr><td>Protection, Unalloted, etc.</td><td>225,125</td><td>26,107,759</td><td>112,563</td><td>0</td><td>112,563</td><td>893887</td><td>-825719</td><td>25282040</td></tr>
<tr><td>Selection Group, Protection and Improvement</td><td>863,348</td><td>100,122,485</td><td>431,674</td><td>0</td><td>431,674</td><td>3427492</td><td>-3166070</td><td>96956415</td></tr>
<tr><td>Coppice with Standards</td><td>55,229</td><td>6,404,943</td><td>27,615</td><td>0</td><td>27,615</td><td>219260</td><td>-202537</td><td>6202406</td></tr>
<tr><td>Clear Felling with Simple Coppice</td><td>95,196</td><td>11,039,869</td><td>47,598</td><td>0</td><td>47,598</td><td>377928</td><td>-349102</td><td>10690766</td></tr>
<tr><td>Plantation/ Afforestation</td><td>139,211</td><td>16,144,308</td><td>69,606</td><td>0</td><td>69,606</td><td>552668</td><td>-510515</td><td>15633793</td></tr>
<tr><td>Mainly Artificial Regeneration</td><td>225,160</td><td>26,111,862</td><td>112,580</td><td>0</td><td>112,580</td><td>893747</td><td>-825568</td><td>25286294</td></tr>
<tr><td>Other/ Unclassed</td><td>144,451</td><td>16,751,982</td><td>72,226</td><td>0</td><td>72,226</td><td>573470</td><td>-529731</td><td>16222252</td></tr>
<tr><td>**Total**</td><td>**2,586,318**</td><td>**299,935,300**</td><td>**1,293,159**</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>**-9484545**</td><td>**290450754**</td></tr>
</table>

SUSTAINABLE ENVIRONMENT PERFORMANCE INDEX (SEPI) FOR UTTARAKHAND

Uttarakhand is one of the fastest growing states in India which has witnessed one of the highest Gross Domestic Product (GDP) growth rates (2005-2014), second only to Sikkim. To ensure that this economic growth of the state is not eroding the natural capital, the backbone of such growth, it is important to monitor the health of the state's natural resources actively. In this regard, a Sustainable Environment Performance Index (SEPI) for the state of Uttarakhand was developed under this study.

SEPI helps in assessing the overall environment performance and sustainability of the state. This index allows year-on-year comparative analysis of the environmental achievements, challenges and priorities of a state, including the state's progress on environment- related Sustainable Development Goals (SDGs). It is indicative of the state's general environmental condition, capturing both historical resource endowments and achievements of policies and strategies undertaken by various stakeholders in conserving natural resources.

The SEPI comprises 8 sub-indices or sectors providing additional insights on the performance of each sector - Agriculture, Horticulture and Animal Husbandry; Disaster Risk and Vulnerability; Energy; Forest and Biodiversity; Human Health and Air Quality; Tourism and Education; Waste Management; and Water and Sanitation. Figure 2 highlights some of the key activities that went into developing the SEPI.

Figure 2: Key Activities of the SEPI Development Process

SEPI

Results across four scenarios with weightages given based on varying frameworks.

- **Scenario 1:** SEPI estimated with weightages for indicators within sectors and weightages between sectors based on results of the AHP group convergence exercise.
- **Scenario 2:** SEPI estimated with weightages for indicators within sectors based on AHP group convergence exercise and EQUAL weightages taken between sectors.
- **Scenario 3:** SEPI estimated with weightages for indicators within sectors based on SIR framework* and EQUAL weightages taken between sectors.
- **Scenario 4:** SEPI estimated with weightages for indicators within sectors based on SIR framework and weightages between sectors based on AHP group convergence exercise.

*SIR framework: Within each sector the indicator weights are allocated based on SIR (State-Impact-Response) category. The total weights assigned to "State" indicators category = 0.3, "Impact" indicators category = 0.2 and "Response" indicators category = 0.5. Within each category weights are split equally. For example, if there are 4 Response indicators in a particular sector, each indicator within the response category will get weightage = 0.5/4 = 0.125.

The sector-wise and overall SEPI scenario 1 results are presented in Table 7. Index and sub-index values above 100 show an improvement over base year (2014) values and values below 100 shows a decline in environmental performance since 2014. These estimates are based on 77 validated indicators and their corresponding weights determined using group AHP Group Convergence workshop. There were data gaps or limitations for 17 of these 77 indicators as elaborated in Table 57 Dummy values (showing no change) have been used for these 17 indicators.

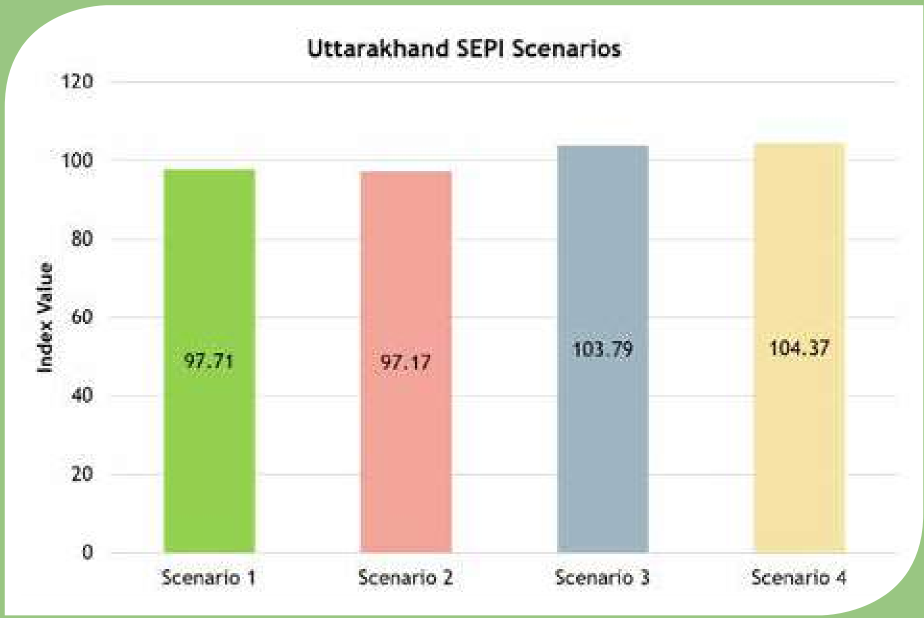

Table 7 SEPI Scenario 1 Results

	Sector	Sector Sub-Index	Sector Weights	Weighted Sector Totals
1	Forest and Biodiversity (FB)	100.45	26.0%	26.11
2	Water and Sanitation (WS)	98.15	13.4%	13.14
3	Energy (EN)	116.40	12.6%	14.72
4	Disaster Risk and Vulnerability (DRV)	61.26	9.0%	5.53
5	Tourism and Education (TED)	105.12	3.5%	3.72
6	Human Health and Air Quality (HAQ)	92.18	14.5%	13.33
7	Agriculture, Horticulture and Animal Husbandry (AHA)	108.34	9.1%	9.82
8	Waste Management (WM)	95.44	11.9%	11.33
	SEPI 2015-16	97.71		

The overall environmental performance of Uttarakhand has deteriorated marginally in the year 2015-16 when compared with 2014-15. The decline is caused by poor performance in sectors such as disaster risk and vulnerability, human health and air quality, and waste management.

Increasing forest fires and loss of animal lives due to natural disasters are causes of concern. In 2015, 4,433 ha was affected owing to forest fires. Another major priority area is the state of air and water quality, both of which are in decline. These are linked to SDG 3 and SDG 6, i.e. Good Health and Well-Being and Clean Water and Sanitation, respectively. Hence, despite Uttarakhand being declared an ODF state, sanitation can improve further by focusing on cleaning water bodies and air quality, particularly in the Terai areas.

Average per capita waste water generation in 92 towns of Uttarakhand has risen from 67 LPCD to 90 LPCD. This is expected with increased migration to the Terai regions. However, waste water treatment before discharge did not improve with only 25.3 per cent being treated.

The sectors which have performed well during SEPI 2015 are Energy and Agriculture, Horticulture and Animal Husbandry. Uttarakhand has performed well on Sustainable Development Goal 7 (Affordable and Clean Energy). Renewable energy share in the state's total installed capacity has increased. Households using clean fuel for cooking such as LPG, biogas or electricity has increased as well.

There has been a steady increase in areas under organic certification. The deficit in fodder availability and requirement is reducing as well. Response measures such as forming Biodiversity Management Committees (BMCs) and signing contracts under the Access and Benefit Sharing mechanism (ABS) have also seen an improvement.

MAPPING ECOSYSTEM SERVICES

The current study applies one of the most widely used tools for mapping ecosystem services, Integrated Valuation of Ecosystem Services and Trade-Offs (InVEST). Constrained by data availability for Uttarakhand, 2 of the 18 available models in the InVEST 3.0 package were applied for the entire state of Uttarakhand. These include the Carbon Storage and Sequestration: Climate Regulation Model and the Water Yield: Reservoir Hydropower Production Model.

According to the carbon storage model, the forests of Uttarakhand store 327.95 million tonnes of carbon across its four pools. The water yield model estimated the total water yield volume for Uttarakhand at 10.46 billion cubic metres. This estimate does not account for consumptions as per land uses.

GROSS ENVIRONMENTAL PRODUCT (GEP) FRAMEWORK FOR UTTARAKHAND

Based on the studies conducted to estimate the GEP/Green GDP two scenarios have been considered suitable for the state of Uttarakhand keeping in view the Demography, Economy, Ecosystem extent and condition.

GEP internalizing the cost of environmental pollution and resources depletion (depreciation of ecological goods and services) excluding the value of natural resources.

GEP internalizing the Value of Ecological Services (Environmental Goods and Service not considered under traditional GDP) and ecological cost/losses.

Gross ecosystem product (GEP) = Traditional GDP (Value of Goods and Services) + Value of Ecological Services (Environmental Goods and Service not considered under traditional GDP) – Ecological Cost

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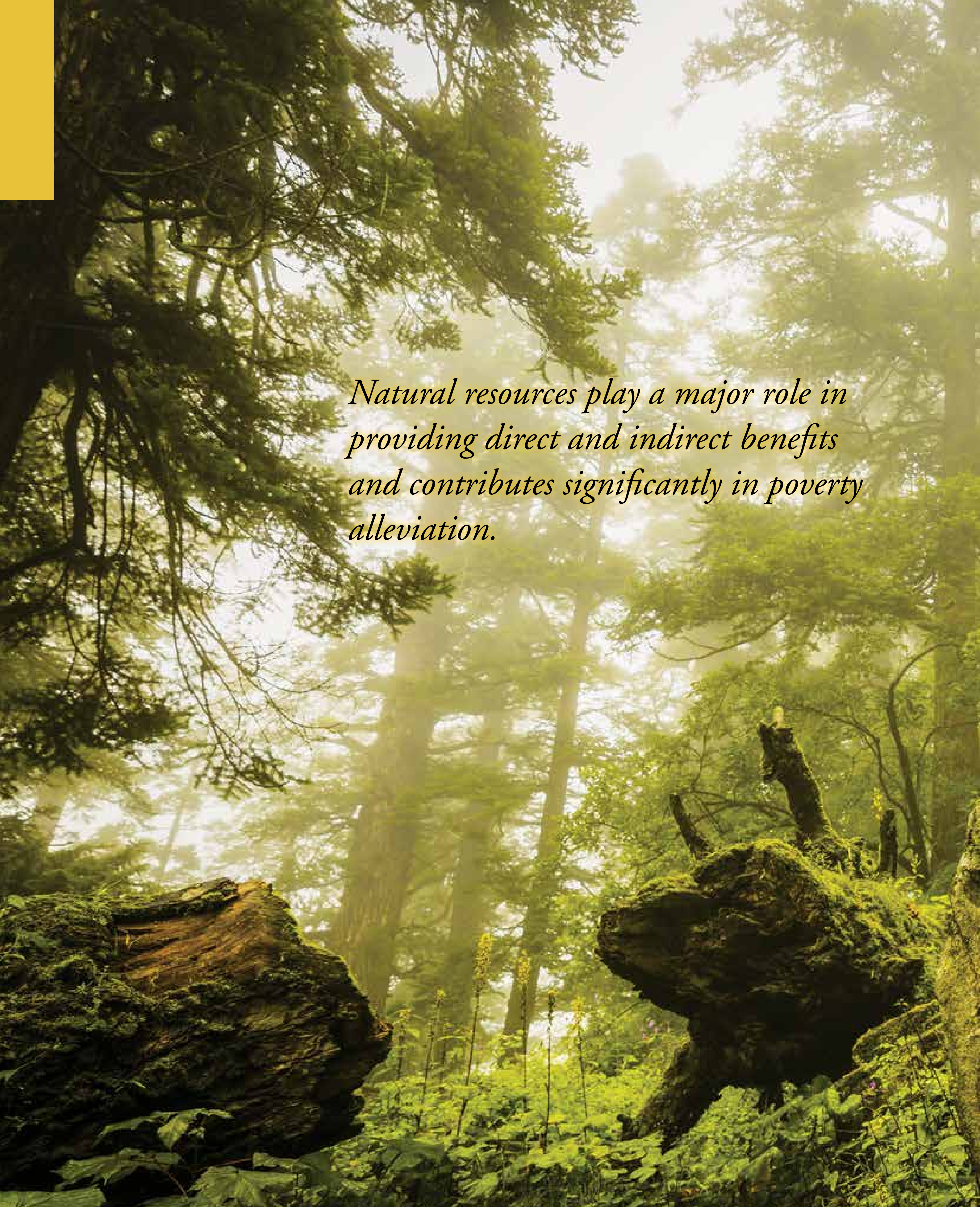
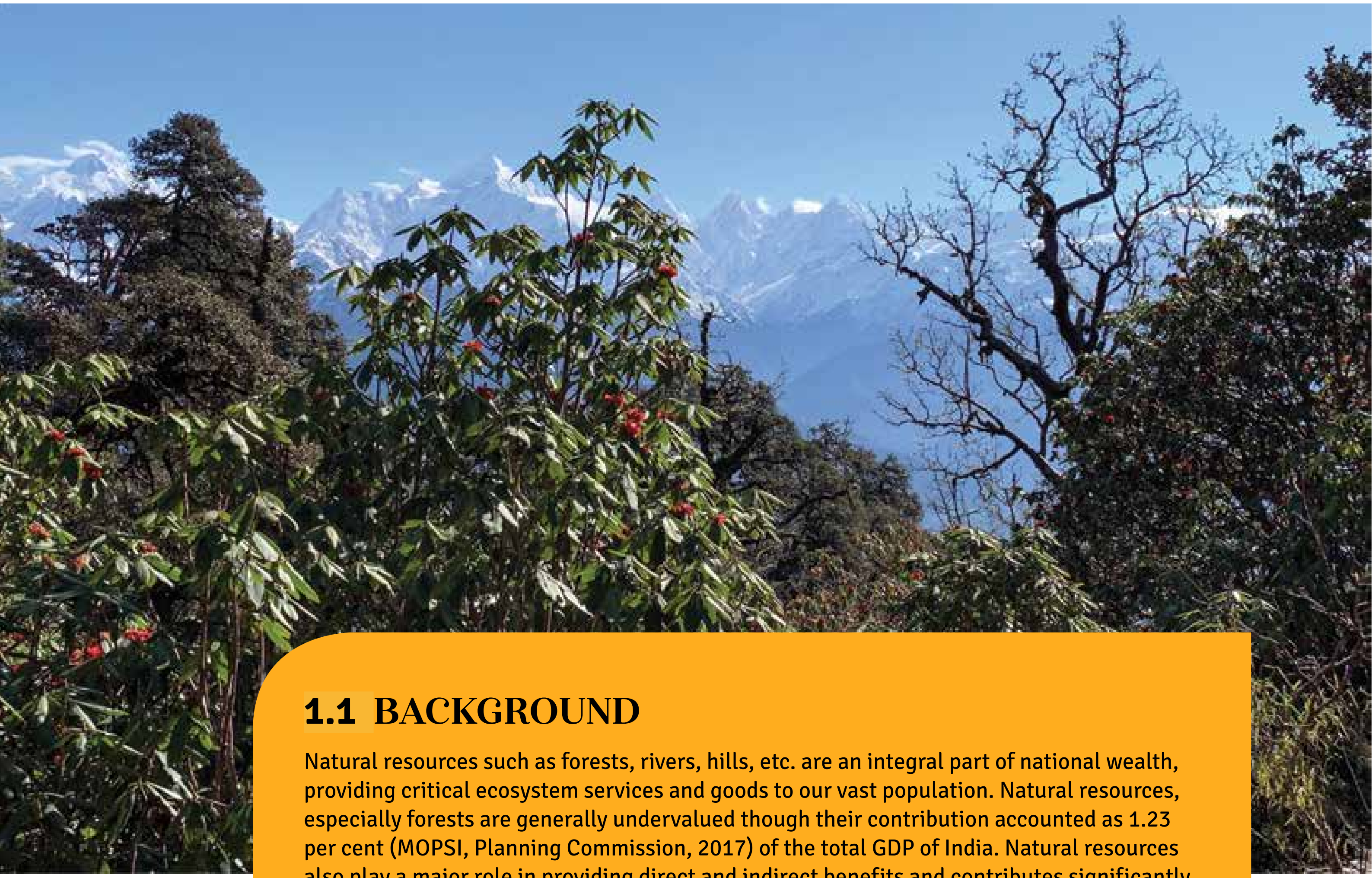


Natural resources play a major role in providing direct and indirect benefits and contributes significantly in poverty alleviation.

INTRODUCTION

CHAPTER 01



1.1 BACKGROUND

Natural resources such as forests, rivers, hills, etc. are an integral part of national wealth, providing critical ecosystem services and goods to our vast population. Natural resources, especially forests are generally undervalued though their contribution accounted as 1.23 per cent (MOPSI, Planning Commission, 2017) of the total GDP of India. Natural resources also play a major role in providing direct and indirect benefits and contributes significantly in poverty alleviation. The goods and services obtained from forests are often not monetized in the market and this may lead to a constant overuse and degradation of our forests. This degradation may result in poor quality of life for all our citizens, but the impact is particularly pronounced on the poor and vulnerable groups, as it is they who suffer the most from degraded access to clean water, air and sanitation, as well as from climate shocks.

Several framework and methodologies have been evolved in the past two decades to identify the ecosystem services and its valuation, e.g. Total Economic Value (TEV), The Economics of Ecosystems and Biodiversity (TEEB), Millennium Assessment (MA 2005), Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), etc.

The current study focuses on valuation and accounting of forest resources of Uttarakhand and drafting a framework for accounting of other natural resources, e.g. water, land, energy, etc. to realize the actual benefits of natural resources present in the state and its policy implications. An attempt has been made to prepare environmental accounts for forest resources as per the best practices that are being followed worldwide and provide frameworks for accounting of all other natural resources, e.g. land, water, etc. The study will help us to understand the data gaps that exist to prepare complete accounts for all-natural resources as per best practices and to design a roadmap for the way forward.

1.2 ECOSYSTEM SERVICES AND NATURAL CAPITAL IN UTTARAKHAND'S CONTEXT

Uttarakhand, also known as the realm of gods, has abundant natural resources due to hills and forests, several highly venerated pilgrimage places, natural lakes, etc. Uttarakhand is home to rich natural resources and wildlife habitats. It is a land of natural beauty, comprising of 93 per cent mountainous and 71 per cent recorded forest area. Its geographical location, the climate and the vegetation in the region vary greatly with the elevation and is an eco-sensitive zone. The state is home to more than 175 species of rare medicinal, aromatic and herbal plants. Uttarakhand is also ideal for several adventure sports activities because of its geographical attributes. A glimpse of Uttarakhand's demography is given below.

Table 8 Uttarakhand at a Glance

Geographic area (Sq. Km)	53,843
Population (Census 2011)	10,086,292
Rural Population (%)	69.76
Number of Districts	13
Agricultural Land (% of Total Geographical Area)	13.20
Recorded Forest Area (km²)	38,000
Per Capita Forest Area (ha)	0.37
Forest Area as Percentage of Geographical Area	70.57
Forest Cover (km²)	24,295
Major Rivers	Ganga, Yamuna, Ramganga and Sharda
Major Occupation	Agriculture, Forest-Based Activities

Uttarakhand, according to FSI 2017, has a total Recorded Forest Area of 38,000 km² under various classes. The forest cover as reported in ISFR 2017 is 24,295 km² mapped which includes 4,969 km² under Very Dense Forest (VDF), 12,884 km² Moderately Dense Forest (MDF), and 6,442 km² Open Forest (OF). The state also has 767 km² under Tree Cover. In addition to this, Uttarakhand has 355 km² of area under water bodies in Forest Area and total Carbon Stock of 284.664 million tonnes (Forest Survey Of India, 2017)

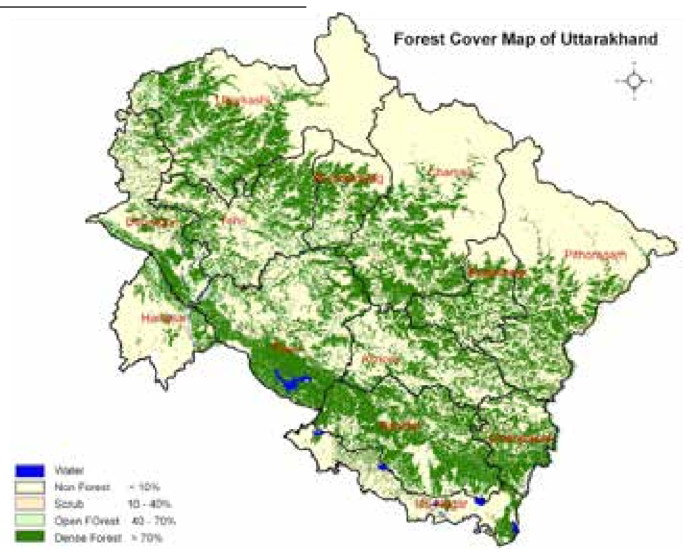


Figure 3: Forest Cover Map of Uttarakhand
(Source: Uttarakhand State Perspective and Strategic Plan)

There are four major river systems, viz. Ganga, Yamuna, Ramganga and Sharda originating from the state along with their tributaries which are major sources of water for drinking, irrigation and hydropower (Figure 4).

Uttarakhand has soil distribution which is generally fully shallow, gritty, impregnated with unweathered fragments of parent rocks and are not fertile. Important minerals that are found in the state are high-grade limestone in Almora, Bageshwar, Dehradun, Nainital, Pauri-Garhwal, Pithoragarh and Tehri-Garhwal districts; magnesite and steatite in Almora, Bageshwar, Chamoli and Pithoragarh districts; and tungsten in Almora district.

Other minerals that are found in the state are asbestos in Chamoli district; barytes and marble in Dehradun district; copper in Almora, Dehradun and Pithoragarh districts; dolomite in Dehradun, Nainital and Tehri-Garhwal districts; graphite in Almora district; gypsum in Dehradun, Pauri-Garhwal and Tehri-Garhwal districts; lead-zinc and silver in Dehradun and Pithoragarh districts; and rock phosphate in Dehradun and Tehri-Garhwal districts. The production value of minerals in Uttarakhand was 89 crores in 2015-16. Land use and land cover for the state of Uttarakhand explains the diversity of natural resources available in the state in Figure 6 and 5. As per the map given in Figure 6, 48 per cent of the land comes under forest followed by 20 per cent in agriculture and the rest in snow and glaciers, wetlands/water bodies, barren, built-up, etc.

Figure 4: River Drainage Network of Uttarakhand

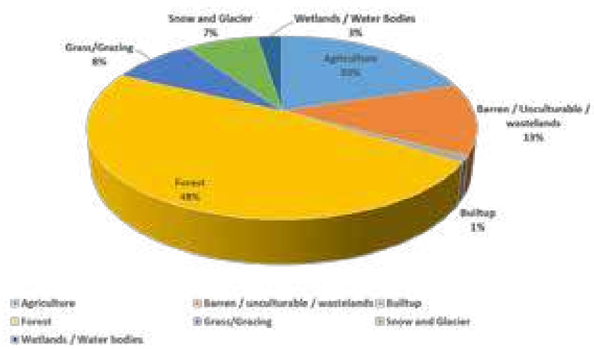


Figure 5: Distribution of Land Use/Land Cover: Uttarakhand

Uttarakhand being one of the hilly states has a mandate, as directed by the Supreme Court to keep two-thirds of their geographical area under forests. Maintaining such large forest areas not only benefits the state in terms of benefits related to microclimate regulation, tourism and forest products, but also results in a significant quantum of positive externalities through benefits related to water that are largely accrued to downstream states. These benefits, a major proportion of which are accrued to other states are however realized through costs borne by Uttarakhand in terms of opportunity cost of not being able to use the forest land for other purposes. Thus, public investment by the state in maintaining large areas under forests benefits several downstream states.

1.3 SCOPE OF THE STUDY

Uttarakhand in the light of making a substantial contribution towards sustainable development has made several efforts in the field valuation and accounting of forest resources, partial implementation of payment for ecosystem and is a leading state in conducting research work in the field of environment and forests. Extensive work has been done on ecosystem valuation on the Corbett National Park located in Nainital district of Uttarakhand and Himalayan Landscape of the state.

The current study intends to know the economic value of the state's natural resources and its contribution to the states and national GDP. In addition to this the development of Sustainable Environmental Performance Index and Natural Resource Accounting Framework will help keeping a track of the state's accountability for the management and protection of natural resources and monitoring sustainable development.

Uttarakhand being a developing state, sustaining its forests and other natural resources has a significant opportunity cost due to the unavailability of land for other development purposes which impacts both the revenue capacities and the expenditure needs of the states. With such a high endowment of natural forests, Uttarakhand should get a "Green Bonus" for meeting expenditure on preserving and regenerating depleted, degraded natural forests and environmental resources. The current study will be a stepping stone to provide scientific justification for such claims.

1.4 OBJECTIVES OF THE STUDY

The state of Uttarakhand despite having a rich natural base, which provides an enormous amount of benefits not only to the state but to the entire country and the rest of the world, the current recorded contribution of Natural Resources (Agriculture, Forestry, Fishing, Mining and Quarrying) in Gross State Domestic Product of Uttarakhand is reflected as 7.78 per cent only (Table 9).

Table 9: Contribution of Natural Resources in Uttarakhand's GDP

S.No	Item	% Share in GSDP
	Crops	4.52
	Forestry and Logging	1.85
	Fishing and Aquaculture	0.03
	Mining and Quarrying	1.37
	Total	7.78

To ensure that due attention is given to forests and natural resources in the state, given their huge potential to contribute in the society and economy, it is imperative to assess and value them appropriately. Economic Valuation and Accounting of the state's natural resources can be handy, which would go a long way in achieving Uttarakhand's goal of sustainable development.

Hence the current study attempts to address its terms of references through enlisting the following objectives.

- Construction of Green Accounts of Forest Resources (Physical and Monetary) of Uttarakhand-Valuation of forest ecosystem services compiled into Forest Resource Accounts following internationally acclaimed frameworks.
- Construction of Sustainability Environmental Performance Index (SEPI) for the state of Uttarakhand.
- Developing frameworks for Green Accounts of land, water, minerals (outside forests) for the state of Uttarakhand.
- Capacity building of department personnel on economic valuation and natural resource accounting.

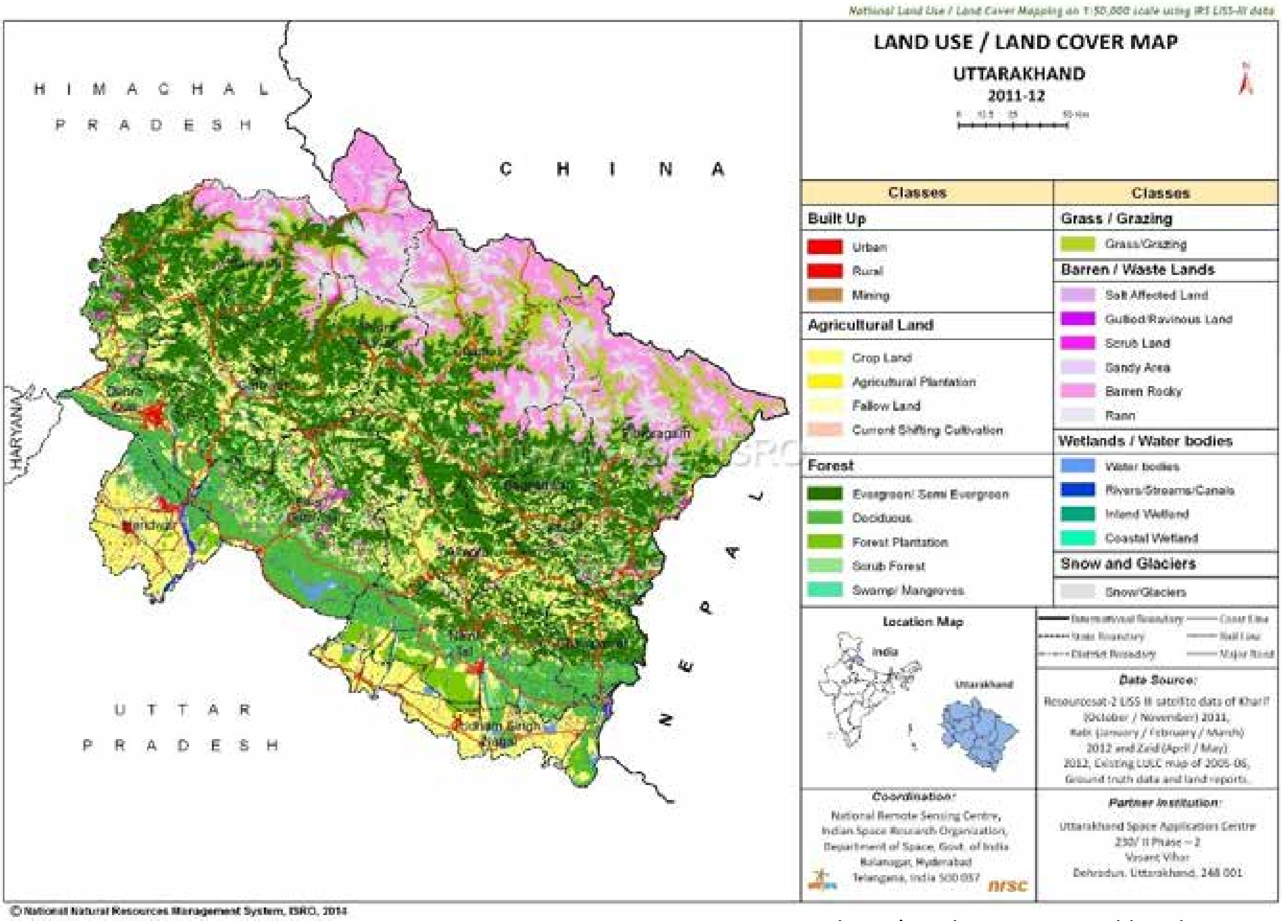


Figure 6: Map Land Use/Land Cover: Uttarakhand

1.5 METHODOLOGY

The methodology followed in conducting the current study has been discussed in detail in Table 10.

Table 10: Methodology in Detail

S.No	Activity	Description
	Mapping of various forest ecosystem services	Identification, understanding and enlisting various ecosystem services from Uttarakhand forests through departmental statistics, key informant interviews, group consultations, workshops, stakeholder meetings etc.
	Formulation of quantification and valuation framework	Review of literature, frameworks like WAVES Natural Capital Accounts, SEEA 2012 and other applicable frameworks for Forest Resource Accounting for initial scoping and developing valuation modules.
	Identification of data to be collected on forest ecosystem services	Database of indicators required to understand the extent and condition of forest ecosystem and its services. This work would be in close coordination with relevant government departments to understand data sources, availability and gaps.
	Remote sensing and GIS analysis	RS and GIS analysis at various successive stages of the study analysis as well as running spatial valuation model InVEST.
	Fieldwork and data collection	Data collection through secondary and primary sources and collation of data.
	Valuation of ecosystem services	Collation of data, analysis and estimation of forest ecosystem services.
	Construction of Forest Resource Accounts	Preparation of Forest Resource Accounts based on international framework and interpretation of results.
	Sustainable Environmental Performance Index (SEPI)	Listing of environmental indicators of the key sectors aligned with SDG Goals using DPSIR Framework and weightages using Analytical Hierarchy Process. Further elaboration of the SEPI methodology can be found in Chapter 6.
	Framework for Other Natural Resources	Accounting frameworks for other natural resources as per international norms.
	Framework for Gross Environmental Product	Based on literature review developing framework for GEP (Including land, water, energy, etc.)
	Capacity Building	Training of officials from different sectors on the concepts and methods for ecosystem services valuation, data collection, natural capital and forest resource accounting, and incentive-based mechanisms, SEPI.

Despite covering a substantial amount of forest area present in Uttarakhand, the registered contribution of forests towards state GDP (2015-16) is a meagre 2.08 per cent only (Directorate of Economics and Statistics, Uttarakhand, 2016). This underrepresentation of forests in the state's economy is due to the limitation of the current accounting system owing to which the true contribution of forests is not being reflected in the state's GDP.

The Natural Resource Accounts so developed could be of immense use to national and state legislatures, natural resource management agencies and for policy advocacy. Below is the flow chart which provides a more detailed explanation of the valuation steps and the critical questions for each step. The section after that indicates how to use the values for policy recommendations and implementation in conservation initiatives by government, multilateral and bilateral agencies.

Figure 7: Valuation Process Flow and Policy Connect

Identification of goods and services from under different ecosystems.	What ecosystem services will be valued? What is the geographical scale?
Selection of appropriate valuation method and technique, environmental Indicators, etc.	Which method is the most appropriate for capturing which services? Environmental indicators for key sectors
Data sources and availability of the data.	What data are already available? What new data needs to be collected? Proxy values/Benefits transfer?
Develop a detailed research design and instruments for data collection.	How will data be collected? How will questions be framed? If CVM is chosen, should we measure WTP? or WTA?
Collect data: primary, secondary, expert survey, weightages (AHP).	Expert survey? Brainstorming? How to collect field data, from how many sites, by whom? How to measure data quality?
Analyse data: calculations, cost benefits of alternative options, write report.	How will data be analysed? How will data collected by different techniques be integrated?
Develop options and make recommendations for sustainable use and conservation of ecosystem.	How to provide meaningful inputs to the decision- makers?

1.6 THE POLICY CONNECT

Mainstreaming natural capital and ecosystem services into policy and decision-making requires a better understanding of the complex decision-making processes of the private and public sector across different policy levels. A better understanding of ecosystem service production functions, underpinned by biodiversity, is also essential to link natural capital with human well-being and society (Maes et al., 2014).

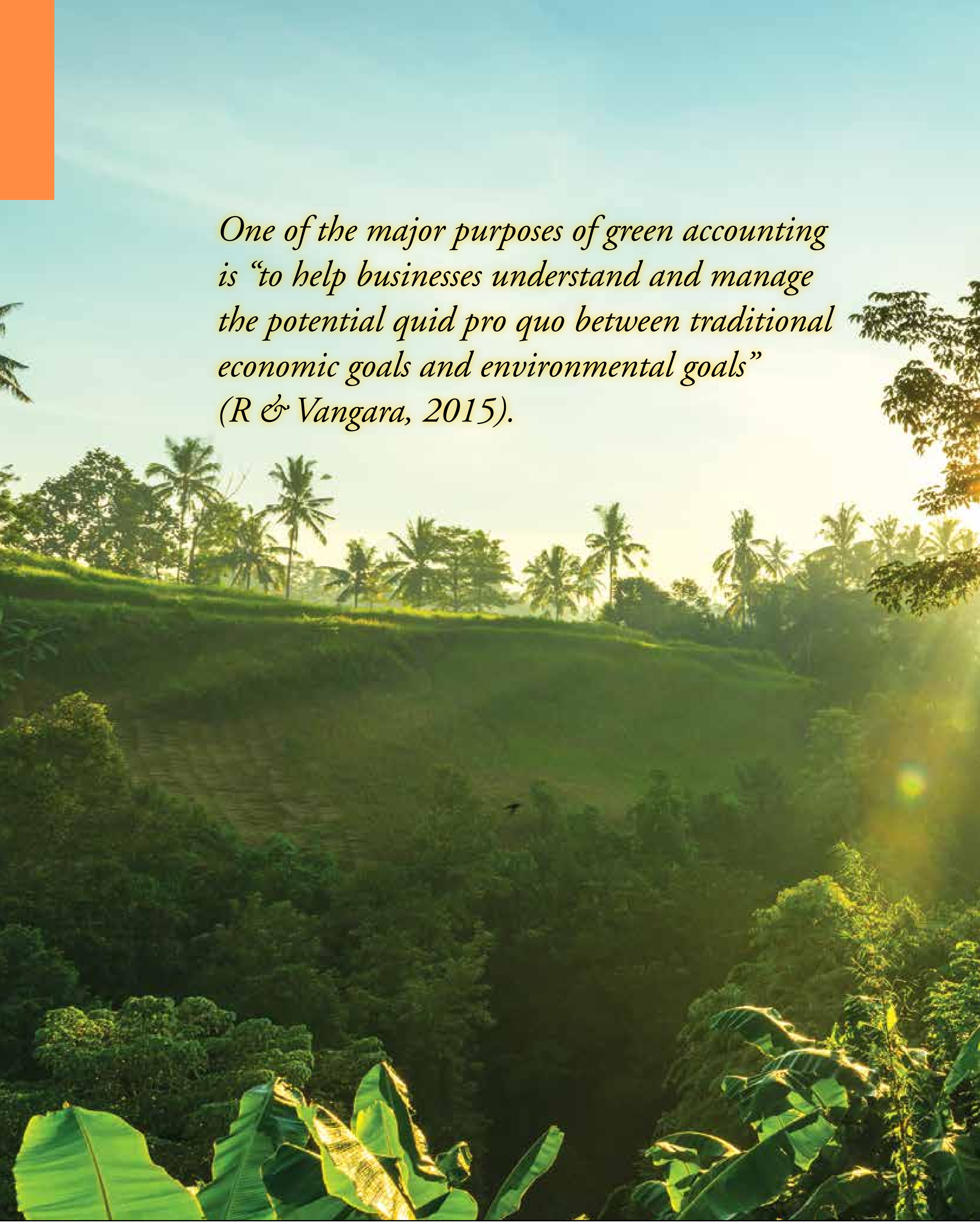
There is wide-ranging evidence that the economic valuation of ecosystems has greatly enriched the design of public policy. While capturing the benefit of ecosystem services, the cost component must also be identified to help the policy makers who are confronted with limited and competing funds and conflicting policy goals (Thompson et al., 2011).

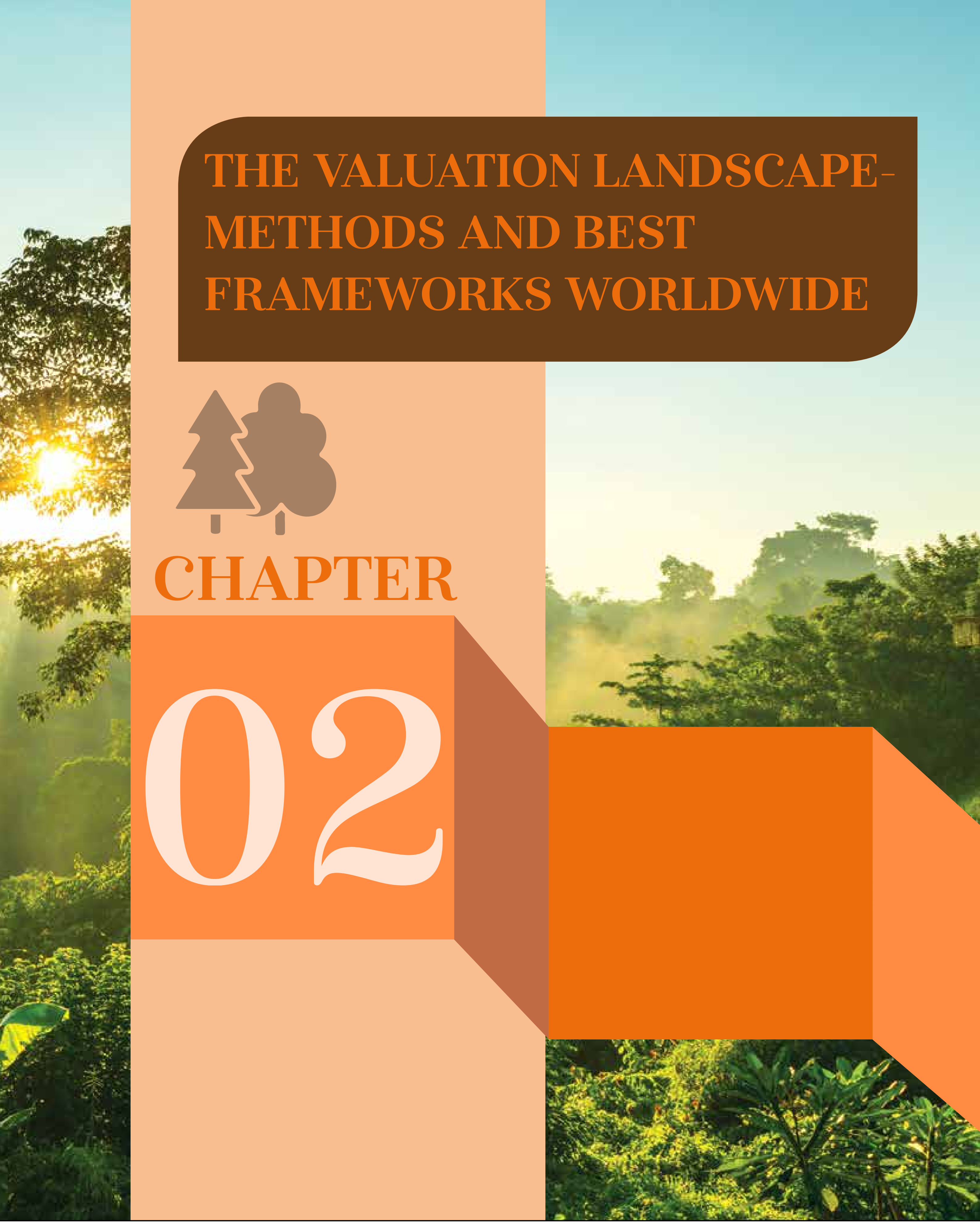
The economic valuation of ecosystem services can also help link the state of Uttarakhand in developing conservation strategies to mainstream policies at national and regional levels. It can contribute to the efficacy of decision-making criteria (as in cost–benefit analysis or multi-criteria analysis) and can thereby modify humans' choice of activities that subsequently impact the condition and trend of the ecosystems under consideration (Kumar and Kumar, 2008)

Ecosystem services mapping and valuation is also needed to underpin the implementation of environmental legislation, the integration of biodiversity objectives into sectoral policies and the development of, sustainable agriculture, forest management and fishing (Maes et al., 2014).

Ecosystem mapping and valuation can also be used to identify priority areas for green infrastructure development, habitat restoration and conservation, while also confirming that enhancing and protecting green infrastructure has benefits across sectors and policies.

One of the major purposes of green accounting is "to help businesses understand and manage the potential quid pro quo between traditional economic goals and environmental goals" (R & Vangara, 2015).





THE VALUATION LANDSCAPE- METHODS AND BEST FRAMEWORKS WORLDWIDE

CHAPTER

02

2.1 NATURAL CAPITAL, ECOSYSTEM SERVICES AND GREEN ACCOUNTING

Natural capital is the stock of natural resources or assets such as forests, soil, geology, air, etc. This includes environmental assets, such as timber and minerals, ecosystem assets, and goods and services that flow from the assets.

The term "Ecosystem Services" has been used more often in the last few decades in research and policy advocacy. Ecosystem services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life (Daily, 1997). In other words, ecosystem services are the benefits people obtain from ecosystems which are of great importance to human well-being, health, livelihoods, climate regulation and survival.

Natural capital and the associated flows of ecosystem services are central concepts in green accounting. Green accounting is the compilation of data on natural resources within an accounting framework and is an attempt to factor environmental costs into the financial results of operations. It has been argued that gross domestic product ignores the environment and therefore policy makers need a holistic model that incorporates ecological aspects into accounting framework. The concepts have been translated from economic theory and provide a bridge between the economic, social, and environmental domains.

One of the major purposes of green accounting is "to help businesses understand and manage the potential quid pro quo between traditional economic goals and environmental goals"(R & Vangara, 2015). Green accounting will also help to provide information on the state of natural resources and the changes affecting them. It is therefore an important link in the chain of sustainable development. Green accounts may involve either physical quantities or stocks valued in monetary terms. Green accounts differ from other data in that they are organized in terms of stocks and flows. The terms 'natural resource accounting', 'green accounting' and 'environmental accounting' are used interchangeably in the literature on the subject and are regarded as synonyms for this paper.

2.2 LITERATURE REVIEW-

2.2.1 FOREST VALUATION AND ACCOUNTING ACROSS THE GLOBE AND IN INDIA

Forest ecosystems provide a range of goods and services that are essential for human well-being. Several techniques have been developed and applied under ecological economics to estimate values for ecosystem services. Globally, Costanza et al., (1997) estimated the total value of forest ecosystem goods and services at $4.7 trillion annually. After this, a number of studies attempted to map different biomes and ecosystem services emanating from them using various valuation methods and tools, e.g. (de Groot et al., 2012), Kubiszewski et. al (2013) significantly greater than the Gross Domestic Product (GDP) (Costanza et al., 2014).

Forest ecosystem functions provides a number of ecosystem services to humans and are generally undervalued though their contribution accounted as 1.23 per cent (MOPSI, Planning Commission, 2017) of the total GDP of India. Hence it is important to realize the actual worth of the forest area in India. Several studies have been carried out for valuation of forest area in India by institutions such as the World Bank, TEEB, IIFM, etc. The studies show that a strong interlink exists between the forest and biodiversity present in it and how the sustainable extraction of benefits from forest area with traditional knowledge of the local people can alleviate poverty from the grass-root level.

Since the first study by T.M. Das in 1980 entitled 'The Value of a Tree' in which he gave an astronomical figure for a single tree of Rs.15.7 lakhs, economic valuation of forests has received major attention as a research area. One of the attempts was to calculate water supply benefits from the Almora forests by indirect methods (Chaturvedi, 1992). Chopra (1993) estimates the value of non-timber forest products: An estimation for tropical deciduous forests of India. In another study, the value was calculated using biomass extraction at 1.2 lakhs per hectare (Kadekodi and Ravindranath, 1997 (Chopra & Kadekodi, 1997) estimated the value of watershed for soil conservation at Rs. 2.0 lakhs/ha metre of soil in the Yamuna Basin.

Between 1999-2000, (Madhu Verma, 2000) conducted a study in Himachal Pradesh where the Total Economic Value (TEV) of forests was calculated for the first time. Sinha and Mishra, (2015) also assess the willingness to pay for ecosystem service valuation for enhancing conservation and livelihoods in a sacred village in the landscape of the Indian Himalayas.

Many of the recent studies like the (World Bank, 2013) use economic valuation for biodiversity at the national level, Vandermeulen et. al.(2011) use economic valuation to create public support for green infrastructure investments in urban areas, and (Bahuguna and Bisht, 2013) estimate the value of ecosystem goods and services for the Indian forests. Ghosh et. al (2017) have calculated the value of ecosystem services at landscape level from Terai Arc landscape in Uttarakhand.

Related studies on economic valuation such as "Revision of Rates of Net Present Value Applicable for Different Class/Category of Forests" by (Madhu Verma, Negandhi, Wahal, and Verma et. al. (2013) were conducted to estimate the cost of forest diversion for non-forestry purposes.

Other studies like economic valuation of tiger reserves in India Verma et. al. (2015) takes into account six tiger reserves from six different landscapes to calculate the value of 25 ecosystem services emanating from them. Forests of Himachal Pradesh, Uttarakhand and Arunachal Pradesh have been valued for their ecosystem services in the studies (Madhu Verma, 2000 and Madhu Verma et. al, 2016), (Madhu Verma, 2007) and (Kumar, and Chaudhry, 2015) respectively. Natural resource accounting for the land and forestry sector in the states of Madhya Pradesh and Himachal Pradesh was also done by Verma and Kumar (2006). Ninan and Kontoleon (2015) value forest ecosystem services from Nagarhole National Park in Karnataka and Chaudhary et al. 2016 calculate the same for Pakke Tiger Reserve in Arunachal Pradesh. (Badola et al., 2010) India. The direct cost was derived from secondary sources, and indirect and opportunity costs through socioeconomic surveys. For recreational value the individual approach to travel cost method was used, and to assess carbon sequestration the replacement cost method was used. The maintenance cost of the reserve was estimated as US 2,153,174.3 per year. The indirect costs in terms of crop and livestock depredation by wild animals ranged from US 2,408 to US 37,958 per village over a period of 5 years. The dependence of local communities was for fuel wood (US 7,346 per day assess the ecosystem services from Corbett Tiger Reserve. Every valuation exercise should recognize that the services provided by the ecosystem are priceless and by valuing them we are not setting a price on them. The understanding of the complexity of economic, cultural, and social values is increasingly embedded in decision-making. Economic valuation acts as catalysts to aid policy decisions and creating awareness about the natural systems we have. Valuation can also be used to prioritize and compare ecosystems and their services on the basis of their relative contribution to individual or social objectives. It may include the number of people who benefit from these services, their preferences, the cost of gaining/ providing access to the service, and the availability and cost of substitutes (Proxy Values).

2.3 NEED OF VALUATION AND NATURAL RESOURCE ACCOUNTING (NRA)

The traditional system of measuring the state's growth based on Gross (State) Domestic Product (GDP/GSDP) and Net Domestic Product (NDP) prepared based on the existing System of National Accounts (SNA) has proven to be inadequate in terms of accurately measuring the contribution of, and impact on, the environment. Natural Capital Accounting is one of the tool to internalize this deficiency in the current growth measuring regimes and support environmental policy, alongside instruments such as environmental impact assessments at a project level, integrated environmental and economic analyses for policy work at the sectoral and macro-economic levels, and public investment/ expenditure reviews (Harris and Fraser, 2002).

The provision of information on the income and expenditure associated with the maintenance or restoration of natural resources can also be an aim of natural resource accounting. Natural resource accounting is seen as a means of demonstrating linkages between the environment and the economy.

Natural resource accounts may contain either physical units or monetary values. Physical quantities are always a first, necessary step.

Their inherent value lies in the fact that they provide a means for direct monitoring and for the evaluation of stocks and flows relating to the state of the environment. Physical quantities need to be expressed in monetary terms when monetary accounts are compiled. The resultant information can form the basis for the computation of environmental performance indicators. At a macro-economic level these indicators can include for example, a 'green' national product or other ‘green aggregates’ such as ‘green’ savings.

Natural resource accounting can be used for (Gundimeda, Sukhdev, Sinha, and Sanyal, 2007):

- Demonstration of accountability for the management and protection of natural resources.
- Identifying environmental problems such as resource depletion.
- Analysing government policy.
- Undertaking resource management and decision-making.
- Monitoring sustainable development.
- Drawing up (macro-economic) indicators for environmental performance or prosperity.

Improving benchmarks for measuring a country’s national product.

2.4 THE VALUE+ APPROACH

Valuation of ecosystem services has come a long way in the past few decades. The idea of applying monetary values has become an effective bridge between ecological and economic approaches and has found its way to policy advocacy. Though many formal methods for valuation of ecosystems services from different biomes have evolved, but we still have a long way to go, especially since we have limited understanding of our natural systems and the valuation is not absolute.

Taking these limitations into consideration the current study uses a VALUE + approach which signifies that the value arrived at by the process of valuation is a conservative estimate owing to lack of knowledge, understanding, technology and resources. The symbol ‘+’ signifies that the system provides many additional services which are not accounted for due to human limitations. Our natural systems have huge potential storage and are a repository of unidentified values.

THE CURRENT STUDY USES A VALUE + APPROACH WHICH SIGNIFIES THAT THE VALUE ARRIVED AT BY THE PROCESS OF VALUATION IS A CONSERVATIVE ESTIMATE OWING TO LACK OF KNOWLEDGE, UNDERSTANDING, TECHNOLOGY AND RESOURCES.

2.5 TECHNIQUES OF VALUATION

Valuation of ecosystem services is not only price-based but it takes into consideration many other cost, value, ordinal and benefits transfer approaches (Figure 8):

- Cost-based Approaches: Cost-based approaches are based on estimations of the costs that would be incurred if ecosystem service benefits needed to be recreated through artificial means (Garrod and Willis, 1999). Different techniques exist, including, (a) the avoided cost method (b) replacement cost method and (c) mitigation or restoration cost method.
- Price-based Approaches: Market prices reflect both the private and social willingness to pay (WTP) for the traded ecosystem services. Market price-based methods are often used to obtain the value of provisioning ecosystem services.
- Value-based Approaches: Value is a marginal concept insofar that it refers to the impact of small changes in the state of the world, and not the state of the world itself. In this regard, the value of ecological assets, like the value of other assets, is individual-based and subjective, context-dependent, and state-dependent (Goulder and Kennedy, 1997, Nunes and van den Bergh, 2001). Estimates of economic value thus reflect only the current choice pattern of all human-made, financial and natural resources given a multitude of socio-ecological conditions such as preferences, the distribution of income and wealth, the state of the natural environment, production technologies, and expectations about the future (Barbier et al., 2009).

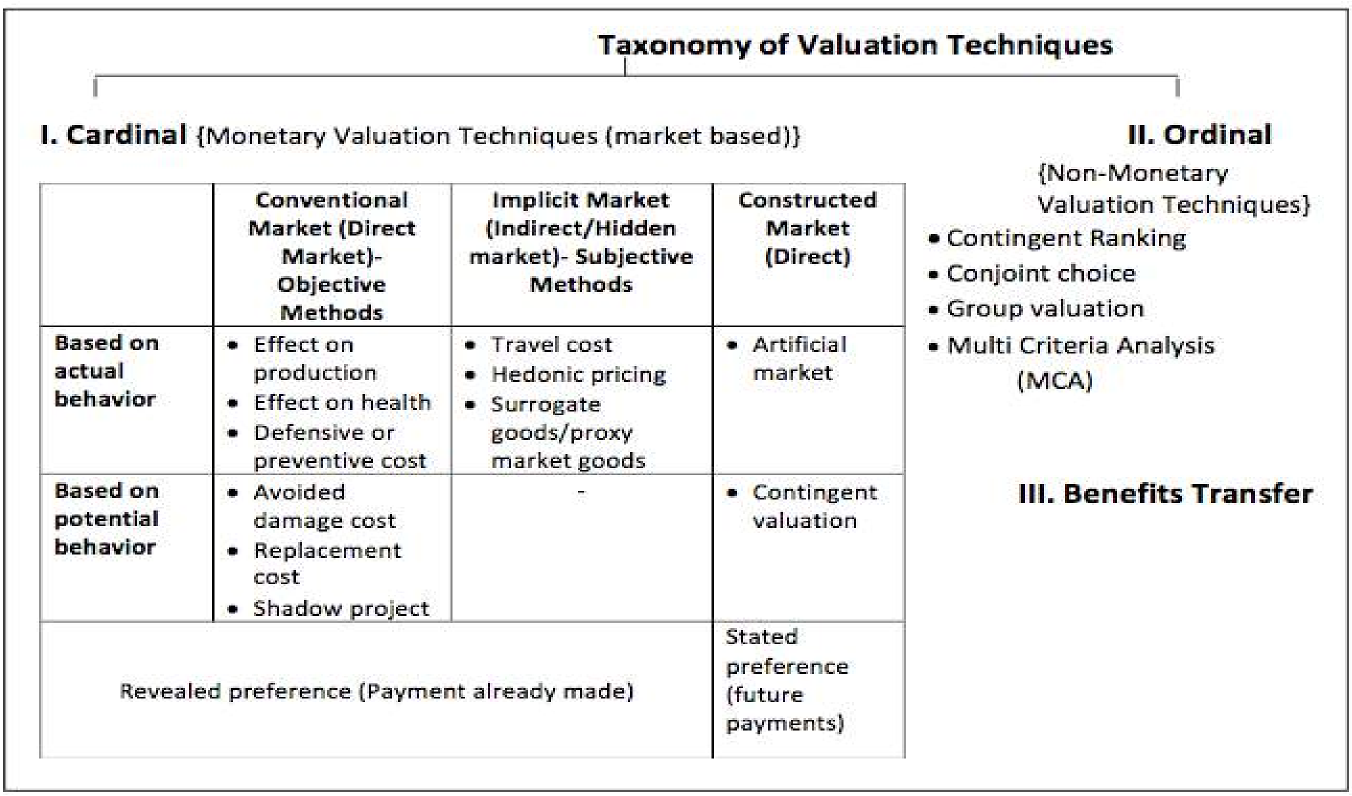


Figure 8: Taxonomy of Valuation Techniques.

The methods are conventionally classified as cardinal (market-based) where a specific value of an ecosystem service can be ascertained or ordinal (non-market based) where instead of a specific number ranking of services can be obtained (Figure 8). Cardinal methods are further divided into major categories of conventional/direct/objective methods where payments are directly made for an ecosystem service or implicit/indirect/hidden/subjective methods where surrogate markets or indirect market data is used like statistical and econometric models to arrive at the value. The direct and indirect market methods are also termed as revealed preference approaches where payments have already been made. But there are cases where market information cannot be used directly or indirectly. The simulation process is used to arrive at market like behaviour and in such cases markets are artificially created or constructed and information regarding future payments is sought. These methods comprise artificial markets and contingent valuation and are termed as stated preference classification.

There are several situations where economic values cannot be converted into single units and thus need to be expressed through qualitative or through preference ranking, i.e. an order to express the extent of utility to the beneficiaries of ecosystem services. These methods are termed as ordinal methods which comprise contingent ranking, conjoint analysis, multi-criteria analysis, etc.

All the techniques described above require a considerable amount of information on various variables that over time may not be possible in a situation where valuation of ecosystem services has to be done in a short span of time or when funds and time are constrained. In such situations based on the primary studies done in similar sites are used to transfer the values to the new site adjusting various factors like population, purchasing power, etc. Such a technique is termed as benefits transfer technique.

2.5.1 PRODUCTION METHOD

Production function-based approaches estimate how much a given ecosystem service (e.g. regulating service) contributes to the delivery of another service or commodity which is traded on an existing market. These approaches are based on the contribution of ecosystem services to the enhancement of income or productivity (Pattanayak and Kramer, 2001; Pattanayak, 2004).

2.5.2 HEALTH METHOD

This approach is based on health effects caused by pollution and environmental degradation. It estimated the value of human output lost due to ill health or premature death like loss of potential net earnings owing to environmental degradation. The cost of healthcare is being added as a replacement or preventive expenditure.

2.5.3 DEFENSIVE OR PREVENTIVE COST METHOD

Cost that may have been voluntarily incurred by individuals or community to correct damage due to environmental degradation in the catchment area leading to reduction in water filtration function is a defensive cost approach. It provides an end of the pipeline solution. On the contrary, preventive cost approach provides beginning of the pipeline solution by taking suitable measures at the site itself to prevent flow of any pollutant causing downstream damages like catchment area treatment to prevent soil erosion, floods, nutrient, load, etc.

2.5.4 AVOIDED DAMAGE COST METHOD

This method estimates the value of an ecosystem by the costs of damages avoided resulting from loss of that service, i.e. costs incurred in the absence of that service. It takes the market price of the equivalent mechanism or non-ecosystem services needed.

2.5.5 REPLACEMENT COST METHOD

The replacement cost technique is simple to use and has the added benefit of being an objective valuation of an impact that has already occurred or is quantifiable. The replacement cost approach is used to measure the cost of damage done to the protected area/ forest by assessing at how much it would cost to replace the assets that are damaged.

2.5.6 SHADOW PROJECT METHOD

A shadow project is usually designed specifically to offset the environmental damage caused by another project like doing plantations of the equivalent area of forest which may have been diverted due to developmental activity.

2.5.7 THE TRAVEL COST METHOD

The travel cost method is mostly relevant for determining recreational values related to biodiversity and ecosystem services and is based on the rationale that recreational experiences are associated with a cost (direct expenses and opportunity costs of time) (Bharali and Mazumder, 2012). The basic premise of the travel cost method is that the time and travel cost expenses that people incur to visit a site is an indicator for the willingness to pay people to visit the site. There are three basic approaches in applying the TCM. The first is the simple zonal travel cost approach, the second the individual travel cost approach which uses a more detailed survey of visitors, and the third random utility approach which uses survey and other data, and more complicated statistical techniques.

The zonal travel cost method is the simplest and least expensive approach. It is used to estimate a value for recreational services of the site as a whole. The zonal travel cost method is applied by collecting information on the number of visits to the site from different distances. In order to determine the willingness to pay visitors, distance circles are drawn around the site. The TCM assumes that people in all circles have homogeneous preferences. This information is used to construct the demand function for the site, and estimate the consumer surplus, or economic benefits, for recreational services of the site.

The individual travel cost approach is similar to the zonal approach, but uses survey data from individual visitors in statistical analysis, rather than data from each zone. This method requires more data collection and a slightly more complicated analysis, but will give more precise results because it allows correcting for heterogeneity among visitors within the distance circles.

The random utility approach is the most complicated and expensive of the travel cost approaches. It allows for much more flexibility in calculating benefits and the most appropriate approach when there are many substitute sites. It is assumed that individuals will choose the site that they prefer based on the tradeoffs between site quality and the price of travel to the site, out of all possible similar sites.

Hence, this intensive model data requires information on all possible sites that a visitor might select, their quality characteristics, and the travel costs to each site. (Koundouri, n.d.)

2.5.8 HEDONIC PRICING METHOD

The hedonic pricing approach uses information about implicit demand for an environmental attribute of marketed commodities. For instance, houses or property in general consist of several attributes, some of which are environmental in nature, such as proximity of a house to a lake or whether it has a view on an attractive forested landscape. Hence, the value of a change in biodiversity or ecosystem services will be reflected in the change by value of property Verma et al. 2001.

This method estimates economic values for ecosystem or environmental services that directly affect market prices of some other goods. Most commonly applied to variations in housing prices that reflect the value of local environmental attributes (Marlies Wierenga, 2003).

2.5.9 SURROGATE GOODS/ PROXY MARKET GOODS METHOD

The method is used when an ecosystem service has no readily determined market value, and a close substitute exists that does have a competitively determined price. In such a case the price of the marketed substitute is used as surrogate or proxy value for the value of ecosystem service (Munasinghe, M., and McNeely, J., 1994).

2.5.10 CONTINGENT VALUATION METHOD (CVM)

The contingent valuation method (CVM) uses questionnaires to ask people how much they would be willing to pay to increase or enhance the provision of an ecosystem service, or alternatively, how much they would be willing to accept for its loss or degradation (Hadker, Sharma, David, and Muraleedharan, 1997). It is used to calculate non-use values: existence, bequest and option values.

2.5.11 CONTINGENT RANKING

Under this method, ranking and scores are obtained for a range of products and Numeraire or anchor item with known value is used to obtain WTP of respondents for various products. Here the value of benefits is expressed in terms of the value of 'Numeraire'.

2.5.12 CONJOINT CHOICE METHOD

Conjoint choice, also known as conjoint analysis was developed in the field of marketing and phycology to measure preferences for different characteristics or attributes of a multi-attribute choice. In this method respondents are asked to state a preference between one group of environmental services or characteristics at a given price or cost to the individual and another group of environmental characteristics at a different price or cost (NAP, 2005).

2.5.13 GROUP VALUATION METHOD

The group valuation method combines stated preference techniques with elements of deliberative processes from political science and are increasingly used as a way to capture value types that may escape individual-based surveys, such as value pluralism, incommensurability, non-human values, or social justice.

2.5.14 MULTI CRITERIA ANALYSIS (MCA)

MCA uses mathematical programming techniques to select an option based on objective functions including weighted goals of decision-maker, with explicit consideration of constraints and cost. Apart from the two mentioned above, conjoint analysis, participatory economic valuation is also used.

2.5.15 BENEFITS TRANSFER METHOD

This method includes a value or function transfer approach. The value from one site known as a "policy site" is transferred to the current valuation site known as "study site" after due adjustments. Both the sites should be similar to each other for better estimation. Transferring value can be done by three methods, i.e. unit value transfer, value function transfer and meta-analytic function transfer (As adapted from the Guidance Manual on Value Transfer for Ecosystem Services, UNEP, 2013).

Please note: the benefits transfer method requires technical expertise and expert guidance at each step. Hence it is advisable to use the services of some technical expert or institutional support while using the method.

There is no single economic valuation technique that can be applied to all ecosystem services, as methods vary depending on the characteristics of ecosystem services, as well as data availability. One of the reasons why placing 'value' on the natural world is controversial is because in large part, valuation is often taken to mean economic valuation. The benefit of economic valuation is that it can provide a single common unit which can be used to condense a complex system and to compare the impacts of alternative policy measures, a fact that could be of great use to decision-makers.

Table 11 below explains how different valuation techniques can be applied for various ES.

Table 11: Summary of Valuation Methods; Source: NZIER, adapted from de Fries and Pagiola, MEA (2003)

Methodology	Approach	Applications	Data Requirements	Limitations	MEA Applications
Market Methods					
Value of Outputs	Estimate volume and value of marketable output	Any marketable output like timber, food, etc.	Sales volume and representative prices	Confined to marketable goods and services	Provisioning
Cost-Based Methods					
Productivity Change	Trace impact of change in environmental services on goods produced	Any impact that affects production of goods and services	Change in service; impact on production; net value of goods and services produced	Data on change in service and linked to impact on production often deficient	Provisioning
Replacement Costs (and Variants like Relocation Cost)	User cost of replacing the lost goods or service; next best alternative	Any loss of goods and services	Extent of loss of goods or services; cost of replacing them with risk of less than full success in replacing the service	Tends to overestimate the actual value in many circumstances, especially if building is contingent for risk	Provisioning, Regulating, Cultural
Revealed Preference Methods					
Hedonic Pricing	Extract effects of environmental factors on price of goods that reflect those factors	Property price analysis with respect to air quality, scenic beauty, open space, cultural benefits; also analysis of risk premiums in wages	Prices and characteristics of goods	Requires large data sets to control for all variables influencing the price; very sensitive to model specification	Regulating, Cultural

Travel Cost Analysis	Derive demand curve from data on actual travel costs between origins and a single site	Recreation	Survey site users to collect monetary and trip time costs and distance travelled	Limited to recreational benefits; problematic when applied to multi-site trips	Cultural
Hedonic Travel Cost Method	Derive demand curve from data on actual travel costs between origins and several site	Recreation (or any other origin-destination travel)	Data on travel patterns and cost across the district of interest	Requires extensive data on both travel activity and characteristics of different sites that affect their demand	Cultural
Stated Preference Methods					
Contingent Valuation Method	Ask respondents directly about their willingness to pay for a specified service (Example: protection of species, landscapes, water supply)	Any service	Survey that presents scenarios and elicits willingness to pay for specified service	Many sources of bias in responses; guidelines exist to improve reliability, but critically depends on framing the right question	Provisioning, Regulating, Cultural
Choice Modelling and Variants Like Conjoint Analysis, Contingent Ranking	Ask respondents to choose their preferred option from a set of multi-attribute alternatives to derive a price for each attribute	Any service	Survey of respondents that present the options and variation in key attributes	Analysis of data generated is complex; critically depends on how the question is framed	Provisioning, Regulating, Cultural
Other Methods					
Benefits Transfer	Use results obtained in one context in another similar setting	Any for which suitable comparison studies are available	Valuation exercises at another similar site; using any of the above methods	Can be wildly inaccurate as many factors can vary even when the context seems similar	Provisioning, Regulating, Cultural

2.6 VALUATION FRAMEWORKS

To suit various contexts and differential needs for decision-making, various frameworks on valuation have been proposed. In order to consider the categories of benefits derived from forests of Uttarakhand, the study uses a list of frameworks under which different benefits have been categorized and estimated/ qualified. These are listed below and described briefly in the context of this study in the following sections.

