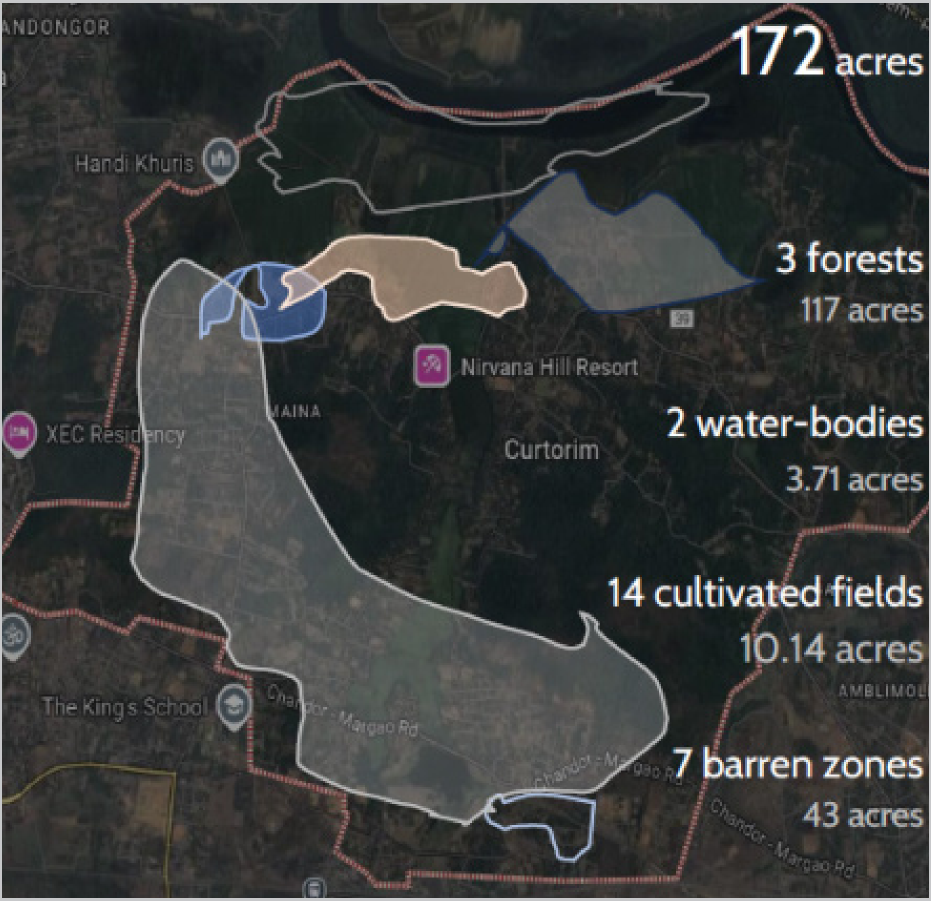

A Primer on Natural Capital Accounting

Environmental Accounting for local stakeholders

Natural Capital Accounting: A Course Primer

Environmental Accounting

for local stakeholders

2024

Natural Capital Accounting: A Course Primer
Environmental Accounting for local stakeholders

Author: Bindu Mohanty (The author bears full responsibility for any errors and omissions). Cover picture supplied by Eccounting.org

Supported by:

K2A Swissnex India Grants 2023
k2a@swissnex.org

Eccounting, Arthify, Inc.
mitesh@arthify.com

Layout:
AVDzines, Auroville

Table of Contents

Abbreviations and Acronyms -- 7

List of Tables and Figures --- 8

Preface --- 9

Module 1 – Key Concepts in Environmental Accounting ---------- 10

Unit 1: Introduction --- 10

Unit 2: Conceptual Frameworks ------------------------------ 12

Unit 3: Key concepts in environmental accounting ------- 13

Unit 4: Types of Accounts and Accounting Principles ---- 15

Conclusion --- 15

Module 2 – Ecosystem Extent Accounts ----------------------------- 18

Unit 1: Spatial Units: Introduction ---------------------------- 18

Unit 2: Ecosystem extent account --------------------------- 25

Conclusion --- 27

Module 3 – Ecosystem Condition Accounts -------------------------- 28

Unit 1: Accounting for Ecosystem Condition --------------- 28

Unit 2: Ecosystem Condition Indicators and Reference Levels 32

Conclusion --- 33

Module 4 – Ecosystem Services Accounts --------------------------- 34

Unit 1: Ecosystem Services and Benefits: Basic Principles - 34

Unit 2: Accounting for ecosystem services ------------------- 36

Unit 3: Ecosystem Services Reference List -------------------- 38

Conclusion --- ------ 40

Abbreviations and Acronyms

BSU	Basic Spatial Unit
EA	Ecosystem Asset
EAA	Ecosystem Accounting Area
ECT	Ecosystem Condition Typology
EFG	Ecosystem Functional Group
ESG	Environmental and Social Governance
ET	Ecosystem Type
GET	Global Ecosystem Typology
I	Indicator
IUCN	International Union for Conservation of Nature
SDG	Sustainable Development Goals
SEEA	System of Environmental-Economic Accounting
SEEA-EA	System of Environmental-Economic Accounting Ecosystem Approach
V	Variable

List of Tables and Figures

Tables

Table 2.1: Classification of Biomes and Ecosystem Function Groups in the Terrestrial Realm

Table 2.2: Example of size of Ecosystem Types within an Eco system Accounting Area

Table 2.3: Ecosystem extent accounts

Table 2.4: Dimensional measures of ecosystem types

Table 3.1: Ecosystem Condition Typology

Table 3.2: Ecosystem Condition Variable Account

Table 3.3: Example of using weighted mean in Ecosystem Condition Variable Account

Table 4.1: Example of generic logic chain

Table 4.2: Simplified Supply Table for Ecosystem Services

Table 4.3: Simplified Use Table for Ecosystem Services

Table 4.4: Categories of Ecosystem Services

Table 4.5: Example 1 of SEEA Ecosystem Services Reference list

Table 4.6: Example 2 of SEEA-EA Ecosystem Services Reference list

Figures

Figure 1.1: Global Ecosystem Typology

Figure 1.2: Overview of Ecosystem Accounts

Figure 2.1: The six levels of Global Ecosystem Typology

Figure 2.2: Example of Extent Account spatial units

Preface

Services provided by the natural world contribute a total global value of around $145 trillion per year to human society. Yet, to date, this economic contribution is taken for granted when making important developmental decisions. Businesses tend to treat their impact on natural resources as externalities, and, this has resulted in overexploitation, habitat destruction, and pollution to the extent that we are now looking at irreversible damage to the biosphere. Recognizing the fact that nature and its benefits must be integrated into existing decision frameworks and economic ledgers, the United Nations Statistical Commission launched an internationally accepted framework for natural capital accounting called the System of Environmental-Economic Accounting (SEEA) in 2012 with revisions in subsequent years. SEEA frameworks are complex and technical; thus, their use has been restricted to academic experts and scientists working at the national level. Countries worldwide have developed or are in the process of developing environmental accounts using the SEEA frameworks. However, SEEA accounting reports generally offer a macro-economic view and common people are still largely unaware of the need for natural capital accounting. Another lacuna is that while SEEA provides some economic insights into a region's natural resources, it does not provide any guidance as to how these insights can be translated into meaningful decisions and actions on the ground.

Natural Capital Accounting: A Course Primer has been designed to inform local communities and businesses on how they can adapt United SEEA frameworks for environmental accounting for their projects in natural resource management. This Course Primer comprises four modules and guides local communities on how to keep track of their natural capital wealth with environmental accounting by using the System of Environmental-Economic Accounting—Ecosystem Approach (SEEA-EA) framework.

SEEA frameworks are closely aligned with the 17 United Nations Sustainable Development Goals (SDG) in that they are s based on the fundamental premise that development must balance social, economic, and environmental sustainability.

Module 1 – Key Concepts in Environmental Accounting

This module comprises 4 Units and introduces us to key concepts and internationally accepted frameworks in environmental accounting.

Unit 1: Introduction

Environmental Accounting, also referred to as Natural Capital Accounting, is an umbrella term for systematic measurements of changes in our natural capital or resources.[1] Our natural capital is a source of economic wealth that benefits society and the economy, and environmental accounting seeks to provides a comprehensive understanding of how our economy is affected by the decrease or increase of our natural capital.

Reasons for environmental accounting

Learning to account for environmental ecosystems is important for several reasons:

1. ***Sustainable Resource Management:*** Accounting for ecosystems helps us assess the condition of natural resources and ecosystems, identify trends and pressures, and evaluate the effectiveness of management strategies. This information is crucial for making informed decisions about resource use and conservation to ensure their sustainable management for future generations.
2. ***Valuing Ecosystem Services:*** Ecosystems provide a wide range of services that are essential for human well-being, such as clean air and water, food, climate regulation, and recreational opportunities. By accounting for ecosystems, we can better understand the contribution of these services to economic activity.
3. ***Policy Development:*** Environmental accounting provides policymakers with data and insights to develop evidence-based policies and regulations that promote sustainable development, protect ecosystems, and enhance resilience to environmental challenges.
4. ***Economic Decision-Making:*** Incorporating environmental considerations intoeconomic decision-making allows us to better understand the trade-offs between economic development and environmental protection. By accounting for thecosts and benefits of ecosystem services, businesses, governments, and non- governmental organisations (NGOs) can make more informed decisions that balance economic, social, and environmental objectives.
5. ***Global Reporting Initiatives:*** There is growing recognition of the importanceof environmental accounting in international initiatives and agreements, such as the United Nations Sustainable Development Goals (SDG) and the Paris Agreement on climate change. Learning to account for ecosystems helps countries meet their reporting obligations and commitments, track progress toward sustainability goals, and contribute to global efforts to address environmental challenges.

