Chapter V
Asset accounts

5.1 Introduction

5.1 Assets are considered items of value to society. In economics, assets have long been defined as stores of value that, in many situations, also provide inputs to production processes. More recently, there has been consideration of the value inherent in the components of the environment and the inputs the environment provides to society in general and the economy in particular. The term "environmental asset" is used to denote the source of these inputs which may be measured in both physical and monetary terms.

5.2 One motivation for considering environmental assets is the concern that current patterns of economic activity are depleting and degrading the available environmental assets more quickly than those assets can be regenerated. Hence, there is also concern about their long-term availability. Current generations may thus be seen as "stewards" for the range of environmental assets on behalf of future generations. There is a general aim to improve the management of environmental assets, taking into account the sustainable use of resources and the capacity of environmental assets to continue to provide inputs to the economy and society.

5.3 This general aim is a key driver for the development of the SEEA and, in particular, for the measurement of assets and the compilation of asset accounts. In this context, the aim of asset accounting in the SEEA is to measure the quantity and value of environmental assets and to record and explain changes in those assets over time.

5.4 For environmental assets, the physical and monetary changes over the period include additions to the stock of environmental assets (due, e.g., to natural growth and discoveries) and reductions in the stock of environmental assets (due, e.g., to extraction and natural loss).

Chapter structure

5.5 The present chapter describes accounting for environmental assets. Section 5.2 provides a detailed discussion of the concept of environmental assets in the Central Framework, working from the general definition of environmental assets outlined in chapter II. Section 5.3 describes the structure of the accounts and the accounting entries that are required to compile asset accounts, including opening and closing stocks, additions to stock, reductions in stock and revaluations.

5.6 Section 5.4 examines two key dimensions of the compilation of asset accounts: the principles of defining depletion of environmental assets in physical terms, with particular focus on the depletion of renewable environmental assets, such as aquatic and timber resources; and, in relation to monetary asset accounts, approaches to the valuation of environmental assets and, in particular, the net present value (NPV) approach. The annex to the chapter discusses NPV in greater depth.

5.7 Sections 5.5-5.11 outline asset accounting for the range of individual environmental assets. Detail is provided on the measurement scope for each of these assets, the structure of the asset accounts and other relevant conceptual and measurement issues. While there are general principles that can be applied across all environmental assets, each environmental asset has specific characteristics that must be considered individually.

5.2 Environmental assets in the SEEA Central Framework

5.2.1 Introduction

5.8 As defined in chapter II, environmental assets are the naturally occurring living and non-living components of the Earth, together constituting the biophysical environment, which may provide benefits to humanity. In the Central Framework, environmental assets are viewed in terms of the individual components that make up the environment, with no direct account taken of the interactions between these components as part of ecosystems.

5.9 The present section explains the general measurement boundary for environmental assets in the Central Framework, including a description of the classification of environmental assets and an articulation of the relationship between environmental and economic assets.

5.2.2 Scope of environmental assets

5.10 The scope of environmental assets in the Central Framework is determined through a focus on the individual components that make up the environment. This scope comprises those types of individual components that may provide resources for use in economic activity. Generally, the resources may be harvested, extracted or otherwise moved for direct use in economic production, consumption or accumulation. The scope includes land and inland waters that provide space for undertaking economic activity.

5.11 There are seven individual components of the environment that are considered environmental assets in the Central Framework. They are mineral and energy resources, land, soil resources, timber resources, aquatic resources, other biological resources (excluding timber and aquatic resources), and water resources. These individual components have been the traditional focus for the measurement of environmental assets through the development of specific asset or resource accounts. This chapter discusses asset accounts for each of these environmental assets and the relevant measurement boundaries in physical and monetary terms.

5.12 The coverage of individual components in the Central Framework does not extend to the individual elements that are embodied in the various natural and biological resources listed above. For example, carbon and nitrogen are not considered individual environmental assets in the Central Framework.

5.13 The measurement scope of the environmental assets of a country is limited to those contained within the economic territory over which a country has control. This includes all land areas, including islands; coastal waters including waters and seabeds within a country's exclusive economic zone (EEZ); and any other water or seabeds in international waters over which the country has a recognized claim. The extension of geographical scope beyond environmental assets on land is of particular relevance in the measurement of stocks of aquatic resources and mineral and energy resources.

5.14 In physical terms, the measurement scope for each individual component is broad, extending to include all of the resources that may provide benefits to humanity. However, in monetary terms, the scope is limited to those individual components that have an economic value based on the valuation principles of the SNA. For example, in physical terms, all land within a country is within scope of the SEEA so as to allow for a full analysis of changes in land use and land cover. However, in monetary terms, some land may have zero economic value and hence should be excluded. The broader scope applied in physical terms aims to account better for the environmental characteristics of the individual components. Issues concerning the valuation of environmental assets are described in more detail in section 5.2.3.

Classification of environmental assets in the Central Framework

5.15 The classification of environmental assets in the Central Framework presented in table 5.1 focuses on individual components. For each of these environmental assets, a measurement boundary in physical and monetary terms must be drawn for the purposes of asset accounting. These boundaries are described in sections 5.5–5.11.

Table 5.1
Classification of environmental assets in the SEEA Central Framework

1	**Mineral and energy resources**
1.1	Oil resources
1.2	Natural gas resources
1.3	Coal and peat resources
1.4	Non-metallic mineral resources (excluding coal and peat resources)
1.5	Metallic mineral resources
2	**Land**
3	**Soil resources**
4	**Timber resources**
4.1	Cultivated timber resources
4.2	Natural timber resources
5	**Aquatic resources**
5.1	Cultivated aquatic resources
5.2	Natural aquatic resources
6	**Other biological resources** (excluding timber resources and aquatic resources)
7	**Water resources**
7.1	Surface water
7.2	Groundwater
7.3	Soil water

5.16 The volume of water in the sea is not considered in scope of water resources in the Central Framework because the stock of water is too large to be meaningful for analytical purposes. The exclusion of the sea in terms of a volume of water resources does not in any way limit the measurement of sea-related individual components such as aquatic resources (including fish stocks on the high seas over which a country has harvesting rights) and mineral and energy resources on or under the seabed. The volume of air in the atmosphere is also not in scope of environmental assets in the Central Framework.

5.17 Although seas and the atmosphere are excluded, the measurement of exchanges and interactions with them is of interest. In this context, the interactions between the economy and the sea, and between the economy and the atmosphere, are recorded in the Central Framework in various ways. For example, measures of the abstraction of sea water are included in the physical flow accounts for water, and measures of emissions from the economy to the atmosphere and seas are recorded in physical flow emission accounts.

Natural resources

5.18 Natural resources are a subset of environmental assets. ***Natural resources include all natural biological resources (including timber and aquatic resources), mineral and energy resources, soil resources and water resources.*** All cultivated biological resources and land are excluded from scope.

Land and other areas

5.19 For most environmental assets in the Central Framework, conceptualizing the supply of materials to economic activity—for example, in the form of fish, timber and minerals—is straightforward. The exception in this regard is land.

5.20 The primary role of land in the SEEA is to provide space. Land and the space it represents define the locations within which economic and other activity is undertaken and within which assets are situated. Although not physical, this role of land is a fundamental input to economic activity and can have significant value, as is most commonly observed in the varying valuations given to similar dwellings in locations that have different characteristics in terms of landscape, access to services, etc. This conceptualization of land can also be applied to marine areas over which a country has a recognized claim, including its exclusive economic zone.

5.21 The term "land" as applied in the SEEA also encompasses areas of inland water such as rivers and lakes. For certain measurement purposes, variations in this boundary may be appropriate, for example, when considering the use of marine areas for aquaculture, conservation or other designated uses. These considerations are discussed in section 5.6.

5.22 A clear distinction is made between land and soil resources. The physical inputs of soil are reflected in the volume of soil and its composition in the form of nutrients, soil water and organic matter. This distinction is discussed further in sections 5.6 and 5.7.

5.23 In the valuation of land, both the location of an area and its physical attributes (e.g., topography, elevation and climate) are important considerations. The valuation of land is discussed in Section 5.6.

Timber, aquatic and other biological resources

5.24 ***Biological resources include timber and aquatic resources and a range of other animal and plant resources such as livestock, orchards, crops and wild animals.*** Like most environmental assets, they provide physical inputs to economic activity. However, for biological resources, a distinction is made between whether the resources are cultivated or natural, based on the extent to which there is active management over the growth of the resource.