2.6.1 TOTAL ECONOMIC VALUE (TEV)

- Millennium Ecosystem Assessment (MA)
- Stock and Flow Benefits
- Tangibles and Intangibles Benefits
- EPA's Benefit Scenarios
- Investment Multiplier
- Health Benefits Framework
- Ecosystem Services Based on Human Values and Ecosystem Assets Framework

2.6.2 TOTAL ECONOMIC VALUE (TEV)

The concept of Total Economic Value (TEV) is one of the most widely used frameworks for identifying and categorizing forest benefits (Pearce 1990; Emerton 2003). It attempts to account comprehensively for all forest ecosystem services, categorizing these into direct values, indirect values, option values and existence values.

Total economic value has two components, i.e. use value and non-use value. They are further categorized into direct values, indirect values, option values and existence values. These are explained below along with examples:

Direct use values include revenues from timber and values of non-timber forest products. While timber values are not this paper's main focus of interest, the sector is considered to have considerable commercial potential given appropriate management regimes.

Indirect-use values or "functional" values relate to the ecological functions performed by forests, such as global biogeochemical cycling, the protection of soils, and the regulation of watersheds.

Option value or quasi-option value is the expected value of the information on the benefits of an asset, conditional on its preservation enabling an increase in the stock of knowledge relevant to the utilization of the asset. A frequently evoked example of quasi-option value is associated with genetic resources; for example, future pharmaceuticals developed from plant materials.

Existence value relates to the value of environmental assets irrespective of current or optional uses. Empirical measures of existence values based on donations to conservation organizations, or on the contingent valuation method suggest these can be a significant element in total economic value, especially in contexts where the asset has unique characteristics or cultural significance (DEFRA, 2007).

2.6.3 MILLENNIUM ECOSYSTEM ASSESSMENT

The Millennium Ecosystem Assessment (MA) has identified four overarching categories of benefits provided by ecosystems which include:

Provisioning Services: Products obtained from forests such as timber and fodder

Regulating Services: Benefits obtained from regulation of ecosystem processes such as water and climate regulation

Cultural Services: Non-material benefits people obtain from forests through spiritual enrichment, cognitive development, recreation and aesthetic experiences such as sacred sites and wildlife safari

Supporting Services: Services that are necessary for the production of provisioning, regulating and cultural services such as soil formation and retention

2.6.4 STOCK AND FLOW BENEFITS

The benefits forests can also be categorized into stock and flow benefits. Broadly, stock benefits refer to potential supply, while flow benefits refer to real feasible flow of benefits. In the study context, standing timber and carbon stock refer to stock benefits, while carbon sequestration can be referred to as a flow benefit.

2.6.5 TANGIBLE AND INTANGIBLE BENEFITS

Broadly, tangible benefits from ecosystems refer to goods obtained from the forest while intangible benefits include the set of services which improve human well-being indirectly. While tangible benefits may be of great importance, especially to the local community, the current study has specially emphasized on intangible benefits as many of these are not marketed and perhaps not appropriately managed. The study is a deliberate attempt to factor intangibles in our decision-making calculus.

2.6.6 EPA BENEFIT CATEGORIES

While ecosystem values can be theoretical, they can be converted to indicate benefits when they are received by an individual or a community. For example, the value of trees in the water filtration process adds a benefit to a community that derives its clean drinking water from that source. Research suggests that for a wide range of these benefits, natural ecosystems remain the most cost effective delivery mechanisms. In cases where particular ecosystems have unique aesthetic, cultural and spiritual values, they are literally irreplaceable. The current study acknowledges the fact that in spite of our increased appreciation of many of nature's functions and processes, we still have limited understanding of how we benefit from nature. Table 12 below summarizes all the scenarios based on different benefits, as categorized the EPA science advisory board, for which valuation can be done in economic and non-economic terms.

Table 12: Summary of Ecosystem Services Based on EPA Effect Categories

Type of Value	Description
EPA Effect Category 1	Benefits which can be assessed and monetized using available ecological models and appropriate economic valuation methods, including benefits transfer
EPA Effect Category 2	Benefits which cannot be monetized, but can be quantified in biophysical terms using available ecological models and for which some indicator(s) of economic benefits exist
EPA Effect Category 3	Benefits which can be quantified in biophysical terms but for which no indicators of economic benefits exist
EPA Effect Category 4	Benefits which can be qualitatively described even if they cannot be quantified
EPA Effect Category 5	Benefits which have important non-economic values

2.6.7 INVESTMENT MULTIPLIER

To demonstrate the benefits of investing in natural capital, the aggregate flow benefits from forests is compared with its management costs to obtain an 'Investment multiplier'. The aggregate flow benefits are derived from the ecosystem services that are possible to value in monetary terms. The management costs are derived from the annual expenditure by the state of Uttarakhand. Broadly, the 'Investment multiplier' demonstrates the quantum of benefits derived from forests by spending 1 rupee in its management costs.

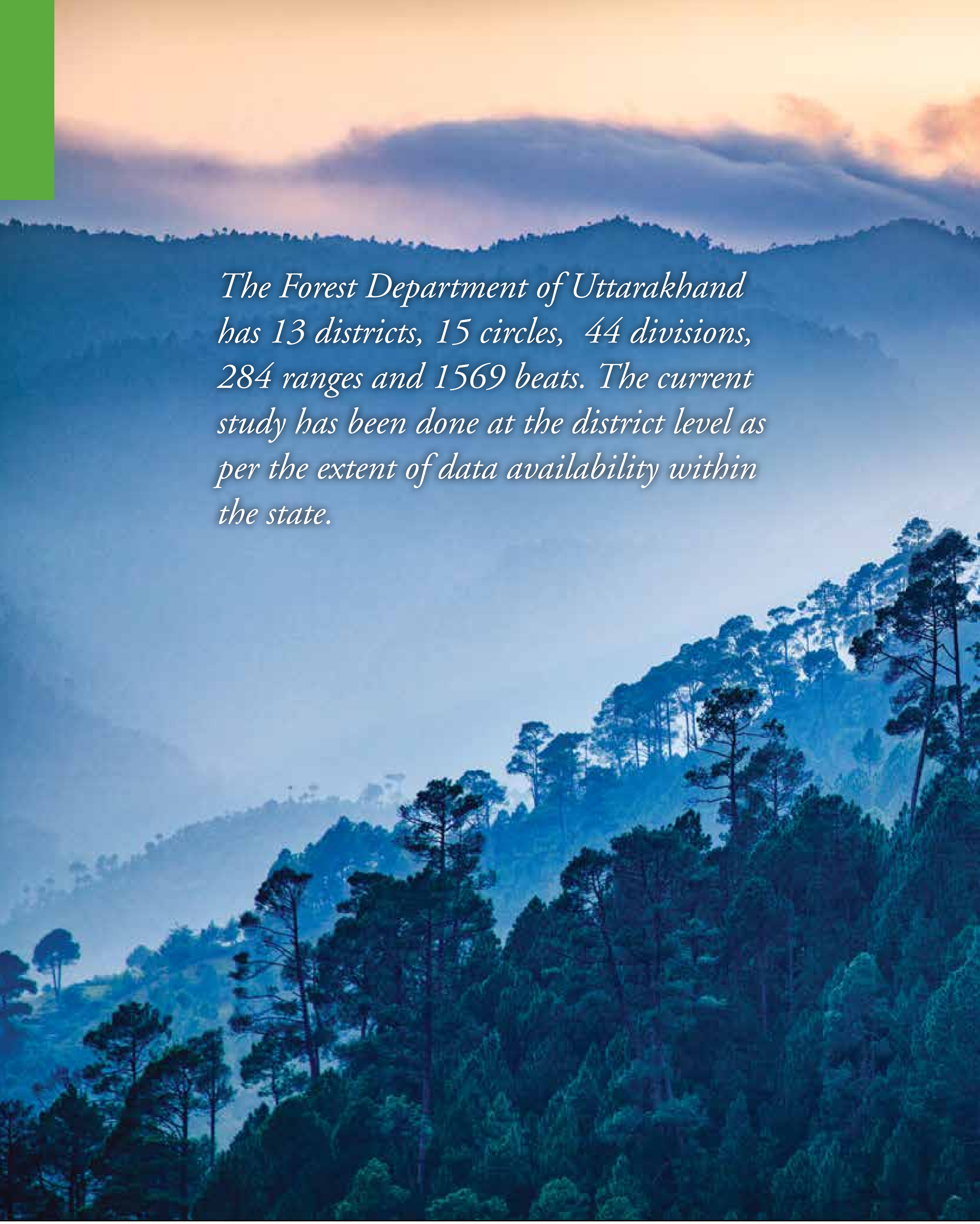
2.6.8 HUMAN VALUES AND ECOSYSTEM ASSETS FRAMEWORK

Ecosystem services are crucial for human well-being and therefore this classification highlights the synergies between human values and ecosystem services (Wallace, 2007)the concept of ecosystem services offers an important opportunity to develop a framework to underpin the wise use of biodiversity and other natural resources. Although the merit of using ecosystem services to frame biodiversity evaluations has been documented, the classification systems employed mix processes (means. This framework helps in classifying the ecosystem functions and processes that are means to achieve the end product which are our ecosystem services. It highlights the linkages between ecosystem services, ecosystem assets and human values such as socio-cultural fulfilment, protection from various parasites, benign physical and chemical environment and adequate human resources. The following table shows the relation between these values.

Category of Human Values	Corresponding Ecosystem Services- Experienced at Individual Level
Adequate Resources	Food (for energy, structure and key chemical reactions
	Oxygen
	Potable water
	Energy (for cooking-warming component under physical and chemical environment)
	Dispersal aids (transport)
Protection from Predators/ Diseases/Parasites	Protection from predation
	Protection from disease and parasites
Benign Physical and Chemical Environment	Benign environmental regimes of temperature (energy, includes use of fire for warming)
	Moisture regimes
	Light (e.g. to establish circadian rhythm)
	Chemical cycles
Socio-Cultural Fulfilment	Access to resources for spiritual/philosophical contentment
	Social company- a benign social group including access to mates and being loved
	Recreation/leisure
	Meaningful occupation
	Aesthetics
	Opportunity values- capacity for cultural and biological evolution (knowledge/education and genetic resources)

2.6.9 HEALTH BENEFITS

Health benefits are closely linked with ecosystem services emerging from the state's forest ecosystem. All ecosystem services play an important role in maintaining the overall well-being of humans. Some of them have a direct impact and others have an indirect role in the same.

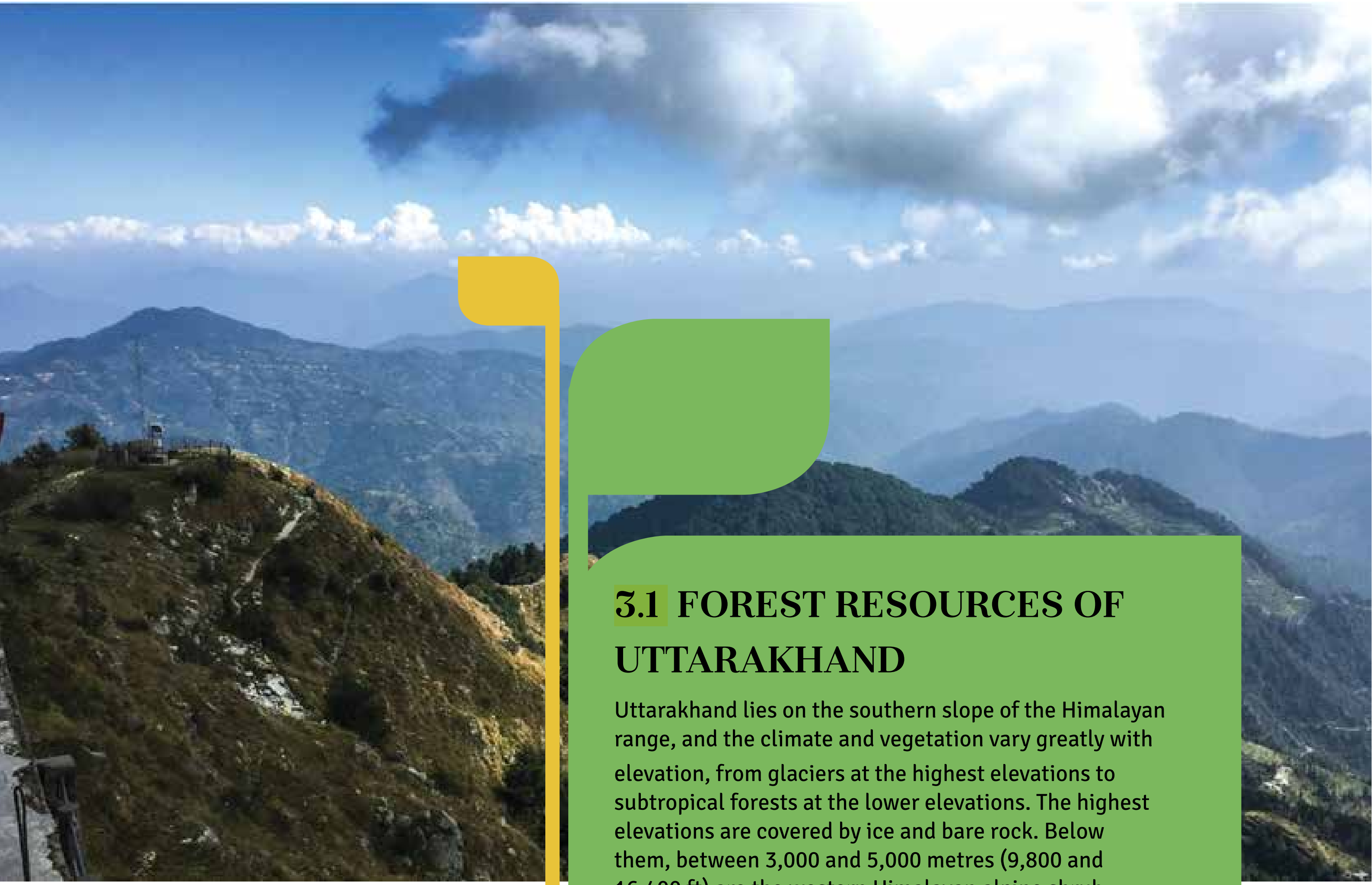


The Forest Department of Uttarakhand has 13 districts, 15 circles, 44 divisions, 284 ranges and 1569 beats. The current study has been done at the district level as per the extent of data availability within the state.

VALUATION OF FOREST ECOSYSTEM SERVICES FOR THE STATE OF UTTARAKHAND

CHAPTER

03



3.1 FOREST RESOURCES OF UTTARAKHAND

Uttarakhand lies on the southern slope of the Himalayan range, and the climate and vegetation vary greatly with elevation, from glaciers at the highest elevations to subtropical forests at the lower elevations. The highest elevations are covered by ice and bare rock. Below them, between 3,000 and 5,000 metres (9,800 and 16,400 ft) are the western Himalayan alpine shrub and meadows. The temperate western Himalayan subalpine conifer forests grow just below the tree line. At 3,000 to 2,600 metres (9,800 to 8,500 ft) elevation they transition to the temperate western Himalayan broadleaf forests, which lie in a belt from 2,600 to 1,500 metres (8,500 to 4,900 ft) elevation. Below 1,500 metres (4,900 ft) elevation lie the Himalayan subtropical pine forests. The Upper Gangetic Plains moist deciduous forests and the drier Terai-Duar savanna and grasslands cover the lowlands along the Uttar Pradesh border in a belt locally known as Bhabar. These lowland forests have mostly been cleared for agriculture, but a few pockets remain. Table 13 below shows the total forest area as per different density classes.

BELOW
1,500 METRES (4,900 FT)
ELEVATION LIE THE HIMALAYAN SUBTROPICAL PINE FORESTS.

Table 13: Total Forest Area as Per Different Density Classes

Sl. No.	Forest Type	Forest Cover of Uttarakhand (ha)				
		VDF	MDF	OF	SCRUB	TOTAL
1	Alpine Scrub	2300	13000	5100	600	21000
2	Montane and Moist Temperate Forest	161200	501400	243500	2800	25.3
3	Sub Alpine and Dry Temperate Forests	38600	88200	20800	1100	148700
4	Subtropical Pine/ Broadleaved Hill Forests	76900	443200	172100	18900	711100
5	Tropical Dry Deciduous Forests	8100	85100	56900	7800	157900
6	Tropical Moist Deciduous Forests	110400	280600	71600	800	463400

The Forest Department of Uttarakhand has 13 districts, 15 circles, 44 divisions, 284 ranges and 1569 beats. The current study has been done at the district level as per the extent of data availability within the state. Table 14 below shows the district-wise area distribution of different forest types in the state of Uttarakhand.

Table 14: District-wise Area Distribution of Different Forest Types in the State of Uttarakhand (In Square Km)

S.No	District	Total Area	Under Forest Department	Civil Soyam Forest Under Revenue Department	Area Completely Recorded as Van Panchayat	Area Under Control of Van Panchayat but Recorded in RF	Total (Van Panchayat)	Under Private Agencies	Total Forest Area
1	Almora	3139	785.195	848.558	698.531	0	698.531	29.557	2361.841
2	Bageshwar	2246	690.333	23.021	387.829	0	387.829	0.413	1101.596
3	Pithoragarh	7090	2200.34	417.48	2729.05	42.703	2771.753	11.93	5401.503
4	Champawat	1766	735.379	275.48	312.328	0	312.328	0.188	1323.375
5	Nainital	4251	2574.452	111.892	280.678	0	280.678	15.338	2982.36
6	U.S.Nagar	2542	938.37	0	0	0	0	0	938.37
7	Garhwal	5329	2327.024	983.675	528.14	0	528.14	12.103	3850.942
8	Rudraprayag	1984	1277.783	318.854	207.016	0	207.016	0	1803.653
9	Chamoli	8030	2817.198	447.174	1786.706	96.845	1883.551	9.924	5157.847
10	Tehri	3642	2315.175	768.665	131.8	0	131.8	0	3215.64
11	Uttarkashi	8016	6954.914	231.889	29.838	42.807	72.645	0	7259.448
12	Dehradun	3088	1522.708	342.016	76.586	0	76.586	76.991	2018.301
13	Haridwar	2360	724.307	0	0	0	0	0	724.307
			25863.178	4768.704	7168.502	182.355	7350.857	156.444	38139.183

Source: Uttarakhand Forest Statistics (2015-2016)

3.2 VALUATION OF ECOSYSTEM SERVICES

Following the Millennium Ecosystem Assessment framework, major ecosystem services from forest areas at district level were identified for the state. All the ecosystem services were valued for individual districts either through direct methods or through benefits transfer approach. The following section explains the methodology used for physical quantification and economic valuation of each ecosystem service and also presents the results derived. The Table 15 below provides a snapshot of the ecosystem services, which have been valued.

Table 15: Ecosystem Services Mapped for the Current Study

Provisioning	**Fuelwood**	**Fodder**	**Employment Generation**	**Non-Timber Forest Products**		**Standing Timber**
Regulating	**Carbon Sequestration**	**Gene-Pool Protection**	**Water Provisioning**	**Pollination**	**Flood Regulation**	**Carbon Storage**
	Water Purification	**Sediment Regulation /Retention**	**Gas Regulation**	**Biological Control**	**Waste Assimilation**	
Cultural	**Recreation**					
Supporting	**Habitat for Species**			**Nutrient Cycling/Retention**		

Flow Values | **Stock Values**

A. PROVISIONING SERVICES

3.2.1 EMPLOYMENT GENERATION

Forests are immense sources of employment especially for daily wage earners in the remote areas of the state. Considering the lack of livelihood opportunities in these remote regions, a regular source of employment is highly valued by the local communities. Locals are employed on daily wages by the state forest department for undertaking conservation activities like plantations, establish water harvesting structures, clearing forests from various unwanted species like *lantana*, etc.

At the state level, the forest department generates a minimum of 1 crore man days' worth of work across forests in the state. For generating values at district level, the ratio of rural population of that district to the state's population was taken and multiplied with the total man days. For calculating the economic value, Rs. 300 was considered as the average per day wage for casual laborer. Table 16 provides the indicative value of employment generated at individual district forest areas.

Table 16: Summary of Methodology Used for Value of Employment Generated

Ecosystem Service	Employment Generation	
Method	Production Method	
	Data Used	**Data Sources**
Physical Estimation	At state level, a minimum of 1 crore man days' worth of work across forests in the state. Value divided across districts based on population data.	Forest Dept.
Market Price	Wage rate for casual labour of Rs 300/day	Forest Dept.
Total Physical Volume	1 crore man days	
Economic Value	Rs 300 crores/year	

Figure 9 below shows the district-wise distribution of annual benefits due to employment generation in the state of Uttarakhand.

Apart from casual labour, forests also generate various other employment opportunities in areas of tourism, logging, etc. As these activities have been accounted under various ecosystem services, to avoid double counting, they have not been included in the above estimates.

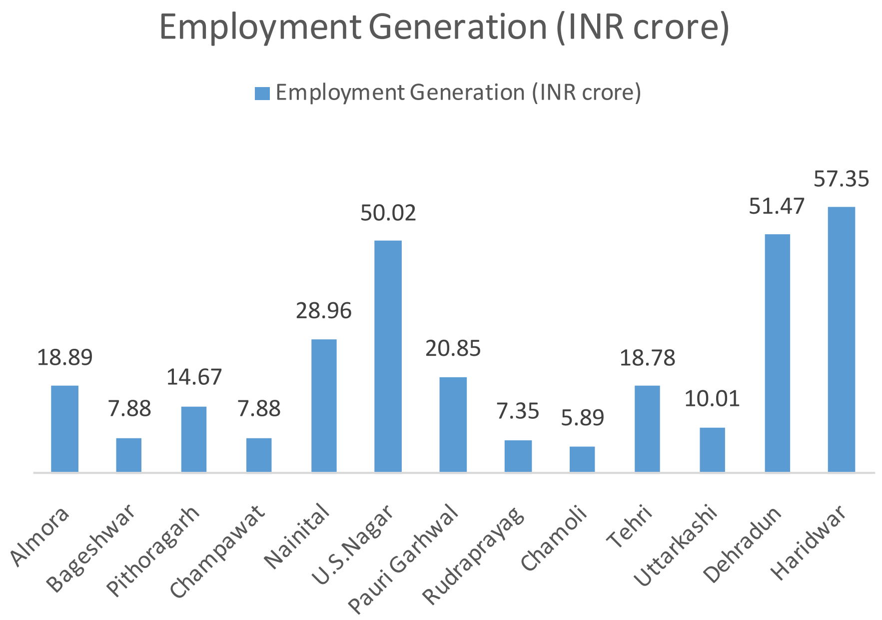


Figure 9:District-wise Distribution of Annual Benefits Due to Employment Generation

3.2.2 FUELWOOD

The communities living inside and along the fringe villages of forests are largely dependent on these areas to fulfil their energy requirement of cooking and heating. These communities are legally permitted to extract fuelwood from nearby forests, but often extraction takes place in an illegal manner as well.

As part of the current study, physical estimation of fuel extracted from forest areas is done by compilation of data from two data sources. The first is the FRI study "Forest resource dependence and ecological assessment of forest fringes in rain-fed districts of India", in which primary data for 9 districts across Uttarakhand has been collected. Using per capita consumption in rural areas, for these 9 districts, calculations have been done for the remaining 4 districts. The second data source has been the values provided in the annual report of the forest department which includes fuel sold through department timber depots at district level.

Economic quantification of fuelwood has been achieved using Rs. 5 per kg as the average selling price across the state. The same selling price has been used across the state to ensure comparability amongst districts.

Table 17: Summary of Methodology Used for Valuation of Fuelwood

Ecosystem Service	Fuelwood Flow	
Method	Market Price Method	
	Data Used	Data Sources
Physical Estimation	District-wise fuelwood taken as recorded by FD (legal stack) (tonnes/year)	Forest Dept.
	District-wise illegal fuelwood extraction (tonnes/year)	Kumar & Kushwaha (2018)
Market Price	Fuelwood price assumed as Rs 5/kg	Verma et al. (2015)
Total Physical Volume	67,90,469 tonnes/year	
Economic Value	Rs 3,395.2 crores/year	

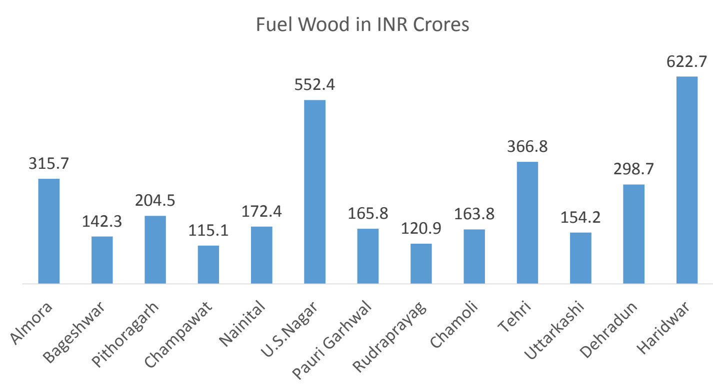


Figure 10: Economic Estimates of Annual Fuelwood Extraction at Various Districts

Highest extraction is observed at Haridwar followed by U.S. Nagar while the lowest extraction is observed at Champawat and Rudraprayag. The results clearly indicate a direct correlation between fuelwood extraction and the number of forest dependent people.

3.2.3 FODDER

Rural communities residing in the vicinity of forest areas are largely dependent on forest areas to fulfill fodder requirements of their livestock. As the communities are heavily dependent on livestock, fodder is of critical importance for them. As part of the current study, physical estimation of fodder from forest areas is done using the FRI study "Forest resource dependence and ecological assessment of forest fringes in rain-fed districts of India", in which primary data for 9 districts across Uttarakhand has been collected. Using per capita consumption in rural areas, for these 9 districts, calculations have been done for the remaining 4 districts.

Economic quantification of fodder has been achieved using Rs.3 per kg as the average selling price across the state. The same selling price has been used across the state to ensure to ensure comparability amongst districts. Table 18 below is the summary of the methodology used for estimating flow value of fodder.

Table 18: Summary of Methodology Used for Flow Value of Fodder.

Ecosystem Service	Fodder	
Method	Market Price Method	
	Data Used	Data Sources
Physical Estimation	District-wise fodder extraction (m^3/year)	Kumar & Kushwaha (2018)
Market Price	Fuelwood price assumed as Rs 3/kg (Average of tree fodder and grasses)	"Quantitative Estimation of Livestock Feed from Forests in Uttaranchal Himalayas" by ICFRE
Total Physical Volume	2,59,20,296.47 tonnes/year	
Economic Value	Rs 7,776.1 crores/year	

Figure 11 shows the district-wise distribution of annual flow benefits from fodder in the state of Uttarakhand. As observed for fuelwood a similar trend can be seen in fodder consumption. Haridwar and U.S.Nagar have the highest level of extractions, whereas Bageshwar and Nainital have the lowest fodder consumption.

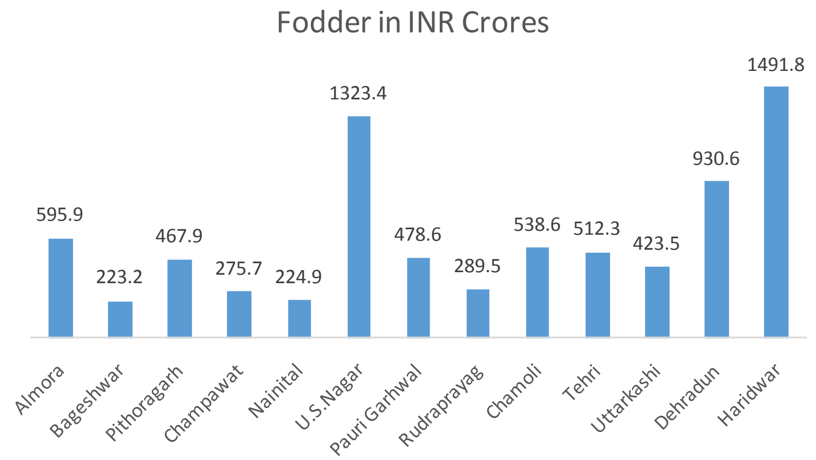


Figure 11: District-wise Distribution of Annual Benefits from Fodder

3.2.4 TIMBER

Sustainable harvesting of timber is practiced in forest areas as per the working plan of respective forest divisions. Physical values are derived using the district-wise production data provided by state forest departments along with data from the FRI study. The economic value of timber at district level is calculated by deriving the weighted average selling price of wood across the state for 2013-2014 @ Rs. 19455/m3. Table 19 below is the summary of the methodology used for estimating the flow value of timber.

Table 19: Summary of Methodology Used for Flow Value of Timber

Ecosystem Service	Timber Flow	
Method	Market Price Method	
	Data Used	Data Sources
Physical Estimation	District-wise timber as recorded by FD Depot (m3/year)	Forest Dept.
	District-wise illegal timber extraction (m3/year)	Kumar & Kushwaha (2018)
Market Price	Weighted average price of timber estimated at Rs 19,455/m3 using: Per unit rate of different types of timber Production of different types of timber	Forest Dept.
Total Physical Volume	6,38,994 m3/year	
Economic Value	Rs 1,243.16 crores/year	

Figure 12 below shows the district-wise distribution of annual flow benefits from timber in the state of Uttarakhand. As it can be seen from the table above, timber extractions are highest from U.S.Nagar and Pithoragarh, whereas Pauri Garhwal and Rudraprayag report ... at district level in the state.

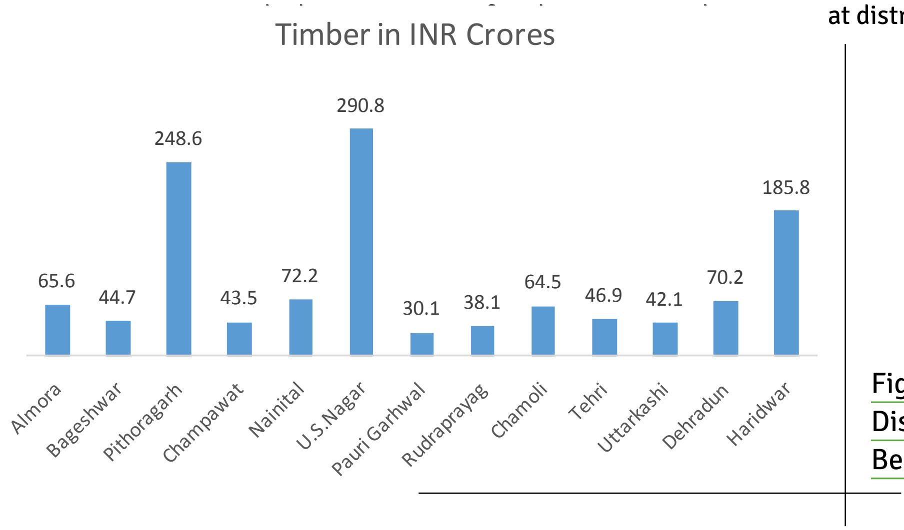


Figure 12: District-wise Distribution of Annual Flow Benefits from Timber

3.2.5 STANDING TIMBER (STOCK VALUE)

Growing stock of standing timber in each district was sourced from FSI. However, total timber stock value for Champawat and Udham Singh Nagar districts were not available in the data provided by FSI and hence not included in the estimated below. The economic value of timber at district level is calculated by deriving the weighted average selling price of wood across the state for 2013-2014 @ Rs. 19455/m^3. Total growing stock in Uttarakhand was accounted approximately at 370.65 million m^3. Table 20 below is the summary of the methodology used for estimating stock value of timber.

Table 20: Summary of Methodology Used for Stock Value of Timber

Ecosystem Service	Timber Stock	
Method	Market Price Method	
	Data Used	Data Sources
Physical Estimation	District-wise total timber stock (m^3)	Forest Survey of India
Monetary Valuation	Weighted average price of timber estimated at Rs 19,455/m^3 using: Per unit rate of different types of timber Production of different types of timber	Forest Dept.
Total Physical Volume	370.65 million m^3	
Economic Value	Rs. 7,21,101.68 crores	

Figure 13 below shows the district-wise distribution of annual stock benefits from timber in the state of Uttarakhand. From the results it can be observed that Uttarkashi has the highest value in terms of standing timber (stock value).

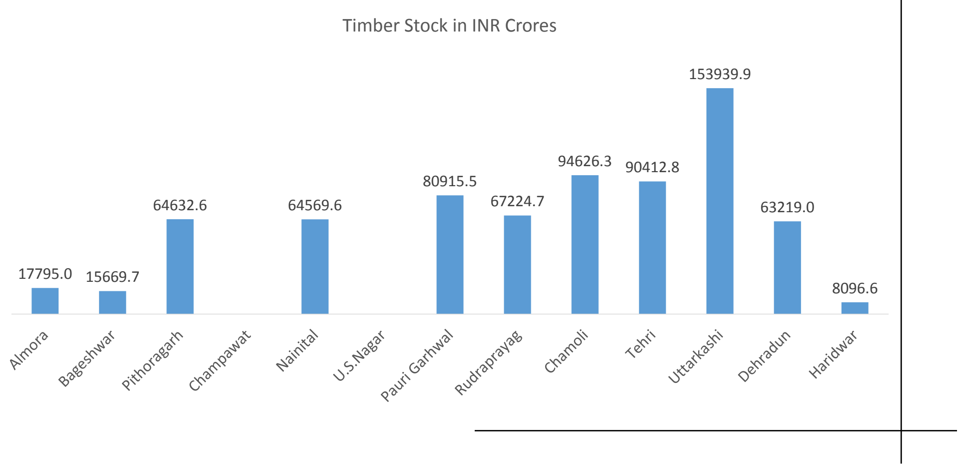


Figure 13: District-wise Distribution of Annual Stock Benefits from Timber

3.2.6 NON-TIMBER FOREST PRODUCE (NTFP)

Most of the rural households living in forest proximity are heavily dependent on NTFP for subsistence and/or income. Most of the population of the remote areas use NTFP for health and nutritional needs. Women from poor households generally rely more on NTFP for household use and income. At a local level, NTFP also provide raw materials for large-scale industrial processing. NTFP have also attracted considerable global interest in recent years due to the increasing recognition of their contribution to environmental objectives, including the conservation of biological diversity. Presently, data for NTFP extraction is compiled at state level by the state forest department along with its monetary values in Table 21 below. Due to paucity of data the state values were divided based on the ratio of VDF, MDF forest present in the district to that of the state.

Table 21: Summary of Methodology Used for Flow Value of NTFP

Ecosystem Service	Non-Timber Forest Products (NTFP)	
Method	**Market Price Method**	
	Data Used	Data Sources
Physical Estimation	Quantity of and revenue from NTFP extraction (Resin, medicinal plants, sand and boulders, bamboo, bamboo grass, Bhabad grass, Cane and Jhool grass) available at state level. Divided amongst districts based on the ratio of VDF, MDF forest present in the district to that of district.	Forest Dept.
Market Price	Direct revenue from NTFP extraction recorded in forest statistics	Forest Dept.
Total Physical Volume	Multiple units	
Economic Value	Rs 303.7 crores/year	

Figure 14 below shows the district-wise distribution of annual flow benefits from NTFP in the state of Uttarakhand. The values are an underestimate of the actual overall NTFP extraction happening from the forests. It is recommended that an in-depth study on the NTFP sector should be undertaken up to derive a comprehensive value of the sector.

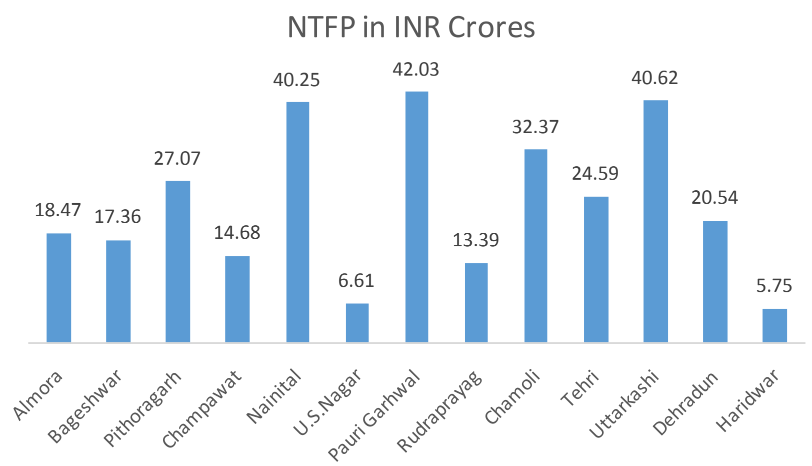


Figure 14: District-wise Distribution of Annual Flow Benefits from NTFPs

B. REGULATING SERVICES

3.2.7 GENE-POOL PROTECTION

A. The economic value of gene-pool protection is envisaged in the study in terms of its biological information value and its insurance value. These are further discussed briefly.

Biological Information Value - Existing biodiversity within the forests, especially endemism and speciation, is the result of evolutionary processes over thousands of years. This diversity thus embodies a stock of information. Since the evolutionary process has occurred in various environmental contexts, the diversity of natural organisms embodies characteristics that make them resilient to further 'natural' change. Natural organisms, especially endemic species, have evolved an astounding variety of chemical compounds to escape predators, capture prey, enhance reproductive success and fight infections. These compounds have proved to be of great value when adapted for various human uses, especially the pharmaceutical industry. For example, leukemia is today treated with medicines derived from the rosy periwinkle of Madagascar, and the bark of the Pacific yew tree is the source of a treatment for ovarian cancer. Further, with recent advances in biotechnology, the researchers are now better equipped to investigate these organisms at the genetic level; thereby increasing its potential for future product leads manifolds. Biodiversity is not only a source of new drugs with large market potential but is also an important source of germplasm for agricultural crops. These germplasms may enhance resistance to disease, drought, and salinity among other shocks to enhance productivity or other desirable traits of farm stock. The wild cultivars and crop wild varieties serve as the world's repositories of crop genetic diversity and represent a vital source of genes that can ensure future food security. In the studies on the Green Revolution, it was shown that the genetic diversity in the plant population could significantly increase the productivity of agriculture. Native forests thus provide an insurance cover for agriculture. In our country where the majority of the workforce is employed in agriculture, this insurance is of paramount importance. For example, a disease carried by the brown plant virus had threatened the Asian rice species with the danger of destroying a substantial proportion of the crop. The International Rice Research Institute in the Philippines in their effort to develop a form of rice resistant to the virus found a local wild variety of rice that was not used commercially but was resistant to the virus. The resistant gene was successfully identified and transferred to the commercial rice varieties, thereby yielding commercial rice resistant to the threatening disease.

B. Insurance Value - The insurance value of forest areas relates to the role of biodiversity in guaranteeing resilience of ecological systems at the local, regional, and national scale, and thereby guaranteeing service provision in the future. It is widely agreed that high biodiversity and more complexity in a system leads to higher adaptability and resistance to environmental changes. This value of biodiversity is likely to become increasingly important over time as climate change impacts may subject these reserves to further external shocks.

While it is relatively easy to identify the benefits obtained from individual components of biodiversity and its associated information value, it is particularly difficult to describe and estimate the benefits of variability itself. Diversity not only lends more resilience to the system by providing a kind of natural insurance against risks, it also increases the likelihood of finding useful products as the number of natural expressions (information) increase with higher biodiversity. More diverse ecosystems are thus likely to contain economically useful plants, animals or biological compounds.

On account of lack of site-specific studies for estimating the economic value of gene-pool conservation, the method of benefits transfer has been used. Based on unit area values of gene-pool conservation for different types of ecosystems from a recent meta-analysis study by GIST (2006), the economic value of this ecosystem service has been derived for the forests at district level. The values estimated in the report are based on the annual sales turnover of pharmaceutical firms using plant-based raw materials along with their operating expenditures and R&D costs. In the absence of estimates specific to Uttarakhand, value for Himachal Pradesh, i.e. Rs 2,99,439/ha. /Year (Adjusted to WPI) used as.

Table 22: Summary of Methodology Used for Flow Value of Gene-Pool Protection

Ecosystem service	**Gene-Pool Protection**	
Method	**Benefits Transfer Method**	
	Data Used	Data Sources
Physical Estimation	District-wise total forest cover (ha.)	Forest Survey of India (2015)
Benefits Transfer Value	Rs 2,99,439/ha. /Year (Adjusted to WPI) Value for Himachal Pradesh used as Uttarakhand specific value NA.	GIST Monograph 4 (2006)
Total Physical Volume	Total forest cover 24,508 km^2 (2015)	
Economic Value	Rs 73,386.5 crores/year	

Table 22 provides an indicative value of the economic flows occurring due to forest conservation in the state.

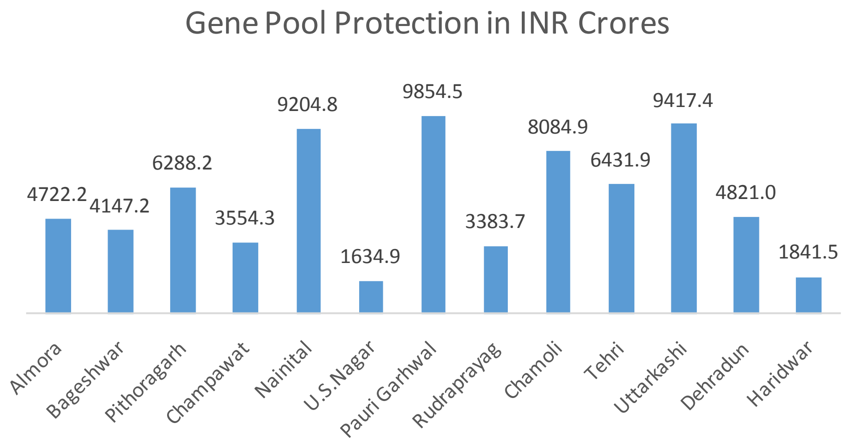


Figure 15: District-wise Distribution of Annual Flow Benefits from Gene Pool Protection

3.2.8 CARBON STORAGE (STOCK VALUE)

Carbon storage in forest biomass (biological material) is an essential attribute of stable forest ecosystems and a key link in the global carbon cycle. After carbon dioxide is converted into organic matter by photosynthesis, carbon is stored in forests for a period of time in various forms before it is ultimately returned to the atmosphere through respiration and decomposition or disturbance. A substantial pool of carbon is stored in woody biomass (roots, trunks, and branches). Another portion eventually ends up as organic matter in forest floor litter and in soils. All the carbon pools, i.e. AGB, BGB, Deadwood, Litter, SOM have been accounted and a total of 29 million tonnes of carbon have been estimated as carbon stock under VDF, MDF and OF for Uttarakhand. Social costs of carbon specific to India have been estimated at country-level using recent climate model projections, empirical climate-driven economic damage estimations and socio-economic projections, i.e. 37.5 USD per tCO_2 (Nordhaus 2016) for lower bound estimates and 86 USD per tCO^2 (Ricke, Drouet, Caldeira, and Tavoni, 2018)a world-level approach obscures the heterogeneous geography of climate damage and vast differences in country-level contributions to the global SCC, as well as climate and socio-economic uncertainties, which are larger at the regional level. Here we estimate country-level contributions to the SCC using recent climate model projections, empirical climate-driven economic damage estimations and socio-economic projections. Central specifications show high global SCC values (median, US$417 per tonne of CO^2 (tCO^2 have been considered for an economic estimate of carbon stock and Table 23 is the summary of the methodology used for estimating stock value of carbon.

Table 23: Summary of Methodology Used for Stock Value of Carbon

Ecosystem Service	Carbon Stock	
Method	Avoided Cost Method	
	Data Used	Data Sources
Physical Estimation	District-wise total forest cover under VDF, MDF and OF (ha.)	Forest Survey of India (2015)
	Carbon stock (5 pools - AGB, BGB, Deadwood, Litter, SOM) per Ha. Under VDF, MDF and OF for Uttarakahnd	FSI Carbon Report (2012)
Monetary Value of Cost Avoided (Lower Bound)	Social cost of carbon (specific to India) USD 37.5 per ton	(Nordhaus, 2016)
Upper Bound	Social cost of carbon (specific to India) USD 86 per ton	(Ricke et al., 2018)
Total Physical Volume	29,03,33,266 tonnes of carbon	
Economic Value	Lower Bound	Upper Bound
	Rs 2,55,725.541 crores/year	Rs 5,86,462.666 crores/year

Uttarakhand has most of its area under a conservation regime storing sizeable quantities of carbon.

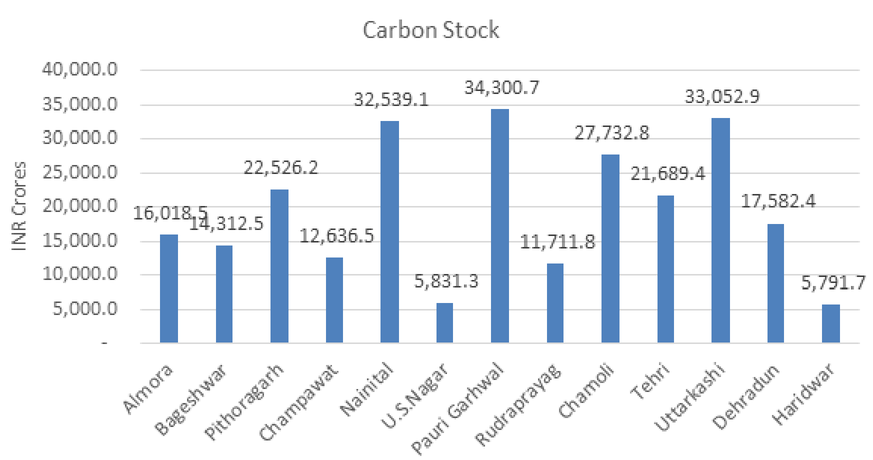


Figure 16: District-wise Distribution of Annual Stock Benefits from Carbon (Lower Bound)

3.2.9 CARBON SEQUESTRATION

Carbon sequestration is the process involved in carbon capture and the long-term storage of atmospheric carbon dioxide. Carbon sequestration involves long-term storage of carbon dioxide or other forms of carbon to mitigate or defer global warming. It has been proposed as a way to slow the atmospheric and marine accumulation of greenhouse gases, which are released by burning fossil fuels. Based on a research study conducted by (Singh, 2007) and (Bijalwan, Dobriyal, & Upadhyay, 2016), the average carbon sequestration rate for forests of Uttarakhand are said to be approximately 2.52 to 12 tons per hectare (conservative estimates). To estimate its economic value, social costs of carbon specific to India have been estimated at country-level using recent climate model projections, empirical climate-driven economic damage estimations and socio-economic projections, i.e. 37.5 USD per tCO_2 (Nordhaus, 2016) for lower bound estimates and 86 USD per tCO_2 (Ricke, Drouet, Caldeira, and Tavoni, 2018). A conversion factor of Rs.64 per USD has been used for conversion of USD to INR.

Table 24: Summary of Methodology Used for Flow Value of Carbon Sequestration

Ecosystem Service	Carbon Sequestration	
Method	Benefits Transfer Method	
	Data Used	Data Sources
Physical Estimation	District-wise total forest cover (ha.)	Forest Survey of India (2015)
	Average carbon sequestration rate of forest 2.52 to 12 tonnes per Ha.	(Singh, 2007) and (Bijalwan et al. 2016) Uttarakhand

Lower Bound Values	Social cost of carbon (specific to India) USD 37.5 per ton	(Nordhaus, 2016)
Upper Bound Values	Social cost of carbon (specific to India) USD 86 per ton	(Ricke et al., 2018)
Total Physical Volume	61,760.16 - 45767019.6 tonnes/year	
Economic Value	Lower Bound	Upper Bound
	Rs 1,482.24 crores/year	Rs 25,190.0 crores/year

Figure 17 below shows the district-wise distribution of annual flow benefit from carbon sequestration in the state of Uttarakhand.

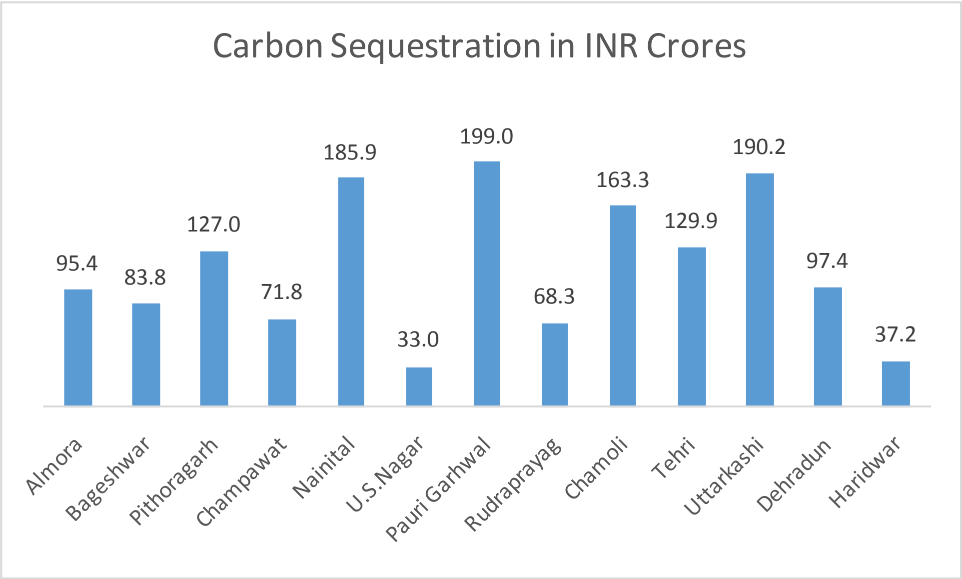


Figure 17: District-wise Distribution of Annual Flow Benefits from Carbon Sequestration (Lower Bound)

3.2.10 WATER PROVISIONING

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. When precipitation falls on a forested landscape, it is intercepted by the dense canopy cover, thereby reducing its intensity. Some of the water that reaches the land surface evaporates back, some goes away as run-off and some of it is absorbed back by the roots of the trees and moves out into the atmosphere through transpiration. After the soil moisture reaches its field or saturation capacity, the remaining water recharges the groundwater table.

For quantifying water provisioning services, the additional water recharge on account of reduced runoff is estimated on the basis of a simple water balance equation. This is then used with the economic value of water for agriculture to estimate the economic value of additional water recharge. The value is derived for each of the districts based on the respective forest area under VDF and MDF. Rs. 18.43 per m^3 is considered as the economic value of differential water recharge happening because of forests. Table 25 below is the summary of the methodology used for estimating the flow value of water provisioning.

Table 25: Summary of Methodology Used for Flow Value of Water Provisioning

Ecosystem Service	Water Provisioning		
Method	Benefits Transfer Method		
	Data Used		Data Sources
Physical Estimation	District-wise total forest cover under VDF and MDF (ha.)		Forest Survey of India (2015)
	Average water recharge value of forest 214 m^3/ha./year		GIST Monograph 7 (2006)
Benefits Transfer Value	Rs 18.43 per m^3 is considered as the economic value of differential water recharge happening because of forests		World Bank Study
Total Physical Volume	Total forest cover 24,508 km^2 (2015)	Recorded Forest Area 38,139.18 km^2	
Total Physical Volume	40,43,74,400 m^3/year	816178516.2 m^3/year	
Economic Value	Rs 745.3 crores/year	Rs 1506.66 crores/year	

Figure 18 below shows the district-wise distribution of annual flow benefits from water provisioning in the state of Uttarakhand.

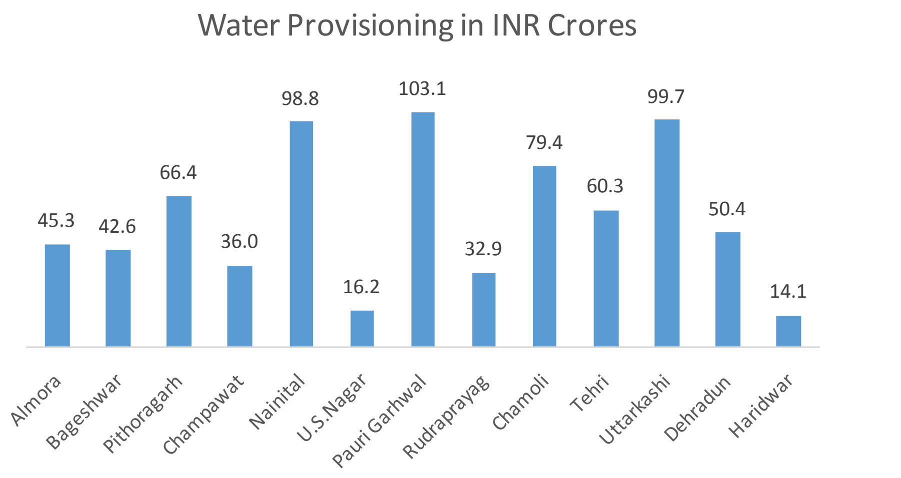


Figure 18: District-wise Distribution of Annual Flow Benefits from Water Provisioning

Pauri Garhwal and Uttarkashi with its large pristine forests are the largest contributor towards water recharge function in the state.

3.2.11 WATER PURIFICATION

Natural ecosystems filter out and decompose organic wastes introduced into inland water. In doing so, forests avoid the cost of establishment and operation of a water purification plant. Many rivers originate from the forests of the state that cater to drinking water requirements of numerous people. As in the case of Uttarakhand, most of the population is provided drinking water without much processing. Annual drinking water requirements met by forests reserve without the need of a water treatment plant have been estimated using guidelines provided by India's National Commission on Urbanization. Minimum domestic water requirement has been taken at 200 litres per day per person. An assumption is taken that 100 per cent of the domestic water requirement is met through natural sources in rural areas, while 70 per cent is met through natural sources in urban areas. Using census 2011 population data, the total domestic water demand is calculated for each of the districts. A nominal rate of Rs 10/m^3 of clean water has been taken to calculate the economic value of the water purification service. Table 26 is the summary of the methodology used for estimating flow value of water purification.

Table 26: Summary of Methodology Used for Flow Value of Water Purification

Ecosystem Service	Water Purification	
Method	Market Price Method	
	Data Used	Data Sources
Physical Estimation	Rural and urban population data	Census Data
	Minimum domestic water requirement of 200 LPD 100% assumed to be met from natural sources for rural areas 70% assumed to be met from natural sources for urban areas	
Market Price	Rs 10/m^3	Nominal Prices
Total Physical Volume	12,28,22,047.4 m^3/year	
Economic Value	Rs 655.66 crores/year	

Figure 19 below shows the district-wise distribution of annual flow benefits from water purification in the state of Uttarakhand.

Haridwar, U.S. Nagar along with Dehradun, districts in the Terai region are the largest beneficiaries of the water purification service being rendered by catchment areas in the hilly districts of the state.

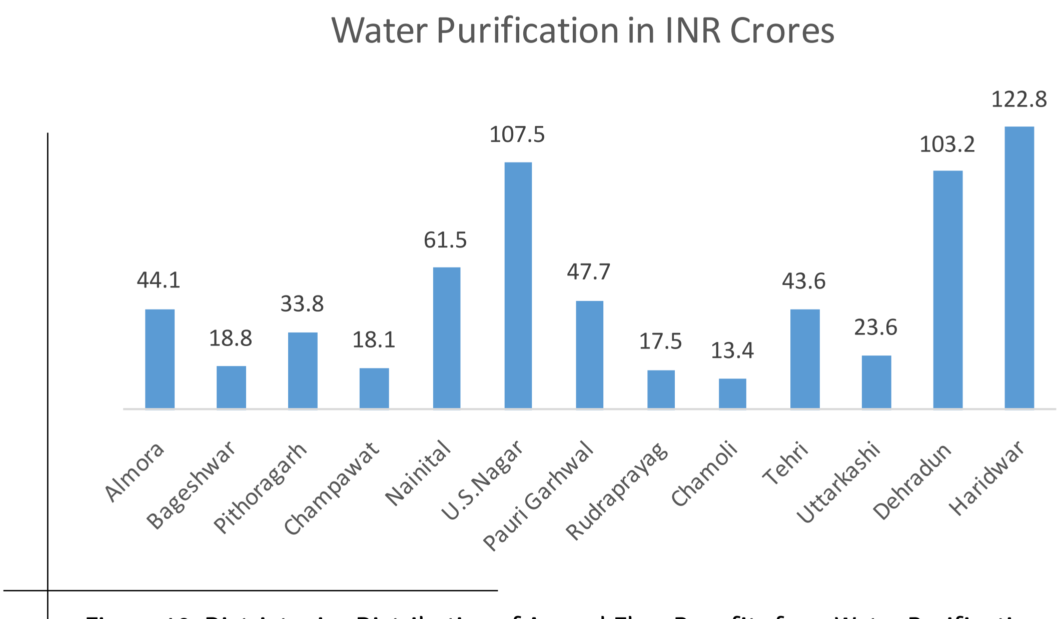


Figure 19: District-wise Distribution of Annual Flow Benefits from Water Purification

3.2.12 Soil Conservation/ Sediment Regulation

Owing to dense canopy cover and thick humus layer on the ground, forests play a pivotal role in arresting soil erosion and ensuring slope stabilization. The economic value of soil conservation in the study has been estimated using the avoided offsite costs from sedimentation. Secondary literature has been used extensively to estimate the marginal contribution of ecosystems in arresting soil erosion compared to managed ecosystems. The physical quantification of sediment retention was based on the values provided in the GIST study, which said that 12.3 tons of sediment retention is prevented by each hectare of dense forests.

The physical quantity of soil erosion avoided is used together with cost estimates by the Central Water Commission on earth excavation costs to derive the economic value of soil conservation services. Table 27 below is the summary of the methodology used for estimating the flow value of sediment regulation.

Table 27: Summary of Methodology Used for Flow Value of Sediment Regulation

Ecosystem Service	Sediment Regulation	
Method	Substitution Cost and Benefits Transfer Method	
	Data Used	Data Sources
Physical Estimation	District-wise total forest cover under VDF and MDF (ha.)	Forest Survey of India (2015)
	Soil loss prevented by forest @ 12.295 tonnes per ha	GIST Monograph 7 (2006)
Cost of Substitute	Dredging cost @ Rs 285 per 1.2cum	Dredging Corporation of India
Total Physical Volume	2,36,20,000 tonnes of sediments/year	
Economic Value	Rs 560.975 crores/year	

Figure 20 below shows the district-wise distribution of annual flow benefits from sediment regulation in the state of Uttarakhand.

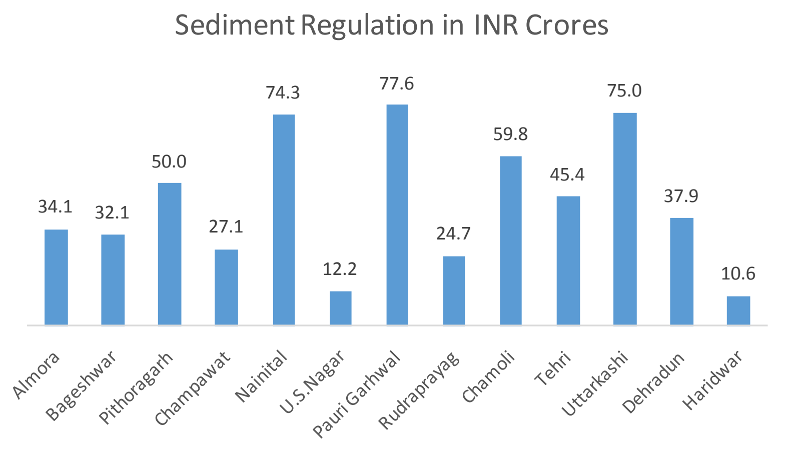


Figure 20: District-wise Distribution of Annual Flow Benefits from Sediment Regulation

In addition, the off-site costs of soil erosion include roadway, sewer and basement siltation, drainage disruption, undermining of foundations and pavements, gullying of roads, earth dam failures, eutrophication of waterways, siltation of channels, loss of wildlife habitat, disruption of stream ecology, among others which have not been considered here.

3.2.13 BIOLOGICAL CONTROL

Forests and other natural ecosystems moderate the risk of infectious diseases by regulating the populations of disease organisms (viruses, bacteria and parasites), their hosts, or the intermediate disease vectors (e.g. rodents and insects). There is growing evidence that deforestation results in an increased spread and/or incidence of human infectious diseases. On account of inadequate of site- specific studies for estimating the economic value of the ecosystem service related to biological control which includes regulation of diseases, the method of benefits transfer has been used. Based on unit area values of biological control for different types of ecosystems from a recent meta-analysis study (@ Rs. 660/ha/yr), the economic value of the ecosystem service has been derived for forests at the district level.

Table 28 Summary of the Methodology Used for Estimating Flow Value of Biological Control

Ecosystem Service	Biological Control	
Method	Benefits Transfer Method	
	Data Used	Data Sources
Physical Estimation	District-wise total forest area (ha.)	Forest Dept.
Benefits Transfer Value	Rs.660/hs./Year	Costanza (2014)
Total Physical Volume	Total forest area 38,139.18 km2 (Area under FD, Civil Soyam Forest Under Revenue Department, Van Panchayat and Private Agencies)	
Economic Value	Rs. 251.7 crores/year	

Figure 21 below shows the district-wise distribution of annual flow benefits from nutrient regulation in the state of Uttarakhand.

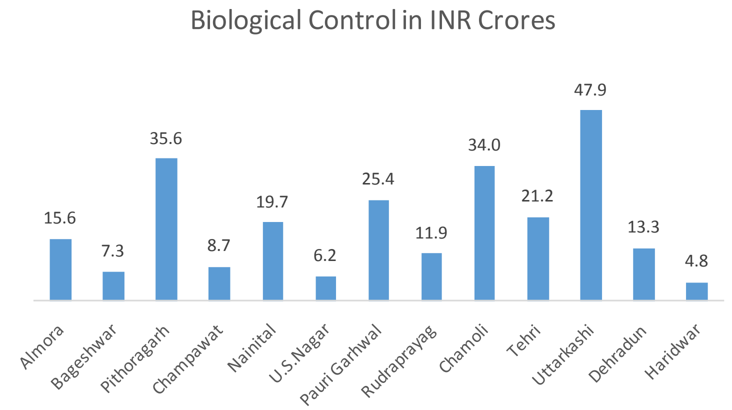


Figure 21: District-wise Distribution of Annual Flow Benefit from Biological Control Services

3.2.14 POLLINATION

Forests provide a natural habitat to pollinators which consequently help in increasing the quantity and quality of pollinator-dependent crops in the surrounding areas. On account of insufficient site-specific studies for estimating the economic value of pollination, the method of benefits transfer has been used. Based on unit area values of pollination for different types of ecosystems from a recent meta-analysis study, the economic value of the ecosystem service has been derived (@ Rs. 1800/ha/yr) as shown in Table 29 below.

Table 29: Summary of Methodology Used for Flow Value of Pollination

Ecosystem Service	Pollination	
Method	Benefits Transfer Method	
	Data Used	Data Sources
Physical Estimation	District-wise total forest cover (ha.)	Forest Survey of India
Benefits Transfer Value	Rs.1,800/ha./Year for tropical forests	Costanza (2014)
	Lower Bound	Upper Bound
Total Physical Volume	Total forest cover 24,508 km^2 (2015)	Recorded Forest Area 38,139.18 km^2
Economic Value	Rs. 441.1 crores/year	Rs. 686.50 crores/year

Figure 22 below shows the district-wise distribution of annual flow benefits from pollination services in the state of Uttarakhand.

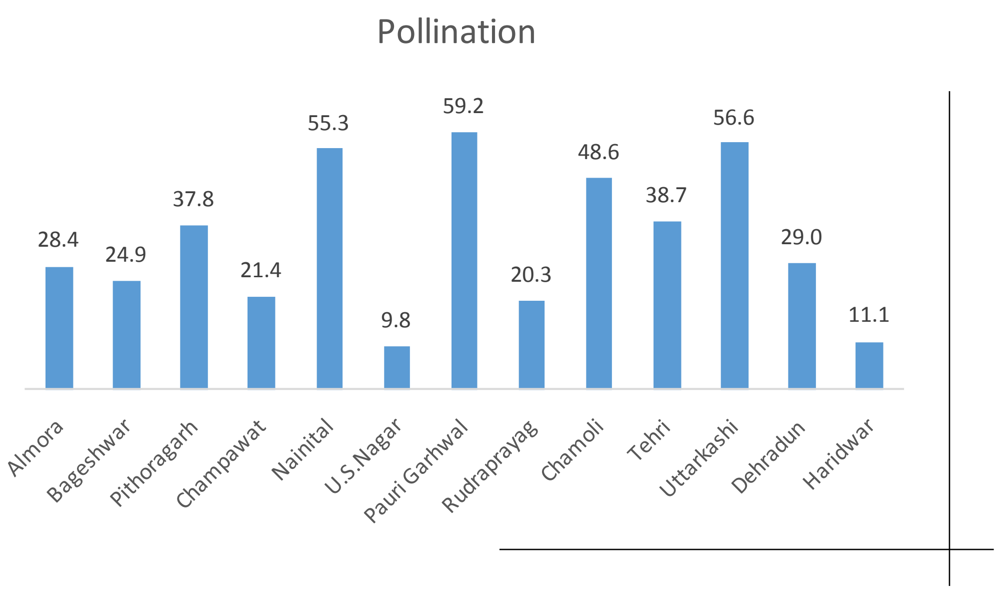


Figure 22: District-wise Distribution of Annual Flow Benefit from Pollination Services

3.2.15 GAS REGULATION

Natural ecosystems regulate chemical composition of various atmospheric gases such as oxygen, ozone and sulphur oxides. On account of scanty site-specific studies for estimating the economic value of gas regulation, the method of benefits transfer has been used. Based on unit area values of gas regulation for different types of ecosystems from a recent meta-analysis study, the economic value of the ecosystem service has been derived (@ Rs. 720/ha/yr).

