Using the SEEA EA for Calculating Selected SDG Indicators

Report of the NCAVES Project

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System of Environmental Economic Accounting

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Indicators and Natural Capital Accounting

The Natural Capital Accounting and Ecosystem Service Valuation (NCAVES) project is a joint initiative launched by the United Nations Statistics Division, the United Nations Environment Programme and the Secretariat of the Convention on Biological Diversity and funded by the European Union. NCAVES is working in collaboration with the five participating partner countries, namely Brazil, China, India, Mexico and South Africa, to advance the knowledge agenda on ecosystem accounting.

The indicator workstream of the NCAVES project assesses the linkages of the System of Environmental-Economic Accounting Ecosystem Accounting (SEEA EA) to the existing global monitoring frameworks, such as those used for reporting on the Sustainable Development Goals (SDGs), the Aichi targets and emerging post-2020 Global Biodiversity Framework, as well as the national indicator initiatives from the NCAVES countries. This assessment is summarised in the following reports:

- **Assessing the linkages between global indicator initiatives, SEEA Modules and the SDG Targets (2019):** Presents an assessment of the potential to derive or align key global environmental and development indicators with the SEEA.
- **Assessing the linkages between national indicator initiatives, SEEA Modules and the SDG Targets (2021):** Presents an assessment of the potential to derive or align national indicator sets of the NCAVES countries with the SEEA.

As part of the activities of the indicator workstream, a set of technical notes were produced to support the NCAVES countries to test the generation of a selected set of SDG indicators using the SEEA. The technical notes describe SEEA based approaches to calculate four of the global SDG indicators from the indicator framework developed by the Inter-Agency and Expert Group on SDG Indicators (IAEG-SDGs). The technical notes are in alignment with the methods described for calculating these global SDG indicators, as described in their associated metadata sheets.[1] The approach to implementing the technical notes and the countries experiences in testing them are summarised in the following reports:

- **Using the SEEA EA for Calculating Selected SDG Indicators (2020):** Presents a series of *Technical Notes* to support the calculation of 4 priority SDG Indicators using the SEEA EA framework.
- **Using the SEEA EA for Calculating Selected SDG Indicators – Project country testing experiences (2021):** Summarises the experiences of the NCAVES countries in evaluating and implementing these technical notes.

The indicator workstream confirms the broad potential for the SEEA to support the calculation and mainstreaming of many global indicators. The assessment of linkages with global indicators, identifies that 34 of the 147 Aichi target indicators and 21 of the 230 SDG indicators can be aligned to selected modules of the SEEA. The usefulness of the SEEA as a tool to mainstream the environment and biodiversity into national planning processes is also explicitly recognised via SDG Indicator 15.9.1 and via Aichi Target 2. The potential for the SEEA EA to support other key international environmental conventions and platforms, including the UNCCD, Ramsar and IPBES, is also identified.

The assessments of linkages to national indicators confirms the strong potential for the SEEA to support national reporting on SDGs and the general measurement of national indicators in the NCAVES countries. An important collective observation from the national assessments is that the

[1] https://unstats.un.org/sdgs/metadata/

different SEEA accounting modules can inform on a range of environmental policy objectives, themes, development perspectives and analytical objectives (including indicator gap analysis). This illustrates a key advantage in using the SEEA as an organising framework for indicator calculation, as it is a multipurpose framework with a modular approach, allowing countries to focus on both policy and analytical priorities.

The development of four technical notes provided the opportunity to test the potential of the SEEA EA for SDG indicator generation in practice. Testing the technical notes across four NCAVES countries confirmed the strong potential of the SEEA to support the calculation of SDG Indicators. Most countries were able to generate a national version of SDG 15.1.1 (Forest area as a proportion of total land area), SDG 6.6.1 (Change in the extent of water-related ecosystems over time) and SDG 11.7.1 (Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities). in practice. Calculating SDG 15.3.1 (Proportion of land that is degraded over total land area) was found to be more challenging, typically due to data constraints. However, the potential for the SEEA EA to support the generation of this indicator, in due course, was highlighted by the NCAVES countries.

An important insight from the testing is that there is often a need to tailor global SDG indicator methods to make the indicators meaningful to national circumstances. The flexible nature of the SEEA as an organising framework was highlighted by the NCAVES countries as being very useful to aid calculating these nationally tailored SDG indicators in a rigorous and consistent manner. With regular updates, these can also be matched and integrated into different national policy cycles and planning strategies for various sectors. This will be key for fostering integrated policy making that is built on understanding of the interactions, synergies and trade-offs between the environment and economy. This is fundamental to informing sustainable development that proceeds in balance with nature.

The reports highlighted above are available from the UNSD SEEA webpages at: https://seea.un.org/content/indicators-and-natural-capital-accounting.

1 Introduction

This document presents a set of technical notes describing approaches to calculate four priority Sustainable Development Goal (SDG) indicators, as described in Section 1.2. These SDG indicators were identified as priorities based on an initial report: *Assessing the linkages between global indicator initiatives, SEEA Modules and the SDG Targets*, also produced by UNEP-WCMC and UNSD as part of the NCAVES indicator work stream (see UNSD, 2019). The technical notes presented in this document concern the following global SDG Indicators:

- SDG Indicator 15.1.1 – Forest area as a proportion of total land area.
- SDG Indicator 15.3.1 - Proportion of land that is degraded over total land area.
- SDG Indicator 6.6.1 – Change in the extent of water-related ecosystems over time.
- SDG Indicator 11.7.1 – Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities.

This document is supported by a supplementary report presenting the outcomes of testing the above methodological notes with the NCAVES project countries. The assessment of global indicators is also supported with a supplementary report assessing the linkages between national indicator sets of the NCAVES projects, SEEA Modules and the SDGs.

1.1 SDGs and the SEEA

The 2030 Agenda for sustainability is a plan of action for people, the planet and prosperity. To enable countries to measure progress towards achieving the 2030 Agenda and its 17 Sustainable Development Goals (SDGs), the UN Statistical Commission has endorsed a Global Indicator Framework comprised of 232 SDG Indicators. The SDGs and their targets are founded upon addressing the three dimensions of sustainability: The environment (biosphere); society; and, the economy, as shown in Figure 1.

Figure 1: Integration of the 17 SDGs across environment (biosphere), society and economy.[2]

The SEEA Ecosystem Accounting (SEEA EA) is an integrated statistical framework for organizing data for measuring ecosystem services, tracking changes in ecosystem assets and linking this

[2] https://www.stockholmresilience.org/research/research-news/2016-06-14-how-food-connects-all-the-sdgs.html

information to economic and other human activity (UN, et al., 2014b; UN et al., 2017).[3] The ability of the SEEA EA to organise and integrate data on the environment and the economy in a consistent manner makes it an ideal framework to assist countries in reporting on a number of SDG Indicators. A recent report from UNSD (2019) has shown the potential of SEEA EA and its companion, the Central Framework, to organise information for the calculation of 17 of the 232 SDG Indicators (these are listed in Appendix A).

There are multiple advantages in using the SEEA for calculating SDG Indicators, as well as other global and national indicators. The framework is flexible, adapting to different contexts, but providing consistent definitions and concepts. As such, it allows harmonization of environmental data from multiple sources and brings coherence and consistency across disparate statistics. It also establishes a centralized system for organizing information on the environment and the economy, thereby reducing the possibilities for repetition of data collecting activities across different government agencies and can help streamline reporting across multiple national reporting commitments. It also ensures that information can be compared with confidence across time. Further, by organizing information from different agencies and sectors in a consistent manner, the SEEA opens up dialogue across these agencies and sectors and enables trade-offs and synergies related to environmental management decisions to be more readily revealed.

The SEEA EA is grounded in the set of concepts and classifications that is consistent System of National Accounts and that can be aligned with the social statistics routinely compiled by national statistical offices. As such, the SEEA EA also provides a mechanism to mainstreaming environmental information into economic and national development planning. It is compatible with the Balance of Payments and International Investment Position framework, the International Standard Industrial Classification of All Economic Activities, the Central Product Classification system, and the Framework for the Development of Environment Statistics. This also opens up pathways to implement a range of integrated economic–environmental modelling approaches (Banerjee et al., 2016).

The broad consistency that the SEEA brings to organizing environmental information is clearly essential to delivering a planning approach that considers all the social, economic and environmental dimensions to sustainable development in an integrated way. As such, it is a powerful tool for multiple line ministries, especially those concerned with sustainable national development and delivering better outcomes for the environment and society.

1.2 Aims and objectives

This document provides an overview of the steps likely to be required to implement a national programme of work for compiling SEEA EA accounts for calculating selected SDG Indicators. There are two primary audiences for this document. The first are National Statistics offices (NSOs) and other agencies involved in the production and compilation of SEEA EA accounts and calculating SDG Indicators. The second are the line ministries and other organizations who have responsibilities for delivering on a countries goals for sustainable development. These stakeholders are key to the development of SEEA EA accounts and have an essential role in their institutionalization, resourcing and articulating the needs and priorities for specific accounts and related indicators. This document is written so as to be accessible to both these audiences.

As well as providing an operation note, this document is also intended to raise awareness of the SEEA amongst policy makers' / line ministries tasked with SDG reporting and facilitate working relationships across line ministries, with the objective of developing a common programme of

[3] In March 2013, the United Nations Statistical Commission (UNSC) endorsed the System of Environmental-Economic Accounting – Experimental Ecosystem Accounting (SEEA EEA) as the basis for commencing testing and further development of this new field of national accounting. The SEEA EEA is current being revised and expected to be adopted by UNSC in 2021. As the qualifier "experimental" is likely to be dropped, we will refer to it in this document as SEEA EA. See https://seea.un.org/ecosystem-accounting

work which would be beneficial to the various institutions. It is stressed that the intention of the document is not to replace indicators calculated under existing reporting mechanisms, rather to reach an alignment between these indicators and the SEEA EA and take advantage of the possibilities for understanding trade-offs, synergies and wider environmental-economic analyses that emerge as a result.

The structure of this document is as follows. Chapter 2 provides a brief overview of SEEA EA framework. Chapter 3 describing the steps to put in place an inter-institutional collaboration among different stakeholders to implement a national programme of work for compiling SEEA EA accounts for calculating SDG Indicators. Chapters 3 to 6 provide technical guidance on compiling SEEA EA accounts for specific SDG Indicators (SDG Indicators 15.1.1; 15.3.1; 6.6.1; and 11.7.1).

2 Overview of the SEEA EA

The SEEA is a multipurpose framework for understanding the interactions between the environment and the economy, thereby extending the established System of National Account (SNA) used for the measurement of economic activity and related stocks and flows. The SEEA EA extends this framework to consider ecosystems as assets. The issues that it addresses are long-standing, relating to accounting for the degradation of ecosystems and the full suite of benefits that society obtains from ecosystems.

The SEEA EA is built on five core accounts. These accounts are compiled using spatially explicit data and information about the extent, condition and value of ecosystem assets and the flows of ecosystem services they deliver. The five ecosystem accounts are:

1. ECOSYSTEM EXTENT accounts record the total area of ecosystem assets, classified by ecosystem type, within a specified area (the ecosystem accounting area). They record the opening and closing extents of different ecosystem types over an accounting period (e.g., 1 year) in ecosystem accounting areas (e.g., nation, province, river basin, protected area, etc.), thus illustrating the changes in extent from one ecosystem type to another over the accounting period.

2. ECOSYSTEM CONDITION accounts record the condition of ecosystem assets in terms of selected characteristics over accounting periods. Over time, they record the changes to their condition and provide valuable information on the ecological integrity of ecosystems and their capacity to supply ecosystem services.

3. & 4. ECOSYSTEM SERVICES flow accounts (physical and monetary) record the supply of ecosystem services by ecosystem assets and the use of those services by economic units, including households.

5. MONETARY ECOSYSTEM ASSET accounts record information on stocks and changes in stocks (additions and reductions) of ecosystem assets in monetary terms. This includes accounting for ecosystem degradation and enhancement. These monetary values are based on the net present value of the discounted future flow of ecosystem services expected from ecosystem assets.

The SEEA EA also supports ‘thematic accounting’, which organizes data around specific policy-relevant environmental themes, such as biodiversity, climate change, oceans and urban areas. Other important thematic accounts would include accounting for protected areas, wetlands and forests.

A key aspect of ecosystem accounting is that it allows the contributions of ecosystems to society to be expressed in monetary terms so those contributions to society’s well-being can be more easily compared to other goods and services we are more familiar with. Monetary estimates can provide information for decision-makers, for example for economic policy planning, cost-benefit analysis, and for raising awareness of the relative importance of nature to society. Ecosystem service values are derived by using a range of economic valuation techniques. The relationship between the five core accounts of SEEA EA is shown in Figure 2.

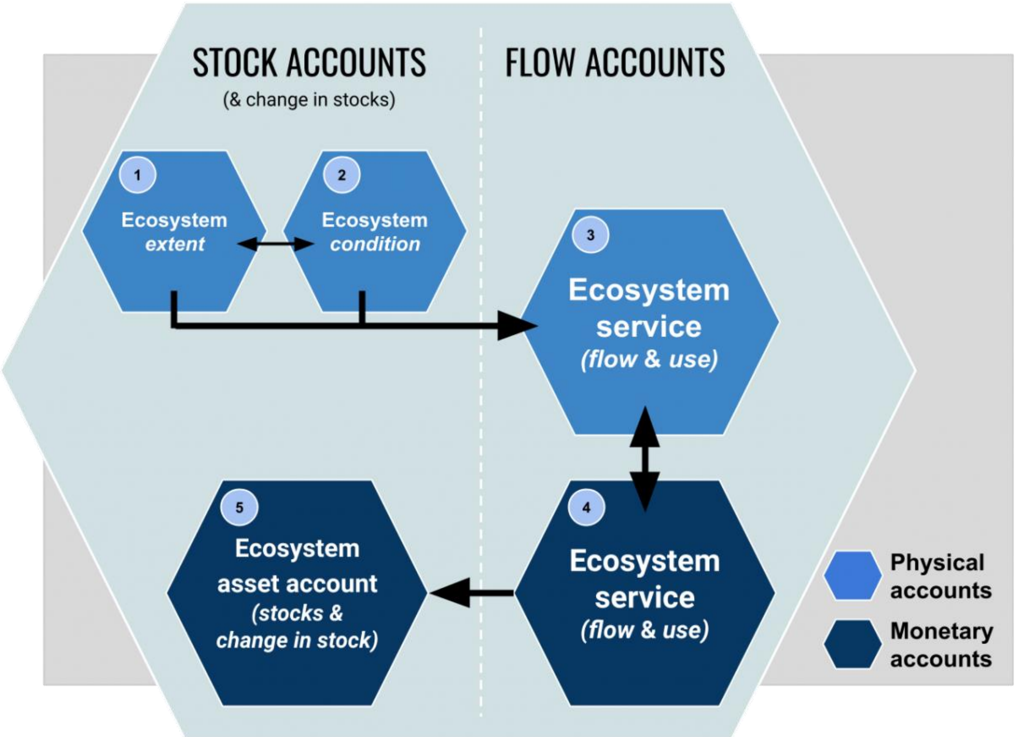

Figure 2: Core Accounting Modules of the SEEA EA

2.1 Description of the Ecosystem Extent Account

The (UNSD, 2019) assessment of linkages between global indicators and the SEEA, identified that the ecosystem extent features as a key determinant in a number of the SDG Indicators. This is because it is can provide an indicator for wider sustainable development concerns. For example, forest extent is a reasonable proxy for conservation of forest biodiversity and the delivery of forest ecosystem services.

In order to compile an ecosystem extent account, a classification of ecosystem types is required. This allows the delineation of areas within a country into a set of mutually exclusive and collectively exhaustive (MECE) spatial units that represent all the different ecosystem assets in an ecosystem accounting area (EAA) (i.e., there are no gaps or overlaps when these units are mapped out, MECE principle). These ecosystem assets are contiguous areas covered by a specific ecosystem types (e.g. forest or deciduous forest). Where an ecosystem type is defined as a distinct class of ecosystem assets, with comparable ecology and ecosystem use.

2.1.1 Using a global ecosystem typology for ecosystem extent accounting

Bogaart et al., (2019) review a series of proposed ecosystem type classifications as candidates for a globally consistent typology for ecosystem extent accounting using the SEEA EA. The preferred option that has emerged from the SEEA EA community is the use of the IUCN Red List of Ecosystems Classification (hereafter IUCN ET classification). The IUCN ET classification represents a global typological framework, which is scalable enough to support generalizations about groups of functionally similar ecosystems, yet recognizes different sub-types within these groups. The sub-types are defined by their contrasting biotic composition (Bogaart et al., 2019). The classification comprises of 4 realms of the biosphere, disaggregated to 25 biomes. These biomes are then further disaggregated to 98 functional groups (albeit 7 of these relate to subterranean ecosystems). An extract of the classification system for the two terrestrial biomes is presented as Table 1, the classification system is provided in full as an Excel file in Appendix B.

These functional groups are recommended as a global ecosystem typology (ET) to support the SEEA EA. Whilst this realizes a large number of ecosystem types, it is highlighted that only a sub set of these will be present in any given country. Creating maps delineating the extent of different ecosystem assets (by IUCN ET) for two or more periods in an ecosystem accounting area (EAA), allows an ecosystem extent account to be compiled by aggregating data on the extent of each ecosystem type within the EAA for each period. An example structure of an ecosystem extent account compiled using the IUCN Ecosystem Typology is presented as Table 6, Section 4.2.2.

Table 1: Hierarchical Structure of the IUCN to national ecosystem typology

Realm(s)	Biome	Functional group (Ecosystem type)
Terrestrial	T1 Tropical-subtropical forests	T1.1Tropical/Subtropical lowland rainforests
		T1.2 Tropical/Subtropical dry forests and scrubs
		T1.3 Tropical/Subtropical montane rainforests
		T1.4 Tropical heath forests
	T2 Temperate-boreal forests & woodlands	T2.1 Boreal and montane needle-leaved forest and woodland
		T2.2 Temperate deciduous forests and shrublands
		T2.3 Cool temperate rainforests
		T2.4 Warm temperate rainforests
		T2.5 Temperate pyric humid forests

2.1.2 Using a national ecosystem typology and map for ecosystem extent accounting

It is anticipated that countries will also require their own ecosystem typology (ET) that provides a finer and more tailored resolution of ecosystem assets in the landscape. Ideally, these ecosystem extent maps will be sufficiently detailed to indicate the uses of ecosystems.

A key initial decision in compiling an ecosystem extent account using a national ET is whether an existing ecosystem or land cover map should be used or whether a new map with new ETs should be developed. As countries will often have ecosystem or land cover maps based on an existing classification system these can be used as a starting point. If these maps already have a classification that represents ecosystems or habitats well, they may be suitable for direct use. However, where land cover accounts provide the starting point for ecosystem extent accounting, efforts should be made to move to more meaningful representations of ecosystems as soon as possible (UN et al., 2017).

Whether starting from scratch or developing existing land cover maps, any final ecosystem typology and map should be based on the integration of multiple data. For example, the map should also consider ecological characteristics, such as vegetation type, soil type and hydrology (Bogaart et al., 2019). It should also include information on land use, such as the types of crops grown, if forests are being used for logging or area strictly protected, natural shrubland versus shrubland resulting from forest clearance, etc. (UN et al., 2017).

It is also important that any national ET can be cross-walked to the IUCN ETs for international comparisons and aggregations. This highlights a third possibility for construction a national ecosystem map based on a top-down approach and further disaggregation of the IUCN ETs. It is also highlighted that any national ecosystem map or crosswalk must ensure that the MECE principle is observed. Further guidance on constructing national and regional ecosystem type classifications is provided in Bogaart et al., (2019).

3 Indicative implementation steps for SEEA EA based SDG indicators

The implementation of the SEEA EA requires strategic planning and the establishment of appropriate institutional mechanisms and arrangements for the ongoing compilation of accounts for different uses. These uses may include the calculation of SDG Indicators, as well as the mainstreaming SDG relevant data into economic planning to help achieve the SDGs. Ultimately, the implementation should aim to define a coordinated, long term, national programme of work involving a range of uses and users of the accounts and a number of different source data agencies. The national statistical office (NSO) has the fundamental role in coordinating this process and quality assuring the accounts and any indicators calculated from them.

The intention of this chapter is to provide a useful introductory overview to NSOs and other agencies of the various steps that should be considered in implementation of the SEEA EA for compiling SDG Indicators, as well as links to relevant material and guidance. These steps should be considered in the context of the other, multiple, uses for planning the implementation of the SEEA EA. The four indicative steps set out for this process are presented in Figure 3. These steps draw on the UNSD (2014) SEEA Implementation Guide, which should also be consulted by NSOs embarking on a programme of implementing the SEEA.

As shown in Figure 3, a fundamental role for the NSO across all steps is that of quality assurance. For instance, with respect to input data, data providers, accounts compilation, indicator calculation and validation. This quality assurance role is a key advantage of involving the NSO in the SDG indicator process. UN DESA (2019) provides quality assurance guidelines for official statistics, produced partly in response to the data challenges of achieving the 2030 Agenda for Sustainable Development. NSOs will also have their own national quality assurance frameworks.

As Figure 3 also shows, stakeholder engagement and capacity building (in both the use and production of the accounts) are also key features across all steps of the implementation process. It is essential to maintain communication with these stakeholders throughout the process to ensure the compilation of SEEA EA Accounts that are relevant, credible and legitimate.

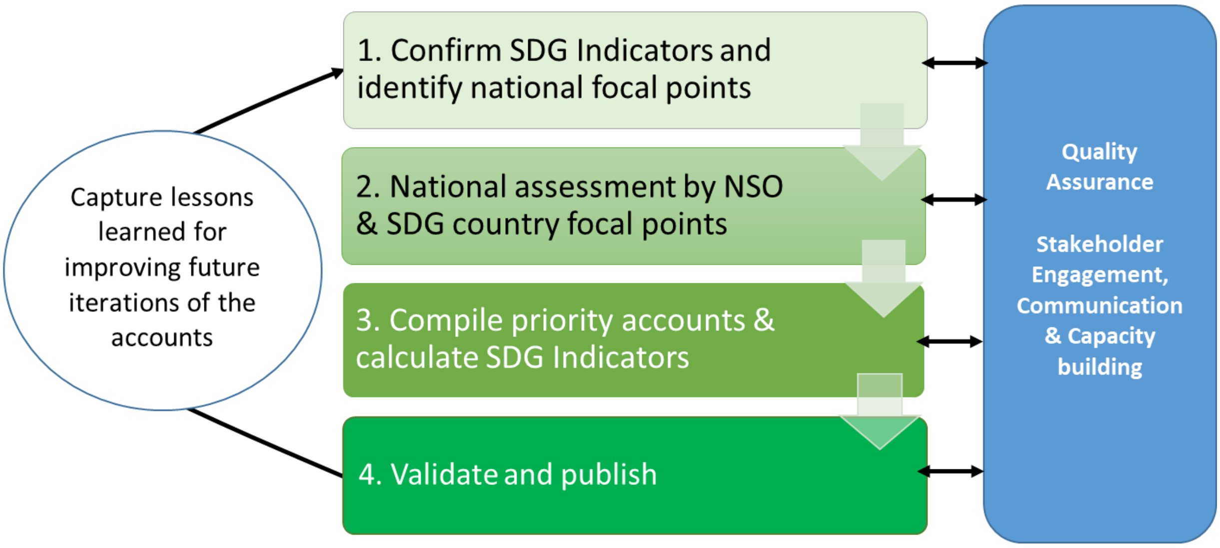

Figure 3: Four indicative steps for compiling SEEA EA Accounts for calculating selected SDG Indicators

3.1 Step 1: Confirm SDG Indicators and identify national focal points

SEEA EA accounts are a policy support tool which helps communicate a particular form of evidence to assist decision makers evaluating land-use, ecosystem restoration and other development options, progress to policy targets and in policy formulation. With respect to assessing progress towards the sustainable development goals, there are 17 global SDG target indicators presented in Appendix A that have been assessed as possibilities for calculation using the SEEA. In addition, there are likely to be additional national indicators that can be considered as part of the process of implementing the SEEA EA. This may include a number of nationally tailored SDG indicators, which are better suited to reporting on particular national circumstances.