5.25 Maintaining this distinction in the Central Framework is important for ensuring that clear linkages can be established to the treatment of these resources in the production accounts and asset accounts of the SNA.

5.26 The cultivation of biological resources can take a wide range of forms. In some cases, the management activity is highly involved, which is the case for battery farming of chickens and the use of greenhouses for horticultural production. In these situations, the unit undertaking the production creates a controlled environment, distinct from the broader biological and physical environment.

5.27 In other cases, there may be relatively little active management as is the case, for example, with broad-acre cattle farming and the growing of plantation timber. In these cases, the biological resource is exposed constantly to, and interacts as a part of, the broader biological and physical environment. There are also situations in which the cultivation of various areas over hundreds of years has transformed the natural environment.

5.28 In practice, it may be difficult to distinguish between cultivated and natural biological resources. Relevant considerations in relation to timber resources and aquatic resources are presented in sections 5.8 and 5.9.

5.29 Many cultivated biological resources may be grown and harvested over a short period of time. In cases where the cultivation occurs within an accounting period, there are no opening or closing stocks of those assets to be recorded. However, depending on the time of the growing and harvesting season relative to the times of the accounting period, there may be cultivated biological resources to be recorded and in such cases, they should be recorded as part of environmental assets.

Forests

5.30 In the SEEA, forests are considered a form of land cover and forestry is considered a category of land use. Often, forests are seen predominantly in terms of timber resources, i.e., the volume of standing timber; however, forests are used in the production of a wide range of products, hence forests and timber resources should not be equated. It is also the case that timber resources are not found solely in forests: in many countries, other types of land cover, for example, other wooded land, contain timber resources. Given both the distinction between forests and timber resources, and the resource focus for environmental assets in the Central Framework, the classification of environmental assets in table 5.1 includes forests as a subcategory of land, and distinguishes the timber resources located on this land as a separate environmental asset. Asset accounts for forests and other wooded land are described in section 5.6 and asset accounts for timber resources, in section 5.8.

5.2.3 Valuation of environmental assets

5.31 In principle, all of the benefits delivered by environmental assets can be valued in monetary terms. However, many complexities are associated with undertaking these broad valuations, including the quantification of the benefits themselves and the consideration of the value of benefits to society as a whole rather than only to individuals. These measurement issues are not discussed further in the Central Framework.

5.32 In the Central Framework, consistent with the SNA, the scope of valuation is limited to the benefits that accrue to economic owners. ***An economic owner is the institutional unit entitled to claim the benefits associated with the use of an asset in the course of an economic activity by virtue of accepting the associated risks.*** Further, following the SNA***, an asset is a store of value representing a benefit or series of benefits accruing to the economic owner by holding or using the entity over a period of time.***[47] Examples of economic assets include houses, office buildings, machines, computer software, financial assets, and many environmental assets.

5.33 The benefits underlying the definition of economic assets are economic benefits. ***Economic benefits reflect a gain or positive utility arising from economic production, consumption or accumulation.*** For environmental assets, economic benefits are recorded in the accounts in the form of operating surplus from the sale of natural resources and cultivated

47 See para. 10.8 of the 2008 SNA.

biological resources, in the form of rent earned on permitting the use or extraction of an environmental asset, or in the form of net receipts (i.e., excluding transaction costs) when an environmental asset (e.g., land) is sold.

5.34 Economic assets in the SNA are classified as produced assets, non-produced assets or financial assets. The relevant concepts and measurement approaches to constructing estimates of economic assets are fully described in the SNA. ***Produced assets are assets that have come into existence as outputs of processes that fall within the production boundary of the SNA.*** Produced assets include fixed assets (e.g., buildings and machines); inventories (e.g., stores of wheat for future use); and valuables that are held as stores of value and expected to increase in value over time (e.g., artworks and precious metals).

5.35 Cultivated biological resources are a type of produced asset in the SNA and also a type of environmental asset in the SEEA. They may be either fixed assets (e.g., sheep for wool, breeding stocks of fish, and orchards) or inventories (e.g., livestock for slaughter and certain trees for timber). Other types of produced asset are often relevant to the measurement of economic activity related to the environment but they are not considered environmental assets (e.g., mining equipment, fishing vessels and dam walls for storing water).

5.36 ***Non-produced assets are assets that have come into existence in ways other than through processes of production.*** They include natural resources; contracts, leases and licences; and purchased goodwill and marketing assets. In the SNA, natural resources include all those assets considered to be natural resources in the SEEA. Land is also considered part of natural resources in the SNA.[48] While some contracts, leases and licences, and purchased goodwill and marketing assets may be relevant in the assessment of economic activity related to the environment, none of these types of non-produced asset are also environmental assets.

5.37 Financial assets, and the corresponding financial liabilities, relate to claims to future payments, or series of payments between economic units. They are defined in detail in the SNA. While some financial assets may be relevant to assessment of economic activity related to the environment, there are no financial assets that are also environmental assets.

Relationship between environmental and economic assets

5.38 Many environmental assets are also economic assets. In particular, natural resources and land are considered non-produced assets, and cultivated biological resources may be either fixed assets or inventories, depending on their role in production. Figure 5.1 displays the relationship between the classes of environmental assets and the high-level asset classes within the SNA. All environmental assets that are classed as cultivated must be recorded as either fixed assets or inventories.

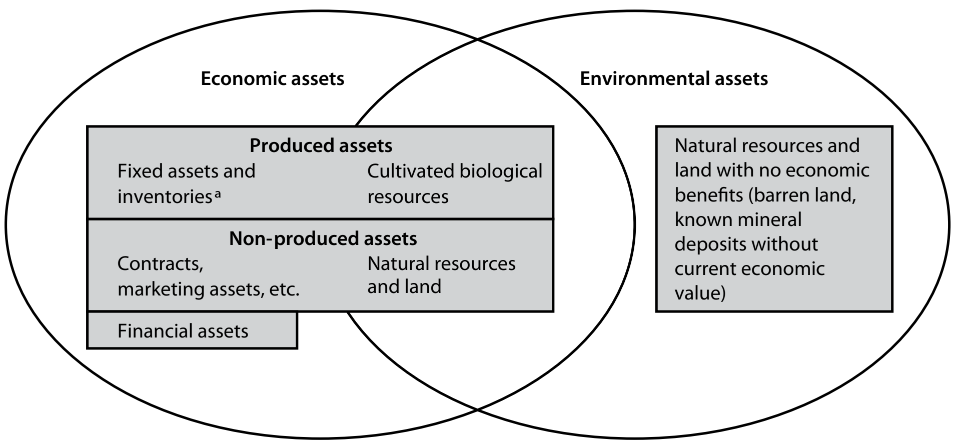
5.39 In physical terms, the scope of environmental assets measured in the Central Framework may be greater than the scope of environmental assets measured in monetary terms following the SNA definition of economic assets. This is because there is no requirement in physical terms that environmental assets must deliver economic benefits to an economic owner. For example, remote land and timber resources should be included within the scope of the environmental assets of a country even if they do not currently or are not expected to deliver benefits to an economic owner.

---

48 The 2008 SNA also includes radio spectra within its scope of natural resources, as the utilization of the radio spectra generates significant income for various economic units. In the SEEA, radio spectra are not considered part of the biophysical environment and are excluded therefore from the scope of environmental assets.

5.40 Consequently, there may be environmental assets that are recorded in the Central Framework in physical terms which have no measured monetary value and are therefore excluded from environmental assets measured in monetary terms. Where such assets are recorded in physical terms, the quantities should be recorded separately from quantities of environmental assets that do deliver economic benefits to economic owners.

Figure 5.1
Relationship between environmental and economic assets



[a] Other than cultivated biological resources.

Economic assets used in activities related to the environment

5.41 There is interest in economic assets, primarily produced assets, that are used in activities related to the environment but are not themselves environmental assets. They include assets relevant to undertaking environmental protection and resource management activities and assets used in the extraction and harvest of natural resources such as water dams, fishing vessels, and cutting and drilling equipment for mining. A discussion of these types of assets is included in chapter IV primarily in the context of environmental protection expenditure accounts (EPEA). Produced assets for natural resource extraction are also important subjects of consideration in the calculation of resource rent and the valuation of environmental assets. Relevant measurement issues are discussed in section 5.4.