[1] https://seea.un.org/content/frequently-asked-questions#What%20is%20natural%20capital%20accounting?

Re asons for using SEEA and SEEA-EA frameworks for environmental accounting

Using the System of Environmental-Economic Accounting (SEEA) and the System of Environmental Economic Accounting – Ecosystem Approach (SEEA-EA) to account for environmental ecosystems offers several benefits:

1. ***Integrated Approach:*** SEEA and SEEA-EA provide a comprehensive framework for integrating environmental and economic information. By accounting for both environmental assets and their economic interactions, these frameworks allow for a more holistic understanding of the relationship between the environment and the economy.
2. ***Standardized Methodology:*** SEEA and SEEA-EA provide standardized methodologies and guidelines for collecting, organizing, and analysing environmental and economic data. This ensures consistency and comparability across different regions and sectors, making it easier to track trends, assess impacts, and monitor progress over time. At present, there are large amounts of data collected by various agencies, both at the global level and the local level. However, this data is not easily integrated due to a lack of common interpretations and terminology. SEEA also provides a bridge between economists and environmental scientists as well as between economic and environmental information. Over time, standardizing methodology for environmental accounting leads to better data quality, easier integration of data from sub-national to international levels, and provides analysts with actionable
3. ***Valuation of Ecosystem Services:*** SEEA-EA specifically focuses on the accountingof ecosystems and their services. By quantifying and valuing ecosystem servicessuch as water availability and carbon sequestration, these frameworks enable us to understand the benefits provided by nature and incorporate them into decision-making processes.
4. ***Policy Relevance:*** SEEA and SEEA-EA are designed to meet the needs of policymakers and other stakeholders involved in environmental and economic management. By providing relevant and actionable information, these frameworks support evidence-based policy development, resource management, and sustainable development planning.
5. ***Scalable:*** SEEA frameworks are scalable and have been applied at sub-national levels for different types of ecosystems or land uses. This allows for economic activity and environmental management at the local level to be nested within an overarching national policy framework. Similarly, the private sector can use the SEEA frameworks to comply with Environmental and Social Governance (ESG) guidelines in context and monitor their environmental impact.
6. ***International Standards:*** SEEA and SEEA-EA are endorsed by the United Nations and other international organizations as global standards for environmental

accounting. By adopting these frameworks, countries can align their accounting practices with international best practices and improve the comparability of their data with other countries, facilitating global reporting and collaboration on environmental issues.

7. ***Support for Sustainable Development Goals:*** SEEA and SEEA-EA are closely aligned with the United Nations Sustainable Development Goals (SDG) and provide a robust framework for monitoring progress towards sustainability targets. By using these frameworks to account for environmental ecosystems, countries can better track their contributions to the SDG and identify areas for action and investment.

Unit 2: Conceptual Frameworks

System of Environmental-Economic Accounting—Central Framework (SEEA): This internationally accepted framework, developed by the United Nations Statistical Commission, integrates economic and environmental data. Integrating environmental and economic data allows for sustainable growth as natural resources are not regarded as "external costs" but accounted for in economic ledgers. SEEA is designed to have a similar accounting structure as the System of National Accounts (SNA) and is being used by many countries.

SEEA-EA (System of Environmental-Economic Accounting -Ecosystem Accounting): This framework is an extension of SEEA that specifically focuses on the accounting of ecosystems and their services. It provides a standardized methodology for assessing the contribution of ecosystems to human well-being and economic activity, including the valuation of ecosystem services. Ecosystem services can be valued both in physical terms and monetary terms and separate accounts are maintained for this in SEEA-EA. SEEA-EA, however, does not capture all the benefits that ecosystems provide. There are still limitations in our understanding of the complex and often synergistic interactions in an ecosystem. SEEA-EA is a flexible framework that can also be used by local communities to keep track of their natural resources.

To summarize the differences between the two frameworks, SEEA provides a comprehensive framework for integrating environmental and economic information, while SEEA-EA extends this framework to specifically address the accounting of ecosystems and their services. SEEA-EA builds upon SEEA principles and methodologies but focuses on the unique characteristics and challenges associated with environmental accounting. Both frameworks play important roles in improving our understanding of the relationship between the environment and the economy and supporting sustainable development initiatives.

Unit 3: Key concepts in environmental accounting

The following concepts are key to understanding and keeping environmental accounts of ecosystems:

Ecosystem Assets: Ecosystem assets are contiguous spaces comprising biotic and abiotic components and their interactions that together define an ecosystem. For example, forests, lakes, rivers, grasslands are all ecosystem assets. An asset as a spatial unit forms the basis of Environmental Accounting. To determine the value of an asset, in physical or economic terms, we measure the extent and condition of the asset and the services it provides.

Ecosystem Type: SEEA-EA uses the classification framework of the International Union for Conservation of Nature (IUCN) Global Ecosystem Typology to classify all the different ecosystems of the Earth. An ecosystem type is a distinct set of biotic and abiotic components and their interactions. There are many different ways of describing ecosystem types, and some are best defined locally. However, a common generic classification system allows us to have a shared understanding of our natural resources. Eccounting.org is developing a platform that will allow local stakeholders to define ecosystems both by using the SEEA-EA Ecosystem Typology and the locally accepted term. SEEA-EA Ecosystem Typology is a complex hierarchical classification based on the IUCN Global Ecosystem Typology (GET)[2] . GET allows for the comparison of ecosystem types across nations as well as local definitions of ecosystems. GET has six levels as shown in Fig. 1.1. below.

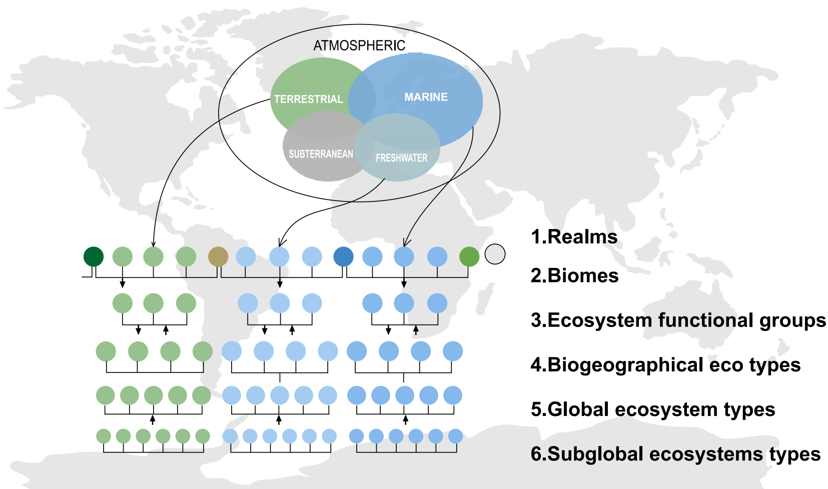

Fig. 1.1: Global Ecosystem Typology (Source: IUCN resources on Global Ecosystem Typology)[3]

Ecosystem Extent: The size of an ecosystem asset is referred to as Ecosystem Extent. It is a crucial starting point for environmental accounting. Ecosystem extent accounts allow us to compile accounts of ecosystem types. For example, the extent of all of India's Tropical and Sub-Tropical Forests across different states can be aggregated, if we use the same accounting principles to measure the extent of each forest.

Ecosystem Condition: Ecosystem condition refers to the quality or health of an ecosystem, as determined by its biotic and abiotic characteristics. It assesses the ecological integrity of the ecosystem by assessing its composition, structure, and function. The condition or ecological integrity of the ecosystem determines its resilience— its ability to provide ecological services on an ongoing basis. There can be many variables to assess the health of an ecosystem, but some key variables are Soil quality, Water quality, Biodiversity, and Habitat Fragmentation.

Ecosystem services: Ecosystem services are benefits that humans derive from ecosystems, directly or indirectly. These services can be categorized into four main types:

1. ***Provisioning Services:*** These are the products obtained from ecosystems, including:

- Food: such as crops, fish, meat, and wild fruits.
- Water: from freshwater bodies and groundwater.
- Raw materials: such as timber, and minerals.

2. ***Regulating Services:*** These are the benefits provided by ecosystems that regulate environmental processes and support life-sustaining conditions, including:

- Climate regulation: through carbon sequestration, air purificationect.
- Water purification: through filtration, nutrient cycling, and waste decomposition.
- Flood and erosion control: through soil stabilization, flood buffering etc.

3. ***Cultural Services:*** These are the non-material benefits that people obtain from ecosystems, including:

- Aesthetic and recreational values: such as scenic landscapes, parks, and outdoor recreational activities.
- Spiritual and cultural values: including cultural heritage sites, sacred places, and traditional knowledge systems.
- Sense of place and identity: fostering connections to local landscapes and cultural traditions.