Table 30: Summary of Methodology Used for Flow Value of Gas Regulation

Ecosystem Service	Gas Regulation	
Method	Benefits Transfer Method	
	Data Used	Data Sources
Physical Estimation	District-wise total forest cover (ha.)	Forest Survey of India
Benefits Transfer Value	Rs.720/ha./Year for tropical forests	Costanza (2014)
	Lower Bound	Upper Bound
Total Physical Volume	Total forest cover 24,508 km^2 (2015)	Recorded Forest Area 38,139.18 km^2
Economic Value	Rs.176.5 crores/year	Rs.274.66 crores/year

Figure 23 below shows the district-wise distribution of annual flow benefits from gas regulation in the state of Uttarakhand.

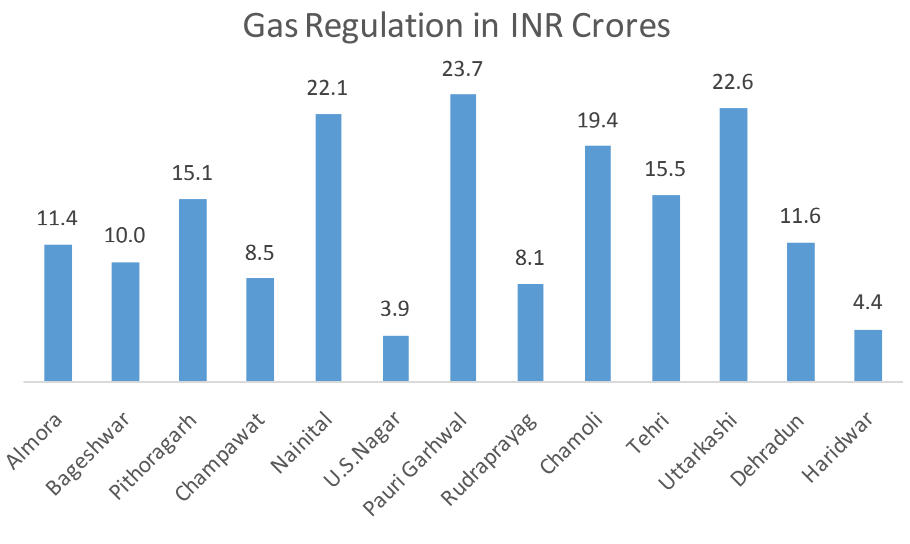


Figure 23: District-wise Distribution of Annual Flow Benefits from Gas Regulation

3.2.16 WASTE ASSIMILATION

Similar to water purification services, natural vegetation and biota within forest areas break down xenic nutrients and compounds and help in pollution control and detoxification. As data for physical estimation of the ESs was not available, for economic value of waste assimilation, the method of benefits transfer has been used. Based on unit area values of waste assimilation for different types of ecosystems from a recent meta-analysis study (@Rs. 7200/ha/yr), the economic value of the ecosystem service has been derived for different districts as indicated in Table 31 below.

Table 31: Summary of Methodology Used for Flow Value of Waste Assimilation

Ecosystem Service	Waste Assimilation	
Method	Benefits Transfer Method	
	Data Used	Data Sources
Physical Estimation	District-wise total forest cover (ha.)	Forest Survey of India
Benefits Transfer Value	Rs.7,200/ha./Year for tropical forest	Costanza (2014)
	Lower Bound	Upper Bound
Total Physical Volume	Total forest cover 24,508 km^2 (2015)	Recorded Forest Area 38,139.18 km^2
Economic Value	Rs 1,764.6 crores/year	Rs. 2746.0 crores/year

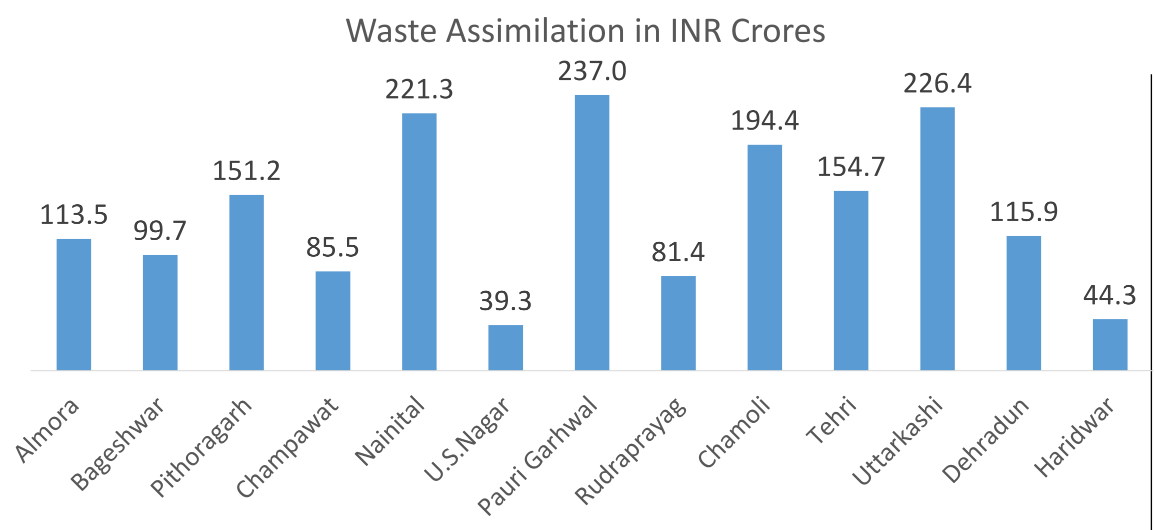


Figure 24: District-wise Distribution of Annual Flow Benefits from Waste Assimilation (Lower Bound)

3.2.17 FLOOD REGULATION

Floods are the most frequent natural disasters and cause damage in terms of not only human life but also physical property. Floods also cause diseases and displacement of humans on a large scale. Some plausible causes of floods are high intensity of rainfall over a particular region and alterations in the natural drainage of the river basin area by its being converted to human settlement, necessitating deforestation. Of the above, the link between deforestation and floods has been found to be very significant.

It is believed that forests act as a sponge, absorbing large quantities of water during the rainy season. Dense vegetation slows down water movement, reduces surface flow, and facilitates water infiltration into the ground. The leaves catch rainfall on the forest canopy while the leaf litter on the floor intercepts rain flow and protects the soil. It also helps water infiltrate more effectively into the soil, until soil saturation capacity is reached. Only after that does the excess water get converted into surface run-off. If the rainfall intensity is very high, then the very infiltration capacity of the system is reduced and even afforestation cannot make much difference to the overall flood situation. Table 32 below is the summary of the methodology used for estimating the flow value of flood regulation.

Table 32: Summary of Methodology Used for Flow Value of Flood Regulation

Ecosystem Service	**Flood Regulation**	
Method	Benefits Transfer Method	
	Data Used	Data Sources
Physical Estimation	NA	NA
Benefits Transfer Value	Rs. 540 crores per annum. The value was adjusted for WPI.	GIST Monograph 7 (2006)
Total Physical Volume	NA	
Economic Value	Rs. 1,306.5 crores/year	

In the absence of any site specific study, the benefits transfer approach has been used to arrive at the economic value of Flood Regulation ESs. The value has been adopted from the GIST monograph in which the value of flood regulation ES for Uttarkhand forests was calculated at Rs. 540 crores per annum. The value was adjusted for WPI. The value was equally distributed amongst 13 districts of the state. Thus economic value for each district was Rs. 100.5 crores p.a. for flood regulation ES's.

3.2.18 NUTRIENT CYCLING/RETENTION

Forests and other natural ecosystems prevent significant erosion into neighboring rivers and streams. An indirect benefit of the avoidance of soil erosion is retention of nutrients which would have been lost forever along with the soil. These natural ecosystems ensure that the flow of nutrients is regulated and their loss is avoided. In scientific literature, the ecosystem service is mostly estimated using the replacement cost of fertilizers, and a similar approach has been used here.

Owing to soil erosion in the absence of forests, the nutrients will be lost along with sediments. The litter also has significant nutrient concentration and if these forests had not existed, the nutrients would further leach from this litter nutrient pool.

Considering this hypothesis, physical quantification of nutrient cycling or nutrient retention ecosystem service has been estimated using estimates of soil erosion avoided and concentration of NPK (nitrogen, phosphorus and potassium) in soil derived from the GIST study. The study suggests that each kg of avoided erosion contains 2.32 g of Nitrogen, 0.044 g of Phosphorus and 8.25 g of Potassium. Using these values, the physical quantity of nutrient loss avoided by forests is estimated. This physical estimate is then used along with the price of NPK fertilizers in India to obtain the economic value of nutrient cycling from forest areas as shown below.

Table 33: Summary of Methodology Used for Flow Value of Nutrient Cycling/Retention

Ecosystem Service	Nutrient Cycling/Retention	
Method	Substitution Cost and Benefits Transfer Method	
	Data Used	Data Sources
Physical Estimation	District-wise total forest cover under VDF and MDF (Ha.)	Forest Survey of India (2015)
	Soil loss prevented by forest @ 12.295 tonnes per ha	GIST Monograph 2 (2006)
	Each kg of avoided erosion contains 2.32 g of Nitrogen, 0.044 g of Phosphorus and 8.25 g of Potassium	GIST Monograph 2 (2006)
Cost of Substitute	Price of NPK	Price of NPK Fertilizers in India
Total Physical Volume	2,36,20,000 tonnes of sediments r/year	
Economic Value	Rs 420.9 crores/year	

Figure 25 below shows the district-wise distribution of annual flow benefits from nutrient regulation in the state of Uttarakhand.

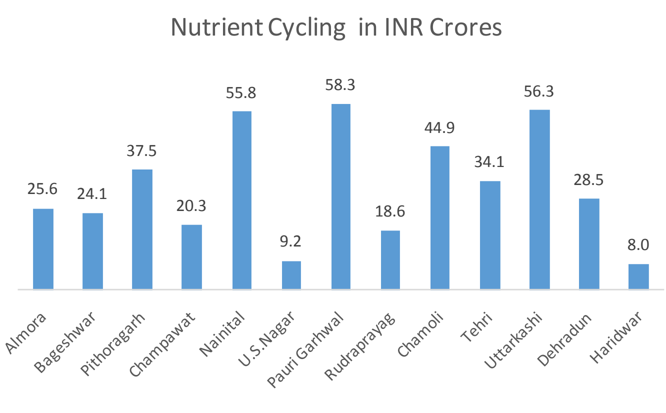


Figure 25: District-wise Distribution of Annual Flow Benefits from Nutrient Regulation

3.2.19 HABITAT FOR SPECIES

Forests provide suitable living space and food for wild animals. Further, intact natural ecosystems within the forest with their buffering functions (e.g. cooling effects, interception of precipitation and evapotranspiration, water storage and wind shield) can significantly contribute to the mitigation of and adaptation to extreme weather events. For example, the shade of riparian forests can help reduce thermal stress to aquatic life as climate warming intensifies. In an attempt to move beyond instrumental value, the economic value of habitat/refugia for wildlife is envisaged.

On account of the shortage of site-specific studies for estimating the economic value of habitat/refugia, the method of benefits transfer has been used. Based on unit area values of habitat / refugia for different types of ecosystems from a recent meta- analysis study, the economic value of this ecosystem service has been derived for forest areas (@ Rs. 2340/ha/yr). Table 34 provides the district wise economic value of the service. Figure 26 shows the district-wise distribution of annual flow benefits from gas regulation in the state of Uttarakhand.

Table 34: Summary of Methodology Used for Flow Value of Habitat for Species

Ecosystem Service	Habitat for Species	
Method	Benefits Transfer Method	
	Data Used	Data Sources
Physical Estimation	District-wise total forest area (ha.)	Forest Dept.
Benefits Transfer Value	Rs. 2,340/ha./Year for tropical forests	Costanza (2014)
Total Physical Volume	Total forest area 38,139.18 km^2 (Area under FD, Civil Soyam Forest Under Revenue Department, Van Panchayat and Private Agencies)	
Economic Value	Rs. 892.5 crores/year	

3.2.20 RECREATION

Uttarakhand has numerous tourist attractions, because of its natural heritage. The team faced an immense challenge in quantification of recreation from forest areas as no distinct datasets are in place which can differentiate tourists based on their place of visit. Thus, the team decided to go ahead with the data collected by the state forest department at its different tourist centres. For the year 2014-15, the forest department has reported that 3,22,936 individuals visited various tourist attractions at state forests. The total revenue generated from these individuals by the forest department was Rs. 9.94 crore. In order to know the upper-bound estimates the values revenue generated from Corbett National Park has been used for the complete forest cover. The upper bound estimates hence calculated is 126 crores/year. Owing to inadequate site specific data, the value was equally divided amongst all districts to arrive at the individual contribution at district level.

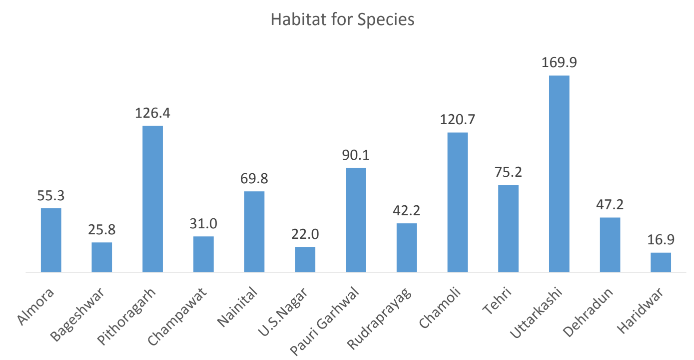


Figure 26: District-wise Distribution of Annual Flow Benefits from the Habitat for Specie

Ecosystem Service	Recreation	
Method	Benefits Transfer Method	
	Data Used	Data Sources
Physical Estimation	Number of individuals that visited various tourist attractions at state forests Forest Dept.	Forest Dept.
Monetary Valuation	Total revenue generated from these individuals by the forest department WTP for Forest Dept.	Forest Dept.
Total Physical Volume	3,22,936 individuals visited various tourist attractions at state forests	
	Lower Bound	Upper Bound
Economic Value	Rs. 9.94 crore/year	Rs. 126 crore/ year

Table 35: Summary of Methodology Used for Flow Value of Recreation Services

3.3 WATERSHED PROTECTION

Uttarakhand being one of the Himalayan states with more than 12,000 glaciers and 8 major river catchments act as the lifeline for the entire hydrological system of the Indo-Gangetic plain. Watersheds in the state are under great threat due to increase in population, degradation of forests, climate change, unscientific practices degrading the landscape and quality of water, hydrologic imbalances and natural calamities. In this report, though most of the ecosystem benefits from watersheds have already been accounted for under water provisioning, flood regulation, waste assimilation, water purification, sediment retention, etc., the range of benefits from watersheds have larger scope in Uttarakhand's context than what has been estimated so far. The values for water provisioning, flood regulation, waste assimilation, water purification, sediment retention, etc. have been listed only so as to further compound the benefits on account of watershed functions of Uttarakhand forests. But for working out the overall watershed value of forests estimated from the watershed study on the Yamuna Basin by Chopra and Kadekodi (1997) in terms of Rs./Hectares has been used. Thus the watershed value of the entire Uttarakhand forest area amounts to Rs. 76278 crores annually. Many such values are actually embedded in the production system of various other sectors but their sizeable proportion needs to be accounted under the forestry sector.

3.4 POSSESSION VALUE OF LAND

While many studies have attempted to estimate the economic value of forests in terms of the ecosystem services they generate, an important aspect that is often missed is the value of land itself. To address this concern, the NPV report suggested that the possession value of land should also be included in the NPV to be charged for agencies seeking to divert forest land. Along similar lines, the median circle rates for one tehsil in each district of the state have been calculated to estimate the possession value of land. Care has been taken not to include the major city centres of the district so that the average value is not overestimated. Uttarakhand being a hilly state it has land at different altitudes shown in Table 36 and Figure 27. Considering the high ratio of area under hilly terrain land value should be calculated accordingly.

Table 36: Zones in Districts as Per Altitudes

S.No	Name of the Zone	Altitudinal Range	Districts
	Tropical	Up to 1000m	Almora (Part), Champawat (Part), Pauri-Garhwal (Part), Haridwar, Udham Singh Nagar, Nainital (Part)
	Sub-Tropical	1000 to 1500m	Almora(Part), Dehradun (Part), Champawat (Part), Pauri-Garhwal (Part), Nainital (Part)
	Cool Temperate	1500 to 2400m	Almora(Part), Dehradun (Part), Champawat (Part), Pauri-Garhwal (Part), Nainital (Part), Tehri Garhwal (Part), Chamoli (Part), Rudra Prayag (Part), Uttarkashi, Pithoragarh and Bageshwar
	Sub Alpine	Above 2400m	Uttarkashi, Chamoli (Part)

In a recommendation report "Cost-Disabilities of Hill States in India" submitted to the Fourteenth Finance Commission, an attempt has been made to factor hill land disability index into the economic valuation. States with mountainous and hilly terrain, especially the Himalayan region comprise a unique ecosystem that provides ecosystem services which are important for local, regional, national and international well-being in the context of sustainability and unique challenges and in addressing their developmental needs in a manner that takes care of conservation concerns for sustainable development. Hence in the case of Uttarakhand an elevation factor of 1.14 Table 37 has been taken to internalize the hill factor while calculating the land rates.

Table 37: Elevation 3D-2D Ratio

State	2-D Area in (Sq.Km)	3-D area (Sq.Km)	Difference (3D – 2D) (Sq.Km)	Ratio of 3D-2D Data
Uttarakhand	53607.1	60969.47	7362.37	1.14

Source: Study Report "Cost-Disabilities of Hill States in India" Submitted to the Fourteenth Finance Commission.

Altitude Zone	VDF	MDF	OF	Total
0-500	548	1732	546	2826
500-1000	1035	2189	794	4018
1000-2000	1727	5477	2820	10024
2000-3000	1345	3074	1202	5621
3000-4000	99	1126	506	1731
>4000	0	4	16	20
Total	4754	13602	5884	24240
VDF = Very Dense Forest, MDF= Moderately Dense Forest, OF= Open Forest				

Figure 27: Density of Forest at Different Altitudes

Average per hectare land rate for each district of Uttarakhand estimated using the circle rates given by the revenue department. The possession value of land value calculated including cost-disability index of hill for the state is Rs. 4,36,849 crores indicated in Table 38.

Table 38: Valuation of Land: Uttarakhand

S.No	District	Total Forest Area	Land Rate (Cr/ha)	Economic Value INR Crores
1	Almora	2361.841	0.057	13462.5
2	Bageshwar	1101.596	0.114	12558.2
3	Pithoragarh	5401.503	0.103	55419.4
4	Champawat	1323.375	0.057	7543.2
5	Nainital	2982.36	0.171	50998.4
6	U.S.Nagar	938.37	0.114	10697.4
7	Pauri Garhwal	3850.942	0.037	14267.7
8	Rudraprayag	1803.653	0.060	10794.9
9	Chamoli	5157.847	0.228	117598.9
10	Tehri Garhwal	3215.64	0.066	21361.5
11	Uttarkashi	7259.448	0.100	72826.8
12	Dehradun	2018.301	0.228	46017.3
13	Haridwar	724.307	0.046	3302.8
			Total	**4,36,849**

3.5 SUMMARY : VALUATION OF ECOSYSTEM SERVICES FROM THE FORESTS OF UTTARAKHAND

The forests of Uttarakhand provide ecosystem services ranging worth 15,08,788.7-1,865,436.18 crores annually (Stock +Flow Values). Table 39 is the summary sheet for flow values of 18 ecosystem services mapped. From the table below it can be seen that the flow values of ecosystem services from the forests of Uttarakhand ranges from 95,112.52 crores to 1,93,904 crores.

Table 39: Summary Sheet: Valuation of Ecosystem Services (Flow Values)

Uttarakhand Forest Ecosystem Service (Flow Values)	Economic Value (INR crores)		(Flow Values) Including Watershed	
	Lower Bound	Upper Bound	Lower Bound	Upper Bound
Fuelwood	3,395.2	3,395.2	3,395.2	3,395.2
Fodder	7,776.1	7,776.1	7,776.1	7,776.1
Timber	1,243.2	1,243.2	1,243.2	1,243.2
Non-Timber Forest Products	303.7	303.7	303.7	303.7
Employment Generation	300	300	300	300
Gene-Pool Protection	73,386.5	73,386.5	73,386.5	73,386.5
Carbon Sequestration	1,482.2	25190.0	1,482.2	25190.0
Water Provisioning	745.3	1506.66	76278	76278
Water Purification	655.7	655.7		
Sediment Regulation/Retention	561	561		
Nutrient Cycling/Retention	420.9	420.9		
Biological Control	251.7	251.7		
Pollination	441.1	686.5	251.7	251.7
Habitat for Species	892.5	892.5	441.1	441.1
Gas Regulation	176.5	274.66	892.5	892.5
Waste Assimilation	1,764.6	2746.0	176.5	274.5
Flood Regulation	1,306.5	1,306.5	1,764.60	2,746.00
Recreation	9.9	126.0	9.9	126
Total Flow Value	95,112.52	1,21,022.82	1,68,755.92	1,93,904.86

Table 40 is a summary of the stock values for timber stock, carbon stock, and land value for Uttarakhand's forests. These values calculated for different ecosystem services were spread across the districts of the state in Table 41. In order to do so, per ha values of the services were taken and multiplied with the corresponding forest area or forest cover depending on the nature of the ecosystem service. At the end the possession value of land was also added.

Table 40: Summary Sheet: Valuation of Ecosystem Services (Stock Values)

Uttarakhand Forest Ecosystem Service (Stock Values)	Economic Value (INR crores)		Physical Volume
	Lower Bound	Upper Bound	
Timber Stock	7,21,101.70	7,21,101.70	370.65 million m^3
Carbon Stock	2,55,725.50	5,86,462.66	290.33 million tonnes of carbon
Land Value	4,36,849.00	4,36,849.00	Total forest area 38,139.18 km^2
Total Stock Value	**14,13,676.20**	**17,44,413.36**	**N.A.**

3.6 VALUATION SCENARIOS

An attempt has been made to estimate the economic value of ecosystem services from forests in Uttarakhand using both primary and secondary sources. To gain a better perspective on the total economic value of forests, scenarios have been developed based on widely acclaimed or relevant studies which provide such progression in enlisting, data and methodologies and provide spectrum of value of the same resource, i.e. Uttarakhand Forests with these four different lenses.

Costanza 1997 Scenario: Costanza, R. et al., 1997. The Value of the World’s Ecosystem Services and Natural Capital. Nature, 387 (May), pp.253–260.

de Groot et al. (2012), de Groot, R., Brander, L., van der Ploeg, S., Costanza, R., Bernard, F., Braat, L.,Van Beukering, P. (2012). Global Estimates of the Value of Ecosystems and Their Services in Monetary Units. Ecosystem Services, 1(1), 50–61.

https://doi.org/10.1016/j.ecoser.2012.07.005

Ida et al. 2013 Scenario:Ida Kubiszewski, Robert Costanza, Lham Dorji, Philip Thoennes, and Kuenga Tshering. An Initial Estimate of the Value of Ecosystem Services in Bhutan. 2013.

Costanza, 2014 Scenario: Costanza, R. et al., 2014. Changes in the Global Value of Ecosystem Services. Global Environment Change. 26(2014) 152-158.

3.6.1 SCENARIO I: COSTANZA ET AL. (1997)

This is one of the earliest studies which attempted to estimate the total economic value of ecosystem services from various ecosystems and considers a whole gamut of ecosystem services. Although somewhat controversial, it nevertheless provided the first-of-its-kind methodology to put an economic value to services that nature provides. Costanza and his team stated that the services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the earth’s life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet.

They estimated the current economic value of 17 ecosystem services for 16 biomes, based on published studies and a few original calculations. For the entire biosphere, the value most of which is outside the market) is estimated to be in the range of US$16–54 trillion (1012) per year, with an average of US$33 trillion per year. On account of the nature of the uncertainties, this must be considered a minimum estimate. The total global gross national product is around US$18 trillion per year.

Table 41: Values Calculated Spread Across the Districts of the State (Lower Bound) in INR Crores

District	Almora	Bageshwar	Pithoragarh	Champa-wat	Nainital	U.S.Nagar	Pauri Garhwal
Employment Generation	18.89	7.88	14.67	7.88	28.96	50.02	20.85
Fuelwood	315.7	142.3	204.5	115.1	172.4	552.4	165.8
Fodder	595.9	223.2	467.9	275.7	224.9	1323.4	478.6
Timber	65.6	44.7	248.6	43.5	72.2	290.8	30.1
NTFP	18.47	17.36	27.07	14.68	40.25	6.61	42.03
Gene Pool	4722.2	4147.2	6288.2	3554.3	9204.8	1634.9	9854.5
Carbon Sequestration	95.4	83.8	127.0	71.8	185.9	33.0	199.0
Water Provisioning	45.3	42.6	66.4	36.0	98.8	16.2	103.1
Water Purification	44.1	18.8	33.8	18.1	61.5	107.5	47.7
Sediment Regulation	34.1	32.1	50.0	27.1	74.3	12.2	77.6
Nutrient Cycling	25.6	24.1	37.5	20.3	55.8	9.2	58.3
Biological Control	15.6	7.3	35.6	8.7	19.7	6.2	25.4
Pollination	28.4	24.9	37.8	21.4	55.3	9.8	59.2
Habitat for Species	55.3	25.8	126.4	31.0	69.8	22.0	90.1
Gas Regulation	11.4	10.0	15.1	8.5	22.1	3.9	23.7
Waste Assimilation	113.5	99.7	151.2	85.5	221.3	39.3	237.0
Flood Regulation	100.5	100.5	100.5	100.5	100.5	100.5	100.5
Recreation	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Stock Value							
Timber Stock	57620.5	50605.2	76729.9	43370.7	112318	19949.8	120246.8
Carbon Stock	3978.8	3494.4	5298.4	2994.9	7755.8	1377.6	8303.3
Land Value	13462.4	12558.2	55419.4	7543.2	50998.3	10697.4	14267.7
Total	81368.5	71710.7	145480.7	58349.7	181781.5	36243.6	154432.3

	Rudraprayag	Chamoli	Tehri	Uttarkashi	Dehradun	Haridwar	TOTAL
	7.35	5.89	18.78	10.01	51.47	57.35	300
	120.9	163.8	366.8	154.2	298.7	622.7	3395.2
	289.5	538.6	512.3	423.5	930.6	1491.8	7776.1
	38.1	64.5	46.9	42.1	70.2	185.8	1243.2
	13.39	32.37	24.59	40.62	20.54	5.75	303.7
	3383.7	8084.9	6431.9	9417.4	4821.0	1841.5	73386.5
	68.3	163.3	129.9	190.2	97.4	37.2	1482.2
	32.9	79.4	60.3	99.7	50.4	14.1	745.3
	17.5	13.4	43.6	23.6	103.2	122.8	655.7
	24.7	59.8	45.4	75.0	37.9	10.6	561.0
	18.6	44.9	34.1	56.3	28.5	8.0	420.9
	11.9	34.0	21.2	47.9	13.3	4.8	251.7
	20.3	48.6	38.7	56.6	29.0	11.1	441.1
	42.2	120.7	75.2	169.9	47.2	16.9	892.5
	8.1	19.4	15.5	22.6	11.6	4.4	176.5
	81.4	194.4	154.7	226.4	115.9	44.3	1764.6
	100.5	100.5	100.5	100.5	100.5	100.5	1306.5
	0.76	0.76	0.76	0.76	0.76	0.76	9.9
	41288.0	98652.8	78483.7	114912.2	58826.3	22470.9	895474.7
	2851.0	6812.2	5419.5	7935.0	4062.1	1551.7	61834.8
	10794.8	117598.9	21361.5	72826.7	46017.2	3302.8	436849
	59213.9	232833.2	113386	206831.1	115733.9	31906.0	1489271

SCENARIO I: COSTANZA ET AL. (1997)

Ecosystem Services	Almora	Bageshwar	Pithorag-arh	Champa-wat	Nainital
Gas Regulation	0	0	0	0	0
Climate Regulation	4.7	3.4	11.8	10.2	19.8
Disturbance Regulation	0.1	0.1	0.3	0.2	0.5
Water Regulation	0.1	0.1	0.2	0.2	0.4
Water Supply	0.2	0.1	0.4	0.3	0.6
Erosion Control and Sediment Retention	5.2	3.7	13.0	11.2	21.7
Soil Formation	0.2	0.2	0.5	0.5	0.9
Nutrient Cycling	19.5	14.0	49.1	42.2	81.9
Waste Treatment	1.8	1.3	4.6	4.0	7.7
Food Production	0.7	0.5	1.7	1.5	2.9
Raw Materials	6.7	4.8	16.8	14.4	28.0
Genetic Resources	0.9	0.6	2.2	1.9	3.7
Recreation	2.4	1.7	5.9	5.1	9.9
Cultural	0.0	0.0	0.1	0.1	0.1
Total	42.5	30.4	106.8	91.8	178.0

U.S.Nagar	Pauri Garhwal	Rudrapr-ayag	Chamoli	Tehri Garhwal	Uttarkashi	Dehradun	Haridwar	Total
0	0	0	0	0	0	0	0	0
12.1	30.2	35.4	118.6	247.8	1169.4	1534.1	722.2	3919.5
0.3	0.7	0.8	2.7	5.7	26.7	35.0	16.5	89.4
0.2	0.6	0.7	2.3	4.8	22.9	30.0	14.1	76.6
0.4	1.0	1.2	3.9	8.1	38.1	50.0	23.5	127.7
13.2	33.1	38.8	130.1	272.0	1283.6	1684.0	792.8	4302.6
0.5	1.4	1.6	5.4	11.3	53.3	70.0	32.9	178.7
49.9	125.0	146.5	491.2	1026.8	4845.0	6356.2	2992.5	16239.9
4.7	11.8	13.8	46.3	96.9	457.1	599.6	282.3	1532.1
1.8	4.4	5.2	17.4	36.3	171.4	224.9	105.9	574.5
17.1	42.7	50.1	168.0	351.1	1656.9	2173.7	1023.4	5553.7
2.2	5.6	6.6	22.0	46.0	217.1	284.8	134.1	727.7
6.0	15.1	17.7	59.5	124.3	586.6	769.5	362.3	1966.2
0.1	0.2	0.2	0.8	1.6	7.6	10.0	4.7	25.5
108.6	271.8	318.6	1068.2	2232.8	10535.7	13821.7	6507.3	35314.2

3.6.2 SCENARIO II: DE GROOT ET AL. (2012)

This paper gives an overview of the value of ecosystem services of 10 main biomes expressed in monetary units. In total, over 320 publications were screened covering over 300 case study locations. Approximately 1350 value estimates were coded and stored in a searchable Ecosystem Service Value Database (ESVD). A selection of 665 value estimates was used for the analysis.

Ecosystem Services	Almora	Bageshwar	Pithoragarh	Champawat	Nainital
Food	3.07	2.20	7.72	6.64	12.87
Water	0.42	0.30	1.04	0.90	1.74
Raw Materials	1.29	0.92	3.24	2.79	5.41
Genetic Resources	0.20	0.14	0.50	0.43	0.84
Medicinal Resources	23.09	16.53	58.05	49.93	96.79
Air Quality Regulation	0.18	0.13	0.46	0.40	0.77
Climate Regulation	31.38	22.47	78.89	67.86	131.55
Disturbance Moderation	1.01	0.73	2.55	2.19	4.25
Regulation of Water Flows	5.25	3.76	13.20	11.35	22.01
Waste Treatment	0.09	0.07	0.23	0.20	0.39
Erosion Prevention	0.23	0.17	0.58	0.50	0.97
Nutrient Cycling	0.05	0.03	0.12	0.10	0.19
Pollination	0.46	0.33	1.16	1.00	1.93
Biological Control	0.17	0.12	0.43	0.37	0.71
Nursery Service	0.25	0.18	0.62	0.53	1.03
Genetic Diversity	0.35	0.25	0.89	0.76	1.48
Recreation	13.31	9.53	33.46	28.78	55.80
Total	80.80	57.85	203.12	174.73	338.71

All Values in Crores/yr

U.S.Nagar	Pauri Garhwal	Rudraprayag	Chamoli	Tehri Garhwal	Uttarkashi	Dehradun	Haridwar	Total
7.85	19.65	23.04	77.24	161.45	761.80	999.40	470.52	2553.45
1.06	2.65	3.11	10.43	21.80	102.84	134.92	63.52	344.99
3.30	8.25	9.68	32.44	67.81	319.96	419.75	197.62	1073.29
0.51	1.28	1.50	5.02	10.49	49.52	64.96	30.58	166.10
59.04	147.78	173.25	580.85	1214.07	5728.74	7515.51	3538.30	19216.96
0.47	1.18	1.38	4.63	9.69	45.71	59.96	28.23	153.33
80.24	200.84	235.46	789.40	1649.97	7785.60	10213.89	4808.70	26116.66
2.59	6.49	7.60	25.49	53.28	251.39	329.80	155.27	843.30
13.43	33.60	39.40	132.08	276.07	1302.68	1708.98	804.59	4369.81
0.24	0.59	0.69	2.32	4.84	22.85	29.98	14.12	76.66
0.59	1.47	1.73	5.79	12.11	57.14	74.96	35.29	191.66
0.12	0.30	0.35	1.16	2.42	11.43	14.99	7.06	38.33
1.18	2.95	3.46	11.59	24.22	114.27	149.91	70.58	383.32
0.43	1.08	1.27	4.25	8.88	41.90	54.97	25.88	140.55
0.63	1.57	1.84	6.18	12.92	60.94	79.95	37.64	204.44
0.90	2.26	2.65	8.88	18.57	87.61	114.93	54.11	293.88
34.03	85.19	99.87	334.84	699.86	3302.40	4332.41	2039.70	11077.86
206.59	517.13	606.27	2032.58	4248.42	20046.77	26299.27	12381.69	67193.94

3.6.3 SCENARIO III: IDA ET AL. (2013)

Based on the benefit transfer approach having used Ida et al. (2013) more than 200 valuation studies from which many are contemporary and thus provides an updated economic value for ecosystem services. The study site is the temperate forests of Bhutan which have a close socio-economic and environmental resemblance to the current study location of Uttarakhand.

Provides value for a wide array of ecosystem services from forests. Ida and her team estimated the value of ecosystem services in Bhutan using a quick and cost-effective benefit transfer methodology in order to get an initial rough assessment of their overall contribution to human well-being. They estimated the annual value of 22 different

Ecosystem Services	Almora	Bageshwar	Pithoragarh	Champawat	Nainital
Bioprospecting	0.12	0.1	0.3	0.3	0.5
Food	3.7	2.7	9.3	8.0	15.6
Genetic Resources	0.3	0.2	0.7	0.6	1.2
Timber	0.7	0.5	1.7	1.5	2.8
Water	2.5	1.8	6.3	5.4	10.4
Air Quality	13.1	9.4	32.9	28.3	54.8
Biodiversity Protection	14.9	10.7	37.4	32.2	62.4
Biological Control	0.1	0.1	0.3	0.3	0.6
Climate Regulation	18.7	13.4	47.1	40.5	78.5
Erosion Prevention	0.9	0.6	2.2	1.9	3.7
Pollination	5.8	4.1	14.5	12.5	24.2
Soil Formation	0.2	0.1	0.4	0.4	0.7
Water Purification	0.4	0.3	1.1	0.9	1.8
Water Regulation	0.0	0.0	0.0	0.0	0.0
Cultural Values	0.0	0.0	0.1	0.1	0.1
Education	0.0	0.0	0.0	0.0	0.0
Science/Research	0.0	0.0	0.0	0.0	0.0
Tourism/ Recreation	16.0	11.4	40.1	34.5	66.9
	77.4	55.4	194.5	167.3	324.3

All Values in Crores/yr

ecosystem services in Bhutan for 9 different land cover types. The total estimated value was approximately $15.5 billion/year (NU 760 billion/yr), significantly greater than the gross domestic product (GDP) of $3.5 billion /yr. Most of this value was from forested land, which covers over 74.5 per cent of the land surface and contributes 93.8 per cent of the total estimated value. Cropland is second in value with 3.7 per cent of total value, from only 8.0 per cent of land area.

U.S.Nagar	Pauri Garhwal	Rudraprayag	Chamoli	Tehri Garhwal	Uttarkashi	Dehradun	Haridwar	Total
0.3	0.8	0.9	3.1	6.5	30.5	40.0	18.8	102.1
9.5	23.8	27.9	93.5	195.3	921.8	1209.3	569.3	3089.7
0.7	1.9	2.2	7.3	15.3	72.4	94.9	44.7	242.6
1.7	4.3	5.1	17.0	35.5	167.6	219.9	103.5	561.8
6.4	15.9	18.7	62.6	130.8	617.1	809.5	381.1	2068.3
33.4	83.7	98.1	329.0	687.8	3245.3	4257.5	2004.4	10877.7
38.0	95.2	111.6	374.2	782.2	3690.9	4842.1	2279.7	12371.4
0.4	0.9	1.0	3.5	7.3	34.3	45.0	21.2	114.9
47.9	119.9	140.5	471.2	984.8	4647.0	6096.4	2870.2	15576.0
2.3	5.7	6.7	22.4	46.8	220.9	289.8	136.5	740.5
14.8	36.9	43.3	145.2	303.5	1432.2	1878.9	884.6	4800.5
0.4	1.1	1.3	4.2	8.9	41.9	55.0	25.9	140.4
1.1	2.8	3.2	10.8	22.6	106.7	139.9	65.9	357.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.2	0.2	0.8	1.6	7.6	10.0	4.7	25.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.8	102.1	119.7	401.3	838.7	3957.6	5191.9	2444.3	13265.2
197.8	495.1	580.5	1946.1	4067.6	19193.6	25179.9	11854.7	64334.1

3.6.4 SCENARIO IV: COSTANZA ET AL. (2014)

In 1997, the global value of ecosystem services was estimated to average $33 trillion/yr in 1995 $US ($46 trillion/yr in 2007 $US). This paper provides an updated estimate based on updated unit ecosystem service values and land use change estimates between 1997 and 2011. It also addresses some of the critiques of the 1997 paper. Using the same methods as in the 1997 paper but with updated data, the estimate for the total global ecosystem services in 2011 is $125 trillion/yr (assuming updated unit values and changes to biome areas) and $145 trillion/yr (assuming only unit values changed), both in 2007 $US. From this Costanza and his team estimated the loss of eco-services from 1997 to 2011 due to land use change at $4.3–20.2 trillion/yr, depending on which unit values are used.

Ecosystem Services	Pithoragarh	Champawat	Nainital	U.S.Nagar	Pauri Garhwal
Gas Regulation	0.18	0.13	0.46	0.40	0.77
Climate Regulation	31.38	22.47	78.89	67.86	131.55
Disturbance Regulation	1.01	0.73	2.55	2.19	4.25
Water Regulation	0.12	0.09	0.31	0.27	0.52
Water Supply	0.42	0.30	1.04	0.90	1.74
Erosion Control and Sediment Retention	5.17	3.71	13.01	11.19	21.69
Soil Formation	0.22	0.15	0.54	0.47	0.90
Nutrient Cycling	0.05	0.03	0.12	0.10	0.19
Waste Treatment	1.84	1.32	4.63	3.98	7.72
Pollination	0.46	0.33	1.16	1.00	1.93
Biological Control	0.17	0.12	0.43	0.37	0.71
Habitat/Refugia	0.60	0.43	1.51	1.30	2.51
Food Production	3.07	2.20	7.72	6.64	12.87
Raw Materials	1.29	0.92	3.24	2.79	5.41
Genetic Resources	23.29	16.68	58.55	50.36	97.63
Recreation	13.31	9.53	33.46	28.78	55.80
Cultural	0.03	0.02	0.08	0.07	0.13
Total	**82.61**	**59.15**	**207.68**	**178.64**	**346.31**

All Values in Crores/yr

Rudraprayag	Chamoli	Tehri Garhwal	Uttarkashi	Dehradun	Haridwar	Total
0.47	1.18	1.38	4.63	9.69	45.71	65.01
80.24	200.84	235.46	789.40	1649.97	7785.60	11073.63
2.59	6.49	7.60	25.49	53.28	251.39	357.56
0.31	0.79	0.92	3.09	6.46	30.47	43.34
1.06	2.65	3.11	10.43	21.80	102.84	146.28
13.23	33.11	38.82	130.15	272.04	1283.63	1825.74
0.55	1.38	1.61	5.41	11.30	53.33	75.85
0.12	0.30	0.35	1.16	2.42	11.43	16.25
4.71	11.79	13.82	46.34	96.87	457.08	650.12
1.18	2.95	3.46	11.59	24.22	114.27	162.53
0.43	1.08	1.27	4.25	8.88	41.90	59.59
1.53	3.83	4.49	15.06	31.48	148.55	211.29
7.85	19.65	23.04	77.24	161.45	761.80	1083.53
3.30	8.25	9.68	32.44	67.81	319.96	455.08
59.55	149.06	174.75	585.87	1224.56	5778.26	8218.54
34.03	85.19	99.87	334.84	699.86	3302.40	4697.08
0.08	0.20	0.23	0.77	1.61	7.62	10.84
211.23	**528.72**	**619.86**	**2078.15**	**4343.67**	**20496.24**	**29152.25**

3.6.5 SUMMARY

Based on the above estimation, a range of spectrum of value for the ecosystem services from Uttarakhand forests has been summarized below. The values indicate that the values/ benefits accrued due to ecosystem services from the forest area of Uttarakhand are dynamic and may be estimated considering a range of factors.

Scenario	Ecosystem Services Value
Costanza et al. (1997)	**35314.2 Crores/Yr**
de Groot et al. (2012)	67193.94 Crores/Yr
Ida et al. (2013)	64334.1 Crores/Yr
Costanza et al. (2014)	29152.25 Crores/Yr

3.7 REPRESENTATION OF FOREST RESOURCES VALUATION IN DIFFERENT FRAMEWORKS

In order to cater to different needs for decision-making, various frameworks on valuation have been proposed earlier. In this section ecosystem services values/benefits in different frameworks of valuation have been listed.

3.7.1 TOTAL ECONOMIC VALUE (TEV)

In the given Table 42 benefits in terms of Conventional Approach of Total Economic Value from the forest of Uttarakhand has been discussed.

Table 42:Representation of Economic Valuation in Total Economic Value (TEV)

Type of Value	Value	Unit
Direct Use Value	13018.2	In INR Crores
Fuelwood, Fodder, Timber, Non-Timber Forest Products, Employment Generation		
Indirect Use Value	8707.9	In INR Crores
Carbon Sequestration, Water Purification, Water Provisioning, Recreation/Tourism, Sediment Regulation/Retention, Biological Control, Pollination, Gas Regulation, Waste Assimilation, Habitat for Species, Nutrient Cycling/Retention, Flood Regulation		
Option Value	73386.5	In INR Crores
Gene-Pool Protection		
Total Flow Value - Grand Total	95,112.60	In INR Crores

3.7.2 MILLENNIUM ECOSYSTEM ASSESSMENT (MA)

Based on the economic valuation methodology developed and data generated for the ongoing study the preliminary estimates of the value of the Ecosystem Service for the state of Uttarakhand in terms of the Millennium Ecosystem Assessment (MA) framework has been summarized in Table 43 below.

Table 43: Representation of Economic Valuation in Millennium Assessment Framework(MA)

Ecosystem Services	Uttarakhand Forest Ecosystem Service (Flow Values)	Economic Value (INR crores)	Physical Volume
Provisioning Services (A)	Fuelwood	3,395.20	67,90,469 tonnes/year
	Fodder	7,776.10	2,59,20,296.47 tonnes/year
	Timber	1,243.20	6,38,994 m^3/year
	Non-Timber Forest Products	303.7	Multiple units
	Employment Generation	300	1 crore man days
	Total	**13,018.20**	
Regulating Services (B)	Carbon Sequestration	1,482.20	61,760.16 tonnes/year
	Water Purification	655.7	12,28,22,047.4 m^3/year
	Water Provisioning	745.3	40,43,74,400 m^3/year
	Gene-Pool Protection	73,386.50	N.A. as based on BT
	Sediment Regulation/ Retention	561	2,36,20,000 tonnes of sediments/year
	Biological Control	251.7	Benefits Transfer: Rs 660/ha./Year
	Pollination	441.1	Benefits Transfer: Rs 1,800/ha./Year for tropical forests
	Gas Regulation	176.5	Benefits Transfer: Rs 720/ha./Year for tropical forests
	Waste Assimilation	1,764.60	Benefits Transfer: Rs 7,200/ha./Year for tropical forest
	Flood Regulation	1,306.50	Benefits Transfer: Rs 540 crore per annum. The value was adjusted for WPI
	Total	**80,771.10**	
Cultural Services (C)	Recreation/Tourism	9.9	3,22,936 individuals visited various tourist attractions
	Total	**9.9**	
Supporting Services (D)	Habitat for Species	892.5	Total forest area 38,139.18 km^2
	Nutrient Cycling/Retention	420.9	NPK present in 2,36,20,000 tonnes of sediments/ year
	Total	**1313.4**	
Total Flow Value - Grand Total (A+B+C+D)		**95,112.60**	

3.7.3 STOCK AND FLOW

Based on the economic valuation methodology developed and data generated for the ongoing study the preliminary estimates of value of the Ecosystem Service for the state of Uttarakhand in terms of stock and flow benefits has been summarized in Table 44.

Table 44: Representation of Economic Valuation in Stock and Flow

	Uttarakhand Forest Ecosystem Service (Stock Values)	Economic Value (INR crores)	Physical Volume
Stock Benefits	Timber Stock	7,21,101.70	370.65 million m^3
	Carbon Stock	2,55,725.50	290.33 million tonnes of carbon
	Land Value	4,36,849.0	Total forest area 38,139.18 km^2
	Total Stock Value	**1413676.20**	**N.A.**

	Uttarakhand Forest Ecosystem Service (Flow Values)	Economic Value (INR crores)	Physical Volume
Flow Benefits	Fuelwood	3,395.20	67,90,469 tonnes/year
	Fodder	7,776.10	2,59,20,296.47 tonnes/year
	Timber	1,243.20	6,38,994 m^3/year
	Non-Timber Forest Products	303.7	Multiple units
	Employment Generation	300	1 crore man days
	Carbon Sequestration	1,482.20	61,760.16 tonnes/year
	Water Purification	655.7	12,28,22,047.4 m^3/year
	Water Provisioning	745.3	40,43,74,400 m^3/year
	Gene-Pool Protection	73,386.50	N.A. as based on BT
	Sediment Regulation/ Retention	561	2,36,20,000 tonnes of sediments/year
	Biological Control	251.7	Benefits Transfer: Rs 660/ha./Year
	Pollination	441.1	Benefits Transfer: Rs 1,800/ha./Year for tropical forests
	Gas Regulation	176.5	Benefits Transfer: Rs 720/ha./Year for tropical forests
	Waste Assimilation	1,764.60	Benefits Transfer: Rs 7,200/ha./Year for tropical forest
	Flood Regulation	1,306.50	Benefits Transfer: Rs 540 crores per annum. The value was adjusted for WPI
	Recreation/Tourism	9.9	3,22,936 individuals visited various tourist attractions
	Habitat for Species	892.5	Total forest area 38,139.18 km^2
	Nutrient Cycling/Retention	420.9	NPK present in 2,36,20,000 tonnes of sediments/year
	Total	**95,112.60**	**NA**

3.7.4 TANGIBLE AND INTANGIBLE

Based on the economic valuation methodology developed and data generated for the ongoing study the preliminary estimates of value of Ecosystem Service for the state of Uttarakhand in terms of tangibles and intangible benefits has been summarized in Table 45.

Table 45: Representation of Economic Valuation in Tangible and Intangible

Ecosystem Services	Uttarakhand Forest Ecosystem Service (Flow Values)	Economic Value (INR crores)	Physical Volume
Tangible	Fuelwood	3,395.20	67,90,469 tonnes/year
	Fodder	7,776.10	2,59,20,296.47 tonnes/year
	Timber	1,243.20	6,38,994 m^3/year
	Non-Timber Forest Products	303.7	Multiple units
	Employment Generation	300	1 crore man days
	Total	**13,018.20**	
Intangible	Carbon Sequestration	1,482.20	61,760.16 tonnes/year
	Water Purification	655.7	12,28,22,047.4 m^3/year
	Water Provisioning	745.3	40,43,74,400 m^3/year
	Gene-Pool Protection	73,386.50	N.A. as based on BT
	Sediment Regulation/ Retention	561	2,36,20,000 tonnes of sediments/year
	Biological Control	251.7	Benefits Transfer: Rs 660/ha./Year
	Pollination	441.1	Benefits Transfer: Rs 1,800/ha./Year for tropical forests
	Gas Regulation	176.5	Benefits Transfer: Rs 720/ha./Year for tropical forests
	Waste Assimilation	1,764.60	Benefits Transfer: Rs 7,200/ha./Year for tropical forests
	Flood Regulation	1,306.50	Benefits Transfer: Rs 540 crores per annum. The value was adjusted for WPI
	Recreation/Tourism	9.9	3,22,936 individuals visited various tourist attractions
	Habitat for Species	892.5	Total forest area 38,139.18 km^2
	Nutrient Cycling/Retention	420.9	NPK present in 2,36,20,000 tonnes of sediments/year
	Sub Total	**82,094.40**	
Total Flow Value – Grand Total (A+B+C+D)		95,112.60	

3.7.5 EPA BENEFIT SCENARIO

Based on the economic valuation methodology developed and data generated for the ongoing study the preliminary estimates of the value of Ecosystem Service for the state of Uttarakhand in terms of EPA benefits scenario as discussed in Section 2.6.5 has been summarized in Table 46.

Table 46: Representation of Economic Valuation in EPA Benefit Scenario

Summary of Ecosystem Services Based on EPA Effect Categories	
Type of Value	**Value**
EPA Effect Category 1	**INR Crores**
Timber (Stock), Carbon Storage, Fuelwood, Fodder, Timber, Non-Timber Forest Products, Employment Generation Carbon Sequestration, Water Purification, Water Provisioning, Sediment Regulation/Retention, Biological Control, Pollination, Gas Regulation, Waste Assimilation, Habitat for Species, Nutrient Cycling/Retention, Flood Regulation	**95102.7**
EPA Effect Category 2	**INR Crores**
Recreation	**9.9**

3.7.6 INVESTMENT MULTIPLIER

As discussed earlier in Section 2.6.5 the benefits of investing in natural capital, the aggregate flow benefits from forests if compared with its management costs will give us 'Investment multiplier.' The aggregate flow benefits derived from the ecosystem services that are possible to value in monetary terms amount to 95112.6 crores annually in terms of flow value and 1413676.2 crores annually in terms of stock values. The management costs derived from the annual expenditure by the Uttarakhand state forest department was 194 crores (2015-2016). The investment multiplier for Uttarakhand forests was 490 for flow values and 7286 for stock values.

3.7.7 HEALTH BENEFITS FRAMEWORK

Important services impacting human health identified and estimated with the state are Carbon Sequestration, Water Purification, Sediment Retention/Soil Conservation, Nutrient Retention, Pollination, Gas Regulation, Waste Assimilation and Flood Regulation. The total estimated worth of these services is around 6808.5 INR crores.

3.7.8 ECOSYSTEM SERVICES BASED ON HUMAN VALUES AND ECOSYSTEM ASSETS FRAMEWORK

As discussed in Section 2.6.8 the economic valuation methodology developed and data generated for the ongoing study of the preliminary estimates of value of Ecosystem Services for the state of Uttarakhand as per Human Values and Ecosystem Assets Framework has been summarized in Table 47.

Table 47: Estimated Values as Per Human Values and Ecosystem Assets Framework

Summary of Ecosystem Services Based on Human Values and Ecosystem Assets Framework		
Type of Value	Value	Unit
Adequate Resources	449,567.23	INR Crores
Timber (Flow), Fuel Wood, NTFP, Water Provisioning, Land		
Protection from Disease/Predators/Parasites	251.7	INR Crores
Biological Control		
Benign Physical and Chemical Environment	7,701.0	INR Crores
Carbon Sequestration, Water Purification, Sediment Retention/Soil Conservation, Nutrient Retention, Pollination, Gas Regulation, Waste Assimilation, Habitat for Species, Flood Regulation		
Socio-Cultural Fulfilment	309.9	INR Crores
Employment Generation, Recreation		
Ecosystem Assets	1050213.70	INR Crores
Standing Timber, Carbon Storage, Genepool Protection		

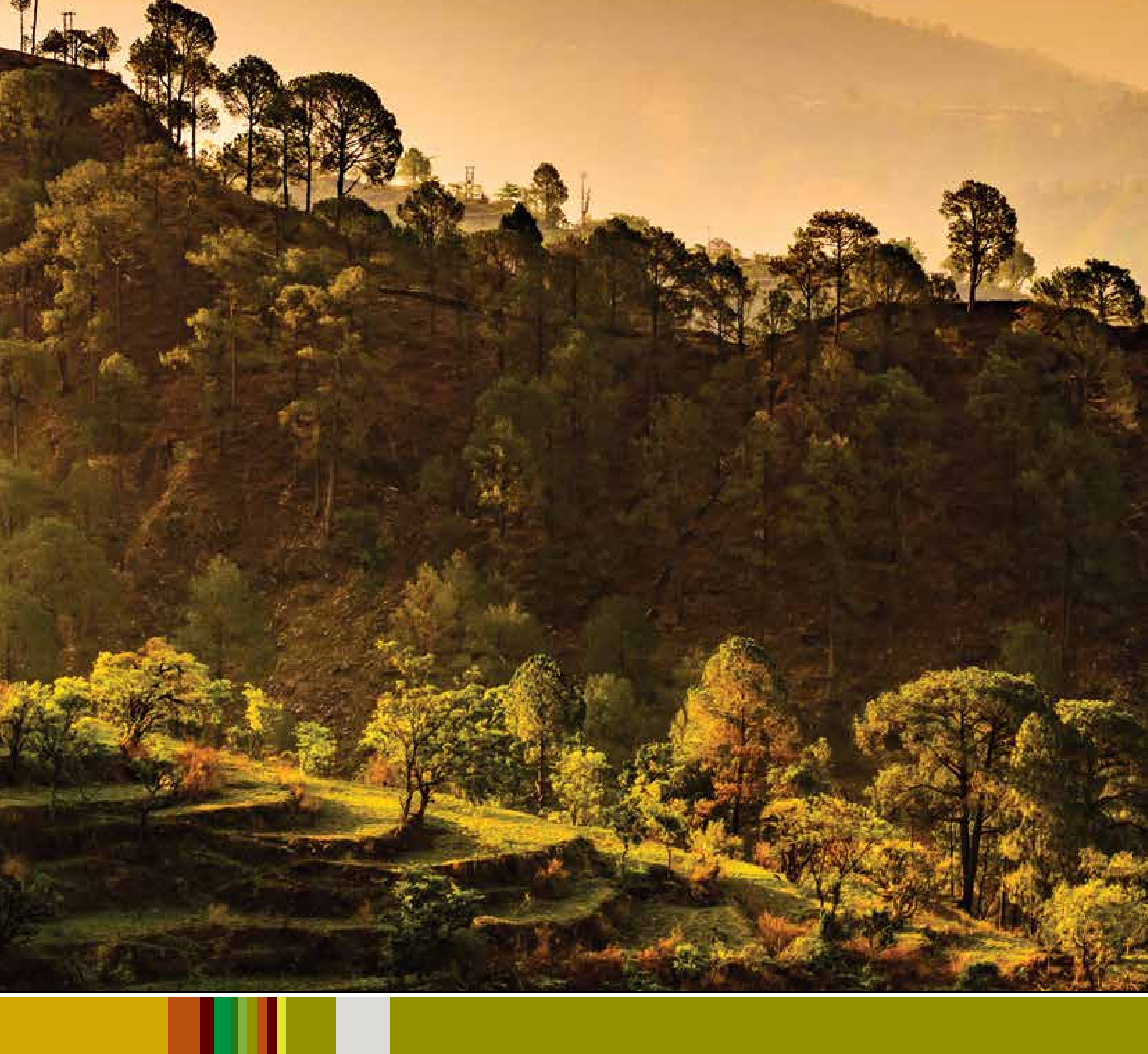
3.8 CONCLUSION

Uttarakhand is one of the fastest growing states in India and is endowed with a number of life-sustaining natural resources such as forests, glaciers, rivers, wildlife, minerals, livestock and agro-climatic conditions.

The study provides economic estimates for as many as 21 (18 flow and 3 stock) ecosystem services from the forest area of Uttarakhand. The study findings indicate that the monetary value of flow benefits emanating from Uttarakhand forests range from Rs. 95,112 (lower bound) to 1,93,904 crores annually. This is equivalent to an annual flow value of Rs. 3,88,085 per hectare (lower bound) of forests in Uttarakhand.

In addition, Uttarakhand forests protect and conserve stock comprising the value of land, timber stock and carbon storage is valued in the range of Rs. 14,13,676.20 (lower bound) to 17,44,413.36 crores. The study findings also indicate that a substantial proportion of flow benefits are intangible, and hence often unaccounted for in the market transaction. An attempt has been made to know the premium value of protected area in Uttarakhand. Uttarakhand has 6 National Parks and 7 Wildlife Sanctuaries and 4 Conservation Reserves. The study findings indicate that the range of ecosystem services value (premium) ranges from 324753.98 crores to 662072.40 crores.

The study provides economic estimates for as many as 21 (18 flow and 3 stock) ecosystem services from the forest area of Uttarakhand. The study findings indicate that the monetary value of flow benefits emanating from Uttarakhand forests range from Rs. 95,112 (lower bound) to 1,93,904 crores annually. This is equivalent to an annual flow value of Rs. 3,88,085 per hectare (lower bound) of forests in Uttarakhand.



SYSTEM OF ENVIRONMENTAL-ECONOMIC ACCOUNTING (SEEA)

CHAPTER

04

4.1 SEEA OVERVIEW

Natural capital is a critical asset, especially for developing countries where it makes up a significant share (36 per cent) of total wealth (World Bank). Realizing this fact - Agenda 21, adopted at the 1992 United Nations Conference on Environment and Development held in Rio de Janeiro, Brazil, called for the establishment of a "programme to develop national systems of integrated environmental and economic accounting in all countries". In response to the policy demands from the World Commission on Environment and Development—or Brundtland Commission— (1983-1987) and, subsequently, Agenda 21 (1992), the 1993 Handbook of National Accounting: Integrated Environmental and Economic Accounting (SEEA 1993) was developed.

The SEEA provides the internationally agreed framework for providing indicators that directly respond to the demand of integrated policy-making, reversing the historical 'information silo' approach to statistics. Policymakers and managers benefit from consistent, comparable and comprehensive statistics and indicators when the integrated accounting approach of the SEEA is used. Importantly, the trade-offs of their decisions that affect natural resources and associated services are made explicit.

The SEEA accounts bring into direct focus the relationship between the environment and well-being not revealed through traditional measures of economic activity, such as GDP and national income. The SEEA does not propose or recommend any single indicator or basket of indicators for use in developing and accessing policy. Indeed, some of its major strengths are in its approach to integrating statistics to allow for multiple purposes and multiple scales of analysis. However, there are several key aggregates and indicators that are directly derived from the accounting tables and are of interest to policy analysis and goal-setting. The SEEA can be implemented in countries which are at various stages of development. The implementation of the framework can be incremental starting from aggregated tables and accounts that can be disaggregated based on policy needs and data development.

4.2 UNITED NATIONS STATISTICAL DIVISION (UNSD)

The United Nations Statistics Division compiles and disseminates global statistical information, develops standards and norms for statistical activities, and supports countries' efforts to strengthen their national statistical systems. UNSD also facilitates the coordination of international statistical activities and supports the functioning of the United Nations Statistical Commission as the apex entity of the global statistical system.

The Division regularly publishes data updates, including the Statistical Yearbook and World Statistics Pocketbook, and books and reports on statistics and statistical methods.

4.2.1 ROLE UNSD IN ENVIRONMENTAL-ECONOMIC ACCOUNTING

The United Nations Statistics Division (UNSD) contributes to the development of standards, compilers manuals and implementation guides on environmental economic accounts. Through its work as secretariat to the United Nations Committee of Experts on Environmental-Economic Accounting (UNCEEA), the Division has facilitated the revision of the Handbook of National Accounting: Integrated Environmental and Economic Accounting 2003 (SEEA 2003) and the elevation of the SEEA Central Framework to an international statistical standard. The Division plays a leading role in advancing the methodology and implementation of environmental-economic accounting including ecosystem accounting.

The Division also provides capacity building and technical assistance for the compilation of water accounts by conducting regional and interregional workshops on the implementation of SEEA-Water. With the adoption of the SEEA Central Framework as the international statistical standard for environmental-economic accounting, the Division is working on developing a capacity building programme for the implementation of environmental economic accounts and supporting statistics.

The Division maintains a website which serves as the global hub for environmental-economic accounts providing information on, among others, the process of revising the SEEA and of developing its subsystems, meetings and other events. It also maintains a digital library containing methodological and compilation publications about environmental-economic accounting from national statistical offices, international agencies, academia and NGOs.

4.3 EVOLUTION OF SEEA

The concept of measuring natural capital in a systematic framework emerged way back in 1980. In 1992, during the first United Nations Conference on Environment and Development held in Rio de Janeiro, the United Nations Statistical Division was given the task for drafting the first international document on environmental-economic accounting. Though this handbook was issued as an "interim" version of work in progress, since the discussion of relevant concepts and methods had not been concluded but still the resultant document also known popularly as the System of Environmental-Economic Accounting or SEEA was the first ever framework with Integrated Environmental and Economic Accounting.

Two groups were formed: The London Group (1993) and Nairobi Group (1995) on Environmental Accounting consisting of experts from national and international agencies and non-governmental organizations for discussion on concepts and methods of environmental-economic accounting, accompanied with country experiences, which led to an increasing convergence of concepts and methods for various modules of the SEEA.

In 2000, Handbook of National Accounting: Integrated Environmental and Economic Accounting: An Operational Manual (United Nations, 2000), was published by the United Nations Statistical Division and the United Nations Environment Programme (UNEP).

In 2003 after a series of expert meetings and a wide consultation process the updated Handbook of National Accounting: Integrated Environmental and Economic Accounting 2003 (SEEA-2003) was produced by the United Nations, the European Commission, the International Monetary Fund, the Organization for Economic Cooperation and Development and the World Bank. This report was considered as one of the landmarks for harmonization of concepts, definitions and methods in environmental and economic accounting.

The SEEA-2003 presented both a number of different methodological options for carrying out quantification of environmental accounts that address area specific key policy question and a range of country examples showing varying country practices. It also provided a well-accepted and robust framework for the compilation of environmental and economic accounts—one that has been used by many countries around the world.

Since then the deliberations and consultations are continuing under the newly formed United Nations Committee of Experts in Environmental-Economic Accounting (UNCEEA).

4.4 SEEA CENTRAL FRAMEWORK

The System of Environmental-Economic Accounting 2012—Central Framework (SEEA Central Framework) is a multipurpose conceptual framework which helps to recognize the true value of natural capital and describes the interactions between the economy and the environment, and the stocks and changes in stocks of environmental assets.

The SEEA provides information related to a broad spectrum of environmental and economic issues including, in particular, the assessment of trends in the use and availability of natural resources, the extent of emissions and discharges to the environment resulting from economic activity, and the amount of economic activity undertaken for environmental purposes (SEEA Central Framework, 2012).

The main purpose of the environmental-economic accounting is to supplement the conventional national accounts with resources/information which inform policy makers of environmental and natural resource availability, use, depletion and degradation.

Over the past 25 years there has been important broadening of focus of the SEEA from a primary focus on extensions and adjustments to GDP and national wealth, to incorporating accounting structures for physical information on environmental stocks and flows such as water, energy, emissions and waste, and most recently, to the measurement of ecosystems. These three areas of the SEEA are covered through a series of publications of the SEEA Central Framework and the SEEA Experimental Ecosystem Accounting (SEEA EEA).

As of now the SEEA 2012 comprises three volumes:

- The SEEA Central Framework;
- SEEA EEA; and
- SEEA 2012 Applications and Extensions.

In addition, various thematic SEEA publications, technical recommendations on methodologies have been developed including a SEEA for Agriculture, Forestry and Fisheries (FAO and UNSD, 2017).

All these various publications within the SEEA “family” are connected through their common basis in the national accounting principles and structures of the international standard for economic accounting – the System of National Accounts (referred to here as the SNA). It is the SNA that defines the measure of GDP and many other common economic aggregates that form the basis for much macro-economic assessment and policy. Indeed, the logic driving the development of the SEEA is that

- The SNA's accounting for the environment is insufficient and
- Highlighting the significance of the environment may be best achieved by mainstreaming environmental information via the standard framework for economic measurement. Thus the SEEA is envisioned as a complementary system to the SNA rather than a competing or alternative approach.

This approach of integrating environmental accounts with the SNA leads to some important choices in measurement, for example standardizing traditionally approached assessment of the links between the economy and the environment done earlier by environmental economists.

4.5 SEEA -EXPERIMENTAL ECOSYSTEM ACCOUNTING (EEA)

The System of Environmental-Economic Accounting: Experimental Ecosystem Accounting (SEEA-EEA) is a measurement framework integrating biophysical data, mapping ecosystem services, tracking changes in ecosystem assets and other human activity. SEEA Experimental Ecosystem Accounting complements the SEEA Central Framework's perspective of the economy and its economic units, residual flows and environmental assets with perspective of ecosystems and links ecosystems to economic and other human activities.

The SEEA EEA ecosystem accounting framework has five main components.

The accounting for the various biotic and abiotic components within an ecosystem asset (1) that is represented by a spatial area; each ecosystem asset has a range of relevant ecosystem characteristics and processes (2) that together describe the functioning of the ecosystem; the stock and changes in stock of ecosystem assets is measured by assessing the ecosystem asset's extent and condition using indicators of the relevant ecosystem asset's area and characteristics ; Each ecosystem asset generates a set or basket of final ecosystem services (3) which are defined as contributions to the production of benefits. Final ecosystem services encompass a wide range of services provided to economic units (businesses, governments and households) and may be grouped into provisioning services (i.e. those relating to the supply of food, fibre, fuel and water); regulating services (i.e. those relating to actions of filtration, purification, regulation and maintenance of air, water, soil, habitat and climate) and cultural services (i.e. those relating to the activities of individuals in, or associated with, nature).