5.3 The structure of asset accounts

5.3.1 Introduction

5.42 Asset accounts record both the opening and the closing stock of assets and the changes over the accounting period. The present section outlines the basic form of asset accounts in physical and monetary terms and describes the relevant accounting entries. Sections 5.5-5.11 describe in more detail the relevant asset accounts for each type of environmental asset.

5.3.2 Conceptual form of the physical asset account

5.43 Physical asset accounts are usually compiled for specific types of assets rather than for a range of different assets because each asset will usually be recorded in different units.

This means that aggregation across different assets in physical terms is generally not possible. While aggregation is generally possible only in monetary terms, the asset account entries in physical terms are essential in the compilation of monetary estimates when no transactions of the environmental assets take place.

5.44 Ideally, estimates of the opening and closing stocks of an asset should be compiled with information pertaining to the reference dates of the accounting period. If information in respect of those dates is not directly available, relevant information may need to be time-adjusted. From time to time, new information will emerge that leads to a change in the assumptions underlying a set of estimates. When additional information is being incorporated, it is important that the estimates continue to reflect the quantities and values that could reasonably be expected at the reference dates.

5.45 The entries concerning the changes between opening and closing stocks of each asset are divided into: (*a*) additions to the stock and (*b*) reductions in the stock. However, within these broad categories, there are many different types of entries which are often labelled differently by type of asset. For example, the term "extraction" is generally used in relation to mineral and energy resources, while the term "abstraction" is generally used for water resources. Both terms, however, relate to removing environmental assets through processes of economic production.

5.46 Table 5.2 presents the range of accounting entries for physical asset accounts by type of asset. It provides an overview of the structure of physical asset accounts that are elaborated in detail for each asset in sections 5.5-5.11.

5.47 The table provides a complete listing of possible entries for each asset type. In practice, only certain entries are likely to be important and not all cells that reflect the possibility of an entry in table 5.2 should be shown separately in the published accounts for each type of asset.

5.48 There are four types of additions to the stock of an environmental asset:

(*a*) *Growth in stock.* These additions reflect increases in the stock of resources over an accounting period due to growth. For biological resources the growth may be natural or cultivated and is often estimated net of normal losses of stock;

(*b*) *Discoveries of new stock.* These additions concern the arrival of new resources to a stock and commonly arise through exploration and evaluation;

(*c*) *Upward reappraisals.* These additions reflect changes due to the use of updated information that permits a reassessment of the physical size of the stock. The reassessments may also relate to changes in the assessed quality or grade of the natural resource, or changes in the economic viability of extraction (including those due to changes in extraction technology) that are not solely due to changes in the price of the natural resource. The use of updated information may require the revision of estimates for previous periods to ensure a continuity of time series;

(*d*) *Reclassifications.* Reclassifications of environmental assets will generally occur in situations in which an environmental asset is used for a different purpose; for example, increases in forest land due to afforestation are recorded here. An increase in one category of an asset should be offset by an equivalent decrease in another category, meaning that, for the environmental asset as a whole, reclassifications have no impact on the total physical quantity of an individual asset type.

5.49 There are five types of reductions in the stock of an environmental asset:

(*a*) *Extraction.* These are reductions in stock due to the physical removal or harvest of an environmental asset through a process of production. Extraction includes both those quantities that continue to flow through the economy as products and those quantities of stock that are immediately returned to the environment after extraction because they are unwanted, for example, discarded catch in fishing;

(*b*) *Normal reductions in stock*. These reductions reflect expected losses of stock during the course of an accounting period. They may be due to natural deaths of biological resources or to accidental causes that are not significant enough to be considered catastrophic and might reasonably be expected to occur based on past experience;

(*c*) *Catastrophic losses*. Losses due to catastrophic and exceptional events are recorded when large-scale, discrete and recognizable events occur that may destroy a significantly large number of assets within any individual asset category. Such events will generally be easy to identify. They include major earthquakes, volcanic eruptions, tidal waves, severe hurricanes, and other natural disasters; acts of war, riots and other political events; and technological accidents, such as major toxic spills or the release of radioactive particles into the air. Also included here are major losses of biological resources through drought or outbreaks of disease;

(*d*) *Downward reappraisals*. These reductions reflect changes due to the use of updated information which permits a reassessment of the physical size of the stock. The reassessments may also relate to changes in the assessed quality or grade of the natural resource, or changes in the economic viability of extraction (including those due to changes in extraction technology) that are not solely due to changes in the price of the natural resource. The use of updated information may require the revision of estimates for previous periods to ensure a continuity of time series;

(*e*) *Reclassifications*. Reclassifications of environmental assets will generally occur in situations in which an environmental asset is used for a different purpose; for example, decreases in forest land due to permanent deforestation are recorded here. A decrease in one category of an asset should be offset by an equivalent increase in another category meaning that, for the environmental asset as a whole, reclassifications have no impact on the total physical quantity of an individual asset type.

5.50 Entries related to changes in land cover and land use—for example, within an asset account for forest and other wooded land—are generally in the nature of reclassifications. Thus, for the analysis of changes in land cover and land use, it is often useful to record entries relating to different types of reclassifications. The relevant entries in the case of land accounts are described in section 5.6.

5.51 The depletion of natural resources concerns the physical using up of natural resources due to extraction which thereby limits the potential to extract amounts in the future. For non-renewable resources, the quantity depleted is the same as the quantity extracted but this is not the case for natural biological resources that can regenerate over time. The definition of depletion in physical terms is covered in detail in section 5.4.

5.52 It may not be possible to directly observe all of the accounting entries outlined in the conceptual form of the physical asset account in table 5.2. Consequently, some entries may need to be estimated using appropriate models or derived on the basis of other accounting entries. Depending on the particular entry and its importance in the overall accounting for

Table 5.2

General structure of the physical asset account for environmental assets (*physical units*)

	Mineral and energy resources	Land (including forest land)	Soil resources	Timber resources		Aquatic resources		Water resources
				Cultivated	Natural	Cultivated	Natural	
Opening stock of resources	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Additions to stock of resources								
Growth in stock	na	Yes*	Soil formation	Growth	Natural growth	Growth	Natural growth	Precipitation
			Soil deposition					Return flows
Discoveries of new stock	Yes	na	na	na	na	na	Yes*	Yes*
Upward reappraisals	Yes	Yes	Yes*	Yes*	Yes*	Yes*	Yes	Yes*
Reclassifications	Yes	Yes	Yes	Yes	Yes	Yes	Yes	na
Total additions to stock								
Reductions in stock of resources								
Extractions	Extractions	na	Soil extraction	Removals	Removals	Harvest	Gross catch	Abstraction
Normal reductions in stock	na	na	Erosion	Natural losses	Natural losses	Normal losses	Normal losses	Evaporation Evapotranspiration
Catastrophic losses	Yes*	Yes*	Yes*	Yes	Yes	Yes	Yes	Yes*
Downward reappraisals	Yes	Yes	Yes*	Yes*	Yes*	Yes*	Yes	Yes*
Reclassifications	Yes	Yes	Yes	Yes	Yes	Yes	Yes	na
Total reductions in stock								
Closing stock of resources	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: "na" means not applicable.

* An asterisk indicates that this entry is usually not significant for the resource or is typically not separately identified in the source data. In practice, not all cells that reflect the possibility of an entry here should be shown separately in published accounts for each type of resource.

changes in the stock of a resource, it may also be appropriate to combine some accounting entries for the purposes of preparing physical asset accounts for publication.

5.53 All of the details regarding the definition and measurement of these flows in relation to individual environmental assets are set out in Sections 5.5-5.11.

Accounting entries for institutional sector accounts

5.54 The compilation of asset accounts by institutional sector may be desirable for particular types of environmental assets where the ownership of resources is of policy or analytical interest, including the attribution of mineral and energy resources between government units and extracting units, and the assessment of the ownership of land.

5.55 In constructing institutional sector accounts, two types of entries are required that are additional to those shown in table 5.2, for the purpose of accounting for transactions and other exchanges between sectors. These entries are:

(*a*) *Acquisition and disposals of environmental assets.* These entries are recorded when transactions in environmental assets take place between institutional units in different sectors. The acquisition of environmental assets represents an addition to the stock of the acquiring sector and the disposal represents a reduction in the stock of the other sector;

(*b*) *Uncompensated seizures.* These changes in stock occur when institutional units take possession of or remove environmental assets without providing appropriate compensation to the original owner. An addition to stock is recorded for the sector that takes ownership of the environmental asset and a corresponding reduction in stock is recorded for the sector that previously owned the asset.