4. ***Supporting or Intermediate Services:*** These are the underlying processes, such as soil formation and nutrient cycling, photosynthesis and primary production, biodiversity maintenance, and habitat provision), that enable the production of other ecosystem services. These underlying supporting services are not accounted for in SEEA-EA.

---

[2]The International Union for Conservation of Nature (IUCN) is a membership Union with more than 1,400 Member organisations comprising both government and civil society organisations. Its Global Ecosystem Typology is detailed at this link: https://portals.iucn.org/library/sites/library/files/documents/2020-037-En.pdf

[3]https://portals.iucn.org/library/sites/library/files/documents/2020-037-En.pdf

Unit 4: Types of Accounts and Accounting Principles

Types of Accounts

Environmental accounting requires us to systematically record the stocks and flows from ecosystem assets. To do this, we need to maintain minimally three types of accounts—two for gauging the stock of the asset and one for determining flows from these stocks in physical terms. SEEA-EA's framework also allows for the calculation of the monetary value of ecosystem flows and services. We will discuss economic valuation and monetary accounts in a subsequent module.

Spatial units for Environmental Accounting: Determining the spatial unit of an ecosystem is the starting point of Environmental Accounting. Ecosystems can be as big as Lake Chilika in Odisha, India, or as small as a pond on a farm. However, for accounting purposes, the spatial unit or the Environmental Accounting areas should be no smaller than the spatial data used to compile the ecosystem account. In other words, the smallest possible size of the environmental accounting area depends on the availability of data. If the available resolution of spatial data is 1 sq. km, the environmental accounting area should also be 1 km.

Stock Accounts

1. ***Accounting for Ecosystem Extent:*** To account for ecosystem extent, we need to measure the area of the spatial unit of the ecosystem and any changes, additions, or reductions, to it. The unit of measurement for extent accounts is hectares or km^2 or m^3
2. ***Accounting for Ecosystem Condition:*** To account for ecosystem condition, we need to measure changes in the biotic and abiotic characteristics of the ecosystem. As these changes are dependent on many variables, local stakeholders can choose the variables that they want to monitor such as the pH value of the soil or its composition. Researchers use normalised indices using reference levels to measure ecosystem conditions. However, ecosystem condition can also be generically and simply described in terms of its trend over time. For instance, based on historical data, we can say whether the condition of a given ecosystem is declining or improving.

Flows Account

3. ***Accounting for Ecosystem Services:*** To account for ecosystem services, we need to determine the supply and use of various ecosystem services. For example, we can determine how much water is supplied from a bore well each year and the ways in which they are used. Depending on the ecosystem service we need to measure, we can use an appropriate unit of measurement such as cubic meters for water. The mainstream practice is to measure only provisioning services as the economic value of these services can be calculated on the basis of market prices. Local stakeholders, however, may choose to determine the value of different ecosystem services other than market pricing. For example, instead of

just calculating the value of timber in a forest, local stakeholders may choose to value the cultural or spiritual significance the forest has for them.

In subsequent modules, we will learn more about how to keep these three types of accounts. The fourth type of account that can be included in environmental accounting is Monetary Accounts that seek to calculate the economic value of Ecosystem Services. However, Monetary Accounting, referred to in SEEA-EA as Monetary Ecosystems Asset, is complex, and as of yet, there are no universally accepted standards for Monetary Accounts. The focus of this primer is primarily on Environmental Accounts and not on Monetary Accounts. Figure 1.2 below shows the interconnections of all four accounts.

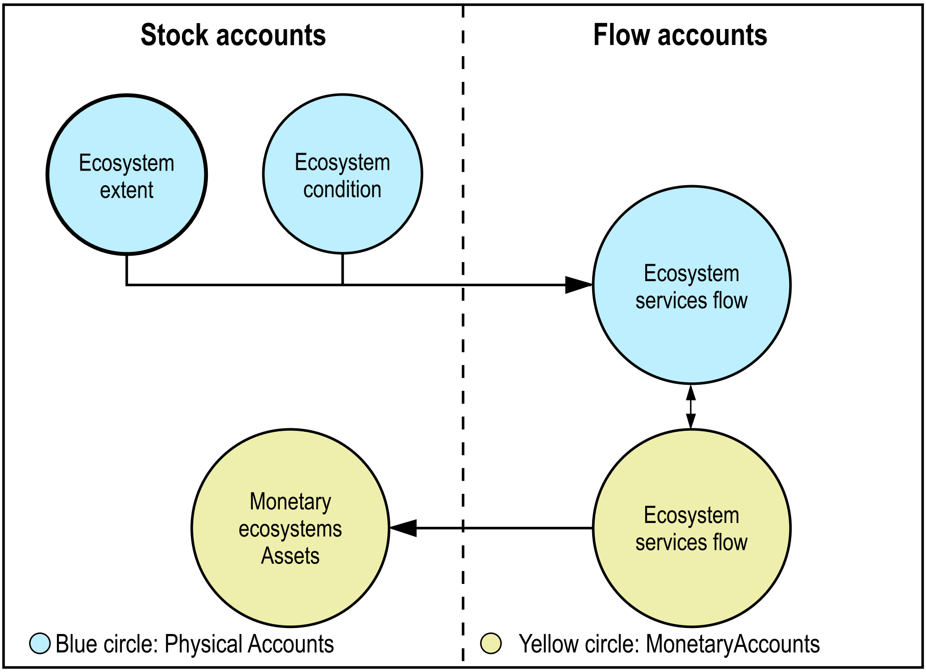

Figure 1.2: Overview of Ecosystem Accounts (Source: SEEA-EA, United Nations)[4]

[4] https://seea.un.org/content/seea-e-learning-resources

Accounting Principles

To account for our natural capital wealth and include it in our economic decisions, environmental accounting principles should mirror economic accounting principles. Due to the complexity of ecosystems and the lack of availability of data, environmental accounting is quite challenging. Environmental accountants will have to deal with a lot of uncertainties and address these uncertainties as best as they can with sensible assumptions. Despite these challenges, basic standards of economic accounting, such as recording transactions on an accrual and/or depreciation basis, can be followed for environmental accounting. Gaps in data can be addressed by allowing for multiple data sources and interpolating or extrapolating data. Using multiple reliable sources of data also helps with the data validation process. Listed below are three main accounting principles:

1. ***Length and frequency of accounting period:*** In economic accounting, the length of the accounting period is generally one year, often compiled on a quarterly basis. For informed decision-making, environmental accounts should also be regularly compiled.
2. ***Time of accounting:*** Economic accounting follows a double-entry system of bookkeeping where every transaction is simultaneously recorded in two accounts—a debit account and a credit account. Similarly, in environmental flow accounts, the supply of ecosystem services must be recorded in the same accounting period as the use of those ecosystem services. For example, if a well supplies 1000 cubic meters of water daily, then how much of that water is being used and by whom, in a given accounting period, should be recorded. Environmental stock accounts, which measure the value of an asset, should be in sync with the opening and closing dates of the accounting period.
3. ***Scale of application:*** The SEEA-EA framework can be tailored to meet the needs of local stakeholders. Thus, the scale of application can pertain to a single asset (eg. one well), a single ecosystem (eg. a forest) or ecosystem type, and/or one or more ecosystem services (eg. to measure and regulate water supply). Another useful application of the SEEA-EA framework can be to account for areas of land that are under common land use or land management practices (eg. a national park).

Conclusion

To sum up, Module 1 introduces the conceptual framework of SEEA-EA, basic accounting principles, and the three main types of accounts— Ecosystem Extent, Ecosystem Condition, Ecosystem Services—that need to be maintained for environmental accounting. Subsequent modules will further detail how to maintain these three types of accounts.

Module 2 – Ecosystem Extent Accounts

This module comprises 2 Units and gives an overview of how to determine ecosystem extent accounts.

Unit 1: Spatial Units: Introduction

The starting point of ecosystem accounting is the integration of spatial data about ecosystem location, extent, and condition. For accounting purposes, different ecosystems are treated as discrete spatial units. The availability and the quality of spatial data are important factors in ecosystem accounting. In this unit, we will learn how to delineate and classify spatial units as well as how to organize data of spatial units for accounting purposes.

We distinguish between three types of spatial units—Ecosystem Assets (which are assigned to one particular Ecosystem Type), Ecosystem Accounting Area, and Basic Spatial Unit—all of which are described below.

Ecosystem Assets (EA)

To delineate ecosystem assets for environmental accounting, some key features need to be borne in mind:

1. The ecosystem asset should be capable of being mapped: Each asset should be mapped or defined by a unique location, size, and shape.

2. The ecosystem asset should be spatially comprehensive: Each asset should be a distinct spatial and contiguous spatial unit. The size of this spatial unit is referred to as the extent of the ecosystem asset.

3. The ecosystem asset should be conceptually comprehensive and mutually exclusive: One should be able to conceptually describe each asset as a single ecosystem with unique biotic and abiotic characteristics. Each asset should also be a discrete geographical unit that does not overlap with other spatial units.

4. Biotic and abiotic components: When describing ecosystems, we need to remember that ecosystems do not just exist in the two dimensions of a spatial unit. Ecosystems are functional three-dimensional systems comprising biotic or living things like trees as well as abiotic or non-living components such as soil, air, subterranean water etc.