Benefits (4) may be SNA benefits- goods or services (products) produced by economic units (e.g. food, water, clothing, shelter, recreation) currently included in the economic production boundary of the SNA; or non-SNA benefits – benefits that accrue to individuals, or society generally, that are not produced by economic units (e.g. clean air). Further, in each sequence of use of ecosystem services and production of benefits there is an associated user (5) being an economic unit – business, government or household.

There are five core ecosystem accounts which reflect a system of accounts that present a coherent and comprehensive view of ecosystems (Table 48).

Highlighting the significance of the environment may be best achieved by mainstreaming environmental information via the standard framework for economic measurement. Thus the SEEA is envisioned as a complementary system to the SNA rather than a competing or alternative approach.

Table 48: Core Ecosystem Accounts

S.No.	Account Details
1	Ecosystem extent account – physical terms
2	Ecosystem condition account – physical terms
3	Ecosystem services supply and use account– physical terms
4	Ecosystem services supply and use account – monetary terms
5	Ecosystem monetary asset account – monetary terms

4.6 CASE STUDY - NATURAL RESOURCES ACCOUNTING IN CHINA

In recent years, the issue of natural resources and environment has aroused the world's common concern. China being the largest developing country in the world, many experts engaged themselves in the settlement of environmental issues and conducting accounting on resources and environment and bringing it into the national economic accounting system of the country. The National Bureau of Statistics (NBS), Ministry of Environmental Protection, Ministry of Water Resources, and State Forestry Administration (SFA) have been working since 2004 in this domain.

According to priority areas of natural resources balance sheet compiling, land, forest and water were chosen as prior fields of NRA.

As a result, the study was able to give these three main outputs:

- Theoretical framework of Forest Resources Accounting (FRA)
- Forest land and timber accounting
- Forest ecosystem services valuation

The resultant accounts were presented in Bangkok in 2017. The theoretical framework is as shown below.

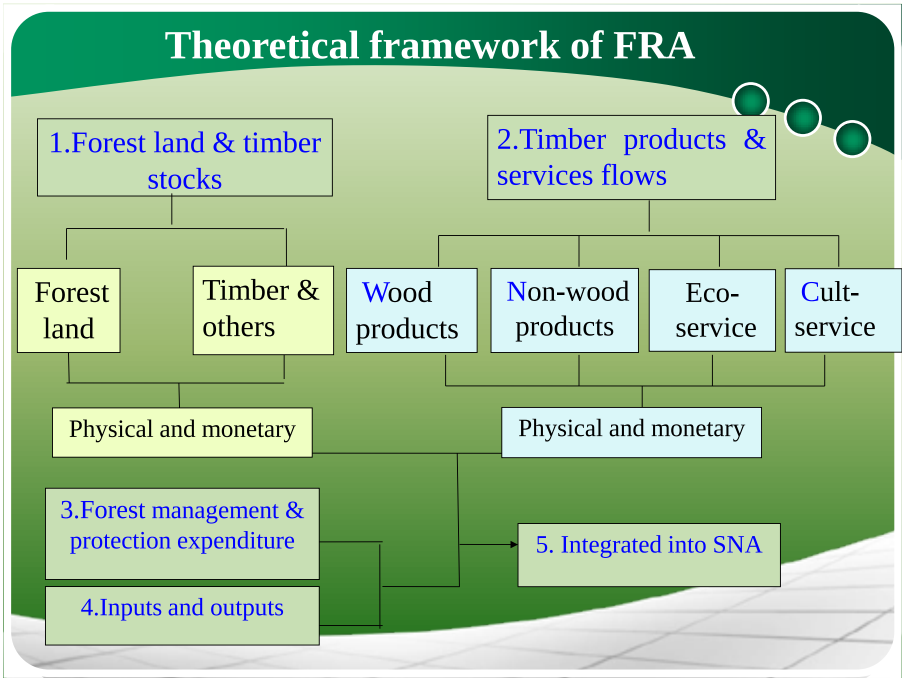


Figure 28: Theoretical Framework of FRA for China

Accounting for forest land & timber

Based on the 8th National Forest Resources Inventory, the forest land stocking was following.

Forest land stocking table (2013)

unit: million ha

Item	Cultivated asset	Non-cultivated asset
Natural forest land		124.71
Planted forest land	70.47	
Other forest land	17.86	97.41
Total	88.33	222.12

Figure 29: Forest Land Stock

Accounting for forest land & timber

Based on the 8th National Forest Resources Inventory ,the timber resource stocking was following:

Timber resource stocking table (2013)

unit: million m^3

Item	Cultivated asset	Non-cultivated asset
Natural forest		12385.34
Planted forest	2499.43	
Other forest	400.68	788.59
Total	2900.11	13173.93

Figure 30: Timber Resource Stock Table

Forest land account

(currency units: billion yuan)

Item	Primary forest	Naturally regenerated forest	Planted forest	Other wooded land
Opening stock（2008）	244.85	2274.58	1674.58	1323.95
Additions to stock		237.89	481.57	377.22
Economic factors		14.23	287.69	297.12
Natural factors		223.65	193.88	80.10
Reductions in stock		179.98	247.66	502.69
Economic factors		109.25	172.65	217.96
Natural factors		70.74	75.01	284.73
Revaluation		894.60	592.99	471.55
Net additions to stock		952.50	826.90	346.08
Closing Stock（2013）	244.85	3227.08	2501.48	1670.03

Figure 31: Forest Land Account

Forest timber account

(currency units: billion yuan)

Item	Natural forest	Planted forest	Other timber wood
Opening stock (2008)	5216.87	3812.86	443.62
Additions to stock	1023.33	950.00	222.34
Economic factors	53.81	575.54	174.85
Natural factors	986.39	419.34	50.71
Reductions in stock	632.95	568.69	179.50
Economic factors	325.55	340.74	76.04
Natural factors	324.88	178.69	107.04
Revaluations	1852.41	1353.87	157.52
Net additions to stock	2242.79	1735.18	200.36
Closing Stock (2013)	7459.65	5548.04	643.98

Figure 32: Forest Timber Account

Value of Forest Ecosystem Service

RMB 12680 billion in 2013

Category	Monetary value (RMB billion)	Percentage (%)
Water conservation	3182.28	25.10
Soil conservation	2003.68	15.81
Carbon capture and Oxygen release	1073.59	8.47
Atmosphere environmental purification	1177.36	7.6
Biodiversity	4334.70	34.20
Farmland protection and wind erosion prevention	54.88	0.43
Forest recreation	849.88	6.7

Figure 33: Value of Forest Ecosystem Services

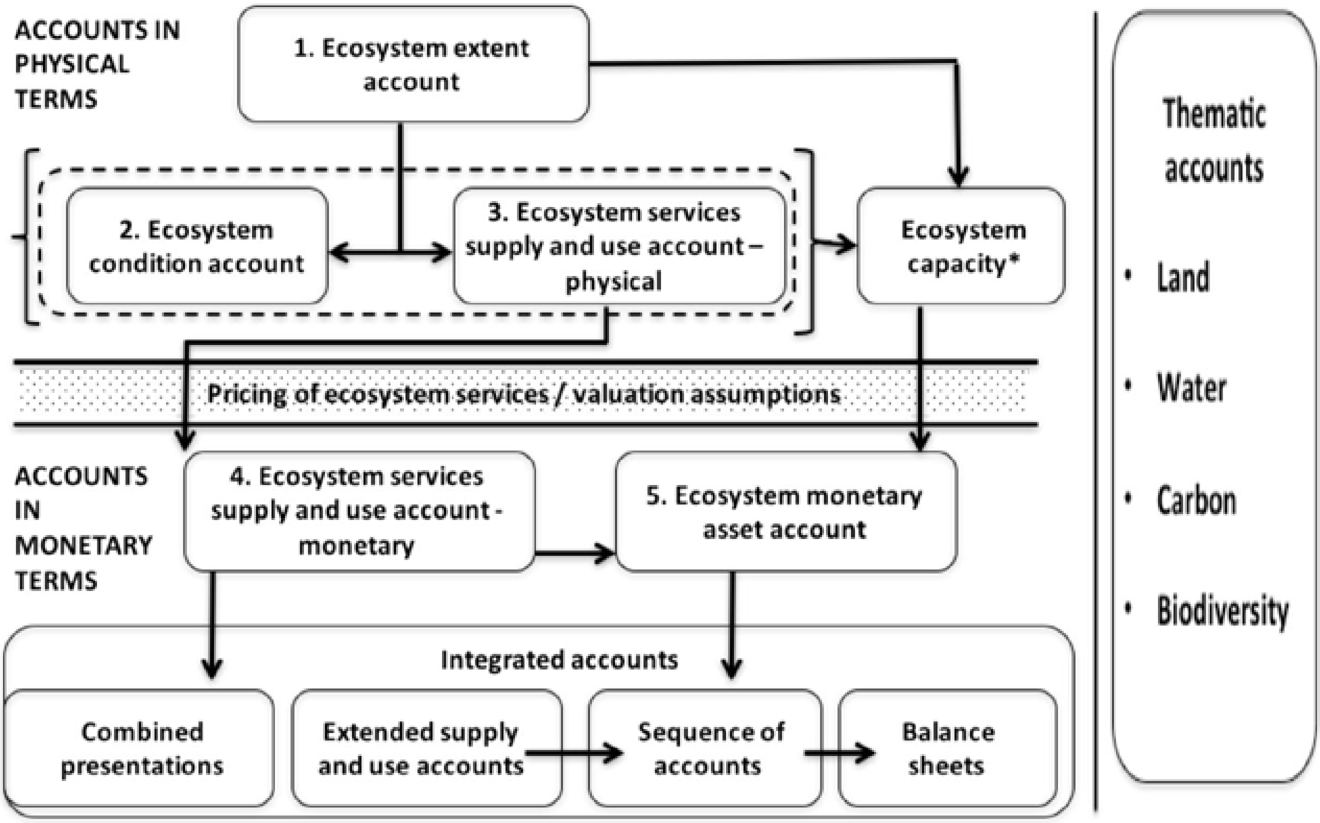


Figure 34: Connections Between Ecosystem and Related Accounts and Concepts (SEEA-EEA, 2017)

The connections between the various ecosystem accounts and to these related accounts and concepts are shown in Figure 34.

4.7 PROCESS FLOW FOR SEEA EEA

For initiating any ecosystem accounting, the starting point is the assessment of ecosystems, for which their key characteristics are considered. Ecosystem characteristics relate to the ongoing operation of the ecosystem and its location. Key characteristics of the operation of an ecosystem are:

- Its structure (e.g. the food web within the ecosystem).
- Its composition, including living (e.g. flora, fauna and micro-organisms) and non-living (e.g. mineral soil, air, sunshine and water) components.
- Its processes (e.g. photosynthesis, decomposition), and
- Its functions (e.g. recycling of nutrients in an ecosystem, primary productivity).

Key characteristics of ecosystem location are:

- Its extent.
- Its configuration (i.e. the way in which the various components are arranged and organized within the ecosystem). The landscape forms (e.g. mountain regions, coastal areas) within which the ecosystem is located; and
- The climate and associated seasonal patterns.

As per (SEEA-EEA, UN, 2017) for implementation the ecosystem accounting the first set of steps encompasses accounting is in physical terms and the second set of steps is in monetary terms. Though the framework provides sequencing, but it also mentions that multiple iterations may be required and that the precise starting point may differ. The steps involved are illustrated through Figure 35.

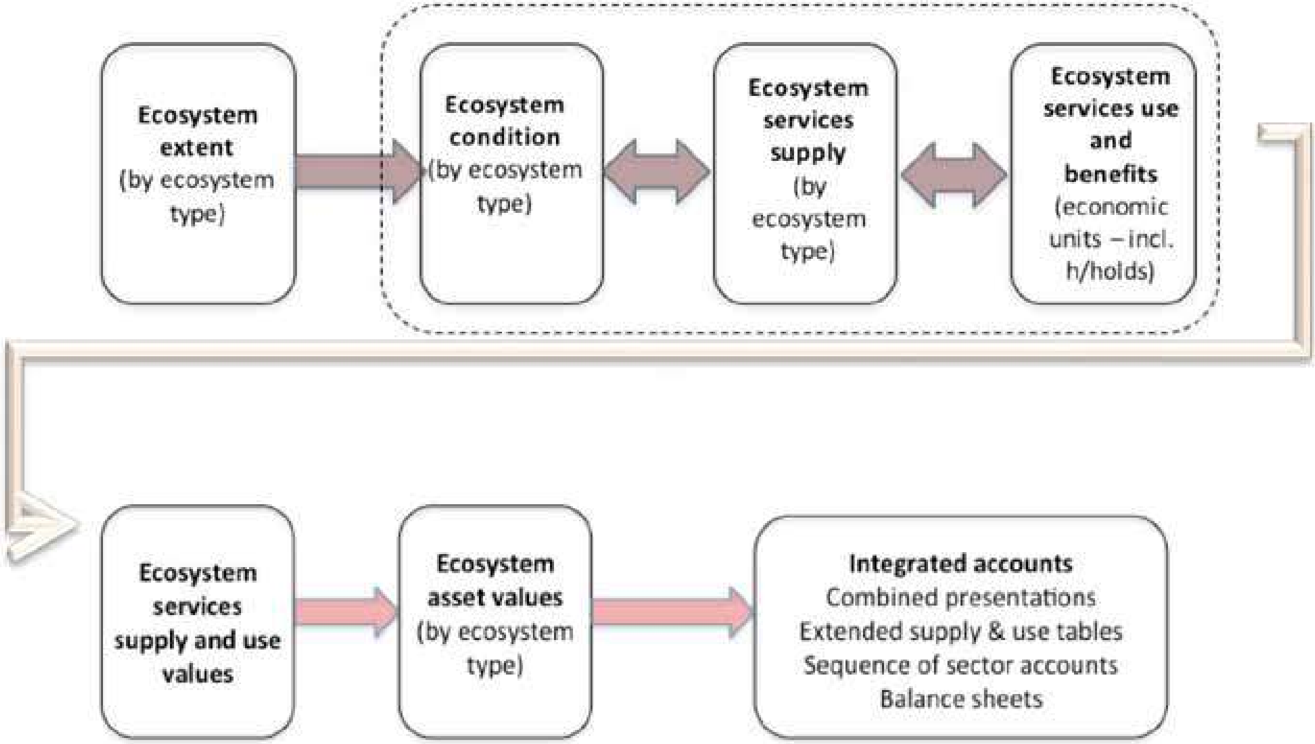


Figure 35: Broad Steps in Ecosystem Accounting

- Ecosystem Extent and Ecosystem Condition Accounts: The core biophysical accounts for measuring the stocks of ecosystem assets
- Ecosystem Services: Supply and Use (Physical and Monetary) Accounts: Accounts which record the actual flows of services and goods from ecosystems to the economy in both physical and monetary terms
- Thematic Biodiversity, Water, Carbon and Land Accounts: The proposed thematic bio-physical accounts
- SEEA-CF Physical Asset Accounts: Accounts which align with relevant provisioning services (e.g., timber, water) to provide particular measures of 'Stock'.
- SEEA-CF Monetary Accounts: Estimation of monetary values for ecosystem services and ecosystem assets for integrated presentation of accounts aligned with the requirements of SNA.

4.8 ECOSYSTEM EXTENT ACCOUNT

A common starting point for all ecosystem accounting work will be organizing information on the extent or area of different ecosystem types within a country. Particularly at national level, accounting for ecosystem extent may commence with accounting for changes in land cover following the descriptions in the SEEA Central Framework. This is important for four reasons.

- The task of defining the ecosystems of interest for accounting purposes is by no means straightforward and a balance between scale of analysis, available data and policy questions will need to be found. It is appropriate to start this discussion by examining the most conceptually straightforward issue of the definition of ecosystem assets and the delineation of their extent.
- The organization of information required to establish an ecosystem extent account will provide the basis for subsequent measurement of ecosystem condition and many ecosystem services since indicators will generally vary by ecosystem type.
- The structure of the ecosystem extent account, as shown below, gives a clear indication of the nature of accounting for assets in a SEEA context. The requirement to produce a time series of data to allow meaningful comparison between the opening and closing of an accounting period is clear.
- While the ecosystem extent account provides a clear base for the development of the other ecosystem accounts, it also provides important information in its own right. For example, when compiled at appropriate levels of detail, ecosystem extent accounts can provide an assessment of ecosystem diversity at a national level.

Extent accounts can also support the derivation of indicators of deforestation, desertification, urbanization and other forms of land use driven change.

4.9 ECOSYSTEM CONDITION ACCOUNT

The measurement of ecosystem condition is a central aspect of ecosystem accounting since it provides information to inform on the capacity of ecosystems to provide ecosystem services into the future. In general terms, ecosystem condition is measured by collating indicators for various ecosystem characteristics for different ecosystem types. Within this broad framing there are different approaches to the measurement of condition ranging from more aggregate to more detailed.

For some characteristics in certain ecosystem types, condition metrics are well established although further testing is required to assess their use for ecosystem accounting. In other cases, the selection and measurement of relevant characteristics is less established and measurement is more difficult. Generally, the development of indicators relating to vegetation, water, soil, biomass, habitat and biodiversity for different ecosystem types, as well as indicators of relevant pressures and drivers of ecosystem change, will be appropriate.

A key challenge for ecosystem accounting is developing a full coverage of measures in a manner that supports aggregation and comparison. Reference condition approaches are one technique for developing measures that can be monitored over time and can be compared across ecosystem types and across countries. Determining reference conditions for multiple ecosystem types and more than one country is not straightforward and further testing of relevant approaches for ecosystem accounting is required.

In advancing work on ecosystem condition measurement, it is essential that experts with knowledge of local ecosystems are engaged to ensure the relevance of selected metrics and to take advantage of existing monitoring and research. Figure 36 gives an overview of ecosystem condition account.

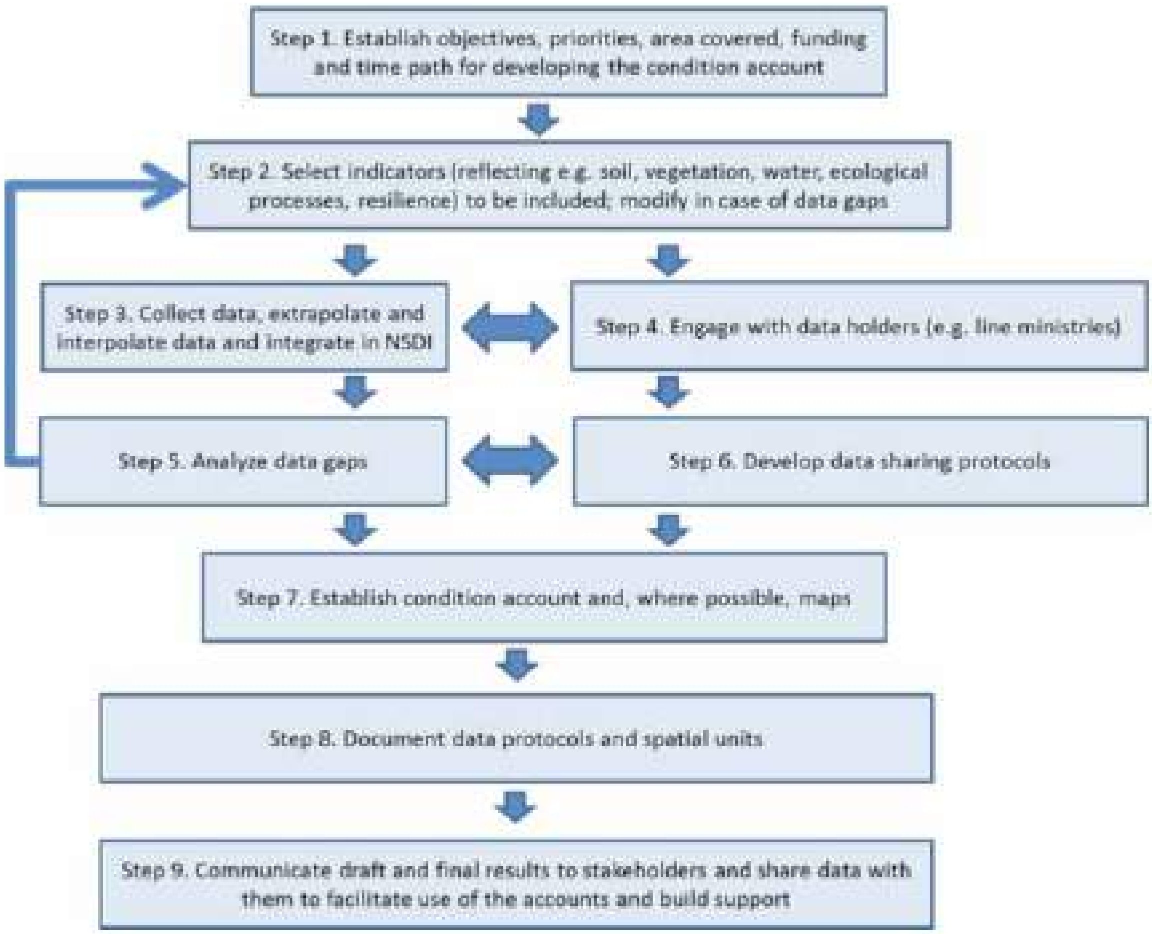


Figure 36: Ecosystem Condition Account

4.10 ECOSYSTEM SERVICES SUPPLY AND USE ACCOUNTS - PHYSICAL

The supply of ecosystem services by ecosystem assets and the use of these services by economic units, including households, is one of the central features of ecosystem accounting. These are the flows that reflect the link between ecosystem assets and economic and human activity. The supply and use account records the actual flows of ecosystem services supplied by ecosystem assets and used by economic units during an accounting period and may be compiled in both physical and monetary terms.

In ecosystem accounting, ecosystem services are defined from the perspective of contributions that ecosystems make to benefits used in economic and other human activity. It is therefore important to distinguish clearly between ecosystem services and benefits.

Generally, most focus for national level accounting is on final ecosystem services. All final ecosystem services have a direct link between ecosystems and economic units.

Intermediate ecosystem services are important for understanding relationships and dependencies between ecosystems and can be incorporated into the ecosystem accounting model but they are not a priority area for measurement. Further discussion and research on accounting for intermediate ecosystem services is required.

The use of a classification of ecosystem services, such as CICES, FEGS-CS or NESCS is an important aspect in compiling estimates of ecosystem services flows.

There are two principal ways to populate the Ecosystem Services Supply and Use Account with data. The first approach starts with data that is already in the national accounts and identifies the ecosystem

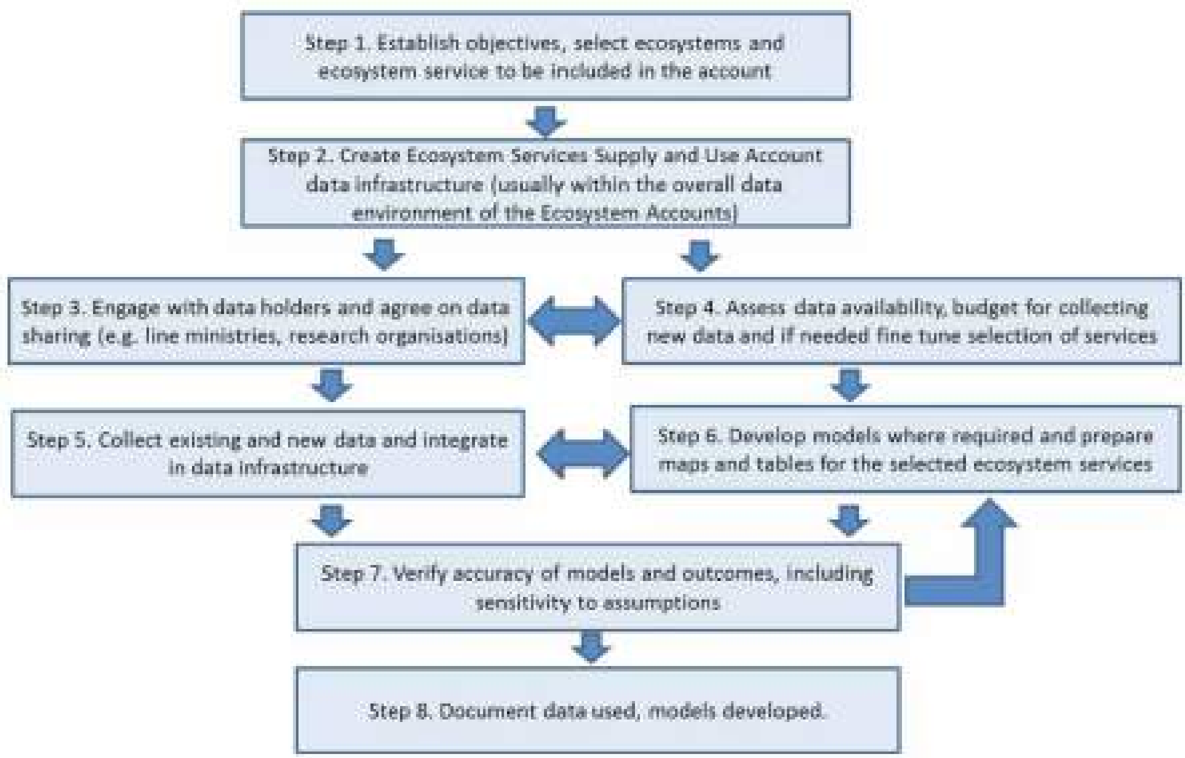


Figure 37: Ecosystem Services Supply and Use Accounts

contribution to the benefits involved. Preparation of maps subsequently requires spatial allocation of data on ecosystem services. The second approach is required for ecosystem services that are not connected to a specific benefit measured in the accounts. This is often the case for regulating services. In this case spatial models are required to quantify the ecosystem services.

In order to construct the Ecosystem Services Supply and Use Account it is also important to consider the use of ecosystem services by different beneficiaries including households, business and governments.

In some cases, biodiversity may be considered a cultural ecosystem service but generally, biodiversity is best considered as a characteristic of ecosystem assets that can be degraded or improved over time, and which underpins the supply of ecosystem services. It is recorded, in particular, in the biodiversity accounts and as part of ecosystem condition accounts.

4.11 ECOSYSTEM SERVICES SUPPLY AND USE ACCOUNTS - MONETARY

The estimation of monetary values for ecosystem services and ecosystem assets can be undertaken for various purposes. It is essential that the purpose of valuation is well understood.

In ecosystem accounting, the underlying role of valuation in monetary terms is the integration of information on ecosystem condition and services with information in the standard national accounts. For this purpose, the valuation concepts and approaches used for ecosystem accounting needs to be consistent with the valuation concept used in the national accounts.

The purpose of integration leads to the application of the valuation concept of exchange values – i.e. those values that reflect the price at which ecosystem services and ecosystem assets would be exchanged between buyers and sellers if a market existed.

The use of the exchange value concept implies that some valuation techniques commonly used in the valuation of ecosystem services are not appropriate. However, quite a number of techniques are relevant or may be adapted for use in accounting.

The focus on exchange values is not intended to suggest that valuation for other purposes is not appropriate. For example, valuation that takes into account changes in welfare is central to much economic policy and analysis. However, welfare values should not be used directly in accounting.

In ecosystem accounting, the valuation of ecosystem services is the starting point for the valuation of ecosystem assets. A clear distinction should be made between these two objects of valuation. Further testing on valuation methods is required, especially in the context of ecosystem accounting. Further research is needed to understand the connection between exchange and welfare-based valuations and the extent to which different valuation techniques may be adapted to estimate exchange values.

4.12 THEMATIC ACCOUNTS AND CONCEPTS

The set of ecosystem accounts just summarized above reflects a complete accounting coverage for all ecosystem assets and ecosystem services within a given ecosystem accounting area in both physical and monetary terms. However, these accounts and the information they contain cannot be considered in isolation. Two connections to other accounts must be described.

The first connection concerns the integration of ecosystem accounting information with the standard economic accounts, i.e. the compilation of integrated ecosystem-economic accounts. The compilation of such accounts is relevant for the derivation of degradation adjusted measurement of national income, the measurement of national wealth in extended balance sheets, and to support the incorporation of ecosystem services into extended input-output and other economic models and the measurement of other macro-economic indicators such as environmentally-adjusted measurement of multi-factor productivity.

Second, there are connections to the various accounts of the SEEA Central Framework and similarly structured accounts for carbon and species-level biodiversity. The accounts of the SEEA Central Framework, as for carbon and species-level biodiversity, focus on individual resources or flows such as water, energy, timber, fish, soil and land. Since these individual components are present within ecosystems, from an accounting perspective, there must be a consistency in the picture presented between these individual or thematic accounts on the one hand, and the ecosystem accounts on the other.

Four key thematic accounts are for land, water, carbon and species-level biodiversity are needed for completion of the system. The information from these accounts is likely for direct relevance in the compilation of ecosystem accounts, particularly from the perspective of supporting consistency in measurement across different ecosystem types, for example by providing a broad framework for the integration of information on stocks and flows of water resources.

In addition, to these two accounting connections, an important concept not portrayed directly in the set of ecosystem accounts listed above is ecosystem capacity. Ecosystem capacity reflects the ability of an ecosystem to sustainably generate an ecosystem service under certain assumptions. It underpins the measurement of the valuation of ecosystem assets since the asset life of an ecosystem will be directly related to changes in its capacity. In effect the concept of capacity can serve to integrate measures of ecosystem condition, ecosystem services and ecosystem degradation.

4.12.1 Accounting for Land

Accounting for land, particularly land cover, will be a common starting point for compilers of ecosystem accounts, given the focus on terrestrial ecosystems. A distinction is made here between land accounting and ecosystem extent accounts. Land accounting is considered to encompass compilation of various accounts using different classifications of land including land use/management, land cover, and land ownership in applying these classification links to standard SNA classifications of industry (ISIC) and institutional sector. Land accounting will include standard asset account structures and also change matrices and tables that cross classify land, for example land cover cross classified with land ownership (by institutional sector). These various aspects of land accounting are covered in the SEEA Central Framework Chapter 5. Ecosystem extent accounts on the other hand are a specific account recording the area and change in the area of different ET. Where the classes of ET are defined solely on the basis of land cover, then ecosystem extent accounts and land cover accounts (as described in the SEEA Central Framework) will be equivalent.

As part of the accounts compilation process, the information from land cover accounts can be used to help define the relevant spatial areas, to determine the extent of different ecosystem types at a broad level, to support understanding the links between ecosystem services supply and the beneficiaries of those ecosystem services and finally, to facilitate the scaling of other data to finer and broader levels of detail.

From an analytical and policy perspective, information on land cover can, at a national scale, provide important information on trends in deforestation, desertification, urbanization and similar forms of landscape change. As recognized in ecosystem accounting, understanding these types of changes is not sufficient for understanding the effects on ecosystem condition or flows of ecosystem services but it is a relevant starting point.

The total area of a state may also be classified according to land use or land ownership criteria. An interim land use classification is provided in the SEEA Central Framework. Land ownership may be classified by institutional sector (corporations, government, households) or by industry (agriculture, manufacturing, retail, etc.). In some cases, a reasonably clear connection can be made between different classifications of land – for example there will often be a clear link between tree-covered areas and forestry. However, it is not possible for a simple integration of land cover and land use classes to be described.

Information on land use and land ownership will be important in understanding the connection between ecosystem assets and the beneficiaries of ecosystem services. For that reason, it is recommended that, where possible, accounts for land use and land ownership be compiled following the advice in the SEEA Central Framework. A useful output for ecosystem accounting may be a table which cross-classifies land cover and land use at a given point in time. Such a table would highlight the relative significance of different land cover types to specific uses.

Land accounts can also provide an important tool to link environmental and socio-economic data, essentially providing a means by which policy can be placed in a spatial context. A key link here is recognizing that implementation of policy to maintain and restore ecosystem conditions is likely to require the involvement of land holders. Hence, understanding the connection between land ownership, current use and the relevant ecosystems can provide the means by which decisions on appropriate policy interventions can be made.

Generally, the initial focus of land accounting is on terrestrial areas of a country, including freshwater bodies. Within this scope land must be classified into various classes (type of cover, type of use, or type of owning economic unit). Often there will be relevant national classifications and datasets but alignment or correspondence to international classifications is a positive step.

The basic structure of a land account follows the structure of an asset account as described in the SEEA Central Framework. That is, there will be an opening stock, additions and reductions in stock and a closing stock. Ideally, changes in stock over an accounting period would be separated into those that are naturally driven and those due to human activities. Both the SEEA Central Framework and the SEEA EEA describe the structure of a land cover and land use accounts.

In addition to an asset account, information on land cover and land use may be organized in the form of properly vetted and quality-controlled change matrices which show how, over an accounting period, the composition of land has changed.

4.12.2 Accounting for Water Related Stocks and Flows

Water is a fundamental resource. It is essential for all life and underpins the production of food, fibre and energy in many countries. The management of water, including taking into account cross-boundary flows (e.g. the Nile River), and the joint ownership of surface water bodies, is an important focus for many governments around the world.

Accounting for water is relevant to ecosystem accounting in a number of ways. First, water is a key feature of ecosystems and hence the measurement of the stocks and changes in stocks of water resources is a relevant aspect in the measurement of the ecosystem condition. Accounting for changes in water quality would also be an important contribution to ecosystem accounting. However, this area of accounting is not well developed at this stage.

Second, there are numerous ecosystem services which relate directly to water. These include the provisioning service of water when it is abstracted for use (irrigation, drinking, and hydropower), the regulating role of water in filtering pollutants and other residual flows, and the cultural services associated with water such as fishing and other recreational activities. In addition, there are a number of ecosystem services to which water is linked, for example, the regulation of water flows to provide flood protection and the filtration of water by the soil in catchments.

Measurements in all these areas are ultimately important within a complete set of ecosystem accounts. The water resource accounts of the SEEA Central Framework and the SEEA Water focus on two areas – (a) the supply and use of water and (b) the asset account for water. They provide the basis for accounting for water. Of particular note is that the accounting can be undertaken at a sub-national level, compilation at catchment level is recommended. The application of accounting principles to ecologically defined boundaries is directly applicable in ecosystem accounting where measurement of flows of water between spatial areas is required.

4.12.3 Accounting for Biodiversity

Biodiversity (the diversity of ecosystems, species and genes) plays an essential role in supporting human well-being. Biodiversity helps maintain functioning and resilient ecosystems that in turn deliver ecosystem services such as food, the regulation of our climate, aesthetic enjoyment and other cultural benefits. The SEEA EEA provides a framework to measure and link ecosystem service flows supported by biodiversity and other characteristics (e.g. soil type, altitude) with the economy and other human activities. It also allows comparison and integration of data on ecosystem services with other economic and social data. Biodiversity accounts can help to build an understanding of the relationship between biodiversity and economic activity.

On the whole, the perspective taken for ecosystem accounting in the SEEA EEA is that biodiversity is a feature that is directly relevant in measurement of the condition of ecosystem assets. Measures of biodiversity, whether of ecosystem-level biodiversity or species-level biodiversity (the inclusion of genetic-level biodiversity measures has not yet been examined), are considered to relate primarily to the stocks component in the accounting model. Thus potential uses of biodiversity, such as birdwatching or fishing, are considered derivative from biodiversity rather than flows of biodiversity in their own right.

This approach is consistent with a view that biodiversity can be degraded or enhanced over time, an attribute that applies only to stocks and not to flows (i.e. ecosystem services). In this context, the connection between biodiversity and ecosystem functioning may often be difficult to make. This is related to both to the limitations of ecosystem dynamics models as well as data gaps for many ecosystems world-wide.

People may appreciate and therefore value specific elements of biodiversity, for example when they take an interest in the conservation of endemic and/or iconic species. This is reflected, for instance, in the creation of protected areas in many countries. These species can only survive in the long-term when the overall condition of the ecosystems in which they occur is maintained. In order to reflect the multi-layered relation between biodiversity, ecosystem functioning, ecosystem services and the human appreciation of ecosystems, a range of biodiversity indicators should be considered. Species indicators may be selected on the basis of the importance of species for specific ecosystem processes, for being indicative of ecosystem quality or functioning, or because the species represent specific aspects that people appreciate in biodiversity, such as the occurrence or abundance of threatened, endemic and/or iconic species.

4.12.4 Accounting for Energy

A major portion of natural resource goes into the energy sector as one of the raw materials. Flows of air emissions and solid waste generated by energy production and use are not included, although all types of waste used as inputs in the production of energy are included. Accounting for energy flows generally consists of:

- Energy from natural inputs,
- Flows of energy products and
- Energy residuals.

Energy from natural inputs encompasses flows of energy from the removal and capture of energy from the environment by resident economic units. These flows include energy from mineral and energy resources (e.g. oil, natural gas, coal and peat, and uranium), natural timber resources and inputs from renewable energy sources (e.g. solar, wind, hydro and geothermal).

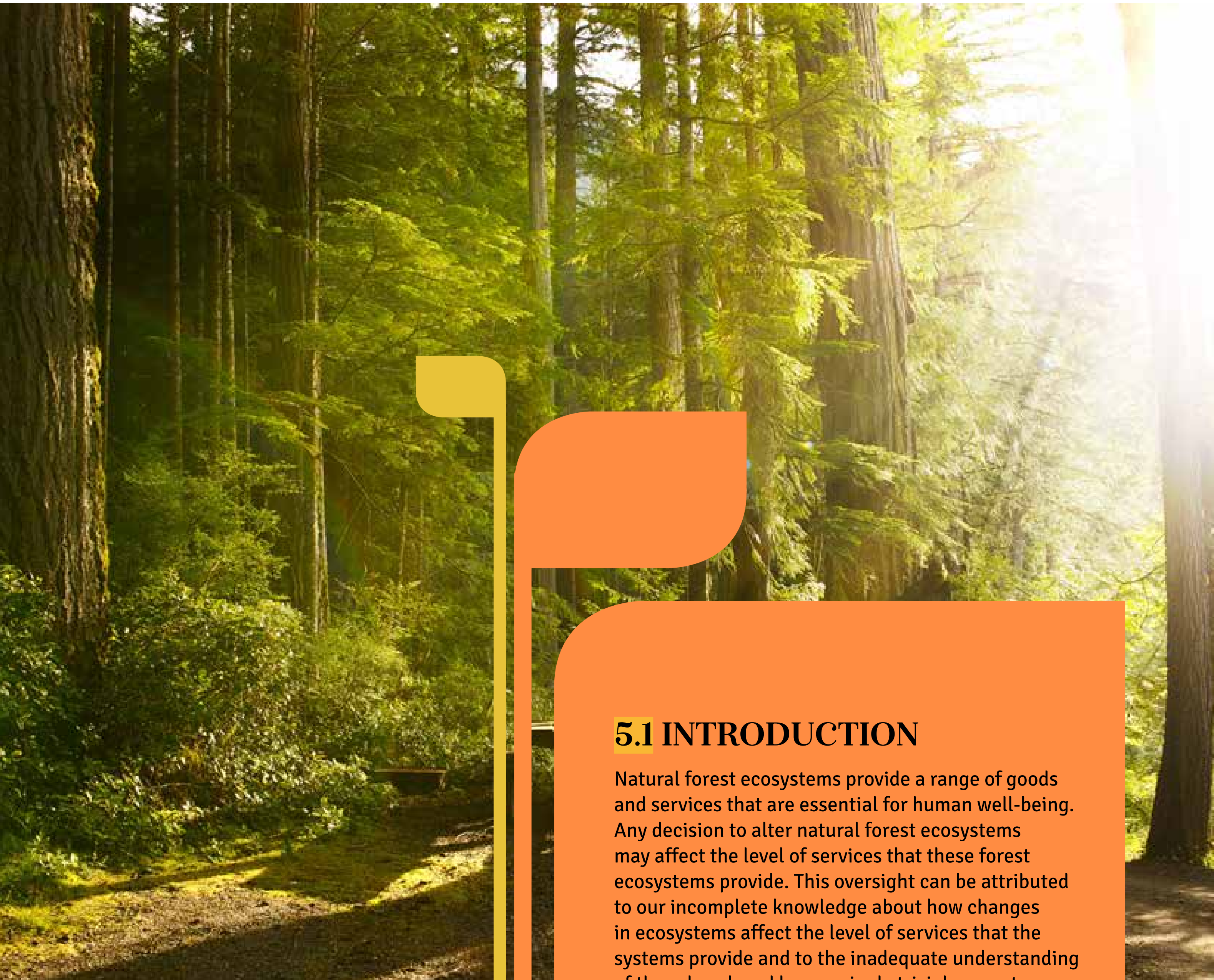
Energy products are products that are used (or might be used) as a source of energy. A distinction can be made between primary and secondary energy products. Primary energy products are produced directly from the extraction or capture of energy resources from the environment. Secondary energy products are the result of transformation of primary, or other secondary, energy products into other types of energy products. Examples include petroleum products from crude oil, charcoal from fuelwood and electricity from fuel oil.

Energy residuals in physical terms comprise several components. Energy residuals may include heat generated when end-users (either households or enterprises) use energy products for energy purposes (e.g. electricity).

FOREST RESOURCE ACCOUNTING FOR UTTARAKHAND

CHAPTER

05



5.1 INTRODUCTION

Natural forest ecosystems provide a range of goods and services that are essential for human well-being. Any decision to alter natural forest ecosystems may affect the level of services that these forest ecosystems provide. This oversight can be attributed to our incomplete knowledge about how changes in ecosystems affect the level of services that the systems provide and to the inadequate understanding of the roles played by seemingly trivial ecosystem components. Several techniques have been developed and applied under ecological economics to estimate values for ecosystem services. Globally, Costanza et al. (1997b) estimated the total value of forest ecosystem goods and services at $4.7 trillion annually. Several studies have been undertaken to provide realistic estimates of various ecosystem services provided by forests like watershed, climate regulation and carbon sequestration, biodiversity regulation and landscape values such as tourism and recreation services.

The present chapter intends to estimate the value of the forests of Uttarakhand using the SEEA-EEA framework

5.2 SCOPE OF FRA

Forests are one of the most important components of the terrestrial environmental system and a complete resource base. They form an ecological system consisting of tree-dominated vegetative cover (Verma and Kumar, 2006).

IIED and WCMC (1994) define forest resource accounting (FRA) as a management tool which integrates forest information from many sources and makes it available in forms which are useful for policy-making and planning. An FRA system tracks changes in forests used for both production and protection – especially in their area, legal status, condition and management. It reports these changes in ways which help to improve forest valuation, policy, planning and management, and which help to demonstrate national progress in achieving policy objectives. FRA contributes to the development of natural resource accounts by providing much of the core, stock taking information required for the resource accounts (IIED and WCMC, 1994; IIED and WCMC, 1996). The calculation of natural growth should be based on the forest resources available at the beginning of the accounting period (Balasubramanium, 2013). Accounting for forest wealth has many policy useful benefits, which is why it is necessary to maintain such accounts which incorporate all those benefits.

Quantifying and monitoring the flows of ecosystem services is critical. Forest Resource Accounting (FRA) provides a realistic estimate of the contribution of forests to the GDP of the economy. Presently, the budgetary allocation in India is nearly following the quid pro quo technique of budgetary allocation in relation to contribution to GDP. States with large geographical areas under forests like Madhya Pradesh, Himachal Pradesh, Arunachal Pradesh, Uttarakhand, Chhattisgarh, etc. could make a strong case for higher budgetary allocation using ecosystem quantity and value estimate for their forestry sector so as to promote sustainable development. Otherwise the states will always face a resource crunch in the forestry sector. Further the communities conserving forests like JFM committees will also have a sustained interest in investing in this natural capital.

When the contributions are recorded through a system of FRA, the contributing stakeholders can also be identified and this would help setting up a compensation/ payment /incentive-based mechanism to such conservationists. The logic has been appreciated by the 14th Finance Commission of India, wherein for the first-time in the history of the Finance Commission of India, it assigned 7.5 per cent weight to the forest cover into the horizontal tax devolution formula for the allocation of the divisible pool of taxes among the states. If a regular system of FRA is established, it will further help in such budgetary allocations leading to improved management of India's forests.

5.3 FRA FRAMEWORK AND METHODOLOGY

5.3.1 (XU. ET. AL 1995)

A typical resource accounting exercise for the forestry sector would take into account the existing system of recording the stocks and flows, and then try to create a linkage with potential accounts. This is done usually by either expanding the assets boundary or by accounting for implicit depletion/ degradation of assets which were not done before. The system of Forest Resource Accounting proposed by (Z. Xu, Bradley, and Jakes, 1995 focuses on the concepts of actual accounts, linkage accounts and potential accounts that have been adopted particularly in respect of parameters indicated in Figure 38.

- Actual capacity accounts measure the flow of goods and services flowing from the forest ecosystem to the economy currently. This flow can be assessed by the construction of Asset Accounts both physical and monetary asset accounts.
- Potential capacity accounts record the various ecosystem features which determines both the Actual Capacity and Potential flow of benefits of those features, based on various ecosystem quality indices.
- Linkage Accounts tries to link together the Actual Capacity Accounts and Potential Capacity Accounts, and consists of estimates of costs of various ecological imperatives required to maintain some ecological indicators at a specified level or to avoid losses in the flow of future goods and services (potential benefits)

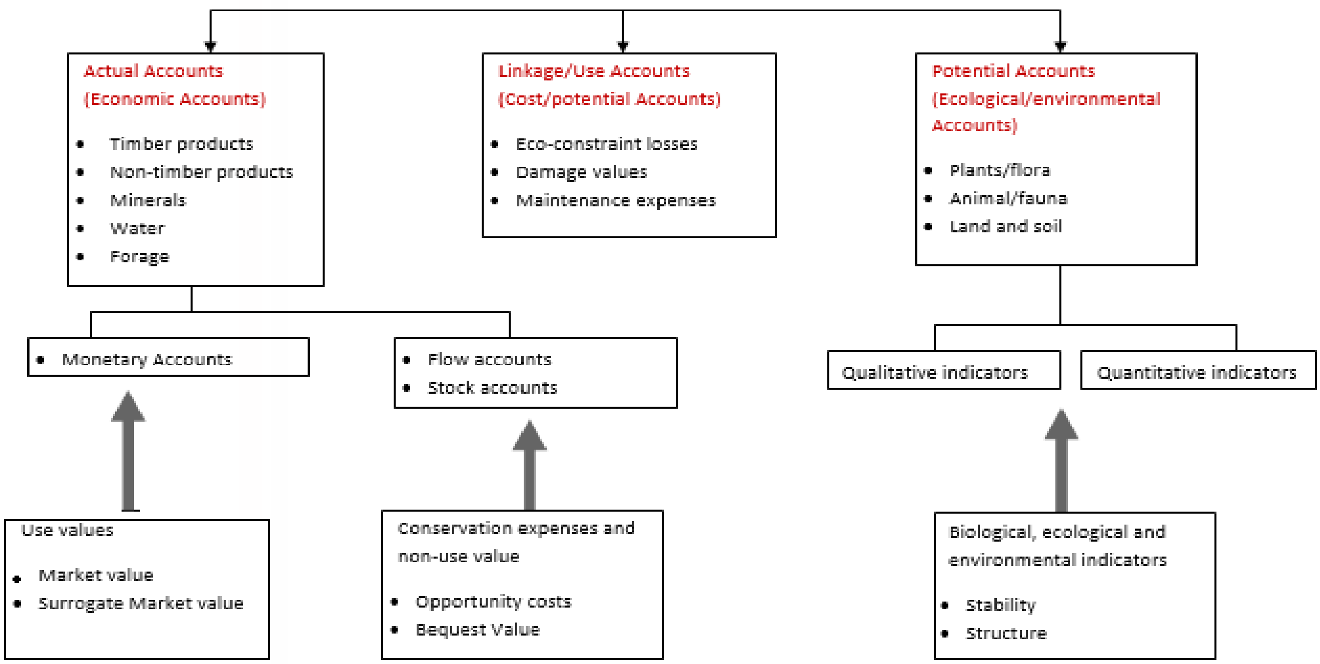


Figure 38: Framework for Forest Accounting Adapted from Xu. et al. 1995

Valuing depletion and degradation within a national accounting framework is a viable proposition today, as a result of significant progress in valuation techniques for environmental resources and as a result of the expanding foundation that theoretical developments are placing under the methods of “green” national accounting (Hamilton, 2002). But the very complexity of forest–economy and land-economy interactions, especially in a country like India, makes forest and land-related adjustments prone to error, if not guided by economic theory as well as a complete set of relevant and reliable data to support the assumptions of such theories. The SEEA proposes a framework of creating and linking a system of satellite environmental accounts to the national income accounts which this study has adopted.

One of the major lacunae in the present system of accounting for the contribution of the “forestry and logging” in the national income accounts is the high degree of underestimation that riddles the computation. One of the major reasons for this is the fact that a varied type and amount of forest outturn is attributed to other sectors, mainly agriculture and livestock, fisheries and tourism. For example, all forest food and food additives, forest grazing and fodder are reported under agriculture for the most part. Non-wood construction materials (thatching materials, bamboo, grass, fibres, etc.) are estimated to be used by 250 million Indians living below the poverty line, with a value of 2500 million US dollars (UN-CSD/IPF, 1996).

Forestland transferred to support development in other sectors like mining, irrigation, hydropower, surface transport, etc. adds to the capital stock of these recipient sectors, while forestry hardly gets compensated for such transfers. Hence the major focus of the accounting exercise has been to rectify the imputation of zero cost to the consumption of the above mentioned resources.

5.3.1.1 METHODOLOGY

Asset accounts record stocks and changes in stocks of natural resources over time. Forest asset account typically includes a balance account for forest land and stocks of standing timber.

The forest-related asset accounts can be of the following types, both in physical and monetary terms:

Area Accounts (Wooded Land): Land area and economic value by main species, natural and cultivated forest land, available for wood supply/ not available, etc.

Volume Accounts (Standing Timber): Volume and monetary value of the main sp., natural and cultivated forest land, available for wood supply or not available, etc., Depletion and depreciation of standing timber.

The study thus conducts economic valuation of the forests of Himachal and then uses the above framework to generate forest resource accounts to provide relevant information for its use for various purposes like substantiating demand for incentives and reward for forest conservation and receiving due compensation for damage to the forest ecosystem and desired budget for various forest management interventions.

As explained in the above Figure 22, the accounting exercise is initiated with identification of the ecosystem extent. In this, the study area is mapped and classified into different land use classes. For each land use, the corresponding ecosystem services are identified and quantified. Through this quantification, economic values are derived thus compiling the ecosystem accounts. For forest resource accounts, the same approach was adopted for the land use type “Forest” as classified by NRSA, in the land use map of Uttarakhand.

Acknowledging that our current understanding about the role of biodiversity in ensuring human well-being is rudimentary to say the least, the study has adopted the ‘VALUE+’ approach as mentioned earlier. While recognizing that economic value of all the categories of benefits cannot be estimated, different approaches may be required to put together for those services which can be estimated to a certain degree of certainty. The study thus uses the following valuation approaches to demonstrate the economic value of forests.

- Economic valuation of ecosystem services through widely accepted valuation methodologies, benefits transfer where required, and scenarios based on widely quoted economic valuation studies.
- Mapping ecosystem services using a tool called InVEST. In the last few years, the ecosystem valuation process has evolved from analytical models to GIS-based spatial simulation models. These simulation models are able to comprehend the local ecosystem characteristics in a better way; thus enriching the overall valuation. Such a mapping of ecosystem services can provide very useful management prescriptions for forest reserve managements to optimize benefits from forests. The current study applies one of the most widely used tools for mapping ecosystem services, Integrated Valuation of Ecosystem Services and Trade-Offs (InVEST) developed by the Natural Capital Project at Stanford University.

All the ecosystem services have been calculated at district level and then merged together to arrive at the combined Forest Resource Accounts for the state of Uttarakhand.

Uttarakhand's Forest Resource Accounts

5.3.1.2 UTTARAKHAND'S FOREST RESOURCE ACCOUNTS

Forest Resource Accounts for Uttarakhand

Actual Accounts

Uttarakhand Forest Ecosystem Service (Flow Values)	Economic Value (INR crores)
Fuelwood	3,395.20
Fodder	7,776.10
Timber	1,243.20
Non-Timber Forest Products	303.7
Employment Generation	300
Carbon Sequestration	1,482.20
Water Purification	655.7
Water Provisioning	745.3
Gene-Pool Protection	73,386.50
Sediment Regulation/Retention	561
Biological Control	251.7
Pollination	441.1
Gas Regulation	176.5
Waste Assimilation	1,764.60
Flood Regulation	1,306.50
Recreation/Tourism	9.9
Habitat for Species	892.5
Nutrient Cycling/Retention	420.9
Total	95,112.60

Linkage/Use Accounts

Expenditure Heads	Outlay Budget 2017-2018
Administration and Capacity Building	448.76
Forestation and Conservation	152.68
Forest Protection	135.45
Ecotourism	5.67
Wildlife Management, Parks & Bird Sanctuaries Management	36.91
Infrastructure Development (Building and Roads)	9.20
Strengthening of Forest Panchayats	1.45
Research and Technology	1.19
Rehabilitation and development Program	18.68
Biodiversity Coservation and Rural Livelihood Improvement Project (BCARLIP)	11.50
Uttarakhand Forest Resource Management Program (JICA)	123.00
Total	822.83

Potential Accounts

Uttarakhand Forest Ecosystem Service (Stock Values)	Economic Value (INR crores)
Timber Stock	7,21,101.70
Carbon Stock	2,55,725.50
Land Value	4,36,849.00
Total	14,13,676.2

5.3.2 SYSTEM OF ENVIRONMENTAL-ECONOMIC ACCOUNTING (SEEA)

The System of Environmental-Economic Accounting (SEEA) Experimental Ecosystem Accounting is an integrated statistical framework for organizing biophysical data, measuring ecosystem services, tracking changes in ecosystem assets and linking this information to economic and other human activity. SEEA Experimental Ecosystem Accounting provides a complementary perspective to the accounting approaches described in the SEEA Central Framework but does not have the status of an international statistical standard.

The work on SEEA EEA was able to take advantage of the more recent developments in the measurement of ecosystem services, such as presented in the Millennium Ecosystem Assessment (MA, 2005) and the original TEEB study (TEEB, 2010). The SEEA EEA represents a synthesis of approaches to the measurement of ecosystems adapted to enable integration with standard national accounting concepts and measurement boundaries.

According to the UN's technical recommendations Report (2017) for SEEA - EEA (2012), the accounting framework described in SEEA-EEA extends, supports and complements other ecosystem and biodiversity measurement initiatives in four important ways.

- It involves accounting for ecosystem assets in terms of both ecosystem condition and ecosystem services.
- It encompasses accounting in both biophysical terms (e.g. hectares, tonnes) and in monetary terms using various valuation techniques.
- It is designed to facilitate comparison and integration with the economic data prepared following the System of National Accounts (SNA) by adopting certain measurement boundaries and valuation concepts that are not systematically applied in other forms of ecosystem measurement.
- It provides a broad, cross-cutting perspective on ecosystems at a country or large, sub-national level. However, many ecosystem measurements are conducted at a detailed, local level. The SEEA EEA framework provides an organizing structure by which detailed data can be placed in context and used to paint a rich picture of the condition of ecosystems and the services they supply.

Given below in

Table 49 is a list of environmental data domains and base accounts for complete accounting. As the current report focuses on forest resource accounting, hence data domains and base accounts for forestry products and environmental assets have been developed.

Table 49: List of Data Domains and Base Accounts for Complete Environmental Accounting of Agriculture, Forestry and Fisheries

Environment Data Domains	Base Accounts
Agricultural products and related environmental assets	Physical flow account for crops*
Physical flow account for livestock products*	
	Asset account for livestock*
	Asset account for plantations*
Forestry products and related environmental assets	Physical flow account for forestry products*(timber and NTFP produce)
	Asset account for forests
	Asset account for timber resources
Fisheries products and related environmental assets	Physical flow account for fish and aquatic products*
	Asset account for fish and other aquatic resources*
Water resources	Asset account for water resources
	Physical flow account for water abstraction
	Physical flow account for water distribution and use
Energy	Physical flow account for energy use
Air emissions	Physical flow account for air emissions
Fertilizers, nutrient flows and pesticides	Physical flow account for fertilizers*
	Physical flow account for pesticides*
Land	Asset account for land use
	Asset account for land cover
Soil resources	Asset account for soil resources

To fill in the desired accounts as itemized in the above sections, Table 50 provides an overview of indicators/datasets to map, model, assess, quantify and value ecosystem services. The table is classified into three main categories: 1) Core datasets, 2) Bio-physical data and 3) Other required datasets.

Further the data have been characterized into spatial and non-spatial type. These are potential sources that provide information for Indian scenarios but also there are international agencies /institutions that provide global datasets from which information can be derived to assess ecosystem services. Such data sets would help to generate the EEA following core and thematic accounts proposed in SEEA- under the SEEA-EEA framework:

Table 50: Nature of Data Required and its Source for Assessing Various Ecosystem Services

Data Inventory			
	Data Requirements	Data Type	Sources
Core datasets	Administrative boundary	Spatial	Survey of India, Forest Department
	Land use/land cover (LULC)	Spatial	NRSC, FSI
	Forest type	Spatial	FSI
	Forest cover	Spatial	FSI, Forest Department
	DEM (topography)	Spatial	ASTER
Bio-physical data	Carbon in above ground biomass, below ground biomass, dead organic matter, and soil	Non-Spatial	FSI
	Precipitation	Spatial	IMD
	Evapotranspiration	Spatial	IMD
	Soil type, soil depth, soil texture	Spatial	NBSS and LUP, Survey of India
	Wood stock, volume	Non-Spatial	FSI, Forest Department
	Agriculture data(productivity, produce)	Non-Spatial	Agriculture Census, ICAR, IARI
	Livestock feed	Non-Spatial	Livestock census
	Growing stock and flow, rotation and harvesting	Non-Spatial	FSI, Forest Department
	Population	Non-Spatial	Census of India, Forest Department
	Water demand, water requirement	Non-Spatial	CWC, CGWB, Watershed Department
	Health, environmental statistics	Non-Spatial	India stat, ZSI, Forest Department
	Vegetation Type	Non-Spatial	FSI, Forest Department, Biodiversity Information System(BIS)-IIRS
	Fragmentation	Spatial	FSI, Forest Department, BIS-IIRS
	Disturbance Index	Spatial	FSI, Forest Department, BIS-IIRS
	Biological Richness	Spatial	FSI, Forest Department, BIS-IIRS
	Waste Water Information/ Water Quality	Non-Spatial	CWC, CGWB, Watershed Department
	NTFP extraction data (annual production)	Non-Spatial	Forest Department, Independent Studies
Other required datasets	Questionnaires and interviews	Non-Spatial	Forest Department
	Market value/price	Non-Spatial	Forest Department
	Wage rate	Non-Spatial	FSI, Forest Department
	Benefit transfer method	Non-Spatial	
	Social cost of carbon	Non-Spatial	

Fuelwood	Fodder	Food	Timber	Non-Timber Forest Products	Employment Generation	Carbon Sequestration	Water Purification	Water Provisioning	Gene-Pool Protection	Sediment Regulation/ Retention	Biological Control	Pollination	Gas Regulation	Waste Assimilation	Flood Regulation	Recreation/ Tourism	Habitat for Species	Nutrient Cycling/ Retention
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The specific requirements of data across various methods of capturing the physical and monetary values of ecosystem services are presented Table 51 below.

Table 51: Data Requirement Across Valuation Techniques

Ecosystem service	Stock / Flow	Indicator/Index	Data Requirements	Data Availability	Methods
Timber	Stock	Biomass	Species-wise stand Stumpage value	Medium	Market Price
	Flow	MAI	Species-wise stand Volumetric equations	Medium	Market Price
Employment Generation	Flow	Man Days	Number of man-days generated	Medium	Market Price
Agriculture	Flow	Agricultural Produce	Value of agriculture produce	High	Production Function
Fuelwood	Stock	Biomass	Species-wise stand	Medium	Market Price
	Flow	Extraction	Specific study on fuelwood extraction? Average household requirements? FSI?	Medium	Market Price
Fodder	Flow	Dependent Cattle Population	Dependent cattle units on forests; Cattle population in and around forest areas; FSI?	High	Market Price
NWFP	Flow	Extraction	Specific studies for nationalized NWFP? Plot data correlation with biomass	Medium	Market Price
Fisheries	Flow	Extraction	Study on fish catch from wetlands / rivers inside forest?	High	Market Price
Recreation	Flow	Consumer Surplus	Visitation rates in NP/ WLS/TR Willingness to Pay Studies Park Entry Fees	Medium	Travel Cost Method
Carbon storage	Stock	Carbon Stock	Carbon stock in various pools (AGB, Soil) Social Cost of Carbon	Medium	Production Function
Carbon sequestered	Flow	MAI	Stand-level biomass data IPCC Coefficients	Medium	Production Function

Water	Flow	Water Quantity Evapotranspiration	Any hydrological modelling study? Any data on water flows? Economic value of water	Medium	Production Function
Nutrient Regulation	Stock	NPK in Soils	Tested soil samples for NPK content? Organic carbon?	Low	Market-Price
	Flow	Erosion Prevention	Study on erosion prevention from forests?	Low	Replacement Cost
Erosion Regulation	Flow	Erosion Prevented/ Erodibility Index	Study on erosion prevention from forests? Sediment excavation costs	Low	Replacement Cost
Pollination	Flow	Agriculture Production Biodiversity Habitat Index	Primary pollinator abundance in forests? Agriculture areas near forests?	Low	Production Function
Habitat Provision	Flow	Wildlife Population	Population count of key species? Nursery areas for key species	Low	Replacement Cost
Gas Regulation	Flow	Air Quality Index	Land-cover data	Low	Benefits Transfer
Waste Assimilation	Flow	Waste Treated	Cost of waste treatment plant	Medium	Avoided Cost/ Benefits Transfer (Land Cover)
Biological Control	Flow	Wildlife Population/ Diversity Index		Low	Benefits Transfer (Land Cover)
Moderation of Extreme Events	Flow	Loss Avoided	Property loss avoided?	Low	Avoided Damage to Life and Property
Other services	Flow		Land-cover data	Medium	Benefits Transfer

As seen through tables and information that the SEEA is a system for organizing statistical data for the derivation of coherent indicators and descriptive statistics to monitor the interactions between the economy and the environment and the state of the environment to better inform decision-making. SEEA is a multi-purpose system that generates a wide range of statistics and indicators with many different potential analytical applications and not just any single headline indicator. The process of synthesizing such information for its purposeful use is depicted in Figure 39.

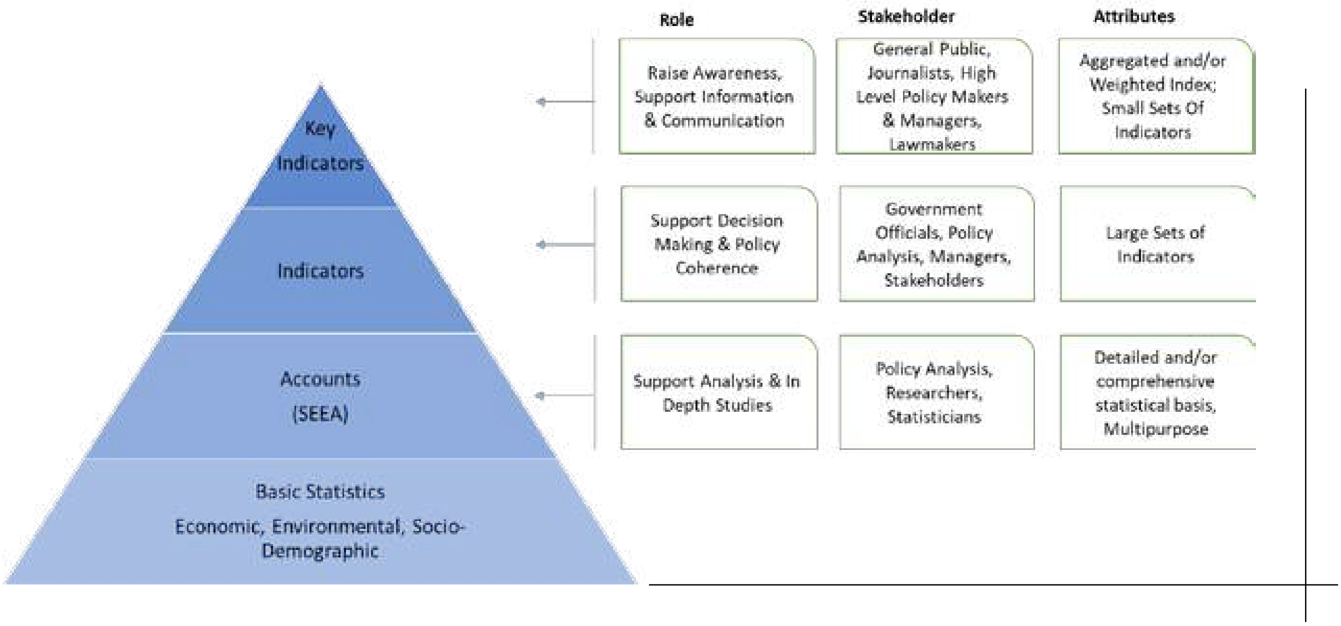


Figure 39: SEEA Information Pyramid (Source: SEEA Central Framework, 2012, UN (2014))

5.4 SEEA-EEA ACCOUNTING TABLES FOR UTTARAKHAND

5.4.1 FOREST ECOSYSTEM EXTENT ACCOUNTS (AREA ACCOUNTS)

As discussed earlier to start with ecosystem accounting it is important to organize the extent of different ecosystem types within a study area (Uttarakhand forest area) in terms of area. Table 52 and Table 53 focus on the Forest Ecosystem Extent Account for Uttarakhand Recorded Forest Area and Forest Cover.

Table 52: Forest Ecosystem Extent Account for Uttarakhand (Recorded Forest Area)

Physical Asset Account for Recorded Forest Area (In Hectares (ha))					
	Opening Stock	**Addition to Stock**	**Reduction to Stock**	**Net Changes in Stock**	**Closing Stock**
Forests and Other Wooded Land	3799960	-	-	-	3799960
Forest Land	2654700	-	-	-	2654700
Primary Forests	2361157.51	-	-	-	2361157.51
Other Natural Regenerated Forest	79834.586	-	6684.096	6684.096	73150.49
Total Natural Forests	2440992.096	-	-		2434308
Planted Forests	139211	12799		12799	152010
Other Wooded Land	-	-	-	-	-
Total Forest Land	**2580203.096**	**12799**	**6684**	**6115(+)**	**2586318**

Source: Uttarakhand State Forest Department Report.