5.56 It is also noted that reclassifications of environmental assets between sectors may be common entries in institutional sector accounts.

5.57 Although not common, it is also possible that entries are required at a national level for the acquisition and disposal or uncompensated seizure of environmental assets. This would arise in the case of transactions in land between countries or in situations in which political changes lead to changes in the overall area of a country. Since these entries are not commonly required they are not incorporated into the standard form of the physical asset account presented in table 5.2.

5.3.3 Conceptual form of the monetary asset account

5.58 The general form of the monetary asset account is presented in table 5.3. There are close links to the structure of the physical asset account.

5.59 The definitions of the entries presented in the monetary accounts align exactly with the same entries as defined in physical terms in paragraphs 5.48 and 5.49. Thus, the monetary account reflects a valuation of physical flows as recorded in the physical asset account, although it is to be noted that for some environmental assets, the measurement scope is broader in physical terms (e.g., timber resources not used for wood supply are included in physical terms but excluded in monetary terms). For most environmental assets, it will be the case that measurement requires the estimation of the physical flows followed by estimation of the monetary flows.

5.60 The only additional entry recorded in the monetary asset account compared with the physical asset account concerns revaluations. Revaluations relate to changes in the value of assets due solely to price changes and reflect nominal holding gains and losses on environmental assets. The nominal holding gain for environmental assets is calculated as the increase in value accruing to the owner of the asset as a result of a change in its price over an accounting period.

Table 5.3
Conceptual form of the monetary asset account (*currency units*)

Opening stock of resources
Additions to stock of resources
Growth in stock
Discoveries of new stock
Upward reappraisals
Reclassifications
Total additions to stock
Reductions in stock of resources
Extractions
Normal loss of stock
Catastrophic losses
Downward reappraisals
Reclassifications
Total reductions in stock
Revaluation of the stock of resources
Closing stock of resources

5.61 As discussed in section 2.7, changes in price should be distinguished from both changes in the quantity and changes in the quality of the relevant asset. For environmental assets, the quality of an asset, such as land or water resources, may change due to the effects of pollution or the treatment of previous environmental damage. Ideally, where the price of an asset changes in response to a change in quality, this should be considered a change in the volume of the asset rather than a revaluation. In effect, there has been a reclassification between different qualities of the same asset.

5.62 In addition to determining the nominal holding gain, it is interesting to know how the change in value compares with the general rate of inflation. If the value of an asset rises over an accounting period at the same rate as the general inflation rate, this gain is referred to as a neutral holding gain. The difference between the nominal holding gain and the neutral holding gain is referred to as the real holding gain.

5.63 Revaluations should incorporate changes in the value of environmental assets due to changes in the assumptions made in the valuation approaches that are often used to estimate the economic value of environmental assets, in particular the net present value approach. The assumptions that should be taken into account are those regarding future rates of extraction and natural growth, the length of the asset/resource life and the discount rate. Changes in the physical stock of resources due to discoveries, catastrophic losses, etc., that lead to changes in the expected asset life should be accounted for separately.

5.64 As with physical asset accounts, it may not be possible to directly estimate all of the accounting entries set out in the conceptual form of the monetary asset account in table 5.3. Consequently, some entries may need to be estimated using appropriate models or derived on the basis of other accounting entries. Depending on the particular entry and its importance in the overall accounting for changes in the stock of a resource, it may also be appropriate to combine some accounting entries for the purposes of preparing monetary asset accounts for publication.

Relationship to SNA accounting entries[49]

5.65 Rather than effecting a broad separation into additions and reductions in the stock, the SNA focuses on (*a*) changes due to transactions and (*b*) other changes in the volume of assets. As a means of supporting the links between the SEEA and the SNA, the relevant SNA entries may be appended to the monetary asset account; they can be derived directly from the information presented in the monetary asset account. These derivations are shown in table 5.4.

5.66 The SNA accounting entries are different depending on whether the environmental asset is produced or non-produced. In the SEEA, this distinction is reflected only in whether an environmental asset is cultivated (i.e., produced in SNA terms) or natural (i.e., non-produced in SNA terms). For SNA purposes a further distinction is needed for cultivated assets as to whether they are fixed assets or inventories.[50]

Table 5.4
Derivation of accounting aggregates

Accounting aggregate	Cultivated biological resources		Natural environmental assets
	Fixed assets	Inventories	
Gross fixed capital formation	Growth in stock *less* extractions	na	na
Changes in inventories	na	Growth in stock *less* extractions	na
Economic appearance	na	na	Growth in stock *plus* discoveries of new stock *plus* upward reappraisals
Economic disappearance	na	na	Extractions *plus* catastrophic losses *plus* downward reappraisals

Note: "na " means not applicable.

5.67 For fixed assets, the relevant accounting entry is gross fixed capital formation; for inventories, the relevant accounting entry is change in inventories. For natural environmental assets, the relevant SNA entries are economic appearance of non-produced assets and economic disappearance of non-produced assets. There are also SNA entries related to the range of other additions and reductions in stock. These entries are defined equivalently for the monetary asset account in table 5.3 and the SNA.

5.68 In addition to the accounting entries shown in tables 5.3 and 5.4, there are two entries, depletion and consumption of fixed capital, that relate to the physical using up of assets over time. Consumption of fixed capital relates to the using up of fixed assets and, in the context of cultivated biological resources, is reflected in the value of the normal reductions in stock, based on, for example, mortality rates of livestock.[51]

5.69 Depletion relates to the physical using up of natural resources through extraction. In monetary terms, it represents the decline in future income that can be earned from a resource due to extraction. Details on the definition and measurement of depletion are presented in section 5.4.

49 Detailed descriptions of the relevant accounting entries are contained in chapters 10, 12 and 13 of the 2008 SNA.

50 See also paras. 5.24-5.30.

51 For further discussion on consumption of fixed capital, see paras. 6.240-6.244 of the 2008 SNA.

Institutional sector accounts in monetary terms

5.70 Institutional sector asset accounts may also be compiled in monetary terms and may be of particular interest, since they can be related directly to the full sequence of institutional sector accounts as presented in the SNA. Key aggregates that can be compiled from a full recording of asset accounts by institutional sector are depletion-adjusted net saving and net worth.

5.71 The accounting entries required to compile monetary asset accounts by institutional sector are the same as those required to compile physical asset accounts by institutional sector, with the only addition being the inclusion of entries for revaluations (as outlined in para. 5.60).

5.4 Principles of asset accounting

5.4.1 Introduction

5.72 Accounting for changes in the stocks of environmental assets presents various measurement challenges, including accurately measuring the physical stock of environmental assets, all of which have their own unique characteristics, for example, in the case of biological resources, the capacity to regenerate over time. Understanding the population dynamics is therefore important in making a reasonable assessment of certain environmental assets.

5.73 In addition to estimates calculated in physical terms, estimates of the values of environmental assets in monetary terms should also be compiled. Aside from land and soil resources, few environmental assets are actively traded on markets before they are extracted; therefore, determining their in situ value is not a straightforward task.

5.74 Although there are challenges involved, a range of techniques and underlying concepts have developed that permit the compilation of asset accounts. Section 5.4.2 describes a key challenge in physical asset accounting; the measurement of depletion in physical terms. Sections 5.4.3 and 5.4.4 discuss the principles of asset valuation and the net present value approach, respectively. In section 5.4.5, the approaches to estimating resource rent and the main steps required to apply the NPV approach are explained. Details concerning the NPV approach are presented in annex A5.1 and a discussion of discount rates is presented in annex A5.2. Section 5.4.6 discusses the measurement of environmental assets in volume terms. Applications of the various definitions and principles of asset accounting are described for each environmental asset in sections 5.5-5.11.

5.4.2 Defining depletion in physical terms

5.75 In accounting for environmental assets, the measurement of depletion is often a particular focus. The depletion of environmental assets relates to the physical using up of environmental assets through extraction and harvest by economic units, including households, resulting in a reduced availability of the resource. Depletion does not fully account for all possible changes in the stock of an asset over an accounting period and hence should not be linked directly to measures of sustainability. Assessments of the sustainability of environmental assets should take into account a broader range of factors, such as the extent of catastrophic losses or discoveries and potential changes in the demand for inputs from environmental assets.