National focal points for SDGs and their target indicators must be identified and engaged in this selection process. The UN Statistics Division (UNSD) maintains a set of excel files with data collection information and focal points, which will help to identify national focal points for specific SDG Indicators if necessary.[4] UNSD also maintains a dissemination platform for data compiled through the UN System for reporting on progress towards the SDGs, which provides results for the SDG Indicators [5] and an associated country profile platform that summarises results and trends in SDG Indicators.[6]

The final selection of specific SDG Indicators should not be undertaken purely by NSO. This should respond to a clear demand from stakeholders and, particularly, future users of the accounts (e.g., with respect to economic mainstreaming of SDG data) and the SDG Indicators they will yield. This may be established in national planning documents and countries Voluntary National Reviews (where available) will also provide an important insight into national priorities for SDG Indicators.[7] Engagement with potential user groups is also essential in order to obtain a clear mandate and support to proceed with compilation of SEEA EA Accounts for national SDG reporting.

3.2 Step 2: National assessment by NSO and SDG country focal points

3.2.1 Initial assessment of stakeholders

Working with the national focal points, the NSOs should identify:

- The mechanism currently established to monitor the selected SDG targets[8]
- How these indicators are currently reported on?

This will allow for identification and initial assessment of the stakeholders involved in the current SDG reporting process, including key data holders for each SDG Indicator. However, the NSO and national focal point team should look beyond these current stakeholders and identify the full set of potential stakeholders that may be interested in, or need to use, the information the SEEA EA accounts provide (e.g., across sectors) and / or may have wider environmental-economic data that would be useful to integrate within any data foundation for calculating SDG Indicators. This

[4] Available at: https://unstats.un.org/sdgs/dataContacts/
[5] Available at: https://unstats.un.org/sdgs/indicators/database/
[6] Available at: https://country-profiles.unstatshub.org/
[7] A Voluntary National Review Database is maintained by the UN Statistics Division: https://sustainabledevelopment.un.org/vnrs/
[8] Meta datasheets for SDG Indicators are provided by UNSD: https://unstats.un.org/sdgs/metadata/ As well as the Voluntary National Review Database: https://sustainabledevelopment.un.org/vnrs/

will be very relevant to those interested in using information from the SEEA EA for planning sustainable development. This initial stakeholder assessment should identify:

- Which are the agencies responsible for calculating the indicators?
- Which are the important agencies compiling data that feed into the indicator calculations?
- What is the policy framework for the selected SDG indicators?
- Who are the potential users of the accounts and SDG indicators calculated from them for development planning, policy making and other uses?

Understanding who are the data holders and accounts producers is fundamental to establishing the institutional arrangements for data coordination and the compilation of accounts going forward. Understanding the multiple policy entry points for the SEEA EA Accounts and any calculated indicators is also essential for identifying all the potential users that can help steer the accounts compilation process and create a long term user base that will build the demand to institutionalise the accounts production. Appendix D provides example descriptions of policy frameworks for 4 SDG Indicators described below, which will help guide readers of this document in this type of process.

Table 2 provides a structure to assess each stakeholder. This provides an example structure based on the four SDG Indicators for which technical notes are presented in this document. Specifically: SDG Indicator 15.1.1 – Forest area as a proportion of total land area; SDG Indicator 15.3.1 - Proportion of land that is degraded over total land area; SDG Indicator 6.6.1 – Change in the extent of water-related ecosystems over time; and, SDG Indicator 11.7.1 – Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities.

In Table 2, stakeholder categories and the specific stakeholder in each category should be arranged in the rows. For each SDG Indicator, each stakeholder should be specified as:

- Producer: These are the stakeholders that supply the data required to compile the accounts, or contribute to the accounts compilation process, for the calculation of the SDG Indicators.

- User: These stakeholders are those that will potentially use the accounts and the SDG Indicators from the accounts in decision-making processes (a stakeholder may be both user and producer).

Table 2 is presented as a minimal initial stakeholder assessment. The actual stakeholders will be country-specific and this list should be adapted to the national situation. Further details on how to structure a stakeholder assessment for implementation of the SEEA are provided in Section IV and Annex III of the UNSD (2014) SEEA Implementation Guide. For instance, it may also be useful to add a further column on “Statistical Capacity” for each stakeholder to produce relevant data / statistics to support the account compilation or to be able to use the accounts in their decision-making processes, once they have been compiled.

Table 2: Initial assessment of stakeholders (adapted from Table 4.1, UNSD, 2014)

Stakeholder category		Accounts for Calculating:							
		SDG 6.6.1:		SDG 11.7.1		SDG 15.1.1		SDG 15.3.1	
	1	2	3	4	5	6	7	8	9
	Stakeholder	Producer	User	Producer	User	Producer	User	Producer	User
Central government agencies	National Statistics Office								
	Central Bank								
	Ministry of Finance								
Human, industry and economic government agencies	Culture								
Environment and natural resource government agencies	Environment								
	Water								
	Energy								
Universities (specify institute or centre)	University centre 1								
	University centre 2								
NGOs and private industry associations	Industry associations								
	National environmental								
	NGOs								
	International NGO								

3.2.2 Initial assessment of data sources

Working with the national focal points, the NSOs should now identify the existing data foundation for each selected SDG Indicator and additional data that could support compiling SEEA EA Accounts for calculating the SDG Indicator. This should include an initial assessment of:

- National data sources currently available to support the compilation of the SEEA EA Accounts for calculating the SDG Indicator.
- Global data sources and platforms available to support the compilation of the SEEA EA Accounts for calculating the SDG Indicator that can address national data gaps.

The ideal is to use nationally validated data for the production of SEEA EA Accounts. Where this is unavailable, global data sources can be evaluated for use, including any bespoke platforms for calculating the SDG Indicator that are available. There is a key role for the NSO in ensuring both national and global data is fit for purpose in producing SEEA EA Accounts. The assessment of national and global data should not only focus on the data sources and platforms that are currently being used for SDG reporting but additional sources that have the potential to support the compilation of the accounts.

Table 3 provides a structure to capture the initial assessment of data sources. Table 3 is separated into global and national data sections, with national data further organized under different data themes (i.e., environmental, economic and other). Table 3 should be completed for each individual selected SDG Indicator.

It is highlighted the initial assessment of data sources aims to provide an insight into the data that are available compiling SEEA EA Accounts for calculating SDGs. In due course it will be necessary to undertake a more detailed assessment, in line with relevant quality assurance frameworks. Further details on how to structure the initial assessment of data sources are provided in Section IV and Annex III of UNSD (2014) SEEA Implementation Guide.

Table 3: Initial assessment of data sources (adapted from Table 4.4, UNSD, 2014)

Data source	Status	Responsible Organisation	Data Sharing (Accessibility)	Time series	Statistical standards / Quality assurance
Global data sources (generally physical data - often remotely sensed)					
Earth Observations of Vegetation indexes		NASA			
National environmental data (generally physical data)					
Land and geospatial statistics		Ministry of Environment			
Agricultural production		Ministry of Agriculture			
Soil quality data		University centre 1			
Urban green space areas		Municipal governments			
Species distributions		National NGO			
National economic data (generally monetary data)					
National accounts		NSO			
Household surveys		NSO			
Other data					
Population and census data		NSO			

The first column in Table 3 captures the name of the data source. Status, for column 2, refers to the general existence of the data sources. This provides a rating on whether the data source is: complete and comprehensive (rating of 1); incomplete or partial (2); or, too incomplete to use for accounting (3).

National data sources should be aligned to all stakeholders identified as ‘Producers’ in Table 2 in column 3 of Table 3. The fourth column in Table 3 is intended to establish if data sharing arrangements are in place with the NSO. This is key information as creating linkages between the data sources and the agencies that own and manage relevant data is fundamental in developing the required networks for the co-ordination of data provision and regular compilation of the accounts. For defining the situation on data sharing, it is recommended the following categories are used (based on UNSD, 2014):

- "Open Access": Data is open access and available to use. It is recommended that any web link or reference is also provided.
- "Agreed": If data sharing arrangements are in place with the NSO
- "None": If data sharing agreements need to be developed, e.g., establishing a memorandum of understanding with service level agreements.

The fifth column in Table 3 specifies the time series characteristics of the data. The final column in Table 3 refers to the statistical standards to which the data source adheres. In line with the NSO's quality assurance role, this column can be disaggregated to capture additional metadata on other quality assurance dimensions. This may include methods of collection, relevance to the SDG Indicator, timeliness and interpretability. UN DESA (2019) provides additional insight into what metadata may be relevant in these regards. It may also be useful to assess 'Data security and IT', which covers the arrangements in place to ensure the integrity, availability and authenticity of the data within the data holder organisation.

3.2.3 Identify priority accounts and their status

The SEEA EA is conceived as an integrated, internally consistent series of accounts that can be implemented in a modular way. It is recommended that only a limited number of accounts or modules be considered in early phases of implementation. Further accounting modules can then be compiled in response to user needs and as capacity is built across data suppliers, accounts producers and accounts users as resources become available.

With the above in mind, the NSO, with national focal points, should identify the priority SEEA accounts for calculating the selected SDG Indicators and establish their current status. For most countries it is anticipated that ecosystem extent accounts will be a priority account, given the relevance of extent measures to a number of SDG Indicators. The initial assessment of data sources will also help to establish the feasibility of compiling these accounts using national (or global) data sources.

Table 4 provides a structure to capture the prioritization of accounts and assessment of their status. The first column identifies the relevant SEEA EA Account (SEEA Central Framework Accounts are also included for illustration). The second column captures information on the accounts current status. For defining status, it is recommended the following categories are used (based on UNSD, 2014):

- "Ongoing": Accounts have been produced and published.
- "Developmental": In the development stage and completion and publication is planned
- "Prototype": The account has been attempted but is incomplete or development has stopped.
- "Discontinued": This indicates the account has been produced in the past but is no longer.
- "Non-existent": The account has never been attempted.

The remaining columns in Table 4 identify the priority of each account to the selected SDG Indicator. The global assessment of linkages between global indicators and the SEEA presented in (UNSD, 2019), can assist in identifying relevant accounts for the different SDG Indicators identified in Appendix A. Following UNSD (2014), the following ranking can be used:

- "2": The account is essential to calculating the SDG Indicator as set out in the minimum requirements of its accompanying official metadata sheet.[9]
- "1": The account provides additional information to support more progressive reporting on the SDG Indicator.
- "0": The account is not relevant to the calculation of the SDG Indicator.

It is highlighted the above ranking can be adapted to best suit different purposes. For example, additional rankings may be added (or substituted) for identifying which indicators can also be derived independently of the accounts or which can be incorporated into the accounts.

Table 4 is intended as a minimum information set to identify the priority accounts for compilation. Additional columns can be added for the other SDG Indicators in Appendix A, nationally tailored SDG Indicators and the wider set of national indicators where the SEEA can contribute to their calculation and monitoring. It is also highlighted that Table 4 should not be used as the sole basis for determining which SEEA EA Accounts to produce. There are multiple, other important uses for the accounts that should inform the SEEA EA implementation process.

Table 4: Inventory of SEEA Accounts and their priority for selected SDG Indicators

SEEA Account	**Column**				
	1	**2**	**3**	**4**	**5**
	Status	**SDG 6.6.1**	**SDG 11.7.1**	**SDG 15.1.1**	**SDG 15.3.1**
Ecosystem Extent	Non-existent	2	2	2	2
Ecosystem Condition	Non-existent	1	1	0	2
Ecosystem Services (PSUT)	Non-existent	0	0	0	0
Ecosystem Services (MSUT)	Non-existent	0	0	0	0
Thematic Biodiversity	Non-existent	0	0	0	0
Thematic Carbon	Non-existent	0	0	0	1
Thematic Urban	Non-existent	0	2	0	0
SEEA Central Framework - Land	Non-existent	0	0	0	1
SEEA Central Framework - Water	Non-existent	1	0	0	0
SEEA Central Framework - Other	Non-existent	0	0	0	0
Carbon	Non-existent	0	0	0	1

PSUT = Physical Supply and Use Table; MSUT = Monetary Supply and Use Table

3.3 Step 3: Compile Priority Accounts and Calculate SDG Indicators

Step 2 was aimed at establishing policy entry points, potential users and evaluating the data foundation for the compilation of the priority accounts for the selected SDG Indicators. In Step 3, this information is used in the implementation process for compiling the accounts and engaging future users of the accounts in this process. Engaging future users is key for ensuring the

[9] https://unstats.un.org/sdgs/metadata/

accounts and indicators are legitimate and relevant to the decisions users face, fostering ownership amongst potential users and stimulating demand (Vardon et al., 2016).

The first sub-step in the compilation of the priority accounts is to establish an implementation team and build mechanisms for the accounts compilation process. The initial assessment of stakeholders (Table 2) and data sources (Table 3) will identify the 'Producer' stakeholders that are essential for compiling the first set of accounts. The key users of the accounts should also be identified in the initial assessment of stakeholders (Table 2) so they can be engaged in the implementation process. This collective group of stakeholders should be brought together to agree a specific implementation plan. This may be in a workshop setting, or similar, and should achieve the following outcomes.

- Reach agreement on whether an international definition or an adapted national definition of the indicator will be used to guide the compilation of the accounts
- Define the role of the NSO in the compilation of the priority accounts and calculation of selected SDG Indicators. A fundamental part of this is ensuring quality assurance in accordance with the requirements for official national statistics, to the degree possible. In addition, it may include actual compilation of the accounts, specification of requirements of data suppliers or other accounts producers, calculation and reconciliation of indicator values, etc.
- Define and assign roles and responsibilities and establish data sharing arrangements where necessary with other stakeholders for the implementation process.
- Establish a technical working or steering group should be formed to oversee the implementation process (including the production of technical notes for compiling priority SEEA EA accounts).
- Agree timelines, milestones and resourcing arrangements for the compilation process.

As part of the implementation process, the NSO should lead on writing a series of technical notes based on Technical Recommendations in support of the SEEA 2012 Experimental Ecosystem Accounting (SEEA EEA Technical Recommendations) (UN et al., 2017) and assessments in Step 2 for compiling priority SEEA EA accounts and calculating selected SDG indicators. UNSD (2014), Annex IV, provides an indicative structure for these types of notes. Sections 4 to 7 in this document provides a set of example technical notes pertaining to SDG 15.1.1; 15.3.1; 6.6.1; and, 11.7.1. It is highlighted that a collaborative and iterative design process will be required to developing these notes and the accounting approach, both in terms of organizing input data but also presenting it in a way that is easy to use. This may also require revisiting some of the roles and responsibilities previously assigned. Establishing the technical working or steering group will help streamline interactions between the producer and user stakeholder groups during this process.

Once the technical notes and roles and responsibilities across the implementation team are confirmed, the accounting approach should be implemented and the accounts compiled and the selected SDG Indicators calculated. At this stage it may be necessary to clearly explain and document any differences to SDG Indicator values generated via the existing report processes. This should be supported by bridging tables that reconcile these differences in clear, quantified terms (see Table 8,

Table 18 and Table 21 for examples). A final action in this step is to update the technical notes to reflect the final compilation approach implemented.

3.4 Step 4: Validate and publish

Once the accounts have been compiled and the selected SDG Indicators calculated, they should be validated with the stakeholders identified in Step 2 and engaged in Step 3. The validation process should also establish next steps for future iterations of the accounts, both for improvement and to stimulate wider use. Consideration could be given to holding a validation workshop for Step 4. The key outcomes from the validation process should include:

- Validating the accounts in accordance with the national quality assurance framework, identifying if appropriate validation was possible, identifying any corrections that need to be made to the accounts and the associated technical notes.
- Capturing lessons learned and best practices for accounts production, for example lessons learned on:
    - Sourcing and collating data.
    - Formatting and organising data.
    - Analysing and presenting data.
- Identifying how to communicate and promote the accounts so they will be more widely used in policy and land management decision-making processes. This includes developing communication materials for different target audiences. These may include:
    - Policy briefs for key messages / statistics
    - Maps identifying ecosystem loss and degradation
    - Combined presentations of information on ecosystem services and socio-economic statistics. For example, linking ecosystem degradation statistics with vulnerable populations to prioritise restoration action.
- Establishing the longer-term strengthening of the institutional arrangements to make compilation of the accounts an ongoing process.
- Identifying useful extensions to the current accounts and opportunities to implement any additional accounts or supporting environmental-economic analyses that respond to identified user needs.
- Identifying and committing to a set of concrete next steps on how the accounts will be improved in future iterations.

The validation process should be documented in a short report to inform future iterations of the accounts (this report should be ready within 3 months of initial compilation of the accounts). An important part of this is capturing the type of lessons learned identified above and committing to the next steps for future iterations of the accounts. A template validation report structure for is provided in Appendix C in table form. Finally, technical notes should be updated as necessary for next iteration of the accounts based on the outcomes of the validation process.

3.5 Methodological notes for different indicators

The next sections of this document present a series of Technical Notes to support the calculation of 4 priority SDG Indicators identified as ‘Full Possibilities’ for alignment with the SEEA (see UNSD, 2019). These four SDG Indicators were selected as priorities for alignment with the SEEA because they speak to multiple reporting commitments. These priority SDG Indicators comprise:

- SDG Indicator 15.1.1 – Forest area as a proportion of total land area.
- SDG Indicator 15.3.1 - Proportion of land that is degraded over total land area.
- SDG Indicator 6.6.1 – Change in the extent of water-related ecosystems over time.
- SDG Indicator 11.7.1 – Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities.

The technical notes presented provide an overview of how to compile a set of environmental-economic accounts relevant to these four global SDG Indicators is in accordance with the SEEA EA framework The notes are intended to provide suitable accounting structures to organize information, and a broad overview of associated measurement approaches and data sources to compile the accounts. This can contribute regular information to support the calculation and reporting of each indicator and support the integration of information on each indicator into economic and land use planning processes. These notes should be read in conjunction with the key references cited for detailed information and guidance where necessary. They are intended to be read as standalone documents, as such there is some very minor repetition across the four notes.

4 Extent of forest ecosystems – SDG 15.1.1

This technical note pertains to SDG Target 15.1: *By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements*. Specifically, it describes the role of the SEEA in supporting the calculation of SDG Indicator 15.1.1: Forest area as a proportion of total land area. SDG 15.1.1 is a Tier I SDG indicator, meaning it is conceptually clear, has an established methodology and standards are available, and data are regularly produced by countries for at least 50 per cent of countries and of the population in every region where the indicator is relevant.

By organising information on forests in a way that is consistent with other environmental and economic concerns, the SEEA EA presents information in a way that can speak to the multiple policy objectives and their targets for forests. The consistency of the SEEA with economic statistics can also aid in mainstreaming information on forests into a wide range of sectoral and macroeconomic policies and economic development planning.

The importance of appropriate validation and quality assurance by national statistics offices of the accounting outputs discussed in this note, and the input data required for the changes they track, is highlighted and stressed. A summary of the Policy Framework for SDG 15.1.1. and associated entry-points is provided in Appendix D. Understanding this framing can help foster constructive dialogue across government agencies sectors and inform an integrated, cross sectoral approach to forest management as synergies and trade-offs are revealed.

4.1 Concepts and definitions

There are a number of concepts and definitions used in the analysis of forests. Indeed, the definitions of forests employed by countries and agencies vary considerably. This note adopts the definitions proposed by the Food and Agriculture Organization of the United Nations (FAO) with respect to these and associated concepts. These definitions are taken directly from the SDG 15.1.1 Metadata Sheet (UNSD, 2018b), for which the FAO is custodian. This section sets out these particular concepts and definitions for the avoidance of doubt.

SDG Indicator 15.1.1: Forest area as a proportion of total land area

Total land area: The total surface area of a country less the area covered by inland waters, like major rivers and lakes (UNSD, 2018b). For clarity sea and marine and coastal and inter-tidal areas are also excluded from total land area in this technical note.

Forest: The definition of forests follows that outlined by the FAO (UNSD, 2018b), where forest is defined as land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use. A more detailed description includes the following:

- Forest is determined both by the presence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5 meters.
- It includes areas with young trees that have not yet reached but which are expected to reach a canopy cover of at least 10 percent and tree height of 5 meters or more. It also includes areas that are temporarily unstocked due to clear-cutting as part of a forest management practice or natural disasters, and which are expected to be regenerated within 5 years. Local conditions may, in exceptional cases, justify that a longer time frame is used.

- It includes forest roads, firebreaks and other small open areas; forest in national parks, nature reserves and other protected areas such as those of specific environmental, scientific, historical, cultural or spiritual interest.
- It includes windbreaks, shelterbelts and corridors of trees with an area of more than 0.5 hectares and width of more than 20 meters.
- It includes abandoned shifting cultivation land with a regeneration of trees that have, or are expected to reach, a canopy cover of at least 10 percent and tree height of at least 5 meters.
- It includes areas with mangroves in tidal zones, regardless whether this area is classified as land area or not.
- It includes rubberwood, cork oak and Christmas tree plantations.
- It includes areas with bamboo and palms provided that land use, height and canopy cover criteria are met.
- It excludes tree stands in agricultural production systems, such as fruit tree plantations, oil palm plantations, olive orchards and agroforestry systems when crops are grown under tree cover. Note: Some agroforestry systems such as the "Taungya" system where crops are grown only during the first years of the forest rotation should be classified as forest.

As highlighted above, the FAO definition of forest used for reporting on SDG Indicator 15.1.1 is very detailed. This creates challenges for achieving a specific representation of forest extent using generalized ecosystem type classes in an accounting framework. This is discussed further in this note.

Nonetheless, with suitable information on the extent of forest ecosystems, the SDG 15.1.1 indicator (Forest area as a proportion of total land area) can be readily calculated using equation 1 below:

$$SDG\ 15.1.1 = \left(\frac{Forest\ Area\ (reference\ year)}{Total\ Land\ Area}\right) \times 100\ (eq.1)$$

4.2 SEEA EA Accounts for Forest Extent.

This section sets out an approach to compile SEEA EA Accounts for forest extent that can support the generation of SDG 15.1.1 and can be used to integrate information on forest extent into wider economic planning processes.

4.2.1 Relevant accounts and classifications

Ecosystem accounting requires the delineation of areas within a country into mutually exclusive collectively exhaustive (MECE) spatial units that represent ecosystem assets. This requires an ecosystem typology that suitably represents all ecosystems in an ecosystem accounting area (EAA) and spatially explicit information on extent of all these ecosystem types, including forests. As highlighted in Figure 2, this information on ecosystem extent is then organized by the ecosystem extent account and compiling this is usually the first step in an ecosystem accounting process. Given the focus of SDG Indicator 15.1.1 on forest extent, the ecosystem extent account is the priority account for calculating this indicator.

4.2.2 Compiling an ecosystem extent account using a global ecosystem typology

A detailed description of the Ecosystem Extent Account and the IUCN global ecosystem typology is provided in Section 2.1. Table 6 shows an ecosystem extent account for an ecosystem accounting area containing 15 of these global IUCN ecosystem types (IUCN ETs). The structure of the rows in Table 6 corresponds to the basic logic of asset accounts, as further described in the SEEA EEA Technical Recommendations. It has rows describing the opening extent (in hectares, ha), closing extent, net change, additions and reductions.

The additions and reductions rows in Table 6 capture the gross changes in extent over an accounting period. For example, with Temperate deciduous forests and shrublands (T2.2) extent, this may be due to afforestation and natural expansion or deforestation and natural regression. The SEEA definitions of afforestation and deforestation include both anthropogenic managed (e.g., increasing the extent of plantations (T7.3)) and natural causes. In order to calculate SDG 15.1.1, the extent of ecosystem types aligned to the FAO definition of forests should be calculated for a year and divided by total land area. This is discussed further in Section 4.3.

4.2.3 Compiling an ecosystem extent account using a national ecosystem typology

The ecosystem extent account presented in Table 6 using the IUCN ETs is intended to provide a presentation of ecosystem extent that can be aggregated across countries to inform regional and global trends and consistent comparisons across countries. As described in Section 2.1, it is anticipated that countries will also require their own ecosystem typology that provides a finer and more tailored representation of ecosystem assets in the landscape.

A key decision when designing ecosystem extent accounts will be the level of disaggregation of ecosystem types necessary to meet the needs of users of the accounts. With respect to organising information for reporting on SDG 15.1.1, this typology will need to overcome any issues where forest extent (as defined under SDG 15.1.1) becomes conflated with other ecosystem types (notably within the IUCN ETs). This is discussed further in Section 4.3. Given such resolutions may not be possible in all cases, Section 4.4 provides a presentation on how the information on Forest Extent in the Ecosystem Extent Account can be aligned with that reported under SDG 15.1.1 and any discrepancies quantified and made explicit.