Table 53: Forest Ecosystem Extent Account for Uttarakhand (Actual Forest Cover)

Area Accounts for Uttarakhand's Forests (In Square KM)					
Forests and Other Wooded Land	**Opening Stock (2013 ISFR)**	**Addition to Stock**	**Reduction to Stock**	**Net Changes in Stock**	**Closing Stock(2017 ISFR)**
Reserve Forests	24643	1904	0	1904	26547
Protected Forests	9885	0	0	0	9885
Unclassed and Vested Forest	123	1445	0	1445	1568
Forest Land (Under Forest Department)	34651	3349	0	3349	38000
Trees Outside Forests and Tree Cover	703	64	0	64	767
Total Forests and Tree Cover	**35354**	**3413**	**0**	**3413**	**38767**

Source: Indian State Forest Report 2013 and 2017.

5.4.2 ECOSYSTEM CONDITION ACCOUNT (PHYSICAL)- GROWING STOCK (TIMBER)

The next step in preparing ecosystem accounts is to prepare ecosystem conditions accounts. The ecosystem condition reflects the overall quality of an ecosystem asset in terms of its characteristics. The assessment of the ecosystem condition involves two distinct stages of measurement with reference to both the quantity and the quality aspects of the characteristics of the ecosystem asset. In the first stage, it is necessary to select appropriate characteristics and associated indicators of changes in those characteristics. The selection of characteristics and associated indicators should be implemented on a scientific basis so that there is an assessment of the ongoing functioning, resilience and integrity of the ecosystem asset. In this case the indicator taken for the forest ecosystem of Uttarakhand is growing stock. Opening stock has been estimated in proportion with the forest cover from ISFR 2017 for the state. Mean annual increment has been taken from FAO estimated for India which is 0.5 m^3/ /ha. As specific data for each category mentioned in Table 54 was not available, hence figures are equally distributed in proportion with the area each category possesses.

Table 54: Physical Accounts for Growing Stock

	Opening Stock (Growing Stock) (Cubic Metre)		Addition to Stock(Cubic Metres)			Reduction to stock (Cubic Me	
Type of Timber Resources	**Area Coverage in Hectares**	**Volume in Cubic Metre**	Natural Growth	Reclassification	Total Addition	Removals	Felling Residual
Mainly Natural Regeneration	838,597	97,252,092	419,298	0	419,298	308885 (Timber) + 83063 (Firewood)= 391948	10 % of the Total Removals = 39194.8
Protection, Unalloted, etc.	225,125	26,107,759	112,563	0	112,563		
Selection group, Protection and Improvement	863,348	100,122,485	431,674	0	431,674		
Coppice with Standards	55,229	6,404,943	27,615	0	27,615		
Clear Felling with Simple Coppice	95,196	11,039,869	47,598	0	47,598		
Plantation/ Afforestation	139,211	16,144,308	69,606	0	69,606		
Mainly Artificial Regeneration	225,160	26,111,862	112,580	0	112,580		
Other/Unclassed	144,451	16,751,982	72,226	0	72,226		
Total	**2,586,318**	**299,935,300**	**1,293,159**				

In addition to this, to have complete accounts for the purpose of Green GDP/Gross Environmental or Ecosystem Products, framework for land, water and energy have been developed and discussed in Chapter 8.

etre)				Net Changes in Stock	Closing Stock
Losses	Catastrophic Losses	Reclassification	Others (Overall Reduction observed from 2015 to 2017)	(Cubic Metres)	(Cubic Metres)
Forest Fire (55914.59	Losses due to Diseases or Other Reasons	Forest Diversion (22968.37)	3329230	-3075303	94176789
			893887	-825719	25282040
			3427492	-3166070	96956415
			219260	-202537	6202406
			377928	-349102	10690766
			552668	-510515	15633793
			893747	-825568	25286294
			573470	-529731	16222252
				-9484545	**290450754**

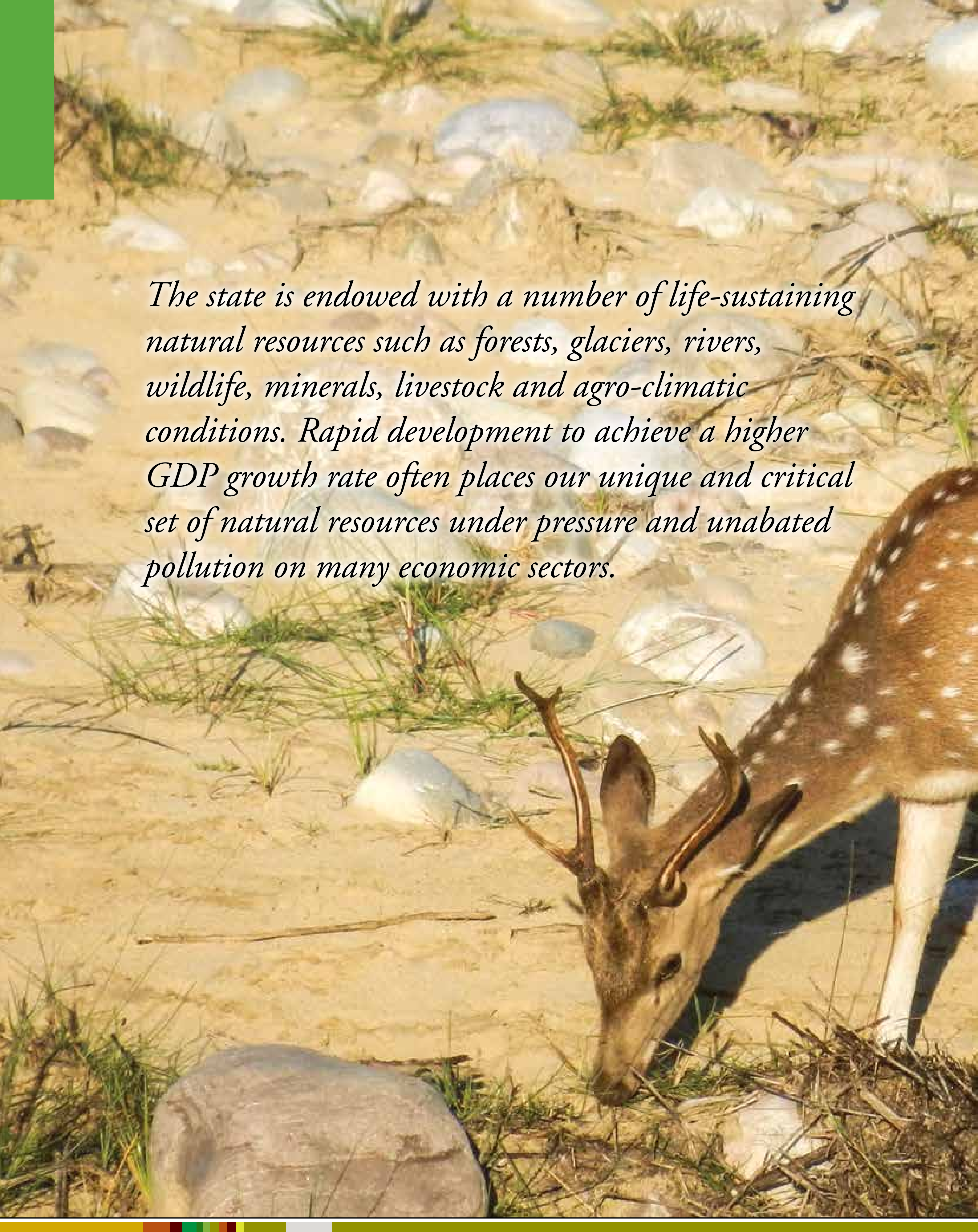
5.5 DATA GAPS

The main focus of the study was to integrate all the information related to forestry products and environmental assets for the purpose of accounting. However only a part of the data available was used for this purpose. The data gaps found during the study have been discussed in detail in

Table 55 for future reference.

Table 55: Data Gaps for Forest Accounts

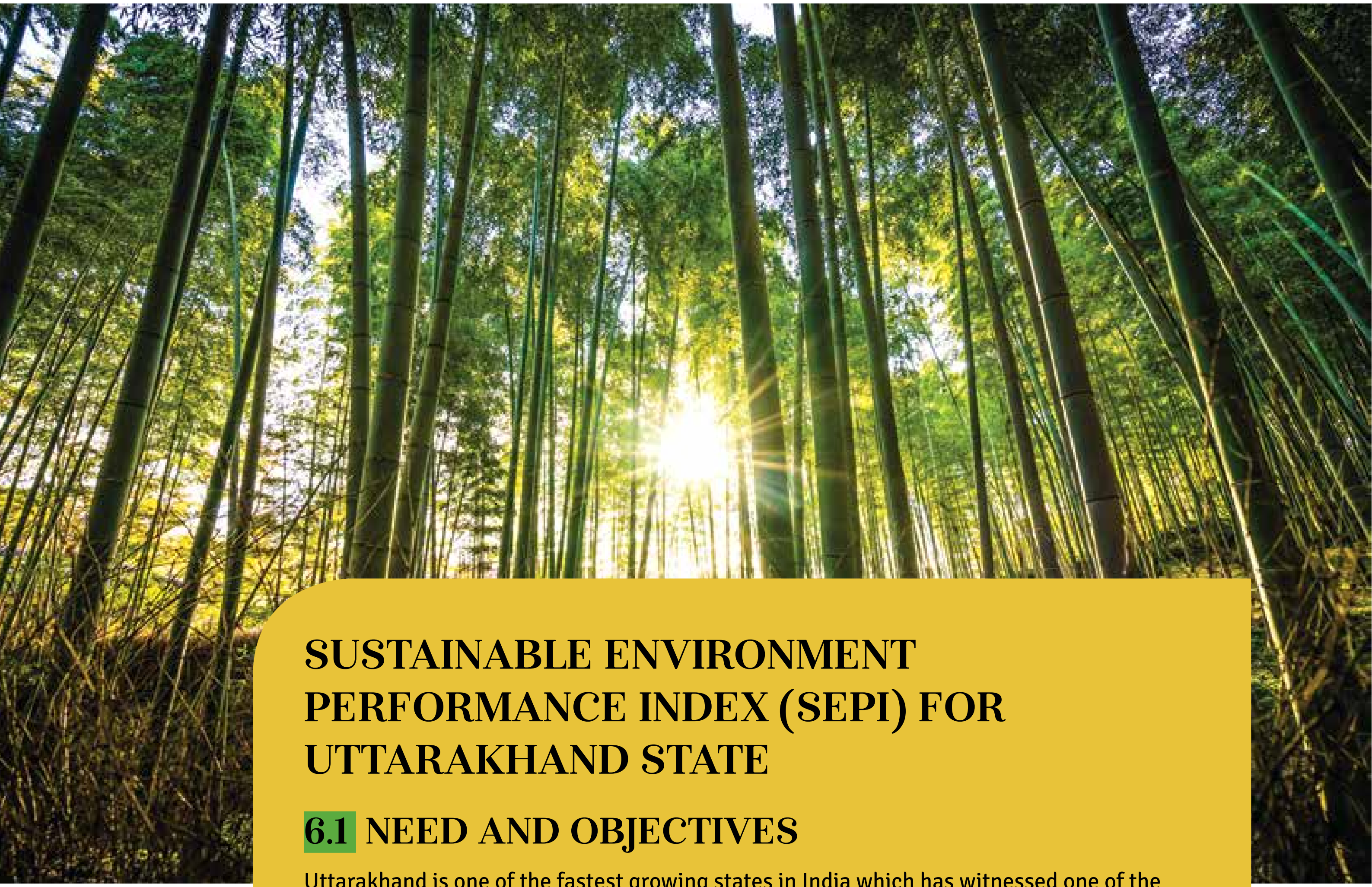
S. No.	Components	Data Requirements/Gaps
	Timber/Fuelwood	Growing stock (species and forest type-wise)
		Current Annual Increment (CAI) and Mean Annual Increment (MAI)
		Volume extracted in terms of timber
		Fuelwood auction price, hidden market price
		Timber annual extraction, felling losses, catastrophic losses
		Sector-wise supply and use of timber (annual usage of timber in the state, amount being imported or exported)
	Land Use	Annual change in land use/land cover
	NTFP Produce	NTFP extraction district level data.
		Sector-wise use NTFP in supply chain.
	Forest Cover/ Land Use Change	Forest land (land class-wise area): Naturally grown forest
		Artificially regenerated, change in cover (on annual basis), increase in green cover due to plantation, natural growth of forest area.
		Forest area lost (green cover lost) due to natural reasons e.g fire, floods etc.



The state is endowed with a number of life-sustaining natural resources such as forests, glaciers, rivers, wildlife, minerals, livestock and agro-climatic conditions. Rapid development to achieve a higher GDP growth rate often places our unique and critical set of natural resources under pressure and unabated pollution on many economic sectors.

SUSTAINABLE ENVIRONMENT PERFORMANCE INDEX (SEPI) FOR UTTARAKHAND STATE

CHAPTER 06



SUSTAINABLE ENVIRONMENT PERFORMANCE INDEX (SEPI) FOR UTTARAKHAND STATE

6.1 NEED AND OBJECTIVES

Uttarakhand is one of the fastest growing states in India which has witnessed one of the highest Gross Domestic Product (GDP) growth rates (2005 - 2014), second only to Sikkim. The state is endowed with a number of life-sustaining natural resources such as forests, glaciers, rivers, wildlife, minerals, livestock and agro-climatic conditions. Rapid development to achieve a higher GDP growth rate often places our unique and critical set of natural resources under pressure and unabated pollution on many economic sectors. Uttarakhand state, which lies in the foothills of the Himalayas, is no exception in this context.

In order to ensure that the economic growth of the state is not eroding the natural capital, the backbone of such growth, it is important to monitor the health of the state's natural resources actively. In this regard, the development of the Sustainable Environment Performance Index (hereby referred to as SEPI) for the state of Uttarakhand becomes significant. Such an index complements economic indices such as the State / District GDP to ensure holistic and sustainable growth.

Given the vast economic prospects, it is in the state's interest and priority to conserve the integrity of Uttarakhand and its natural capital base. Loss of natural forests and biodiversity is a concern in the state. Land use/cover changes in the state has resulted in significant reduction of wild and traditional domestic animals. Agricultural land has increased, pastures have degraded (Rao, 2001), glaciers have been retreating and many extreme events have been reported to increase in Uttarakhand.

Development needs to be viewed holistically and a customized Sustainable Environment Performance Index for the state, then, is necessary. To arrest rampant exploitation of natural resources and environmental degradation of Uttarakhand state, SEPI helps in assessing the overall environment performance of the state and ensuring overall sustainability. This index allows comparative analysis of the environmental achievements, challenges and priorities of a state. It is indicative of the state's general environmental condition, capturing both historical resource endowments and achievements of policies and strategies undertaken by various stakeholders in conserving natural resources. The index aggregates indicators that reflect,

- State of air quality, water quality, land use and agriculture, forests and biodiversity.
- Measures of the impact of the current state of the environment and resource extraction on the ecosystem and human health.
- Policy responses and society's efforts to preserve the environment.

SEPI is one of its kind index which has been customized to suit the ecological and socio-economic context of the state. Following global best practices, SEPI is built using a widely accepted DPSIR framework (Driving Force – Pressure – State – Impact – Response) developed by the Organization for Economic cooperation and Development (OECD) and European Environmental Agency (EEA) in the context of environmental indicators during the 1990s.

This conceptual framework (Figure 40) helps to identify indicators for each sector in a meaningful way and allows using an extensive dataset for the characterization of environment. The index aggregates a wide range of indicators across varied sectors in a coherent framework to inform decision-makers and identify corrective actions in a timely and effective manner. Therefore, SEPI draws a holistic perspective on measuring the state's performance and benefitting multiple agendas.

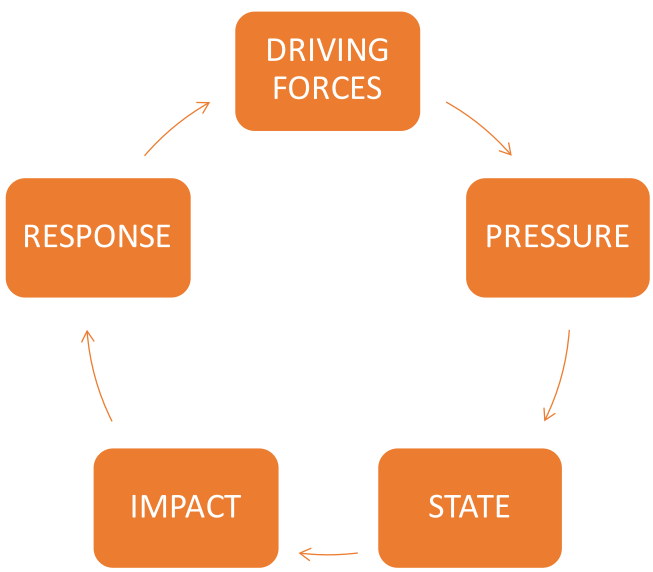


Figure 40: DPSIR Framework for SEPI

6.2 ALIGNMENT OF SEPI WITH SUSTAINABLE DEVELOPMENT GOALS (SDGS)

The Sustainable Development Goals are a UN Initiative, which comprises a set of 17 universal goals (Error! Reference source not found.) and 169 related targets, agreed upon by 193 countries in September 2015. The SDGs are comprehensive and focus on five Ps: People, Planet, Prosperity, Peace and Partnership. The SDGs cover interconnected elements of sustainable development– economic growth, social inclusion and environment protection.

The SDGs indicator framework will play a pivotal role in tracking the achievement of "The 2030 Agenda for Sustainable Development Goals", adopted by India in 2015. Focusing on India's commitment to the SDGs, NITI Aayog has been assigned as the nodal agency to oversee effective implementation of the SDGs in India with the support of the Ministry of Statistics and Programme Implementation (MoSPI) . The 17 goals and 169 targets of SDGs are of special interest to SEPI. It covers issues and aspects of the environment that are relevant for policy analysis and decision-making. These SDG goals and targets have been linked to each of the indicators falling under sectoral indices apart from the one holistic SEPI. These sectoral indices provide additional insights on the performance of the state across different sectors – energy, water, forests, agriculture, education, health, etc. Besides offering a credible way to quantitatively measure the state's performance, SEPI may even highlight trends and trade-offs between sectors providing more focus direction to the policy makers. It also allows comparison of the state's performance against national and global goals. Sustainable

Figure 41: Overview of Sustainable Development Goals

Assist state depts in streamlining their based on towards SDGs framework	Allows comparison of the state's performance against national and global commitments	Allows comparison of the state's current with past performance	Establishing best practices as well as identifying areas of further improvement

Figure 42: Benefits of Aligning SEPI with SDG Indicator Framework

Development Goals and Targets covered by the SEPI:

Goal 1 – Target 1.5,

Goal 2 – Targets 2.4, 2.5,

Goal 3 – Target 3.9,

Goal 6 – Targets 6.1, 6.2, 6.3, 6.4,

Goal 7 – Targets 7.1, 7.2, 7.3,

Goal 8 – Target 8.9,

Goal 11 – Targets 11.3, 11.4,

Goal 12 – Targets 12.4, 12.5, 12.6, 12.7, 12.8, 12.9, 12.10,

Goal 13 – Targets 13.1, 13.2, 13.3,

Goal 15 – Targets 15.1, 15.2, 15.3, 15.4, 15.5

There is also a significant prospective for long-term institutionalization of the SEPI based on SDGs since there is already a momentum among government departments in this direction given that India adopted the SDGs in 2015. Given the expansive nature of the SDGs targets, it is necessary to have a clear roadmap for its implementation process in states. In a way by streamlining the process of data gathering for the SEPI, we will also be assisting the state departments in organizing their processes for the SDGs.

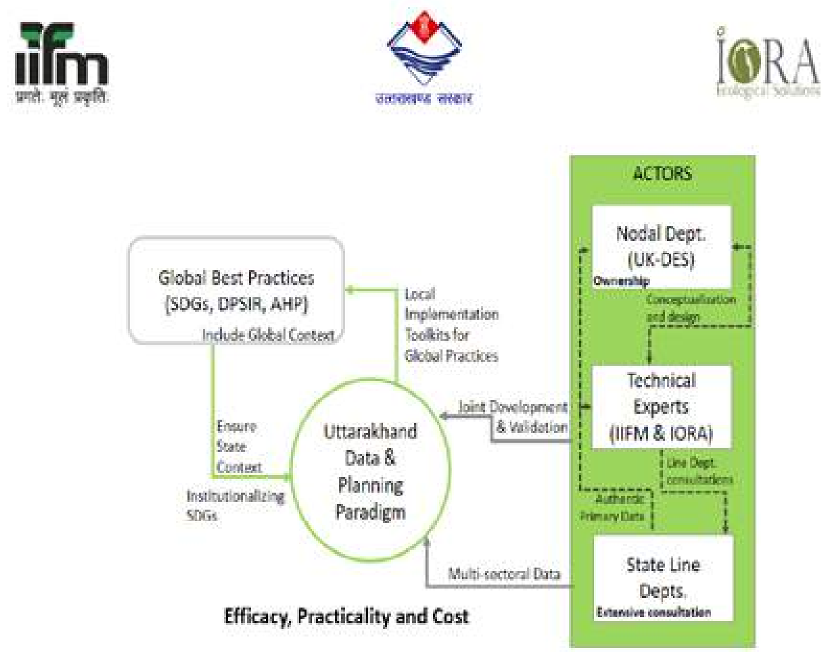


Figure 43: Approach for SEPI

6.3 HISTORY AND REVIEW OF ENVIRONMENTAL INDICES

An index is essentially a collection of indicators aggregated together to provide simplified interpretation of complex issues. The use of indicators per se, especially to judge the state of the environment, dates back even further than modern era science and technology.

Environmental indicators have always been present within the diverse bank of traditional knowledge of indigenous communities. These were acquired through observation and experience, and transmitted over generations in the form of laws, rituals, stories or sometimes even songs. Indigenous communities across the world relied and still rely on their observations and traditional knowledge to predict, prevent or adapt to natural disasters or changes to their environment. Thus, the importance of observing and monitoring our natural environment can be witnessed in human history.

A defining moment in the history of the global environmental movement was the United Nations Conference on the Human Environment in Stockholm in 1972. The international community met for the first time out of concern for the deteriorating state of the earth and its resources. One of the key outcomes of this conference was also the acknowledgement of a clear knowledge gap in environment data. This led to studies such as the Global Environmental Outlook Report which provided a global environment assessment using various cross-sectoral indicators.

Over the years, such environmental indicators were then further constructed into composite indicators or indices. Most of such composite indicators or indices compare and rank the performance of countries based on their economy, environment or other aspects. The Human Development Index (HDI) and Environmental Performance Index (EPI) are some of these popular indices which are discussed along with other indices in Table 56. The table provides a glimpse of various environmental indices across the globe, comparison of their indicators and methodologies being used.

Table 56: Review of Existing National and International Indices

Sl. No.	Name of Index/ Tool	What it Measures?	Sub-indices / Indicators	Method of Standardization
I. GLOBAL INDICES				
1.	Human Development Index (UNDP)	The HDI is a measure of human development.	It has 3 sub-indices: 1. Life Expectancy Index 2. Education Index 3. Income Index	Indicators are standardized using maximum and minimum value. Aggregated using geometric mean.
2.	Environmental Performance Index (Columbia and Yale University)	The index is designed to measure and compare environmental performance across countries.	The EPI derives from a collection of data sets aggregated into 10 policy categories and 22 indicators.	Indicators are standardized using distance from target and range. Aggregated using arithmetic mean.

3.	Environmental Sustainability Index (ESI) (Columbia and Yale University)	The ESI benchmarks the ability of nations to protect the environment over the next several decades. The countries are ranked by their ESI scores – from highest (best) to lowest (worst).	The ESI tracks the relative success for each country in five core components: 1. Environmental Systems 2. Reducing Stresses 3. Reducing Human Vulnerability 4. Social and Institutional Capacity 5. Global Stewardship.	
4.	Environmental Vulnerability Index (EVI) (South Pacific Applied Geoscience Commission)	The EVI quantifies the vulnerability of the natural environment to damage from natural and anthropogenic hazards at national scales.	50 EVI indicators are also divided and classified in the issue categories for use as required: Climate change, biodiversity, water, agriculture and fisheries, human health aspects, desertification, and exposure to natural disasters.	As the indicators are heterogeneous, they include variables for which responses are numerical, qualitative and on different scales (linear, non-linear, or with different ranges) they are mapped onto a 1–7 vulnerability scale.
5.	Global Climate Risk Index (German watch)	The Global Climate Risk Index 2017 analyses to what extent countries have been affected by the impacts of weather-related loss events (storms, floods, heat waves, etc.).	Indicators were analysed: 1. Number of deaths 2. Number of deaths per 100,000 inhabitants 3. Sum of losses in US$ in purchasing power parity (PPP) 4. Losses per unit of Gross Domestic Product (GDP).	In each of the four categories ranking is used as normalization Technique.
6.	Happy Planet Index (HPI) (Friends of the Earth - New Economics Foundation)	A measure that shows the ecological efficiency with which human well-being is delivered around the world.	The global HPI incorporates three separate indicators: ecological footprint, life-satisfaction and life expectancy.	The Global HPI incorporates four separate indicators: ecological footprint, life expectancy, experienced well-being and inequality of incomes

7.	Climate Change Performance Index (CCPI) (Germanwatch and Climate Action Europe)	Evaluates and compares the climate protection performance of the 56 countries that, together, account for more than 90 per cent of the global energy-related CO2 emissions.	Rates countries based on scores of three sub-indices: 1) Per-capita emissions trend of previous years (50%) 2) Absolute energy-related CO2 emissions (30%) 3) National and international climate policies (20%)	
8.	Water Poverty Index (WPI)	WPI is a measure, which links household welfare with water availability and indicates the degree to which water scarcity impacts on human populations.	Five major components, each with several sub-components: 1) Resources 2) Access 3) Capacity 4) Use 5) Environment	Indicators are standardized using maximum and minimum value of the highest value country and the lowest value country respectively.
9.	Ecological Footprint (WWF)	A measure of the consumption of renewable natural resources by a human population, be it that of a country, a region or the whole world.	A population's EF is the total area of productive land or sea required to produce all the crops, meat, seafood, wood and fibre it consumes, to sustain its energy consumption and to give space for its infrastructure.	
10.	Disaster Risk Index (DRI) (UNDP)	Measures the risk of death in disasters (earthquakes, tropical cyclones and floods).	Does not provide an overall score or rank of countries. Instead, countries are indexed for each hazard type according to their degree of physical exposure, their degree of relative vulnerability and their degree of risk.	
11.	National Biodiversity Index (NBI) (UNEP – CBD)	The NBI index is based on estimates of a country's richness and endemism in four terrestrial vertebrate classes and vascular plants.	Countries are not ranked; only the NBI score is presented.	Vertebrates and plants are ranked equally with index values ranging between 1.000 (maximum) and 0.000 (minimum).

II. INDIAN INDICES				
12.	Environmental Sustainable Index (IFMR Lead)	ESI gives a comparative picture of the environmental conditions of the states of India	Follows DPSIR framework. Initially there were 75 indicators but were reduced to 41 due to data constraints.	Indicators standardized based on z-scores which represent deviations from the means.
13.	Ministry of Health and Family Welfare (Statistics Division). Score Card User Manual – Using HMIS Indicators			Indicators are standardized using maximum and minimum value. Describes methods for negative indicators as well. Aggregated using arithmetic mean.
III. OTHER TOOLS FOR COMPOSITE INDICATORS				
14.	Climate Analysis Indicators Tool (CAIT) (World Resources Institute) http://cait.wri.org	Comparable database of GHG emissions and other climate-related indicators.	Ranks countries based on: 1) GHG emissions 2) Socio-economic factors 3) Natural factors	
15.	Index of Social Vulnerability to Climate Change (SVI)	The SVI is an index that empirically assesses relative levels of social vulnerability to climate change-induced variations in water availability which allows cross country comparison in Africa.	Five composite sub-indices: Economic well-being and stability (20 per cent), demographic structure (20 per cent), institutional stability and strength of public infrastructure (40 per cent), global interconnectivity (10 per cent) and dependence on natural resources (10 per cent)	Countries are ranked from highest to lowest social vulnerability, depending on the score of the Social Vulnerability Index (SVI) with 1 being highest vulnerability and 0 lowest on a comparative basis
16.	Sustainability Index (Zurich Cantonal Bank (ZKB))	The sustainability ratings intend to fill a gap left by traditional credit ratings, which include only minimal information on the environmental situation and on social factors.	The evaluation of sustainability is based on 100 largely quantitative, but in part also qualitative, environmental and social aspects. Environmental and social aspects each receive a 50 per cent weighting in the rating.	The sustainability rating is based on a on a scale of 1 to 10 points and is calculated using the arithmetic mean of environmental and social ratings.
17.	Dashboard of Sustainability (IISD and JRC)	Illustrates the complex relationships among economic, social, instructional and environmental issues.		

6.4 METHODOLOGY FOR UTTARAKHAND SEPI

6.4.1 STEP-WISE DETAILED APPROACH FOR THE DEVELOPMENT OF SEPI

The following section provides a detailed description of the methodology used for development of the Uttarakhand Sustainable Environment Performance Index (SEPI).

STAKEHOLDER CONSULTATION

Stakeholder consultation workshop was held on September 1, 2016 to discuss and agree on the scope of the index to be prepared for Uttarakhand state. During this consultation, key sub-sectors to be considered for SEPI were finalized: Agriculture, Horticulture and Animal Husbandry; Disaster Risk and Vulnerability; Energy; Forests and Biodiversity; Human Health and Air Quality; Tourism and Education; Waste Management and Water and Sanitation.

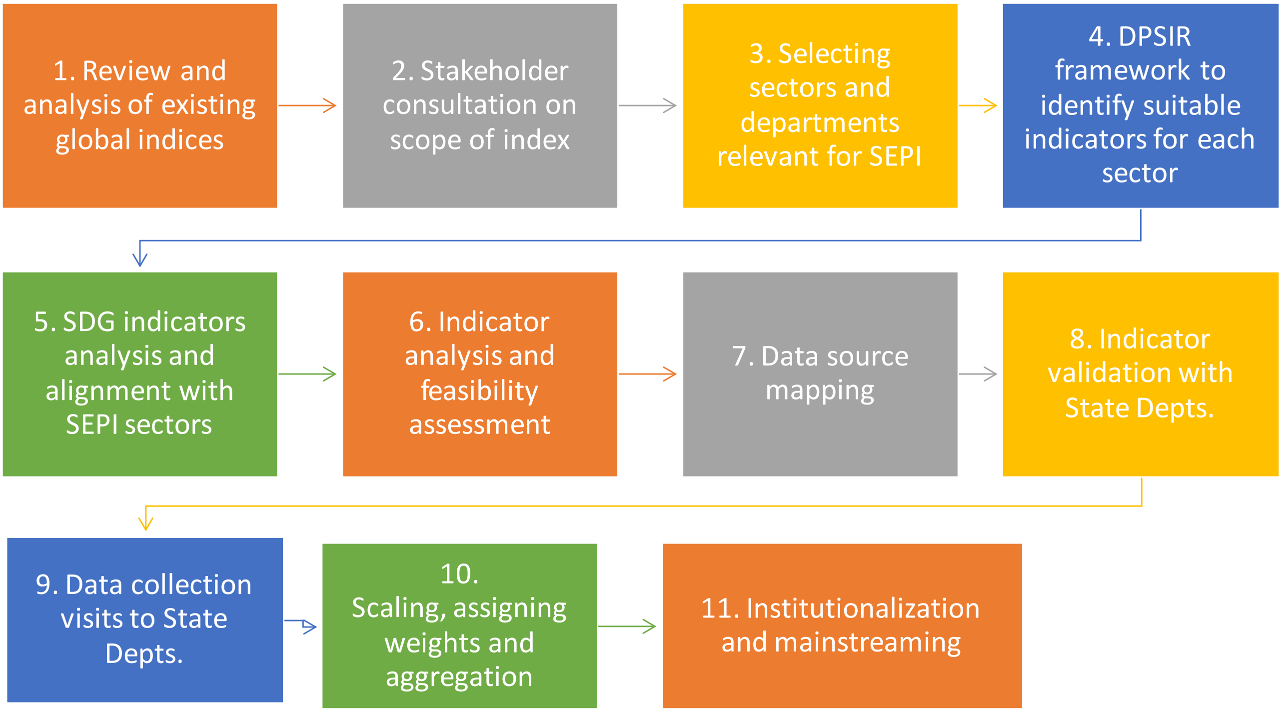


Figure 44 Overall Approach Used for SEPI

Figure 45 Stakeholder Consultation on Scoping of Index

THEORETICAL FRAMEWORK

DPSIR FRAMEWORK

The selection of indicators for the index should follow a systematic, structured and objective process described in the theoretical framework. A theoretical framework provides the basis for the selection and aggregation of indicators into a meaningful index. The "Drivers, Pressure, State, Impact and Response (DPSIR)" framework has been taken as the theoretical framework for identifying the indicators within each sector of the SEPI. This framework was used to identify:

- The driving forces of change within each sector, with focus on negative environmental changes.
- The resulting environmental pressures.
- The state of the environment.
- Impacts resulting from the changes in the environment.
- The various response measures to these changes.

Shown in Figure 46 and 47 are some of the initial indicators identified for the 'Forest and Biodiversity' and 'Water and Sanitation' sectors of the SEPI using the DPSIR framework.

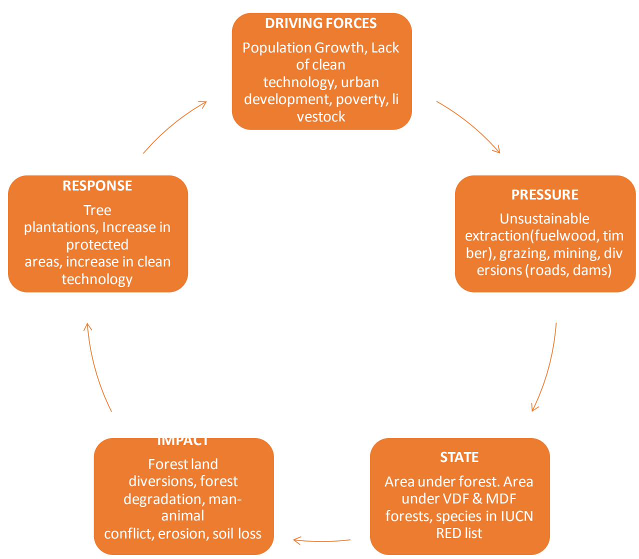


Figure 46 DSPIRIindicators for Forest and Biodiversity Sector

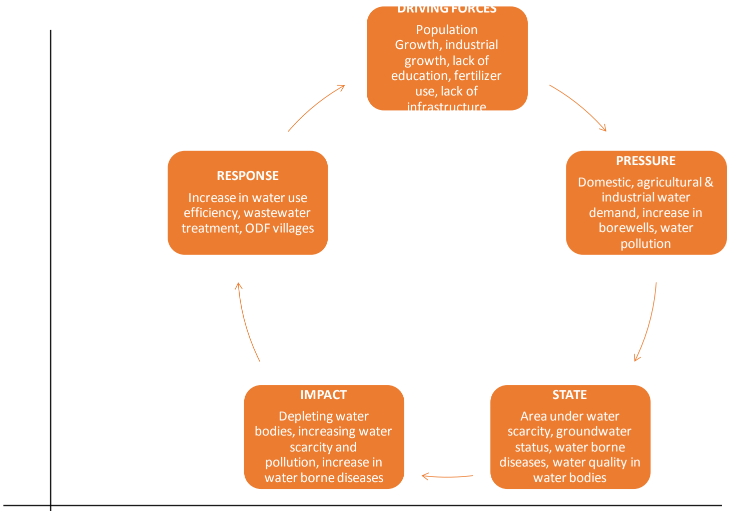


Figure 47: DSPIR indicators for the Water and Sanitation Sector

SEPI VIS-À-VIS UN SUSTAINABLE DEVELOPMENT GOALS (SDGS)

Parallel to the DPSIR framework, SEPI has been aligned with the "UN Sustainable Development Goals (SDGs)". In pursuit of achieving SDGs, SEPI will help Uttarakhand state to a) measure and monitor progress on the SDGs, b) strategize and prioritize the state's actions and c) support collection and compilation of environment statistics.

The SDGs include many goals that are environmentally related. To this end, all 169 targets and 230 indicators falling under 17 SDG goals were screened to identify environmentally-related SDGs (the ones which directly or indirectly contribute to environmental sustainability) and most related to Uttarakhand state. Each of the indicators identified through the DPSIR framework was further linked to its contributing SDG target(s) and SDG goal(s).

INDICATOR FEASIBILITY ASSESSMENT

The DPSIR-SDG analysis helped to identify several indicators across the 8 sub-sectors. These indicators represent the most relevant environmental issues in the Uttarakhand context. As a next step, these were further analysed based on their measurability, analytical soundness, data source and other data characteristics.

It was found that most of the "driving force" indicators are very broad indicators and common across sectors. A few of them are difficult to quantify. Most of the "pressure" indicators are quantifiable. However not all are measured regularly. It will also be important to determine the threshold beyond which these indicators actually start exerting a detrimental pressure. "State" indicators are straightforward sound indicators and data for most of them is easily available. Some of the "Impact" indicators are difficult to quantify and are not measured regularly. However, quite a few of them are important as they represent unique non-overlapping aspects which would not be accounted for in the other category. "Response" indicators are quantifiable and measured regularly. Hence, from the DPSIR analysis, a mix of "State", "Impact" and "Response" indicators for each sector were finalized. The "Response" indicators will reward points for policy measures taken by the government towards environmental sustainability and the "State" and "Impact" indicators will rewards/penalize based on the actual state of the resources. Hence, "State", "Impact" and "Response" will complement each other.

The indicators were analysed and further mapped with relevant data sources and corresponding state departments against each selected indicator. As a next step, a final list of indicators against relevant sectors along with the concerned line department was prepared. One-on-one consultations were held with select departments to validate the indicator list and fill all data gaps

Regular follow-ups were done with the departments to obtain requisite data for the index. The SEPI has 77 indicators, Annexure 1 lists the meta-tables for each indicator. The meta-tables give the total description of the indicator -- type, linkage to SDG, the measures, rationale for inclusion, unit, base year value, current year value, data source, etc.

IMPUTATION OF MISSING DATA

In the case of certain important indicators, the data is not readily available. Currently, there are 17 such indicators for which data is either awaited from government departments, not collected regularly or not collected at all. For some of these indicators data collection has started only in recent years and is not available for 2014 and 2015. These indicators will be updated in the following years as data becomes available and do not have an effect on the SEPI calculation at present.

Such indicators present an opportunity to identify new data sources or put in place monitoring processes for collecting data on these vital indicators. Some of these are SDG indicators and putting in place processes to monitor them is a step towards institutionalizing the SDGs in Uttarakhand.

Sectors	Water & Sanitation										SDG	SDG Goal
DPSIR	Indicator	Year / Period		Last available data	Data Source	Base year value	Min. Value	Max. Value	Target Method	% change method	Target	
State	% villages free from drinking water scarcity	2015-16	+ve	99.987%	UK-DES	Collected for 2014-15	0%	100%	Maybe 0 villages target	Yes	6.1	
	% of total blocks falling under Safe zone category in the state	2011	+ve	94.74%	SGWB website	Last available for 2011			Maybe 0 districts target	Yes	6.1, 6.4	
	% of monitoring stations meeting prescribed water quality (drinkable, fishable and swimmable i.e Class A)	2016	+ve	41.94%	PCB	2015 data from website (50% i.e 8/16 monitoring stations)	0%	100%	100% target?	Yes	6.3	
Impact	Incidence of water borne diseases (Acute Diarrhoeal Diseases, Enteric Fever (Typhoid), Viral Hepatitis (All Causes) & Cholera)	2016	-ve	1,55,776 cases	Health Dept	1,53,336 cases in 2015	0%	100%	Maybe 0 cases target	Yes	3.9	

Figure 48: Illustrative example of the water and sanitation sector

Table 57 Treatment of Indicators with Missing Data

No. of Indicators	Data and Indicator Status
60	Data available. Indicator included in SEPI calculations.
3	Data collection started in recent years and so not available for 2014 and 2015. Dummy values included in SEPI calculations which do not have an effect on SEPI value. The indicator will be updated in future years as data becomes available.
10	Data awaited or not available. Dummy values included in SEPI calculations which do not have an effect on SEPI value. The indicator will be updated in future years as data becomes available.
4	Removed but after AHP weightage exercise. Dummy values included in SEPI calculations which do not have an effect on SEPI value.

NORMALIZATION

The indicators have varied units of measurements owing to which normalization of the dataset is required before aggregation. There are several ways of normalizing data each of which has its pros, cons and data requirements. Ranking, z-scores, min-max, distance to target, categorical scale and percentage difference are some examples.

It was decided not to follow any target-based normalization as targets are set through policy actions which fluctuate. Also every indicator does not have a target. Similarly, establishing minimum-maximum values for each indicator is also not feasible. Ranking and categorical scale are simpler normalization methods. However, information is lost and cannot be evaluated on absolute terms. Keeping the above and our dataset in mind, percentage of difference over the base year value method has been selected for the SEPI. In this method each indicator is measured based on its percentage change with respect to a base year value of that indicator instead of the absolute level. 2014 has been taken as the base year.

WEIGHTAGE AND AGGREGATION

Weightages have been assigned at two levels of aggregation – between sectors and across indicators within each sector. In the field of composite indices, the issues of weighting and aggregation are particularly sensitive and subjective. There is no clear consensus among experts on how best to determine a methodological strategy for combining diverse issues. Furthermore, the process of assigning weightings is as much of a political process as it is a scientific process. Hence, weights for the SEPI were established following participatory methods involving key stakeholders. The Analytical Hierarchy Process (AHP) was used to calculate weightages or coefficients for indicators and sectors relative to each other. This method takes into account the participants' perception on the quality of data, importance of the indicators, data characteristics and the degree relevance to the index's objectives. Box 1 elaborates the instructions provided to participants of the group convergence exercise conducted during the project workshop in Mukhteshwar.

Aggregation of indicators can be done using the arithmetic or geometric mean. The geometric mean punishes extremely low scores more harshly per unit than better scores. Thus, in order to achieve high performance, performance has to be adequate across all indicators and excellent in some. Unfortunately, geometric aggregation is difficult to communicate, and thus reduces the transparency of the index. Hence, aggregation was done following the arithmetic mean in the case of SEPI.

Box 1: Group Convergence Exercise: Analytic Hierarchy Process

The Sustainable Environmental Performance Index (SEPI) for Uttarakhand consists of various indicators spread across 8 sectors. The relative contribution of these indicators towards measuring environment sustainability goals in Uttarakhand vary and hence it is important to give weights prior to aggregation. To do this in an unbiased and transparent manner, we propose to conduct a group convergence exercise during this workshop to take into account varied perspectives of multi-sectoral expertise of the participants through the Analytic Hierarchy Process (AHP).

AHP is a theory of measurement that relies on the judgements of experts making pair-wise comparisons between elements (indicators or sectors) to derive priority weights.

Nine pair-wise comparison matrice sheets are enclosed. Eights sheets are for assigning weights to indicators within each of the 8 sectors and 1 sheet for assigning weights between sectors.

The comparison matrix presents the indicators within that sector, represented as "A, B, C, D ", along the rows and columns:

We request you to fill each entry of the matrix based on your expertise. Each cell entry represents the importance of the row indicator relative to the column indicator. For example, value of X_{AC} shows how important indicator A is to indicator C.

In the case of the row indicator being less important than the column indicator, we request you to leave that cell entry blank. For example, X_{CA} C is less important than A, then this cell should be left empty. The value the cell X_{CA} is the reciprocal of X_{AC} which will be filled by you once you complete the entire table.

To make comparisons, we need a scale of numbers that indicates how many times more important one indicator is over another indicator with respect to judging environmental sustainability. Table 1 exhibits this scale. You can assign any number between 1 - 9.

6.4.2 OVERVIEW OF ENVIRONMENT RELEVANT SEPI SECTORS

FOREST AND BIODIVERSITY SECTOR

Uttarakhand's total forest cover, according to India's State of Forest Report 2017, is about 24,295 square kms, which is 45.43 per cent of its total geographic area. In addition to forests, the state of Uttarakhand is endowed with a number of life-sustaining natural resources in terms of glaciers, rivers, soil, minerals and air. Despite its rich natural base, Uttarakhand is losing its dense forests. The area under Moderately Dense Forest (MDF) has reduced by 718 sq.kms and Open Forest (OF) has increased by 558 sq.kms as per the India State of Forest Report 2017.

The forestry and biodiversity sector has important links with various other sectors as well such as agriculture, animal husbandry, water resources and alternative energy. Since a large portion of the population of Uttarakhand is dependent on forests for their basic needs such as fuel and fodder, it is important to conserve forests and biodiversity. SEPI will help to improve forest and biodiversity management practices through monitoring of multiple strategies and initiatives in the state to minimize the impacts of human-induced activities and promote the overall well-being of the state and its people.

WATER AND SANITATION SECTOR

Uttarakhand's water resources, notably water from the Himalayan glaciers and rivers, address the water needs of people of the state and a significant part of India as a whole. However, despite the state's multiple water reserves including rivers, several snow-fed glaciers and lakes, many districts of Uttarakhand face acute water scarcity. Water resources are diverted for activities in many sectors including agriculture, energy, tourism and forestry. Many of the state's rural water supply system no longer meets community needs, especially when frequent landslides damage water pipes and infrastructure. The agriculture sector is the greatest consumer of water in the state, accounting for 75 per cent of the total demand. Increasing population and the rising standard of living also led to a great demand for water. Deterioration of water quality has been reported by many villages in the state. SEPI recognizes the critical importance of water resources to the state and covers all water-related issues. This will ensure water resources management in the state on an ongoing basis.

ENERGY SECTOR

Uttarakhand is one of the few states in India which not only has high hydro potential of 18,175 MW but also has higher per capita consumption than the national average of 1000 kWh (per capital consumption of the state has steadily grown from 1,012 kWh in FY 12 to 1,154 kWh in FY 15). Uttarakhand has also notified policies/ schemes for promotion of clean energy and energy efficiency measures in the state. With an increase in energy consumption in households/industries and an increase in irrigation needs, the supply–demand deficit will increase. The geographical conditions in the state, with many villages in remote areas, makes access difficult. Further, there are frequent natural calamities such as landslides and cloudbursts. There is need to promote efficient and reliable access to energy for the rural population and promote efforts for harnessing the potential of renewable energy through solar energy, micro hydro-projects, biogas and biomass energy in industries.

DISASTER RISK AND VULNERABILITY SECTOR

Uttarakhand state is vulnerable to and has been devastated repeatedly by many hazards that include earthquakes, landslides, floods, flash floods, droughts and avalanches. These have inflicted heavy loss of human lives, infrastructure, property and other resources. The state falls in either Zone IV or Zone V of the Earthquake Zonation Map of India. Pithoragarh, Bageshwar, Chamoli and Rudraprayag districts together with some areas of Almora, Champawat, Tehri, Uttarkashi and Pauri district fall in Zone V while Udhamsingh Nagar, Nainital, Haridwar and Dehradun districts fall fully in Zone IV. As per the Vulnerability Atlas of India, around 56 per cent houses in Uttarakhand are constructed using mud, un-burnt bricks and stone walls. This is enough to highlight structural vulnerability of the built environment, particularly to seismic tremors to which the state is highly vulnerable. Even though it is not always possible to prevent occurrence of natural hazards, with efforts and planning it is possible to reduce such calamities.

Here, SEPI becomes significantly important in ensuring a high level of preparedness at all times and at all levels for disaster risk reduction. SEPI is designed in such a way that it monitors all phases of disaster management. The indicators in this sector covers structural, environmental and institutional measures thereby aiming to build disaster resilience in the state by preventing and reducing hazard exposure and vulnerabilities to disaster.

TOURISM AND EDUCATION SECTOR

Uttarakhand also known as the Abode of the Gods, has several popular pilgrimage places. It is an ideal destination for several adventure sports activities because of its geographical attributes. Rishikesh is a major centre for yoga study in Uttarakhand. The state also has numerous peaks, mountains and pristine high-altitude lakes of interest to mountaineers, trekkers and outdoor enthusiasts. Uttarakhand ranks eighth among the states of India in terms of tourist arrivals, which are expected to grow exponentially. Increased tourism activities will put tremendous pressures on existing resources and infrastructure.

It will cause severe stress on the fragile Himalayan ecosystems, which are already reeling under the pressure of water scarcity, excessive constructions, heavy usage of fuelwood and improper waste management, to name a few.

Inadequate management planning, poor environmental awareness, increase in traffic and pollution pose severe and negative impacts on the environment. The indicators under this sector covers aspects such as the need for conducting carrying capacity studies, promoting more responsible and community- based tourism in the state.

HUMAN HEALTH AND AIR QUALITY SECTOR

Unplanned development, together with rapid urban growth and the inflow of tourists and pilgrims, has made critical health impacts on the population of Uttarakhand. Further, climate change has aggravated these effects which can be direct, such as through increased heat stress and loss of life in floods and storms, or indirect, through changes in the range's disease vectors, such as mosquitoes, water-borne pathogens and water and air quality. The wide range of studies has shown that climate change is bound to affect the basic requirements for maintaining health. It leads to extremes and violent weather events and the resurgence of disease organisms and vectors. It affects the quantity and quality of air and water, agriculture and the stability of the ecosystems on which we depend.

Increasing traffic and exhaust as well as industrial emissions are raising concentrations of SO2, NOx, O3 and particulate matter in the state, which are known to damage human health. Thus, this sector becomes important in the development of SEPI and will helps to understand impacts of environmental degradation on human health by collecting, compiling and analysing relevant data and information in terms of affected cases in the state on a regular basis.

AGRICULTURE, HORTICULTURE AND ANIMAL HUSBANDRY SECTOR

Agriculture consists of a share of 7.5 per cent in GSDP in 2013-14. The sector registered a growth rate of 4 per cent in 2013-14. Basmati rice, wheat, soybeans, groundnuts, coarse cereals, pulses, and oil seeds are the main crops of Uttarakhand. Fruits like apples, oranges, pears, peaches, litchies, and plums are horticulture products of Uttarakhand. Productivity in Udham Singh Nagar, Haridwar, Nainital and Dehradun is very high, though the productivity of the hilly area is very low. Out of the total reported area of 53.48 lakh ha, only 7.66 lakh ha (14 per cent) is under cultivation. Most of the agriculture in the state is rain-fed. The net irrigated area of the state is 3.36 lakh ha (2010-11), which is mostly confined to the plains. Therefore, watershed management programmes, soil and water conservation initiatives, rainwater harvesting, input availability and efficiency, mechanization, promoting horticulture and medicinal cultivation and compensation for crop depredation by wildlife are some key measures to promote sustainable agriculture, conservation of biodiversity and environmental security.

The livestock sector in Uttarakhand is extremely livelihood intensive and it has been estimated that, in dryland and mountain ecosystems, livestock contributes anywhere between 50 and 75 per cent of the total household income of the rural population (Twelfth Five Year Plan Approach Paper 2012—Planning Commission of India). Adequate support to these massive and highly diverse livestock populations in these regions is needed, commensurate with its importance.

WASTE MANAGEMENT SECTOR

The Himalayan region of India, characterized by a wide variation in topography, geology, soil, climate, flora, and fauna, and various ethnic groups with varied socio-cultural traditions, is a unique geographical entity of our country. Human activities in this region are the prime cause of environmental degradation within this region. Lakes and water bodies, which are also attractions for tourists, are polluted due to the uncontrolled discharge of wastewater and disposal of solid wastes.

The state which has a combined rural and urban population over a crore has its municipal solid waste management system in a total state of disarray. Uttarakhand municipal waste generation is estimated to accelerate to approximately 9500 tons per day by 2040, resulting in an estimated total of 9.0 million tons of municipal waste being generated during 2014-41. Solutions are therefore needed urgently. Thus, SEPI will assist the state in collecting and collating the necessary evidence on an ongoing basis and help identify causes of all these issues, monitor activities and plan strategies for wastewater management and reduce/recycle waste, thereby contributing a positive impact in making the environment of Uttarakhand state sustainable.

6.5 WEIGHTAGES AND SEPI RESULTS SCENARIOS

6.5.1 ANALYTIC HIERARCHY PROCESS (AHP) GROUP CONVERGENCE EXERCISE RESULTS

The table below shows results of the AHP group convergence exercise to determine weights across sectors and of indicators within sectors. These and the following weightage tables were arrived at as a result of the AHP group convergence exercise with 24 participants from 9 state government departments.

Across sectors, the Forest and Biodiversity sector got the highest average weightage (26 per cent) followed by the Human Health and Air Quality (14.5 per cent), Water and Sanitation (13.4 per cent), Energy (12.6 per cent) and Waste Management (11.9 per cent). Tourism and Education received the lowest weightage (3.5 per cent). Figure 49 shows the variation in weightage scores by the 5 groups during the AHP exercise. It can be seen that there were no great variations among the scores. Forest and Biodiversity was given the highest weightage by 4 of the 5 groups. Similarly, Tourism and Educations received the lowest weightages by 4 of the 5 groups.

Table 58 Weightages Across Sectors

S.No.	All Groups Average Weightage	Sector's Name
A	26.0%	Forest and Biodiversity (FB)
B	13.4%	Water and Sanitation (WS)
C	12.6%	Energy (EN)
D	9.0%	Disaster Risk and Vulnerability (DRV)
E	3.5%	Tourism and Education (TED)
F	14.5%	Human Health and Air Quality (HAQ)
G	9.1%	Agriculture, Horticulture and Animal Husbandry (AHA)
H	11.9%	Waste Management (WM)

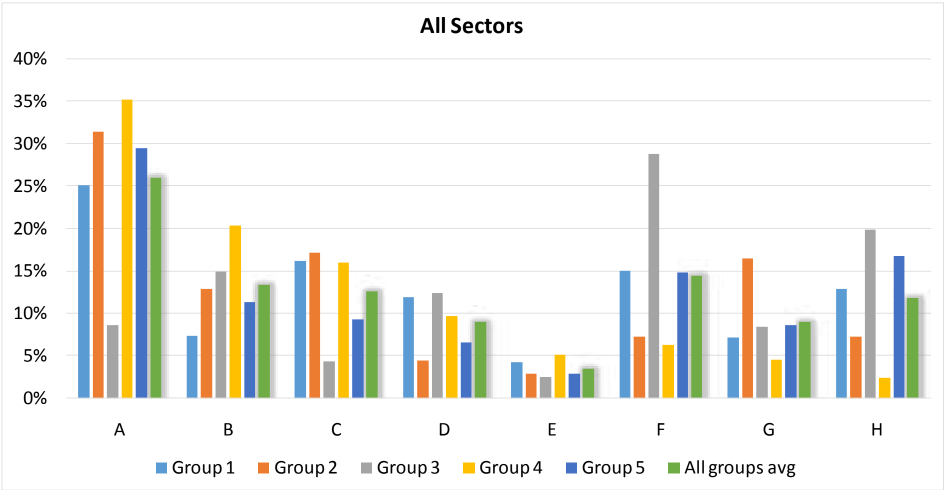


Figure 49 Group-wise Weightages Across Sectors

The table below presents the weightage distribution among indicators within each of the 8 sectors.

Table 59 Forest and Biodiversity Sector Weightages

S.No.	Average Weightage	Indicator Description
A	13.0%	% forest area under VDF and MDF forests
B	12.7%	% area under tree cover with reference to total geographical area
C	6.6%	% of total species not in IUCN RED list (BSI info)
D	7.6%	% of endemic species not in IUCN RED list (BSI info)
E	11.8%	Diversion of forest land (including roads, payjal, transmission lines, mining, dams and others)
F	4.4%	Man-animal conflict (human deaths and injury)
G	2.5%	Man-animal conflict (livestock deaths)
H	2.8%	Man-animal conflict (crop area damaged)
I	2.3%	Man-animal conflict (houses damaged)
J	2.7%	Animal deaths due to man-animal conflict (tigers, leopards and elephants) excluding natural deaths
K	11.1%	Tree plantations / Area afforested
L	9.8%	Total area under protected areas (NP, WLS and CRs)
M	5.0%	Households using clean fuel for cooking (LPG, biogas or electricity)
N	4.3%	Total no. of BMCs formed till date
O	3.5%	Total no. of contracts signed till date under the Access and Benefit Sharing mechanism (ABS)

Table 60: Water and Sanitation Sector Weightages

S.No.	Average Weightage	Indicator Description
A	12.7%	% of total blocks falling under safe zone category (<70% GW utilization) in the state
B	12.3%	% of monitoring stations meeting prescribed water quality (drinkable, fishable and swimmable i.e Class A)
C	22.6%	Incidence of water-borne diseases (acute diarrhoeal diseases, enteric fever (typhoid), viral hepatitis (all causes) and cholera)
D	10.0%	% villages with tapped drinking water
E	7.7%	% irrigation potential used for irrigation potential created till date
F	13.6%	% of domestic waste water treated
G	21.0%	% of population living in ODF (gramin) free villages

Table 61: Energy Sector Weightages

S.No.	Average Weightage	Indicator Description
A	12.2%	Households using clean fuel for cooking (LPG, Biogas or electricity)
B	11.9%	% households having access to electricity
C	21.7%	% of renewable energy mix in installed capacity (MW) of power utilities in the state (includes: small hydro, biogas, biomass, waste and wind energy)
D	25.5%	Energy Intensity
E	11.0%	% observations on which air quality has been reported at safe levels (average of PM10, SO2, NO2)
F	5.6%	Prevalence of Chronic respiratory diseases (asthma/ bronchitis / emphysema)
G	5.0%	Installed community solar cooker till date
H	7.0%	Solar Photo Programme (Solar Lantern and Solar Light-Street) till date

Table 62: Disaster, Risk and Vulnerability (DRV) Weightages

S.No.	Average Weightage	Indicator Description
A	12.2%	Number of occurrence disasters reported (avalanche, cold and exposure, landslide, lightning and other natural causes)
B	9.3%	Number of chronically disaster-prone villages in Uttarakhand
C	6.2%	% of area under flood-prone zones
D	7.3%	% of area under landslide-prone zones
E	10.4%	Annual loss of human life due to natural disasters in Uttarakhand state
F	6.0%	Annual loss of animals due to natural disasters in Uttarakhand state
G	4.2%	Annual loss of agricultural land due to natural disasters in Uttarakhand state
H	5.7%	Annual loss of property/infrastructure due to natural disasters in Uttarakhand state

I	8.2%	Total area affected due to forest fire incidents
J	5.6%	No. of 10 days Search and Rescue and First Aid training programmes conducted
K	5.9%	No. of 6 days mason training on earthquake safe construction
L	9.3%	Number/area of chronic landslide zones treated
M	9.8%	Fire lines prepared by FD

Table 63: Tourism and Education Sector (TED) Weightages

S.No.	Average Weightage	Indicator Description
A	31.7%	Number of tourist destinations covered under study to assess carrying capacity
B	12.2%	% of registered home stays to total infrastructure in the Uttarakhand state
C	29.7%	Number of ecotourism destinations setup in the state
D	14.0%	Number of eco clubs in schools/colleges
E	12.4%	Number of trainings for promoting ecotouism courses related to environmental education in government schools and colleges

Table 64: Human Health and Air Quality Sector (HAQ) Weightages

S.No.	Average Weightage	Indicator Description
A	20.0%	% observations on which air quality has been reported at safe levels
B	15.9%	% of urban area under tree cover
C	23.4%	Life expectancy in the state
D	10.0%	% households having tapped water connections
E	15.9%	Incidence of water-borne diseases
F	8.9%	Prevalence of respiratory diseases
G	5.9%	% of pesticides on global banned list and also banned in the state

Table 65: Waste Management (WM) Weightages

S.No.	Average Weightage	Indicator Description
A	6.2%	Total solid waste generated in the state
B	7.8%	Average per capita waste water generation in 92 towns
C	11.6%	% of monitoring stations meeting prescribed water quality (Class A)
D	20.6%	% of waste water treated before discharge
E	11.4%	% of total biomedical waste treated by certified agencies
F	12.5%	% of total hazardous waste treated by certified agencies
G	13.1%	% of total e-waste treated/recycled by certified agencies
H	9.1%	% of air polluting industries having pollution control and monitoring devices
I	7.7%	% of construction, demolition waste (CandD) recycled

Table 66: Agriculture, Horticulture and Animal Husbandry (AHA) Weightages

S.No.	Average Weightage	Indicator Description
A	5.3%	Annual per hectare NPK fertilizer consumption
B	13.3%	Per acre productivity in the state
C	4.2%	% deficit in fodder requirement and availability in the state
D	6.2%	% of indigenous breeds compared with total of the state
E	8.4%	Forest land diversion to agriculture
F	7.0%	Pesticide per hectare consumption
G	13.0%	Area under organic certification in the state
H	11.0%	% irrigation potential used for to irrigation potential created till date
I	8.5%	Number of seed banks in the state
J	7.6%	Area brought under grassland development and grass reserve
K	5.8%	Number of fodder banks established till date in the state
L	4.8%	Total number of BMCs formed till date
M	5.0%	Total number of contracts signed till date under Access and Benefit Sharing (ABS) mechanism

6.5.2 UTTARAKHAND SEPI RESULTS FOR 2015-16

This section presents SEPI results across four scenarios with weightages given based on varying frameworks.

Scenario 1: SEPI estimated with weightages for indicators within sectors and weightages between sectors based on results of the AHP group convergence exercise explained in Section 1.5.1.

Scenario 2: SEPI estimated with weightages for indicators within sectors based on AHP group convergence exercise and equal weightages taken between sectors.

Scenario 3: SEPI estimated with weightages for indicators within sectors based on SIR framework* and equal weightages taken between sectors.

Scenario 4: SEPI estimated with weightages for indicators within sectors based on SIR framework and weightages between sectors based on the AHP group convergence exercise.

*SIR framework: Within each sector the indicator weights are allocated based on SIR (State-Impact-Response) category. The total weights assigned to “State” indicators category = 0.3, “Impact” indicators category = 0.2 and “Response” indicators category = 0.5. Within each category weights are split equally. For example, if there are 4 response indicators in a particular sector, each indicator within the response category will get weightage = 0.5/4 = 0.125.

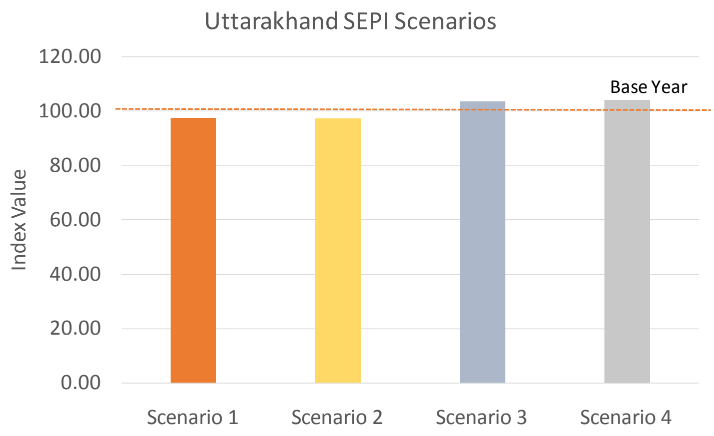


Figure 50: Uttarakhand SEPI Scenarios

Scenario 1: Sector-wise Results The sector-wise and overall SEPI scenario 1 results are presented in Table 67. Index and sub-index values above 100 show an improvement over base year (2014) values and values below 100 indicates a decline in environmental performance since 2014. These estimates are based on 77 validated indicators and their corresponding weights determined using group AHP Group Convergence workshop. There were data gaps or limitations for 17 of these 77 indicators as elaborated in Table 57 Dummy values (showing no change) have been used for these 17 indicators.

Table 67: SEPI 2015-16 Results and Sector Sub-Indices Results

	Sector	Sector Sub-Index	Sector Weights	Weighted Sector Totals
1	Forest and Biodiversity (FB)	100.45	26.0%	26.11
2	Water and Sanitation (WS)	98.15	13.4%	13.14
3	Energy (EN)	116.40	12.6%	14.72
4	Disaster Risk and Vulnerability (DRV)	61.26	9.0%	5.53
5	Tourism and Education (TED)	105.12	3.5%	3.72
6	Human Health and Air Quality (HAQ)	92.18	14.5%	13.33
7	Agriculture, Horticulture and Animal Husbandry (AHA)	108.34	9.1%	9.82
8	Waste Management (WM)	95.44	11.9%	11.33
	SEPI 2015-16	97.71		

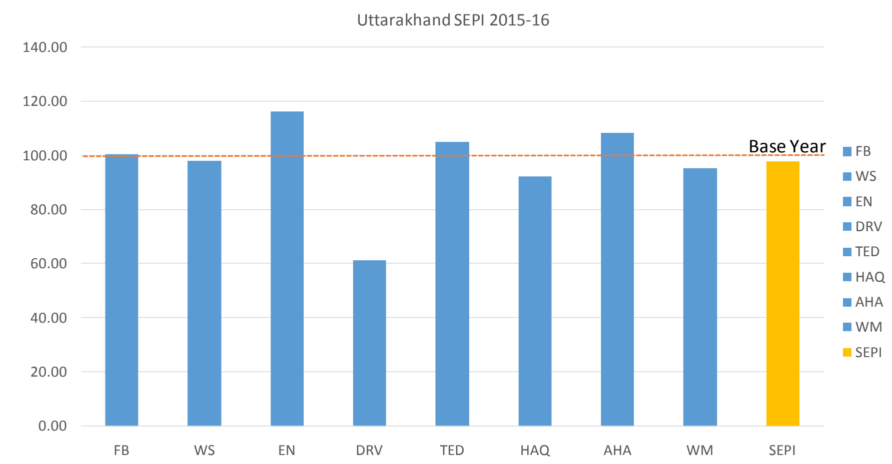


Figure 51: SEPI 2015-16 Results and Sector Sub-Indices Results Over 2014 Base Year Values

6.6 SEPI DISCUSSION

OVERALL AND INTER-SECTOR PERFORMANCE

The overall environmental performance of Uttarakhand has deteriorated marginally in 2015-16 when compared with 2014-15. The decline is caused by poor performance in sectors such as disaster risk and vulnerability, human health and air quality and waste management.

Increasing forest fires and loss to animal life due to natural disasters are causes of concern. In 2015, 4,433 Ha of area was affected owing to forest fires. Another major priority area is the state of air and water quality, both of which are in decline. These are linked to SDG 3 and SDG 6 i.e. Good Health and Well-Being and Clean Water and Sanitation, respectively. Hence, despite Uttarakhand being declared an ODF state, sanitation can improve further by focusing on cleaning water bodies and air quality, particularly in the Terai areas.

Average per capita waste water generation in 92 towns of Uttarakhand has risen from 67 LPCD to 90 LPCD. This is expected with increased migration to the Terai regions. However, waste water treatment before discharge did not improve with only 25.3 per cent being treated.