5.76 ***Depletion, in physical terms, is the decrease in the quantity of the stock of a natural resource over an accounting period that is due to the extraction of the natural resource by economic units occurring at a level greater than that of regeneration.***

5.77 For non-renewable natural resources, such as mineral and energy resources, depletion is equal to the quantity of resource that is extracted because the stock of these resources cannot regenerate on human time-scales. Increases in the stock of non-renewable natural resources (e.g., through discoveries) may permit the ongoing extraction of the resources. However, these increases in volume are not considered regeneration, and hence do not offset measures of depletion. The increases should be recorded elsewhere in the asset account.

5.78 For natural biological resources, such as timber resources and aquatic resources, the equality in physical terms between depletion and extraction does not hold. The ability for these resources to regenerate naturally means that in certain management and extraction situations, the quantity of resources extracted may be matched by a quantity of resources that are regenerated and, in this situation, there is no overall physical depletion of the environmental asset. More generally, only the amount of extraction that is above the level of regeneration is recorded as depletion. Provided below is a more detailed outline of the measurement of depletion in physical terms for natural biological resources.

5.79 Depletion is not recorded when there is a reduction in the quantity of an environmental asset owing to unexpected events such as losses due to extreme weather or pandemic outbreaks of disease. These reductions are recorded as catastrophic losses. In contrast, depletion must be seen as a consequence of the extraction of natural resources by economic units.

5.80 Depletion can also be measured in monetary terms by valuing the physical flows of depletion using the price of the natural resource in situ. This step is explained in detail in annex A5.1. It is noted that the monetary value of depletion is equal to the change in the value of the natural resource that is due to physical depletion.

Depletion of natural biological resources in physical terms

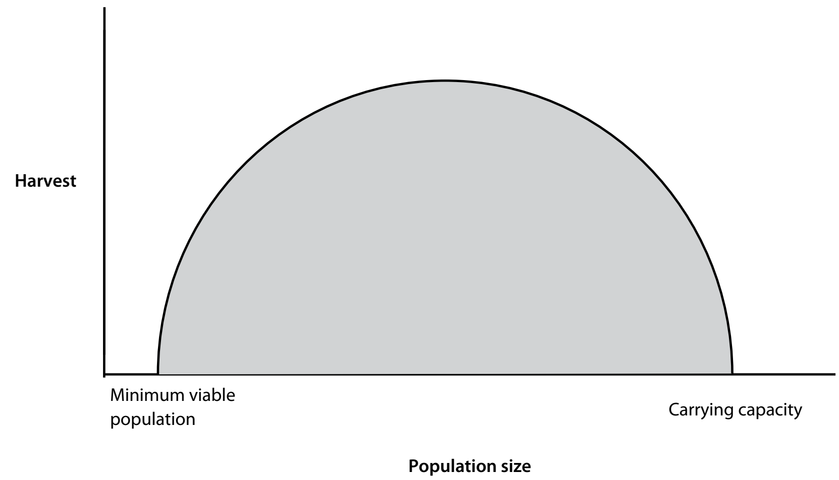
5.81 Natural biological resources are able to reproduce and grow over time. Thus, in the estimation of depletion, it is necessary to consider both the extraction and the regeneration of these resources. While the rates of extraction can be observed directly, measurement of the rates of regeneration can be complex and usually requires consideration of biological models. These models will usually account for both the structure and the size of populations; and exhibited by their general form, when the stock or population of the specific type of resource is small, the rate of growth will be small but, as the population increases, the rate of growth will also increase. Eventually, as the population within a given area reaches the carrying capacity of the area, i.e., as the density reaches a maximum, the rate of growth in the population will slow substantially.

5.82 Based on this general model, for any given population, it is possible to calculate the number of animals or volume of plants by age or size class that may be removed from the population without affecting the capacity of the population to regenerate itself (i.e., opening stock equals closing stock). In effect, there is a "surplus" or excess that can be harvested from the existing stock. In biological models, this surplus is known as the sustainable yield.

5.83 The level of the sustainable yield rises and falls in line with the overall size and structure of the population. For example, in populations where the growth rates are low, the sustainable yields are also low. These relationships are shown in figure 5.2, with population size being used as a proxy for both population size and structure. It is noted that the same level of extraction will have a different relationship to the sustainable yield depending on the population size. Referring to figure 5.2, a given level of extraction may be above, on or under the sustainable yield curve.

5.84 For a given population, if the amount of extraction is less than the sustainable yield, i.e., points under the curve in figure 5.2, no depletion should be recorded. In this situation, assuming no catastrophic losses or other changes, it would be expected that the stock would increase over the accounting period.

Figure 5.2
Stylized sustainable yield curve



5.85 In principle, depletion is recorded wherever the amount of extraction is greater than the sustainable yield corresponding to the population size and structure. This is reflected by points above the curve in figure 5.2 and represents the case where quantities extracted are greater than the regeneration or growth for any given population.

5.86 However, for most populations of natural biological resources, the estimation of sustainable yield is difficult, as the natural processes of growth and death, the relationship to other species (including predators) and the impact of extraction are usually non-linear, variable (e.g., due to variations in climatic conditions) and often not fully understood in scientific terms. Thus, it is recommended that some year-on-year variation around an estimate of sustainable yield be considered normal. Consequently, in practice, depletion should be recorded when extraction is beyond the normal variation in sustainable yield for a particular population.

5.87 The estimation of the required variables will involve the use of biological models and assumptions regarding the growth, death and other changes in population. If such models are unavailable, other indicators of and changes in stock size may be used. Possible methods are discussed in relation to timber resources in section 5.8 and in relation to aquatic resources in section 5.9.

The relationship between depletion and degradation

5.88 Although the measurement of degradation in physical and monetary terms is not pursued in the Central Framework, there are links with the definition and measurement of depletion that are explained in the Central Framework. The measurement of degradation is considered in the SEEA Experimental Ecosystem Accounting.

5.89 The focus in measuring depletion is on the availability of individual environmental assets in the future and changes in that availability due to extraction and harvest by economic units. There is a particular focus on the specific benefits that arise from the extracted materials, including the capacity of the extraction of the resources to generate income for the extractor.

5.90 ***Degradation considers changes in the capacity of environmental assets to deliver a broad range of contributions known as ecosystem services (e.g., air filtration services from forests) and the extent to which this capacity may be reduced through the action of economic units, including households.*** In this sense, since depletion relates to one type of ecosystem service, it can be considered a specific form of degradation.

5.91 The measurement of degradation is complicated because the capacity of environmental assets to deliver ecosystem services is not attributable solely to individual assets, and because individual assets may deliver a number of different ecosystem services. Further, while individual environmental assets, such as water and soil resources, may have been degraded over time, separating the degradation of an individual asset from the degradation of the overall ecosystem may not be straightforward.

5.92 The measurement of degradation in physical terms is also complicated inasmuch as it generally relies on a detailed assessment of the condition of ecosystems rather than the relatively simpler changes in the quantities of individual environmental assets that are used in the estimation of asset accounts in physical terms and in the estimation of depletion. For example, to assess whether a body of water has been degraded, assessments might be made of the various pollutants in the water as part of a broader assessment of the overall change in condition. While individual accounting for each of these pollutants might be undertaken, it will not be directly related to the volume of water in cubic metres that is used to account for water resources in an asset account.

5.93 Although separately identifying degradation in physical terms is complex, implicitly, the monetary value of individual environmental assets that have been degraded will be affected by the changing quality of the asset. Ideally, where the price of the asset changes to reflect a different quality, this should be considered a change in the volume of the asset rather than a revaluation. However, isolating the price change due to degradation from other causes of price change is likely to be difficult in practice.

5.4.3 Principles of asset valuation

5.94 One general advantage of applying valuation approaches is that different environmental assets can be compared using a common numeraire, which is not possible using purely physical data. Further, environmental assets can be compared against other assets in order to assess relative returns, national wealth and similar types of analysis. Since it is commonly the case that governments have a high level of ownership of or influence over the extraction of environmental assets, valuation of these assets in monetary terms may provide useful information for assessing future streams of income for government, for example, in the estimation of future government revenue from the extraction of oil and natural gas.

5.95 It is also the case that in business accounts, enterprises involved in extraction make assessments regarding their future income streams and in this regard, the ability to place these individual enterprise-based valuations in a broader, national context is of relevance. There is also increasing use of market-based mechanisms, such as quotas, to allocate access rights to environmental assets. These mechanisms may relate directly to aggregate valuations for environmental assets.