It is also important that the national typology can be cross-walked to the IUCN ETs for consistent international comparisons and aggregations. This crosswalk should be documented, for example using the type of structure presented in Table 5 (presented for the IUCN T1 Tropical-subtropical forests biome only, IUCN ETs for all other forest biomes are presented in Table 7).

Table 5: Crosswalk from IUCN to national ecosystem typology

IUCN Biome	IUCN ET	National Ecosystem Typology
T1 Tropical-subtropical forests	T1.1 Tropical/Subtropical lowland rainforests	*List all relevant types……*
	T1.2 Tropical/Subtropical dry forests and scrubs	*List all relevant types……*
	T1.3 Tropical/Subtropical montane rainforests	*List all relevant types……*
	T1.4 Tropical heath forests	*List all relevant types……*

Table 6: Ecosystem Extent Account using global IUCN ETs

	Ecosystem type (IUCN ET)																		
	T2.2 Temperate deciduous forests and shrublands^	T4.4 Temperate wooded savannas^	T4.5 Temperate grasslands	T6.4 Temperate alpine meadows and shrublands	T7.1 Croplands	T7.2 Sown pastures and old fields	T7.3 Plantations*	T7.4 Urban and infrastructure lands	FT1.2 Seasonal floodplain marshes	FT1.5 Boreal, temperate and montane peat bogs	TOTAL LAND AREA	F1.1 Permanent upland streams	F1.2 Permanent lowland rivers	F2.2 Large permanent freshwater lakes	F2.3 Small permanent freshwater lakes	F4.1 Large reservoirs	TOTAL AREA
Opening Stock (ha)																	
Additions to stock																	
Managed expansion																	
Natural Expansion																	
Upward reappraisals																	
Other additions																	
Total additions to stock																	
Reductions in stock																	
Managed regression																	
Natural Regression																	
Downward reappraisals																	
Other reductions																	
Total reductions in stock																	
Net change in stock																	
Closing stock (ha)																	

* Green Indicates ecosystem types relevant to forest area of SDG indicator 15.1.1.

^ Orange indicated the type may conflate forests with other vegetation types that do not contribute to SDG 15.1.1

4.3 Calculating SDG 15.1.1 from the Ecosystem Extent Account

In order to calculate SDG 15.1.1, information on both forest extent and total land area are used in the following equation:

$$SDG\ 15.1.1 = \left(\frac{Forest\ Area\ (reference\ year)}{Total\ Land\ Area}\right) \times 100 \quad (eq. 1)$$

4.3.1 Forest extent

In order to calculate SDG 15.1.1 using an ecosystem extent account it is necessary to identify the ecosystem types that are consistent with the FAO definition of forests. As an example, Table 7 presents the IUCN ETs that specifically reference forest or plantations in an Ecosystem Extent Account structure. Inspection reveals that a number of forest ecosystem types are distinct by the geographical location (e.g., tropical-subtropical forest versus temperate-boreal forest and woodland biomes). In Table 6 the ecosystem types that contribute to SDG Indicator 15.1.1 (e.g., T7.3 Plantations), area identified with an asterisk “*” and in green.

For a number of the ecosystem types in Table 7, the finer resolution of a national typology will be required as forest become conflated with other vegetation types. For instance, T2.2 includes both temperate deciduous forests and shrublands. Where shrubland predominates in an area, that area may not satisfy the definition of a forest area. A particular case for SDG 15.1.1 is for mangroves, which will similarly be included in MFT1.2 Intertidal forests and shrublands. T4.4 Temperate wooded savannas is a further case, where the national typology will need to be able to distinguish areas where the canopy cover exceeds 10% and meets the FAO thresholds for forest. In Table 6 these ecosystem types where forest area may be conflated with other vegetation cover (i.e., T2.2 Temperate deciduous forests and shrublands and T4.4 Temperate wooded savannas) are identified with a caret “^” and in orange.

Once the relevant ecosystem types for forest have been identified within the ecosystem extent account, the total forest extent can be readily calculated for the opening or closing year of the account. It is highlighted that the relationship between different IUCN ETs and the SDG 15.1.1 definition of forests has not been validated and any final decision on ecosystem types contributing to forest extent must be arrived at via an appropriate and authoritative national consensus.

4.3.2 Total land area

Under the SEEA EA, the structure of the ecosystem extent account organises information on the extent of all different ecosystem types within an ecosystem accounting area. This information is aggregated across columns, with the final column presenting the aggregated measure that should match the total extent of the ecosystem accounting area. Where this is national, it will include all water bodies and the extent of a countries maritime area (i.e., it exclusive economic zone).

Under SDG 15.1.1, ‘Total land area’ is different from the total area described above. It excludes the ecosystem types associated with inland water bodies, coastal water and sea and marine areas. It is highlighted that the metadata sheet for SDG indicator 15.1.1 (UNSD, 2018b), is unclear whether inter-tidal areas are excluded from the total land area. This note assumes that intertidal areas are excluded from total land area calculations. Here it is important to identify a somewhat contradictory approach in calculating SDG 15.1.1, specifically that forest area includes mangroves (and other forests) in inter tidal zones, regardless whether this area is classified as land area or not (UNSD, 2018b).

Table 7: Ecosystem Extent Account structure showing all IUCN ETs for Forests and Plantation

	Ecosystem type (IUCN ET)														
	T1.1Tropical/Subtropical lowland rainforests*	T1.2 Tropical/Subtropical dry forests and scrubs*	T1.3 Tropical/Subtropical montane rainforests*	T1.4 Tropical heath forests*	T2.1 Boreal and montane needle-leaved forest and woodland*	T2.2 Temperate deciduous forests and shrublands*	T2.3 Cool temperate rainforests*	T2.4 Warm temperate rainforests*	T2.5 Temperate pyric humid forests*	T2.6 Temperate pyric sclerophyll forests and woodlands*	T7.3 Plantations*	FT1.1 Tropical flooded forests and peat forests*	FT1.3 Subtropical/temperate forested wetlands*	MFT1.2 Intertidal forests and shrublands*	TOTAL FOREST AREA*
Opening Stock (ha)															
Additions to stock															
Managed expansion															
Natural Expansion															
Upward reappraisals															
Other additions															
Total additions to stock															
Reductions in stock															
Managed regression															
Natural Regression															
Downward reappraisals															
Other reductions															
Total reductions in stock															
Net change in stock															
Closing stock (ha)															

* Green Indicates ecosystem types relevant to forest area of SDG indicator 15.1.1.

In Table 6 an additional column has been added, where the ecosystem types to the left are considered to contribute to 'total land area', whereas those to the right are excluded. This allows for total land area to be readily presented for the opening or closing year of the ecosystem extent account.

Once the information on forest extent and land area are determined for the opening and closing period of the accounts, SDG 15.1.1 can readily be calculated for each period using equation 1. However, it is highlighted that calculating equation 1 using the information compiled in the ecosystem extent accounts may only provide a first approximation for SDG indicator 15.1.1.

4.4 Aligning the SEEA and SDG 15.1.1

The concept of forest extent is consistent across SDG 15.1.1 and the SEEA EA Ecosystem Extent Accounts. However, there is likely to be some difference between the definition of forest under SDG 15.1.1 and the ecosystem type classifications considered indicative of forest in the ecosystem extent account. This is the case where the IUCN ETs are employed.

Where there are known systematic overestimates and underestimates of forest areas within different ecosystem types these can be addressed using a bridging table and a revised calculation for SDG 15.1.1 achieved. This may be necessary when a higher resolution national ecosystem typology is unable to resolve some of the conflation issues discussed above. These bridging tables will be important tools for resolving confusion where differences in indicates from the SEEA EA and other SDG Indicator reporting processes, including in the context of international comparisons.

Bridging tables show the relationship between measures of data in environmental accounts and measures under different reporting mechanisms. Table 8 provides an example bridging table between the extent of forest in Ecosystem Extent Accounts (see Table 6) and the extent of forest that would be reported under SDG 15.1.1. The example presented assumes all areas that meet the FAO definition of forest were known. The example is based on the assumption that the ecosystem types: T7.3 Plantations and T2.2 Temperate deciduous forests and shrublands are assumed to be forest by the national compilers of the ecosystem extent account and T4.4 Temperate wooded savannas are considered not to be forest, in a general sense.

However, as shown in the Table 8 example, whilst the majority of the extent of T2.2 Temperate deciduous forests and shrublands may meet the FAO definition of forests, there may be areas of shrubland that do not (e.g., canopy cover < 10%). These areas will need to be omitted from the extent of forest reported under SDG 15.1.1. Conversely, whilst a majority of the extent of T4.4 Temperate wooded savannas may not meet the FAO definition of forests, there may be patches of denser woodland that do (e.g., canopy cover > 10%). As shown in Table 8, these areas will need to be identified and included in the extent of forest reported under SDG 15.1.1.

Table 8: Bridging table for Ecosystem Extent Account and SDG 15.1.1.

Summary Forest Extent Bridging Table showing relationship of Ecosystem Extent Accounts measure to SDG 15.1.1

		Forest extent (ha)		
	+/-[9]	**2005**	**2010**	**2015**
Ecosystem Extent Account - Extent of forest ecosystem types		**100,000**	**95,000**	**110,000**
minus Extent of shrubland in T2.2 Temperate deciduous forests and shrublands	(-)	8,000	6,000	4,000
plus Extent of forest in T4.4 Temperate wooded savannas	(+)	5,000	7,000	10,000
Forest extent reported under SDG 15.1.1		**97,000**	**96,000**	**116,000**

It is stressed that Table 8 is intended to provide an example scenario only, where bridging tables may be used in the context of SDG 15.1.1. It is important that full consideration is given to national applications and ecosystem typologies in the development of any bridging tables. This should be based on reaching a consensus across relevant national stakeholders.

4.5 Extensions

Future work could look at using condition accounts to track forest degradation, which can provide links to ecosystem service accounts and wider economic benefits. Integrating these condition accounts with forest extent will provide an insight into the impact of forest management on the condition of forests, and how these relate to the provision of forest ecosystem services. For example, identifying forests particularly important for carbon storage in above-ground and below-ground biomass, biodiversity and for the ecosystem services associated with soil erosion control and water supply. This can identify priority areas for conservation and management.

Developing ecosystem service accounts for forest would also be very helpful for presenting additional economic arguments for the allocation of resources to forest conservation, and their sustainable management. In tandem with condition accounts for forests, this would be extremely helpful for monitoring the sustainable management of forests, as per SDG Target 15.2 and SDG Indicator 15.2.1.

4.6 Data sources

Generating ecosystem type maps for accounting will require the integration of different datasets, e.g. on land cover, cadastral information indicating land use, soil maps, hydrological maps, information on the location of protected areas and vegetation maps. The remainder of this section sets out a number of national and global sources of data relevant to compiling ecosystem extent accounts. Given the focus on SDG 15.1.1, there is particularly attention paid to data on forest ecosystem extent.

4.6.1 National forest inventories and forestry statistics

Since 1946, the FAO has been collecting and analysing data every 5-10 years as part of the Global Forest Resources Assessment (FRA). The FRA contains information on many different countries and territories, on a number of variables related to the extent, condition and use of forests. Each country provides the FAO this data in a standardised format, including all raw data. These data provide valuable country level information on forests, such as their extent (ha), annual change (ha) and change rate (%). These can be used to provide thorough and up-to-date information on the changes of forest extent, which can be complemented with earth observation data, and land cover maps. This data is used to produce forest statistics, and this is archived in the FAO Statistical Database FAOSTAT.[10]

In developing ecosystem extent accounts, it is important to incorporate information on land use as well as land cover. As per the FAO (UNSD, 2018b) definition, forests include trees that are expected to reach a canopy cover of at least 10%, and a tree height of 5m or more. It also includes area that are temporarily unstocked due to forest management practice or natural disasters (e.g. fires), and are expected to regenerate within 5 years. Additionally, abandoned shifting cultivation land, which are being regenerated with trees that are expected to reach the canopy and height thresholds (10% canopy and at least 5m tall) need to be included within calculations. This information can be derived through national forest monitoring systems. These systems are based on statistical sampling methods and fieldwork, and collect data on area extent and other elements of forest ecology and management. Data is collected by national forest authorities on management activities (e.g. thinning or harvesting), afforestation, reforestation and land use change can assist. Other institutions may have datasets which can

[10] Available at: http://www.fao.org/faostat/en/#home

complement official forest data sources (e.g., research institutions and commercial forest companies).

In addition to the above, it is anticipated that the data review process outlined in Section 3.2 will also yield a number of useful data sources. Their use may require suitable data sharing and processing arrangements to be agreed with the relevant national stakeholders

4.6.2 Global Data

Earth Observation (EO) data, in combination with ground observations, are used to produce forest cover maps at national and sub-national levels. These can be used to help evaluate SDG indicator 15.1.1 and the extent of forest cover, and provide a more detailed picture of forest areas. A selection of EO products relevant to forest extent are provided in Table 9, following the format for the initial assessment of data sources recommended in Section 3.2.2, Table 3. In addition, EO data on vegetation indices or canopy cover can also be used to measure forest extent and associated changes, where appropriate thresholds and algorithms are developed.

Table 9: Global EO data relevant for Forest Extent

Data holder	Data source	Description	Time series	Data sharing
NASA	SEEA-MODIS	Provides annual land cover products based on the FAOSTAT Land Cover Classification System 3, which is adopted for the SEEA land Cover Classes	Annual (1992 – 2015)	Open Access: https://modis.gsfc.nasa.gov/data/dataprod/mod12.php
ESA	SEEA-CCI-LC	Provides annual land cover products based on the FAOSTAT Land Cover Classification System 3, which is adopted for the SEEA land Cover Classes	Annual (1992 – 2015)	Open Access: https://www.esa-landcover-cci.org/
University of Maryland	Global Forest Change	Provides global tree cover baseline for 2000 and tree cover losses on an annual basis	Annual (2000 - 2018)	Open Access: https://earthenginepartners.appspot.com/science-2013-global-forest
WRI	Global Forest Watch	A platform providing spatial data related to forest cover, condition and use	Various, largely annual from 2000	Open Access: http://www.globalforestwatch.org/
UNEP-WCMC	Global Mangrove Watch	Provides geospatial information about mangrove extent and changes	1996; 2007; 2008; 2009; 2010; 2015; 2016	Open Access: https://data.unep-wcmc.org/datasets/45

Data holder	Data source	Description	Time series	Data sharing
FAO hosted	Open Foris Collect Earth	Collect Earth enables data collection through Google Earth. In conjunction with Bing Maps and Google Earth Engine, users can analyse high resolution satellite imagery for a wide variety of purposes, including national forest inventories	Various	Open Access: http://www.openforis.org/tools/collect-earth.html
Fao hoisted (Open Foris tool)	SEPAL	The System for Earth Observation Data Access, Processing and Analysis for Land Monitoring provides land cover data and a platform for processing and analysing satellite data using an online cloud-based supercomputer	Various	Open Access: https://sepal.io
ESA	The Forestry Thematic Exploitation Platform	The platform offers pre-processed optical and radar data from the Sentinel satellites of the EU Copernicus programme, as well as data from other instruments. In addition, ancillary data and third party data are made available	Various	Open Access: https://f-tep.com/

The linkages between EO data and official statistics, and thus statistical frameworks such as the SEEA, are explored in a recent UN report on the role of EOs for official statistics (UN Satellite Imagery and Geospatial Data Tasks Team, 2017). However, it is important to highlight that EO data has limitations in the context of SDG 15.1.1 (UNSD, 2018b). Firstly, slow changes to forests, such as forest regrowth cannot be easily observed, these require data collected over long time periods. Secondly, remote sensing techniques cannot easily assess land use, they primarily record land cover. Thirdly, forest area with low canopy cover density (e.g. 10-30%) are difficult to observe. As such, the compilation of detailed ecosystem extent accounts requires data and statistics other than land cover (typically the best EO can do) from national forest inventories and other data sources.

5 Land degradation – SDG 15.3.1

This technical note pertains to SDG Target 15.3: *By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world*. Specifically, it describes the role of the SEEA in supporting the calculation of SDG Indicator 15.3.1: Proportion of land that is degraded over total land area. (UNSD, 2018c). SDG 15.3.1 is a Tier II SDG indicator, meaning it is conceptually clear, established methodology and standards are available but data are not regularly produced by countries.

The centralised statistical collation process that the SEEA provides can alleviate a significant portion of the data collation and processing burden for calculating this indicator. Furthermore, by arranging land degradation statistics in a format that is compatible with national statistical systems, it is also possible to more readily associate trends in land degradation with economic statistics, particularly for the agricultural sector. By presenting this information alongside key socio-economic statistics on unemployment, poverty and population, decision-makers will get a better picture of where livelihoods and well-being may be suffering most from the impacts of land degradation. This will allow for appropriate responses to be prioritised for different areas, for example designing and implementing schemes to incentivise improved soil management. This can, in turn, help reduce the demand for land for economic activities, including for agricultural production.

The importance of appropriate validation and quality assurance by national statistics offices of the accounting outputs discussed in this note, and the input data required for the changes they track, is highlighted and stressed. A summary of the Policy Framework for SDG 15.3.1 and associated entry-points is provided in Appendix D. Understanding this framing can help foster constructive dialogue across government agencies and sectors and inform a more integrated approach to land management and addressing land degradation as synergies and trade-offs are revealed.

5.1 Concepts and definitions

There are a number of concepts and definitions used in the analysis of land degradation. Indeed, the term land degradation itself may be defined in several ways. This note adopts the definitions adopted by the UN Convention to Combat Desertification (UNCCD) with respect to land degradation and associated concepts. These definitions are taken directly from the SDG 15.3.1 Metadata Sheet (UNSD, 2018c), for which the UNCCD is custodian. In addition, the alignment between the UNCCD definition of land degradation and the SEEA EA definition of ecosystem degradation (in physical and monetary terms) is highlighted in this note. For the avoidance of doubt, these particular concepts and definitions as used in this note are set out below:

Land Degradation: The reduction or loss of the biological or economic productivity and complexity of rain fed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from a combination of pressures, including land use and management practices.

Land Degradation Neutrality (LDN): A state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specified temporal and spatial scales and ecosystems.

Total land area: The total surface area of a country excluding the area covered by inland waters, like major rivers and lakes.

Ecosystem Degradation: In the SEEA EA, ecosystem degradation is defined in relation to the decline in condition of an ecosystem asset as a result of economic and other human activity (para. 4.31, UN *et al.,* 2014). It can be measured in physical terms via changes in the condition of ecosystems and in monetary terms via changes in the net present value of expected future ecosystem services delivered by ecosystems (i.e., via monetary ecosystem asset accounts).

SDG indicator 15.3.1: A binary - degraded/not degraded - quantification based on the analysis of available data for three sub-indicators to be validated and reported by national authorities. The sub-indicators (Trends in Land Cover, Land Productivity and Carbon Stocks) were adopted by the UNCCD's governing body in 2013 as part of its monitoring and evaluation approach.

Land cover: Refers to the observed physical cover of the Earth's surface which describes the distribution of vegetation types, water bodies and human-made infrastructure. It also reflects the use of land resources (i.e., soil, water and biodiversity) for agriculture, forestry, human settlements and other purposes

Land productivity: Refers to the total above-ground net primary production (NPP) defined as the energy fixed by plants minus their respiration, which translates into the rate of biomass accumulation that delivers a suite of ecosystem services.

Carbon stock: Is the quantity of carbon in a "pool": a reservoir which has the capacity to accumulate or release carbon and is comprised of above- and below-ground biomass, dead organic matter, and soil organic carbon.

The method of computation: For SDG Indicator 15.3.1 follows the "One Out, All Out" statistical principle and is based on the baseline assessment and evaluation of change in the sub-indicators to determine the extent of land that is degraded over total land area.

The One Out, All Out Principle: This is applied taking into account changes in the SDG 15.3.1 sub-indicators which are depicted as (i) positive or improving, (ii) negative or declining, or (iii) stable or unchanging. If one of the sub-indicators is negative (or stable when degraded in the baseline or previous monitoring year) for a particular land unit, then it would be considered as degraded subject to validation by national authorities.

The measurement unit: For SDG Indicator 15.3.1 is the spatial extent (hectares or km^2) expressed as the proportion (percentage) of land that is degraded over total land area.

The UNCCD's Scientific Conceptual Framework for Land Degradation Neutrality (LDN) established a universal methodology for deriving the SDG 15.3.1 target indicator (see Orr *et al.*, 2017). This is supported by a Good Practice Guidance Document for calculating the indicator (see Sims *et al.*, 2017). The methodology is based on the use of national and global datasets, with the expectation that countries will move to using national data over time.

Given the challenges in assessing land degradation using a single indicator, the methodology to calculate SDG 15.3.1 is grounded in three sub-indicators. These comprise:

1. Assessment and evaluation of land cover and land cover changes.
2. Analysis of land productivity status and trends based on net primary productivity.
3. Determination of carbon stock values and changes.

The decision on whether an area of land is degraded is made if <u>any</u> one of these indicators shows a significantly negative trend with respect to the established baseline (based on information on each indicator from 2000 to 2015) or were assessed as degraded during the baseline period and have not shown a significant improvement since. This is referred to as the one out, all out (1OAO) principle.

The assessment of areas of degraded land is made for each land cover class or ecosystem type and then aggregated for the entire area of analysis (or ecosystem accounting area). The total degraded area across all classes or types within a monitoring period t_n $(A(Degraded)_{t_n})$, comprises the sum of land that has degraded within that monitoring period (t_n) and the land already assessed as degraded at the beginning of that monitoring period and also remains degraded at the end of the monitoring period.

Once the information on the total degraded area identified over a monitoring period has been organised, SDG 15.3.1 can be calculated by dividing this by the total area within the ecosystem accounting area $(A(Total))$ (UNSD, 2018c). This is shown in equation 2 below (which would represent the closing extent of degraded area for an accounting period):

$$SDG\ 15.3.1 = \left(\frac{A(Degraded)_{t_n}}{A(Total)}\right) \times 100\ (eq. 2)$$

5.2 SEEA EA Accounts for Land Degradation.

This section sets out an approach to compile SEEA EA Accounts for organising information on land degradation that can support the calculation of SDG 15.3.1 and can be used to integrate information on land degradation into wider land use and economic planning processes.

5.2.1 Relevant accounts and classifications

Ecosystem accounting requires the delineation of areas within a country into mutually exclusive collectively exhaustive (MECE) spatial units that represent ecosystem assets. This requires an ecosystem typology that suitably represents all ecosystems in an ecosystem accounting area and spatially explicit information on extent of all these ecosystem types. As highlighted in Figure 2, this information on ecosystem extent is then organized by the ecosystem extent account. The ecosystem extent account then provides information for inferring degradation via the land cover change sub-indicator of SDG 15.3.1. This is achieved using an ecosystem type change matrix and identifying the ecosystem changes that are indicative of degradation.[11]

The concept of land degradation is also clearly aligned to that of ecosystem condition. The Ecosystem Condition Accounts shown in Figure 2 allow trends in the land productivity and carbon stock sub-indicators for land degradation and SDG 15.3.1 to be integrated with the extent of different ecosystem (or land cover) types. As such, they are also clearly relevant structures for organising information to calculate SDG 15.3.1. The information on the carbon stock sub-indicator could also be organised using the thematic carbon accounts identified in Figure 2, if these accounts were to be developed.

The approach to calculating SDG 15.3.1 is based on organising spatially explicit data on the three sub-indicators in an integrated manner. A practical approach to this, is to assign information on each of the three sub-indicators to a pixel or gird cell derived from a georeferenced grid, ideally a resolution of 250m to 1ha grids. These grid cells are entirely

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[11] The information on land cover change could similarly be obtained using Land Cover Account and associated change matrix. As shown in Figure 2, the Land Cover Account is a thematic account of the SEEA EEA. It is and also an important asset account of the SEEA Central Framework (see Table 5.6.3, UN et al., 2014b).

consistent with the concept of Basic Spatial Units (BSUs) described in the SEEA EA. BSUs are not accounting units per se, but provide a consistent spatial unit for data integration. Further guidance on BSUs and associated spatial data infrastructures is provided in Chapter 3 of the SEEA EEA Technical Recommendations. Organising information on land degradation by BSU means each BSU can be assessed as either degraded or not on the basis of any of the sub-indicators being indicative of degradation (i.e., via the one out, all out principle).