The sectors which have performed well during SEPI 2015 are Energy and Agriculture, Horticulture and Animal Husbandry. Uttarakhand has performed well on Sustainable Development Goal 7 (Affordable and Clean Energy). The renewable energy share in the state's total installed capacity has increased. Households using clean fuel for cooking such as LPG, biogas or electricity has increased as well.

There has been a steady growth in areas under organic certification. The deficit in fodder availability and requirement is reducing as well. Response measures such as forming biodiversity management committees (BMCs) and signing contracts under the Access and Benefit Sharing mechanism (ABS) have also seen an improvement.

6.7 INTRA-SECTOR PERFORMANCE

6.7.1 FOREST AND BIODIVERSITY

Forest and biodiversity performance has remained stable with a marginal increase. The good performers in this sector have been households using clean cooking and signing contracts under the Access and Benefit Sharing mechanism (ABS). Forest cover and tree plantations are more or less similar as in 2014. A cause for concern is the rise in the man-animal conflict leading to livestock death, crop damage and damage to houses. This may probably be linked to the other poor performing indicator, i.e. increase in diversion of forest land.

6.7.2 WATER AND SANITATION

The performance of the Water and Sanitation sector has decreased to 98.15 in 2015 when kept as 100 in 2014. This decrease is due to poor water quality and increased incidence of water-borne diseases. The good performers in this sector have been the fact that 100 per cent of population live in ODF villages now and 99.99 per cent have tapped drinking water.

6.7.3 ENERGY

The energy sector has been the best performer in 2015. As mentioned earlier, this can be attributed to a rise in renewable energy share in the state's total installed capacity as well as an increase to 51 per cent of the households using clean fuel for cooking such as LPG, biogas or electricity. Household electrification as stood at 99.52 per cent in 2015. Another good performer is the decline in energy intensity from 2014. The only bad performer in this sector is poor air quality recorded at monitoring stations.

6.7.4 DISASTER RISK AND VULNERABILITY

The Disaster Risk and Vulnerability sector records the poorest performance in SEPI 2015. As mentioned earlier, this is on account of increased area affected by forest fires, loss of animals due to natural disasters and rise in the number of chronically disaster-prone villages. However, the response indicators show an improvement with an increase in Search and Rescue and First Aid training programmes.

6.7.5 TOURISM AND EDUCATION

The good performing indicators in this sector have been an increase in the number of trainings and festivals organized for promoting ecotourism and an increase in the number of ecotourism destination setups. This sector, however, lacks data. There is a dearth of data on the effect of the tourism sector on the environment. Recently a few important studies have been commissioned such as studies to assess the carrying capacity of population tourist destinations. So far this has been done for 105 tourist destinations in Uttarakhand. Such indicators will be updated in future as data becomes available.

6.7.6 HUMAN HEALTH AND AIR QUALITY

Human health and air quality sector has not performed well in 2015. This is a serious cause of concern since it is linked to critical sustainable development goals such as Goal 3: Good Health and Well-Being. Air quality (PM10, SO2, NO2) has declined in the urban areas. Incidence of water-borne diseases has increased to 1,51,250 cases of acute diarrhoeal diseases, enteric fever (typhoid), viral hepatitis (all causes) and cholera a year. Prevalence of asthma/ chronic respiratory diseases however witnessed a decline despite the poor air quality.

6.7.7 AGRICULTURE, HORTICULTURE AND ANIMAL HUSBANDRY

This sector has performed well in 2015. There has been a steady increase in areas under organic certification. The deficit in fodder availability and requirement is reducing as well. Response measures such as forming biodiversity management committees (BMCs) and signing contracts under the Access and Benefit Sharing mechanism (ABS) have also seen an improvement. However, the decline in the share of indigenous livestock to total livestock should not be ignored.

6.7.8 WASTE MANAGEMENT

The Waste Management sector needs improvement. Average per capita waste water generation in 92 towns of Uttarakhand has risen from 67 LPCD to 90 LPCD. This is expected with increased migration to the Terai regions. However, waste water treatment before discharge did not improve with only 25.3 per cent being treated. The effect of this is also evident with decline in water quality as recorded at monitoring stations. This sector has three important indicators for which data collection has been initiated only in recent years. These are:

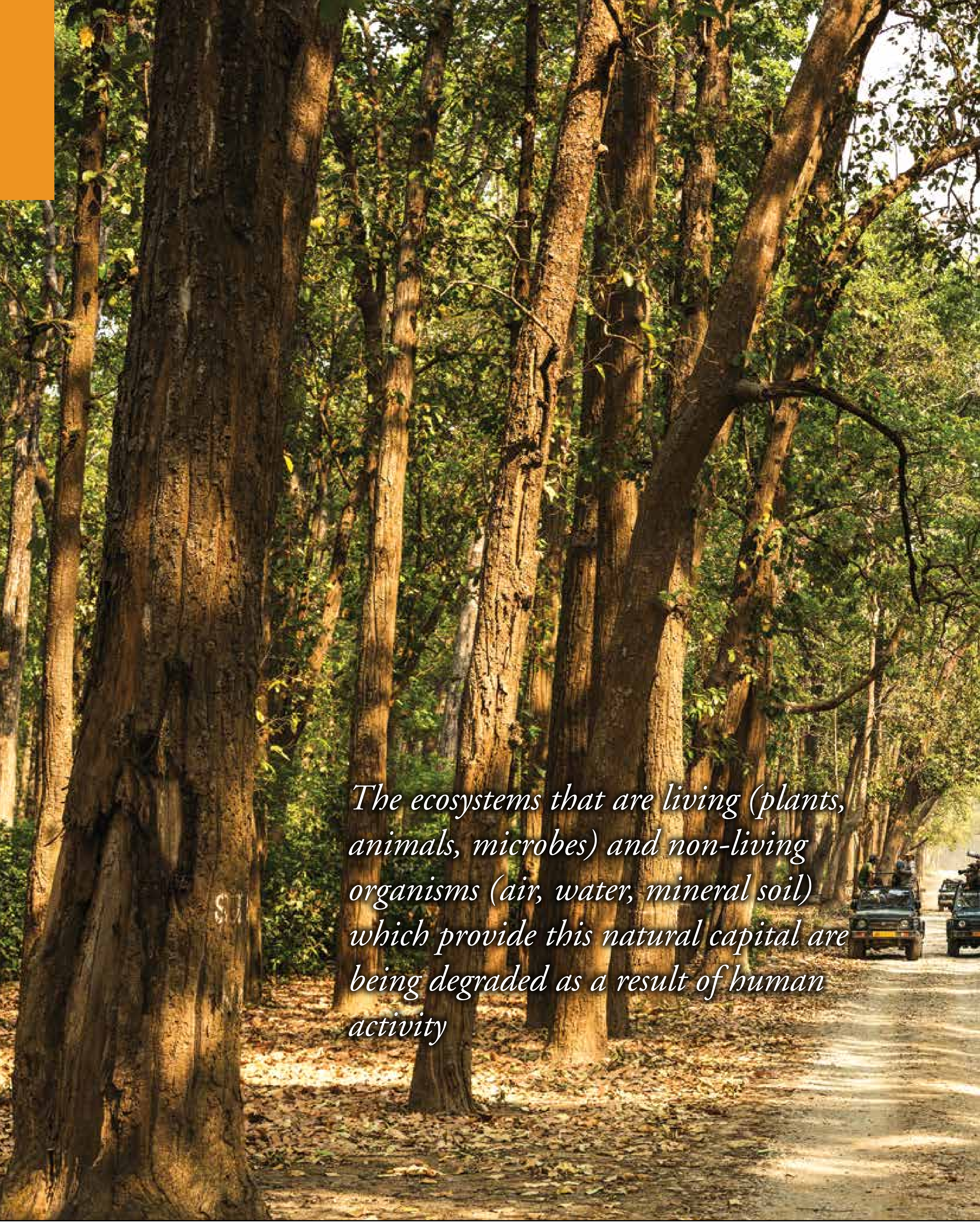
- % of total biomedical waste treated by certified agencies
- % of total hazardous waste treated by certified agencies
- % of total e-waste treated/recycled by certified agencies

These indicators will be updated in future as data becomes available for more years.

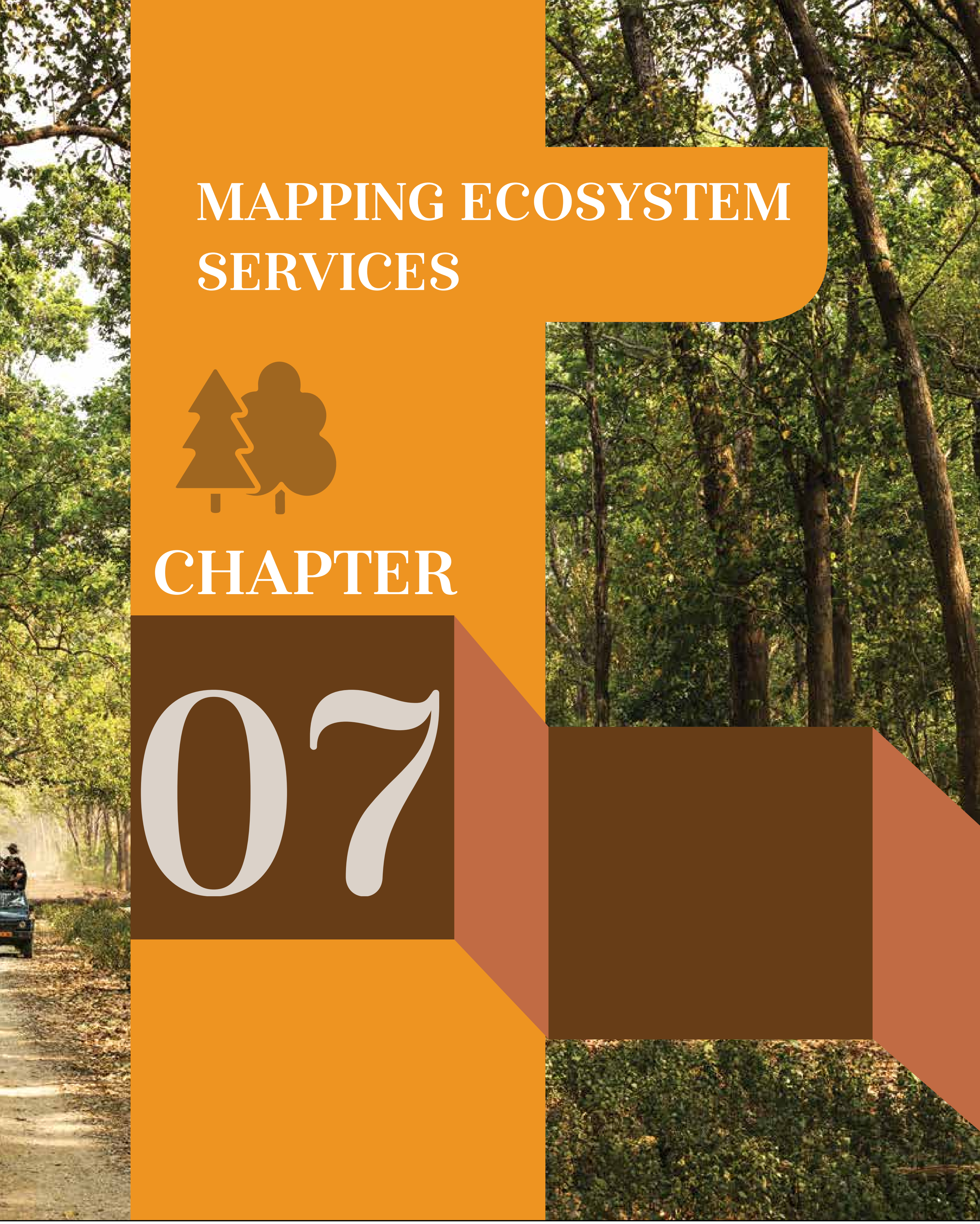
6.8 CONCLUSION

To ensure a holistic and sustainable growth, the Sustainable Environment Performance Index (hereby referred to as SEPI) for the state of Uttarakhand has been developed in the section. Such an index complements economic indices such as the State / District GDP.

The index aggregate indicators reflect state of air quality, water quality, land use and agriculture, forests and biodiversity; measures of the impact of the current state of the environment and resource extraction on ecosystem and human health; and policy responses and society's efforts to preserve the environment. Different scenarios based on weightages given to the sectors and indicators have been discussed. SEPI so formed may help prioritize the sectors on which the Government of Uttarakhand should focus. A total of 68 indicators were incorporated in the index as per the relevance and availability of the data within the state which may be further expanded based on activities related to any of the eight sectors considered in the current study. Such an index will be very effective if updated annually.



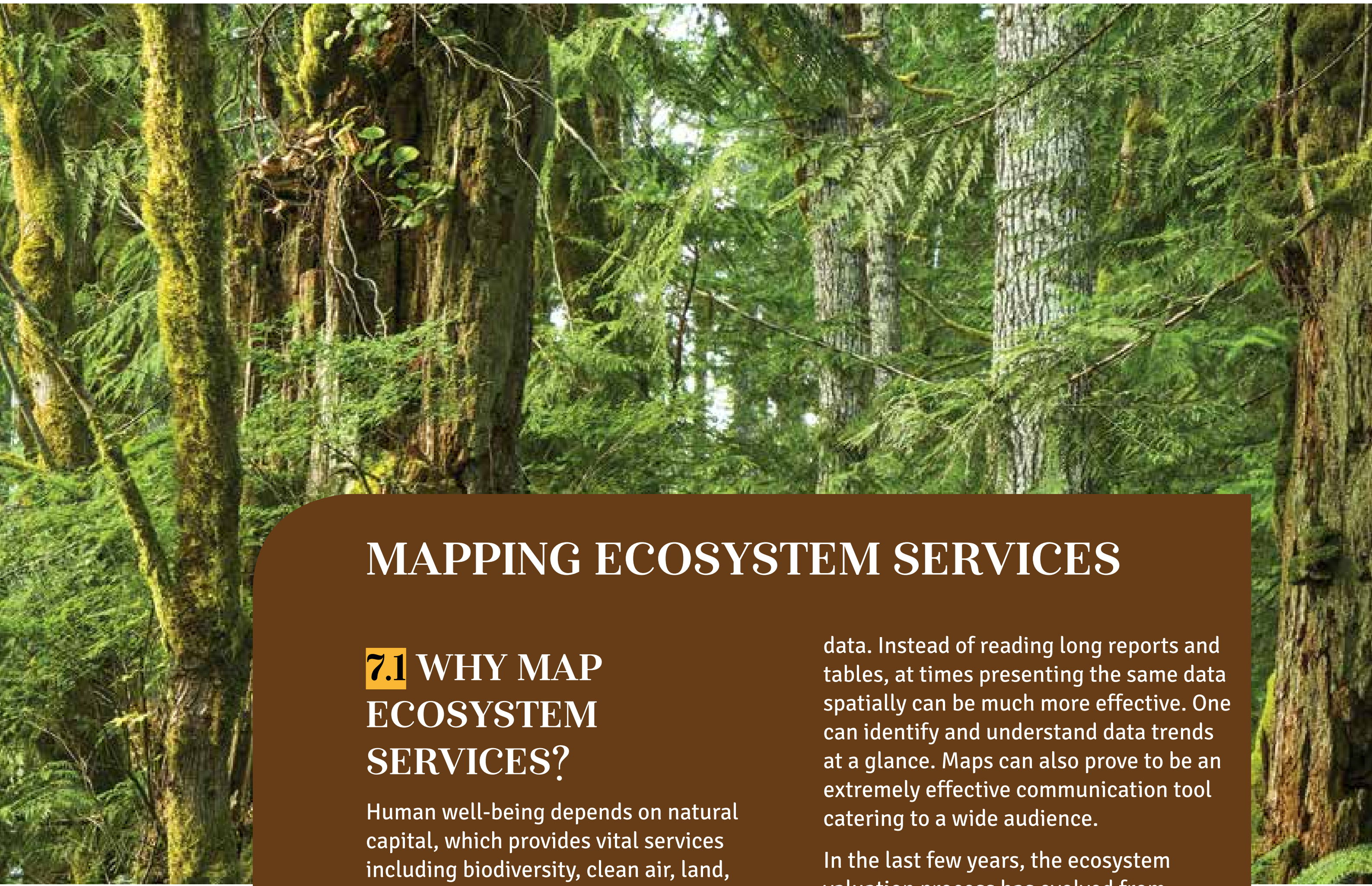
The ecosystems that are living (plants, animals, microbes) and non-living organisms (air, water, mineral soil) which provide this natural capital are being degraded as a result of human activity



MAPPING ECOSYSTEM SERVICES

CHAPTER

07



MAPPING ECOSYSTEM SERVICES

7.1 WHY MAP ECOSYSTEM SERVICES?

Human well-being depends on natural capital, which provides vital services including biodiversity, clean air, land, and water, natural flood protection and climate regulation. However, the ecosystems that are living (plants, animals, microbes) and non-living organisms (air, water, mineral soil) which provide this natural capital are being degraded as a result of human activity (Newbold et al., 2015). Therefore, there is an urgent need to protect and enhance this natural capital and thus, spatially explicit mapping and assessment is needed to understand to what extent and where these processes occur.

Maps provide a quick and easy-to-read representation of otherwise detailed data. Instead of reading long reports and tables, at times presenting the same data spatially can be much more effective. One can identify and understand data trends at a glance. Maps can also prove to be an extremely effective communication tool catering to a wide audience.

In the last few years, the ecosystem valuation process has evolved from analytical models to GIS-based spatial simulation models. These simulation models are able to comprehend the local ecosystem characteristics in a better way, thus enriching the overall valuation. Such a mapping of ecosystem services can provide very useful management prescriptions for forest resources to optimize the flow of ecosystem services. Ecosystem analysis and mapping can form a valuable knowledge base for policymakers, enabling them to look at the spatial variations in the pressures on different ecosystems.

7.2 AVAILABLE TOOLKITS FOR BIOPHYSICAL ASSESSMENTS

The paper (Bagstad, Semmens, Waage, and Winthrop, 2013) evaluated 17 multiple ecosystem service tools and their applicability to environmental decision-making across both public- and private-sector contexts. These tools have been identified that assess, quantify, model, value and map ecosystem services. The majority of ecosystem service tools seek to quantify services and their trade-offs at a landscape scale in order to support scenario analysis using simplified underlying biophysical models or "ecological production functions" (Daily et al., 2009). Also, the most appropriate tools and approaches depend on the issue to be addressed, the data and resources available, and the technical capacity to conduct assessments. Many of the tools listed in Table 68 are complementary and can be used at different stages of the process of assessing in natural capital.

Table 68: Description of Various Tools for Biophysical Assessment of Ecosystem Services (Bagstad et al., 2013)

Tool	Quantifiable, Approach to Uncertainty	Time Requirements	Capacity for Independent Application	Level of Development and Documentation	Scalability	Generalizability	Nonmonetary and Cultural Perspectives	Affordability Insights, Integration with Existing Environmental Assessment
ESR	Qualitative	Low, depending on stakeholder involvement in the survey process	Yes	Fully developed and documented	Multiple scales	High	No valuation	Most useful as a low-cost screening tool
InVEST	Quantitative, uncertainty through varying inputs	Moderate to high, depending on data availability to support modelling	Yes	Models fully developed and documented	Watershed or landscape scale	High, though limited by availability of underlying data	Biophysical values, can be monetized	Spatially explicit ecosystem service trade-off maps
ARIES	Quantitative, uncertain through Bayesian networks and Monte-Carlo simulation	High to develop new case studies, low for pre-existing case studies	Yes, through web explorer or standalone software tool	Fully documented; case studies complete but global models and web tool under development	Watershed or landscape scale	Low until global models are completed	Biophysical values, can be monetized	Spatially explicit ecosystem service trade-off, flow, and uncertainty maps; currently time-consuming for new applications
LUCI	Quantitative, currently does not report uncertainty	Moderate; tool is designed for simplicity and transparency, ideally with stakeholder engagement	Yes, detailed user manual available	Initial documentation and case study complete	Site to watershed or landscape scale	Relatively high; a stakeholder engagement process is intended to aid in "localizing the data and models"	Illustrates trade-offs between services but does not include valuation	Spatially explicit ecosystem service trade-off maps; designed to be relatively intuitive to use and interpret

MIMES	Quantitative, uncertainty through varying inputs	High to develop and apply new case studies	Yes, assuming user has access to SIMILE modelling software	Some models complete but not documented	Multiple scales	Low until global or national models are completed	Monetary valuation via input-output analysis	Dynamic modelling and valuation using input-output analysis; currently time-consuming to develop and run
EcoServ	Quantitative, uncertainty through varying inputs	High to develop new case studies, low for pre-existing case studies	Yes	Under development, not yet documented	Site to landscape scale	Low until global and national models are completed	Biophysical values, can be monetized	In development, will offer spatially explicit maps of ecosystem service trade-offs
Costing Nature	Quantitative	Low	Yes	Partially documented	Landscape level	High	Output indexed, bundled ecosystem service values	Rapid analysis of indexed, bundled services based on global data, along with conservation priority maps
SolVES	Quantitative, no explicit handling of uncertainty	High if primary surveys are required, low if function transfer approach is used	Yes, assuming user has access to ArcGIS	Fully developed and documented	Watershed or landscape scale	Low until value transfer can be shown to successfully estimate values at new sites	Non-monetary preferences (ranking) of relative values for stakeholders	Provides maps of social values for ecosystem services; time-consuming for new studies but lower cost for value transfer
Envision	Quantitative	High to develop new studies	Yes	Developed and documented for Pacific and Northwest case study sites	Landscape level	Place specific	Allows non-monetary trade-off comparison, also supports monetary valuation	Cost-effective in regions where developed; time consuming for new applications

EPM	Quantitative	High to develop new case studies, low for existing case studies	Yes, through web browser	Developed and documented for three case study sites	Watershed or landscape scale	Place specific	Ecological economic, and quality of life attributes could support non-monetary valuation	Cost-effective in regions where developed; time-consuming for new applications
InFOREST	Quantitative	Low, accessed through online interface	Yes, through web browser	Developed and documented only for Virginia	Site to landscape scale	Currently place specific	Designed as a credit calculator, no economic valuation	Cost-effective in regions where developed; time-consuming for new applications
EcoAIM	Quantitative	Relatively low for basic mapping, greater for non-monetary mapping	No	Public documentation not available	Watershed or landscape scale	High	Incorporates stakeholder preferences via modified risk analysis approach	Spatially explicit ecosystem service trade-off maps; relatively time- consuming to run
ES Value	Quantitative, uncertainty through Monte Carlo simulation	Relatively high to support consultant stakeholder valuation process	No	Public documentation not available	Watershed or landscape scale	High	Non-monetary preferences via ranked analysis of trade-offs by stakeholders	Stakeholder based relative ecosystem service value assessment; relatively time-consuming
Eco Matrix	Quantitative	Relatively low to support field visits and data analysis	No	Public documentation not available	Site scale	High where ecological production functions are available	Designed as credit calculator, no economic valuation	One method for site scale ecosystem services assessment

NAIS	Quantitative, reports range of values	Variable depending on stakeholder involvement in developing the study	No	Developed but public documentation unavailable	Watershed or landscape scale	High, within limits of point transfer	Dollar values only	Point transfer for "ballpark numbers" building awareness of values
Ecosystem Valuation Toolkit	Quantitative, reports range of values	Assumed to be relatively low	Yes	Under development	Watershed or landscape scale	High, within limits of point transfer	Dollar values only	Point transfer for "ballpark numbers" building awareness of values
Benefit Transfer and use Estimating Model Toolkit	Quantitative, uncertainty through varying inputs	Low	Yes	Fully developed and documented	Site to landscape scale	High	Dollar values only	Low cost approach to monetary valuation

ERS - Ecosystem Services Review	InVEST – Integrated Valuation of Ecosystem Services and Trade-Offs
ARIES - Artificial Intelligence for Ecosystem Services	LUCI - Land Utilization and Capability Indicator
MIMS - Multiscale Integrated Models of Ecosystem Services	SolVES - Social Values for Ecosystem Services
EPM - Ecosystem Portfolio Model	

7.3 INVEST

The current study applies one of the most widely used tools for mapping ecosystem services, Integrated Valuation of Ecosystem Services and Trade-Offs (InVEST) developed by the Natural Capital Project at Stanford University in partnership with the Chinese Academy of Science, University of Minnesota, The Nature Conservancy and World Wildlife Fund. It is a suite of free, open-source software models used to map and value the goods and services from nature that sustain and fulfil human life.

InVEST enables decision-makers to assess quantified trade-offs associated with alternative management choices and to identify areas where investment in natural capital can enhance human development and conservation. The toolset currently includes eighteen distinct ecosystem service models designed for terrestrial, freshwater, marine, and coastal ecosystems, as well as many “helper tools” to assist with locating and processing input data and with understanding and visualizing outputs.

InVEST models are spatially-explicit, using maps as information sources and producing maps as outputs. InVEST returns results in either biophysical terms (e.g. tons of carbon sequestered) or economic terms (e.g. net present value of that sequestered carbon).

However, InVEST is a data-hungry tool. Constrained by data availability for Uttarakhand, we applied 2 of the 18 models available in the InVEST 3.0 package for the entire state of Uttarakhand. These include the Carbon Storage and Sequestration: Climate Regulation Model and the Water Yield: Reservoir Hydropower Production Model.

Table 69: Data Requirements for InVEST Models (Tallis et al., 2018)

InVEST Data and Model Inventory

	Step	Data requirements	Process	Outputs
Biodiversity: Habitat Quality and Rarity (Tier 0)				
Required	**Supply**	Current Land use/land cover Threat impact distance Relative threat impact weights Form of threat decay function Threat maps Habitat suitability (optional: by species group) Habitat sensitivity to threats Half saturation constant	Calculate habitat quality and degradation based on threat intensity and sensitivity	Habitat degradation index; Habitat quality index
Optional	**Supply**	Protected status		
		Baseline land use/land cover	Calculates rarity of current and/or future habitat types relative to baseline; calculates quality and degradation of baseline based on threat intensity and sensitivity	Relative habitat rarity index for current and/or future land use/land cover; Degradation and quality for baseline
		Future land use/land cover	Calculates quality and degradation of future scenario based on threat intensity and sensitivity; optionally calculates habitat rarity relative to baseline	Habitat degradation, quality and optionally rarity for future scenario

Carbon Storage and Sequestration

Required	Service	Land use/land cover Carbon in aboveground biomass Carbon in belowground biomass Carbon in dead organic matter Carbon in soil	Looks up carbon stock(s) per pixel	Total carbon stock (Mg/pixel)
Optional	Service	Carbon removed via timber harvest First year of timber harvest Harvest frequency Half life of harvested wood products Carbon density in harvested wood Biomass conversion expansion factor	Calculates carbon stored in harvested wood products per pixel	Total carbon stock, including that in HWP (Mg/pixel)
		Future land use/land cover	Calculates difference between carbon stocks	Carbon sequestration rates (Mg/pixel/yr)
Optional	Value	Value of sequestered carbon Discount rate Timespan Annual rate of change in price of carbon	Calculates value of carbon	Value of sequestered carbon (currency/pixel/yr)

Hydropower Production (Tier 1)

Required	Supply	Land use/land cover Mean annual precipitation (mm) Mean annual reference evapotranspiration (mm) Plant available water content (fraction) Evapotranspiration coefficient Root depth (mm) Effective soil depth (mm) Seasonality factor	Calculates pixel level yield as difference between precipitation and actual evapotranspiration	Mean annualyield (mm/watershed/yr, mm/pixel/yr)
Required	Service	Consumptive use by LULC Subwatershed and Watershed shapefiles	Subtracts water consumed forby different land use and cover	Mean annual water yield available for hydropower production (mm/watershed/yr,
Optional	Value	Calibration coefficient Turbine efficiency (0.7-0.95) Inflow volume for hydropower (fraction) Hydraulic head (m)	Estimates power for a given volume of water	Energy production (KWH/watershed/yr, KWH/pixel/yr)
		Operation cost (currency) Hydropower price (currency) Life span of the hydropower station (years) Discount rate (%)	Calculates net present value of energy produced over lifetime of dam	Net present value (currency/watershed/yr, currency/pixel/yr)

Water Purification: Nutrient Retention (Tier 1)

Required	Supply	Land use/land cover DEM Water yield (output from Hydropower model; refer to Hydropower model for input data requirements) Export coefficient in kg/ha/yr (for nutrient(s) of interest) Nutrient filtration efficiency (%)	Calculates nutrient export and retention	Nutrient export (kg/watershed/yr, kg/pixel/yr) Nutrient retention (kg/watershed/yr, kg/pixel/yr)
Required	Service	Allowed level of nutrient pollution Subwatershed and watersheds shapfiles	Subtracts retention equal to amount of allowed pollution	water purification through ecosystem nutrient retention (kg/watershed/yr, kg/pixel/yr)
Optional	Value	Mean annual nutrient removal costs Lifespan (years) Discount rate (%)	Calculates present value of costs	Avoided treatment costs (currency/watershed/yr,c basin/yr)

Sediment Retenion Model: Avoided Dredging and Water Quality Regulation (Tier 1)				
Required	**Supply**	Land use/land cover	Calculates generated and retained sediment at pixel scale using USLE and routing	Mean annual erosion (tons/watershed/yr, tons/pixel/yr) Mean annual sediment retention (tons/watershed/yr, tons/pixel/yr)
		Rainfall erosivity		
		Soil erodibility		
		Crop factor		
		Management factor		
		DEM		
		Sediment retention efficiency for each LULC		
		Slope threshold (%)		
		Flow accumulation threshold		
Required	**Reservoir Service**	Reservoir dead volume (reservoir points of interest)	Subtracts sediment loads in reservoir dead volume	Mean annual generated and retained sediment loads (tons/watershed/yr.
		Subwatershed and Watershed shapfiles		
Required	**Treatment Plant Service**	Allowed sediments load in rivers (TMDL, etc.)	Subtracts sediment loads equal to allowed load	Annual average sediment retention of value to water treatment plants
Optional	**Avoided Dredge Value**	Mean annual dredging cost (Currency)	Calculates present value of dredging costs	Avoided dredge costs (currency/watershed/yr, currency/pixel/yr)
		Lifespan (years)		
		Discount rate (%)		
	Avoided Treatment Value	Mean annual sediment removal cost (Currency)	Calculates present value of treatment costs	Avoided treatment costs (currency/watershed/yr, currency/pixel/yr)
		Lifespan (years)		
		Discount rate (%)		

Managed Timber Production (Tier 1)				
Required	**Service**	Location of timber parcels	Calculates amount of timber harvested	Harvested timber volume (m3/parcel/yr) Harvested timber biomass (Mg/parcel/yr)
		Area per timber parcel		
		Proportion of timber harvested per parcel per period		
		Wood biomass harvested per parcel per period		
		Harvest period per parcel		
		Harvested wood mass:volume conversion factor		
Optional	**Value**	Market price of timber	Calculates net present value of timber harvested	Net present value of timber (currency/parcel/yr)
		Annual average plantation maintenance costs		
		Annual average harvest costs		
		Timeframe into future harvests will be valued		
		Discount rate		

Crop Pollination (Tier 0)				
Required	**Supply**	Land Use/Land Cover	Calculates relative abundance of pollinators	Index of pollinator abundance (relative abundance/pixel, relative abundance/watershed)
		Nesting Habitat Preference		
		Relative Index of seasonal pollinator activity		
		Relative availability of nesting habitat types		
		Relative abundance of flowers per LULC		
		Average foraging distance		
Required	**Service**	Relative abundance index (supply from above)	Calculates relatve abundance of pollinators visiting each farm	Index of relative pollinator abundance on farms (relative abundance/farm)
Optional	**Value**	**Crop half saturation constant**	Calculates relative additional value of pollination	Index of crop yield value from pollination (relative value/pixel)

Food from Fisheries

Required	**Supply**	spatial structure life history traits: age/stage-specific survival, fecundity, age structure productivity (R/S) fishing mortality rate (age/stage specific)	estimates adult abundance available for harvest or escapement; trend (lambda) of returns	Number of total returns (escapement + catch) or escaped spawners per year or trend in returns or escapement
Required	**Service**	harvest management strategy: 1. sector-specific catch or harvest rate; or 2. target escapement and sector-specific allocation	estimates number of landed fish from each population	number of fish landed per year by sector (commercial and subsistence)
Optional	**Value**	Annual average sediment removal cost market price operating costs	Calculates present value of fish landed	net present value of fish landed by sector

Food from Aquaculture

Required	**Service**	farm operations (number of fish, feed, target harvest weight, weight at outplanting, date of outplanting, fallowing practices) farm locations temperature	estimates biomass of fish produced per farm	Biomass of fish produced per farm
Optional	**Value**	operating costs market price revenues	Calculates present value of fish produced per farm	net present value of fish produced per farm

Protection from coastal erosion

Required	**Supply**	wind field wave field bathymetry tides shoreline type/backshore characteristics benthic biogenic habitats topography (optional)	calculates attenuated wave height; calculates total water level from run-up (via wave height and wave set-up) and/or via storm surge; calculates cross-shore erosion	area of shoreline lost per storm event
Required	**Service**	Land use/land cover map (location of properties or beaches eroded) location and type of infrastructure placed in nearshore region	calculates avoided loss of beach or shoreline w&w/o biogenic habitat	avoided loss of property or infrastructure per event (private property); avoided loss of beach per event (private property)
Optional	**Value**	value of property or beaches eroded Beach carrying capacity beach nourishment costs value of infrastructure eroded shoreline hardening costs	Calculates present value of damage per event, of a beach visitor, beach nourishment or shoreline hardening.	value of avoided property or infrastructure damage per event; value of avoided dune nourishment or shoreline protection; value of avoided tourist revenue lost

Protection from coastal inundation				
Required	**Supply**	wind field wave field bathymetry tides shoreline type/backshore characteristics benthic biogenic habitats topography	calculates attenuated wave height; calculates total water level from run-up (via wave height and wave set-up) and/or via storm surge; calculates stability of sand dunes	area of property or infrastructure flooded per event
Required	**Service**	Land use/land cover map (location of properties or beaches eroded) location and type of infrastructure placed in nearshore region	calculates avoided area flooded w&w/o biogenic habitat	avoided property or infrastructure damage per event
Optional	**Value**	value of property inundated dune nourishment costs value of infrastructure inundated man-made shoreline protection construction costs	Calculates present value of flooded area or infrastructure, costs of dune nourishment or added shoreline protection	value of avoided property or infrastructure damage per event; value of avoided dune nourishment or shoreline protection
Wave energy generation				
Required	**Supply**	wave height wave period bathymetry tides	calculates wave power resource from wave data	wave power resource at each location
Required	**Service**	device attributes (conversion efficiency) array design array location	calculates captured wave energy	captured wave energy per array (MWh)
Optional	**Value**	capital costs (e.g., device, cables, etc.) operating costs revenue life span of array facility	Calculates present value of electricity captured per array	net present value of electricity captured from waves per array
Aesthetic value from viewsheds				
Required	**Supply**	attributes of marine environment (location of natural desired features & development/infrastructure) attributes of shoreline environment (location of natural desired features & development/infrastructure) bathymetry topography	calculates points from which natral/desired or infrastructure can be observed	
Required	**Service**	access points location of public parks location of private property	calculates points from which infrastructure can be observed	number of natural (non-infrastructure or development) views per location

Recreation Value				
Required	**Supply**	location of natural desired features for recreation (e.g., whale sightings, mammal haul outs, kelp for SCUBA, beaches, etc.)	maps locations of recreation activities	
		location and quality of environmental conditions affecting recreation value (e.g., wave energy for beach enjoyment or wildlife viewing)		
Required	**Service**	location of infrastructure in support of recreation activities (e.g., campgrounds, boat launches, etc.)	calculates index of recreation importance	index of recreation importance by activity and weighted overall index
		distance between access points and activities		
		visitation rates for each location, activity		
Optional	**Value**	visitation for each activity	Calculates present value of electricity captured per array	net present value of electricity captured from waves per array
		travel costs		
		revenue from activities		

7.4 CARBON STORAGE: CLIMATE REGULATION

Terrestrial ecosystems, which store more carbon than the atmosphere, are vital to influencing carbon dioxide-driven climate change. The InVEST model uses maps of land use and stocks in four carbon pools (above ground biomass, below ground biomass, soil, dead organic matter) to estimate the amount of carbon currently stored in a landscape or the amount of carbon sequestered over time. Additional data on the market or social value of sequestered carbon and its annual rate of change, and a discount rate can be used in an optional model that estimates the value of this ecosystem service to society. Limitations of the model include an oversimplified carbon cycle, an assumed linear change in carbon sequestration over time, and potentially inaccurate discounting rates.

Carbon storage on a land parcel largely depends on the sizes of four carbon “pools:” above ground biomass, below ground biomass, soil, and dead organic matter. The InVEST Carbon Storage and Sequestration model aggregates the amount of carbon stored in these pools according to the land use maps and classifications produced by the user. Above ground biomass comprises all living plant material above the soil (e.g., bark, trunks, branches, leaves). Below ground biomass encompasses the living root systems of above ground biomass. Soil organic matter is the organic component of soil, and represents the largest terrestrial carbon pool. Dead organic matter includes litter as well as lying and standing dead wood.

7.4.1 CARBON STORAGE MODEL

The model runs on a grid map of cells called raster format in GIS. Each cell in the raster is assigned a land use and land cover (LULC) type such as forest, pasture, or agricultural land. For each LULC type, the model requires an estimate of the amount of carbon in at least one of the four fundamental pools described above. If the user has data for more than one pool, the modelled results will be more complete. The model simply applies these estimates to the LULC map to produce a map of carbon storage in the carbon pools included.

If, maps of both current and future LULC are provided, then the net change in carbon storage over time (sequestration and loss) and its social value can be calculated. To estimate this change in carbon sequestration over time, the model is simply applied to the current landscape and a projected future landscape, and the difference in storage is calculated, map unit by map unit.

Outputs of the model are expressed as Mg of carbon per grid cell, or if desired, the value of sequestration in dollars per grid cell. The developers recommend using the social value of carbon sequestration for expressing sequestration in monetary units as it is the social value of a sequestered ton of carbon which actually reflects the social damage avoided by not releasing the ton of carbon into the atmosphere.

The valuation model estimates the economic value of sequestration (not storage) as a function of the amount of carbon sequestered, the monetary value of each unit of carbon, a monetary discount rate, and the change in the value of carbon sequestration over time. Thus, valuation can only be done in the carbon model if you have a future scenario. Valuation is applied to sequestration, not storage, because current market prices relate only to carbon sequestration.

7.4.2 DATA INPUTS

Estimating carbon storage using InVEST requires two essential data inputs:

Current land use/land cover (LULC) map: It is a GIS raster dataset, with an LULC code for each cell. An LULC map of Uttarakhand provided by the Forest Survey of India was used in conjunction with a forest type density map of Uttarakhand (Figure 52). Both were for the year 2017.

Carbon pools: A table of LULC classes, containing data on carbon stored in each of the four fundamental pools for each LULC class. Only information on some carbon pools present in forest type density classes was included. This information was derived from the Forest Survey of India report titled India State of Forest Report in 2017. Other classes such as cropland, settlement and waterbodies were omitted from the map by leaving all values for their pools equal to 0. The values used in calculations are shown in Table 70.

Table 70 Biophysical Table for Carbon Calculation

Lucode	LULC_Name	C_Above	C_Below	C_Soil	C_Dead
1	Evergreen 10-40	29.09	7.68	48.86	0.2
2	Evergreen 40-70	46.31	12.15	117.52	0.36
3	Evergreen >70	71.12	20.04	96.56	1.24
4	Deciduous 10-40	12.33	3.73	40.28	0.26
5	Deciduous 40-70	42.18	14.19	57.2	1.16
6	Deciduous >70	49.83	16.09	66.96	0.81
7	Scrub 10-40	22.93	6.12	39.22	0.19
8	Scrub 40-70	29.95	8.12	75.72	0.36
9	Scrub >70	65.15	17.85	82.75	1.19

Here lucode corresponds to the code given to relevant land use in the LULC map. C_above refers to above ground carbon, C_below to below ground carbon, C_soil to carbon stored in soil and C_dead refers to carbon stored in dead and decaying biomass. All the above values are in Mg/ha

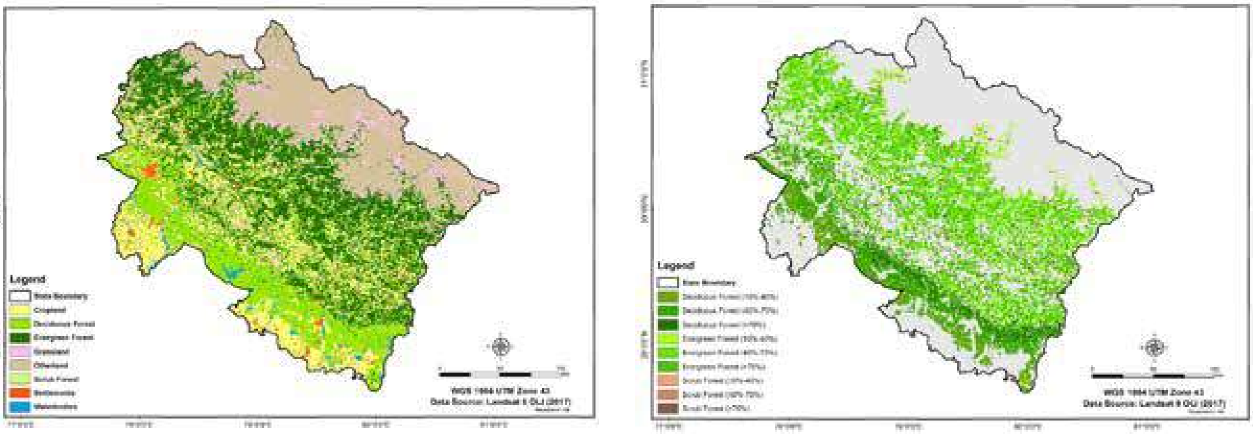


Figure 52 Uttarakhand LULC and Forest-Type Density Maps

7.4.3 MODEL OUTPUT

The InVEST model output provided a summary table and a spatial assessment of carbon stored in the forests of Uttarakhand across different pools. As per the model, the forests of Uttarakhand store 327.95 million tonnes of carbon across its four pools (Figure 54). Figure 53 shows the spatial distribution of carbon stock across Uttarakhand, while Figure 55 and Figure 56 show the distribution for each of the 4 carbon pools.

The Carbon Sequestration model could not be executed for valuation purposes due to various data and model limitations. The model calculates sequestration only when a future land use map is provided. For Uttarakhand, this would have meant providing a future land use land cover scenario map. As such a plan map has not been prepared for the state, the team decided not to use the sequestration model of InVEST. As for valuation, InVEST does valuation only for Sequestered Carbon and since the sequestration model was not executed, the valuation model could not be executed.

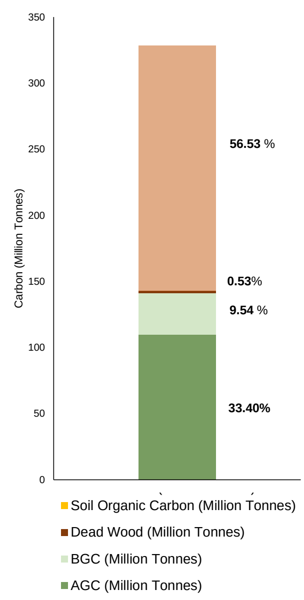


Figure 53 Carbon Storage Across Pools in Forests of Uttarakhand

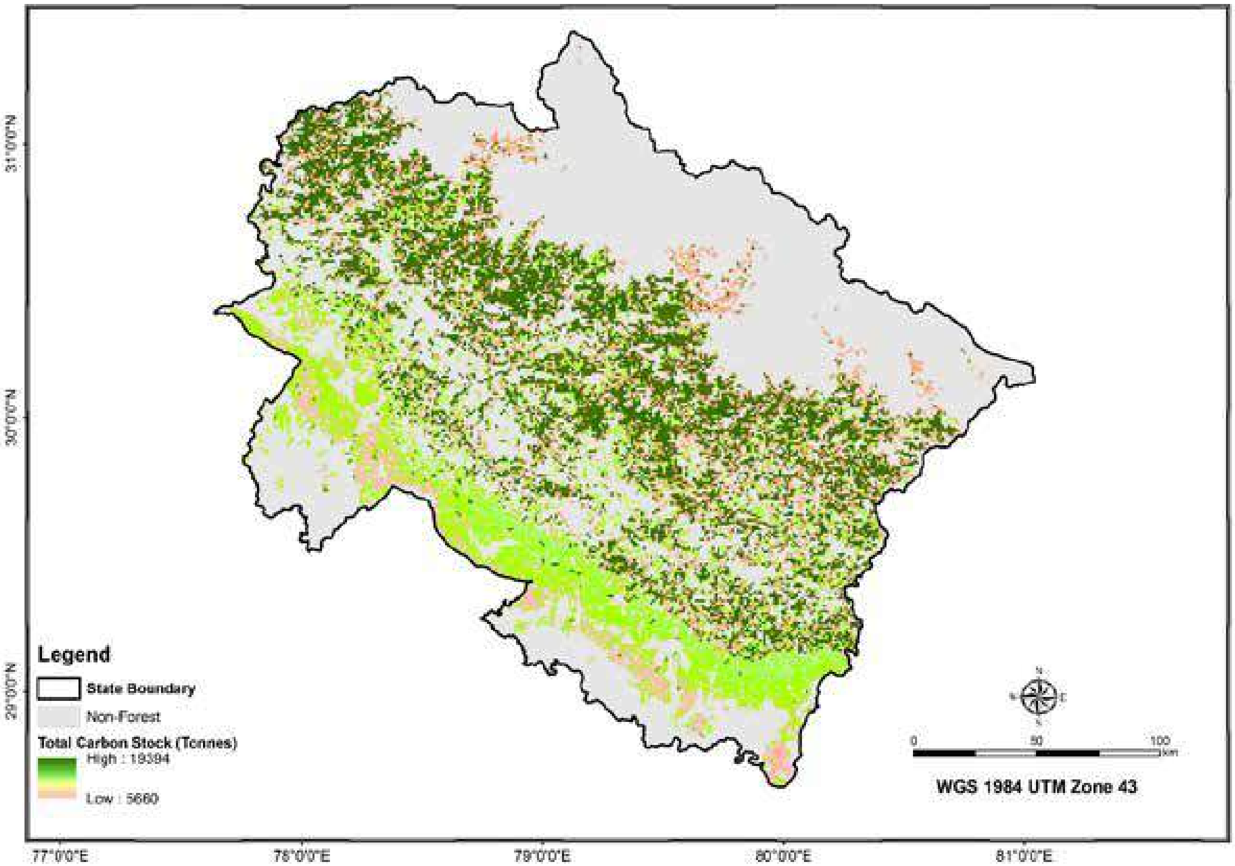


Figure 54 Carbon Storage Map of Uttarakhand

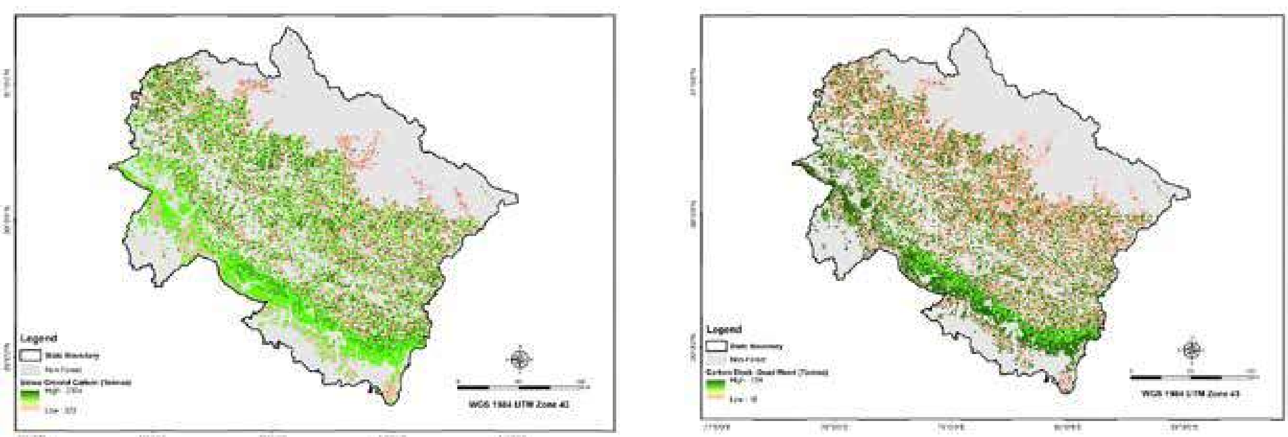
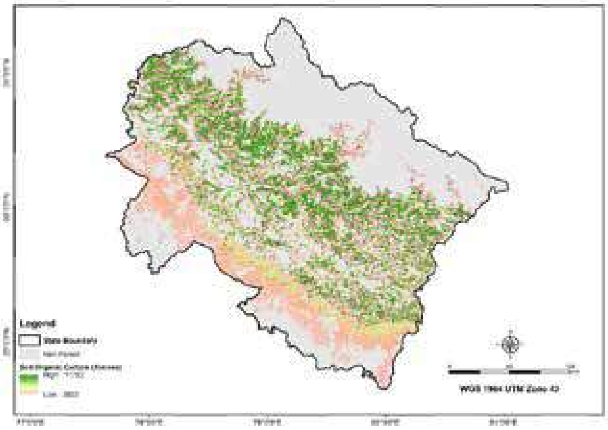


Figure 55: Uttarakhand Forest above Ground Carbon Stock Map (Top) and Below Ground carbon Map



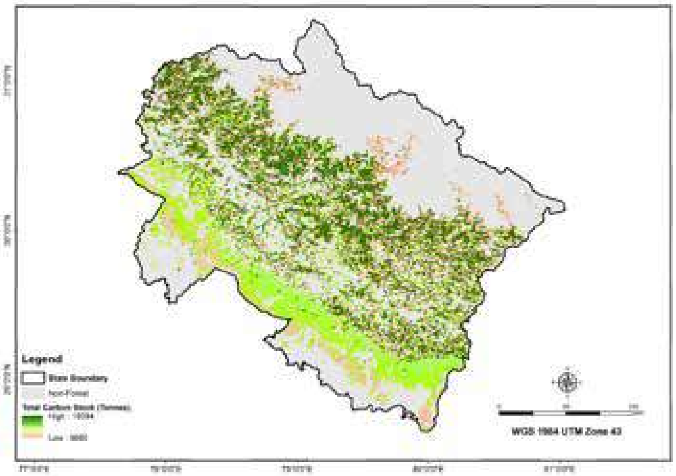


Figure 56: Uttarakhand Forest Deadwood Carbon Stock Map (Top) and soil Organic Carbon Map

7.4.4 LIMITATIONS AND SIMPLIFICATIONS

The model simplifies the carbon cycle which allows it to run with relatively limited information, but also leads to important limitations. For example, the model assumes that none of the LULC types in the landscape are gaining or losing carbon over time. Instead it is assumed that all LULC types are at some fixed storage level equal to the average of measured storage levels within that LULC type. Under this assumption, the only changes in carbon storage over time are due to changes from one LULC type to another. Therefore, any grid cell that does not change its LULC type will have a sequestration value of 0 over time. In reality, many areas are recovering from past land use or are undergoing natural succession. The problem can be addressed by dividing LULC types into age classes (essentially adding more LULC types), such as three ages of forest. Then, parcels can move from one age class to the other in scenarios and change their carbon storage values as a result.

A second limitation is that because the model relies on carbon storage estimates for each LULC type, the results are only as detailed and reliable as the LULC classification used. Carbon storage clearly differs among LULC types (e.g. tropical forest vs. open woodland), but often there can also be significant variation within a LULC type. For example, carbon storage within a “tropical moist forest” is affected by temperature, elevation, rainfall, and the number of years since a major disturbance (e.g. clear-cut or forest fire). The variety of carbon storage values within coarsely defined LULC types can be partly recovered by using a LULC classification system and related carbon pool table which stratifies coarsely defined LULC types with relevant environmental and management variables. For example, forest LULC types can be stratified by elevation, climate bands or time intervals since a major disturbance. Of course, this more detailed approach requires data describing the amount of carbon stored in each of the carbon pools for each of the finer LULC classes.

Another limitation of the model is that it does not capture carbon that moves from one pool to another. For example, if trees in a forest die due to disease, much of the carbon stored in above ground biomass becomes carbon stored in other (dead) organic material. Also, when trees are harvested from a forest, branches, stems, bark, etc. are left as slash on the ground.

The model assumes that the carbon in wood slash "instantly" enters the atmosphere.

Finally, while most sequestration follows a non-linear path such that carbon is sequestered at a higher rate in the first few years and a lower rate in subsequent years, the model's economic valuation of carbon sequestration assumes a linear change in carbon storage over time. The assumption of a constant rate of change will tend to undervalue the carbon sequestered, as a non-linear path of carbon sequestration is more socially valuable due to discounting than a linear path (Error! Reference source not found.).

7.5 WATER YIELD: RESERVOIR HYDROPOWER PRODUCTION

The "Water Yield: Reservoir Hydropower Production" model of InVEST estimates the water yield or value for each part of the landscape and its annual contribution towards hydropower production. In the current study this model has been used to assess the water provisioning service being rendered by the watersheds of Uttarakhand. The provision of freshwater is an ecosystem service that contributes to the welfare of society and is necessary for survival. The systems are designed to account for annual variability in water volume, given the likely levels for a given watershed, but are vulnerable to extreme variation caused by land use and land cover (LULC) changes. LULC changes can alter hydrologic cycles, affecting patterns of evapotranspiration, infiltration and water retention, and changing the timing and volume of water that is available for use.

The InVEST Reservoir Hydropower model estimates the relative contributions of water from different parts of a landscape, offering insight into how changes in land use patterns affect annual surface water yield. With the model identifying areas of high water yield in Uttarakhand, concentrated efforts can be made in sustaining the areas with high water yield and also improve upon areas facing degradation.

The model runs on a gridded map. It estimates the quantity and value of water used for hydropower production from each sub-watershed in the area of interest. It has three components, which run sequentially. In the first component, it determines the amount of water running off each pixel as the precipitation reduces the fraction of the water that undergoes evapotranspiration. The model does not differentiate between surface, subsurface and base flow, but assumes that all water yield from a pixel reaches the point of interest via one of these pathways. This model then sums and averages water yield to the sub-watershed level. The pixel-scale calculations allows representation of the heterogeneity of key driving factors in water yield such as soil type, precipitation, vegetation type, etc. These values are then extrapolated from sub-watershed to watershed scale.

In the second component, beyond annual average runoff, it calculates the proportion of surface water that is used for hydropower production by subtracting the surface water that is consumed for other uses. Finally in the third component, it estimates the energy produced by the water reaching the hydropower reservoir and the value of this energy over the reservoir's lifetime. This study uses the first component of this model to determine the water yield from each watershed.

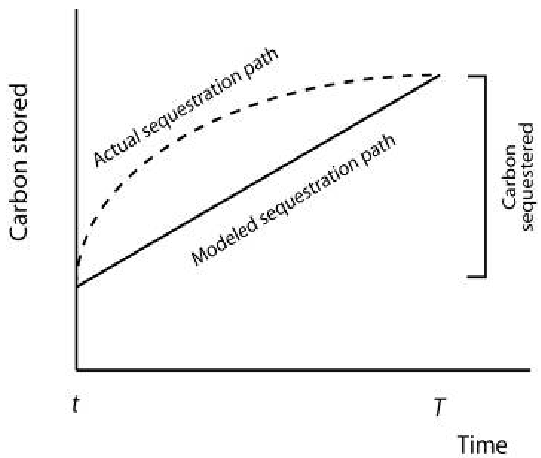


Figure 57: Difference Between Actual Sequestration and InVEST Approach

7.5.1 WATER YIELD MODEL

The water yield model is based on the Budyko curve and annual average precipitation. First, we determine annual water yield Y(x) for each pixel on the landscape x as follows:

$Y(x) = (1 - AET(x)/P(x)) \cdot P(x)$

where AET(x) is the annual actual evapotranspiration for pixel x and P(x) is the annual precipitation on pixel x.

The conceptual diagram of the water balance model is used in the hydropower production model. The water cycle is simplified, including only the parameters shown in colour, and ignoring the parameters shown in grey (Figure 58).

For vegetated LULC, the evapotranspiration portion of the water balance, AET(x)P(x) , is based on an expression of the Budyko curve proposed by Fu (1981) and Zhang et al. (2004):

$AET(x)/P(x) = 1 + PET(x)/P(x) - [1 + (PET(x)/P(x))^{\omega}]^{1/\omega}$ (1)

where PET(x) is the potential evapotranspiration and ω(x) is a non-physical parameter that characterizes the natural climatic-soil properties, both detailed below.

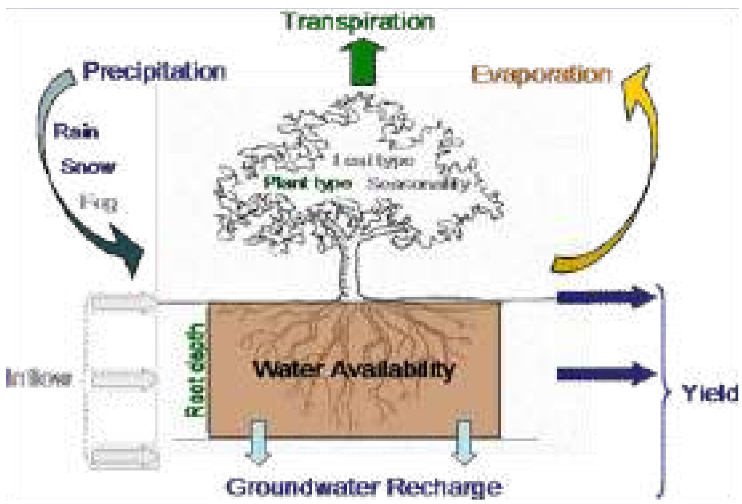


Figure 58: Conceptual Diagram of water Balance Model Used in InVest

Potential evapotranspiration PET(x) is defined as:

$PET(x) = Kc(lx)\, ET0(x)$

where, ET0(x) is the reference evapotranspiration from pixel x and Kc(lx) is the plant (vegetation) evapotranspiration coefficient associated with the LULC lx on pixel x. ET0(x) reflects local climatic conditions, based on the evapotranspiration of a reference vegetation such as grass of alfalfa grown at that location. Kc(lx) is largely determined by the vegetative characteristics of the land use/land cover found on that pixel (Allen et al. 1998). Kc adjusts the ET0 values to the crop or vegetation type in each pixel of the land use/land cover map.

(x) is an empirical parameter that can be expressed as linear function of AWC N/P, where N is the number of events per year, and AWC is the volumetric plant available water content (see below for additional details). While further research is being conducted to determine the function that best describes global data, we use the expression proposed by Donohue et al. (2012) in the InVEST model, and thus define:

$(x) = Z(AWC(x)/P(x)) + 1.25$

where:

- AWC(x) is the volumetric (mm) plant available water content. The soil texture and effective rooting depth define AWC(x), which establishes the amount of water that can be held and released in the soil for use by a plant. It is estimated as the product of the plant available water capacity (PAWC) and the minimum of root restricting layer depth and vegetation rooting depth:

AWC(x) = Min(Rest.layer.depth,root.depth) PAWC

Root restricting layer depth is the soil depth at which root penetration is inhibited because of physical or chemical characteristics. Vegetation rooting depth is often given as the depth at which 95 per cent of a vegetation type's root biomass occurs. PAWC is the plant available water capacity, i.e. the difference between field capacity and wilting point.

- Z is an empirical constant, sometimes referred to as "seasonality factor", which captures the local precipitation pattern and additional hydrogeological characteristics. It is positively correlated with N, the number of rain events per year. The 1.25 term is the minimum value of (x), which can be seen as a value for bare soil (when root depth is 0), as explained by Donohue et al. (2012). Following the literature (Yang et al., 2008; Donohue et al. 2012), values of (x) are capped to a value of 5.

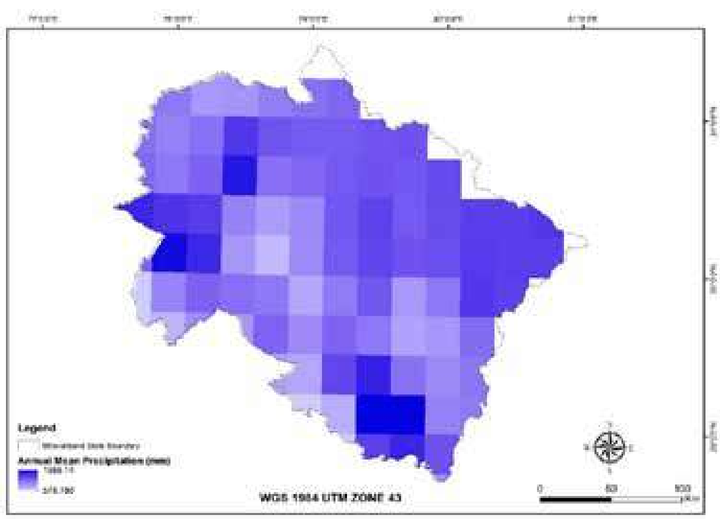


Figure 59 Annual Mean Precipitation Map

For other LULC (open water, urban, wetland), actual evapotranspiration is directly computed from the reference evapotranspiration ET0(x) and has an upper limit defined by the precipitation:

AET(x) = Min(Kc(lx) ET0(x),P(x))   (2)

where ET0(x) is the reference evapotranspiration, and Kc(lx) is the evaporation factor for each LULC.

7.5.2 DATA INPUTS

The maps and data tables used to execute Water Yield model for Uttarakhand are listed below:

- Land use/land cover (LULC) map: It is a GIS raster dataset, with an LULC code for each cell. An LULC map of Uttarakhand provided by the Forest Survey of India was used here (Figure 52).
- Annual precipitation map: This is the average annual precipitation for each cell in a GIS raster format with all non-zero values in millimetres. IMD meteorological data was used for preparing this layer (Figure 59).

- **Annual average reference evapotranspiration map:** This is a GIS raster dataset (Figure 60), with an annual average evapotranspiration value for each cell. Reference is the potential loss of water from soil by both evaporation from the soil and transpiration by healthy alfalfa (or grass) if sufficient water is available. This layer was estimated using IMD data.

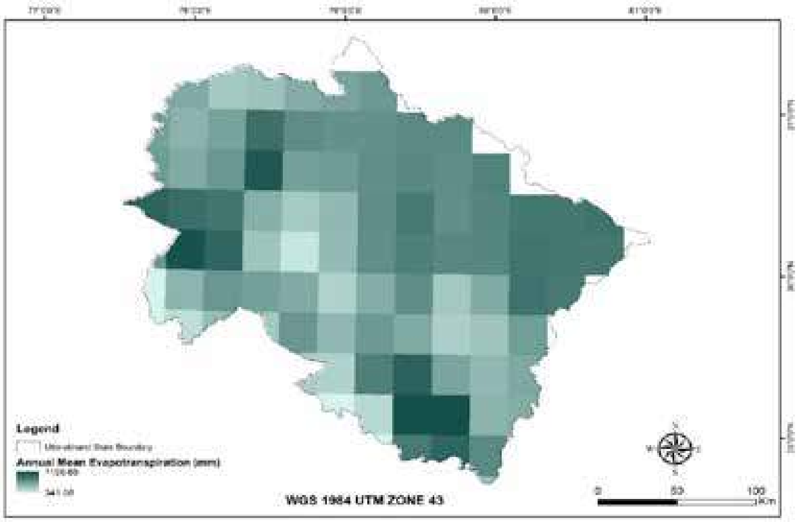


Figure 60 Annual Mean Evapotranspiration Map

- Plant available water content map: This is a GIS raster dataset (Error! Reference source not found.) with a plant available water content value for each cell. Plant Available Water Content fraction (PAWC) is the fraction of water that can be stored in the soil profile that is available for the use of plants. This layer was generated by integrating data from the Soil Survey of India and Hydrology and Water Budgeting software (SPAW) downloaded from the United States Department of Agriculture.

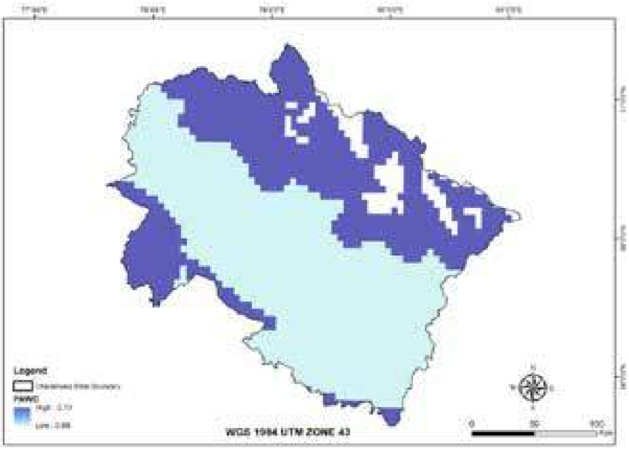


Figure 61: Plant Available Water Content Map

- **Root restricting layer depth:** This is a GIS raster dataset with an average root restricting layer depth value for each cell. The root restricting layer depth is the soil depth at which root penetration is strongly inhibited because of physical or chemical characteristics. Vegetation rooting depth is often given as the depth at which 95 per cent of a vegetation types root biomass occurs. The layer should be in millimetres and the data was obtained from soil grids, ISRIC World Soil Information. Watersheds: This is a shapefile, with one polygon per watershed. The layer was derived using the SRTM 1 arc second Digital Elevation Model on ArcGIS using hydrology tool.

Figure 62: Uttarakhand Watershed Map

- Sub-watersheds: This is a shapefile, with one polygon per sub-watershed. The layer was derived using the SRTM 1arc second Digital Elevation (Figure 63) Model on ArcGIS using hydrology tool.
- Biophysical table: It is a table of land use/ land cover (LULC) classes, containing data on biophysical coefficients used in the model. For the water yield model, the table had the following values:
  - lucode (Land use code): Unique integer for each LULC class
  - LULC_desc: Descriptive name of land use/ land cover class
  - LULC_veg: Contains the information on which AET equation to use (Eq. 1 or 2). Values should be 1 for vegetated land use except wetlands, and 0 for all other land uses, including wetlands, urban, water bodies, etc.
  - root_depth: The maximum root depth for vegetated land use classes, given in integer millimetres. This is often given as the depth at which 95 per cent of a vegetation type's root biomass occurs. As reference evapotranspiration is already estimated for each land use, rooting depth is not needed.