5.96 Since many environmental assets are not purchased in a marketplace and, unlike buildings and equipment, have not been produced, there are generally no observable prices for the value of the opening and closing stock of environmental assets or for the flows between these two dates.

5.97 Where market prices do not exist, the estimation of values requires the use of assumptions and models. Overall, these models have proved to be sound tools for the development of meaningful valuations for produced assets. At the same time, there are complexities involved in the application of these models, which compilers and users should be aware of before applying the models in practice.

5.98 Explained below are the principles for the valuation of assets and the approaches that can be used to estimate the values in monetary terms.[52] Specific measurement issues relevant to individual environmental assets are addressed in later sections of this chapter.

General principles of valuation

5.99 The prices at which assets are bought or sold on markets are a basis of decisions by investors, producers, consumers and other economic agents. Market prices are assessed by investors and producers in relation to their expectations of the flows of income they can derive from the assets. For example, investors in renewable energy infrastructure assets (such as wind turbines) and environmental assets (such as land) make decisions in respect of acquisitions and disposals of these assets in the light of their values in the market relative to the income they expect the assets to generate over time.

5.100 Ideally, observable market prices should be used to value all assets, and every item should be valued as if it were being acquired on the date to which the estimate of the stock relates. These two recommendations enable the values of different types of assets, including environmental, financial, and other economic assets, to be compared in meaningful ways, and allow the formation of opening and closing values of stocks that can be used to assess national and institutional sector estimates of wealth in monetary terms.

5.101 At the same time, market-based estimates of asset values will commonly not account for all aspects that may be considered to be relevant in forming a valuation for an asset. For example, the value of a second-hand car in the marketplace will often be less than the value that the current owner places on the benefits of utility and flexibility associated with car ownership. At the same time, the car's value to its owner may not reflect the impact on the environment of emissions arising from operating the car. Thus, while the use of market prices allows comparison across asset types, those prices may not reflect the value of the asset from an individual or societal perspective. This aspect of market based prices is often mentioned in relation to the valuation of environmental assets.

5.102 An important additional consideration in the application of general principles of valuation to environmental assets is that the objective is to estimate the value of the asset in situ rather than after its removal.

5.103 The approaches described in the SEEA, in particular the net present value approach, provide reasonable proxies for observable market prices and consistency with the SNA, but do not take into account the full range of benefits (and costs) that might be considered relevant.

Approaches to the valuation of assets

5.104 The ideal sources of market-price observations for assets are values observed in markets in which each asset traded is completely homogeneous, is often traded in considerable volume, and has its market price listed at regular intervals. Such markets yield data on prices that can be multiplied by indicators of physical stocks to enable computation of the total market value of different classes of assets. These types of price observation are available for

52 The principles of valuation explained here align fully to the SNA 2008 (see paras. 13.16-13.25).

most financial assets, newly purchased produced assets, including many types of transport equipment (such as cars and trucks), and livestock.

5.105 In addition to providing direct observations on the prices of assets actually traded, information from such markets may also be used to price similar assets that are not traded. For example, information on house and land sales may be used to estimate the value of houses and land that have not been sold.

5.106 When there are no observable prices because the items in question have not been purchased or sold on the market in the recent past, an attempt has to be made to estimate what the prices would be if a regular market existed and the assets were to be traded on the date to which the estimate of the stock relates.

5.107 One approach is to use the ***written-down replacement cost***. The value of an asset will decline over time as the value at the time of acquisition, the acquisition price, is reduced by consumption of fixed capital (more commonly referred to as depreciation) over the asset's life. Furthermore, the acquisition prices of equivalent new assets will change. In theory, the value of an asset at any given point in its life is equal to the current acquisition price of an equivalent new asset less the accumulated consumption of fixed capital over its life. When reliable directly observed prices for used assets are not available, this procedure gives a reasonable approximation of what the market price would be were the asset to be offered for sale.

5.108 In the context of environmental assets, this approach may be applied to estimate the value of the stock of cultivated biological resources that are fixed assets, for example, orchards.

5.109 A second approach is to use the ***discounted value of future returns***. For many environmental assets, there are no relevant market transactions or set of acquisition prices that would permit the use of the previous two approaches. Thus, although prices can be found to value the output from extraction or harvest of an environmental asset, no values for the asset itself, *in situ*, are available.

5.110 In this situation, the discounted value of future returns approach, commonly referred to as the net present value (NPV) approach, uses projections of the future rate of extraction of the asset, together with projections of its price, to generate a time series of expected returns. Typically, these projections are based on the history of returns earned from the use of the environmental asset. Assuming that returns earned in the current period are worth more to the extractor than returns earned in the future, the stream of expected returns is discounted to reflect the value that a buyer would be prepared to pay for the asset in the current period.

5.111 The next section outlines the key components of the NPV approach. Additional details, including the relevant mathematical derivations related to the NPV approach, are provided in annex A5.1.

5.4.4 The net present value (NPV) approach

5.112 There are five key components of the NPV approach that require explanation: (*a*) the measurement of returns on environmental assets, (*b*) the determination of the expected pattern of resource rents based on expected extraction profiles and prices, (*c*) the estimation of the asset life, (*d*) the selection of a rate of return on produced assets and (*e*) the choice of discount rate.

The measurement of returns on environmental assets

5.113 In the SEEA, returns are defined using the concept of economic rent. ***Economic rent is best considered to be the surplus value accruing to the extractor or user of an asset calculated after all costs and normal returns have been taken into account***.

5.114 The surplus value, referred to as resource rent in the context of environmental assets, can be taken to be the return attributable to the asset itself. The logic of the NPV approach requires estimating the stream of resource rents that are expected to be earned in the future and then discounting these resource rents back to the present accounting period. This provides an estimate of the value of the asset at that point in time.[53]

5.115 One common feature in definitions of resource rent is that the amount of resource rent is always derived relative to the returns earned by other firms on average over time, i.e., normal returns. Resource rent, as a residual, may be positive or negative. Economic theory suggests that, over the long term, resource rents should be positive.

5.116 The measurement of resource rent provides a gross measure of the return to environmental assets. As for produced assets, it is also relevant to consider the derivation of a net measure of the return by deducting depletion from resource rent, i.e., depletion-adjusted resource rent. For produced assets, the equivalent deduction is for depreciation. Depletion, as defined earlier in this section, reflects the change in the value of an environmental asset that is due to extraction in excess of regeneration. Putting aside any changes in expectations for future returns or differences between expected and realized outcomes, the measure of depletion-adjusted resource rent corresponds, in economic terms, to a net return to capital or net return to environmental assets. Further, it is shown in annex A5.1 that depletion-adjusted resource rent is equal to the nominal (or overall) return to environmental assets less the expected revaluations of the environmental asset.

5.117 Resource rent and the net return to environmental assets can be derived within the national accounts framework through a focus on the operating surplus of extracting enterprises. In this context, the operating surplus earned by an enterprise is considered to comprise a return for the investment in produced assets and a return to the environmental assets used in production.

5.118 The relationships between the relevant variables are shown in table 5.5. The table presents the standard derivation of gross operating surplus based on the SNA using measures of output, intermediate consumption, compensation of employees, and other taxes on and subsidies for production.

5.119 Before deriving measures of resource rent, it is necessary to take into account the effects of any specific taxes and subsidies that relate to the extraction activity. Specific taxes and subsidies are those that apply solely to the extracting enterprises and are not generally applicable across the economy.[54] Examples include subsidies provided based on the quantity of resources sold and taxes levied solely on inputs used in the extracting industries. The deduction of specific subsidies from and the addition of specific taxes to the standard national accounts measures of gross operating surplus are such that the resulting measure of resource rent is neutral to these flows; that is to say, while these flows affect the incomes of

53 There are a number of different theories concerning what factors drive the generation of resource rent accruing to the extractor or user of an asset. Examples of sources of resource rent include differential rent, scarcity rent and entrepreneurial rent. Different sources of resource rent are not mutually exclusive and consequently the estimates of resource rent that underpin the NPV estimates in the SEEA should not be regarded as emerging from any one particular source of resource rent.

54 Specific taxes exclude special payments of income taxes and rent that may be applicable for extracting industries.

the extracting industries, they are effectively redistributions within the economy and should not influence the estimated return to the underlying environmental asset.