5.2.2 Inferring Land Degradation from Ecosystem Type Change Matrix

A detailed description of the Ecosystem Extent Account and the IUCN global ecosystem typology (IUCN ET) is provided in Section 2.1. Table 6, Section 4.2.2, of the note on forest extent and SDG 15.1.1, provides and describes an ecosystem extent account for an ecosystem accounting area containing 15 of these global IUCN ecosystem types (IUCN ETs). Using the IUCN ETs allows aggregation and comparison of information across countries, although it is anticipated that countries will also require their own ecosystem typology that provides a finer and more tailored map of ecosystem assets in the landscape.

Compilation of the ecosystem extent account (or a land cover account as a proxy) is fundamental to calculating the land cover change sub-indicator for SDG 15.3.1. This also requires identifying the areas where ecosystem type changes have occurred and then identifying which changes are representative of degradation. These changes can then be presented using an ecosystem type change matrix.

Table 10 presents an example ecosystem change matrix based on the Ecosystem Extent Account and associated 15 IUCN ETs presented as Table 6, Section 4.2.2. The ecosystem change matrix is generated by comparing two ecosystem maps at the opening and closing time for the accounting period (e.g., 2000 and 2015 in Table 10). The area remaining the same ecosystem type across this accounting period is captured in the diagonal of the matrix (these cells are not colour coded in Table 10). The flows from one ecosystem type in the opening period (i.e., the types listed in the rows) to another ecosystem type in the closing period (types listed in the columns) are captured in the other cells in Table 10. The closing stock for each ecosystem type is simply the sum of the column values. The gross additions to that ecosystem type over an accounting period are the sum of the column values minus the ‘no change’ value on the diagonal. Opening stock and gross reductions over an accounting period for each ecosystem type are measured by similarly summing across rows. Guidance on compiling change matrices is provided in UNSD (2017). It is noted that this structure is slightly different to the land cover change matrix presented as Table 5.14 in the SEEA Central Framework (UN et al., 2014b).

Following the UNCCD approach (Orr et al., 2017), it is also necessary to define all the potential ecosystem type flows in Table 10 as either being indicative of degradation, improvement or being stable with respect to land degradation. This is to inform on the land cover change sub-indicator of for SDG 15.3.1. As a partial example, in Table 10 ecosystem type flows indicative of improvement are coded green. For example, afforestation of cropland. Degradation is coded with a red cell in Table 10. For example, urban expansion into forest. An ecosystem type change is considered as stable (with respect to land degradation) where the ecosystem types remains the same, or similar. Figure 2.2 in Sims *et al.*, (2017) also provides an example matrix based on the 6 IPCC land cover classes.

Table 10: Ecosystem Change Matrix using global IUCN ETs (based on material in UNSD, 2017)

Original Type in 2000 \ Type in 2015 (Ecosystem change matrix (IUCN ET))	T2.2 Temperate deciduous forests and shrublands	T4.4 Temperate wooded savannas	T4.5 Temperate grasslands	T6.4 Temperate alpine meadows and shrublands	T7.1 Croplands	T7.2 Sown pastures and old fields	T7.3 Plantations	T7.4 Urban and infrastructure lands	FT1.2 Seasonal floodplain marshes	FT1.5 Boreal, temperate and montane peat bogs	F1.1 Permanent upland streams	F1.2 Permanent lowland rivers	F2.2 Large permanent freshwater lakes	F2.3 Small permanent freshwater lakes	F4.1 Large reservoirs	Opening Extent (2000)	Reduction
T2.2 Temperate deciduous forests and shrublands^	220				10	5	10	5								250	30
T4.4 Temperate wooded savannas^		215			10	10	-	15								250	35
T4.5 Temperate grasslands		5	55			20		20								100	45
T6.4 Temperate alpine meadows and shrublands				245		5										250	5
T7.1 Croplands	0	5		20	165			55	5							250	85
T7.2 Sown pastures and old fields	0	0			20	195	5	25	5							250	55
T7.3 Plantations	0	0	10	10	20		110		0							150	40
T7.4 Urban and infrastructure lands	0	0	5					45	10							60	15
FT1.2 Seasonal floodplain marshes					5	10	-		45							60	15
FT1.5 Boreal, temperate and montane peat bogs										60						60	0
F1.1 Permanent upland streams											5					5	0
F1.2 Permanent lowland rivers												10				10	0
F2.2 Large permanent freshwater lakes													20			20	0
F2.3 Small permanent freshwater lakes														10		10	0
F4.1 Large reservoirs															10	10	0
Closing Extent (2015)	220	225	70	275	230	245	125	165	65	60	5	10	20	10	10	1,735	
Additions degradation					25	25	10	40								100	
Additions improvement	0	5	5						20							30	
Additions stable	0	5	10	30	40	25	5	80	0	0	0	0	0	0	0	195	

Ecosystem type changes or flows are colour coded: Red = degradation; Green = improvement; Blue = Stable

All reductions in extent (i.e., the sum of row values excluding the no change cell on the diagonal) are captured in the final column in Table 10. The additions are disaggregated by changes indicative of degradation, improvement or stable, with respect to land degradation, in the bottom three rows of Table 10. For any accounting period, the sum of improvement and stable will reflect the ecosystem changes that are not indicative of degradation. The 'Additions degradation' row will reflect the extent of land degradation in an accounting period identified by the land cover change sub-indicator of SDG 15.3.1.

It is stressed that Table 10 is an incomplete and purely illustrative example. It is essential that the decision on which ecosystem type changes are indicative of degradation or improvement is undertaken in close coordination with all relevant national stakeholders. This is because it requires detailed consideration, as ecosystem change is, typically, indicative of an active land use management decision, rather than degradation *per se*. For instance, it may be useful to reflect on whether only illegal or unintentional ecosystem change flows should be considered. Or if there are specific ecosystem types that should be a priority for protection, given the desire to maintain productive ecosystems (e.g., wetlands or native forests).

Where a national ecosystem typology or the IUCN ETs are adopted for the Ecosystem Extent Accounts, an additional processing step of cross walking the ecosystem typology to the six IPCC land cover classes will be required to inform the reporting of SDG indicator 15.3.1. As an example, Table 11 presents cross walk from the IUCN ETs, to any national ecosystem typologies and then on to the IPCC Land Cover Classes. For ease of presentation this is limited to the Ecosystem Types consistent with tropical and subtropical rainforests only. It is important any cross walks are also determined on the basis of an appropriate national consensus.

Table 11: Crosswalk from IUCN ecosystem typology to IPCC land cover classes

IUCN ET	National Ecosystem Typology	IPCC Land Cover Classes
T1.1 Tropical/Subtropical lowland rainforests	*List all relevant types……*	Forest Land
T1.2 Tropical/Subtropical dry forests and scrubs	*List all relevant types……*	Forest Land
T1.3 Tropical/Subtropical montane rainforests	*List all relevant types……*	Forest Land
T1.4 Tropical heath forests	*List all relevant types……*	Forest Land

Table 2.1 in the Good Practice Guidance (Sims et al., 2017) provides a cross walk between these IPPC classes and other legends that may also be useful. Land Cover Meta Language (LCML) also provides a reference structure for the comparison and integration of different land cover classifications systems, including the SEEA Land Cover classes.[12]

5.2.3 Compiling ecosystem condition account for land degradation

This section sets out how land productivity and carbon stock sub-indicators for SDG 15.3.1 can be organized within the SEEA EA Ecosystem Condition Accounts. For both of these sub-indicators, Sims *et al.*, (2017) describe a three tiered approach to their calculation. Tier 2 and 3 are based on the calculation of absolute measures for the sub-indicators. The ecosystem condition account presented in this section are consistent with such a Tier 2 or 3 approach. The final part of this section summarizes the Tier 1 approach, which relies on global data.

5.2.3.1 Land productivity

Land productivity is the biological productive capacity of land. It reflects the net effects of ecosystem functioning on plant and biomass growth. This is, in turn, fundamental to the delivery of a range of provisioning, regulating and cultural ecosystem services (Sims et al., 2017). As such it is an important indicator of *Ecosystem Functioning* (as per MAES, 2018) and, therefore, for ecosystem condition accounting.

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[12] It should be noted that this only became part of the international standard for land cover data in 2012 (Sims et al., 2017).

Land productivity can be measured as the total above ground (annual) net primary productivity (NPP), defined as the energy fixed by plants minus their respiration, which translates into the rate of biomass accumulation (e.g., in kg/ha/yr) (UNSD, 2018c). ANPP is estimated from known correlations between the fraction of absorbed photosynthetically active radiation (fAPAR) and plant growth vigour and biomass (Sims et al., 2017). Ideally, Land Productivity changes should measure using detailed fAPAR based modelling approaches, which are validated using field samples and ground measurements. This will allow estimates of Land Productivity to be determined for different areal units of contiguous ecosystem type (i.e., ecosystem assets).

However, NPP is variable that is time consuming and costly to estimate. Hence the Normalized Difference Vegetation Index (NDVI) is often used as a surrogate for NPP (CI, 2019). This is because it is regularly recorded across the globe using remote sensing and there is a substantial time series of products mapping NDVI, which are available for no cost. NDVI has been used as an indicator in ecosystem condition accounts, for example under the World Bank supported development of ecosystem accounts in Guatemala (Monterroso et al., 2019). Whilst NDVI is a unitless index, it is still suitable for measuring relative change in productivity of a given are over time. Validation against field samples or another calibrated datasets may also enable these relative productivity measures to be converted into ANPP biomass units (e.g., kg/ha/year) (Sims et al., 2017).

It should be noted that some calibration for climate and other factors are required in order to ensure that human induced land degradation is not conflated with degradation from other pressures, such as drought, in the land productivity measure. Options in this regard, such as Rainfall Use Efficiency (RUE) correction, Residual Trends modeling and time series decomposition, are highlighted and discussed by Sims et al., (2017).

It is also highlighted that a review with stakeholders of the appropriateness of using NPP (or trends in NDVI as a surrogate) for measuring trends in land productivity for different ecosystem types is essential. For instance, increases in NPP in wetlands could be indicative of eutrophication, a form of degradation not improvement. Orr et al., (2017) also identify that shrub or bush encroachment into formerly sparsely-vegetated areas might be considered a form of degradation but would deliver an increase in NPP for that area.

5.2.3.2 Carbon Stocks

The accumulation of soil organic carbon (SOC) can be used as a proxy indicator of condition for the soil quality of terrestrial ecosystems and associated functions and processes, including: soil nutrient cycling, soil aggregate stability and soil structure. These have direct implications for water infiltration, vulnerability to erosion and, ultimately, the productivity of vegetation and agricultural yields (Sims et al., 2017).

Ideally, SOC would be assessed via well-designed soil survey monitoring programmes, which yield a time series of representative data. Bespoke modelling approaches can then be used to integrate additional national and earth observation data to extrapolate estimates of SOC across an ecosystem accounting area.

However, regular soil monitoring is costly to implement. Where these programmes are not established, SOC can be assessed using information on changes in ecosystem types. These should be based on nationally-derived ecosystem typologies. The findings of any previous national soil survey studies can also be used to best characterise SOC reference levels for each ecosystem type. Nationally derived 'change factors' for reduction in carbon stocks due to ecosystem change and estimates emission factors associated with drainage, fire or other factors can then be used to estimate changes in SOC stocks following ecosystem change (or conversion). These can best be derived using modelling approaches that incorporate additional data on the management and use of ecosystems, which go beyond just ecosystem type change to generate change factors and emission factors more specific to local conditions.

It is noted that the intention for calculating SDG 15.3.1 is to move to a combined estimate of above and below ground carbon. As such, the methodological approach is anticipated to be updated to include estimates of above ground carbon stocks in due course.

5.2.3.3 Ecosystem condition account

The SEEA EEA Technical Recommendations suggest reporting condition as opening and closing stocks for given years and provide an example table (Table 4.1, UN et al., 2017). Table 12 develops this example table for an Ecosystem Condition Account relevant for land degradation, incorporating the land productivity and carbon sub-indicators for the IUCN ETs presented in Table 10 (except freshwater ecosystems). Table 12 is based on being able to generate absolute measures for these land degradation condition indicators. The columns in Table 12 can be readily adapted to accommodate a national ecosystem typology.

Table 12: Ecosystem Condition Account for Land Degradation (freshwater ecosystems omitted)

	Classifications >>	T2.2 Temperate deciduous forests and shrublands	T4.4 Temperate wooded savannas	T4.5 Temperate grasslands	T6.4 Temperate alpine meadows and shrublands	T7.1 Croplands	T7.2 Sown pastures and old fields	T7.3 Plantations	T7.4 Urban and infrastructure lands	FT1.2 Seasonal floodplain marshes	FT1.5 Boreal, temperate and montane peat bogs
Annual Net Primary Productivity (million tonnes dry matter / ha / year)	*Opening (2000)*										
	Closing (2015)										
Soil Organic Carbon Stocks (tonnes carbon / ha)	*Opening (2000)*										
	Closing (2015)										

5.2.4 SDG 15.3.1 Tier 1 Approach to calculating land productivity and carbon stock indicators

As highlighted in Section 5.2.3, the Tier 1 approach to measuring land productivity and carbon sub-indicators is based on the use of readily available global data. For both indicators, the approach is based on assessing relative change, where a BSU is degraded if land productivity or soil carbon has significantly declined. The approach is described in detail in Sims *et al.*, (2017) and CI (2019) and summarised, briefly, below.

The determination of degradation of a BSU due to declines in land productivity is based on the use of NDVI. It follows the methods described by Ivits and Cherlet (2016) that have been used in the World Map of Desertification. This approach to measuring trends land productivity is based on the assessment of three further sub-indicators:

- **Trajectory:** Measures the rate of change in NPP over time, corrected for the effects of climate variation (including precipitation) within different observation periods (CI, 2019).
- **Performance**: Compares local productivity measures to similar vegetation types in similar land cover, or bioclimatic regions in the country.
- **State**: Compares recent changes in NPP to a baseline period (CI, 2019).

Trends.Earth (CI, 2019) provides a toolkit to implement the algorithms to calculate the three above sub-indicators for land productivity using global NDVI data. The toolkit classifies the Trajectory and State sub-indicators according to whether a BSU is showing Improvement, is

Stable or showing Degradation. Performance of a BSU is classified as either Stable or Degradation. These are then combined to provide an overall degradation assessment with respect to land productivity trends for the BSU.

The Tier 1 approach for determining the carbon sub-indicator for SDG 15.3.1 is based on determining SOC reference levels for different land cover classes using global data (SoilGrids[13] and the IPCC land Cover classes are used in the Trends.Earth approach). Land cover change is then linked to changes in SOC stocks using change coefficients and emission factors reflecting expected loss of soil carbon over a 20-year period. A default assumption of a 10% change in SOC is considered as being significant by Trends.Earth (CI, 2019). Consequently, a BSU where a 10% increase in SOC is anticipated is identified as potentially improved and 10% decrease as potentially degraded. Where the change is less than 10%, the BSU is considered stable with respect to SOC context.

5.3 Combined presentation of land degradation information

The information on ecosystem extent (or land cover) is not only used to detect land cover changes indicative of degradation but also as a means of stratifying the analysis of the other sub-indicators (productivity and carbon stocks) by BSU (Sims et al., 2017). Ideally, whether a BSU has degraded due to negative trends in one of these ecosystem condition sub-indicators will be determined on the basis of robust statistical analysis. For land productivity, Sims et al., (2017) set out detailed statistical approaches. For SOC, comparing average SOC measures in one period against 95% confidence levels for average measures in a baseline period is proposed as a means of identifying significant changes. Alternative approaches are proposed, including the use of a 10% average change in SOC where confidence intervals are large.

Once organised via BSUs, the spatial information on the ecosystem condition sub-indicators and their trends can be readily aggregated to communicate the overall implications of land degradation and where associated impacts are manifesting. Following the SDG 15.3.1. "One Out, All Out" approach, an area of land would be considered degraded if either of the land productivity or SOC sub-indicators were indicative of degradation. The baseline year for each indicator is 2015, with any future improvement or degradation of a BSU judged relative to the assessment of that BSU over the baseline period of 2000 to 2015.

In order to present this information on land degradation in an aggregated manner, Table 13 adapts the ecosystem extent account structure based on the IUCN ETs presented in Table 10. The 2000 to 2015 accounting period for Table 13 reflects the baseline required for UNCCD reporting. The top row provides an opening measure for the degraded and not degraded extent for each IUCN ET (column). Given the baseline starts at 2000 for measuring land degradation neutrality to 2030, whilst degradation will have occurred by this point in time no ecosystems are degraded in the context of SDG 15.3.1 at this point in time. It is highlighted that countries are also likely to be interested in overall, cumulative degradation within their territories.

The top part of Table 13 reclassifies the opening extent of degraded and not degraded land due to ecosystem type changes over the accounting period (i.e., this records to effect of the land cover change sub-indicator). These are the same 'Additions' that are recorded in the ecosystem type change matrix presented in Table 10. The red cells are the 'Additions degradation', these identify an ecosystem type flow over the accounting period indicative of degradation. For example, in Table 13 the extent of T7.1 Cropland has increased by 25 hectares as a result of conversion of ecosystem types that are considered more productive and a priority for protection. Inspection of Table 10 reveals these are: T2.2 Temperate deciduous forests and shrublands; T4.4 Temperate wooded savannas; and, FT1.2 Seasonal floodplain marshes. These 25 hectares will continue to be considered as degraded land (albeit it may be 'good condition' cropland)

[13] https://www.soilgrids.org/

unless they are restored back to their original type or converted to another ecosystem type indicative of improvement with respect to land degradation.

The green cells in the top part of Table 13 are the 'Additions improvement' presented in Table 10. As ecosystem type flows indicative of improvement over the baseline period contribute to the 'Not degraded' areas there are no issues for SDG 15.3.1 calculation in capturing those over the baseline period. The blue cells in Table 13 are stable with respect to land degradation, the values in these cells are the net of all the reductions and the 'Additions stable' in the ecosystem type change matrix presented Table 10.

The 'Further Additions' row of the table summarises how many hectares of ecosystem are degraded (in the 'degraded' sub column) due to either Land Productivity or Carbon Stock trends over the accounting period. The area of BSUs / hectares classed as degraded has to be balanced by a negative balancing amount in the adjacent 'Not Degraded' cell in this part of Table 13. Such negative values are presented in parenthesis.

A similar approach is presented for the 'Further Reductions' part of Table 13. This part of the table captured the additional area of BSUs that are identified as improved due to Land Productivity or Carbon Stock trends. Any reduction in the 'Degraded' area, must be balanced with equivalent addition in the adjacent 'Not degraded' column in Table 13. Both columns will be null over the baseline period.

It is highlighted the 'Net further additions' row records the additional area of BSUs that are identified as 'Degraded' due to either Land Productivity or Carbon Stock trends or 'Not degraded' due to improvement in one of these sub indicators. This reflects the "One Out, All Out" principle of SDG 15.3.1. Care is required not to double count any degraded or improved BSUs where both of these sub-indicators for land degradation shows a change. It is also important not record BSUs that show improvement in one sub-indicator but are still degraded due to the trend in the other sub-indicator as a 'Net further addition' in the 'Not degraded' column. Managing this information requires that a spatial data infrastructure is established for organising this information at BSU (or grid cell) scale.

The final row in Table 13 captures the total 'Degraded Area' and 'Not Degraded Area' for each ecosystem type at the close of the accounting period. This is the sum of the 'Net further additions' and those BSUs classified as 'Degraded' or 'Improved' already due to land cover change. Data is aggregated across all IUCN ETs representing the total land area in the 'Total land Area' columns of Table 13.

Table 13: Land Degradation Summary Table (2000 to 2015). Negative values in parenthesis.

Classifications >>	T2.2 Temperate deciduous forests and shrublands – Degraded	T2.2 – Not Degraded	T4.4 Temperate wooded savannas – Degraded	T4.4 – Not Degraded	T4.5 Temperate grasslands – Degraded	T4.5 – Not Degraded	T6.4 Temperate alpine meadows and shrublands – Degraded	T6.4 – Not Degraded	T7.1 Croplands – Degraded	T7.1 – Not Degraded	T7.2 Sown pastures and old fields – Degraded	T7.2 – Not Degraded	T7.3 Plantations – Degraded	T7.3 – Not Degraded	T7.4 Urban and infrastructure lands – Degraded	T7.4 – Not Degraded	FT1.2 Seasonal floodplain marshes – Degraded	FT1.2 – Not Degraded	FT1.5 Boreal, temperate and montane peat bogs – Degraded	FT1.5 – Not Degraded	Total Land – Degraded	Total Land – Not Degraded	F1.1 Permanent upland streams	F1.2 Permanent lowland rivers	F2.2 Large permanent freshwater lakes	F2.3 Small permanent freshwater lakes	F4.1 Large reservoirs	TOTAL AREA
Opening Extent (Ha, 2000)		250		250		100		250		250		250		150		60		60		60	-	1,680	5	10	20	10	10	1,735
Reclassifications (Land Cover Change																												
Degradation									25		25		10		40						100							
Improvement		-		5		5		-										20				30						
Stable		(30)		(30)		(35)		25		(45)		(30)		(35)		65		(15)		-		(130)						
Reclassified Extent (2015)	-	220	-	225	-	70	-	275	25	205	25	220	10	115	40	125	-	65	-	60	100	1,580						
Further Additions																												
Land Productivity	5	(5)	3	(3)	20	(20)	10	(10)	45	(45)	35	(35)	2	(2)	-	-	2	(2)	-	-	102	(102)						
Carbon stocks	0	-	-	-	10	(10)	4	(4)	10	(10)	15	(15)	-	-	-	-	-	-	-	-	29	(29)						
*Total additions to stock**	5	(5)	3	(3)	24	(24)	12	(12)	48	(48)	40	(40)	2	(2)	0	0	2	(2)	0	0	112	(112)						
Further Reductions																												
Land Productivity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Carbon stocks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
*Total reductions to stock**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Net further additions	5	(5)	3	(3)	24	(24)	12	(12)	48	(48)	40	(40)	2	(2)	-	-	2	(2)	-	-	136	(136)						
Closing (Ha, 2015)	5	215	3	222	24	46	12	263	73	157	65	180	12	113	40	125	2	63	-	60	236	1,444	5	10	20	10	10	1,735

*Further Additions and Further Reductions are not simply the sum of degraded / non degraded areas due to Land Productivity or Carbon Stock trends. This is because a BSU may be degraded by reason of either of these sub-indicators, or due to land cover change. As such, the Net further additions should be expected to be lower that the sum of degraded / non degraded areas due to land cover change, land productivity or carbon stock trends. Where changes in SOC are based on land cover flows these can be captured using a similar 'Reclassifications' approach as employed for the land cover change indicator.

It is highlighted that Table 13 is not a formal account of the SEEA. However, it provides a useful bridging structure to communicate information on land degradation to decision makers and other account users and a way to link this information to the wider set of accounts in the SEEA EA framework. It also directly facilitates the calculation of SDG 15.3.1 and provide a framework for aligning information from the Tier 1 approach for calculating SDG 15.3.1 with the SEEA EA. Where information on carbon stocks is determined as an artefact of land cover change, a similar reclassification approach as described for the land cover change sub indicator in Table 13 will be necessary to integrate this information.

5.4 Calculating SDG 15.3.1 from the Land Degradation Summary Table

Before SDG 15.3.1 can be calculated, a baseline for each sub-indicator and the overall SDG 15.3.1 target indicator for 2000 to 2015 must be determined. The information for calculating the overall SDG 15.3.1. indicator via equation 2 is organized in Table 13. The closing stock (2015) of the extent of degraded land across all ecosystem types ($A(Degraded)_{t_{2015}}$), is provided in the bottom row of the 'degraded' sub column of the 'Total Land' column of Table 13. This is the numerator in equation 2. The total land area within the ecosystem accounting area ($A(Total)$), is provided as the sum of the 'Degraded' and 'Not degraded' areas in the bottom row of the 'Total Land' sub columns of Table 13. This is the denominator in equation 2.

$$SDG\ 15.3.1 = \left(\frac{A(Degraded)_{t_{2000\ to\ 2015}}}{A(Total)}\right) \times 100\ (eq.2)$$

The extent of degraded land in any accounting periods after the baseline period, comprises the sum of land that has degraded within that accounting period and the land already assessed as degraded at the beginning of the accounting period and remaining degraded at the end of the monitoring period. Trends in land degradation relative to the 2015 baseline are to be reported to the UNCCD in four year intervals going forward. As such the next set of accounts would be produced for the 2015 to 2019 period, with an associated reporting obligation in 2022.