Ecosystem Assets: Classification of Ecosystem Types To compare ecosystem assets maintained by different stakeholders—from policymakers to local communities—we need to classify each ecosystem asset as an ecosystem type. Ecosystem types differ from one another based on their composition, structure, and function of biotic and abiotic components. As we learned in the previous module, an ecosystem type is a distinct set of biotic and abiotic components and their interactions. SEEA-EA uses the Global Ecosystem Typology (GET) for classifying Ecosystem Types. GET has six hierarchical levels:

Levels 1-3, namely, Realms, Biomes and Ecosystem Functional Groups define the functional properties of an ecosystem and are the same across nations. These form the basis of ecosystem accounting. As an example, these three higher levels are described for the Terrestrial Realm in table 2.1 below.

Realm	Biome	Ecosystem Functional Group (EFG)
Terrestrial	T1 Tropical-subtropical forests	T1.1Tropical-subtropical lowland rainforests
Terrestrial	T1 Tropical-subtropical forests	T1.2 Tropical-subtropical dry forests and thickets
Terrestrial	T1 Tropical-subtropical forests	T1.3 Tropical-subtropical montane rainforests
Terrestrial	T1 Tropical-subtropical forests	T1.4 Tropical heath forests
Terrestrial	T2 Temperate-boreal forests & woodlands	T2.1 Boreal and temperate montane forests and woodlands
Terrestrial	T2 Temperate-boreal forests & woodlands	T2.2 Deciduous temperate forests
Terrestrial	T2 Temperate-boreal forests & woodlands	T2.3 Oceanic cool temperate rain-forests
Terrestrial	T2 Temperate-boreal forests & woodlands	T2.4 Warm temperate laurophyll forests
Terrestrial	T2 Temperate-boreal forests & woodlands	T2.5 Temperate pyric humid forests
Terrestrial	T2 Temperate-boreal forests & woodlands	T2.6 Temperate pyric sclerophyll forests and woodlands
Terrestrial	T3 Shrublands & shrubby woodlands	T3.1 Seasonally dry tropical shrub-lands

Terrestrial	T3 Shrublands & shrubby woodlands	T3.2 Seasonally dry temperate heaths and shrublands
Terrestrial	T3 Shrublands & shrubby woodlands	T3.3 Cool temperate heathlands
Terrestrial	T3 Shrublands & shrubby woodlands	T3.4 Rocky pavements, screes and lava flows
Terrestrial	T4 Savannas and grasslands	T4.1 Trophic savannas
Terrestrial	T4 Savannas and grasslands	T4.2 Pyric tussock savannas
Terrestrial	T4 Savannas and grasslands	T4.3 Hummock savannas
Terrestrial	T4 Savannas and grasslands	T4.4 Temperate woodlands
Terrestrial	T4 Savannas and grasslands	T4.5 Temperate tussock grass-lands
Terrestrial	T5 Deserts and semi-deserts	T5.1 Semi-desert steppes
Terrestrial	T5 Deserts and semi-deserts	T5.2 Thorny deserts and semi-deserts
Terrestrial	T5 Deserts and semi-deserts	T5.3 Sclerophyll hot deserts and semi-deserts
Terrestrial	T5 Deserts and semi-deserts	T5.4 Cool deserts and semi-des-erts
Terrestrial	T5 Deserts and semi-deserts	T5.5 Hyper-arid deserts
Terrestrial	T6 Polar-alpine	T6.1 Ice sheets, glaciers and pe-rennial snowfields
Terrestrial	T6 Polar-alpine	T6.2 Polar-alpine rocky outcrops
Terrestrial	T6 Polar-alpine	T6.3 Polar tundra and deserts
Terrestrial	T6 Polar-alpine	T6.4 Temperate alpine grasslands and shrublands
Terrestrial	T6 Polar-alpine	T6.5 Tropical alpine grasslands and shrublands
Terrestrial	T7 Intensive land-use systems	T7.1 Croplands

Terrestrial	T7 Intensive land-use systems	T7.2 Intensive livestock pastures
Terrestrial	T7 Intensive land-use systems	T7.3 Plantations
Terrestrial	T7 Intensive land-use systems	T7.4 Cities, villages and infrastructure
Terrestrial	T7 Intensive land-use systems	T7.5 Derived semi-natural pastures and oldfields
Terrestrial	T1 Tropical-subtropical forests	T1.4 Tropical heath forests
Terrestrial	T2 Temperate-boreal forests & woodlands	T2.1 Boreal and temperate montane forests and woodlands
Terrestrial	T2 Temperate-boreal forests & woodlands	T2.2 Deciduous temperate forests
Terrestrial	T2 Temperate-boreal forests & woodlands	T2.3 Oceanic cool temperate rain-forests
Terrestrial	T2 Temperate-boreal forests & woodlands	T2.4 Warm temperate laurophyll forests
Terrestrial	T2 Temperate-boreal forests & woodlands	T2.5 Temperate pyric humid forests
Terrestrial	T2 Temperate-boreal forests & woodlands	T2.6 Temperate pyric sclerophyll forests and woodlands
Terrestrial	T3 Shrublands & shrubby woodlands	T3.1 Seasonally dry tropical shrub-lands

Table 2.1: Classification of Biomes and Ecosystem Function Groups in the Terrestrial Realm (Source: IUCN resources on Global Ecosystem Typology)[5]

Levels 4-6 are used for detailing finer levels, eg., species diversity of an ecosystem, and are relevant for national and sub-national classification. These levels are termed as Biogeographic Ecotype, Global Ecosystem Type, and Sub-global Ecosystem Type in GET, but in practice, these levels can be defined as per local or national usage and relevance. These levels incorporate local knowledge and are thus useful to local community stakeholders.

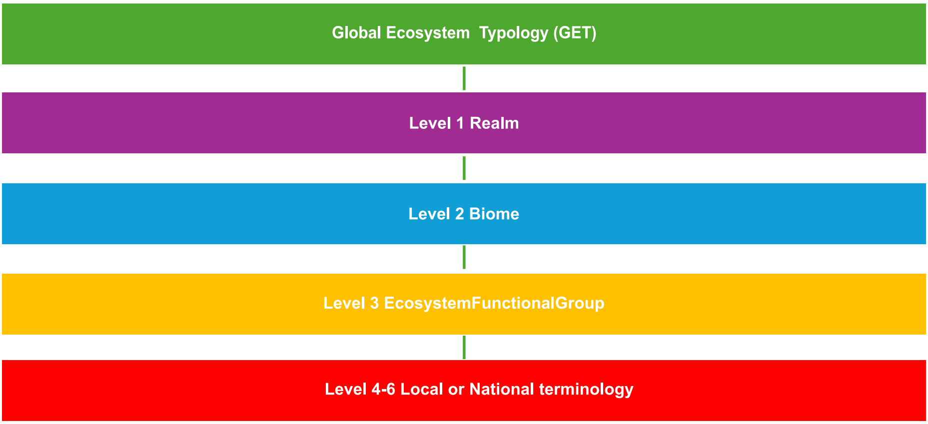

Figure 2.1: The six levels of Global Ecosystem Typology (Adapted from IUCN resources on Global Ecosystem Typology)[6]

Ecosystem Accounting Area (EAA)

When maintaining ecosystem accounts, we need to further determine the geographical area for which we are maintaining accounts. This area is called the Ecosystem Accounting Area (EAA). An EAA can be large or small. For example, the borders of a country for which ecosystem accounts are kept could constitute an EAA. In this case, the EAA will comprise several ecosystem assets (EA) and ecosystem types (ET). But also, a homogenous patch of forest can constitute an EAA, and in thiscase, it will be composed of a single ecosystem asset and a single ecosystem type. In the diagram below, the EAA is marked by bold lines, within which six ecosystem assets and five ecosystem types are numbered and differentiated by a bold dashed line.

Basic Spatial Unit (BSU)

A Basic Spatial Unit (BSU) is a geometrical construct representing a small spatial area. BSUs are a standard tool used in incorporating satellite imagery into Geographical Information Systems (GIS). BSUs can be a geometrical grid or a polygon that can be overlaid on the Ecosystem Accounting Area (EAA). It is standard practice to define the geometrical grid used in g satellite imagery as a BSU. While BSUs are not mandatory

[5]https://portals.iucn.org/library/sites/library/files/documents/2020-037-En.pdf
[6]https://portals.iucn.org/library/sites/library/files/documents/2020-037-En.pdf

for compiling environmental accounts, the use of BSUs greatly helps us in measuring and reporting the size or extent of the EAA and the Ecosystem Asset (EA). BSUs are measured in terms of area such as hectares or km². When using BSUs in environmental accounting, for measurement purposes, the pre-determined BSU should be equal to or less than the size of an EAA or EA. The BSU, as shown in the figure below, is overlaid on the EAA.