Table 5.5
Relationships between different flows and income components

Output (sales of extracted environmental assets at basic prices, includes all subsidies on products, excludes taxes on products)	
Less Operating costs	
	Intermediate consumption (input costs of goods and services at purchasers' prices, including taxes on products)
	Compensation of employees (input costs for labour)
	Other taxes on production plus other subsidies on production
Equals **Gross operating surplus—SNA basis**[a]	
Less Specific subsidies on extraction	
Plus Specific taxes on extraction	
Equals **Gross operating surplus—for the derivation of resource rent**	
Less **User costs of produced assets**	
	Consumption of fixed capital (depreciation) + return to produced assets
Equals **Resource rent**	
	Depletion + net return to environmental assets[b]

[a] Strictly speaking, this accounting identity also includes gross mixed income (the surplus earned by unincorporated enterprises) and should be adjusted for net taxes and subsidies on production. These details do not affect the logic of the explanation provided.

[b] In principle, the net return to environmental assets derived here also incorporates a return to other non-produced assets (e.g., marketing assets and brands), as these assets also play a role in generating the operating surplus. These returns are ignored in the formulation presented here.

5.120 Resource rent is thus derived from standard SNA measures of gross operating surplus by deducting specific subsidies, adding back specific taxes and deducting the user costs of produced assets (themselves composed of consumption of fixed capital and the return to produced assets). As noted above, resource rent is composed of depletion and the net return to environmental assets.

5.4.5 Approaches to estimating resource rent and net present values

Approaches to estimating resource rent

5.121 In practice, there are three main approaches to estimating resource rent: the residual value method, the appropriation method and the access price method.

5.122 The most commonly applied method is the ***residual value method***. Under this method, resource rent is estimated by deducting user costs of produced assets from gross operating surplus after adjustment for any specific subsidies and taxes.

5.123 Estimates of the value of gross operating surplus and specific subsidies and taxes may be obtained from national accounts data sets. Estimates of the user costs of produced assets are not generally available and must be constructed so that each period's resource rent can be obtained. Estimates of the user costs of produced assets are composed of two variables: consumption of fixed capital of produced assets; and normal return on produced assets. Both variables may be estimated within national accounts models designed to estimate the value of the fixed capital stock and related variables for various purposes, including productivity analysis. If such models have not been developed, then each variable may be estimated using assumptions regarding depreciation rates, asset lives and rates of return on produced assets.

A full description of considerations and approaches relevant to the measurement of user costs is presented in *Measuring Capital: OECD Manual—2009* (OECD, 2009).

5.124 A difficulty in estimating resource rents with this method is that one is rarely able, from using the source information, particularly national accounts data, to isolate only the extraction or harvesting activity; and in certain circumstances, multiple resources may be extracted at the same time, particularly in mining. Generally, data on gross operating surplus (GOS) for industries that extract and harvest environmental assets will capture some downstream processing, refinement or other value-added activity also undertaken by the extractor before sale. Since all of these additional activities require inputs of labour and capital, partitioning a firm's GOS into pure extraction activity relating to a single resource is not always straightforward. Nonetheless, every effort should be made to isolate the specific GOS for the extraction activity of individual resources in the underlying data.

5.125 There may be concern that, in situations of over-exploitation of resources, the resulting gross operating surplus will generate a higher estimate of resource rent than can be sustained over the longer term. While this observation is correct, it does not invalidate the measurement approach. The aim of the approach is not to measure what might or should happen under ideal circumstances but to account for expected behaviour in respect of the environmental asset. Thus, if over-exploitation continues, it should be reflected in a shorter remaining asset life and in a greater amount of depletion (as a component of the higher resource rent) than might otherwise be the case.

5.126 The ***appropriation method*** estimates the resource rent using the actual payments made to owners of environmental assets. In many countries, governments are the legal owners of environmental assets on behalf of the country. As legal owners, governments could in theory collect the entire resource rent derived from extraction of the resources that they own. This amount would, in principle be equal to GOS less user costs of produced assets of the extractor, as defined.

5.127 The collection of resource rent is generally undertaken by governments through mechanisms such as fees, taxes and royalties. In practice, the fees, taxes and royalties actually collected tend to understate total resource rent, as the rates may be set with other priorities in mind, for example, encouraging investment and employment in extracting industries. These alternative motivations should be considered before use of the appropriation method.

5.128 The ***access price method*** is based on the fact that access to resources may be controlled through the purchase of licences and quotas, as is commonly observed in the forestry and fishing industries. When these resource access rights are freely traded, it is possible to estimate the value of the relevant environmental asset from the market prices of the rights. The economic logic parallels the residual value method, since it is expected that, in a free market, the value of the rights should be equivalent to the future returns from the environmental asset (after deducting all costs, including user costs of produced assets).

5.129 Where the resource access rights that are purchased provide a very long term or indefinite access to the assets, the market value of the rights should provide a direct estimate of the total value of the asset rather than simply an estimate of the resource rent. In this case, no discounting of future flows of resource rent is needed. If the rights are for a more limited period (e.g., for one year in the case of entitlements), this can provide a direct estimate of the resource rent for that period.

5.130 In practice, in many cases governments may give the access rights direct to extractors for free or do so at a price that is less than the true market value. Further, trading of the rights may be restricted or prohibited. In these cases, there is no directly observable market valuation.

Summary of methods to estimating resource rent

5.131 While, in theory, all of these methods will generate the same estimates of resource rent, it is the case that the application of the appropriation and access price methods are more heavily influenced by institutional arrangements in a country. For these reasons, estimates of resource rent based on the residual value method should be compiled and, where possible, reconciled with estimates obtained using the other methods. Indeed, there may be particular analytical interest in comparing the estimates of resource rent based on the different methods.

Determination of the expected pattern of resource rents

5.132 The critical factor in the valuation of assets is not the past or current returns but the expected returns. An asset with no expected returns has no value in economic terms. Expected returns are, by definition, not observed and hence assumptions concerning these flows must be made.

5.133 Resource rents are a function of quantities of resources extracted, unit extraction costs and commodity prices. The starting point is generally the estimates of resource rent in the current period or the period of the immediate past. In the absence of any additional information on expected future price changes or likely changes in extraction rates, it is recommended that estimates of expected resource rent should be set based on current estimates of resource rent, thus assuming no price changes beyond the general level of inflation, and a realistic rate of resource extraction.

5.134 In general, there is too much volatility in unit resource prices for meaningful assumptions about future resource price changes to be incorporated. Also, in the absence of other information, it may be reasonable to assume that extraction will continue at the same rate as in the past, since this is the extraction rate for which an appropriate amount of produced assets has been acquired. At the same time, if, for example, it was known that the majority of the expected resource rent would be earned in years 5 to 10 over a total asset life of 30 years, then this timing of expected returns should be taken into account.

5.135 Special consideration is needed in situations where the extraction rates in any particular period might be considered abnormal, including where they fall to zero, or close to zero. In practice, this is possible in any given accounting period, for example, if the change in economic circumstances is such that extraction is no longer cost-effective, natural disasters make the resource inaccessible or unharvestable, or access to resources is restricted to allow the recovery of stocks.

5.136 If changes occur in the expected extraction schedule, the resulting NPV estimates may produce results that are difficult to interpret. However, this only highlights the fact that, when the expected extraction schedule changes for any reason, including simply the receipt of additional information, the NPV estimates must be re-estimated, since they should reflect a valuation based on all of the information available at that point in time.

Estimates of the asset life

5.137 ***The asset life (or resource life) is the expected time over which an asset can be used in production or the expected time over which extraction from a natural resource can take place.*** Estimates of the asset life must be based on consideration of the available physical stock of the asset and assumed rates of extraction and growth, in the case of renewable resources. In a very simple case, the asset life can be calculated by dividing the closing physical stock by the excess of expected annual extractions over expected annual growth. However, especially for natural biological resources such as aquatic resources, it is necessary to consider biological models and associated sustainable yields of biological resources in such a way as to ensure the impact of changing age and sex structures is taken into account in the determination of the asset life. A description of relevant considerations is contained in section 5.4.2.

5.138 It may be that, through the use of biological and economic models, optimal extraction paths can be calculated which effectively determine the asset life through alignment between the available stock and rates of extraction. Often implicit in the determination of such extraction paths, particularly for renewable natural resources, are assumptions regarding the sustainability of the resource, for example, that future management of fish stocks will ensure that extraction does not exceed growth.