Land Degradation Neutrality (LDN) for an accounting period is achieved when the Net change for degraded land (and not degraded) is zero hectares. It is highlighted that the overall ambition for LDN is for the net change in degraded land between the 2000 to 2015 baseline and 2030 to be zero.

5.5 Aligning the SEEA and SDG 15.3.1

By design the concept of Land Degradation used in Table 13 is consistent with the concepts and definitions for SDG 15.3.1. The Table 13 presentation itself is a bridging structure to SDG 15.3.1 from the Ecosystem Change Matrix and Ecosystem Condition Accounts presented as Table 10 and Table 12, respectively. The need for this bridging structure reflects that the presentation of degradation in relative and binary terms under SDG 15.3.1 indicator requires an additional processing step beyond the quantitative changes presented in the core SEEA EA accounts.

Nonetheless, the SEEA EA aligns with many of the concepts and measurements approaches underpinning the SDG 15.3.1 methodology. The National Spatial Data Infrastructure (NSDI) recommended for organising environmental-economic data in the SEEA EEA Technical Recommendations will encourage the harmonisation many relevant datasets for land degradation. Centralising such a system and developing associated data catalogues can directly contribute to avoiding replication of data processing efforts, promote consistency and improve the possibilities for integration of data. Developing national ecosystem extent maps and accounts will also directly support the calculation of a nationally tailored land change sub-indicator for SDG 15.3.1, integrating and cross walking this to different land cover classes will also support multiple reporting processes (i.e., as shown in Table 11).

The SEEA EA framework also allows for the various disparate data on land productivity and carbon stocks that may exist in a country to be central organised and data gaps clearly identified. This can encourage investment in improving primary monitoring data and deriving spatial products on these two ecosystem condition parameters, potentially as part of a strategic intervention to improve the national environmental spatial data foundation on land degradation and other issues. Fundamentally, the SEEA EA also provides the framework for mainstreaming information on the various sub-indicators into a range of land use and economic planning processes, for example via Table 10, Table 12 and Table 13. As a first step, this would help the data outputs from the global Tier 1 approach to calculating SDG 15.3.1 inform a more holistic approach to achieving land degradation neutrality in the wider context of sustainable development.

5.6 Extensions

Land degradation has significant implications for the delivery of ecosystem services, in particular provisioning services. Compiling ecosystem services supply and use accounts, especially for enabling food production associated ecosystem services, would help to reveal the correlations between land degradation and, for example, agricultural yields. For these ‘enabling food provisioning’ ecosystem services, supply and use can be equated by using proxy data on biomass (tonnes) of crops and livestock harvested from ecosystems. This would speak to a number of socio-economic concerns and associated SDGs.

The SDG 15.3.1 conceptualization of land degradation is reasonably well aligned to the physical measurement of ecosystem degradation, condition and associated concepts of ecosystem capacity presented in the SEEA EEA Technical Recommendations). However, the SEEA EA also allows for measurement of ecosystem degradation in monetary terms, via the ecosystem monetary asset accounts. The ecosystem monetary asset account is described in Section 7.2 of the SEEA EEA Technical Recommendations. In broad terms, the focus of these accounts is to record changes in the value of ecosystem assets over time. This is based on assumptions of the future flows of ecosystem services from an ecosystem asset, where these assumptions consider the condition and the future use of the asset. Net Present Value (NPV) approaches are then employed to arrive at a present asset value by discounting the monetary value of the future services flows the asset is assumed to deliver.[14]

Whilst ecosystem monetary asset accounts will clearly be challenging to compile, where declines in NPV of ecosystem assets are observed over time this will be reflected in monetary terms. Understanding this monetary cost of ecosystem degradation is important, as these capital costs should be reflected in the in the final prices of any product that ecosystem services contribute to (e.g., food products sold at the farm gate) (para 6.44, UN et al., 2017).

Such valuation of ecosystem degradation would also open up a range of national accounting integration possibilities, for example generating ecosystem degradation adjusted measures of key economic measures, such as GDP, national income and savings. This would internalize the draw-down on natural capital stocks associated with current production practices. These would provide important economic signals for directing investment towards the sustainable use of land

[14] Following the definition of ecosystem degradation in the SEEA EEA Technical Recommendations, and changes in NPV recorded in the monetary asset accounts should result from a loss of condition due to human or economic activity (rather than natural processes). And should also not be an artefact of changes in prices.

and addressing land degradation issues in national economic and development planning processes.

5.7 Data sources

Organizing spatial data on the three land degradation sub indicators will require a significant amount of GIS processing. As highlighted previously, the integration of this spatial information is greatly facilitated by using a common spatial referencing grid (or spatial data infrastructure, more generally) and assigning information to BSUs. Ideally, these BSUs should be at resolutions of 250m to 1ha grid cells for organizing data for SDG 15.3.1.

There are proprietary modeling tools that can assist and reduce the processing burden of organizing and processing this data. Trends.Earth is designed to specifically to run the necessary algorithms to calculate SDG 15.3.1 using global data. The EnSym modelling platform also provides a more general application for organizing spatial data in BSUs. These platforms and additional global data source relevant to land degradation are summarised in Table 14. In addition, Sims *et al.*, (2017) set out a comprehensive list of data sources for the individual sub-indicators SDG 15.3.1, as follows:

- Land cover change – Section 2.5 from page 29
- Land productivity – Section 3.5 from page 56
- Carbon stock – Section 4.5 from page 92

The data review process outlined in Section 3.2 will also yield a number of useful national data sources for land degradation.

Table 14: Platforms and data relevant for Land Degradation

Data holder	Data source	Description	Time series	Data sharing
Conservation International	Trends. Earth	A platform for monitoring land change using earth observations in an innovative desktop and cloud-based system. It calculates SDG 15.3.1 sub-indicators using global data but also allows users to upload their own datasets for processing.	Annual from 2000	Open Access: http://trends.earth/docs/en/
Victoria State Government	EnSym	EnSym is a decision support tool that allows users to build scenarios by establishing a master grid for an ecosystem accounting area and integrating multiple data using the resulting BSU grid cells.	User defined	Open Access: https://ensym.biodiversity.vic.gov.au/cms/

Data holder	Data source	Description	Time series	Data sharing
NASA	SEEA-MODIS	Provides annual land cover products based on the FAOSTAT Land Cover Classification System 3, which is adopted for the SEEA land Cover Classes	Annual (1992 – 2015)	Open Access: https://modis.gsfc.nasa.gov/data/dataprod/mod12.php
ESA	SEEA-CCI-LC	Provides annual land cover products based on the FAOSTAT Land Cover Classification System 3, which is adopted for the SEEA land Cover Classes	Annual (1992 – 2015)	Open Access: https://www.esa-landcover-cci.org/

6 Extent of water-related ecosystems – SDG 6.6.1

This technical note pertains to SDG Target 6.6: *By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes*. Target 6.6 focuses on the protection and restoration of water-related ecosystems in order to secure the delivery of essential ecosystem services. In the context of SDG 6, this specifically relates to the supply of freshwater to society. SDG Indicator 6.6.1, 'Change in the extent of water-related ecosystems over time', is intended to inform on the trends in ecosystem assets that directly provide these services. Reflecting that other water-related ecosystems (e.g., forests and mountains) are covered elsewhere in the SDGs, SDG Indicator 6.6.1 focuses exclusively on waterbodies/wetlands (UNSD, 2018d).

The SEEA provides a flexible framework for collating and integrating data to support reporting on progress towards SDG 6.6.1 with respect to different types of water-related ecosystems (including freshwaters). This will also support countries in other international reporting commitments, in particular under the Ramsar International Convention on Wetlands. The Ramsar Convention (2005) explicitly recognises the dependence of human well-being on wetland ecosystem services and the role of wetlands (including open waters) in supporting sustainable development. By providing an integrated measurement approach that is consistent with a wide range of economic and social statistics, the SEEA provides a pathway for integrating this type of information on wetland benefits into a wide range of policy actions and sector plans, in the spirit of the Ramsar Convention.

The importance of appropriate validation and quality assurance by national statistics offices of the accounting outputs discussed in this note, and the input data required for the changes they track, is highlighted and stressed. A summary of this Policy Framework for SDG 6.6.1 and related policy entry-points is provided in Appendix D.

6.1 Concepts and definitions

UN Environment and the Ramsar International Convention on Wetlands (hereafter, Ramsar) are co-custodians for SDG Indicator 6.6.1. As such, there are two metadata documents hosted in the SDG metadata repository for SDG 6.6.1.

UN Environment maintain the metadata information for SDG 6.6.1a, which relates to measurement of changes in the extent of: vegetated wetlands; rivers and estuaries; lakes; and, artificial waterbodies (UNSD, 2018d). UN Environment (n.d.-a) set out a 2 level progressive monitoring approach for SDG Indicator 6.6.1. Level 1 comprises of Sub-indicator 1 – spatial extent of water-related ecosystems (excluding aquifers). The methodology for this sub-indicator is now classified as a Tier I SDG indicator, meaning it is conceptually clear, has an internationally established and available methodology and standards and data are regularly produced for at least 50 per cent of countries and of the population in every region where the indicator is relevant. Level 1, Sub-indicator 2 – water quality of lakes and artificial water bodies adds a condition component to the measurement of the spatial extent of water-related ecosystems. In Level 2, a further 3 sub-indicators are proposed (discharge in rivers and estuaries; water quality indicators from SDG Indicator 6.3.2; and, groundwater quantity in aquifers).

Ramsar maintain the metadata for SDG 6.6.1b (UNSD, 2018e). Whilst the methodology outlined for SDG 6.6.1b focuses on wetlands specifically, the internationally agreed Ramsar typology of wetlands is broad and includes all freshwater, saline, brackish, alkaline, and subterranean waters. These are aggregated and changes in extent are reported on under the following categories: marine/coastal; inland; and human-made. These data are obtained from the national wetland inventories produced and reported on by Ramsar Member States.

There are a number of concepts and definitions used in the analysis of water-related ecosystems. In particular, the definitions of wetlands employed by countries are noted to vary considerably

(UNSD, 2018e). This note adopts the definitions proposed by UN Environment and Ramsar with respect to calculating SDG 6.6.1 (UN Environment, n.d.-a; UNSD, 2018d, 2018e). This section sets out these particular concepts and definitions for the avoidance of doubt:

SDG Indicator 6.6.1: Change in the extent of water-related ecosystems over time.

Wetlands: In accordance with Article 1.1 of the Ramsar Convention *"Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres"* (UNSD, 2018e).

Open water: As per UN Environment (no date a), this comprises the combined spatial extent of lakes, rivers, estuaries, and artificial waterbodies.

Artificial waterbodies: As per UN Environment (no date a), these comprise open waterbodies created by humans, such as reservoirs, canals, flooded mines and quarries.

Vegetated wetlands: As per UN Environment (no date a), these comprise all wetland areas as defined by Article 1.1. of the Ramsar Convention, with the exception of open water and wetlands containing saltwater (brackish is included). The omission of saltwater wetlands reflects the concern of SDG 6.6 with drinking water. However, information on the extent of saltwater wetland should still be organised within the SEEA to ensure a collectively exhaustive typology of wetlands informs the ecosystem accounting process.

Extent: For SDG 6.6.1 this is expanded beyond spatial extent to also include the quality, and the quantity of water-related ecosystems. This approach aligns well with the measurement of the 'stocks' of ecosystem assets in the SEEA EA, in terms of their extent and condition.

Change: A shift from one condition of extent to another over time, within a water-related ecosystem, measured against a point of reference.

Once suitable information on the extent of all the water-related ecosystems has been obtained, SDG 6.6.1 indicator *(Change in the extent of water-related ecosystems over time)* can be calculated. This is calculated as the sum of changes in the spatial extent of each water-related ecosystem type i $(i = 1\ to\ n)$ over a period t_0 to t_1, divided by the total spatial extent of all wetland ecosystem types i $(i = 1\ to\ n)$ at the start of that period (i.e., at t_0). The opening year extent is subtracted from the closing year extent so that reduction in the extent of water-related ecosystems over an accounting period are expressed as a negative percentage. This is set out in equation 3 below, where the result is multiplied by 100 to express the change as a percentage:

$$SDG\ 6.6.1 = \left(\frac{\sum_{i=1}^{n}\left(Spatial\ Extent_{it_1} - Spatial\ Extent_{it_0}\right)}{\sum_{i=1}^{n} Spatial\ Extent_{it_0}}\right) \times 100 \qquad (eq.3)$$

6.2 SEEA EA Accounts for Water-Related Ecosystems.

This section sets out an approach to compile SEEA EA Accounts for organising information on water-related ecosystem extent that can support the calculation of SDG 6.6.1. The approach draws directly on outputs from the Expert Meeting on SEEA Indicators for SDGs and Post 2020 Agenda, organised by UNEP-WCMC and UNSD in February 2019 and funded via the NCAVES project.[15]

[15] During the course of this workshop a group of environmental policy, ecosystem assessment and environmental-economic accounting experts drafted initial methodological approaches to align the SEEA and SDG 6.6.1, SDG 11.7.1 and SDG 15.3.1. The web page for the workshop can be visited at: https://seea.un.org/events/expert-meeting-seea-indicators-sdgs-and-post-2020-agenda

6.2.1 Relevant accounts and classifications

Ecosystem accounting requires the delineation of areas within a country into mutually exclusive collectively exhaustive (MECE) spatial units that represent ecosystem assets. This requires a typology that suitably represents all ecosystems in an ecosystem accounting area and spatially explicit information on extent of all these ecosystem types, including water-related ecosystems. This creates some challenges given that a number of wetland types occur at the transition between water and land ecosystems and may also be seasonal in nature. Nonetheless, assuming this information on the extent of water-related and other ecosystems can be classified via an appropriate typology, it is then organized by the ecosystem extent account (see Figure 2). Given the focus of SDG Indicator 6.6.1 is on the extent of water-related ecosystems, the ecosystem extent account it is a priority account for calculating this indicator.

However, as part of a progressive monitoring approach to SDG 6.6.1, UN Environment (no date a) propose a complementary indicator for the water quality of lakes and artificial waterbody ecosystems. Data on water quality parameters for these specific ecosystem types can be organized within the Ecosystem Condition Account (Figure 2). Water quality is clearly relevant to the ability of these ecosystems to supply freshwater suitable for consumptive uses. As such, compiling Ecosystem Condition Accounts for lakes and artificial waterbodies will also be relevant to reporting on SDG 6.6.1.

It is highlighted that aquifers are not considered within this technical note. Whilst considered out of scope of the SEEA EA (at least in current applications), they are still relevant to SDG 6.6.1. The accounts set out in the SEEA Water subsystem, would allow for organising information aquifers that could contribute to this more progressive reporting on SDG 6.6.1.

6.2.2 Compiling an ecosystem extent account using a global ecosystem typology

Table 6 shows an ecosystem extent account for an ecosystem accounting area (EAA) containing 18 of the global IUCN ecosystem types (IUCN ETS) described in Section 2.1.1. The structure of the rows in Table 1 corresponds to the basic logic of asset accounts, as described in the SEEA Technical Recommendations. Rows are provided for recording the opening extent (in hectares (ha)), closing extent, net change, additions and reductions.

The additions and reductions rows in Table 15 capture the gross changes in extent over an accounting period. For example, with Boreal and temperate fens (FT1.6) extent, reductions in extent may be due to drainage for agriculture. This would be captured as a managed regression. For large reservoirs (F4.1), increases in extent due to managed expansion would be anticipated over time to cater for increase demand for water storage in an EAA. Table 15 also allows for additions and reductions associated with natural processes and reappraisals due to obtaining better data on ecosystem extent. In order to calculate SDG Indicator 6.6.1, the aggregate extent of ecosystem types meeting the definition of water-related ecosystem types should be calculated for the open and closing periods and the change calculated and recorded in the ‘TOTAL AREA OF WATER-RELATED ECOSYSTEMS’ column (described in Section 0).

6.2.3 Compiling an ecosystem extent account using a national ecosystem typology

The ecosystem extent account using the IUCN ETs presented in Table 15 is intended to provide a presentation of ecosystem extent that can be aggregated across countries to inform regional and global ecosystem extent accounting and consistent comparisons across countries. As described in Section 2.1, it is anticipated that countries will also require their own ecosystem typology and maps for accounting and other purposes.

Generally, national ecosystem typologies and maps will provide a higher resolution of different ecosystem assets in the national landscape. However, for the case of water-related ecosystems, the IUCN ETs are relatively detailed, notably for wetlands (discussed further in Section 0). The detailed Ramsar typology is provided in UNSD (2018d), which also provides a detailed typology for wetlands that will also be useful for developing a national typology that will help with reporting to the Ramsar convention.

Whilst the extent of open waters is relatively straightforward to ascertain, identifying and mapping wetland ecosystems is challenging. Amani *et al.*, (2019), provide an example for Canada based on applying the Canadian Wetland Classification System of five classes: Bog; fen; marsh; swamp; and, shallow water. This is similar to the level of disaggregation of wetlands that might be expected from applying the IUCN ETs.

Table 15 highlights the benefits of being able to identify different types of vegetated wetlands. For example, Subtropical/temperate forested wetlands (FT1.3) provide information on the extent of forest as well as wetlands. This illustrates the benefit of using data on multiple ecosystem characteristics when delineating and mapping wetlands. For instance, in many land cover and ecosystem typologies, non-permanent wetlands may not be identifiable if they are mapped to other land cover or ecosystem types (e.g., just ‘forest’ in this example). When starting with maps / typologies of this nature, further disaggregation of ecosystem types will be necessary to identify the full extent of wetlands.

As part of the Satellite-based Wetland Observation Service (SWOS) initiative, Fitoka *et al.*, (2017) present a set of wetland ecosystem classes to integrate into the MAES ecosystem typology, as specific sub-types. This typology underpins the European Union (EU) Mapping and Assessment of Ecosystems and their Services (MAES) project (MAES, 2013) and the EU Knowledge Innovation Project on Integrated Natural Capital Accounting (KIP-INCA). An alternative approach may be to establish satellite ecosystem extent accounts for wetlands. However, this does create issues for reconciling information on wetlands with wider ecosystem information in the SEEA EA framework. However, it also creates a structure in which to organise all wetland information together.

It is also important that any national ecosystem typology employed can be cross-walked to the IUCN ETs for consistent international comparisons and aggregations. Further cross-walking these typologies to, at least, the minimum level of resolution required for SDG 6.6.1 and Ramsar reporting is also essential if the ecosystem extent accounts are going to support these reporting commitments. This crosswalk should be documented, for example using the type of structure presented in Section 0, Table 17.

Table 15: Ecosystem Extent Account using IUCN Global ETs

	Ecosystem type (IUCN ET)																					
	T2.2 Temperate deciduous forests and shrublands	T4.4 Temperate wooded savannas	T4.5 Temperate grasslands	T6.4 Temperate alpine meadows and shrublands	T7.1 Croplands	T7.2 Sown pastures and old fields	T7.3 Plantations	T7.4 Urban and infrastructure lands	FT1.2 Seasonal floodplain marshes*	FT1.3 Subtropical/temperate forested wetlands*	F1.1 Permanent upland streams*	F1.2 Permanent lowland rivers*	F2.2 Large permanent freshwater lakes*	F2.3 Small permanent freshwater lakes*	F4.1 Large reservoirs*	MFT1.1 Coastal river deltas*	MFT1.3 Intertidal marshes*	FM1.2 Permanently open riverine estuaries and bays*	TOTAL AREA OF WATER-RELATED ECOSYSTEMS*	TM1.3 Sandy Shores	M1.7 Subtidal sandy bottoms	TOTAL AREA
Opening Stock (ha)																						
Additions to stock																						
Managed expansion																						
Natural Expansion																						
Upward reappraisals																						
Other additions																						
Total additions to stock																						
Reductions in stock																						
Managed regression																						
Natural Regression																						
Downward reappraisals																						
Other reductions																						
Total reductions in stock																						
Net change in stock																						
Closing stock (ha)																						

* Blue Indicates ecosystem types relevant to water-related ecosystems and SDG target indicator 6.6.1

6.2.4 Water-related ecosystem condition accounts

As highlighted by UN Environment (no date a), the concept of extent of water-related ecosystems goes beyond spatial area to include quality, as well as quantity. This is also clearly relevant to the measurement and maintenance of the ecological characteristics of wetlands committed to by the signatories of the Ramsar Convention.

The SEEA EA Ecosystem Condition Accounts provide a framework for organizing information on the quality of water-related ecosystems. The SEEA EEA Technical Recommendations suggest reporting 'condition' as opening and closing stocks for given years, and provides an example table (Table 4.1). Table 16 provides an example Ecosystem Condition Account for lakes and artificial water bodies, reflecting the focus of UN Environment (no date a) on the quality of these ecosystems.

Table 16: Ecosystem Condition Account for Lakes and artificial water bodies

UNEP 6.6.1 Classifications>>		Lakes	Artificial
*Suspended matter (TSS)**	*Opening condition*		
	Closing condition		
*Chlorophyll A**	*Opening condition*		
	Closing condition		
*pH^*	*Opening condition*		
	Closing condition		
*Nutrient concentrations (N)^*	*Opening condition*		
	Closing condition		
*Nutrient concentrations (P)^*	*Opening condition*		
	Closing condition		
*Dissolved oxygen^*	*Opening condition*		
	Closing condition		
*Electrical Conductivity^*	*Opening condition*		
	Closing condition		
Temperature	*Opening condition*		
	Closing condition		
Ammonia	*Opening condition*		
	Closing condition		
Dissolved organic carbon (DOC)	*Opening condition*		
	Closing condition		
Salinity	*Opening condition*		
	Closing condition		
Biological Oxygen Demand (BOD)	*Opening condition*		
	Closing condition		
Bacterial coliforms	*Opening condition*		
	Closing condition		
Water-related species populations richness / abundance	*Opening condition*		
	Closing condition		
Alien invasive species abundance	*Opening condition*		
	Closing condition		
Endemic species abundance	*Opening condition*		
	Closing condition		

*Identified as water quality indicators for sub-indicator 2 of SDG 6.6.1.

^ Identified as water quality indicators for sub-indicator 4 of SDG 6.6.1.

The columns in Table 16 can be disaggregated further to accommodate the national, Ramsar or IUCN ET typologies. Further columns could also be added to allow for the condition of a wider range of water-related ecosystems to be reported on.

Total Suspended Solids (TSS) and Chlorophyll A are identified as two parameters of water quality for reporting on SDG 6.6.1 (UN Environment, no date a). These are included as the first two condition parameters in Table 16, identified by an asterisk "*". In addition, UN Environment (no date a) propose a more comprehensive suite of water quality parameters for higher level reporting for SDG 6.6.1. These are identified by a caret "^" in Table 16.

The remaining water quality parameters included in Table 16 are an indicative and non-exhaustive selection proposed at the Expert Meeting in Cambridge. Additional condition parameters may also be considered. For example, river flow is proposed as a condition parameter for river ecosystems in the SEEA EA (see Table 4.4, p83, UN *et al.*, 2014b). This condition parameter is also presented in National River Ecosystem accounts for South Africa (Nel & Driver, 2015) and is identified as relevant to SDG 6.6.1 (UN Environment, n.d-a). Other parameters could include the degree of modification (canalisation, barrages, and reservoirs), fragmentation or connectivity. A wider range of species indicators could also be incorporated into Table 16, for example population indexes of harvested species or the abundance of species that are sensitive to water quality (e.g., pollution) and whose presence is an indicator of 'good' condition. However, it will be important to select those of most relevance and for which the resources are secured to regular provide consistent data and integrate this into accounts.

6.3 Calculating SDG 6.6.1 from the Ecosystem Extent Account

As set out in equation 3, SDG 6.6.1 is calculated as the sum of changes in the spatial extent of each water-related ecosystem type i $(i = 1 \; to \; n)$ over a period t_0 to t_1 (closing extent minus opening), divided by the total spatial extent of all wetland ecosystem types i $(i = 1 \; to \; n)$ at the start of that period (i.e., at t_0):

$$SDG\ 6.6.1 = \left(\frac{\sum_{i=1}^{n}\left(Spatial\ Extent_{it_1} - Spatial\ Extent_{it_0}\right)}{\sum_{i=1}^{n} Spatial\ Extent_{it_0}}\right) \times 100 \qquad (eq. 3)$$

In order to calculate equation 3, a decision needs to be made on the water-related ecosystem types that should contribute to the calculation of SDG 6.6.1. This should be a national decision based on the national ecosystem typology employed. As an example, Table 17 presents the IUCN Ecosystem Types considered to be most relevant to water-related ecosystems. Table 17 also provides a proposed crosswalk to the most aggregated level of the UNEP SDG 6.6.1 and Ramsar classes for wetlands to help inform associated reporting processes.