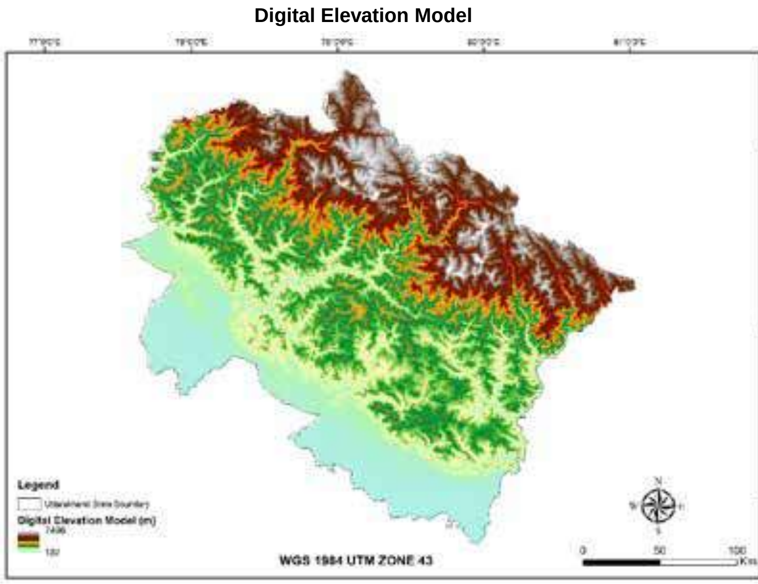


Figure 63 Digital Elevation Model (DEM) for Uttarakhand

In these cases, the rooting depth field is ignored; it may make sense for the user to set it as -1 to indicate the field is ignored (Water Yield: Reservoir Hydropower Production", InVEST).

- Kc: The plant evapotranspiration coefficient for each LULC class. Evapotranspiration coefficient (Kc) values for crops are readily available from irrigation and horticulture handbooks. FAO has an online resource for this as well.

Table 71: Biophysical Table

lucode	LULC_desc	Kc	LULC_veg
0	0	0	0
1	Evergreen	1	1
2	Deciduous	1	1
3	Scrub	0.4	1
4	Cropland	0.65	1
5	Grassland	0.65	1
6	Settlements	0.3	0
7	Otherland	0.3	0
8	Waterbodies	1.2	0

- **Z parameter:** This factor conveys the seasonal distribution of precipitation to the model. It was calculated using expert knowledge and calculation recommended in InVEST documentation. Z = estimate of number of rainfall days in a year * 0.2.

7.5.3 MODEL OUTPUT

The model estimated the total water yield volume for Uttarakhand at 10.46 billion cubic metres. This estimate does not account for consumptions as per land uses. Figure 64 indicates the spatial distribution in water yield throughout Uttarakhand.

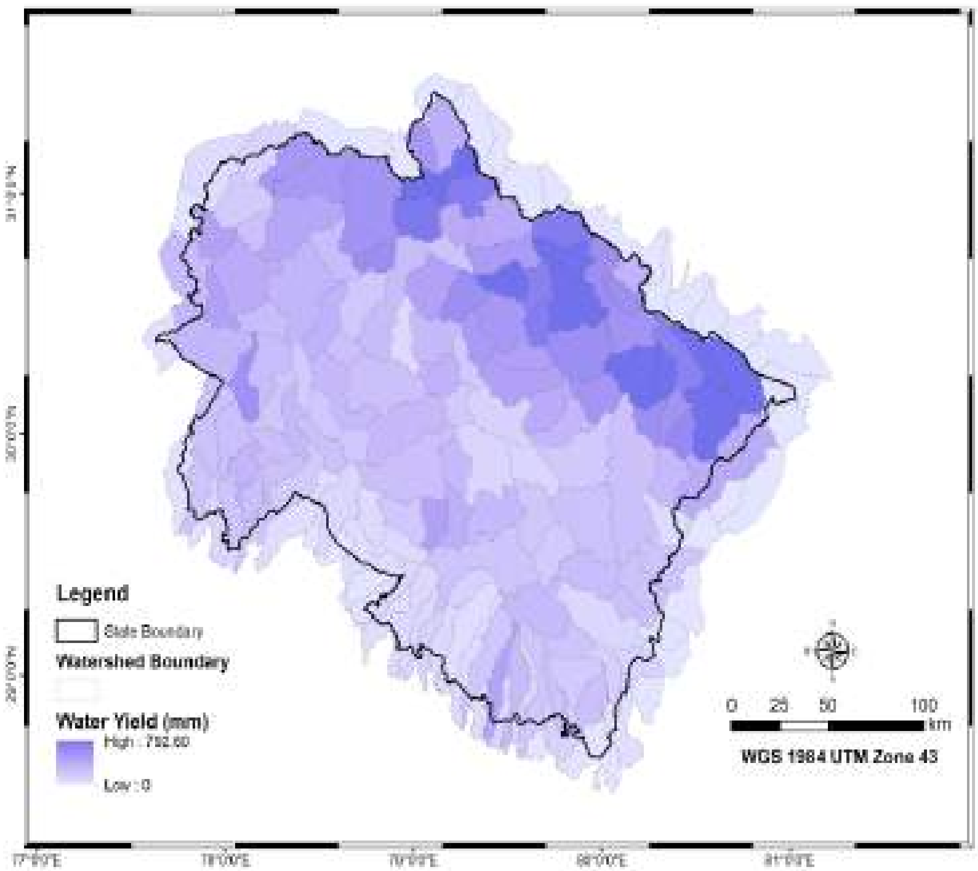


Figure 64: Water Yield output for Uttarakhand

7.5.4 CONCLUSION, LIMITATIONS AND SIMPLIFICATIONS

The current study applies one of the most widely used tools for mapping ecosystem services, Integrated Valuation of Ecosystem Services and Trade-Offs (InVEST). Constrained by data availability for Uttarakhand, 2 of the 18 available models in InVEST 3.0 package were applied for the entire state of Uttarakhand. These include the Carbon Storage and Sequestration: Climate Regulation Model and the Water Yield: Reservoir Hydropower Production Model.

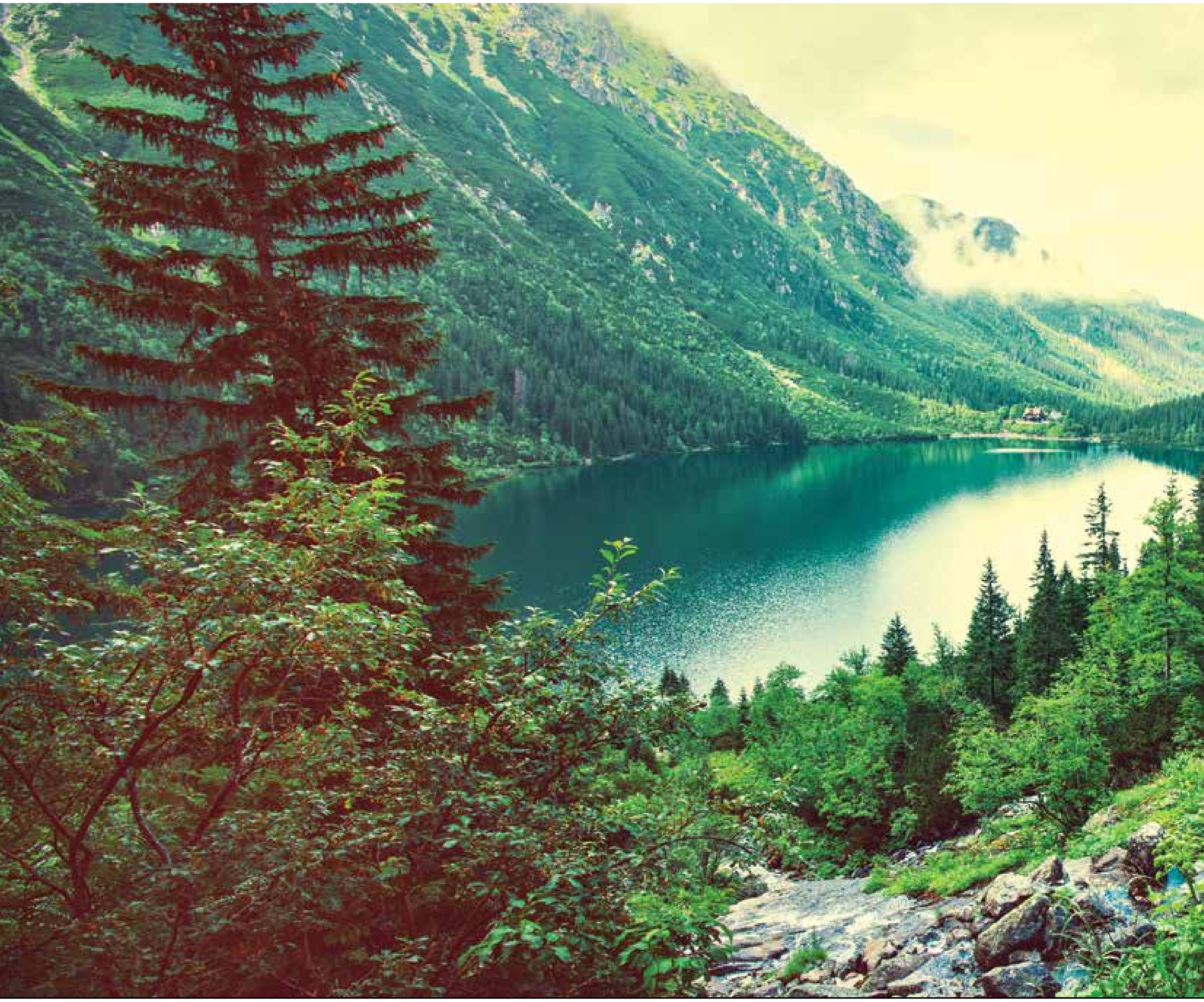
According to the carbon storage model, the forests of Uttarakhand store 327.95 million tonnes of carbon across its four pools. The water yield model estimated the total water yield volume for Uttarakhand at 10.46 billion cubic metres. This estimate does not account for consumptions as per land uses.

The model has a number of limitations as listed below:

- It is not intended for devising detailed water plans, but rather for evaluating how and where changes in a watershed may affect water yield for reservoir systems. It is based on annual averages, which neglect extremes and do not consider the temporal dimensions of water supply.
- The model assumes that all water produced in a watershed in excess of evapotranspiration arrives at the

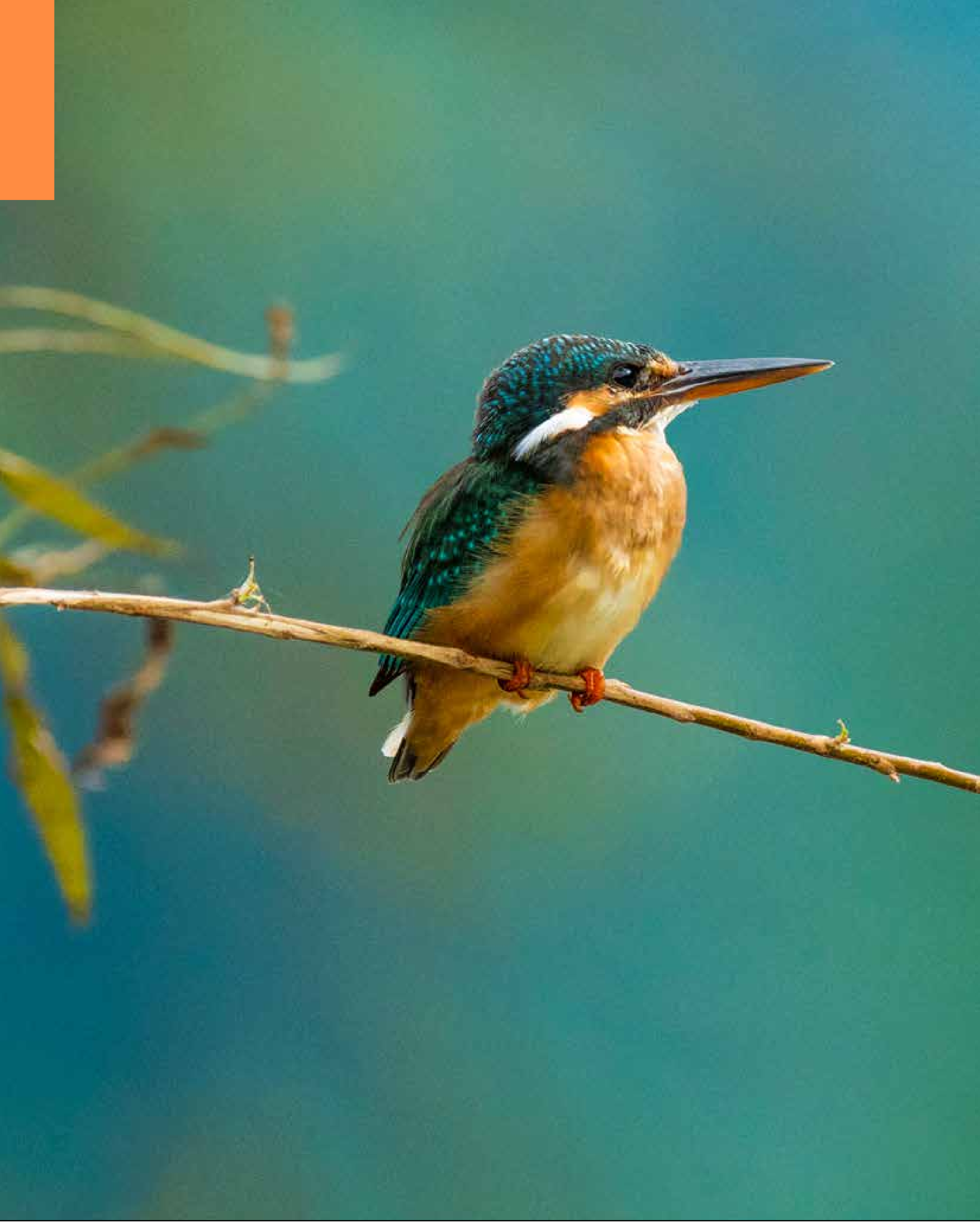
watershed outlet, without considering water capture by means other than primary human consumptive uses. Surface water–ground water interactions are entirely neglected, which may be a cause for error, especially in areas of karst geology. The relative contribution of yield from various parts of the watershed should still be valid.

- The model does not consider sub-annual patterns of water delivery timing. Water yield is a provisioning function and its benefits are affected by flow regulation. The timing of peak flows and delivery of minimum operational flows throughout the year determines the utility towards irrigation and other uses. Changes in landscape scenarios are more likely to affect the timing of flows than the annual water yield, and are a greater concern when considering drivers such as climate change. Modelling the temporal patterns of overland flow requires detailed data that are not appropriate for current approach. Still, this model



provides a useful initial assessment of how landscape scenarios may affect the annual delivery of water to hydropower production.

- The model describes consumptive demand by LULC type. In reality, water demand may differ greatly between parcels of the same LULC class. Much of the water demand may also come from large point source intakes, which are not represented by the LULC class. The model simplifies water demand by distributing it over the landscape.
- Fifth, a single variable (d) is used to represent multiple aspects of water resource allocation, which may misrepresent the complex distribution of water among uses and over time.



GROSS ENVIRONMENT PRODUCT (GEP): DEVELOPING FRAMEWORKS FOR GREEN ACCOUNTS OF LAND, WATER, MINERALS (OUTSIDE FORESTS) FOR THE STATE OF UTTARAKHAND.

CHAPTER

08

Figure 65: View of Economy as Part of a Larger System

8.1 RATIONALE FOR GREEN GDP OR GROSS ENVIRONMENT PRODUCT (GEP)

For more than a half century, the most widely accepted measure of a country's economic progress has been Gross Domestic Product (GDP), an estimate of market throughout, adding together the value of all final goods and services that are produced and traded for money within a given period of time.

The Gross National Product (GNP) is another frequently mentioned measure of economic progress. The difference between GDP and GNP is the production boundaries used. Since its creation, economists who are familiar with GDP have emphasized that GDP is a measure of economic activity, not economic well-being. In 1934, Simon Kuznets, the chief architect of the United States national accounting system, cautioned against equating GDP growth with economic or social well-being, the reason being the GDP does not take into account some of the negative effects of economic growth, like pollution.

GDP measures only monetary transactions related to the production of goods and services. It is based on an incomplete picture of the system within which the human economy operates in which environmental issues are of a low perceived importance. A more complete picture of how the human economic system fits within the social and environmental systems upon which it depends is shown in Figure 65.

It is the need of the hour that integrated environmental economic accounting for GDP is done. Gross Environment Product is one of the unique ways to integrate and valuate the environmental factor in economic terms and is the total value of final ecosystem goods and services supplied to human well-being in a region annually, and can be measured in terms of biophysical value and monetary value.

8.2 FRAMEWORK GROSS ENVIRONMENT PRODUCT (GEP)

Ecosystem products and services are essentials for human survival and development. Gross ecosystem product (GEP) is defined as total values of ecosystem products and services for human welfare and sustainable development. GEP mainly refers to the total value of direct and indirect use values of ecosystem goods and services, including ecosystem provision value, ecological regulation services value and ecological culture services value. The purposes of GEP accounting are to analyse and evaluate the total of economic value support for human survival and well-being. There are three basic tasks in GEP accounting, including functional value accounting, figuring out prices and economic value accounting of the ecosystem products and services.

Accounting of GEP can be used to reveal the ecosystem contributions to economic and social development and human welfare, analyse the ecological linkages between regions, and assess the effectiveness and benefit of ecosystem conservation.

8.3 CHINA CASE STUDY

Green GDP is an effective economic indicator of urban environmental management. Two studies completed in China have been discussed in this section for the purpose of understanding the conceptual framework which can ultimately be applied in the state of Uttarakhand.

8.3.1 CASE STUDY 1

A study conducted by (L. Xu, Yu, and Yue, 2010), Green GDP accounting based on eco-service and a case study of Wuyishan, China introduced a new method of accounting Green GDP, which puts the value of direct ecosystem services into GDP. The study took direct ecosystem services weighted by their virtual prices and aggregated in the same way as market goods and services in GDP. The results show that the value of direct ecosystem services in Wuyishan City in 2005 has reached 2.3 billion yuan RMB, and the green GDP is 15.3 billion yuan RMB which is 5 times than GDP. An equation used for the purpose of estimating GDP.

Green GDP=Traditional GDP+ Ecological GDP

Ecological GDP= Ecosystem Services Value-Ecological Cost

This method could bring external economy into the market regulation in order to internalize external costs. For the sake of avoiding double counting some ecosystem services, the green GDP accounting system was divided further into four components, which are economy system, social system, resource system and environmental system.

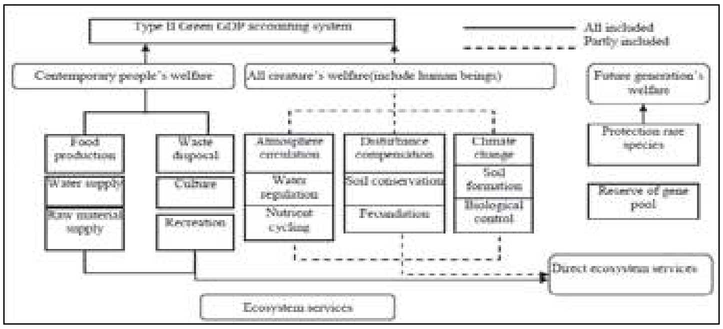


Figure 66: Green GDP Accounting System Adopted in the Study

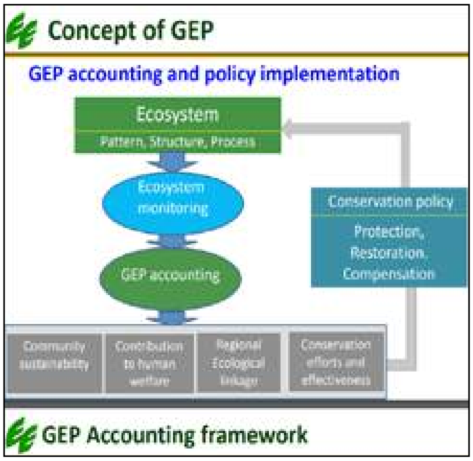


Figure 67: GEP and its Policy Connect

8.3.2 CASE STUDY 2

Similarly in a study conducted by (OUYANG Zhiyun et al., 2013) named "Gross Ecosystem Product: Concept, Accounting Framework and Case Study" calculated GEP of Guizhou Province. The evaluation results showed that the GEP of Guizhou in 2010 was 200134.6 million Yuan, the GEP per capita was 57526 Yuan, which was 4.3 times that of the GDP and per capita GDP.

Figure 67 explains how GEP accounting can help in different policy contexts. GEP so developed will help in contributing to sustainable development and human welfare of the area. In Figure 68 the accounting framework was adopted in the study for the purpose of estimating GEP.

The study suggested that, ecosystems play a pivotal role in supporting economic and social development of Guizhou Province and GEP accounting provides an instrument to understand and assess the efficiency and effectiveness of ecosystem protection management and restoration in the area.

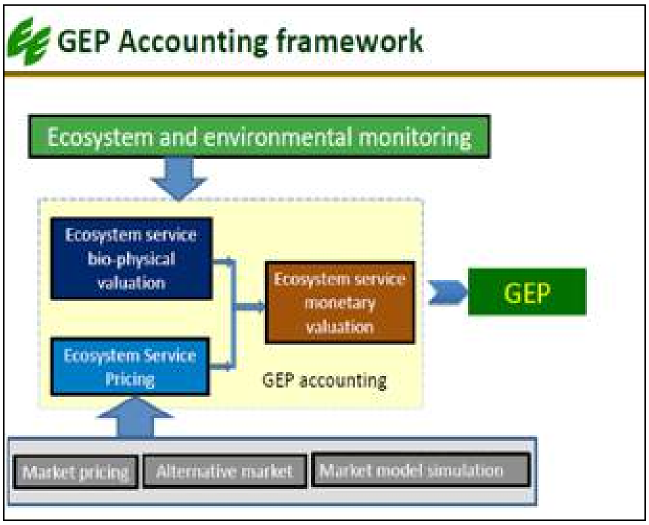


Figure 68: Accounting Framework Adopted in the Study

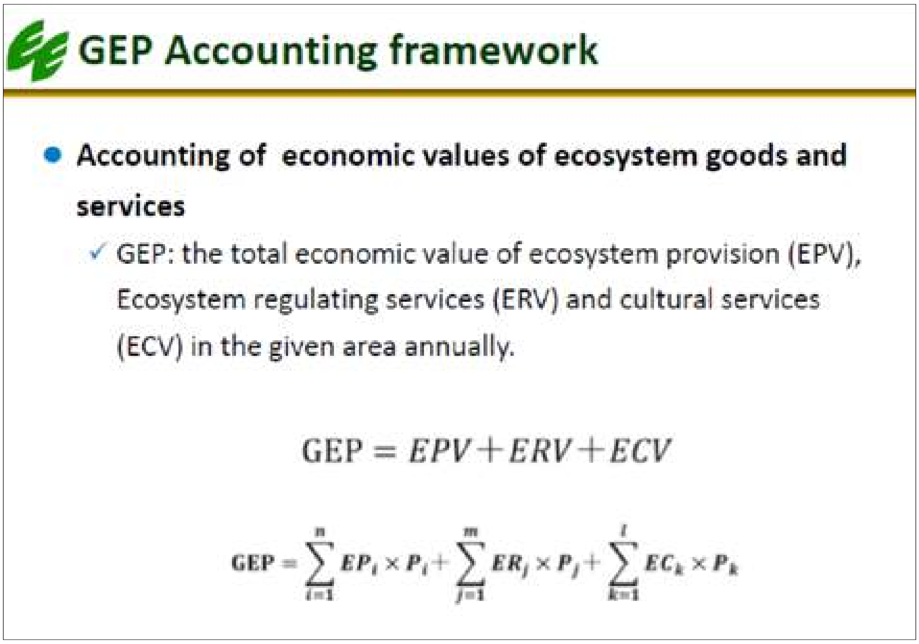


Figure 69: Equation Used in the Study for Gross Environmental/Ecosystem Product

The final equation used for the calculation of GEP is given below in Figure 69. The total economic value of ecosystem provision (EPV), ecosystem regulating services (ERV) and cultural services (ECV) are compounded annually.

GEP = Gross Environmental Product

EPi = Provisioning Services (Biophysical Value)

ERj = Regulating Services (Biophysical Value)

ECk= Cultural Services (Biophysical Value)

Pi,j,k= Price/Value

8.4 ECOLOGICAL-COST

Ecological-costs are a measure to express the amount of a products environmental burden on the basis of prevention of that burden. It is the costs which should be made to reduce the environmental pollution and materials depletion in our world to a level which is in line with the carrying capacity of our earth. In the present framework for Gross Environmental Product, along with value of goods and services the ecological cost of that particular good needs be accounted for as per their life cycle analysis (LCA). To measure the Eco-cost of Goods and Services and Ecological Services (Environmental Goods and Service not considered under traditional GDP) ECO COST model developed by Delft University of Technology (http://www.ecocostsvalue.com/EVR/model/theory/subject/2-eco-costs.html) can be used. The framework for ECO-COST is shown

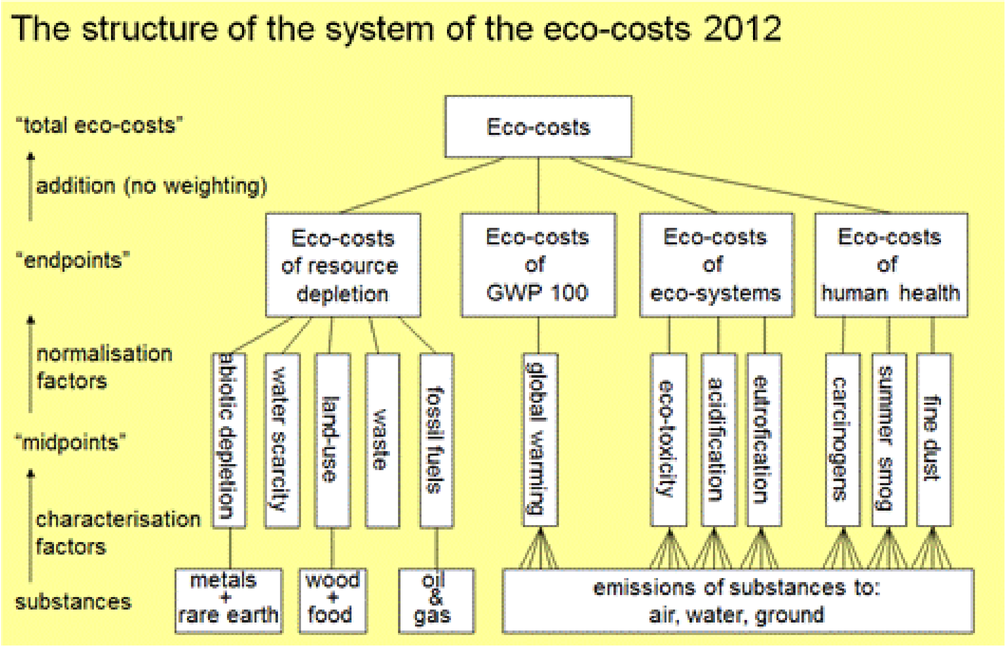


Figure 70: Structure of Systems to Estimates Eco-Costs

8.5 GEP FRAMEWORK FOR THE STATE OF UTTARKHAND

Based on the studies conducted to estimate the GEP/Green GDP two scenarios have been considered suitable for the state of Uttarakhand keeping in view demography, economy ecosystem extent and condition.

1. GEP internalizing the cost of environmental pollution and resources depletion (depreciation of ecological goods and services) excluding the value of natural resource.
2. GEP internalizing the Value of Ecological Services (Environmental Goods and Service not considered under traditional GDP) and Ecological Cost/ losses.

Gross ecosystem product (GEP) = Traditional GDP (Value of Goods and Services) + Value of Ecological Services (Environmental Goods and Service Not Considered Under Traditional GDP) – Ecological Cost

System of Environmental-Economic Accounting - Experimental Ecosystem Accounting (SEEA EEA) accounts can be used for the purpose of estimating Ecosystem Services Product. The ecological losses and cost to the environment can be estimated annually for the state using environment statistics.

The current framework for Gross Environmental Product involves basic environmental accounts from SEEA EEA. The status of our natural resources and their growth if reviewed periodically according to the framework developed specifically for the state of Uttarakhand will help us incorporate the valuation done of ecosystem services and accounts into the main GDP. In order to achieve this target framework for land, water, energy and to measure the ecosystem extent and condition at the end of the accounting period have been developed and listed below from Table 72 to 77. As a new ecological accounting system that measures ecology status, GEP provides powerful scientific support and future indicators for ecological civilization construction. (Source: https://www.iucn.org/asia/countries/china/gross-ecosystem-product-gep%EF%BC%89).

The framework developed in the current study will eventually help to keep a track on the available resources in the state and their current usage pattern. With the help of GEP the state can also form a scientific justification towards the claim of Green Bonus with respect to the contribution Uttarakhand makes towards the environment. In addition to this current system for reporting the extent of biodiversity species available in the state can also take into consideration while preparing GEP for the state. As GEP is still at a nascent stage it is of great importance that full-fledged environmental accounting is done on a priority basis for the state.

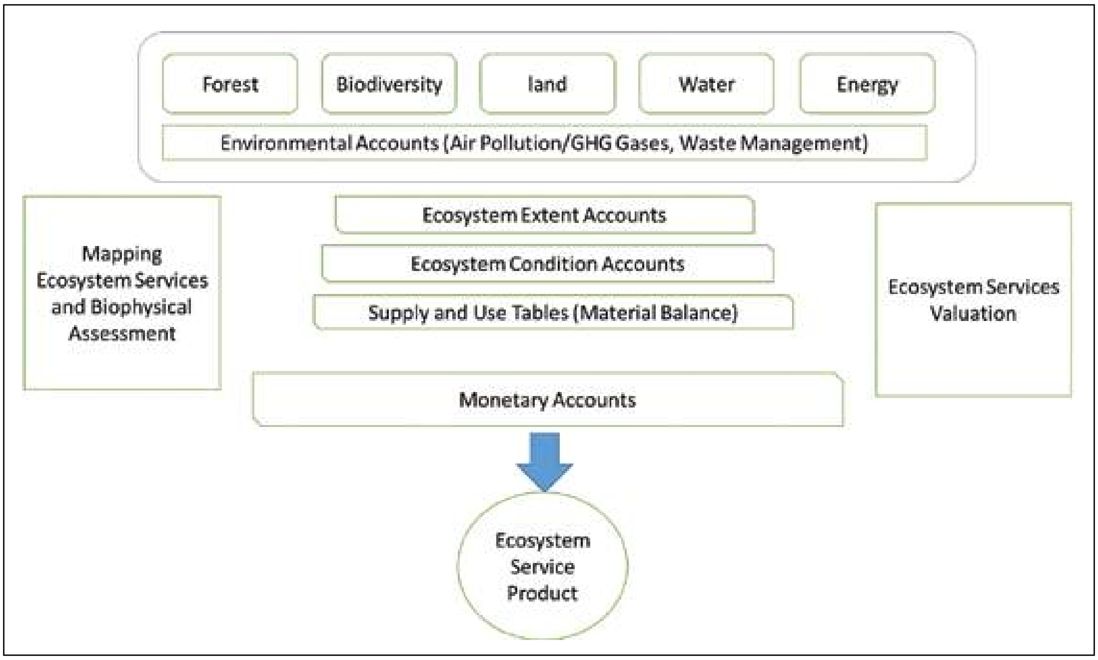


Figure 71: Framework for Environmental Goods and Services Valuation

Table 72: Proposed Framework for Water Supply

	Surface Water			Ground Water		
	ArtificialReservoirs	Lakes	Rivers and Streams	Glaciers, Snow and Ice	Other Sources	Total
Opening stock of water resources						
Additions to stock						
Returns						
Precipitation						
Inflows from other inland water resources						
Discoveries of water in aquifers						
Total additions to stock						
Reductions in stock						
Abstraction/Extraction						
Domestic use						
Industrial use						
Agriculture						
for hydropower generation						
Evaporation and actual evapotranspiration						
Total reductions in stock						
Closing stock of water resources						

Table 73: Proposed Framework for Measures of Ecosystem Condition and Extent at End of Accounting Period

	Ecosystem extent	Characteristics of Ecosystem Condition				
		Vegetation	Biodiversity	Soil	Water	Carbon
Type of EU	**Area**	**Indicators (e.g. Biomass)**	**(e.g. Species Richness)**	**Indicators (e.g. Organic Matter Content)**	**Indicators (e.g. Water Quality)**	**Indicators (e.g. Net Carbon Balance)**
Forest ecosystem units:						
Broadleaved upland forests						
Conifer upland forests						
Conifer low land forests						
Mixed upland forests						

Table 74: Change Matrix for Land Use

Land Use Type	Agriculture	Barren / Unculturable / Wastelands	Built-Up	Forests	Grass/Grazing	Snow and Glacier	Wetlands / Water Bodies	Total
Agriculture								
Barren / unculturable / wastelands								
Built-up								
Forests								
Grass/Grazing								
Snow and Glaciers								
Wetlands / Water Bodies								
Total								

Table 75: Supply Table for Energy

	Coal	Coal by-products	Natural gas	Crude oil and refinery feedstock	Petrol	Diesel	Other refined fuels and products	LPG	Biofuels	Wood and wood waste	Bagasse	Electricity	Hydro energy	Solar energy	Wind energy	Uranium	Total
Supply by industry																	
Agriculture, forestry and fishing																	
Mining																	
Manufacturing																	
Food, beverages, textiles																	
Wood, paper, printing																	
Petroleum and chemical products																	
Iron and steel																	
Non-ferrous metals																	
Other Manufacturing																	
Total Manufacturing																	
Electricity, gas, water and waste																	

Construction																	
Transport																	
Road																	
Rail																	
Air																	
Water																	
Other transport, storage and services																	
Total transport																	
Commercial services																	
Wholesale and retail trade																	
Accommodation																	
Communication																	
Other																	
Total commercial and services																	
Total supply by industry																	
Supply by households																	
Imports																	
Net supply																	

Table 76: Use Table for Energy

	Coal	Coal by-products	Natural gas	Crude oil and refinery feedstock	Petrol	Diesel	Other refined fuels and products	LPG	Biofuels	Wood and wood waste	Bagasse	Electricity	Hydro energy	Solar energy	Wind energy	Uranium	Total
Net use by industry																	
Agriculture, forestry and fishing																	
Mining																	
Manufacturing																	
Food, beverages, textiles																	
Wood, paper, printing																	
Petroleum and chemical products																	
Iron and steel																	
Non-ferrous metals																	
Other manufacturing																	
Total Manufacturing																	
Electricity, gas, water and waste																	
Construction																	
Transport																	

Road																	
Rail																	
Air																	
Water																	
Other transport, storage and services																	
Total Transport																	
Commercial and services																	
Wholesale and retail trade																	
Accommodation																	
Communication																	
Other																	
Total Commercial and services																	
Total net use by industry																	
Net use by households																	
Inventory changes																	
Exports																	

CHAPTER 09

Undervaluation of forests and other natural ecosystems in India is causing immense losses to the forestry sector and to the overall economic system. The situation is like burning candles from both ends. On one hand there has been gross underestimation of tangible benefits from ecosystems and on the other hand complete ignorance of recording ecological contributions to the society. Likewise, the value charged for converting forest land for non-forestry purposes hitherto considers only the marketed values like timber and non-timber forest products. The whole array of ecological services in terms of positive externalities which get lost on account of conversion have not been considered. Both actions lead to generation of externalities and actually reduce, and not add to a country's total wealth. Since the loss of natural ecosystems such as forests is fundamentally economic in nature, its conservation should also be addressed in economic terms.

While emerging challenges in this regard make necessary for governmental organizations mandated to collect and process information which can consequently guide decision-makers, the capacity for environmental statistics and green accounting needs to be urgently built. Such a capacity building exercise is needed to cope with the emerging changes as well as ensuring adaptive management.

Two capacity building programmes for DES officials and participants from other state-government departments were held at Mukteshwar from October 30 - November 3, 2017 and in Bhopal from 10th December-12th December, 2018 (detailed programme is given below). The course proposed to Uttarakhand DES is intended to build capacity at the individual level for environmental statistics and Green Accounting. It is hoped that at the end of the course, the participants are now:

- Able to synthesize the new field of Ecological Economics - a holistic approach towards the solution of environmental and economic problems
- Equipped with tools and techniques of measuring values of ecosystem services and Green Accounting
- Able to understand the mechanism of developing markets for ecosystem services and economic instruments required for such a mechanism specially in the context of climate change
- The Team from IIFM, IES, Uttarakhand Forest Department, Planning Department and Directorate of Economics and Statistics had an exposure visit to Finland and undergone training program at statistics Finland from 27th to 28th June, 2018 and Luke Natural Resource Institute Finland on 29th June 2018. The team also went to Nuuksio National Park and Agroforestry site for field visit.

Figure 72: Detailed Programme on Valuation Held in Mukteshwar

Economic Valuation & Natural Resource Accounting

Five Days Capacity Building Program for Uttarakhand Departmental Officials, organized by Centre for Ecological Services Management, Indian Institute of Forest Management, Bhopal and IORA Ecological Solutions, New Delhi

30 October- 03 November 2017

Venue: Ojaswi Himalayan Resort, Mukteshwar, Uttarakhand

As part of the research project 'Green accounting of forest resources, framework for other natural resources, Sustainable Environmental Performance Index for Uttarakhand state" supported by DES, Uttarakhand

Programme Directors

Dr. Madhu Verma, Dr. Advait Edgaonkar & Mr. Swapan Mehra

Tentative Programme Schedule

Time	Session	Instructor(s)
DAY 1	**30th October (Monday)**	
11:00 – 11:15	Registration on arrival	
11:15-12:30	**Inaugural Session** Welcome by *Dr. Advait Edgaonkar, Asst. Professor, IIFM & Program Director* **(5 Minutes)** Welcome by *Dr. Manoj Pant; CCO planning/Joint Director, DES Uttarakhand* ***(10 Minutes)*** Introduction of participants **(10 Minutes)** Expectation from the Programme (Idea Sharing through cards/papers) **(20 Minutes)** Introduction of the study by *Dr. Madhu Verma, Professor, IIFM & Program Director* ***(15 Minutes)*** Programme Overview by *Mr. Swapan Mehra, CEO, IES & Program Director* ***(15 Minutes)*** *Key note address by Mr. Gambhir Singh IFS PCCF(Planning) Uttarakhand* ***(10 Minutes)*** Vote of thanks by *Dr. Advait Edgaonkar, Assistant Professor, IIFM & Program Director* ***(05 Minutes)***	
12:30 – 13:30	Lunch	

13:30 – 15:15	Ecosystem Services: Classification Frameworks and Values	*Dr. (Mrs.) Madhu Verma, Ms. Parul Sharma*
15:15 – 15:45	Health Break	
15:45 – 17.45	Economic Valuation Methods – I	*Dr. (Mrs.) Madhu Verma, Dr. Advait Edgaonkar*
17:45– 18:45	Introduction to SEPI	*Mr. Swapan Mehra*
DAY 2	31st October (Tuesday)	
7.00-08.00	*Nature Walk*	
09.30- 11.00	Economic Valuation Methods – II	*Dr. (Mrs.) Madhu Verma, Dr. Advait Edgaonkar*
11:00 – 11:30	Health Break	
11:30 – 1:30	Data System for Forestry in India	*Mr. Rajesh Kumar, FSI*
12:30 – 13:30	Ecosystem Services Mapping using InVEST	*Dr. Advait Edgaonkar, Mr. Kunal Bharat*
13:30 – 14:30	Lunch	
14:30 – 16:00	Ecosystem Services Valuation - Case Studies	*Mr. Swapan Mehra, Ms. Parul Sharma, Ms. Charu Tiwari*
16:00 – 16:30	Health Break	
16:30 – 18:30	Natural Resource Accounting – SEEA Experimental Ecosystem Accounting & WAVES	*Dr. (Mrs.) Madhu Verma, Ms. Parul Sharma, Mr. Kunal Bharat*
18.30-18.45	Brief of Field Visit	*Dr. Advait Edgaonkar Mr. Swapan Mehra*
DAY 3	1st November (Wednesday)	
08:00 – 13:30	Field Visit to Nainital Forest Division	*Dr. Madhu Verma, Dr. Advait Edgaonkar, Mr. Swapan Mehra*
13:30 – 14:30	Lunch	
14:30 –15:30	Review of various Environmental Indices	*Ms. Shweta Bhagwat Ms. Pratishtha Singh*
15:30 – 16:30	Linking SDGs to Environment Indices	*Mr. Swapan Mehra, Mr. Kunal Bharat*
16:30 – 17:00	Health Break	
17:00 – 18:30	Results of Uttarakhand FRA & Discussion	*Dr. (Mrs.) Madhu Verma, Mr. Swapan Mehra, Ms. Pratishtha Singh*
8:00 pm onwards	*Cultural Evening*	
DAY 4	2nd November (Thursday)	

10:00 – 10:15	Concept & Framework Development of the Index	*Dr. Manoj Pant, DES*
10:15 – 10:30	Uttarakhand Sustainable Environment Performance Index (SEPI)	*Mr. Swapan Mehra, Mr. Kunal Bharat*
10:30 – 11:00	Briefing on Group Convergence Activity and Group Formation	*Mr. Swapan Mehra, Ms. Shweta Bhagwat Mr. Kunal Bharat, Ms. Pratishtha Singh*
11:00 -11:30	Health Break	
11:30 – 12:30	Sector 1 - Indicators and Group Convergence Activity	*All Team Members*
12:30 - 13:30	Sector 2 - Indicators and Group Convergence Activity	*All Team Members*
13:30 – 14:30	Lunch	
14:30 – 15:00	Sector 3- Indicators and Group Convergence Activity	*All Team Members*
15:00 – 15:30	Sector 4 - Indicators and Group Convergence Activity	*All Team Members*
15:30 – 16:00	Sector 5 - Indicators and Group Convergence Activity	*All Team Members*
16:00 – 16:30	Sector 6 - Indicators and Group Convergence Activity	*All Team Members*
16:30 – 17:00	Health Break	
17:00 – 17:30	Sector 7 - Indicators and Group Convergence Activity	*All Team Members*
17:30 – 18:15	Sector 8- Indicators and Group Convergence Activity	*All Team Members*

DAY 5	**3rd November (Friday)**	
7.00-08.00	*Nature Walk*	
9.30-10.30	All Sectors Group Convergence Activity	*All Team Members*
10.30-11.30	Results of Group Convergence Activity	*Mr. Swapan Mehra, Mr. Kunal Bharat*
11.30-11.45	Health Break	
11:45 – 12:30	Wrap-up Session	*Dr. Advait Edgaonkar, Mr. Swapan Mehra*
12:30 – 13:30	Feedback and Valedictory	*Mr. Gambhir Singh, Dr. Ranjit K. Sinha, Mr. Sushil Kumar Dr. Manoj Pant, Dr. Advait Edgaonkar, Mr. Swapan Mehra*
13:30 – 14:30	Lunch	
15:00 pm onwards	Check-out and Departure	

Economic Valuation & Natural Resource Accounting

Review and Discussion workshop for Uttarakhand Departmental Officials, organized by Centre for Ecological Services Management, Indian Institute of Forest Management, Bhopal and IORA Ecological Solutions, New Delhi

10^{th}-12^{th} December 2018

Venue: IIFM Bhopal

As part of the research project 'Green accounting of forest resources, framework for other natural resources, Sustainable Environmental Performance Index for Uttarakhand state" supported by DES, Uttarakhand

Programme Coordinators

Dr. Madhu Verma, Dr. Advait Edgaonkar and Mr. Swapan Mehra

Course Instructors

Dr. Madhu Verma, Dr. Advait Edgaonkar, Mr. Swapan Mehra, Mr. Ashwin, Mr. Kunal Bharat and Mr. Prabhakar Panda

	Tentative Programme Schedule	
Sessions	**Session**	**Instructor(s)**
Day 1 : 10^{th} December, 2018		
Inaugural Session		
09:45-10:00 am	**Registration**	
10:00-11:00 am	**Welcome** by Dr. Advait Edgaonkar **Major findings of the study** by Dr. Madhu Verma and Mr. Swapan Mehra **Welcome Address** by Director IIFM **Address by** Dr.Sushil Kumar, Director, DES, Uttarakhand **Vote of thanks** by Dr. Madhu Verma	
11:00 am-11:30 pm	**Health Break**	
Technical sessions		
11:30-13:30 pm	Ecosystem Services: Classification, Frameworks and Valuation Methods	**Dr. Madhu Verma Dr. Advait Edgaonkar Mr. Swapan Mehra Mr. Ashwin Mr. Kunal Bharat**
13:30-14:30 pm	**Lunch**	
14:30-15:00 pm	Natural Resource Accounting – SEEA Experimental Ecosystem Accounting & WAVES	
15:00-16:00 pm	Uttarakhand Forest Ecosystem Services Valuation, FRA results and discussion	
16:00-16:30 pm	Ecosystem Services Mapping for Uttarakhand using InVEST	

16:30-17:30 pm	Introduction to SEPI	
17:30 pm	**Evening Tea**	
Day 2: 11th December, 2018		
10:00-11:00 am	Review of various Environmental Indices	**Dr. Advait Edgaonkar** **Mr. Swapan Mehra** **Mr. Ashwin** **Mr. Kunal Bharat** **Mr. Prabhakar Panda**
11:00-11:30 am	Linking SDGs to Environment Indices	
11:30-12:00 pm	**Health Break**	
12:00-13:30 pm	Concept & Framework Development of the Index	
13:30-14:30 pm	**Lunch**	
14:30-15:00 pm	Uttarakhand Sustainable Environment Performance Index (SEPI)	
15:00-16:00 pm	Methodology (Brief on AHP Consultation Process)	
16:00-17:00 pm	Brief on calculation and evaluating SEPI	
Valedictory Session		
17:00 -17:30 pm	**Welcome-** Dr.Madhu Verma Comments by Participants **Concluding Remarks** –Dr.Manoj Pant **Valedictory Address & Award Certificates of Participation** – Dr.Pankaj Srivastava **Vote of Thanks** – Dr.Advait Edgaonkar	
17:30 pm	**Evening Tea**	
Day 3: 12th December, 2018		
Field Visit to Ratapani Wildlife Sanctuary (TBC)		
07:30 am-17:00 pm	Stakeholder consultation for identifying ecosystem services and their valuation at Ratapani WS (Tiger Reserve) and its hinterland	**Dr. Advait Edgaonkar** **Mr. Ashwin** **Mr. Kunal Bharat** **Mr. Prabhakar Panda** **Ms. Charu Tiwari** **Mr. Zuhail Thatey** **Mr. Sumit Anand**

EXPOSURE VISIT ON ENVIRONMENTAL ACCOUNTING TO FINLAND

Date: 27-28 June 2018

Venue: Statistics Finland, Työpajankatu 13, Helsinki (Kalasatama) 2nd floor

PROGRAM

Wednesday 27 June, Meeting Room 8	
9.30–12.00	Welcome
	Objectives of the study visit and overview on the Agenda
	Latest development of environmental accounting in UN and EU Mr Jukka Muukkonen, Ms Johanna Pakarinen, Ms Marika Pohjola
12.00-13.00	Lunch
13.00–16.00	Implementation of environmental accounting in European Union
	Organization and dissemination of environmental accounts in Finland
	Economy-wide material flow accounts
	Waste statistics Ms Johanna Pakarinen, Mr Juha Espo, Mr Jukka Muukkonen
Thursday 28 June, Meeting Room 13	
9.00–12.00	Physical energy flow accounts
	Air emission accounts
	Environmental taxes
	Greenhouse gas inventory in Finland Ms Sini Niinistö, Ms Johanna Pakarinen, Mr Sami Hautakangas, Mr Jukka Muukkonen
12.00–13.00	Lunch
	Environmental expenditures
	Environmental goods and services
	Ecosystem accounts
	Green growth indicators in Finland Ms Susanna Kärkkäinen, Ms Johanna Pakarinen, Mr Sami Hautakangas, Mr Jukka Muukkonen
	Concluding session All participants

PARTICIPANTS OF TEAM INDIA

Dr.(Mrs) Madhu Verma, Professor & PI-DES-UK project, Indian Institute of Forest Management, Bhopal - Delegation Lead

Mr. Gambhir Singh, IFS, PCCF, Planning, Govt. of Uttarakhand

Mr. Amit Singh Negi, IAS, Secretary, Govt. of Uttarakhand

Mr. Ranjit Kumar Sinha, IAS, Secretary Incharge (Planning), Govt. of Uttarakhand,

Dr. Manoj Kumar Pant. CCO, State Planning Commission/Nodal Officer, SSS , Govt. of Uttarakhand

Mr. Amit Verma, Senior Research Officer Finance Statistics, DES, Govt. of Uttarakhand

Mr. Swapan Mehra, CEO, IORA Ecological Solutions, New Delhi

PARTICIPANTS OF STATISTICS FINLAND

Ms Johanna Pakarinen – Senior Statistician, Environment and Energy

Ms Susanna Kärkkäinen – Senior Statistician, Environment and Energy

Mr Sami Hautakangas – Senior Statistician, Environment and Energy

Mr Niko Olsson – Trainee, Environment and Energy

Mr Jukka Muukkonen – Senior adviser, Environment and Energy

Mr Jukka Pakola – Head of Statistics, Environment and Energy

Ms Marika Pohjola – Planning Officer, Communication and Information Services

VISIT OF THE INDIAN INSTITUTE OF FOREST MANAGEMENT (BHOPAL) AND REPRESENTATIVES OF THE GOVERNMENT OF UTTARAKHAND TO LUKE NATURAL RESOURCES INSTITUTE FINLAND

Time: 29 June 2018 at 9-16

Place: Luke Viikki campus, Latokartanontie 9, meeting room Savotta

PROGRAM

09:00-09:10	Opening
09:10-09:40	Overview on forest statistics in Finland, Senior Statistician Aarre Peltola
09:40-10:40	National Forest Inventory (NFI), Dr. Helena Haakana
10:40-10:50	Break
10:50-11:30	Remote sensing based forest inventories, Dr. Sakari Tuominen
11:30-12:45	Lunch
12:45-13:15	Greenhouse gas inventories (LULUCF), Research Scientist Tarja Tuomainen
13:15-14:15	Forest sector market statistics, Leading specialist Aarre Peltola
14:15-14:30	Coffee break
14:30-15:30	Calculations on the Finnish bioeconomy, Leading Specialist Martti Aarne
15:30-15:45	Closing

PARTICIPANTS FROM INDIA:

1. Dr. (Mrs.) Madhu Verma, Professor & PI-DES-UK project, Indian Institute of Forest Management, Bhopal - Delegation Lead
2. Mr. Gambhir Singh, IFS, PCCF, Planning, Government of Uttarakhand
3. Mr. Mr. Amit Verma, Senior Research Officer Finance Statistics, Government of Uttarakhand
4. Mr. Ranjit Kumar Sinha, IAS, Secretary Incharge (Planning), Government of Uttarakhand
5. Mr. Manoj Pant, CCO, State Planning Commission/Nodal Officer, SSS,
   Government of Uttarakhand
6. Mr. Amit Punetha, Deputy Director, DES, Government of Uttarakhand
7. Mr. Swapan Mehra, CEO, IORA Ecological Solutions, New Delhi

PARTICIPANTS FROM LUKE:

Mr. Martti Aarne, Leading Specialist, bioeconomy statistics

Mr. Aarre Peltola, Senior Statistician

Dr. (Mr.) Sakari Tuominen, Senior Scientist

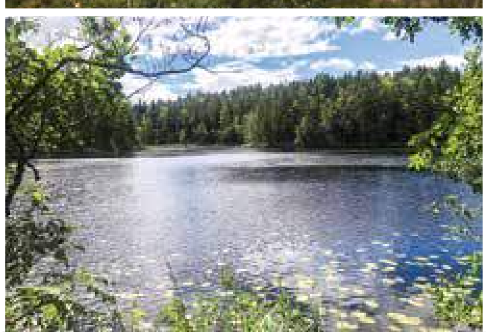
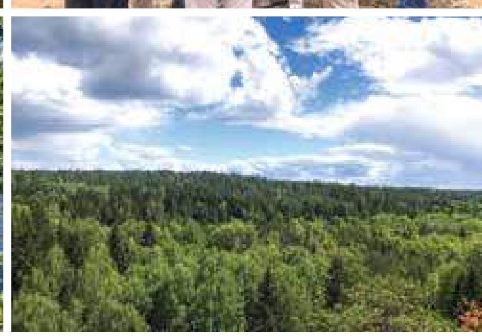
Dr. (Mrs.) Helena Haakana, Research Scientist

Mrs. Tarja Tuomainen, Research Scientist

Mrs. Johanna Logrén, Senior Specialist, international affairs





CONCLUSIONS AND WAY FORWARD

CHAPTER 10

Uttarakhand is one of the fastest growing states in India and is endowed with several life-sustaining natural resources such as forests, glaciers, rivers, wildlife, minerals, livestock and agro-climatic conditions.

The study provides economic estimates for as many as 21 ecosystem services from the forest area of Uttarakhand. The study findings indicate that the monetary value of flow benefits emanating from the Uttarakhand forests ranges from Rs. 95,112 to 1,93,904 crores annually. This is equivalent to an annual flow value of Rs. 3,88,085 per hectare (lower bound) of forests in Uttarakhand.

In addition, Uttarakhand forests protect and conserve stock comprising the value of land, timber stock and carbon storage is valued in the range of Rs. 14,13,676.20to 17,44,413.36 crores. The study findings also indicate that a sizeable proportion of flow benefits are intangible, and hence often unaccounted for in the market transaction.

An attempt has been made to know the premium value of the protected area in Uttarakhand. Uttarakhand has 6 National Parks and 7 Wildlife Sanctuaries and 4 Conservation Reserves. The study findings indicate that the range of ecosystem services value (premium) ranges from 324753.98 crores to 662072.40 crores.

In order to highlight the economic value of the state's natural capital, forest resource accounting has been done based on the available data and international frameworks adapted from Z. Xu et al., 1995 and SEEA –EEA

Accounts compiled based on the above mentioned frameworks will ultimately help policy makers in better decision-making in future and it is high time that a full scale natural resource accounting is done for the state. The current study only takes care of forestry accounts, in addition to this land, water, soil, biodiversity, energy accounts, etc. may be prepared for the preparation of Gross Environmental Product in future. A framework explaining the need and importance of GEP in future has been discussed in the previous section.

Considering that Uttarakhand is a developing state, sustaining its forests has a significant opportunity cost due to the unavailability of land for other development purposes impacts both the revenue capacities and the expenditure needs of the state.

There is also a need to address the concerns of people living in forest areas and ensure a desirable level of development for them.

To ensure a holistic and sustainable growth, the Sustainable Environment Performance Index (hereby referred to as SEPI) for the state of Uttarakhand has been developed in the section. Such an index complements economic indices such as the State / District GDP.

The index aggregates indicators that reflects, state of air quality, water quality, land use and agriculture, forests and biodiversity; measures of the impact of the current state of the environment and resource extraction on ecosystem and human health; and policy responses and society's efforts to preserve the environment. Different scenarios based on weightages given to the sectors and indicators have been discussed. SEPI so formed may help prioritize the sectors on which the Government of Uttarakhand should focus. A total of 68 indicators were incorporated in the index as per the relevance and availability of the data within the state which may be further expanded based on activities related to any of the eight sectors considered in the current study. Such an index will be very effective if updated annually and going forward the state should continue undertaking such studies to update the index for real time scenarios.

The current study applies one of the most widely used tools for mapping ecosystem services, Integrated Valuation of Ecosystem Services and Trade-Offs (InVEST). Constrained by data availability for Uttarakhand, 2 of the 18available models in InVEST 3.0 package were applied for the entire state of Uttarakhand. These include the Carbon Storage and Sequestration: Climate Regulation Model and the Water Yield: Reservoir Hydropower Production Model.

According to the carbon storage model, the forests of Uttarakhand store 327.95 million tonnes of carbon across its four pools. The water yield model estimated the total water yield volume for Uttarakhand at 10.46 billion cubic metres. This estimate does not account for consumptions as per landuses. Going forward more models may be used with the more extensive study on biophysical assessment using InVEST.

Valuation and accounting is now one of the major parts to be included in management plans as per the new forest policy released by MoEFCC. This study will finally help the PA managers/Forest officer/decision-makers to conduct valuation on their own in future which is required for preparing management plans.

It is however important to mention here that valuation is not a panacea. Some important values that these forest areas protect are difficult to capture through economic analysis, including sacred values of particular places to faith groups, health values of living inside or near a healthy natural landscape and natural evolution.

The primary objective of the study was to prepare forest resource account and estimates of the economic value of benefits derived from the Uttarakhand forests. The study acknowledges the following major limitations which may be noted:

- Not all data required for benefits included in the study were available at district level. Hence the values were distributed as per the forest area each district consists of.
- Unavailability of site-specific data on specific input parameters (and constants) both for valuation and the InVEST model. In such cases, secondary literature and global data has been used.

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ANNEXURES: META-TABLES OF SEPI INDICATORS

TABLE 1: SEPI Indicators under Forest & Biodiversity Sector

Forest & Biodiversity Sector	
Indicator Code	FB-S-1
Indicator	% forest area under Very Dense Forest (VDF)& Moderately Dense Forest (MDF)
DPSIR Category	State (S)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 13: Climate Action
	Goal 15: Life on land (Targets 15.1 and 15.2)
What It Measures	Extent of dense forest from the total forest area. Doesn't include forest under the category of 'Open Forest (OF)' by assuming it to be degraded forests.
Rationale for Inclusion	Reduction in the extent of dense forest area has significant negative implications for ecosystem services and habitat protection.Hence, monitoring of the state of forests becomes important.
Unit of Measurement	Percentage Area (%)
Base Year Value	74.89% (2014-15)
Current Year Value	75.72% (2015-16)
Measurement interval	Biannually
Data Source	Forest Survey of India (FSI)
Year of Publication	Indian State of Forest Reports (IFSR) 2013 and 2015
URL	http://fsi.nic.in/details.php?pgID=sb_62

Forest & Biodiversity Sector	
Indicator Code	FB-S-2
Indicator	% area under tree cover with reference to total geographical area
DPSIR Category	State (S)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 13: Climate Action
	Goal 15: Life on land (Targets 15.1 and 15.2)
What It Measures	Extent of area under tree cover
Rationale for Inclusion	Loss in tree cover across a range of causes including anthropogenic deforestation, natural and anthropogenic forest fires, clearingtrees for agriculture, logging, harvesting etc. has important implications for environment sustainability
Unit of Measurement	Percentage Area (%)
Base Year Value	50.33% (2014-15)
Current Year Value	49.88% (2015-16)
Measurement interval	Biannually
Data Source	Forest Survey of India (FSI)
Year of Publication	India State of Forest Reports (IFSR) 2013 and 2015
URL	http://fsi.nic.in/details.php?pgID=sb_62

Forest & Biodiversity Sector	
Indicator Code	FB-S-3
Indicator	% of total species not in IUCN RED list
DPSIR Category	State (S)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 13: Climate Action
	Goal 15: Life on land (Target 15.5)
What It Measures	The extent of a species' range not found in IUCN RED List as a proportion of state's total spe cies population
Rationale for Inclusion	IUCN Red list highlights the global conservation status of biological species and determines the relative risk of extinction. This indicator is important because itinforms and catalyses action for species conservation. This indicator here describes only status of the flora in the state due to data unavailability.
Unit of Measurement	Percentage (%)
Base Year Value	96% (2014-15)
Current Year Value	96% (2015-16)
Measurement interval	Not periodic
Data Source	Botanical Survey of India (BSI)
Year of Publication	Primary Data
URL	-
Notes	Though nearly 10 % of total flora faces some or other kind of threat, but that is applicable at regional level in varying degree at macro/micro level within the state. But since IUCN categories are applicable for entire range (not for regional application, other than core sub-populations, in cases for taxa with broad distribution range) only nearly 4% species in Uttarakhand flowering plants falls in IUCN threat categories [Least Concerned category excluded].

Forest & Biodiversity Sector	
Indicator Code	FB-S-4
Indicator	% of endemic species not in IUCN RED list
DPSIR Category	State (S)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 13: Climate Action
	Goal 15: Life on land (Target 15.5)
What It Measures	The extent of endemic species' range not found in IUCN RED List as a proportion of state's endemic species
Rationale for Inclusion	Endemic species are unique to their region andfound only in restricted areas. This indicator is very important for prioritizing areas for conservation since endemic species falling in Red list categories are based on area of occupancy/extent of occurrence andloss of habitat or degradation of natural ecosystems including forests possess a greater risk of extinction. This indicator here describes only status of the flora in the state due to data unavailability and as for narrow range state endemics, no significant change in status is recorded.
Unit of Measurement	Percentage (%)
Base Year Value	50% (2014-15)
Current Year Value	50% (2015-16)
Measurement interval	Not periodic
Data Source	Botanical Survey of India (BSI)
Year of Publication	Primary Data
URL	-

Forest & Biodiversity Sector	
Indicator Code	FB-I-5
Indicator	Diversion of forest land (including roads, peyjal, transmission lines, mining, dams and others)
DPSIR Category	Impact (I)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 13: Climate Action
	Goal 15: Life on land (Target 15.3)
What It Measures	Forest area diverted for non-forest purposesunder Forest Conservation Act, 1980
Rationale for Inclusion	Forest diversion for non-forest purposeshas an irreparable and irreversible impact on land environment and ecological imbalance. According to the new guidelines, the ecosystem service cost of diversion will be assessed based on the NPV formula. The Net Present value formula (NPV) account for various ecological services like water recharge, nutrients in the soil, carbon sequestration and others.
Unit of Measurement	Hectares (ha)
Base Year Value	288.1018 ha (2014-15)
Current Year Value	298.1793 ha (2015-16)
Measurement interval	Annually
Data Source	Uttarakhand Forest Department(PFM Dept.)
Year of Publication	Uttarakhand Forest Statistics Report 2014-15
URL	http://forest.uk.gov.in/files/sTATISTICS_2013/Uttarakhand_Statistics_2013.pdf

Forest & Biodiversity Sector	
Indicator Code	FB-I-6-a
Indicator	Man-animal conflict (human deaths and injury)
DPSIR Category	Impact (I)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 12: Responsible production & consumption (Target 12.8)
	Goal 15: Life on land (Target 15.5)
What It Measures	Human deaths and injury due to man-animal conflict
Rationale for Inclusion	Man-animal conflict has become a serious wildlifemanagement problem. High dependence on forests for meeting livelihood and increasing encroachment in wild spaces has created a significant threat to human life due to attack by wild animals. Also, increasing dispersal of wild animals in human-dominated landscapes is taking a toll. Measures should be adopted to resolve this issue of man-animal conflict in the interest of human as well as animal well-being.
Unit of Measurement	Number of human deaths and injury
Base Year Value	225 (2014-15)
Current Year Value	213 (2015-16)
Measurement interval	Annually
Data Source	Uttarakhand Forest Department(PFM Dept.)
Year of Publication	Uttarakhand Forest Statistics Report 2014-15
URL	http://forest.uk.gov.in/files/sTATISTICS_2013/Uttarakhand_Statistics_2013.pdf

Forest & Biodiversity Sector	
Indicator Code	FB-I-6-b
Indicator	Man-animal conflict (livestock deaths)
DPSIR Category	Impact (I)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 12: Responsible production & consumption (Target 12.8)
	Goal 15: Life on land (Target 15.5)
What It Measures	Livestock deaths due to man-animal conflict
Rationale for Inclusion	In recent years, rising population and shrinking habitats has increased the number of man-animal conflict. The impacts are often huge in terms of livestock deaths, crop damage, property loss and even animal deaths.Estimating losses caused by wildlife is a priority and measures should be adopted to prevent such losses. Livestock deaths due to man-animal conflict is a major concern for the state.
Unit of Measurement	Number of livestock deaths
Base Year Value	2583 (2014-15)
Current Year Value	3244 (2015-16)
Measurement interval	Annually
Data Source	Uttarakhand Forest Department(PFM Dept.)
Year of Publication	Uttarakhand Forest Statistics Report 2014-15
URL	http://forest.uk.gov.in/files/sTATISTICS_2013/Uttarakhand_Statistics_2013.pdf

Forest & Biodiversity Sector	
Indicator Code	FB-I-6-c
Indicator	Man-animal conflict (crop area damaged)
DPSIR Category	Impact (I)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 12: Responsible production & consumption (Target 12.8)
	Goal 15: Life on land (Target 15.5)
What It Measures	Crop area being damaged due to man-animal conflict
Rationale for Inclusion	In recent years, rising population and shrinking habitats has increased the number of man-animal conflicts and the impacts are often huge in terms of livestock deaths, crop damage, property loss and even animal deaths.Estimating losses caused by wildlife is a priority and measures should be adopted to resolve this issue and prevent such losses.
Unit of Measurement	Hectare
Base Year Value	167.51 ha (2014-15)
Current Year Value	307.39 ha (2015-16)
Measurement interval	Annually
Data Source	Uttarakhand Forest Department(PFM Dept.)
Year of Publication	Uttarakhand Forest Statistics Report 2014-15
URL	http://forest.uk.gov.in/files/sTATISTICS_2013/Uttarakhand_Statistics_2013.pdf

Forest & Biodiversity Sector	
Indicator Code	FB-I-6-d
Indicator	Man-animal conflict (houses damaged)
DPSIR Category	Impact (I)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 12: Responsible production & consumption (Target 12.8)
	Goal 15: Life on land (Target 15.5)
What It Measures	Houses being damageddue to man-animal conflict
Rationale for Inclusion	Besides the damage caused to thousands of acres of crops, loss of livestock, human death & injury; thisindicator measures the damage to property owing to man-wildlife conflict in state.
Unit of Measurement	Number
Base Year Value	17 (2014-15)
Current Year Value	45 (2015-16)
Measurement interval	Annually
Data Source	Uttarakhand Forest Department(PFM Dept.)
Year of Publication	Uttarakhand Forest Statistics Report 2014-15
URL	http://forest.uk.gov.in/files/sTATISTICS_2013/Uttarakhand_Statistics_2013.pdf

Forest & Biodiversity Sector	
Indicator Code	FB-I-6-e
Indicator	Wild animal deaths including tiger, leopard and elephants
DPSIR Category	Impact (I)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 12: Responsible production & consumption (Target 12.8)
	Goal 15: Life on land (Target 15.5)
What It Measures	Wild animal deaths due to poaching, road/train accidents, fire, electrocution, food poisoning, declared dangerous to human life, mutual fight, trapped in snare and others. This indicator excludes natural deaths
Rationale for Inclusion	A number of wild animals, are also killed in retaliation or to prevent future man-animal conflicts. This indicator is important because it assesses the wildlife habitat conservation beyond the boundaries of protected areas. It looks at how well wild animals are managed within and outside the protected areas and the strengthof the legal protections extended to them. This indicator takes into account three wild animals including elephants, tigers, and leopards as per the data availability
Unit of Measurement	Number
Base Year Value	51 (2014-15)
Current Year Value	31 (2015-16)
Measurement interval	Annually
Data Source	Uttarakhand Forest Department(Wildlife wing)
Year of Publication	Primary Data
URL	-

Forest & Biodiversity Sector	
Indicator Code	FB-R-7
Indicator	Tree plantations / Area afforested
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 13: Climate Action
	Goal 15: Life on land (Targets 15.1 & 15.2)
What It Measures	Area under afforestation
Rationale for Inclusion	India's NDC aims to enhance carbon stocks in its forests and tree cover by 2.5-3 GtCO2eby 2030.Afforestation is one such key initiative which will help contribute to increased green cover and generate co-benefits. Moreover, it will help achieve the emission targets of the country.
Unit of Measurement	Hectare
Base Year Value	17404.69 (2014-15)
Current Year Value	17846.26 (2015-16)
Measurement interval	Annually
Data Source	Uttarakhand Forest Department(PFM Dept.)
Year of Publication	Uttarakhand Forest Statistics Report 2014-15
URL	http://forest.uk.gov.in/files/sTATISTICS_2013/Uttarakhand_Statistics_2013.pdf

Forest & Biodiversity Sector	
Indicator Code	FB-R-8
Indicator	Total area under protected areas (NP, WLS & CRs)
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 13: Climate Action
	Goal 15: Life on land (Targets 15.1, 15.2, 15.3, 15.4 & 15.5)
What It Measures	Total area in the state that is protected as under National parks, Wildlife Sanctuaries, Biosphere Reserves, Reserved and Protected Forests, Conservation and Community Reserves and others.
Rationale for Inclusion	India is a megadiverse country which comprises of only 2.4% of the world's land area and accounts for about 8% of recorded global biodiversity1. Protected areas support a significant proportion of country's wildlife population. As on July 2017, 4.93% of the total geographic area of the country falls under Protected Area Network2 ensuringhabitat protectionand biodiversity conservation. This indicator is important because it looks at how the state is dealing with species conservationwithin its borders more broadly.
Unit of Measurement	Square kilometres
Base Year Value	7897.57 (2014-15)
Current Year Value	7897.57 (2015-16)
Measurement interval	Annually
Data Source	Uttarakhand Forest Department(PFM Dept.)
Year of Publication	Uttarakhand Forest Statistics Report 2014-15
URL	http://forest.uk.gov.in/files/sTATISTICS_2013/Uttarakhand_Statistics_2013.pdf

Forest & Biodiversity Sector	
Indicator Code	FB-R-9
Indicator	Households usingclean cooking fuels (LPG, biogas or electricity)
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 7: Access to Clean Energy (Targets 7.1)
	Goal 13: Climate Action
	Goal 15: Life on land (Targets 15.3 & 15.2)
What It Measures	LPG access indicating reduced fuelwood consumption/dependence
Rationale for Inclusion	Unsustainable extraction of fuelwood is a key driver for deforestation and forest degradation. The provision of clean cooking technology especially to rural households located in close proximity to forests helps in decreasing the overall fuelwood consumption, conserving forests. In addition, it generates huge co-benefits, notably for women who suffer from respiratoryillnesses due to smoke from cooking.
Unit of Measurement	Percentage (%)
Base Year Value	36.3% (2014-15) (NFHS 2005-06)
Current Year Value	51% (2015-16) (NFHS 2015-16)
Measurement interval	Annually
Data Source	Directorate of Economics and Statistics, Department of Planning, Uttarakhand
Year of Publication	Statistical Diary, 2016 and 2017
URL	http://www.des.uk.gov.in/contents/listing/3/54-statistical-diary

Forest & Biodiversity Sector	
Indicator Code	FB-R-10
Indicator	Total number of Biodiversity Management Committees (BMCs) formed till date
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 13: Climate Action
	Goal 15: Life on land
What It Measures	Biodiversity Management Committees (BMCs) in the state
Rationale for Inclusion	Biodiversity Management Committees (BMCs) ensureconservation and effective utilisation of biological resources taking into account the rich traditional knowledge of the local communities. This decentralised mechanism is important in decision making and generating social, environmental and economic benefits.
Unit of Measurement	Number
Base Year Value	742 (2014-15)
Current Year Value	775 (2015-16)
Measurement interval	Annually
Data Source	Uttarakhand State Biodiversity Board
Year of Publication	Primary Data
URL	-

Forest & Biodiversity Sector	
Indicator Code	FB-R-11
Indicator	Total number of contracts signed under the Access & Benefit Sharing mechanism (ABS)
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 13: Climate Action
	Goal 15: Life on land
What It Measures	Status of contracts signed under ABS in the state of Uttarakhand
Rationale for Inclusion	This indicator is important as it help generate significant funds for conservation and sustainable use of biodiversity.
Unit of Measurement	Number
Base Year Value	15 (2014-15)
Current Year Value	31 (2015-16)
Measurement interval	Annually
Data Source	Uttarakhand State Biodiversity Board
Year of Publication	Primary Data
URL	-

TABLE 2: SEPI Indicators under Water & Sanitation Sector

Water & Sanitation Sector	
Indicator Code	WS-S-12
Indicator	% of total blocks falling under Safe zone category (<70% stage of groundwater development) in the state
DPSIR Category	State (S)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 6: Clean water & sanitation (Targets 6.1 & 6.4)
What It Measures	The ground water resources are assessed in units i.e. blocks/ talukas/ mandals/ watersheds. There are four categories, namely - 'Safe' areas which have ground water potential for development; 'Semi-critical' areas where cautious groundwater development is recommended; 'Critical' areas; and 'Over-exploited' areas, where there should be intensive monitoring and evaluation and future ground development be linked with water conservation measures.
Rationale for Inclusion	The stage of ground water development indicates that the ratio of annual ground water consumption to annual ground water recharge3. In Uttarakhand, the stage of ground water development is estimated to be 66% highlighting there is no significant long term decline ofpre or post monsoon ground water levels.
Unit of Measurement	Percentage (%)
Base Year Value	94.74% (2011 is the most recent available data)
Current Year Value	94.74% (2011)
Measurement interval	10 years
Data Source	Central Ground Water Board, Uttarakhand
Year of Publication	2011
URL	http://cgwb.gov.in/gw_profiles/Uttarakhand.htm
Notes	As per the CGWA's categorization of blocks in Uttarakhand, 3 blocks fall under Semi- critical and 2 blocks under Overexploited category.