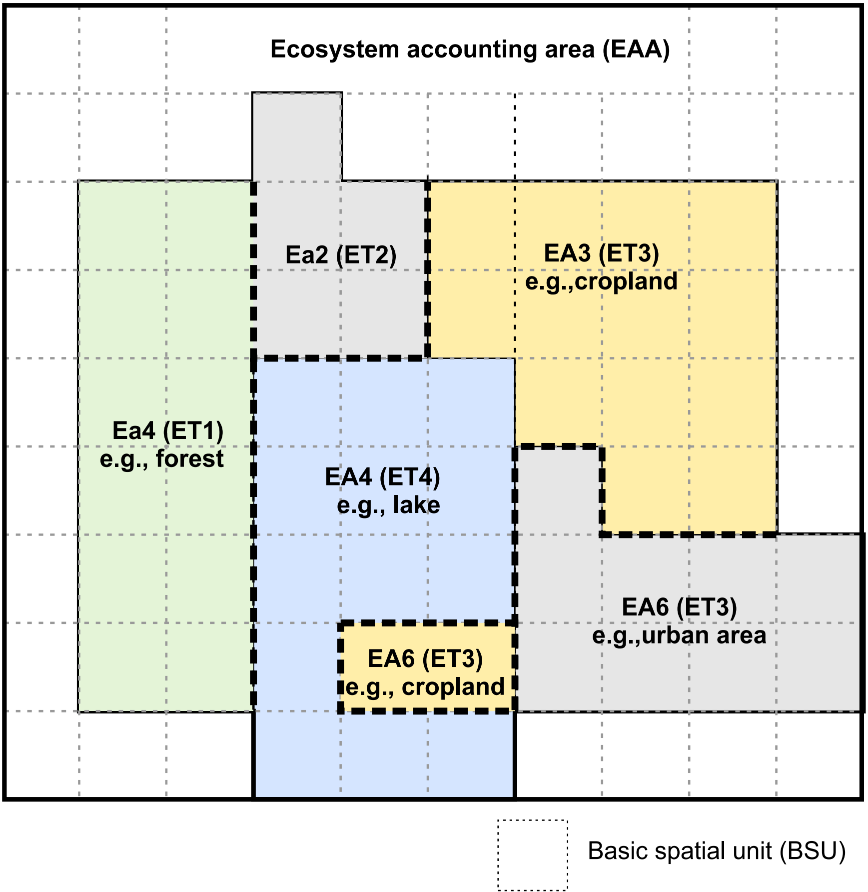

Figure 2.2: Example of Extent Account spatial units (Source: SEEA-EA, United Nations)[7]

As shown above, each Ecosystem Asset (EA) can be assigned to only one Ecosystem Type (ET). In practice, in many cases, it will not be easy to assign an EA to a particular ET as shown in the diagram above. For example, an EA may comprise cropland, which also has some forested area. In such cases, an educated guess will have to be made to determine the primary ET: The EA, in the given example, has to be classified as either cropland or forests.

For accounting purposes, the areas of the same Ecosystem Type (ET) within an Environmental Accounting Area (EAA) can be aggregated using Basic Spatial Units (BSUs) to measure changes over time of that particular ET. In the diagram above, we can see that EA3 and EA6 have the same ET ie. Cropland. When using BSUs for measuring and reporting, Ecosystem Assets (EA) comprising different ETs are attributed to each BSU. As exemplified in Figure 2.2, EA3 comprises 13 BSU while EA6 comprises 2 BSU. Thus, total Cropland in the above EAA is 15 BSU. Naturally, for accurate accounting, the sum of the areas of different ETs should be equal to the EAA as shown in table 2.2 below.

Spatial Unit	**Total Size (can be in hectares or m²)**
Ecosystem Type: ET 1 (Forest)	12
Ecosystem Type: ET 2 (Urban Area)	13
Ecosystem Type: ET 3 (Cropland)	14
Ecosystem Type: ET 4 (Lake)	15
Ecosystem Accounting area (EAA)	54

Table 2.2: Example of calculating the size of Ecosystem Types within an Ecosystem Accounting Area (Source: SEEA-EA, United Nations)[8]

Use of data in environmental accounting

Use of GIS data

Satellite data, analysed using geographical information systems (GIS), help us in defining ecosystem assets. To delineate an ecosystem area, we make use of a geometrical construct, such as the grid cell in satellite images or a polygon drawn on a map, called the Basic Spatial Unit (BSU). The BSU, as explained above, is a useful framework that helps us to incorporate data on the different characteristics of the ecosystem.

[7] https://seea.un.org/content/seea-e-learning-resources

[8] https://seea.un.org/content/seea-e-learning-resources

Land data
Ecosystem Accounting is very often used for Terrestrial realms, especially by local stakeholders. Therefore, it is important to learn about different types of data about the land that can be of use in Ecosystem Accounting. These are:

1. ***Land Cover:*** Land cover data refers to what can be observed on the surface of the Earth, eg., vegetation, buildings etc. Satellite data is widely used to determine land cover of ecosystem assets.
2. ***Land Use:*** Land use refers to the activities undertaken on the land. Very often, there are institutional arrangements on land use such as zoning for urban development or protection of national parks. Land use directly affects the appreciation or depreciation of our natural capital, and hence it is useful to track it.
3. ***Land Management:*** Land management or the use and development of land has positive or negative effects on ecosystems. Monitoring how land is managed can provide stakeholders with crucial insights into protecting ecosystems.
4. ***Land Ownership:*** Ownership directly affects how land is used and managed, and consequently whether an ecosystem asset contributes to or detracts from providing ecosystem services for public good. Tracking ownership, sectorally, ie. determining whether it is the government, a corporation, individuals, or a community owning land also provides insights for protecting our ecosystems.

Unit 2: Ecosystem extent account

Importance of extent accounts
The three types of spatial units allow us to determine ecosystem extent accounts, the primary account on the basis of which we can determine other environmental accounts pertaining to stock, flows, and services. Ecosystem extent as mentioned in Module 1 is the size of an ecosystem asset. Ecosystem extent account units can be in terms of area (two-dimensional assets, eg., cropland), length (one-dimensional assets eg., the length of a stream) or volume (three-dimensional assets eg., the amount of water in an inland lake).

Ecosystem extent accounts support the analysis of temporal changes in spatial configurations of different ecosystem types (ET) within an ecosystem accounting area (EAA). For example, in the above diagram, we have established that the total Cropland ET is 15 BSU. This baseline reference can then be used in time series data to see if total Cropland is increasing or decreasing within this EA.

As mentioned earlier, local stakeholders can use local or national terms to define Levels 4-6 in GET. Maintaining local-level details about ecosystem types aids us in more insightful interpretations and informed policy decisions. For example, let's say that in India, satellite data shows an increase in forest ecosystems in the period 2016-2018. However, data drawn from national and sub-national sources show that there has been an overall increase in plantations but a decrease in a specific unique forest type, such as the Tropical Dry Evergreen Forest. Environmental accounts at this level of detail of ecosystem types can then be used to make reasonable interpretations about the loss of biodiversity, soil health etc., and aid better conservation measures. In other words, extent accounts also help us in determining the condition of the ecosystem asset. In Module 3, we will learn more about Ecosystem Condition accounts.

Structure of extent accounts

In most cases, in the terrestrial realm, extent accounts are maintained in terms of units of area ie. hectares or km². As we learned in Module 1, it is important to follow basic accounting principles, and maintain opening and closing accounts of each ecosystem type for a given period, usually one year. A simple excel sheet can be maintained by local stakeholders to maintain this data as is illustrated in the table 2.3 below:

	Selected ecosystem types (based on Level 3-EFG of the IUCN Global Ecosystem Typology)					TOTAL
Realm	Terrestrial					
Biome	T1 Tropical-subtropical forests					
Ecosystem Functional Group (EFG)	Tropical-subtropical lowland rainforests	Tropical-subtropical dry forests and scrubs	Tropical-subtropical montane rainforests	Tropical heath forests		
	T1.1	T1.2	T1.3	T1.4		
Opening extent						
Additions to extent						
Managed expansion						
Unmanaged expansion						
Reductions in extent						
Managed reductions						
Unmanaged reductions						
Net change in extent						
Closing extent						

Table 2.3: Ecosystem extent accounts (Adapted from SEEA-EA, United Nations)[9]

Local stakeholders can adapt the above table to keep accounts for the ecosystem type that pertains to their interest. The Eccounting.org platform is also designed to allow local stakeholders to choose the appropriate Biome and Ecosystem Functional Group for their ecosystem type. Local stakeholders can be aided by environmental accountants or Eccountants[10] to determine what sort of ecosystem extent accounts they should maintain to suit their purposes and ensure coherence of these accounts with the Global Ecosystem Typology. As indicated in the above table, it is recommended to have opening and closing balances of each account and additions and reductions of the extent of the asset. An additional level that SEEA-EA recommends is distinguishing between managed (due to human intervention) and unmanaged (due to natural processes) expansion/reduction. Such details allow for more informed decisions in the management of our natural capital wealth.

[9]https://seea.un.org/content/seea-e-learning-resources

[10]The term Eccountants was coined as part of the Eccounting.org start up idea. The term denotes resource people trained in environmental accounting, especially SEEA-EA frameworks who can help local stakeholders to keep track of their natural capital.

Dimensions of Extent Account

Earlier, we had noted that ecosystem assets, depending on the ecosystem type, can exist in one, two or three dimensions and be measured by length, area, or volume respectively. Most ecosystem assets are effectively measured by area, which is a two-dimensional footprint ie. length and breadth. Some ecosystem assets, however, are so long, such as a river or stream, that their footprint is effectively one-dimensional. Lastly, there are three-dimensional ecosystem assets, such as water bodies, where it is useful to calculate the volume of water they contain. Accounts of all these different dimensions and different ecosystem assets can be maintained, but it is important to note that dimensional accounts of an ecosystem type need to be separately maintained. In other words, one-dimensional length cannot be aggregated with two-dimensional area or three-dimensional volume. For instance, in the example below, some rivers could be accounted for by their area, but other rivers could only be accounted for by their length. In such a case even though all rivers belong to the same ecosystem type, their accounts cannot be aggregated as shown in table 2.4 below.