It is highlighted that aquifers and subterranean wetlands are excluded from Table 17 as these are considered out of scope of the SEEA EA (aquifers would be considered by the SEEA Water subsystem). Following UNSD (2018c), saline ecosystems are also excluded from Table 17 given they are unlikely to contribute to freshwater supply. As such, shoreline systems, such as Sandy Shores (TM1.3), shown in Table 15, are also excluded. For the same reason, salt lake ecosystems are excluded. However, ecosystems associated with brackish waters are included. The ecosystems considered as 'water-related ecosystems' are identified with an asterisk in Table 15. However, it is highlighted that this has not been validated and any final decision must be via an appropriate and authoritative national consensus.

Referring to the notation in equation 3, once all the number (n) of relevant ecosystem types for water-related ecosystems have been identified the net change in extent of each type (i), as shown in the ecosystem extent account (Table 15) over the accounting period should be determined. This is equivalent to $Spatial\ Extent_{it_1} - Spatial\ Extent_{it_0}$ in equation 3. These net changes should be summed to calculate the numerator of Equation 3. The extent of each type (i) for the opening period (t_0) should then be determined from Table 15 and summed to calculate the denominator for Equation 3. The SDG 6.6.1 indicator (Equation 3) can then readily be calculated.

Table 17: Crosswalk from IUCN ecosystem typology to UNEP SDG 6.61 and Ramsar aggregated classes

IUCN Ecosystem Type	National Ecosystem Typolog	UNEP SDG 6.6.1	Ramsar SDG 6.6.1
F1.1 Permanent upland streams	List all relevant types......	Rivers and estuaries	Inland wetlands
F1.2 Permanent lowland rivers	List all relevant types......	Rivers and estuaries	Inland wetlands
F1.3 Freeze-thaw rivers and streams	List all relevant types......	Rivers and estuaries	Inland wetlands
F1.4 Monsoonal upland stream	List all relevant types......	Rivers and estuaries	Inland wetlands
F1.5 Monsoonal lowland rivers	List all relevant types......	Rivers and estuaries	Inland wetlands
F1.6 Arid episodic lowland rivers	List all relevant types......	Rivers and estuaries	Inland wetlands
F2.1 Freeze-thaw freshwater lakes	List all relevant types......	Lakes	Inland wetlands
F2.2 Large permanent freshwater lakes	List all relevant types......	Lakes	Inland wetlands
F2.3 Small permanent freshwater lakes	List all relevant types......	Lakes	Inland wetlands
F2.4 Ephemeral freshwater lakes	List all relevant types......	Lakes	Inland wetlands
F4.1 Large reservoirs	List all relevant types......	Artificial waterbodies	Human-made wetlands
F4.2 Rice paddies	List all relevant types......	Vegetated wetlands	Human-made wetlands
F4.3 Constructed lacustrine wetlands	List all relevant types......	Vegetated wetlands	Human-made wetlands
F4.4 Canals and storm water drains	List all relevant types......	Artificial waterbodies	Human-made wetlands
FT1.1 Tropical flooded forests and peat forests	List all relevant types......	Vegetated wetlands	Inland wetlands
FT1.2 Seasonal floodplain marshes	List all relevant types......	Vegetated wetlands	Inland wetlands
FT1.3 Subtropical/temperate forested wetlands	List all relevant types......	Vegetated wetlands	Inland wetlands
FT1.4 Episodic arid floodplains	List all relevant types......	Vegetated wetlands	Inland wetlands
FT1.5 Boreal, temperate and montane peat bogs	List all relevant types......	Vegetated wetlands	Inland wetlands
FT1.6 Boreal and temperate fens	List all relevant types......	Vegetated wetlands	Inland wetlands
FT1.7 Artesian springs and oases	List all relevant types......	Vegetated wetlands	Inland wetlands
FT1.8 Geothermal wetlands	List all relevant types......	Vegetated wetlands	Inland wetlands
FM1.2 Permanently open riverine estuaries and bays	List all relevant types......	Rivers and estuaries	Coastal marine wetlands
MFT1.1 Coastal river deltas	List all relevant types......	Vegetated wetlands	Coastal marine wetlands
MFT1.2 Intertidal forests and shrublands	List all relevant types......	Vegetated wetlands	Coastal marine wetlands
MFT1.3 Intertidal marshes	List all relevant types......	Vegetated wetlands	Coastal marine wetlands

6.4 Aligning the SEEA and SDG 6.6.1

A very detailed ecosystem typology is needed to ensure all water-related ecosystems that contribute to SDG 6.6.1 are distinguished in the ecosystem extent accounts. This may not be possible in all cases and discrepancies may arise between the extent of water-related ecosystems identified via the ecosystem extent accounts and those reported under SDG 6.6.1. The most likely cause of this is where areas of vegetated wetlands become conflated or subsumed within another ecosystem type. Where this situation arises bridging tables can be employed to show the relationship between measures of data in the SEEA Ecosystem Extent Account and measures under different reporting mechanisms.

Table 18 provides an example of where a bridging table may be employed in the context of SDG 6.6.1. The example is based on the Ramsar definition of wetlands, which includes seasonally flooded agricultural land. It is possible that these areas of agricultural land may be reported within the IUCN ET Sown pastures and old fields (T7.2) in an ecosystem extent account. In this scenario, the extent of seasonally flooded agricultural land needs to be identified and added to the extent of water-related ecosystems recorded in the ecosystem extent account (Table 15) and the extent of these areas reported under SDG 6.6.1.

Table 18 provides a bridging table illustrating this example. It is highlighted this example is purely illustrative, any bridging tables must be developed with the National Focal Points to identify which ecosystem types may generate such discrepancies.

Table 18: Bridging table for Ecosystem Extent Account and SDG 6.6.1.

Summary Water-Related Ecosystem Extent Bridging Table showing relationship of Ecosystem Extent Accounts measure to SDG 6.6.1		*Water-related ecosystem extent (ha)*		
	+/-[9]	**2005**	**2010**	**2015**
Ecosystem Extent Account - Extent of water-related ecosystem types		**42,000**	**41,000**	**40,500**
minus	(-)			
plus Extent of seasonally flooded agricultural land in T7.2 Sown pastures and old fields	(+)	5,000	4,000	3,900
Water-related ecosystem extent reported under SDG 6.6.1		**47,000**	**45,000**	**44,400**

6.5 Extensions

Extending the set of accounts to include information on the flows of ecosystem services from wetlands to different beneficiaries will be of fundamental interest to land planners and other decision makers. A non-exhaustive list of wetland related ecosystem services and potential data sources on these ecosystem services (in brackets) that could inform the compilation of such accounts is highlighted below.

- Provisioning ecosystem services
  - Water supply / withdrawals (FAO Aquastat[16])
  - Food (e.g., fisheries, aquaculture, honey, molluscs, crabs, etc.)
  - Wetland products (e.g., Papyrus, fuel/wood fuel, etc.)
- Regulating/supporting
  - Flood control (See SWOS[17])
  - Groundwater replenishment (Global dataset on transboundary aquifers[18])
  - Water purification
- Cultural
  - Recreation and tourism

An integration of the information in a comprehensive set of SEEA EA Accounts, including the condition (e.g., water quality) of freshwater ecosystems and the water supply services with the SEEA Water subsystem would deliver an extremely comprehensive information set for SDG 6.6. In addition to providing important economic uses of water, the SEEA Water also provides a framework for organising information on water stocks within aquifers. This is of direct relevance to SDG 6.6.1 and the higher level of monitoring proposed by UN Environment (no date a).

6.6 Data sources

Wetlands are often highlighted as one of the most important ecosystems globally for biodiversity and ecosystem services supply. However, there have been very few good quality wetland extent estimates at national and continental scales and even fewer providing time series estimates of changes in extent. Consequently, the data challenges in estimating SDG 6.6.1 should not be underestimated. A global wetland inventory or a single, large-scale monitoring system for

[16] http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en
[17] http://portal.swos-service.eu/mapviewer/detail/1.html#/wetland/23/product
[18] https://www.un-igrac.org/global-groundwater-information-system-ggis

wetlands that would allow assessment of both the current status and long-term changes in wetlands, has yet to be implemented (Ramsar Convention, 2018a). The remainder of this section sets out a number of national and global sources of data relevant to compiling water-related ecosystem extent and condition accounts that currently exist, or are under active development.

6.6.1 National extent data

Many countries will maintain their own maps on land cover and, potentially, ecosystems. These may provide a ready source of information on the extent of open water ecosystems and permanent wetlands. Some countries and regions may also benefit from specific products that provide spatial data on surface water extent. For example, the Australian government hosts the Water Observations from Space (WOfS) platform that displays the detected surface water from the Australia-wide Landsat 5 and Landsat 7 satellite imagery archive.[19]

The national inventories reported to Ramsar will also be a fundamental information resource for determining the extent of wetlands and reporting on SDG 6.6.1 (as described in UNSD, 2018c). These are the established information sets, for example informing on regional wetland assessments (e.g., Geijzendorffer *et al*., 2018). These national inventories and associated field samples are also essential data for validating remote sensing approaches, and for training the necessary algorithms for classifying wetland areas using remote-sensed data. This provides a practical means to assist countries in mapping the extent of all types of wetlands and updating their national wetland inventories (or a baseline pre-inventory for validation where they are missing). As an example, Amani *et al*., (2019) present a methodology for classifying wetland areas using a combination of Land-sat 8 imagery and a large national inventory of field samples for Canada to predict wetland areas. In their approach, they use the Google Earth Engine to run the classification algorithms for wetland areas. This mitigates the requirement for large, local processing power for a study area the size of Canada and the need to download very large Land Sat imagery files.

The above example highlights that significant technical support may be necessary to develop geospatial data on vegetated wetland extent particularly. Nonetheless, methods are available and established and the possibilities to implement these on a country by country basis have been demonstrated and exist.

6.6.2 Global extent data

Various global, high-resolution datasets which document the extent and change in specific wetland types, have recently been released and made publicly available (Ramsar Convention, 2018b). A key resource in this context is the SDG 6.6.1 data explorer, which measures the extent of water related ecosystems and their changes over time (UN Environment, n.d.-b). This provides global data on the extent of permanent and seasonal waterbodies and associated transition classes, as classified via the EU JRC Global Surface Water Explorer (Pekel et al., 2016). However, it is acknowledged that this data does not capture the full extent of some vegetated wetlands that are not subject to periodic inundation (UN, 2018).

As UN Environment (no date a) highlights, identifying vegetated wetland extent is more challenging than for open waterbodies. It requires the integration of multiple data on physical properties of wetland (soil and vegetation water contents) and wider data on topography, hydrography, drainage, and soil types. A selection of global data source that can assist countries in the identification and delineation of water-related ecosystems is provided in Table 19.

[19] https://www.ga.gov.au/scientific-topics/hazards/flood/wofs

Table 19: Global data sources for water-related ecosystem extent

Data holder	Data source	Description	Time series	Data sharing
UNEP	JRC Global Surface Water Explorer	Global data on the extent of permanent and seasonal waterbodies and associated transition classes. GEOTiff files that can be downloaded for countries.	Annual from 2001	Open Access: https://www.sdg661.app/data-products/data-downloads https://landsatlook.usgs.gov/
WWF	Global Lakes and Wetlands Database	GIS functionality enabled database which focuses in three coordinated levels on (1) large lakes and reservoirs, (2) smaller water bodies, and (3) wetlands.	Not time series	Open Access: https://www.worldwildlife.org/pages/global-lakes-and-wetlands-database
NASA	SEEA-MODIS	Provides annual land cover products based on the FAOSTAT Land Cover Classification System 3, which is adopted for the SEEA land Cover Classes.	Annual (1992 – 2015)	Open Access: https://modis.gsfc.nasa.gov/data/dataprod/mod12.php
ESA	SEEA-CCI-LC	Provides annual land cover products based on the FAOSTAT Land Cover Classification System 3, which is adopted for the SEEA land Cover Classes.	Annual (1992 – 2015)	Open Access: https://www.esa-landcover-cci.org/
SWOS	SWOS	Mapping products and derived products and indicators can be used to map the extent of ecosystems in Europe and worldwide.	Various	Open Access: https://www.swos-service.eu/
UNEP-WCMC	Global Mangrove Watch	Provides geospatial information about mangrove extent and changes.	1996; 2007; 2008; 2009; 2010; 2015; 2016	Open Access: https://data.unep-wcmc.org/datasets/45
ESA & Ramsar	GlobWetland	A platform for informing on wetlands in Africa.	Under development	Open Access: http://globwetland-africa.org/
Copernicus Land Services	Water and wetness probability index (WWPI)	Provides geospatial data product that includes a water and wetness probability index for Europe	2006; 2009; 2012; 2015	Open Access: https://land.copernicus.eu/pan-european/high-resolution-layers/imperviousness

The GEO-Wetlands initiative is supporting the development of a Global Wetlands Observing System (GWOS), which will provide centralized access to wetland related data. This may deliver further data and platforms for assessing water-related ecosystems in the near future. This concept is supported by Ramsar, who also provide guidance on the use of Earth observation for wetland assessment (Ramsar Convention, 2018b).

6.6.3 Ecosystem condition data

There are a number of satellite-based Earth observation products under development to support the measurement of Chlorophyll A and Total Suspended Solids in freshwaters and other wetlands. For example, via the European Space Agency, NASA and under the auspices of the Group on Earth Observations Aquawatch initiative.[20] The EU Copernicus Programme has released a global product for selected lakes,[21] including those in the Global Lakes and Wetlands Database. Changing concentrations in these parameters can also be derived from existing satellite data (e.g., Land Sat) where the appropriate algorithms are developed and implemented (UN Environment, n.d.-a).

Nonetheless, there appears to be a very limited number of derived geospatial data products currently available for directly and readily informing on ecosystem condition parameters for wetlands, including for Chlorophyll A and Total Suspended Solids. Further information on the use of satellite-based Earth Observation data for measuring ecosystem condition parameters for wetlands is provided in Ramsar Convention (2018b). The national inventories reported to Ramsar also provide a key resource for national data on a wide range of parameters relevant to ecosystem condition (UNSD, 2018c).

[20] https://www.geoaquawatch.org/
[21] https://land.copernicus.eu/global/products/lwq

7 Public open spaces in urban areas – SDG 11.7.1

This technical note pertains to SDG Target 11.7: *By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities*. Specifically, it describes the role of the SEEA in supporting the calculation of SDG Indicator 11.7.1: Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities. SDG 11.7.1 is a Tier II SDG indicator, meaning it is conceptually clear, established methodology and standards are available but data are not regularly produced by countries.

UN-Habitat (2017) identifies that cities require monitoring systems that provide clear indicators (including for SDG 11.7.1) and baseline data to support a city in its long term planning to achieve sustainable development goals and targets. This requires a coordination of national statistical offices with local authorities, service providers and numerous other stakeholders that individual cities accommodate. The SEEA EA can assist in this regard by providing a transparent, internally consistent framework to establish baselines and bring together the necessary institutions with multiple interests for data collection to support regular reporting of urban indicators.

The importance of appropriate validation and quality assurance by national statistics offices of the accounting outputs discussed in this note, and the input data required for the changes they track, is highlighted and stressed. A summary of the Policy Framework for SDG 11.7.1 and related policy entry-points is provided in Appendix D.

7.1 Concepts and definitions

There are a number of concepts and definitions used in the analysis of cities and associated urban spaces. Indeed, different countries and administrations often define cities and urban or municipal areas in different ways. This note adopts the definitions proposed by the UN Human Settlements Programme (UN-Habitat) with respect to these and associated concepts. These definitions are taken directly from the SDG 11.7.1 Metadata Sheet, for which the UN- Habitat is custodian (UNSD, 2018a). This section sets out these particular concepts and definitions for the avoidance of doubt.

SDG Indicator 11.7.1: Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities

City: A city is defined by its urban extent.

Urban extent: The total area occupied by the built-up area and the urbanized open space. It consists of all the buildings and small open spaces (<200ha) that are surrounded by buildings plus the open space fringe within 100m of urban and suburban areas (UN-Habitat, 2018).

Built-up area: The contiguous area occupied by buildings and other impervious surfaces. It comprises of Urban and Suburban built up areas.

Urban built-up area: Defined by a density of built-up area of >50% within a 1km walking circle of any building (a circle of around 564m radius). Defined in measurement terms by the grid cells or pixels with this characteristic in GIS format.

Suburban built-up area: Defined by a density of built-up area of 25-50% within a 1km walking circle of any building (a circle of around 564m radius). Defined in terms of grid cells or pixels with this characteristic in GIS format.

Rural built-up area: Defined by a density of built-up area of <25% within a 1km walking circle of any building (a circle of around 564m radius). Defined in terms of grid cells or pixels with this characteristic in GIS format.

Urbanized open space: Mainly refers to unbuilt areas including open countryside, forests, crop fields, parks, unbuilt urban areas, cleared land. Urbanised open space comprises of fringe open space and the captured open space in urban and suburban built-up areas.

Fringe open space: Consists of all open space within 100 meters of urban or suburban areas. Defined in terms of grid cells or pixels with this characteristic in GIS format.

Captured open space: Consists of all open space clusters that are fully surrounded by urban and suburban built-up area that are less than 200 hectares in area.

Streets: Thoroughfares that are based inside towns, cities and neighbourhoods most commonly lined with houses or buildings used by pedestrians or vehicles in order to go from one place to another in the city, interact and to earn a livelihood.

Streets space: Comprises streets, avenues and boulevards, pavements, passages and galleries, Bicycle paths, sidewalks, traffic islands, tramways and roundabouts. Elements excluded from street space include plots (either built-up or not), open space blocks, railways, paved space within parking lots and airports and individual industries.

Land allocated to streets: Refers to the total area of urban surface that is occupied by all forms of streets (as defined above).

Public space: All places of public use, accessible by all, and comprises open public space and streets space for the purpose of reporting on SDG Indicator 11.7.1 (UN-Habitat, 2018).

UN-Habitat's Member States have mandated the agency to develop an approach that promotes the role of public space in meeting the challenges of our rapidly urbanizing world and to assist cities in their initiatives on public space management and monitoring. UN-Habitat have provided a methodological approach for calculating SDG 11.7.1 as a contribution to promoting public spaces in urban development (See UNSD, 2018). This comprises of the following three step process:

1) Spatial analysis to delimit the built-up area of the city (total built up area);
2) Spatial analysis to identify potential open public spaces, field work to validate data and asses the quality of spaces and calculation of the total area occupied by the verified open public spaces (total area of public open space); and,
3) Estimation of the total area allocated to streets (total area allocated to streets);

The final computation of the SDG 11.7.1 target indicator comprises the calculation of the *share of the built-up area of the city that is open space in public use (%)*, as set out in Equation 4. It is noted that this does not consider accessibility for all, by, age, sex or disability.

$$SDG\ 11.7.1 = \frac{(total\ area\ of\ public\ open\ space + total\ area\ allocated\ to\ streets\ )}{total\ built\ up\ area}\ (eq.4)$$

7.2 SEEA EA Accounts for Urban Areas.

While ecosystem accounts were conceived as a framework for application at a national level, applying the framework at sub-national scales could increase their usefulness to a broader group of policy makers (Wang et al., 2019). Indeed, urban ecosystem accounting using the SEEA is underway, including in the UK (ONS, 2018) and for Oslo, Norway (NINA, 2017).

Wang et al., (2019) provides a discussion paper for the treatment of ecosystem assets in urban areas. This section contributes to this by setting out an approach to compile SEEA EA Accounts for urban ecosystem extent that can support the calculation of SDG 11.7.1. The approach draws directly on outputs from an Expert Meeting on SEEA Indicators for SDGs and Post 2020 Agenda, organised by UNEP-WCMC and UNSD in February 2019 and funded via the EU funded Natural Capital Accounting and Ecosystem Service Valuation project.[22]

During the Expert Meeting it was proposed to have a supplementary SDG 11.7.1 indicator. This aims to provides a better insight into the equitability of the distribution of public open space access in cities. This comprises: ***Average share of the built-up area of cities that is Blue Green space for public use for all, by income distribution, by sub-municipal area***. The focus on Blue Green space, reflects the particular importance of this type of space for cultural ecosystem services and associated well-being benefits, as well as the delivery of regulating and (potentially) provisioning ecosystem services. These spaces may also be more amenable to identification via earth observation approaches, thereby reducing data collection costs. As such, developing SEEA EA accounts to support the calculation of this indicator is also given specific consideration within this technical note.

7.2.1 Relevant accounts and classifications

Ecosystem accounting requires the delineation different ecosystem types within an ecosystem accounting area. When implementing urban ecosystem accounting, this first requires establishing the urban ecosystem accounting area. Once this is determined, with a suitable urban ecosystem typology and associated maps for these urban ecosystem assets, information on their can be organized in an urban ecosystem extent account (as shown in Figure 2). Compiling this account is likely to be the first step in an urban ecosystem accounting process and will provide the core information on public open spaces for reporting on SDG 11.7.1. Understanding if these are distributed in a socially equitable manner will require integrating these data with wider social statistics (e.g., Census data).

Urban planners will also be interested in understanding not just the extent of public open spaces in cities but also the overall condition of these spaces and urban ecosystems more generally. This not only includes environmental qualities, such as green versus blue space, but also elements of design. In particular, facilities that support disabled access and where green / blue elements have been built into other urban ecosystem types. There will also be wider concerns regarding the condition of urban ecosystems, for example with respect to safety, pollution and biodiversity. The SEEA EA Ecosystem Condition Accounts can provide useful framework for organising information on parameters associated with these features of the urban environment. Whilst the ecosystem condition account is not essential for calculating SDG 11.7.1 as set out n Equation 4, it is relevant and a potential Urban Ecosystem Condition Account is presented and discussed with respect to possible extensions in Section 7.5.

7.2.2 Defining the Urban Ecosystem Accounting Area(s)

As highlighted by Wang et al., (2019), the determination of thresholds for including specific areas within an urban ecosystem accounting area is currently uncertain. The approach presented by UN-Habitat for reporting on SDG 11.7.1 is set out below (UNSD, 2018a):

1. Identify the study area, this could be all cities or a representative sample. As urban ecosystem accounting applications have been limited to date, it is likely that these would be progressed on a case by case basis or a small initial sample.

2. Obtain satellite imagery for the analysis area (SDG 11.7.1 proposes LANDSAT imagery).

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[22] During the course of this workshop a group of environmental policy, ecosystem assessment and environmental-economic accounting experts drafted initial methodological approaches to align the SEEA and SDG 6.6.1, SDG 11.7.1 and SDG 15.3.1. The web page for the workshop can be visited at: https://seea.un.org/events/expert-meeting-seea-indicators-sdgs-and-post-2020-agenda

3. Using the satellite imagery for the study area to classify pixels (or Basic Spatial Units (BSUs) in SEEA EA terms[23]) as built up, non-built-up and water.

4. Assess the urban-ness of each pixel (BSU) within the ecosystem accounting area. This is achieved by placing a 1-km^2 circle around each built-up pixel and calculating the share of pixels in the circle that are also built-up. If >=50% of the pixels in the circle are built-up, the pixel is classified as Urban. If >=25% and <50% of the pixels in the circle are built-up, the pixel is classified as Suburban. If <25% of the pixels in the circle are built-up, the pixel is classified as Rural.

5. Combine the contiguous urban and suburban pixels (BSUs) to form the urban cluster of the built up area (i.e., the urban ecosystem accounting area).

Figure 4 presents a stylised diagram of what such as process could yield. The urban areas are identified by the dark grey squares (BSUs or pixels), suburban by the lighter colour squares and rural by white squares. The boundary for the urban built-up area is identified by the thick black line bounding the suburban lighter grey squares. In addition, the approach for defining urban area under SDG 11.7.1 also calls for the inclusion of the fringe open space within 100m of urban and suburban areas (also identified in Figure 4).

It is recognised that different countries and municipalities will have different and established urban boundaries. As such, when compiling urban accounts, the full range of different decision making contexts should be considered. Ideally, urban ecosystem accounts should be developed in a manner that supports decision-makers across multiple contexts by using a flexible spatial data infrastructure for organising information by BSU (or pixel) (see Section 3.6, UN et al., 2017) within different urban boundaries.