Water & Sanitation Sector	
Indicator Code	WS-S-13
Indicator	% of monitoring stations meeting prescribed water quality (drinkable, fishable and swimmable i.e. Class A)
DPSIR Category	State (S)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 6: Clean water & sanitation (Targets 6.3)
	Goal 15: Life on land
What It Measures	Access to clean drinking water i.e. 'Class A' category (drinkable, fishable and swimmable) as a main source of water.
Rationale for Inclusion	Monitoring stations meeting prescribed water quality is a proxy foraccess tosafe water. This reduces exposure topollution, disease, and harmful contaminants, thereby promoting health and wellbeing.
Unit of Measurement	Percentage (%)
Base Year Value	54.55% (2014-15)
Current Year Value	50% (2015-16)
Measurement interval	Annually
Data Source	Uttarakhand Environment Protection & Pollution Control Board (UEPPCB)
Year of Publication	2014 and 2015
URL	http://ueppcb.uk.gov.in/pages/display/96-water-quality-data

Water & Sanitation Sector	
Indicator Code	WS-I-14
Indicator	Incidence of water borne diseases (Acute Diarrhoeal Diseases,Enteric Fever (Typhoid), Viral Hepatitis (All Causes) & Cholera)
DPSIR Category	Impact (I)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 3: Good health & well-being (Target 3.9)
What It Measures	How much of theburden of disease observed in a given year can be attributed to past exposure tounsafe water in the state.
Rationale for Inclusion	This indicator actsas a proxy measure for maintaining healthy water supplies, minimizing contact with dangerous bacteria and viruses, and minimizing environmental threats associated with improper waste management
Unit of Measurement	Number
Base Year Value	1,28,610 cases (2014-15)
Current Year Value	1,51,250 cases (2015-16)
Measurement interval	Annual
Data Source	Directorate of Health Services, Uttarakhand
Year of Publication	Primary Data
URL	-

Water & Sanitation Sector	
Indicator Code	WS-R-15
Indicator	% villages with tapped drinking water
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 6: Clean water & sanitation (Targets 6.1)
What It Measures	Access to tapped drinking water indicates the proportion of population having access to drinking water facility.
Rationale for Inclusion	Access to tapped drinking water is the best available proxy foraccess to clean water. Access to reliable, safe water reduces exposure topollution, disease, and harmful contaminants, thereby promoting health and wellbeing.
Unit of Measurement	Percentage (%)
Base Year Value	99.99% (2014-15)
Current Year Value	99.99% (2015-16)
Measurement interval	Annual
Data Source	Directorate of Economics and Statistics, Department of Planning, Uttarakhand
Year of Publication	Statistical Diary, 2016 and 2017
URL	http://www.des.uk.gov.in/contents/listing/3/54-statistical-diary

Water & Sanitation Sector	
Indicator Code	WS-R-16
Indicator	% irrigation potential utilized to irrigation potential created till date
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 6: Clean water & sanitation (Targets 6.4)
What It Measures	Area utilised under irrigation till date
Rationale for Inclusion	This indicator will strengthen the tasks of maintenance, operation and utilisation of efficient irrigation systemin each season leading to assured water supply. Further it also projects that the cropping pattern of the region is satisfactorily adhered to.
Unit of Measurement	Percentage (%)
Base Year Value	74.06% (2014-15)
Current Year Value	73.30% (2015-16)
Measurement interval	Annual
Data Source	Directorate of Economics and Statistics, Department of Planning, Uttarakhand
Year of Publication	Statistical Diary, 2016 and 2017
URL	http://www.des.uk.gov.in/contents/listing/3/54-statistical-diary

Water & Sanitation Sector	
Indicator Code	WS-R-17
Indicator	% of domestic waste water treated
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 6: Clean water & sanitation (Targets 6.3 & 6.4)
What It Measures	The percentage of collected, generated, or produced wastewater that is treated, normalized by the population connected to treatmentfacilities.
Rationale for Inclusion	Wastewater from industrial or household sources can contain avariety of contaminants that are detrimental to both human and ecosystem health. Wastewater treatment is a measure of what percentage of wastewater is treated before it isreleased back into ecosystems. The percentage of wastewater treated represents a measureof largely urban waste collection and treatment, since few rural areas are connected tosewage systems.
Unit of Measurement	Percentage (%)
Base Year Value	25.3% (2014-15)
Current Year Value	25.3% (2015-16)
Measurement interval	Annual
Data Source	Jal Nigam, Uttarakhand
Year of Publication	Primary Data
URL	-

Water & Sanitation Sector	
Indicator Code	WS-R-18
Indicator	% of population living in ODF (Gramin) free villages
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 6: Clean water & sanitation (Targets 6.2)
What It Measures	Percentage of population with access to improved sanitation
Rationale for Inclusion	Access to adequate sanitation is vital for minimizing contact with dangerous bacteria and viruses, andminimizing environmental threats associated with improper waste management.
Unit of Measurement	Percentage (%)
Base Year Value	86.69% (2016-17)
Current Year Value	100% (2017-18)
Measurement interval	Annual
Data Source	Swachh Bharat Mission Dashboard
Year of Publication	2016-17 & 2017-18
URL	http://sbm.gov.in/sbmdashboard/

TABLE 3: SEPI Indicators under Energy Sector

Energy Sector	
Indicator Code	EN-S-19
Indicator	Households using clean fuel for cooking (LPG, biogas or electricity)
DPSIR Category	State (S)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 7: Affordable & clean energy (Target 7.1)
	Goal 15: Life on land (Target 15.2 & 15.3)
What It Measures	The percentage of households having access to clean fuel for cooking
Rationale for Inclusion	The provision of clean cooking technology helps in reducing the overall dependence on forests for fuelwood. In addition, lowers the exposure risks to daily household pollutant concentrations due to smoke from cooking.
Unit of Measurement	Percentage (%)
Base Year Value	36.3% (2005-06)
Current Year Value	51% (2015-16)
Measurement interval	Annual
Data Source	National Family Health Survey- 3 & 4
Year of Publication	2005-06 &2015-16
URL	-

Energy Sector	
Indicator Code	EN-S-20
Indicator	% households having access to electricity
DPSIR Category	State (S)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 7: Affordable & clean energy (Target 7.1)
What It Measures	Percentage of population with access to electricity
Rationale for Inclusion	Modern energy services are important in ensuring a satisfactory quality of life for people and promoting economic development. Access to energy is central to issues such as security, climate change, food production, and strengthening economies while protecting ecosystems.
Unit of Measurement	Percentage (%)
Base Year Value	98.93%
Current Year Value	99.52%
Measurement interval	Annual
Data Source	Directorate of Economics and Statistics, Department of Planning, Uttarakhand
Year of Publication	Statistical Diary, 2014 and 2015
URL	http://www.des.uk.gov.in/contents/listing/3/54-statistical-diary

Energy Sector	
Indicator Code	EN-S-21
Indicator	% of renewable energy mix in installed capacity (MW) of power utilities in the state (includes: small hydro, biogas, biomass, waste and wind energy)
DPSIR Category	State (S)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 7: Affordable & clean energy (Target 7.2)
What It Measures	% of renewable energy mix
Rationale for Inclusion	Because the power sector is the largest contributor to CO2 emissions, the CO2 per kWh indicator measures state's ability to reduce the carbon intensity of electricity and heat production.
Unit of Measurement	Percentage (%)
Base Year Value	5.90%
Current Year Value	7.69% (2015)
Measurement interval	Annual
Data Source	Directorate of Economics and Statistics, Department of Planning, Uttarakhand
Year of Publication	Statistical Diary, 2014 and 2015
URL	http://www.des.uk.gov.in/contents/listing/3/54-statistical-diary

Energy Sector	
Indicator Code	EN-S-22
Indicator	Energy Intensity
DPSIR Category	State (S)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 7: Affordable & clean energy (Target 7.3)
What It Measures	This indicator measures state's energy consumption per unit of GDP.
Rationale for Inclusion	Higher energy intensity will increase state's climate change impact and contribute to resource depletion. This indicator identifies to what extent there is decoupling between energy consumption and economic growth. Relative decoupling occurs when energy consumption grows, albeit more slowly than the economy (i.e. gross domestic product). Absolute decoupling occurs when energy consumption is stable or falls while GDP grows. Absolute decoupling is likely to alleviate the environmental pressures from energy production and consumption.
Unit of Measurement	Mega joules/rupee
Base Year Value	0.0268292 (2014-15)
Current Year Value	0.0246527 (2015-16)
Measurement interval	Annual
Data Source	Central Electricity Authority
Year of Publication	Primary Data
URL	-

Energy Sector	
Indicator Code	EN-S-23
Indicator	% observations on which air quality has been reported at safe levels (avg of PM10, SO2, NO2)
DPSIR Category	Impact
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 3: Good health & well-being (Target 3.9)
What It Measures	Average Exposure to PM10, SO2, NO2
Rationale for Inclusion	Suspended particulates and oxides of sulphur & nitrogen are known to contribute to smog and human health impacts causing lung irritation and acute respiratory infections.
Unit of Measurement	%
Base Year Value	46.67
Current Year Value	33.3
Measurement interval	Annual
Data Source	Uttarakhand Environment Protection & Pollution Control Board (UEPPCB)
Year of Publication	2014 and 2015
URL	http://ueppcb.uk.gov.in/pages/display/95-air-quality-data

Energy Sector	
Indicator Code	EN-I-24
Indicator	Prevalence of Chronic respiratory diseases (Asthma/Bronchitis/ Emphysemas)
DPSIR Category	Impact (I)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 3: Good health & well-being (Target 3.9)
What It Measures	How much of theburden of disease observed in a given year can be attributed to past exposure toair pollution(ambient particulate matter pollution, household air pollution, and ozone pollution).
Rationale for Inclusion	This indicator is a proxy measure to assess the state of air quality.
Unit of Measurement	Number of cases
Base Year Value	70,259
Current Year Value	64,576
Measurement interval	Annual
Data Source	Uttarakhand Health & Family Welfare Society
Year of Publication	2014-15 and 2015-16
URL	-

Energy Sector	
Indicator Code	EN-R-25
Indicator	Installed Community Solar Cooker till date
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 7: Affordable & clean energy (Target 7.1 & 7.2)
What It Measures	Community Solar Cooker installed till date
Rationale for Inclusion	To both advance solar energy and conservation goal in the state, monitoring of this indicator becomes vital.
Unit of Measurement	Number
Base Year Value	400
Current Year Value	750
Measurement interval	Annual
Data Source	Directorate of Economics and Statistics, Department of Planning, Uttarakhand
Year of Publication	Statistical Diary, 2014 and 2015
URL	http://www.des.uk.gov.in/contents/listing/3/54-statistical-diary

Energy Sector	
Indicator Code	EN-R-26
Indicator	Solar Photo Programme (Solar Lantern & Solar Light-Street) till date
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 7: Affordable & clean energy (Target 7.1 & 7.2)
What It Measures	Solar Lantern & Solar Light-Street installed till date
Rationale for Inclusion	To both advance solar energy and sustainable energy conservation goals in the state, monitoring of this indicator becomes vital.
Unit of Measurement	Number
Base Year Value	5,630
Current Year Value	6,493
Measurement interval	Annual
Data Source	Directorate of Economics and Statistics, Department of Planning, Uttarakhand
Year of Publication	Statistical Diary, 2014 and 2015
URL	http://www.des.uk.gov.in/contents/listing/3/54-statistical-diary

TABLE 4: SEPI Indicators under Disaster Risk and Vulnerability Sector

Disaster Risk and Vulnerability Sector	
Indicator Code	EN-S-27
Indicator	Number of occurrence disasters reported (Avalanche, Cold and Exposure, Landslide, Lightning and Other Natural Causes)
DPSIR Category	State (S)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 3: Good health & well-being
	Goal 13: Climate actions
What It Measures	Number of occurrence disasters reported (Avalanche, Cold and Exposure, Landslide, Lightning and Other Natural Causes)
Rationale for Inclusion	Climate change is among the direst environmental challenges. Looking at the fragile ecosystem of the state, it is important to monitor the frequency of occurrence of disasters so that measures can be adopted to help vulnerable populations to adapt.
Unit of Measurement	Number
Base Year Value	Awaited
Current Year Value	Awaited
Measurement interval	-
Data Source	DMMC, Uttarakhand
Year of Publication	-
URL	-

Disaster Risk and Vulnerability Sector	
Indicator Code	EN-S-28
Indicator	Number of chronically disaster prone villages in Uttarakhand
DPSIR Category	State (S)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 3: Good health & well-being
	Goal 13: Climate actions
What It Measures	Number of chronically disaster prone villages in Uttarakhand
Rationale for Inclusion	With a very fragile terrain that is prone to natural disasters, the state of Uttarakhand falls is prone to massive natural calamities, such as rains, cloudbursts, flash floods, landslides, floods, hailstorms and water logging events. It thus become critical to highlight areas and draft action plan to minimise impact to the fragile ecosystems.
Unit of Measurement	Number
Base Year Value	341
Current Year Value	395
Measurement interval	Annual
Data Source	DMMC, Uttarakhand
Year of Publication	2014-15 and 2015-16
URL	-

Disaster Risk and Vulnerability Sector	
Indicator Code	EN-S-29
Indicator	% of area under flood prone zones
DPSIR Category	State (S)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 3: Good health & well-being
	Goal 13: Climate actions
What It Measures	Extent of area falling underflood prone zones
Rationale for Inclusion	Looking at the fragile ecosystem of the state that is prone to natural disasters, it is important to identify vulnerable areas in the state, conduct risk assessment studies and monitor disaster risks to enhance early warning systems.
Unit of Measurement	Number
Base Year Value	Removed but after AHP exercise
Current Year Value	Removed but after AHP exercise
Measurement interval	-
Data Source	DMMC, Uttarakhand
Year of Publication	-
URL	-

Disaster Risk and Vulnerability Sector	
Indicator Code	EN-S-29a
Indicator	% of area under landslide prone zones
DPSIR Category	State (S)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 3: Good health & well-being
	Goal 13: Climate action
What It Measures	Extent of area falling underflood prone zones
Rationale for Inclusion	Looking at the fragile ecosystem of the state that is prone to natural disasters, it is important to identify vulnerable areas in the state, conduct risk assessment studies and monitor disaster risks to enhance early warning systems.
Unit of Measurement	Number
Base Year Value	Removed but after AHP exercise
Current Year Value	Removed but after AHP exercise
Measurement interval	-
Data Source	DMMC, Uttarakhand
Year of Publication	-
URL	-

Disaster Risk and Vulnerability Sector	
Indicator Code	EN-I-30 (a)
Indicator	Annual loss of human life due to natural disasters in Uttarakhand state
DPSIR Category	Impact (I)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 1: No poverty (Target 1.5)
	Goal 13: Climate action (Target 13.1)
What It Measures	Annual loss of human life due to natural disasters in Uttarakhand state
Rationale for Inclusion	Climate change is among the direst environmental challenges. Looking at the fragile ecosystem of the state, it is important to account for loss and damage already experienced towards building potential solutions.
Unit of Measurement	Number
Base Year Value	66 (2014-15)
Current Year Value	56 (2015-16)
Measurement interval	Annual
Data Source	DMMC, Uttarakhand
Year of Publication	Primary Data
URL	-

Disaster Risk and Vulnerability Sector	
Indicator Code	EN-I-30 (b)
Indicator	Annual loss of animals (large & small) due to natural disasters in Uttarakhand state
DPSIR Category	Impact (I)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 13: Climate Action
	Goal 15: Life on land
What It Measures	Annual loss of animals (large & small) due to natural disasters in Uttarakhand state
Rationale for Inclusion	Climate change is among the direst environmental challenges. Looking at the fragile ecosystem of the state, it is important to account for loss and damage already experienced towards building potential solutions.
Unit of Measurement	Number
Base Year Value	371 (2014-15)
Current Year Value	1,017 (2015-16)
Measurement interval	Annual
Data Source	DMMC, Uttarakhand
Year of Publication	Primary Data
URL	-

Disaster Risk and Vulnerability Sector	
Indicator Code	EN-I-30 (c)
Indicator	Annual loss of agricultural land due to natural disasters in Uttarakhand state
DPSIR Category	Impact (I)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 1: No poverty (Target 1.5)
	Goal 13: Climate action (Target 13.1)
What It Measures	Annual loss of agricultural land due to natural disasters in Uttarakhand state
Rationale for Inclusion	Climate change is among the direst environmental challenges. Looking at the fragile ecosystem of the state, it is important to account for loss and damage already experienced towards building potential solutions.
Unit of Measurement	Hectare
Base Year Value	1285.53 (2014-15)
Current Year Value	15.479 (2015-16)
Measurement interval	Annual
Data Source	DMMC, Uttarakhand
Year of Publication	Primary Data
URL	-

Disaster Risk and Vulnerability Sector	
Indicator Code	EN-I-30 (d)
Indicator	Annual loss of property/infrastructure due to natural disasters in Uttarakhand state
DPSIR Category	Impact (I)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 1: No poverty (Target 1.5)
	Goal 13: Climate action (Target 13.1)
What It Measures	Annual loss of property/infrastructure due to natural disasters in Uttarakhand state
Rationale for Inclusion	Climate change is among the direst environmental challenges. Looking at the fragile ecosystem of the state, it is important to account for loss and damage already experienced towards building potential solutions.
Unit of Measurement	Number
Base Year Value	620 (2014-15)
Current Year Value	206 (2015-16)
Measurement interval	Annual
Data Source	DMMC, Uttarakhand
Year of Publication	Primary Data
URL	-

Disaster Risk and Vulnerability Sector	
Indicator Code	EN-I-31
Indicator	Total area affected due to forest fire incidents
DPSIR Category	Impact (I)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 1: No poverty (Target 1.5)
	Goal 13: Climate action (Target 13.1)
What It Measures	Total area affected due to forest fire incidents
Rationale for Inclusion	Forest fires in Uttarakhand have been regular and historic feature. Every year forest fires cause a great loss to the forest ecosystem, diversity of flora and fauna and economic wealth and is one of the major disasters of the state.
Unit of Measurement	Hectare
Base Year Value	701.61
Current Year Value	4433.75
Measurement interval	Annual
Data Source	Uttarakhand Forest Department (PFM Dept.)
Year of Publication	Uttarakhand Forest Statistics Report 2014-15 and 2015-16
URL	-

Disaster Risk and Vulnerability Sector	
Indicator Code	EN-R-32
Indicator	No. of 10 days Search & Rescue and First Aid training programmes conducted
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 13: Climate action (Target 13.1, 13.2 & 13.3)
What It Measures	10 days Search & Rescue and First Aid training programmes conducted
Rationale for Inclusion	This indicator is important to build safety and resilience at all levels and strengthen disaster preparedness for effective response and recovery at all levels.
Unit of Measurement	Number
Base Year Value	72 (2014-15)
Current Year Value	108 (2015-16)
Measurement interval	Annual
Data Source	DMMC, Uttarakhand
Year of Publication	Primary Data
URL	-

Disaster Risk and Vulnerability Sector	
Indicator Code	EN-R-33
Indicator	No. of 6 days mason training on earthquake safe construction
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 13: Climate action (Target 13.1, 13.2 & 13.3)
What It Measures	Training programmes on earthquake safe construction
Rationale for Inclusion	This indicator is important to build safety and resilience at all levels and strengthen disaster preparedness for effective response and recovery at all levels.
Unit of Measurement	Number
Base Year Value	6 (2014-15)
Current Year Value	10 (2015-16)
Measurement interval	Annual
Data Source	DMMC, Uttarakhand
Year of Publication	Primary Data
URL	-

Disaster Risk and Vulnerability Sector	
Indicator Code	EN-R-34
Indicator	Number/area of chronic landslide zones treated
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 13: Climate action (Target 13.1, 13.2 & 13.3)
What It Measures	Number/area of chronic landslide zones treated
Rationale for Inclusion	There is a continuous problem of landslides in many districts of Uttarakhand state that poses danger to the people living in the hills, thus treatment of most chronic landslide zones in the state through slope stabilization methods is crucial.
Unit of Measurement	Number
Base Year Value	Removed but after AHP exercise
Current Year Value	Removed but after AHP exercise
Measurement interval	-
Data Source	DMMC, Uttarakhand
Year of Publication	-
URL	-

Disaster Risk and Vulnerability Sector	
Indicator Code	EN-R-35
Indicator	Fire lines prepared by FD
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 13: Climate action (Target 13.1, 13.2 & 13.3)
What It Measures	Fire lines prepared by the forest department
Rationale for Inclusion	Forest fires can be prevented by reducing orlimiting the exposure of forests to fire risks. This may beachieved by creating fire lines and maintaining them in thesubsequent years.
Unit of Measurement	Kilometer
Base Year Value	16443.578 (2014-15)
Current Year Value	17071.547 (2015-16)
Measurement interval	Annual
Data Source	Uttarakhand Forest Department (PFM Dept.)
Year of Publication	Uttarakhand Forest Statistics Report 2014-15 and 2015-16
URL	-

TABLE 5: SEPI Indicators under Tourism & Education Sector

Tourism & Education Sector	
Indicator Code	EN-R-36
Indicator	No. of tourist destinations covered under study to assess carrying capacity
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 13: Climate Action
	Goal 11: Sustainable cities and communities
	Goal 15: Life on land
What It Measures	Tourist destinations covered under study to assess carrying capacity
Rationale for Inclusion	Assessment of tourism carrying capacity is essential to regulate and efficiently manage tourism growth as well as destinations. It will helpsetting capacity limits for sustaining tourism activity in the state.
Unit of Measurement	Number
Base Year Value	NA (2014-15) taken as 105
Current Year Value	105 (2015-16)
Measurement interval	-
Data Source	Uttarakhand Tourism Department
Year of Publication	Primary Data
URL	-

Tourism & Education Sector	
Indicator Code	EN-R-37
Indicator	% of registered home stays to total infrastructure in the Uttarakhand state
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 13: Climate Action
	Goal 15: Life on land
What It Measures	The proportion of registered home stays to total infrastructure
Rationale for Inclusion	Homestay based tourism activities are important to bring economic opportunities to locals and at the same time minimizing impact on surrounding ecology. It also promote local culture demonstrating arts and crafts.
Unit of Measurement	Percentage (%)
Base Year Value	NA (2014-15) taken as 3.94%
Current Year Value	3.94% (2015-16)
Measurement interval	-
Data Source	Uttarakhand Tourism Department
Year of Publication	Primary Data
URL	-

Tourism & Education Sector	
Indicator Code	EN-R-38
Indicator	Number of Ecotourism destinations set up in the state
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 8: Decent work and economic growth (Target 8.9)
	Goal 11: Sustainable cities and communities
What It Measures	Ecotourism destinations set up in the state
Rationale for Inclusion	This indicator is important to promote sustainable travel and help conserve the local environment, while supporting the culture and encouraging people to look after the natural resources that attracts visitors to the region.
Unit of Measurement	Number
Base Year Value	30
Current Year Value	31
Measurement interval	-
Data Source	Uttarakhand Tourism Department
Year of Publication	Primary Data
URL	-

Tourism & Education Sector	
Indicator Code	EN-R-39
Indicator	No of eco clubs in schools/colleges
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 13: Climate Action
What It Measures	No of eco clubs in schools/colleges
Rationale for Inclusion	Participation of youth through eco clubs in schools/ colleges generate environment consciousness and is a great way to get students energized for biodiversity conservation and local environmental issues.
Unit of Measurement	Number
Base Year Value	Awaited
Current Year Value	Awaited
Measurement interval	-
Data Source	Might be available with Education Dept.
Year of Publication	Primary Data
URL	-

Tourism & Education Sector	
Indicator Code	EN-R-40
Indicator	Number of trainings and festivals organised for promoting ecotourism in the state
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 8: Decent work and economic growth (Target 8.9)
	Goal 11: Sustainable cities and communities
	Goal 12: Responsible consumption & production
	Goal 13: Climate Action
What It Measures	Trainings and festivals organised for promoting ecotourism in the state
Rationale for Inclusion	Promoting eco-tourism through various workshops, festivals and training program encourage and support the diversity of local economies andconserve the environment.
Unit of Measurement	Number
Base Year Value	3 (2014-15)
Current Year Value	4 (2015-16)
Measurement interval	-
Data Source	Ecotourism Wing, Uttarakhand Forest Department
Year of Publication	Primary Data
URL	-

TABLE 6: SEPI Indicators under Human Health & Air QualitySector

Human Health & Air Quality Sector	
Indicator Code	EN-S-41
Indicator	% observations on which air quality has been reported at safe levels (avg of PM10, SO2, NO2)
DPSIR Category	State (S)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 3: Good health & well-being (Target 3.9)
What It Measures	Average Exposure to PM10, SO2, NO2
Rationale for Inclusion	Suspended particulates and oxides of sulphur & nitrogen are known to contribute to smog and human health impacts causing lung irritation and acute respiratory infections.
Unit of Measurement	%
Base Year Value	46.67
Current Year Value	33.3
Measurement interval	Annual
Data Source	Uttarakhand Environment Protection & Pollution Control Board (UEPPCB)
Year of Publication	2014 and 2015
URL	http://ueppcb.uk.gov.in/pages/display/95-air-quality-data

Human Health & Air Quality Sector	
Indicator Code	EN-S-42
Indicator	% of urban area under tree cover
DPSIR Category	State (S)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 11: Sustainable cities and communities (Target 11.3)
What It Measures	Extent of urban area under tree cover
Rationale for Inclusion	Urban tree cover has important implications for environment sustainability.
Unit of Measurement	Percentage (%)
Base Year Value	8.58%
Current Year Value	Awaited
Measurement interval	-
Data Source	Forest Survey of India (FSI)
Year of Publication	2013
URL	-

Human Health & Air Quality Sector	
Indicator Code	EN-S-43
Indicator	Life expectancy in the state
DPSIR Category	State (S)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 3: Good health & well-being (Target 3.9)
What It Measures	Life expectancy in the state
Rationale for Inclusion	This indicator is a proxy measure for environmental quality as environment plays a crucial role in people's physical, mental and social well-being. Degradation of the environment, through air pollution, noise, poor quality water and loss of natural areas, may be contributing to substantial increases in rates of cardiovascular diseases, respiratory diseases, infections etc.
Unit of Measurement	Years
Base Year Value	71.67 (2010-2014)
Current Year Value	Not estimated yet (2015-2019)
Measurement interval	5 years
Data Source	Directorate of Economics and Statistics, Department of Planning, Uttarakhand
Year of Publication	-
URL	-

Human Health & Air Quality Sector	
Indicator Code	EN-S-44
Indicator	% villages with tapped drinking water
DPSIR Category	State (S)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 6: Clean water & sanitation (Target 6.1)
What It Measures	Access to tapped drinking water indicates the proportion of population having access to drinking water facility.
Rationale for Inclusion	Access to tapped drinking water is the best available proxy foraccess to clean water. Access to reliable, safe water reduces exposure topollution, disease, and harmful contaminants, thereby promoting health and wellbeing.
Unit of Measurement	Percentage (%)
Base Year Value	99.99%
Current Year Value	99.99%
Measurement interval	Annual
Data Source	Directorate of Economics and Statistics, Department of Planning, Uttarakhand
Year of Publication	Statistical Diary, 2014 and 2015
URL	http://www.des.uk.gov.in/contents/listing/3/54-statistical-diary

Human Health & Air Quality Sector	
Indicator Code	EN-I-45
Indicator	Incidence of water borne diseases (Acute Diarrhoeal Diseases,Enteric Fever (Typhoid), Viral Hepatitis (All Causes) & Cholera)
DPSIR Category	Impact (I)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 3: Good health & well-being (Target 3.9)
What It Measures	How much of theburden of disease observed in a given year can be attributed to past exposure tounsafe water in the state.
Rationale for Inclusion	This indicator actsas a proxy measure for maintaining healthy water supplies, minimizing contact with dangerous bacteria and viruses, and minimizing environmental threats associated with improper waste management
Unit of Measurement	Number of cases
Base Year Value	1,28,610 (2014-15)
Current Year Value	1,51,250 (2015-16)
Measurement interval	Annual
Data Source	Directorate of Health Services, Uttarakhand
Year of Publication	Primary Data
URL	-

Human Health & Air Quality Sector	
Indicator Code	EN-I-46
Indicator	Prevalence of Chronic respiratory diseases (Asthma/Bronchitis/ Emphysemas)
DPSIR Category	Impact (I)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 3: Good health & well-being (Target 3.9)
What It Measures	How much of theburden of disease observed in a given year can be attributed to past exposure toair pollution(ambient particulate matter pollution, household air pollution, and ozone pollution).
Rationale for Inclusion	This indicator is a proxy measure to assess the state of air quality. Degradation of the environment, through air pollution may be contributing to substantial increases in rates of respiratory diseases.
Unit of Measurement	Number of cases
Base Year Value	70,259 (2014-15)
Current Year Value	64,576 (2015-16)
Measurement interval	Annual
Data Source	Uttarakhand Health & Family Welfare Society
Year of Publication	2014-15 and 2015-16
URL	-

Human Health & Air Quality Sector	
Indicator Code	EN-R-47
Indicator	% of pesticides on global banned list and also banned in the state
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 3: Good health & well-being (Target 3.9)
	Goal 15: Life on land
What It Measures	Pesticides on global banned list and also banned in the state
Rationale for Inclusion	Reducing the risks and impacts of pesticide use on human health and the environment by promoting the use of Integrated Pest Management (IPM) or alternative approaches becomes important in the quest for promoting sustainable agriculture in the state.
Unit of Measurement	Percentage (%)
Base Year Value	Awaited
Current Year Value	Awaited
Measurement interval	-
Data Source	Agriculture/PCB
Year of Publication	Primary Data
URL	-

TABLE 7: SEPI Indicators under Agriculture, Horticulture & Animal HusbandrySector

Agriculture, Horticulture & Animal Husbandry Sector	
Indicator Code	EN-S-48
Indicator	Annual per hectare NPK fertiliser consumption
DPSIR Category	State (S)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 2: Zero hunger (Target 2.4)
What It Measures	Per hectare NPK fertiliser consumption
Rationale for Inclusion	The need for fertilisersis integral to restore and enhance soil fertility and sustain crop production. But, at the same time it can contribute to huge losses to environment and human health, if not managed properly.
Unit of Measurement	Kilogram per hectare
Base Year Value	319.04 (2014-15)
Current Year Value	384.14 (2015-16)
Measurement interval	Annual
Data Source	Uttarakhand Krishi Bhawan
Year of Publication	Primary Data
URL	-

Agriculture, Horticulture & Animal Husbandry Sector	
Indicator Code	EN-S-49
Indicator	Annual per hectare productivity in the state
DPSIR Category	State (S)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 2: Zero hunger (Target 2.4)
What It Measures	Quintal/hectare
Rationale for Inclusion	It highlights the productivity of Kharif and rabi crops in the state covering major crops such as wheat, rice, maize, pulses, mustard, groundnut and sugarcane. This indicator is a proxy measure of promoting good local economies and benefitting farmer well-being.
Unit of Measurement	Acre
Base Year Value	759.36 (2014-15)
Current Year Value	766.25 (2015-16)
Measurement interval	Annual
Data Source	Uttarakhand Krishi Bhawan
Year of Publication	2014-15 and 2015-16
URL	-

Agriculture, Horticulture & Animal Husbandry Sector	
Indicator Code	EN-S-50
Indicator	% deficit in fodder requirement and availability in the state
DPSIR Category	State (S)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 2: Zero hunger (Target 2.4)
What It Measures	Quantity of fodder requirement and availability in the state
Rationale for Inclusion	The production and availability of fodder is not uniform throughout theyear due to shortage of irrigation facilities in hilly areas of Uttarakhand state. This indicator highlights the problem of acute shortage of fodder in the state and calls for strategies to minimize fodder shortage.
Unit of Measurement	Percentage (%)
Base Year Value	43.13 (2007)
Current Year Value	35.02 (2012)
Measurement interval	Annual
Data Source	Uttarakhand Animal Husbandry
Year of Publication	Animal Husbandry Dept. Livestock Census 2012 and 2007
URL	-

Agriculture, Horticulture & Animal Husbandry Sector	
Indicator Code	EN-S-51
Indicator	% share of indigenous/ domestic livestock to total livestock in the state (cattle, buffalo, yak, sheep, goat and pig)
DPSIR Category	State (S)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 2: Zero hunger (Target 2.5)
What It Measures	Share of indigenous/ domestic livestock to total livestock in the state (cattle, buffalo, yak, sheep, goat and pig)
Rationale for Inclusion	Agriculture along with animal husbandry is the principal occupation andsource of livelihood for over 70% of the Uttarakhand state's population. This indicator highlights promotion and raising of local breeds to ensure resistance to infectious diseases and resilience to climate change.
Unit of Measurement	Percentage (%)
Base Year Value	91.52 (2007)
Current Year Value	86.69 (2012)
Measurement interval	Annual
Data Source	Uttarakhand Animal Husbandry
Year of Publication	Animal Husbandry Dept. Livestock Census 2012 and 2007
URL	-

Agriculture, Horticulture & Animal Husbandry Sector	
Indicator Code	EN-I-52
Indicator	Forest land diversion to agriculture
DPSIR Category	Impact (I)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 15: Life on land (Target 15.3)
What It Measures	Forest land diversion to agriculture
Rationale for Inclusion	Forest diversion for non-forest purposeshas an irreparable and irreversible impact on land environment and ecological imbalance. It is important to monitor this parameter to conserve integrity of forest land.
Unit of Measurement	Hectares (ha)
Base Year Value	65.94 ha (2014-15)
Current Year Value	65.94 ha (2015-16)
Measurement interval	Annually
Data Source	Uttarakhand Forest Department(PFM Dept.)
Year of Publication	Uttarakhand Forest Statistics Report 2014-15
URL	http://forest.uk.gov.in/files/sTATISTICS_2013/Uttarakhand_Statistics_2013.pdf

Agriculture, Horticulture & Animal Husbandry Sector	
Indicator Code	EN-I-52a
Indicator	Pesticide consumption per hectare
DPSIR Category	Impact (I)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 2: Zero hunger (Target 2.4)
What It Measures	Pesticide consumption per hectare
Rationale for Inclusion	The need for pesticidesis at times essential to maintain productivity. But, at the same time it can contribute to huge losses to environment and human health, if not managed properly.
Unit of Measurement	Kg/ha
Base Year Value	Awaited
Current Year Value	Awaited
Measurement interval	-
Data Source	Uttarakhand Krishi Bhawan
Year of Publication	-
URL	-

Agriculture, Horticulture & Animal Husbandry Sector	
Indicator Code	EN-R-53
Indicator	Area under organic certification in the state
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 2: Zero hunger (Target 2.4)
What It Measures	Area under organic certification in the state
Rationale for Inclusion	This indicator ensures sustainable food production while establishing an ecological balance to prevent soil fertility or pest problems.
Unit of Measurement	Hectare
Base Year Value	20,518.58
Current Year Value	25,805.17
Measurement interval	Annual
Data Source	Uttarakhand Krishi Bhawan
Year of Publication	2014-15 and 2015-16
URL	-

Agriculture, Horticulture & Animal Husbandry Sector	
Indicator Code	EN-R-54
Indicator	% irrigation potential utilized to irrigation potential created till date
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 6: Clean water & sanitation (Target 6.4)
What It Measures	Area utilised for irrigation to created till date
Rationale for Inclusion	This indicator ensures maintenance and operation of efficient irrigation system with assured water supply to the fields and increased agricultural productivity.
Unit of Measurement	Percentage (%)
Base Year Value	74.06
Current Year Value	73.3
Measurement interval	-
Data Source	Directorate of Economics and Statistics, Department of Planning, Uttarakhand
Year of Publication	Statistical Diary, 2014 and 2015
URL	http://www.des.uk.gov.in/contents/listing/3/54-statistical-diary

Agriculture, Horticulture & Animal Husbandry Sector	
Indicator Code	EN-R-55
Indicator	Number of seed banks in the state
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 2: Zero hunger (Target 2.5)
What It Measures	Seed banks set up in the state
Rationale for Inclusion	Use of traditional and non-conventional seeds ensures resistance to infectious diseases and resilience to climate change.
Unit of Measurement	Number
Base Year Value	1
Current Year Value	1
Measurement interval	Annual
Data Source	Uttarakhand Krishi Bhawan
Year of Publication	2014-15 and 2015-16
URL	-

Agriculture, Horticulture & Animal Husbandry Sector	
Indicator Code	EN-R-56
Indicator	No. of fodder banks established till date in the state
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 2: Zero hunger (Target 2.4)
What It Measures	Fodder banks established till date in the state
Rationale for Inclusion	This indicator highlights measures to increase fodder production and enhance the utility of roughages in the state.
Unit of Measurement	Number
Base Year Value	100 (2014-15)
Current Year Value	100 (2015-16)
Measurement interval	Annual
Data Source	Uttarakhand Animal Husbandry
Year of Publication	Primary Data
URL	-

Agriculture, Horticulture & Animal Husbandry Sector	
Indicator Code	EN-R-57
Indicator	Total no. of BMCs formed till date
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 2: Zero hunger (Target 2.5)
What It Measures	Biodiversity Management Committees (BMCs) in the state
Rationale for Inclusion	Biodiversity Management Committees (BMCs) ensureconservation and effective utilisation of biological resources taking into account the rich traditional knowledge of the local communities. This decentralised mechanism is important in decision making and generating social, environmental and economic benefits.
Unit of Measurement	Number
Base Year Value	742 (2014-15)
Current Year Value	775 (2015-16)
Measurement interval	Annually
Data Source	Uttarakhand State Biodiversity Board
Year of Publication	Primary Data
URL	-

Agriculture, Horticulture & Animal Husbandry Sector	
Indicator Code	EN-R-58
Indicator	Total number of contracts signed under the Access & Benefit Sharing mechanism (ABS)
DPSIR Category	Response (R)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 2: Zero hunger (Target 2.5)
What It Measures	Status of contracts signed under ABS in the state of Uttarakhand
Rationale for Inclusion	This indicator is important as it help generate significant funds for conservation and sustainable use of biodiversity.
Unit of Measurement	Number
Base Year Value	15 (2014-15)
Current Year Value	31 (2015-16)
Measurement interval	Annually
Data Source	Uttarakhand State Biodiversity Board
Year of Publication	Primary Data
URL	-

TABLE 8: SEPI Indicators under Waste Management Sector

Waste Management Sector	
Indicator Code	EN-S-59
Indicator	Total Solid waste generation
DPSIR Category	State (S)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 12: Responsible consumption & production (12.4)
What It Measures	Total Solid waste generation in the state
Rationale for Inclusion	This indicator ensurestackling of issues related to solid waste management and help generate reliable waste statistics along with reduced environmental impacts and contribution to resource efficiency.
Unit of Measurement	Metric tonne per day
Base Year Value	1465 (2011)
Current Year Value	Awaited
Measurement interval	Check
Data Source	Uttarakhand Environment Protection & Pollution Control Board (UEPPCB)
Year of Publication	-
URL	-

Waste Management Sector	
Indicator Code	EN-S-60
Indicator	Average per capita waste water generation in 92 towns
DPSIR Category	State (S)
Type of Indicator	Negative
Linkage to SDG Goal and Target	Goal 12: Responsible consumption & production (12.5)
What It Measures	Average per capita waste water generation in 92 towns
Rationale for Inclusion	This indicator will ensure waste water management and help generate of reliable waste statistics along with reduced environmental impacts and contribution to resource efficiency by recycling and re-use of waste water for key activities.
Unit of Measurement	Litres per capita day
Base Year Value	67
Current Year Value	90
Measurement interval	Annual
Data Source	Uttarakhand Jal Nigam
Year of Publication	2014-15 and 2015-16
URL	-

Waste Management Sector	
Indicator Code	EN-S-61
Indicator	% of monitoring stations meeting prescribed water quality (drinkable, fishable and swimmable i.e. Class A)
DPSIR Category	State (S)
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 6: Clean water & sanitation (Target 6.3)
What It Measures	Access to clean drinking water i.e. 'Class A' category (drinkable, fishable and swimmable) as a main source of water.
Rationale for Inclusion	Monitoring stations meeting prescribed water quality is a proxy foraccess tosafe water. This reduces exposure topollution, disease, and harmful contaminants, thereby promoting health and wellbeing.
Unit of Measurement	Percentage (%)
Base Year Value	50%
Current Year Value	41.94%
Measurement interval	2014 and 2015
Data Source	Uttarakhand Environment Protection & Pollution Control Board (UEPPCB)
URL	http://ueppcb.uk.gov.in/pages/display/96-water-quality-data

Waste Management Sector	
Indicator Code	EN-R-62
Indicator	% of waste water treated before discharge
DPSIR Category	Response
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 12: Responsible consumption & production (12.4 & 12.5)
What It Measures	The percentage of collected, generated, or produced wastewater that is treated, normalized by the population connected to treatmentfacilities.
Rationale for Inclusion	Wastewater from industrial or household sources can contain avariety of contaminants that are detrimental to both human and ecosystem health.The percentage of wastewater treated represents a measureof what percentage of wastewater is treated before it isreleased back into ecosystems.
Unit of Measurement	Percentage (%)
Base Year Value	25.3 (2014-15)
Current Year Value	25.3 (2015-16)
Measurement interval	Annual
Data Source	Jal Nigam, Uttarakhand
URL	-

Waste Management Sector	
Indicator Code	EN-R-63
Indicator	% of total biomedical waste treated by certified agencies
DPSIR Category	Response
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 12: Responsible consumption & production (12.4 & 12.6)
What It Measures	The proportion of biomedical waste treated by certified agencies
Rationale for Inclusion	This indicator will ensure management ofbio-medical waste and generation of reliable waste statistics along with reduced environmental impacts and contribution to resource efficiency.
Unit of Measurement	Number
Base Year Value	To be updated when available (Data collection started in recent years)
Current Year Value	To be updated when available (Data collection started in recent years)
Measurement interval	-
Data Source	Uttarakhand Environment Protection & Pollution Control Board (UEPPCB)
Year of Publication	2014-15 and 2015-16
URL	-

Waste Management Sector	
Indicator Code	EN-R-64
Indicator	% of total hazardous waste treated by certified agencies
DPSIR Category	Response
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 12: Responsible consumption & production (12.4 & 12.7)
What It Measures	The proportion ofhazardous waste treated by certified agencies
Rationale for Inclusion	This indicator will ensure management ofhazardous waste and generation of reliable waste statistics along with reduced environmental impacts and contribution to resource efficiency.
Unit of Measurement	Percentage
Base Year Value	To be updated when available (Data collection started in recent years)
Current Year Value	To be updated when available (Data collection started in recent years)
Measurement interval	-
Data Source	Uttarakhand Environment Protection & Pollution Control Board (UEPPCB)
Year of Publication	2014-15 and 2015-16
URL	-

Waste Management Sector	
Indicator Code	EN-R-65
Indicator	% of total e-waste treated/recycled by certified agencies
DPSIR Category	Response
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 12: Responsible consumption & production (12.4 & 12.8)
What It Measures	The proportion ofe-waste treated/recycled by certified agencies
Rationale for Inclusion	This indicator will ensure management ofe-waste and generation of reliable waste statistics along with reduced environmental impacts and contribution to resource efficiency.
Unit of Measurement	Percentage
Base Year Value	To be updated when available (Data collection started in recent years)
Current Year Value	To be updated when available (Data collection started in recent years)
Measurement interval	-
Data Source	Uttarakhand Environment Protection & Pollution Control Board (UEPPCB)
Year of Publication	2014-15 and 2015-16
URL	-

Waste Management Sector	
Indicator Code	EN-R-66
Indicator	% of industries withair pollution control devices (APCDs) installed
DPSIR Category	Response
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 12: Responsible consumption & production (12.4 & 12.9)
What It Measures	The proportion of industries with air pollution control devices (APCDs) installed
Rationale for Inclusion	This indicator will ensure that daily concentration of pollutants released by the polluting industries are within the prescribed thresholds.
Unit of Measurement	Number
Base Year Value	100%
Current Year Value	100%
Measurement interval	-
Data Source	Uttarakhand Environment Protection & Pollution Control Board (UEPPCB)
Year of Publication	2014-15 and 2015-16
URL	-

Waste Management Sector	
Indicator Code	EN-R-67
Indicator	% of construction, demolition waste (C&D) recycled
DPSIR Category	Response
Type of Indicator	Positive
Linkage to SDG Goal and Target	Goal 12: Responsible consumption & production (12.4 & 12.10)
What It Measures	The proportion of construction, demolition waste recycled to total waste
Rationale for Inclusion	The constructionindustry is one of the most active sector and the majority of C&D waste produced is still landfilled. Therefore, this indicator will ensure waste management for C&D waste and generation of reliable wastestatistics along with reduced environmental impactsand contribution to resource efficiency.
Unit of Measurement	Percentage
Base Year Value	To be updated when available (Data collection started in recent years)
Current Year Value	To be updated when available (Data collection started in recent years)
Measurement interval	-
Data Source	Uttarakhand Environment Protection & Pollution Control Board (UEPPCB)
Year of Publication	2014-15 and 2015-16
URL	-

ABOUT IIFM AND CESM

INDIAN INSTITUTE OF FOREST MANAGEMENT (IIFM)

Established in 1982, the Indian Institute of Forest Management is a sectoral management institute, which constantly endeavours to evolve knowledge useful for the managers in the area of Forest, Environment and Natural Resources Management and allied sectors. It disseminates such knowledge in ways that promote its application by individuals and organizations.

IIFM's mandate is appropriately reflected in its mission statement, "to Provide Leadership in Professional Forestry Management Aimed at Environmental Conservation and Sustainable Development of Ecosystems."

IIFM is a registered society under the Societies Registration Act at Bhopal. The Hon'ble Minister for Forests and Environment, Government of India is the President of the Society. The members of the Society consist of State Forest Departments, State Forest Development Corporations, Ministries of Human Resource Development, Finance, Forest and Environment, Rural Development at the centre, and Forest-Based Industries.

The Director of the Institute, as its executive head, supervises the activities of the faculty and the administration. The Institute prides itself on having a multi-disciplinary faculty which is a mix of academicians and practising forest officers in the following nine faculty areas:

CENTRE FOR ECOLOGICAL SERVICES MANAGEMENT (CESM), IIFM

CESM is a centre of excellence established in 2007 at the Indian Institute of Forest Management on the recommendations of the second Perspective Plan of IIFM (2006-16) with a mission to conduct action and policy research for ecosystem services management. The centre's goal is to function as a think tank to generate a useful database and an appreciation for ecosystem services, their physical assessment, valuation and establish incentive-based mechanisms to promote conservation. The centre focuses on ecological services like water production and watershed conservation, carbon sequestration, biodiversity conservation and bio-prospecting, ecotourism and landscape conservation which are addressed for forests, mangroves, water resources, wetlands, agroforestry and landscapes including grassland ecosystems mainly in the Trans Himalayan and Himalayan region, Western Ghats, eastern mangroves and islands. The areas of work of the centre include ecosystem services physical estimation, data generation, ecosystem modelling, estimation and valuation of carbon sequestration, biodiversity conservation, watershed protection, landscape beauty, etc., environment and conservation finance, impact assessment, developing a market for ecological services, issues relating to instruments for ecosystem service conservation like tradable permits, CDM, taxation and subsidies, ecological services and livelihood management, institutions and environmental governance process for sustainable management of economic services.

The centre has contributed significantly to many important policy decisions in the area of forest and natural resource management in the country. The objectives and core activities of the centre are:

- To conduct action and policy research for ecological services management and function as a think tank to generate an appreciation for ecological services, their physical assessment, valuation and establish a paymentmechanism for such services.
- To collaborate with national and international organizations to mutually learn from each other's expertise.
- To provide consulting services for analytical and policy inputs.
- To provide teaching inputs for IIFM's various PG programmes.
- To conduct short-term certificate courses and training programmes for participants from government, research organizations, non-government organizations, corporate sector, civil society and legislature.
- To provide a platform for policy discussion amongst various stakeholders through seminars, conferences, workshops and round tables.
- To publish policy briefs, working papers and generate bibliographical references by collating activities undertaken by national and international organizations in the area of ecological services management.
- To evolve exchange programmes (visiting fellows/ researchers and students) and have PhD positions.

IIFM'S CONTRIBUTION TO VALUATION AND ACCOUNTING STUDIES (2000-2007)

- Economic Valuation of Forests of Himachal Pradesh – Introduction of CLEV (Compensation for the Loss of Ecological Values)- an Ecological Cess Instrument (2000) -HPFD
- Developing Methodology for Forest and Land Resources (2003-05) – Used by the Supreme Court Committee on NPV (2006) –IEG and MoEFCC
- National Forestry Commission: Framework for Natural Resource Accounting (2006) - NFC
- Developing Markets for Payments for Ecosystem Services in Himachal Pradesh (2007) – IIED
- Valuation of Forest Ecosystem Services in Uttarakhand Himalayas (2007) –LEAD India and HBF

STUDIES CONDUCTED UNDER THE CENTRE OF ECOLOGICAL SERVICES MANAGEMENT, IIFM, BHOPAL (ESTABLISHED IN 2007)

- Developing Mechanism for Increased Allocation of Budgets for States Managing Large Geographical Areas Under Forests (2009) - Thirteenth Finance Commission
- Strengthening Capacity for Alleviating Poverty Through Ecosystem Services – Developing Markets for Ecosystem Services Through Generating Livelihood Benefits (2009-2010) - UNEP
- Roles of CNRM Institution and Poverty Reduction in Gujarat and Madhya Pradesh – Effectiveness of JFMCs in Poverty Alleviation (2009-2012) - ISCG
- Forest Carbon Modelling – for Proposing REDD+ Value from International Markets (2011-2013) – IIASA and TIFAC
- Revision of NPV Rates of Forest Diversion – Fixing Charge for Forest Diversion (2014)- MoEFCC
- Protected Area – Wetland Valuation – Providing Value of Carbon from PA Wetlands (2014)-MoEFCC
- Estimating Ecosystem Services Values of Himachal Forests – Revisiting the Value of Forests of Himachal Pradesh (2014) -HPFD
- Guidelines of Cost Benefit Analysis for Forest Diversion (2014) – MoEFCC
- High Conservation Value Forests (2013-2014) – 14FC
- Capacity Building in National Planning for Food Security (2011-2014)- UNEP
- Economic Valuation of Tiger Reserves in India (2013-15) – NTCA
- Regional Research to Inform the High Level Panel on Global Assessment of Resources for Implementing the Strategic Plan for Biodiversity 2011-20 for the South Asia Region (2013-14) – CBD-WCMC
- Analysing Forest Carbon Accounts for Sustainable Policy Options with Special Reference to Livelihood Issues (2013) with the funding support of the Technology, Information and Forecasting Assessment Council, India and with technical support of the International Institute of Applied Systems Analysis, Laxenberg, Austria
- Co-author National REDD+ Policy and Reference Documents (2014) - MoEFCC
- Co-author in the International TEEB (The Economics of Ecosystems and Biodiversity) 2007-2010- UNEP
- Evolved and Set Up TEEB India Study (2010-12) - MoEFCC
- Expert Member and Lead Author - IPBES (Inter-Governmental Platform on Biodiversity and Ecosystem Services) – Ongoing Since 2013 – UNEP
- Building Regional and Technical Capacity for Economic Valuation of Tiger and Leopard Landscapes in Selected Tiger and Snow Leopard Range Countries for Global Tiger Forum (2015-16)

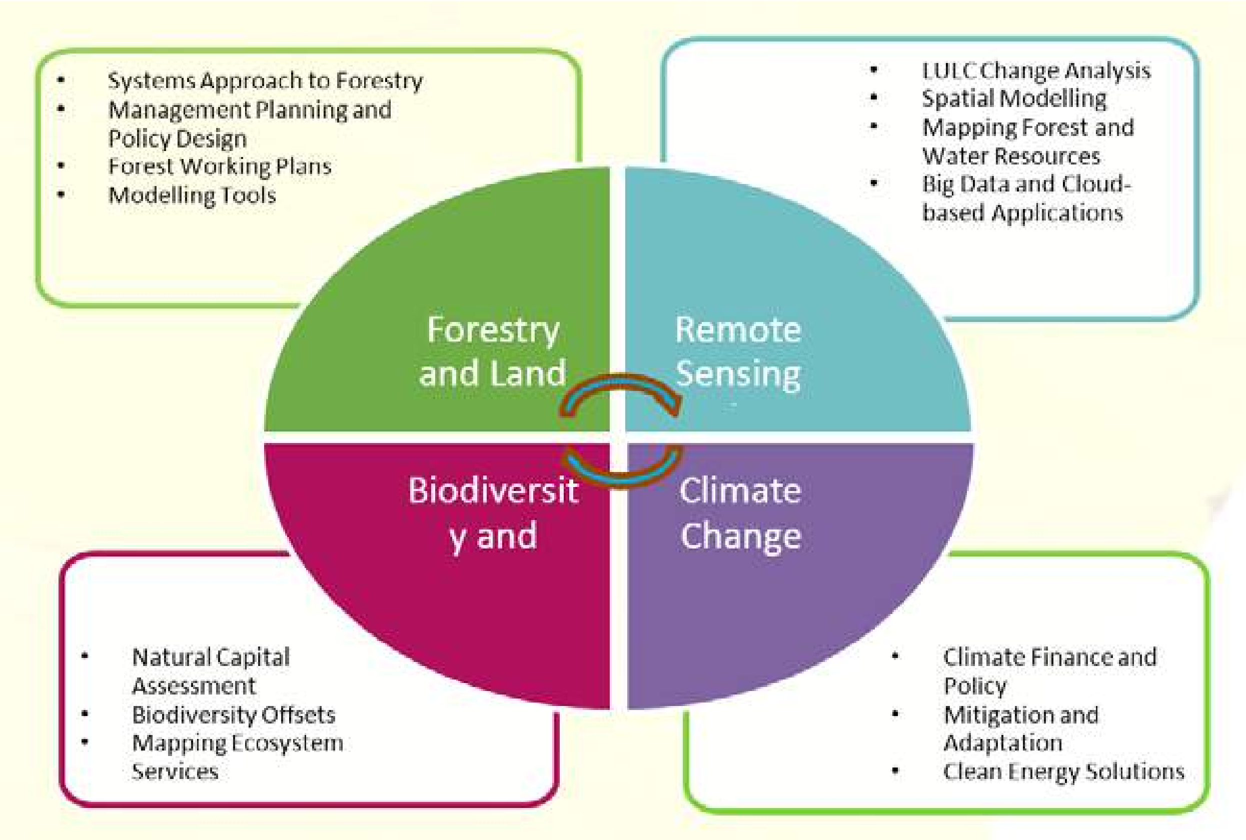
ONGOING VALUATION AND ACCOUNTING STUDIES AT CESM

- Economic Valuation of Ten Additional Tiger Reserves in India for National Tiger Conservation Authority, MoEFCC, GOI (2016-17)
- Forest Resource Accounting and Valuation of Economic Contribution of Forests and Protected Areas in Rajasthan and Capacity Building on Environmental Statistics and Green Accounting for Rajasthan Forest Department (2016-17)
- Review of Existing Ecosystem Accounting Initiatives & amp; literature in India, including biophysical assessments, and economic valuation of ecosystem services and overview of available data sources, organized by ecosystem service and type of account for: UNDP, India for UNSD, UNEP & amp; CBD project on Natural Capital Accounting & amp; Valuation of Ecosystem Services (2018)
- Consensus Building and Development of Action Plans for Joint Bangladesh-India Sundarbans Management (2018) for the International Water Association, The Netherlands
- Urban Water Blueprint (UWB) for India (2017-2019) with The Nature Conservancy (TNC), USA
- Recommendations to the 15th Finance Commission of India for Enriching Current Tax Devolution Formula for Increased Allocations of Funds Towards Forest, Environment & amp; Climate Change for MoEFCC with IORA Ecological Solutions (2018-19)

ABOUT IORA ECOLOGICAL SOLUTIONS

IORA Ecological Solutions (IORA) is an environmental advisory group with expertise in Climate Change Related Mechanisms, Environmental Finance, Policy Advisory, Forestry and Landscape Management, and Biodiversity Conservation.IORA has a team of over 75 members and is headquartered in Delhi with regional offices in Assam, Maharashtra, Karnataka and Madhya Pradesh. In a short span of 9 years, IORA has undertaken more than 70 projects globally partnering with governments, development agencies, NGOs and the private sector.

IORA'S THEMATIC AREAS OF WORK



IORA'S CONTRIBUTION TO NATURAL RESOURCE MANAGEMENT

FOREST AND CLIMATE CHANGE

- Pioneers in REDD+ in India with projects in 7 landscapes including first sub-national jurisdictional REDD+ and VCS landscape based REDD+.
- Developed the first REDD+ methodology as per Verified Carbon Standard from South Asia.
- Developed national frameworks and policy for forest carbon assessment, valuation and REDD+.
- Co-authors National REDD+ Policy and reference documents

NATURAL CAPITAL ASSESSMENTS

- Forest Resource Accounting and Sustainable Environmental Performance Index (SEPI) for theState of Uttarakhand (Partnered with IIFM)
- Study on High Conservation Forest (HCVF) for the 14th Finance Commission of India (Partnered with IIFM)
- Economic Valuation of Tiger Reserves in India (Partnered with IIFM)
- TIFAC Forest Carbon Accounting Studies (Partnered with IIFM)
- Contributors to TEEB India Study

BIODIVERSITY

- Spatial Assessment of Invasive Species in the State of Sikkim to mitigate their impact on Forest Ecosystems and Biodiversity
- Developed Incentive Mechanisms for Agro-Biodiversity Conservation and Use (Biodiversity International)
- Developed International Standard for Biodiversity Offsets (IUCN Global)
- Developed a Biodiversity Finance Framework for the Private Sector in India in Partnership with UNDP/MOEFCC

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SWAPAN MEHRA

Swapan is an environmental finance and policy expert, proficient in designing and implementing projects and policy interventions in forestry, biodiversity conservation, and climate change mitigation and adaptation. After completing an Advanced Diploma in Forest Management from the Indian Institute of Forest Management (IIFM), Bhopal, he worked with some of the largest carbon finance firms in the world.

In 2009, he set up IORA, an environmental policy advisory group that provides implementable solutions in the areas of carbon finance, forestry and biodiversity conservation and new market mechanisms for emission reduction. He has co-authored India's National REDD+ Strategy and also led the development of REDD+ pilots in 5 Indian states. He was involved in the development of REDD+ MRV systems in India as part of USAID India's Forest PLUS Programme.

Over the years, he has won many awards and fellowships including FICCI Young Business Leader, LEAD International Fellow in 2011 and Donella Meadows Fellowship by the Balaton Group.

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Chandan Khanna worked as Subject Expert at the Centre for Ecological Services Management (CESM), IIFM, Bhopal, which acts as an interdisciplinary centre to address crucial policy issues on ecosystem management. He has more than eight years of research experience with major focus on economic aspects of natural resource, in development planning, environmental management and policy development. Prior to this position with CESM he has worked with the Madhya Pradesh State Government in developing the Climate Change Action Plan for the state. Chandan holds a Bachelor of Engineering in Electrical snf Electronics Engineering and postgraduate diploma in Forestry Management from IIFM.

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CHARU TIWARI

Charu Tiwari is an Environment Management professional having three years of experience working in Protected Areas, Ecological Economics, Natural Resource Accounting, Green GDP, Policy Analysis and Advocacy, Ecosystem Conservation and Payment for Ecosystem Services. She is working as Special Project Associate at the Centre for Ecological Services Management (CESM), Indian Institute of Forest Management (IIFM), Bhopal, since 2016. She completed Post Graduate Diploma in Forestry Management (PGDFM) in the class of 2014-16 with specialization in Environment Management module from Indian Institute of Forest Management (IIFM). Area of interest include Natural Resource Management, Protected Areas Ecology, Climate Change, Ecosystem Services and Ecological Economics, Environment Policy, Urban Ecology and Sustainable Development Goals (SDGs).

About The Report

The Report attempts to provide estimates of the value of natural capital stored in the forest area of Uttarakhand. Study findings indicate that a large proportion of flow benefits (as well as stock) are intangible, and hence often unaccounted for in market transactions.

The study has also made a pioneering attempt to develop a "Sustainable Environment Performance Index" for the state of Uttarakhand. The index measures the current state of the environment and resource extraction on ecosystem and human health and measures it on an annual basis to give significant changes in the index.

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