Dimension (D)	Ecosystem Type	Extent		
		Volume m^3	Area (km^2)	Length (km)
3D	Lake	1000		
2D	Forests		100	
	Rivers		5	
1D	Rivers			50
	Streams			200
Total		1000	105	250

Table 2.4: Dimensional measures of ecosystem types (Adapted from SEEA-EA, United Nations)[11]

Conclusion

Ecosystem accounting depends upon spatial data, namely location, size, and condition of the ecosystem. Three types of spatial units—Ecosystem Assets (which are assigned to one particular Ecosystem Type and their extent measured in the dimensional terms of Volume—3D; Area—2D, or Length—1D), Ecosystem Accounting Area, and Basic Spatial Unit, Ecosystem Accounting Area, and Basic Spatial Unit are crucial for determining extent accounts and Condition Accounts. Extent Accounts or the size of the ecosystem assets are primary accounts on the basis of which all other accounts that measure ecosystem condition, flows and services can be maintained. Time series data of extent accounts allow us to draw insightful inferences about the health of ecosystems.

[11] https://seea.un.org/content/seea-e-learning-resources

Module 3 – Ecosystem Condition Accounts

This module comprises 2 Units and gives an overview of how to determine ecosystem condition accounts.

Unit 1: Accounting for Ecosystem Condition

The condition or the health of the ecosystem determines its ability to provide services for our benefit. To ensure a steady supply of services over generations, it is necessary to ensure the health of the ecosystem. Every ecosystem is characterised by biotic and abiotic components that interact with each other in complex ways. These components and their interactions determine the structure of an ecosystem and differentiate it from other ecosystems.

The ecological processes that occur within an ecosystem to maintain terrestrial life are referred to as ecosystem function.

Ecosystem Condition is assessed in terms of its composition, structure, and function. Human interventions and climate-related variables greatly influence the condition of the ecosystem.

Determining Ecosystem Condition Accounts

Accounting within the EAA
As discussed in Module 2, to maintain Ecosystem Condition accounts, we rely on the basic spatial unit of the Ecosystem Accounting Area (EAA). The quality of the ecosystem assets within the EAA are described in biophysical terms and how they change over time. Standard environmental monitoring data, such as water quality, air quality, soil properties, data on biodiversity, form the basis of determining the quality or condition of the ecosystem.

Selecting characteristics and variables
The first step in determining ecosystem condition accounts would be to decide on the biophysical characteristics that stakeholders want to monitor and account for. There can be numerous variables within these biophysical characteristics. So, the next step is for stakeholders to decide on the most important variables they want to monitor. For example, in a forest ecosystem, stakeholders may choose to monitor only the tree canopy of the forest, or they may choose to monitor the plant-species diversity or both. It is advisable that local stakeholders choose to account for only the most important variables, given their needs and resources. Also, some ecosystem characteristics such as topography or geological structure are relatively stable. Local stakeholders are likely to focus on characteristics that change over time due to human activity or climate-related variables such as air quality, precipitation, species diversity, etc. In general, it is easier to track variables that show a reduction or addition to stock accounts.

Ecosystem Condition Typology

In Module-2, we learnt that SEEA-EA uses the Global Ecosystem Typology (GET) for classifying Ecosystem Types. Similarly, SEEA-EA has developed a classification called Ecosystem Condition Typology (ECT) to assess ecosystem conditions in terms of quantitative metrics by classifying them into three groups: abiotic characteristics; biotic characteristics; and landscape-level characteristics. These three groups are further categorised into different classes as shown in table 3.1 below. Biotic and landscape-level characteristics can be subject to multiple definitions or interpretations. What is important in ecosystem condition accounting is to avoid double counting by ensuring that one common interpretation is used and only one measurement unit is assigned to each class. Local stakeholders can use the ECT template of SEEA-EA to determine what characteristics and what variables within each ecosystem characteristic they want to account for.

Ecosystem condition account

In the previous sections, we noted that it is up to the stakeholders to decide on what variables they want to monitor, and we recommend that Eccountants or environmental accountants help them to use the ECT Typology of ecosystem characteristics. As noted in table 3.2 below, basic accounting principles should be followed, such as noting the opening and closing values, and the period over which the change was measured as shown.

Ecosystem Condition Typology (ECT) groups and classes

Group A: Abiotic ecosystem characteristics

Class A1. Physical state characteristics: physical descriptors of the abiotic components of the ecosystem (e.g., soil structure, water availability)
Class A2. Chemical state characteristics: chemical composition of abiotic ecosystem compartments (e.g., soil nutrient levels, water quality, air pollutant concentrations)

Group B: Biotic ecosystem characteristics

Class B1. Compositional state characteristics: composition I diversity of ecological communities at a given location and time (e.g., presence / abundance of key species, diversity of relevant species groups)

Class B2. Structural state characteristics: aggregate properties (e.g,, mass, density) of the whole ecosystem or its main biotic components (e.g,„ total biomass, canopy coverage, annual maximum normalized difference vegetation index (NDVI))

Class B3. Functional state characteristics: summary statistics (e.g., frequency, intensity) of the biological, chemical, and physical interactions between the main ecosystem compartments (e,g.„ primary productivity, community age, disturbance frequency)

Group C: Landscape level characteristics

Class C1. Landscape and seascape characteristics: metrics describing mosaics of ecosystem types at coarse (landscape, seascape) spatial scales (e.g., landscape diversity, connectivity, fragmentation)

Table 3.1: Ecosystem Condition Typology (Adapted from SEEA-EA, United Nations)[12]

[12]https://seea.un.org/content/seea-e-learning-resources

Ecosystem condition account

In the previous sections, we noted that it is up to the stakeholders to decide on what variables they want to monitor, and we recommend that Eccountants or environmental accountants help them to use the ECT Typology of ecosystem characteristics. As noted in table 3.2 below, basic accounting principles should be followed, such as noting the opening and closing values, and the period over which the change was measured as shown.

Ecosystem Condition Typology (ECT) Class	Variables (V)		Ecosystem Type			Time
	Descriptor	Measurement value	Opening value	Closing value	Change	Date [From-To
ECT Class A1: Physical State	V1 (Eg. soil structure)					
	V2 (Eg. soil moisture)					
ECT Class A2: Chemical state	V3 (Eg. soil nutrient levels)					
ECT Class A3: Compositional State	V4 (Eg. foundation species)					
	V5 (Eg. keystone species)					
ECT Class B1: Structural State	V6 (Eg. canopy coverage)					
ECT Class B2: Functional State	V7 (Eg. summary of physical interactions--disturbance frequency)					
ECT Class B3: Landscape/Seascape characteristics	V8 (Eg. fragmentation of landscape)					

Table 3.2: Ecosystem Condition Variable Account (Adapted from SEEA-EA, United Nations)[13]

[13] https://seea.un.org/content/seea-e-learning-resources

As mentioned earlier, in the context of extent accounts, an EAA , may comprise several ecosystem assets that belong to the same ecosystem type, but the different assets have different values for the same variable. To account for different values within the EAA, we need to use statistics to get a reliable mean. For example, if we take as our EAA, the international township of Auroville in south India (a barren plateau rewilded by its residents over five decades), we find that its forests are fragmented. Most belong to an ecosystem type nationally known as the Tropical Dry Evergreen Forest. This means that each patch of forest counts as an environmental asset within the EAA. One mature patch of forest has a contiguous land area of 50 acres, while another young patch of forest is only 10 acres. If we measure the variable condition of the tree canopy of these two ecosystem assets, we find that the mature patch has a tree cover of 80% while the young patch has a canopy of 60%. To calculate the tree canopy for both forests, we will need to use a weighted mean to account for the different sizes of the two forests as seen in table 3.3 below.

Other statistical methods would similarly be needed to be used if stakeholders want to accurately record differing values of complex variables (such as the pH of soil, water quality etc.) of an aggregated ecosystem type in an EAA.

Ecosystem Asset	Area(in m2 or hectares)	Tree Canopy Cover (%)	Weight	Weighted Canopy Cover (%)
Forest 1	50	80%	=50/(50+10)=0.83	=80%* 0.83or 66%
Forest 2	10	60 %	=10 (50+10)=0.16	=60%*0.16 or 10%
Total	60			76%

Table 3.3: Example of using weighted mean in Ecosystem Condition Variable Account (Adapted from SEEA-EA, United Nations)[14]

[14] https://seea.un.org/content/seea-e-learning-resources

Unit 2: Ecosystem Condition Indicators and Reference Levels

Ecosystem Condition Indicators

Ecosystem condition accounts can help us in deriving ecosystem condition indicators to better interpret the change in an ecosystem. Ecosystem condition indicators describe the health of an ecosystem relative to a reference level. Ecosystem condition indicators should be described using the same Ecosystem Condition Typology (ECT) that we used above for determining characteristics and variables. For ease of comparison, SEEA-EA uses a numeric value for an indicator, which is calculated according to a formula.