7.2.3 Establishing a typology for urban ecosystem assets

Ideally, Urban Ecosystem Extent Accounts should be designed to integrate with national ecosystem extent accounts. As described in Section 2.1, the IUCN Ecosystem Types (IUCN ETs) are proposed as the global ecosystem typology for SEEA EA Ecosystem Extent Accounts. The IUCN ET relevant to urban areas is *T7.4 Urban and infrastructure lands*. As this conflates urban areas with infrastructure lands, there is likely to be some further disaggregation of this ecosystem type in national ecosystem extent accounts. The Urban Ecosystem Extent Accounts themselves, will then provide a more detailed spatial disaggregation of the extent of urban sub-ecosystem types in the Total Urban Extent Area on a city by city basis.

Wang et al., (2019) present a number of options for urban ecosystem typologies based on different policy needs. In terms of establishing a typology for urban ecosystem assets relevant to SDG 11.7.1, the following typology can be employed:

- **Public open green spaces:** These are the areas that instinctively come to mind when thinking about public spaces that are used daily in urban areas (UN-Habitat, 2018). They include parks, recreational areas and civic parks, defined further in UNSD (2018). There may be other types of publicly accessible open green spaces, these include cemeteries, sports fields, vacant abandoned spaces, public access green houses and others. A number of these types of open space identified in Figure 4.

  There may also be publicly accessible open green spaces that are better described via ecosystem typologies. These may include urban wetlands (natural and artificial) and city forests. In Figure 4 these comprise the wetland (either natural or built) and treed squares in the urban and suburban areas.

[23] BSUs are described further in Section 7.6

- **Public open blue spaces:** These comprise rivers, streams, ponds and other water features in the urban, suburban and fringe areas. Figure 4 identifies examples in the suburban area. The quality of these spaces may be particularly variable, for instance some docks may be highly attractive and pleasant environs that are regularly visited. Others may be very industrial or derelict and, whilst accessible, generally not visited by the public.
- **Other public open spaces:** These comprise public open spaces that are not characterised as being green or blue. They may comprise of Squares, Markets and Plazas created because of building agglomeration around an open area (these are defined further in UNSD, 2018). Figure 4 identifies such an area at the centre of the urban built-up area.
- **Private open space:** These are open spaces that area not publicly accessible and do not contribute to SDG 11.7.1. They include private garden plots, as indicated in Figure 4.
- **Area allocated streets:** For both the urban and suburban areas the area allocated streets contributes to SDG 11.7.1. How to calculate the area allocated to streets is not described here but is described in some detail in the metadata for the SDG 11.7.1 indicator (See UNSD, 2018).
- **Building footprint and other infrastructure:** This comprises the remainder of the suburban and urban built up areas.
- **Ecosystem types in fringe areas:** Publicly accessible open spaces in the fringe area are also better described via ecosystem typologies. In Figure 4 these comprise cropland, sandy shore and forest. For coastal cities and towns, publicly accessible beaches, such as sandy shores, will be very important for both residents and visitors. Their presence will also compensate if other blue / green spaces in the urban and suburban areas are limited in extent, although access may be limited to certain times by the tides.

With respect to the green, blue and other public open spaces described above, some assumptions may need to be made with respect to the public accessibility of different spaces. For example, it may be reasonable to assume that cemeteries and sports grounds are publically accessible. However, access times are likely to be restricted and these spaces are often under private ownership. Similarly, for private open spaces, some areas may be accessible via footpaths but full use of the area restricted. Municipal golf course would be potential example here. Any assumptions made should be achieved via some consensus with the relevant stakeholders and the SDG 11.7.1. focal point.

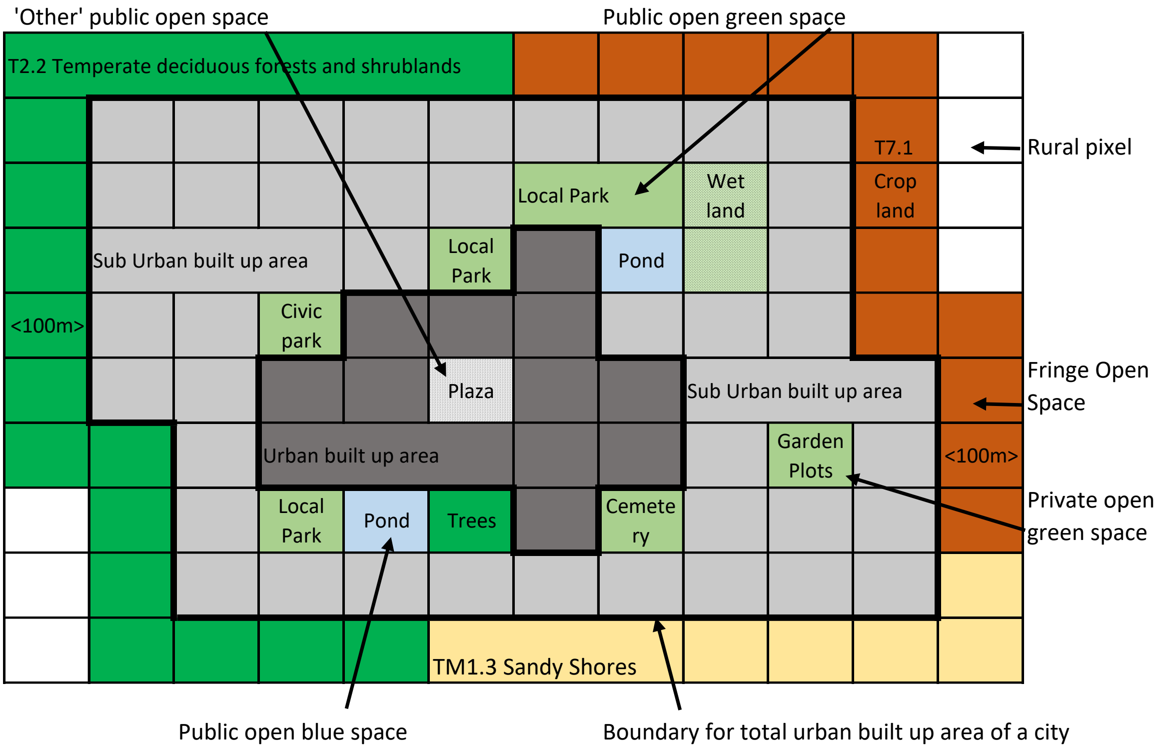

Figure 4: Stylised diagram of urban ecosystem accounting area. Each square represents a 100m BSU

7.2.4 Compiling an urban ecosystem extent account

Table 20 shows an ecosystem extent account for an urban ecosystem accounting area based on the typology described in Section 7.2.3. The structure of the rows in Table 20 corresponds to the basic logic of asset accounts, as described in the SEEA EEA Technical Recommendations. There is a row for recording the opening extent (in hectares (ha)), closing extent, net change, additions and reductions. The additions and reductions rows in Table 20 capture the gross changes in extent over the accounting period (2015 to 2020).

For each of the urban and suburban extents identified in Figure 4, the columns in Table 20 disaggregate these areas into extent of public open green space, public open blue space, other public open space, private open spaces, area allocated to streets, private open space and building footprint and other infrastructure. Table 20 also disaggregates the fringe area into extent of public open green space, public open blue space, other public open space and not publicly accessible space.

In Table 20, the Total Urban Extent generally reflects the definition of urban extent proposed by UN-Habitat (see Section 7.1), essentially comprising the urban extent, suburban extent and the fringe open space within 100m of urban and suburban areas. However, there is one important difference. In Table 20 the threshold for open spaces of 200 ha (i.e., captured open spaces in Section 7.1) is not applied. As such, Total Urban Extent includes these larger open spaces. This is discussed with relevant examples in Section 7.4. The last three columns of Table 20 provide the key information for the measurement of SDG 11.7.1.

Table 20: Urban Ecosystem Extent Account 2015 to 2020

	Urban							Suburban							Fringe open space					TOTAL URBAN EXTENT (Urban + suburban + fringe open sapce)		
Classifications >>	Public open green space^	Public open blue space^	Other public open space	Area allocated to streets	Private open space*	Building footprint and other infrastructure	Total urban area	Public open green space^	Public open blue space^	Other public open space	Area allocated to streets	Private open space*	Building footprint and other infrastructure	Total suburban area	Public open green space^	Public open blue space^	Other public open space	Not publicly accessible	Total fringe open space area	Public open blue / green space	All public open space	TOTAL AREA
Opening Stock (Ha, 2015)																						
Additions to stock																						
Total additions to stock																						
Reductions in stock																						
Total reductions in stock																						
Net change in stock																						
Closing stock (Ha, 2020)																						

^ Public open green and blue space can be disaggregated by ecosystem type (e.g., cropland, wetland and forests in the city or fringe) or detailed descriptors for open space, such as cemetery, local park, etc.

* Private Open Space could be further disaggregated to green, blue and other spaces

As per the footnote in Table 20, it is likely to be useful to urban planners to provide accounts of the extent of the different elements of publicly accessible green space to see how they are represented in the urban landscape. This can be easily achieved using a supplementary extent account for publicly accessible green open space specifically or further disaggregation of columns in Table 20.

7.3 Calculating SDG 11.7.1 from the Urban Ecosystem Extent Account

The Urban Ecosystem Extent Account (Table 20) is the essential ecosystem account for calculating SDG 11.7.1, as per Equation 6:

$$SDG\ 11.7.1 = \frac{(total\ area\ of\ public\ open\ space + total\ area\ allocated\ to\ streets\ )}{total\ built\ up\ area}(eq.6)$$

The penultimate column in Table 20 records the total area of public open space (sum of green, blue and other public open space) in urban, suburban and fringe areas and the area allocated to streets in urban and suburban areas. The value for SDG 11.7.1 is then calculated for 2015 by summing these two measures (their opening stock, see penultimate column and column to right, top row Table 20) by the total urban area (see final TOTAL AREA column, top row Table 20). For 2020 the value for the indicator is similarly calculated using the values in the bottom, closing stock, row.

As highlighted in Section 7.1, **Average share of the built-up area of cities that is Blue Green space for public use for all, by income distribution, by sub-municipal area** was identified as a useful potential indicator for SDG 11.7. This indicator can also be calculated using information from Table 20. The third from last column in Table 20 sums the extent of public open green and blue spaces in the urban, suburban and fringe areas. This can then be dived by TOTAL AREA to calculate the indicator for the opening or closing of the accounting period.

Further information on organising data for urban ecosystem accounting by pixels, grid cells or Basic Spatial Units (BSUs) is provided in Section 7.6. By organizing information using these discrete BSUs, information on publicly accessible green or blue space can be readily aggregated for different sub-municipal areas (as distinct, smaller urban ecosystem accounting areas). Information on income can also be integrated with the information on public open green and blue spaces by BSU (or at least groups of BSU) using spatial socio-economic data (i.e., from census / household survey studies). Pivot tables or similar can then be employed to organize information on the extent of public green or blue public space within specified income categories, thereby to generating this additional indicator.

The approach described above will be incredibly useful to urban planners seeking to ensure equitable and sustainable cities that provide benefits for all. De la Barreraet al., (2016) provide an interesting application of a conceptually similar approach for Santiago, Chile. By organizing information via BSUs within the SEEA EA framework, this approach can be applied to both information in the ecosystem extent and ecosystem condition accounts for urban areas

7.4 Aligning the SEEA and SDG 11.7.1

By design the typology for urban ecosystem accounting areas and types used in Table 20 is consistent with the concepts and definitions for SDG 11.7.1. However, there is a potential discrepancy that may emerge from the thresholds applied to 'open space' areas under SDG 11.7.1. As set out in the metadata sheet for SDG 11.7.1, the urban open spaces comprise fringe open space and captured open space within the urban / suburban area. Where captured open space is defined as all the open areas surrounded by fringe or urban / suburban areas that are less than 200ha area.

The threshold for captured open spaces of <200 ha under SDG 11.7.1, seems somewhat counter intuitive in the context of urban planning. For example, this would omit Central Park in New York (over 300 ha) and Richmond Park in London (over 900 ha). In these examples, it is assumed urban planners would wish to see these parks captured in the ecosystem extent accounts.

Where such discrepancies arise, bridging tables can be used to show the relationship between measures of data in environmental accounts and measures under different reporting mechanisms. Table 8 provides an example bridging table between the extent of publicly accessible open spaces in urban areas in the urban ecosystem extent account (Table 20) and the extent of these areas reported under SDG 11.7.1 based on the central park example.

Table 21: Bridging table for Urban Ecosystem Extent Account and SDG 11.7.1.

Summary Bridging Table showing relationship of Urban Ecosystem Extent Accounts measure to SDG 11.7.1

		Publicly Accessible Urban Open Area Extent (ha)		
	+/-	**2005**	**2010**	**2015**
Ecosystem Extent Account - Extent of publically accessible urban open spaces		**12,500**	**12,200**	**12,250**
minus				
Extent of public open spaces greater than 200 ha in area	(-)	350	350	350
plus				
	(+)			
Extent of publically accessible urban open spaces reported under SDG 15.1.1		**12,150**	**11,850**	**11,900**

UNSD (2018) proposes that national statistics offices will report national figures for SDG 11.7.1 based on data from all cities. However, these will take time to develop. As such, UN-Habitat (2017) provides an approach for countries to select a nationally representative sample of cities for reporting on SDG 11.7.1. This can also be used as a guide to selecting cities for urban ecosystem accounting using the SEEA EA framework. It should also be noted that there may be a requirement to reconcile overlaps between urban ecosystem extent with other ecosystem types in national extent accounts area arising from the inclusion of fringe open space in the total urban extent.

7.5 Extensions

It is highlighted that the characteristics and qualities of public open spaces, especially green and blue public open spaces, will vary significantly. Their location is also an important factor in their capacity to provide services to people. There may also be alternatives that can be built into some areas of the city to provide ecosystem services in the absence of green / blue space, for example green walls and roofs.

The SEEA EA Ecosystem Condition Accounts would be a useful extension for communicating on the environmental quality of cities. The SEEA EEA Technical Recommendations suggest reporting condition as opening and closing stocks for given years and provide an example table (Table 4.1) (UN et al., 2017). Table 22 develops this example table for an Ecosystem Condition Account relevant for urban areas.

As shown in Table 22, the columns organize the total urban extent into their urban, suburban and fringe areas. The rows then provide opening and closing measures for a range of condition metrics relevant to SDG 11. These opening and closing measures reflect the measure of the condition parameter at the beginning and end of the accounting period (e.g., a year). The exception is *Air Pollution Concentrations* where the condition measure reflects the number of days an air quality target was exceeded.

Table 22: Ecosystem Condition Account for Total Urban Extent

	Classifications >>	Urban	Suburban	Fringe open space	TOTAL URBAN EXTENT
Population density (persons / ha)	*Opening condition*				
	Closing condition				
Infrastructure density (floor space ratio)	*Opening condition*				
	Closing condition				
Vegetation (Canopy cover, street tree density)	*Opening condition*				
	Closing condition				
Area of Green Roof or Green Wall (m^2 / ha)	*Opening condition*				
	Closing condition				
Proportion surface area public open green or blue space (%)	*Opening condition*				
	Closing condition				
Proportion surface area public open green or blue space with disabled access and facilities (%)	*Opening condition*				
	Closing condition				
Distance to nearest public open green or blue space	*Opening condition*				
	Closing condition				
Distance to nearest public open green or blue space with disabled access and facilities	*Opening condition*				
	Closing condition				
Soil sealing (% of extent)	*Opening condition*				
	Closing condition				
Air pollutant concentrations (days above target limits / year)	*Opening condition**				
	*Closing condition**				

*For air polution the measure of days exceeding a target limit per year over the previous accouting period should be recorded as the oipening condition. The closing condition is the number of days / year over the actual the accouting period.

Distance to public open green / blue spaces are included in Table 22. This reflects the increasing recognition of green and other open spaces to public health (UN-Habitat, 2013). In light of which a number of cities are now setting distance standards to different types of open spaces for city residents (Balfour & Allen, 2014). There are some significant measurement challenges in evaluating this parameter. Poelman (2016) presents an approach based on the population weighted extent of cities within 10 minutes' walk of green open spaces. Other approaches could focus on the average distance of properties to open green / blue spaces, this is the approached adopted in the UK Urban Ecosystem Accounts.[24] Simply, this is an average measures 'as the crow flies' but can also be evaluated as distance or time via the street network.

The urban ecosystem condition parameters included in Table 22 are an indicative and non-exhaustive selection proposed at the Expert Meeting in Cambridge. Additional condition parameters may also be considered. In particular, there is no information on biodiversity in Table 22. Many cities will have strategies to improve wildlife, especially those of iconic species associated with some cities. It is also likely to be of interest to urban planners to have information on crime (or safety), possibly associated with public open spaces in Table 22. Metrics on litter and vermin are also likely to be relevant.

[24] See Table 8: https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapital/ecosystemaccountsforurbanareas

Developing urban ecosystem service accounts would also be very helpful for informing urban development. Information on recreational and other cultural ecosystem services flows supplied by green / blue spaces to urban populations will allow decision makers to understand how intensively these spaces are being used. They will also provide a more solid economic argument for investment and protection of these spaces in light of the considerable urban development pressures cities face.

7.6 Data sources

Urban scale ecosystem accounts are likely to require high resolution data to compile, which reflects the scale at which planning decisions are made in the urban environment. This can be expected to be an order of magnitude higher resolution than that employed for national ecosystem accounting applications. For example, the Oslo Urban EEA presents land cover data at 10m resolution (NINA, n.d.).

In order to facilitate the integration of different data on the urban environment, there is also a need for a measurement unit to organise spatial data for the compilation of accounts. These are termed Basic Spatial Units (BSUs). BSUs are not accounting units per se, but provide a consistent spatial unit for data integration. Typically, BSUs are organised using a reference grid established with a single reference coordinate system, where each grid cell (or pixel) represents a BSU. As noted for urban ecosystem accounting this is likely to be a high resolution grid (<30m). The concept of BSUs is entirely consistent with the 'pixels' described in the metadata for SDG 11.7.1 (UNSD, 2018a).

Organising data using BSUs provides a flexible spatial infrastructure that allows data to be readily aggregated to compile accounts at different spatial scales. This will facilitate multiple reporting and planning requirements, particularly where administrative boundaries and different definitions of cities and urban extent are employed (e.g., with respect to national or local definitions boundaries and those derived for internationally consistent reporting under SDG 11.7.1).

Further guidance on BSUs and associated spatial data infrastructures is provided in Chapter 3 of the SEEA EEA Technical Recommendations. The remainder of this section sets out a number of national and global sources of data relevant to compiling ecosystem extent accounts.

7.6.1 City level data on urban ecosystems and urban open spaces

Some countries may maintain their own high resolution products for municipal areas. There are also likely to be a number of service providers that could provide products that apply suitable algorithms to global data sources, such as LandSat and Sentinel imagery.

In addition, municipal inventories of public open space may often exist. Additional documents, such as land use maps and cadastral data on land ownership may also provide important information to determine the location of open spaces and their accessibility. It is also anticipated that the data review process outlined in Section 3.2 will also yield a number of useful data sources

As many cities may not maintain inventories of public space, some fieldwork may be required to verify open spaces as publicly accessible. UN-Habitat, in consultation with partners, experts and data producers have developed a detailed tool to facilitate the verification of each space and collection of additional data on the space quality and accessibility.[25]

[25] This tool is freely available at: https://ee.kobotoolbox.org/x/#IGFf6ubq

7.6.2 Global Data

There are now a number of high resolution Earth Observation (EO) datasets and products that can be used to support urban ecosystem accounting. A selection of these are provided in Table 23, following the format for the initial assessment of data sources recommended in Section 3.2.2, Table 3.

Table 23: Global EO data relevant for urban ecosystem accounts

Data holder	Data source	Description	Time series	Data sharing
NASA / USGS	Landsat imagery	Landsat Imagery is made up of several spectral bands that can be used to identify impervious surfaces roughly corresponding to built-up areas	Continuous (LandSat 8 from 2013)	Open Access: https://landsat.gsfc.nasa.gov/data/ https://landsatlook.usgs.gov/
ESA	SENTINEL	Images providing Top-Of-Atmosphere and Bottom-Of-Atmosphere reflectance's in cartographic geometry	Continuous (SENTINEL-2 from 2015)	Open Access: https://sentinel.esa.int/web/sentinel/missions/sentinel-2/data-products
JRC EC	Global Human Settlement	Provides products on built-u area, including an ad-hoc Landsat 8 collection.	2013/14	Open Access: https://ghsl.jrc.ec.europa.eu/datasets.php
Copernicus Land Services	High resolution layer: Imperviousness	Provides products on imperviousness density for the Europe	2006; 2009; 2012; 2015	Open Access: https://land.copernicus.eu/pan-european/high-resolution-layers/imperviousness

In addition, UN-Habitat have compiled data for SDG 11.7.1 for 289 cities in 94 countries (UNSD, 2018a). These data have been compiled via the Global Public Spaces programme, Atlas of Urban Development, UN-Habitats City Prosperity Index, locally collected qualitative data and via a multi-country capacity assessment for SDG 11.7.1. As such data for a number of cities for calculating SDG 11.7.1. exists (see UNSD, 2018 for more information).

7.6.3 Ecosystem condition data

Additional data will be required to support the compilation of the Urban Ecosystem Condition Accounts. A number of proprietary remote sensing or other mapping products may exist that can be used at this stage. For example, maps of population density, canopy cover, soil sealing and air pollution modelling may be available for a number of cities and produced on a regular basis to support ecosystem condition accounting. Any filed work undertaken to verify open spaces should also attempt to collect key data on condition characteristics, including design elements, such as, disabled access facilities. These types of data may also be available from public open space inventories or other local authority data sets. For many data items in the Urban Ecosystem Condition Account, it is likely that datasets will need to be derived using GIS processing (e.g., estimating average distances to public open green or blue space).

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Appendix A: SDG Indicators for testing calculation via the SEEA and their use in other global indicator initiatives

SDG Indicator	SDG Indicator	Relevant Accounts	Aichi Indicator	UNCCD Indicator	RAMSAR Indicator	BIP Indicator	IPBES Indicator	UNECE Indicator	Total
15.3.1	Proportion of land that is degraded over total land area	Ecosystem Condition Account & Ecosystem Extent / Land Cover Account	AT 5.3.2	SO 1-1, SO 4-1, SO 1-3, SO 1-2		BIP X.2		CC.3, CC.21, CC.20	10
6.6.1	Change in the extent of water-related ecosystems over time	Ecosystem Extent / Land Cover Account & SEEA Water Accounts	AT 5.5.3, AT 5.5.1		R 8.6	BIP B.1	IPBES H.10		6
15.1.1	Forest area as a proportion of total land area	Ecosystem Extent / Land Cover Account	AT 5.4.2			BIP B.2	IPBES C.6	CC.3	5
15.9.1	Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011-2020	All	AT 2.1.1, AT 2.3.1, AT 2.2.1						4
6.3.1	Proportion of wastewater safely treated	SEEA Water Accounts			R 2.6, R 2.11, R 2.8				4
6.4.1	Change in water-use efficiency over time	SEEA Water Accounts	AT 4.2.2, AT 4.2.3					CC.36	4
15.2.1	Progress towards sustainable forest management	Ecosystem Extent / Land Cover Account & Ecosystem Condition Account	AT 5.4.4					CC.38	3

SDG Indicator	SDG Indicator	Relevant Accounts	Aichi Indicator	UNCCD Indicator	RAMSAR Indicator	BIP Indicator	IPBES Indicator	UNECE Indicator	Total
15.4.1	Coverage by protected areas of important sites for mountain biodiversity	Biodiversity Account & Ecosystem Condition Account	AT 14.3.3			BIP X.17			3
11.3.1	Ratio of land consumption rate to population growth rate	Ecosystem Extent / Land Cover Account	AT 4.5.2						2
14.5.1	Coverage of protected areas in relation to marine areas	Ecosystem Condition Account and Biodiversity Account	AT 11.2.2						2
15.4.2	Mountain Green Cover Index	Ecosystem Extent / Land Cover Account & Ecosystem Condition Account	AT 14.3.2						2
6.3.2	Proportion of bodies of water with good ambient water quality	SEEA Water Accounts & Ecosystem Condition Account	AT 8.4.4						2
6.4.2	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	SEEA Water Accounts							1
8.9.1	Tourism direct GDP as a proportion of total GDP and in growth rate	Ecosystem Extent / Land Cover Account & Ecosystem Services Account							1

SDG Indicator	SDG Indicator	Relevant Accounts	Aichi Indicator	UNCCD Indicator	RAMSAR Indicator	BIP Indicator	IPBES Indicator	UNECE Indicator	Total
11.7.1	Average share of built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities	Ecosystem Extent / Land Cover Account & Ecosystem Services Account							1
14.4.1	Proportion of fish stocks within biologically sustainable levels	SEEA Central Framework Asset Accounts (Fisheries)							1
14.7.1	Sustainable fisheries as a proportion of GDP in small island developing States, least developed countries and all countries	SEEA Central Framework Asset Accounts (Fisheries)							1

Appendix B: IUCN Ecosystem Typology (Excel file)

IUCN Ecosystem Typology.xlsx

Appendix C: Template for Consultation Step 2

The objective of the validation report is document the scope of the validation process, summarise the key lessons learned and limitations of the accounts and develop concrete proposals for improving the future iterations of the accounts. Table 24 provides an example template in these regards, which can be adapted for different national or sub-national SEEA accounting programmes. Table 24 is intended to be produced for each SDG Indicator identified as part of the strategy for compiling SEEA EEA Accounts for reporting on SDGs. However, Table 24 can be adapted for reporting on different groups of SDG Indicators where this provides a less repetitive summary of the validation process.