Ecosystem Reference Levels

Reference levels make it meaningful for us to compare and interpret changes in measured values of indicators. The reference level for an indicator is generally the ecosystem in its pristine state or best possible desired state. If we take agricultural land, as an example, it cannot be brought back to a pristine natural ecosystem as agricultural cultivation has been a sustained human intervention. So, it is more useful to understand what agricultural practices would help us maintain optimal health of the land ie. its "best possible desired state."

Further to determine a robust reference level, SEEA-EA first defines the highest and lowest bounds of the variable range: For example, the highest bound of the variable range can be the natural state of the ecosystem while the lowest bound can be the most degraded state of the ecosystem (that is degraded to the point where ecological processes cannot support the ecosystem's functions). The highest limit for a variable is described by the term VH and the lowest limit for a variable is described by the term VL. The term V stands for the value of the Variable that was recorded in the Ecosystem Condition Account. As we will see below, these terms, V, VH and VL are used in a formula to get a numeric value for the desired Indicator (I).

Determining ecosystem condition indicators from variables

Describing indicators in terms of numbers allows us to quickly assess the health of the ecosystem in comparison to its reference level. The difference between the numeric value of the Indicator (I) and the reference level represents the degree of change in the ecosystem. To calculate this numeric value, SEEA-EA uses the formula:
$I = (V-VL)/(VH- VL)$

In practice, Eccountants will need to consult with national experts to get precise nationally accepted values for VH and VL and then help local stakeholders to maintain ecosystem condition indicator accounts. Therefore, in this basic course on ecosystem accounting, we will not describe how to maintain ecosystem condition indicator accounts. SEEA-EA resources on this topic can be consulted by Eccountants, should they want to maintain ecosystem condition indicator accounts.

However, it is worth bearing in mind that all ecosystem condition indicators fall within a range of 0 to 1, where 1 represents the fact that the ecosystem condition matches the reference condition and 0 indicates that the ecosystem condition is furthest away from the reference condition, that is in the most degraded condition. Local stakeholders can also use this reference range to give a quantitative value to their subjective assessment of an ecosystem condition. Here's an example from real life: An erstwhile Panchayat president of Curtorim Panchayat in Goa, Mr. R. decided to start a People's Biodiversity Register, as mandated by the Biodiversity Board. As a first step, he conducted fauna surveys of his Panchayat and published a species count of the different fauna. Such a report can be turned into an Ecosystem Condition Account as biodiversity, according to Ecosystem Condition Typology (ECT) is a variable of Class B1 (Compositional state characteristic). Now, let's say, Mr. R, who grew up in Curtorim, remembers that in his childhood he had seen more fauna species and a more pristine habitat. Based on this subjective memory, he decides to assign the value 1 to the Biodiversity Condition that he had seen as a child. The value 1 here would then represent VH ie. the desired state of the Curtorim ecosystem. Based on his survey and other observed data such as the decrease in habitats, the impact of tourists, etc., he decides that the current Biodiversity Condition is 0.6 with reference to his VH. Quantifying the condition of an ecosystem helps us to easily share with others the ongoing degradation or revival of an ecosystem. It also defines a goal for conservationists and marks their progress towards their goal. Naturally, when publicly sharing such data, all subjective values have to be referenced in a footnote.

Conclusion

In summary, to maintain ecosystem condition accounts, we need to follow three steps:

- Select ecosystem characteristics and variables that need to be monitored

- Determine aggregate measures across instances of a given ecosystem type within an EAA, if so needed

- Derive ecosystem indicators from variables

Ecosystem condition accounts help us primarily to monitor change over time. Additionally, these accounts can support us in preparing indicators that describe the ecosystem condition relative to a reference condition.

Module 4 – Ecosystem Services Accounts

This module comprises 3 Units and describes accounting of ecosystem services and their benefits, and how to track benefits through supply and use tables.

Unit 1: Ecosystem Services and Benefits: Basic Principles

Ecosystems represent our wealth in terms of natural capital. The services provided by natural resources or ecosystem services benefit humans economically. Governments, businesses, and households, all consume these benefits. Examples of ecosystem benefits include the extraction of minerals, timber, water, etc. Economic activities result in a wide range of marketed goods and services. In ecosystem accounting, we keep account of the contribution of the ecosystem assets in the production of these marketed goods and services. The contribution of human labour in production, for example, is not included in ecosystem accounting.
In SEEA-EA, ecosystem services and benefits are mapped to ecosystem assets within an ecosystem accounting area. Ecosystem services accounts organize data on the flows of these services and keep track of who uses and benefits from these services. The primary focus of SEEA-EA is on the contribution of ecosystem assets to the economy. The economic value of these services and benefits are described in terms of economic units as defined in the System of National Accounts (SNA) of a country. SEEA-EA, however, also allows accounting for non-SNA uses and benefits.

The concept of benefits and services

Benefits are the final products and services that are used by different stakeholders of the society—government, businesses, and households. In the SEEA general framework, where the focus is on mapping ecosystem benefits to the SNA, ecosystem benefits are congruent with economic units of the market economy. SEEA-EA, on the other hand, includes benefits outside of the market economy. For example, ecosystem services result in benefits such as micro-climate regulation, passive enjoyment of ecosystems as spiritual or cultural heritage that are generally not accounted for economically.

Categorizing ecosystem services

As described in Module 1, the direct and indirect benefits that humans derive from ecosystems are categorized into four main types:

1. ***Provisioning Services:*** These are the products obtained from ecosystems.
2. ***Regulating and Maintenance Services:*** These are the benefits provided by ecosys tems that regulate environmental processes and support life-sustaining conditions.
3. ***Cultural Services:*** These are intangible benefits, such as recreational or aesthetic benefits, that people obtain from ecosystems.
4. ***Supporting or Intermediate Services:*** These are the underlying processes that enable the production of other ecosystem services, such as soil formation and nutrient cycling, photosynthesis and primary production, biodiversity maintenance, and habitat provision.

These underlying supporting services are generally not accounted for in SEEA-EA as the focus is on the final service to human beings.

Provisioning, regulating, and cultural services cannot always be measured directly, but can be accounted for by using a proxy. For instance, to measure the provisioning service of a cropland ecosystem, one can use the proxy of the number of tonnes of food produced in that ecosystem asset. To measure regulating services such as flood regulation by forests, one can calculate the number of people for whom the risks of flooding are lowered. And cultural services such as those derived by tourists to a national park, one can calculate the number of visitors to the park and the length of their visits.

Users versus beneficiaries
For precise accounting, SEEA-EA recommends distinguishing between users and beneficiaries. Users directly use ecosystem services that are provided by the ecosystem as inputs and, as part of a market-value chain, use these inputs to supply services to beneficiaries. Beneficiaries are the ultimate consumers of the goods and services that are derived from ecosystems. Users can be regarded as a subset of beneficiaries, who directly use the services provided by the ecosystem. An example of a user is a mining industry that extracts minerals from an ecosystem and then supplies those minerals to other industries that manufacture goods for the public. Making these nuanced distinctions is important to precisely account for which user or beneficiary gains how much from the ecosystem asset.

Identifying flows of ecosystem services
SEEA-EA uses a table, known as a logic chain, that identifies the beneficiaries of all ecosystem services. This logic chain tabulates the following factors:

1. ***Ecosystem service:*** For each ecosystem service, for example, air filtration services, a logic chain must be maintained.
2. ***Common ecosystem types:*** As a given ecosystem service can be supplied by more than one ecosystem, and as the focus here is on the individual service being provided, all ecosystem types within that ecosystem accounting area must be listed. In the above example, Air filtration services are generally provided by forest ecosystems.
3. ***Factors determining supply (Ecological and Societal):*** Ecological factors such as type and condition of forest cover would determine supply of air filtration services, while societal factors such as the management of the forest could affect the volume of air filtration services that the ecosystem provides.
4. ***Factors determining use:*** To determine how society economically benefits from the ecosystem service, the factors that determine the use of the service must be recorded. For example, the number of people who live near a forest can be used to quantify the benefits of air filtration services.
5. ***Metrics:*** To quantify the benefits of ecosystem services, appropriate metrics must

be used. For example, air filtration services can be quantified by measuring the volume of pollutants removed by the forest. Consideration of appropriate metrics should take into account data availability.

6. ***Benefits:*** Economic and non-economic benefits to society are recorded in the logic chain. In the example of air filtration services, the benefits to human health can be calculated.
7. ***Main users and beneficiaries:*** Lastly, the logic chain lists the main users and beneficiaries of the ecosystem service. Users and beneficiaries are broadly classified as the government, businesses, or households. And, as noted above, further distinctions can be made between users and beneficiaries.

An example of the logic chain for air filtration services is provided below. Annex 6.1 of SEEA-EA Handbook[15] provides a comprehensive list of logic chains for different ecosystem services. Local stakeholders can adapt this table to fulfill their actual needs.