Table 24: Proposed table format template for validation report

SDG Indicator: *State the SDG Indicator*	
Accounts Produced: *Describe the SEEA Accounts compiled for calculating the SDG Indicator*	
Quality Assurance: *Describe the quality assurance framework applied and if quality assurance was possible. If not explain why and options to achieve this.*	
Bridging and Other Tables: *Describe any other tables produced to aid the calculation of the SDG Indicator from the Accounts produced*	
Description of the validation process	1. Identify stakeholders involved in the validation process 2. Identify any errors found during the validation process 3. Summarise corrections implemented and outstanding issues 4. Record any further validation processes and their results
Lessons learned for accounts production	1. Sourcing and collating data. 2. Formatting and organising data. 3. Analysing and presenting data 4. Any other lessons learned for accounts production
Best practices for communication	1. Describe dissemination strategy for accounts to be implemented by stakeholders 2. Identify target audiences 3. List communication products that will be developed to best present the accounts and their findings to different audiences. 4. Any other communication activities identified
Strengthening of the institutional arrangements	1. Agree long term commitments and responsibilities amongst stakeholders to support the ongoing production of the accounts. 2. Agree priorities with respect to user needs for 'institutionalised use' of the accounts across stakeholders. 3. Agree a resourcing plan for ongoing, regular accounts production.
Extensions	1. In response to identified institutional user needs list priority extensions and additions to the current set of SEEA EEA accounts.
Next steps for future iterations of the accounts	1. With user and producer stakeholder agree a list of concrete, realistic next steps for the next iterations of the accounts 2. Set and agree SMART targets for the production of the next set of accounts.

Appendix D: Policy framework for selected SDG Targets

A policy framework represents a governments set of mechanisms to deliver improved outcomes for a given theme or sector and how these should be applied. It includes polices related to that theme and sector and their associated policy instruments, such as regulation, legislation or economic instruments. Additional elements of the framework include codes of conduct, statutory guidance and recommended actions from different groups with a mandate to advise on that theme or sector. These elements may derive from international and national commitments on a given theme or sector.

Policy frameworks arise because no single policy, instrument or individual element will have the capacity to address, in a balanced, holistic and mutually reinforcing way, all the issues relating to a particular theme or sector. A policy framework will typically apply across multiple scales, setting out the mechanisms to achieve global and national commitments, as well as local objectives.

This appendix describes in a generic manner key elements of the policy framework for 4 SDG Indicators (15.1.1, 15.3.1, 6.6.1, 11.7.1) for which method notes were presented (Sections 4, 5, 6 and 7). The purpose is not to provide a comprehensive description of the policy framework for each SDG Indicator. Instead, the intention is to highlight which types of policies, instruments and other elements of the framework are likely to be of key relevance to the theme (or associated sectors) the SDG Indicator informs on. This will help to identify the set of policy entry points that SEEA EEA Accounts for these 4 SDG Indicators could address. Identifying relevant policy entry points will directly assist National Statistical Offices and others in identifying a wide range of potential stakeholders, particularly with respect to future users of the SEEA accounts.

At the national scale, there is clearly a link here between national accounts and national policies. However, in many countries it will also be important to consider sub-national policies and their stakeholders. This is particularly the case in federal, or similar systems, where the management of natural resources is devolved (e.g., to state level). This could realise a significant number of stakeholders across different sub-national jurisdictions that will need to be engaged, likely having different perspectives and ambitions. Once identified, all these different stakeholders will also need to be engaged in the development of the priority SEEA accounts for calculating the SDG Indicators, as described out in Section 3.

This appendix also includes a short summary of the types of economic (policy) instruments that may stimulate progress towards these SDG targets. Understanding these will also be helpful in framing discussions with finance ministries, national planning agencies and others with budget responsibilities.

Key Elements of the Policy Framework for Forests under SDG target 15.1

Forests are a theme that is high on the international agenda due to their importance in protecting climate, biodiversity, food security and livelihoods. This has been reflected in the outcomes of a range of global intergovernmental processes. SDG 15.1 calls to “ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements” by 2020. The associated SDG Indicator 15.1.1, focuses specifically on the extent of forest ecosystems. SDG 15.1 stems from the Strategic Plan for Biodiversity 2011-2020, in particular its Aichi Target 5 (to halve the rate of loss of all natural habitats, including forests) and the associated indicator 5.4.2 (Forest area as a proportion of total land area). The specific intention of this indicator being to measure progress in the conservation of the relatively high biodiversity associated with forest ecosystems.

The key mechanism to implement the national actions towards achievement of Aichi target 5 are set out in countries national biodiversity strategies and action plan (NBSAP). Forest extent is also clearly relevant to international commitments on climate change, including in the context of the Paris Agreement adopted under the UN Framework Convention on Climate Change (UNFCCC). Whereby, actions to reduce emissions derived from deforestation and forest degradation may feature as part of a number of countries nationally determined contributions.

In addition, the FAO Committee on Forestry (COFO) comprising of 124 member states, has a mandate to assess forestry problems and propose concrete actions to member states.[26] COFO has requested and endorsed the FAOs long-term for the Forest Resources Assessment Programmes, and how this can shape policy and encourage investment in increasing the area and quality of sustainably managed forests. Countries reports for the FAO global Forest Resources Assessments (FRA) are essentially for measuring progress towards these aims for forests.[27] The UN Strategic Plan for Forests (2017 – 2030)[28] sets out a set of ambitious, voluntary targets for member states to increase forest extent collectively by 3%. These further international commitments will also require specific national actions if they are to be achieved.

In addition to the above global commitments, most countries have specific forest policies that set out the national objectives for forests, how they are managed and used, as well as mechanisms for achieving these objectives. They typically include the long-term sustainable management of forest resources and may be supported by forest sector development plans. These plans may focus on using forests to support economic extractive activities, especially timber production.

However, there are multiple ways forests can be used and different benefits realised, these 'uses' will be promoted via different elements of the policy framework for forests. For example, a countries NBSAP will set out strategies for using forests to achieve national conservation commitments. National adaptation plans may establish forest management approaches aimed at climate change adaptation and mitigation outcomes. Different uses for forests are also likely to feature in a number of sector policies and strategies. For example, tourism sector policies may seek to increase tourism activities in conserved forest areas. Water sector policies may include using forests to maintain upstream water quality and the energy sector may develop polices related to using forest to prevent soil erosion and loss of capacity in hydropower reservoirs. There will also be links between forests and agriculture, not just in terms of the role of forests in direct food provision and security but also in the delivery of other ecosystem services, such as pollination and protection of inland fisheries from sediment loading. Using forests to deliver these benefits may feature in agricultural policies as well. National development plans and green growth strategies are also likely to provide an important policy framing for reconciling these different objectives for the use of forests and identifying where investments in forests should be made.

The above description is intended to highlight and encourage a holistic approach to the identification of national policy-entry points related to SDG 15.1.1. This speaks to the core strengths of the SEEA, to consistently organise and integrate environmental and economic information.

At the local scale, administrations may also develop planning policies focused on particular communities and maintaining livelihoods associated with access to forest and forest products. Important stakeholders in this local context will include those associated with community managed areas of forest. These local planning policies may also include local management

[26] http://www.fao.org/unfao/govbodies/gsbhome/committee-fo/en/
[27] http://www.fao.org/3/a-au190e.pdf
[28] https://www.un.org/esa/forests/wp-content/uploads/2016/12/UNSPF_AdvUnedited.pdf

actions aimed at climate change mitigation efforts associate with reforestation, restoration or conservation. For example, via bilateral arrangements with other jurisdictions and participation in voluntary carbon offset market projects.

Economic Instruments for Stimulating Progress towards SDG 15.1.1

Subsidies and tax breaks are available in a number of countries to encourage the conservation and restoration of forests and economic activities that make sustainable use of forests. For example, subsidizing local enterprises focused on non-timber forest products or creation of tourism packages in forest areas. These approaches can also be used to encourage diversification of local livelihoods, for instance encouraging activities that add value to forest products locally. Thereby reducing economic pressures associated with deforestation driven by low value timber / wood extraction. Subsidizing and promoting alternative heat and power sources and energy efficiency may also reduce demand for wood fuel from forest, also reducing pressures on forests.

Alternatively, where economic activities are well developed, taxes and charges can be levied and these funds used to invest in forest restoration, for example taxes on timber or levies on tourist's / park users. Certification schemes, such as FSC, allow access to a wider range of markets, providing an incentive for sustainable forestry and replanting. Offsetting and other compensation schemes can also be introduced where deforestation occurs, for instance in the case of land use change from forest to agriculture or industry.

Financing for forest restoration can also be supported by economic instruments through the application of the payment for ecosystem services mechanisms. This can include the use of water funds, tourist charges or carbon payments. Where forests also provide community benefits, those paying for ecosystem services are often willing to pay a premium.

Key Elements of the Policy Framework for Land Degradation under SDG target 15.3

The global commitment to addressing land degradation is set out in the UN Convention to Combat Desertification (UNCCD), whose Strategic Plan for 2018 – 2030 includes the vision for "*A future that avoids, minimizes, and reverses desertification/land degradation and mitigates the effects of drought in affected areas at all levels and strive to achieve a land degradation-neutral world consistent with the 2030 Agenda for Sustainable Development, within the scope of the Convention*". The UNCCD currently has 197 signatories.

The commitment to achieve land degradation neutrality is also adopted as SDG target 15.3 (that "*By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world*"). The associated SDG Indicator 15.3.1. - Proportion of land that is degraded over total land area – provides the means to measure progress towards this. However, it also connects to Aichi Biodiversity Targets 14 (ecosystems and essential services safeguarded) and 15 (ecosystems restored and resilience enhanced), which include elements of ecosystem restoration, particularly related to benefits for people.

The impacts of land degradation – already reducing the well-being of 3.2 billion – have also been flagged in the IPBES land degradation assessment (IPBES 2018). The same report also highlights that action to address land degradation will increase food and water security and contribute substantially to the adaptation and mitigation of climate change. In turn, this could contribute to the avoidance of conflict and migration. This reveals the cross cutting connections across economic, environmental and social policy areas. Responding to this, the recently declared UN Decade on Ecosystem Restoration 2021-2030 aims to substantially scale up the restoration of degraded and destroyed ecosystems for job creation, food security and climate change mitigation and adaptation.[29]

There may be multiple national or regional policy instruments relevant to land degradation. The most obvious are the National Action Plans of countries that have ascended to the UNCCD Convention, required under Articles 9 and 10. These plans bring together policies on biodiversity, climate change and land degradation at the country level (Philippine Government, 2010). These should be revised in line with the UNCCD 10 Year Strategy, which in turn has ensured greater alignment of the Convention with the UNFCCC and the CBD.

As a regionally example, the EU has a number of policies, which are related to land degradation. For example, in the EU, farming is subjected to ‘greening’ measures designed to ensure sustainable farming. These measures also help to contribute to the EU’s efforts to preserve soil quality and biodiversity loss. They include crop diversification, maintaining permanent grassland and dedicating a certain amount arable land specifically to environmentally friendly measures (called 'ecological focus areas') (European Commission, 2017).

At the local level, Strategic Environmental Requirements, such as Environmental Impact Assessments, set out procedures and rules to protect the environment from impacts from development, and provides infrastructure for the remediation of land and resources to combat land and water degradation. Other voluntary schemes, such as certification of sustainably produced products or ecolabels, help to promote sustainable practices. For example, the Forest Stewardship Council developed a certificate for forest products. This certificate ensures product sustainability, but also supports the development of management plans or monitoring schemes, reducing soil erosion, and helping to increase productivity (Cornell *et al.*, 2016). Other schemes, such as those from the Soil Association, provide certification for a range of products and businesses (Soil Association, 2019). These kind of certification schemes ensure that products are grown sustainably, reducing the impacts of land degradation.

Economic Instruments for Stimulating Progress towards SDG 15.3.1

Reflecting the broad interests and benefits in addressing land degradation, the Economics of Land Degradation Initiative (ELD 2015) have analysed the range of policies measures which can address and support efforts to reduce land degradation and encourage restoration. The summary below is taken directly from their Report for Policy and Decision Makers.

- Conservation banking or offsets: Conservation offsets aim at compensating for environmental damage caused by land development. Developers can source conservation credits through a market mechanism to offset the loss of ecosystem services at one site, with conservation gains elsewhere.
- Contract farmland set-asides: Land owners abandon the right to use parts or all of their farmland to foster the delivery of environmental benefits, and receive a payment in return.
- Eco-labels and certification: Eco-labels are a form of sustainability measurement for food and consumer products with the aim to facilitate the purchase of eco-sensitive commodities. Eco-labels result from a standardised certification process controlled by bodies such as the International Organization for Standardization (ISO), FairTrade® Foundation, or Forest Stewardship Council (FSC).
- Insurance schemes: In the US, Canada, and India, the governments provide insurance against crop losses due to weather extremes or declines in global commodity prices. If

[29] https://www.unenvironment.org/news-and-stories/press-release/new-un-decade-ecosystem-restoration-offers-unparalleled-opportunity

crop yields at the end of a cropping season are lower than a pre-established reference amount, farmers receive compensation. This reduces pressure on land owners to use land intensively for increased production to mitigate price or yield volatility.

- Microfinance: Microfinance is a specific form of credits that support the establishment of local, small-scale businesses. Micro-credits are provided at a lower interest rate than those offered by traditional banks and have helped to reduce poverty at the individual and village levels in many developing countries such as Bangladesh. In providing for easily accessible start-up capital, micro-credits are a particularly well suited tool to facilitate livelihood diversification and, promote investment and adoption of sustainable land management practices.
- Payments for conservation investments: Certain investments into sustainable land management are financially rewarded by the government. These payments reflect compensations for more active management actions than set-asides.
- Permanent conservation easements: Permanent conservation easements are voluntary, legally binding agreements by which certain land usages are prohibited. They serve to protect the ecological or aesthetic values of land. National parks are one example.
- Fiscal reform: Reform of subsidies that promote intensive agricultural production processes that lead to intensive land use and land degradation. Introduction of taxes and environmental fees to raise the cost of production or consumption of environmentally damaging goods so as to limit their demand.
- Transferable development rights: These allow for the development of a certain area of land on the condition that land of a comparable type and quality is restored as a compensation measure.

Key Elements of the Policy Framework for water related ecosystems under SDG target 6.6

Society depends on the safe and sustainable provision of water. A number of policies are in place at different levels to manage the consistent supply of sufficient and safe drinking water. SDG target 6.6 calls to “protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes” by 2020. The associated SDG Indicator 6.6.1, focuses specifically on the change in the extent of water-related ecosystems over time. The SDG 6.6.1 indicator also relates to Aichi targets 5 (to halve the rate of loss of all natural habitats, including forests) and 14 (ecosystems and essential services safeguarded). There are also examples of synergies across many of the other Sustainable Development Goal targets, such as SDG target 6.3 (increasing recycling and safe reuse of water) and 6.4 (increasing efficiency and ensuring sustainable withdrawals) (UN Water, 2016).

The IPBES Global Assessment highlighted the need to tackle issues around maintaining freshwater for nature and humanity as a nexus. This reflects that the diversion of fresh water from natural systems has been characterised by an inadequate appreciation of the associated impacts on freshwater ecosystems and the services they provide. This highlights both the direct links between functioning of water-related ecosystems and the regulation, provision and quality of water, and the feedback in terms of the effect of diversion of water for human use on ecosystems degradation. In this way, it connects both the efforts to meet forest related targets and land degradation related targets discussed above.

National and sub-national Integrated Water Resource Management (IWRM) plans may often be developed to addresses synergies across different policies, and provide a coordinated planning and management framework to be implemented across scales. The rationale for IWRM is that water resources are key drivers of the environment, economy and society, and so should be managed holistically, in an equitable manner without compromising the sustainability of ecosystems. This management of water resources aligns with SDG target 6.6, which calls to protect and restore water-related ecosystems.

As an example of a regional approach, a number of EU Directives (e.g., Water Framework; Groundwater; and, Environmental Quality Standards Directives) aim to ensure human use of water is compatible with the environment's own needs. Member States must report key parameters of water quality and management measures, at the national and sub-national level, under these directives. Water Resource Management Plans are then created by national water suppliers. These set out how the companies will manage and develop water resources, so they are able to meet water supply obligations, now and in the future. Water companies work with local authorities to take into account future population growth and development, and use models to test the possible effects of a range of climate change scenarios. This includes monitoring, and modelling the future environmental impacts on water resources, such as reservoirs, lakes and streams (Defra, 2017).

Economic Instruments for Stimulating Progress towards SDG 6.6.1

The value of natural ecosystems for water services, especially in the context of urban areas, is well recognised. For example, TEEB (2009) highlighted research which found that a third of the world's hundred largest cities draw a substantial proportion of their drinking water from forest protected areas. Likewise, 66% of Natural World Heritage Sites have been assessed as important for water quantity and/or quality (Osipova et al 2014).

Payments for water-related ecosystem service (PES) programmes are also reasonably widespread, with the use of Water Funds in particular being a common model in Latin America. These use the value of water services to cities to generate investment in watershed management upstream. These schemes provide an opportunity to put a price on a previously un-priced ecosystem service, bringing them into the wider economy. This PES concept is summarised in Figure 5.

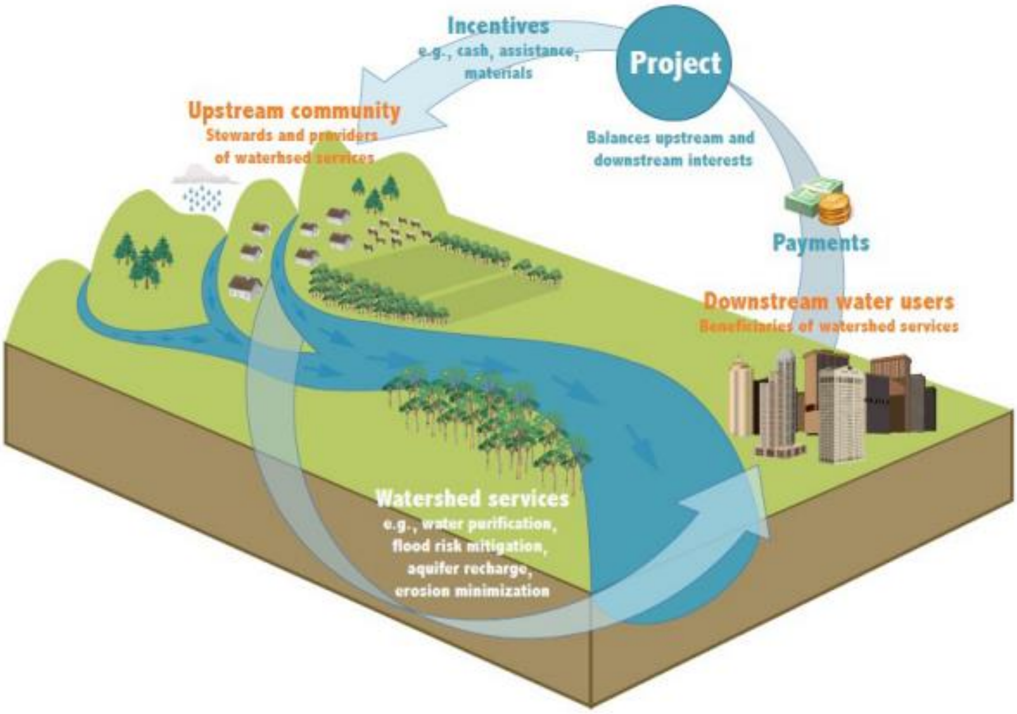

Figure 5: The PES Concept (Defra, 2013)

One of the most famous catchment management programme is from the USA. Where investments in the management of the Catskill Delaware watershed were made in order to avoid the costs of water treatment facilities for the city of New York. Managing the ecosystem offered a significantly cheaper way to improve water quality than end of pipe treatment. However, it did require influencing farmer behaviour to reduce agricultural pollution, so it went beyond simply habitat management and reveals the need for joining up elements and efforts across policy frameworks.[30]

Key Elements of the Policy Framework for urban public open spaces under SDG target 11.7

Urban green spaces have many benefits. These range from improving the resilience of cities to disasters and climate change, including floods, drought risks and heat waves; to improving, physical and mental health, and ambient air quality. SDG target 11.7 calls for "By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities". The associated SDG 11.7.1 Target Indicator focuses more specifically on public open spaces – "Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities". This is also reflected in UN Habitat's New Urban Agenda, which includes commitments to well connected, green and quality public spaces. The World Health Organization also takes the importance of green spaces into account. It recommends a minimum of 9m^2 of green space per capita, and that all residents live within a 15-minute walk of a green space (UN-Habitat, 2013).

The Global Partnership on Cities and Biodiversity was launched in 2008, facilitated by the CBD secretariat and ICLEI-Local Governments for sustainability, to support cities in sustainable management. At COP9, Decision IX/28 on Cities and Local Authorities was adopted (CBD, 2008). This invited Parties to recognise the roles of cities and local authorities in national biodiversity strategies and action plans (NBSAPs). There are many voluntary initiatives in place, to help mobilise key cities and promoting the exchange of experience on urban biodiversity best practices. One of these is the Local Action for Biodiversity (LAB) programme, which was run by the ICLEI Cities Biodiversity Center in partnership with the International Union for Conservation of Nature (IUCN). This was aimed at improving and enhancing ecosystem management at the local level and is clearly aligned to promoting the types of green / blue opens spaces relevant to SDG 11.7.1.

Barcelona's Green Infrastructure and Biodiversity Plan 2020 provides a useful example. It seeks to forge a network of green spaces through developing natural open spaces, river areas, forests, parks, gardens, squares, vegetable gardens, tree-lined streets, street greenery, ponds, roofs and walls. Alongside this commitment, improvements have been made in areas of planning, and the preservation of territory. Progress has been made in metropolitan urban planning to protect and manage open spaces, such as the Parc de Collserola, now a nature park. Preservation criteria and measures have been made into urban planning projects, and strategies are in place to reduce impact of development on the ecology (Ajuntament de Barcelona, 2013). This highlights how urban planning policy, especially with regards to green spaces, is being integrated and implemented at the local level.

Economic Instruments for Stimulating Progress towards SDG 11.7.1

The City of London has published a natural capital account (Greater London Authority, 2017) for its greenspaces which examines values across recreation, mental and physical health, carbon

[30] This case study has been written up for the Convention on Biological Diversity: https://www.cbd.int/financial/pes/usa-pesnewyork.pdf

storage and sequestration, and temperature regulation. This highlight the broad policy framework and range of levers which could be used to draw in investment in urban green space.

Driven by the values of natural capital, the City of London has also published a green infrastructure plan (Greater London Authority, 2015). This included a funding strategy which set out the need to connect the delivery of green infrastructure (including investment in green spaces) with other investments which either impact upon or derive value from urban green space.

As such it highlighted the need to ensure that urban green infrastructure outputs are delivered through other infrastructure funding for surface transport, high streets, housing and regeneration. For example, it proposes recommendations to consider the scope for additional levies or compensatory mechanisms on environmentally detrimental activities, which could assist in funding green infrastructure projects. Including, for example, 'storm water credits' and 'biodiversity offsetting'. Reform of fiscal instruments are also suggested, for example proposing that green infrastructure is allocated a fixed share of any infrastructure funds flowing to the city to ensure an ongoing flow of public investment that can also contribute to maintaining and expanding public open spaces.

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