Ecosystem Service	**Common ecosystem type/s**	**Factors determining supply**		**Factors determining use**	**Potential physical metric(s) for the ecosystem service**	**Benefits**	**Main users and beneficiaries**
		Ecological	**Societal**				
Air Filtration service	Forest and woodland	Type and condition of vegetation, especially Functional state (e.g., Leaf Area Index) and Chemical State (e.g., ambient pollutant concentration	Ecosystem manage-ment; location type and volume of released air pollut-ants	Behavioural responses; and location and number of people and buildings affected by pollution	Tonnes of pollutants absorbed by type of pollutant (e.g., PM10; PM2.5	Reduced concentra-tions ofair pollut-ants providing improved health outcomes and reduced damage to buildings(non SNA benefit)	Households; businesses (through reduced damage to buildings)

Table 4.1: Example of generic logic chain (Source: SEEA-EA, United Nations)[16]

Unit 2: Accounting for ecosystem services

Ecosystem services accounts capture flows of ecosystem services from an Ecosystem Accounting Area in a given accounting period. These flows are firstly captured in the appropriate physical unit of measurement such as tonnes, cubic meters, etc. These physical units can then be the basis of calculating the monetary value of various ecosystem services. SEEA-EA supply and use tables for ecosystem services accounts are designed to measure ecosystem services across multiple ecosystem assets and users.

Ecosystem services accounts can help strategic planning by policy-makers and local stakeholders by comparing services from different ecosystems, identifying ecosystems under threat by tracking ecosystem service flows over time, assessing the importance of ecosystems to human well-being, determining the different categories of users that benefit from an ecosystem service, etc.

[15]https://unstats.un.org/unsd/statcom/52nd-session/documents/BG-3f-SEEA-EA_Final_draft-E.pdf (pp. 150-153)
[16]https://unstats.un.org/unsd/statcom/52nd-session/documents/BG-3f-SEEA-EA_Final_draft-E.pdf (p. 123)

Ecosystem Supply and Use Tables

SEEA-EA follows generic accounting principles to structure supply and use tables, similar to those used by SEEA (Central Framework) and SNA. Supply data frameworks on ecosystem services record flows of final services that are supplied to consumers. These flows can also be captured in terms of economic units. Use data frameworks on ecosystem services record flows of intermediate services among stakeholders in the supply chain. Both frameworks show the total flows of each service for the given accounting period, say one year. And, in a given accounting period, the supply data must equal total use data. Data is captured in the appropriate metric measure such as tonnes, cubic meters, etc. This data on ecosystem services can then be used to calculate the monetary value of these services.

Given below are simplified supply and use tables recommended by SEEA-EA. These tables can be further adapted by local stakeholders to meet their needs.

Supply		Unit of measure	Forest	Lake	Cropland	Urban area	Wetland	Total Supply
Selected ecosystem services								
Provisioning services								
Biomass provisioning	Crop provisioning services	tonnes			150			150
	Wood provisioning services	m^2	140					140
	Aquatic biomass provisioning services	tonnes		3				3
Regulating services	Global climate regulation services	tonnes CO2	150			5	20	175
	Water purification services	tonnes N removed					7	7
Cultural services								
Recreation-related services		# visits	1500	5000		500		7000

Table 4.2: Simplified Supply Table for Ecosystem Services (Source: SEEA-EA, United Nations)[17]

[17]https://seea.un.org/content/seea-e-learning-resources

Use		Unit of measure	Forest	Lake	Cropland	Urban area	Wetland	Total Use
Selected ecosystem services								
Provisioning services								
Biomass provisioning	Crop provisioning services	tonnes			150			150
	Wood provisioning services	m^2	140					140
	Aquatic biomass provisioning services	tonnes		3				3
Regulating services	Global climate regulation services	tonnes CO2	150			5	20	175
	Water purification services	tonnes N removed					7	7
Cultural services								
Recreation-related services		# visits	1500	5000		500		7000

Table 4.3: Simplified Use Table for Ecosystem Services (Source: SEEA-EA, United Nations)[18]

Unit 3: Ecosystem Services Reference List

Unlike the Global Ecosystem Typology, there is no internationally accepted classification of ecosystem services. SEEA-EA has compiled a reference list of key ecosystem services that are considered relevant and important by most countries. This reference list seeks to standardize definitions and the scope of measurement for these services to ensure consistency of measurement across different countries and contexts. As noted earlier, the focus is on capturing benefits from Provisioning Services, Regulating and Maintenance Services, and Cultural Services as these benefits can be translated into economic units.

Table 6.3 of SEEA-EA Handbook[19] provides the full reference list. Snapshots of this list are provided below as examples for adaptation and use by local stakeholders.

Category of Service	Explanation
Provisioning Service	Ecosystem services representing contribution to benefits derived from ecosystems
Regulating and Maintenance Services	Ecosystem services resulting from the ability of ecosystems to influence climate, hydrological and biochemical cycles
Cultural Services	Experiential or intangible services related to the perceived or actual qualities of ecosystems

Table 4.4: Categories of Ecosystem Services (Source: SEEA-EA, United Nations)[20]

[18]https://seea.un.org/content/seea-e-learning-resources
[19]https://unstats.un.org/unsd/statcom/52nd-session/documents/BG-3f-SEEA-EA_Final_draft-E.pdf (pp. 127-129)
[20]https://seea.un.org/content/seea-e-learning-resources

ECOSYSTEM SERVICE		DESCRIPTION
Biomass provisioning services (selected)	Crop provisioning services	Crop provisioning services are the ecosystem contribution to the growth of cultivated plants that are harvested by economic units for various uses including food and fibre production, fodder and energy. This is a final ecosystem service.
	Grazed biomass provisioning services	Grazed biomass provisioning services are the ecosystem contributions to the growth of grazed biomass that is an input to the growth of cultivated livestock. This service excludes the ecosystem contributions to the growth of crops used to produce fodder for livestock (e.g., hay, soybean meal). These contribution are including under crop provisioning services. This is a finalecosystem service but may be intermediate to livestock provisioning services.
	Livestock provisioning services	Livestock provisioning services are the ecosystem contributions to the growth of cultivated livestock and livestock products (e.g., meat, milk, eggs, wool, leather), that are used by economic units for various uses, primarily food production. This is a final ecosystem service. No distinct livestock provisioning services to be recorded if grazed biomass provisioning services are recorded as a final ecosystem service.

Table 4.5: Example 1 of SEEA-EA Ecosystem Services Reference list (Source: SEEA-EA, United Nations)[21]

Eco system services and description	
Selected cultural services	Description
Recreation-related services	Recreation-related services are the ecosystem contributions, in particular through the biophysical characteristics and qualities of ecosystems, that enable people to use and enjoy the environment through direct. in-situ, physical and experiential interactions with the environment. This includes services. to both locals and non-locals (i.e., visitors, including tourists). Recreation-related services may also be supplied to those undertaking recreational fishing and hunting. This is a final ecosystem service.
Visual amenity services	Visual amenity services are the ecosystem contributions to local living conditions in particular through the biophysical characteristics and qualities of ecosystems that provide sensory benefits, especially visual. This service combines with other ecosystem services, Including recreation-related services and noise attenuation services to underpin amenity values, This is a final ecosystem Service.

Table 4.6: Example 2 of SEEA-EA Ecosystem Services Reference list (Source: SEEA-EA, United Nations)[22]

[21]https://seea.un.org/content/seea-e-learning-resources
[22]https://seea.un.org/content/seea-e-learning-resources

Conclusion

The key concepts of this module are summarized below:

- In SEEA-EA, the focus is to calculate the contribution of ecosystem services that benefit society and can be translated into economic units.
- Supply and use tables present the final and intermediate flows of ecosystem services over a given accounting period.
- SEEA-EA has developed a reference list for key ecosystem services structured into three broad categories-- Provisioning Services, Regulating and Maintenance Services, and Cultural Services.

Acknowledgment

The author gratefully acknowledges a grant from K2A, Swissnex in India for the preparation of this module. I would particularly like to thank Manon Céleste Mariller, Prof. Dr. Swetha Dhananka Rao and others in their team for their kind support.

All material related to United Nations System System of Environmental-Economic Accounting (SEEA) frameworks that were used in this primer were taken from these sources maintained by United Nations:

- SEEA e-Learning: https://seea.un.org/content/seea-e-learning-resources
- SEEA Knowledge base: https://seea.un.org/content/knowledge-base
- SEEA-EA Online Course: https://learning.officialstatistics.org/login/index.php

All tables and figures adapted or sourced from the United Nations SEEA frameworks have been duly credited in the text.

The initial idea for a course on Natural Capital Accounting designed for local communities came from Mitesh Thakkar, CEO, Arthify, Inc., who is working on the Eccounting web-based platform—which will eventually offer this course online. Thakkar's support for the development and review of this course primer is duly acknowledged.

Last but not least, the author thanks Island Lesecure, CEO, Treescapes, for his review of the course material. His suggestions on content and meticulous proofreading are highly appreciated.

Natural Capital Accounting: A Course Primer has been designed to inform local communities and businesses on how they can adapt United Nations System of Environmental-Economic Accounting (SEEA) frameworks for environmental accounting for their own projects in natural resource management.

SEEA is closely aligned with the 17 United Nations Sustainable Development Goals (SDGs) in that it is based on the fundamental premise that development must balance social, economic and environmental sustainability. The 17 SDGs are integrated and are a call for action to end poverty and protect the planet by 2030. SEEA provides a robust framework for monitoring progress towards the sustainability targets associated with each goal. This Course Primer, by empowering local communities to use the SEEA framework, allows them to participate in achieving the targets of the SDGs, especially of the following six goals.