5.139 For the SEEA, making such assumptions regarding sustainability is problematic, as it may ignore important environmental information and may imply the adoption of behaviour that may not have been adopted in the past. Unless there is evidence to the contrary, it is recommended that estimates of asset life be based on rates of extraction and growth that have occurred in the recent past rather than through the use of general assumptions on sustainability or intended management practice.

5.140 Estimates of the asset life are required to provide the time frame over which the NPV approach is applied. In practice, depending on the choice of discount rate, if asset lives are longer than about 20 years, the NPV estimates are relatively stable; that is, the values of the expected returns in later years are relatively small. The sensitivity of the NPV estimates to the choice of discount rate over varying asset lives is discussed in annex A5.2.

Rate of return on produced assets

5.141 An expected rate of return on produced assets is required to estimate the user cost of the produced assets utilized in the extraction of the environmental asset. If this cost is not deducted, the resulting estimates of resource rent will be overstated.

5.142 Two approaches can be taken to estimating rates of return on produced assets: an endogenous approach and an exogenous approach. The endogenous approach sets the rate equal to the net operating surplus (gross operating surplus less consumption of fixed capital) divided by the value of the stock of produced assets. This approach implicitly assumes that there is no return attributable to non-produced assets, including environmental assets, and hence it is not recommended. It should, however, form an upper bound of the estimated rate of return on produced assets.

5.143 The exogenous approach is recommended in the SEEA. This approach assumes that the expected rate of return on produced assets is equal to an exogenous (external) rate of return. Ideally, the expected rate of return should relate to activity-specific returns, thus taking into account risks in investing in particular activities. However, in many cases, financial markets may not be sufficiently developed to provide robust estimates of these specific rates of return.

5.144 For this reason, a realistic approach is to use an economy-wide rate of return, perhaps based on government bond rates, where these exist.[55] In all cases, a real rate of return should be used. While exogenous rates of return are unlikely to be perfect proxies for rates of return on individual produced assets, it is likely that they provide a reasonable reflection of normal returns for the derivation of estimates using the NPV approach.

55 It is also the case for technical reasons that a general rate of return is appropriate. If an activity-specific rate of return is used, it is also necessary to include activity-specific expectations in the derivation of the revaluation term in the NPV formula; in this way, the impact of using activity-specific rates of return is offset.

Choice of discount rate

5.145 Discount rates are required to convert the expected stream of resource rents into a current-period estimate of the overall value. A discount rate expresses a time preference—the preference of the owner of an asset to receive income now rather than in the future. It also reflects the owner's attitude to risk. In general, individuals and enterprises will have higher rates of time preference than society; that is, individuals and enterprises will tend to demand a quicker return from ownership of an asset than will the society as a whole. Higher rates of time preference translate into higher discount rates.

5.146 The discount rate used in NPV calculations can be interpreted as an expected rate of return on the non-produced assets. In an enterprise where all assets are identified and measured accurately, and where conditions of perfect competition prevail, the discount rate and the rate of return should be equal. This is because the enterprise should invest only if the rate of return on all assets is aligned to its own time and risk preferences for receiving income.

5.147 To ensure a valuation that is aligned to the general concept of market prices, it is recommended that a market-based discount rate should be used equal to the assumed rate of return on produced assets (see above).

5.148 At the same time, there is also support for the use of social discount rates in the valuation of environmental assets. The rationale is that environmental assets are of broad and long-term value to society as a whole and should be valued in that light rather than solely in relation to their value to a present-day extractor.

5.149 One of the main arguments supporting the use of social discount rates is that, generally, social discount rates are lower than market-based discount rates and lower rates will place higher relative importance on income earned by future generations. From this, it is often inferred that estimates of NPV that use market-based discount rates do not value future generations and the total values obtained are too small, since they do not give sufficient weight to these future incomes.

5.150 Annex A5.2 presents an extended discussion on discount rates and their application, including a table illustrating the sensitivity of valuations based on NPV to the choice of discount rate.

Calculation of net present value

5.151 Using these various components, estimates of the value of an environmental asset are obtained based on the following basic steps and assuming the employment of the residual value method to calculate resource rent:

(*a*) Obtain estimates of GOS, specific subsidies and taxes on extraction, and the user cost of produced assets for the extractive activity, from relevant sources, most likely based on national accounts data, relevant activity-specific information and assumptions regarding rates of return on produced assets;

(*b*) Estimate resource rent as GOS less specific subsidies plus specific taxes less user cost of produced assets;

(*c*) Estimate the asset life based on physical assessment of the stock and projected rates of extraction and growth;

(*d*) Project the estimate of resource rent over the life of the asset, taking into account any expected changes in extraction pattern;

(*e*) Apply the NPV formula using an appropriate discount rate:

$$V_t = \sum_{\tau=1}^{N_t} \frac{RR_{t+\tau}}{(1+r_t)^{\tau}}$$

where V_t is the value of the asset of time t; N is the asset life: RR is the resource rent; and r is a nominal discount rate (for details see annex A5.1)

5.152 Where possible, compilers are encouraged to compare results of NPV calculations that would be obtained using different estimates of the discount rate and also different approaches to the estimation of resource rent. This may be possible where tradable access rights are in existence or where payments of rent are recorded. These alternative estimates of resource rent may be substituted in the general NPV formulation to enable the derivation of alternative valuations.

5.153 If, after adjusting for specific taxes and subsidies, the derived expected resource rent is negative, then the estimated NPV of the asset should be assumed to be zero. This conclusion should not be based on single observations of negative resource rents but should take into account likely future patterns of operating surplus and specific taxes and subsidies. In some cases, the extraction may continue because the level of specific subsidies is sufficient to ensure a suitable income for the extractor. However, in these situations, the income should not be attributed to a return to the underlying environmental asset, but, instead, should be considered a redistribution of incomes within the economy.

5.154 Wherever actual market prices are available, for example, on the basis of actual transactions in environmental assets, this information should be used in preference to NPV-based valuations. In incorporating this information, appropriate adjustments for the scope and coverage of the transactions, compared with the scope of the estimation based on NPV, need to be made.

5.155 Ideally, calculation of NPV estimates should be undertaken for individual stocks, for example, a specific mineral deposit or fish stock. At this level of detail, changes in the stock can be more accurately considered and assumptions more accurately evaluated. More generally, every effort should be made to test assumptions used in the formulation of NPV valuations and, wherever possible, additional information about specific individual stocks should be taken into account—for example, large discoveries of mineral and energy resources or catastrophic losses of timber resources due to exceptional weather events.

5.156 Accounting for the change in the value of assets over an accounting period is a core part of asset accounting. Like the assessment of the value of an asset at the beginning and end of a period, the valuation of changes in the stock, such as discoveries and catastrophic losses, is also dependent on the impact that these changes have on expected returns. Since these changes are not usually evidenced in transactions in the assets themselves, their valuation requires the use of the NPV approach to ensure alignment between stock valuations and valuations of the changes in the stock.

5.157 A complete accounting for NPV and changes in NPV is presented in annex A5.1. The annex highlights the relationships between the quantities of the natural resource, the quantity extracted, the price received for extracted resources (after deduction of extraction costs), i.e., the unit resource rent, and the price of the resource in situ, i.e., before extraction. A key conclusion presented in the annex is that it is incorrect to use the unit resource rent to value the stock of natural resources; rather, the in situ price must be used. At the same time, there is a clear relationship between these two prices and it is therefore possible to estimate the in situ price based on measures of resource rent.

5.158 The second key conclusion discussed in the annex is that the valuation of all changes in the stock of a natural resource (e.g., depletion, extraction, discoveries and catastrophic losses) must also be valued using average in situ resource prices. Using these prices permits a balanced and complete accounting of changes in the value of natural resources over an accounting period.

5.159 Finally, annex A5.1 demonstrates that the valuation of both non-renewable and renewable natural resources can be undertaken within the same accounting framework. Thus, measures of the natural growth of natural biological resources can be accounted for within the NPV framework, and appropriate measures of depletion can be defined.

5.4.6 Measurement of environmental assets in volume terms

5.160 As explained in chapter II, volume measures of assets are not measures of quantities but rather estimates of changes in the value of assets after removing the effects of price change. Thus, volume measures encompass changes due to changes in quantities and changes in quality.

5.161 Volume measures of environmental assets are compiled to assist in the analysis of the changes in environmental assets over time. Removing the effect of price change may be undertaken for two primary reasons: first, to provide an indicator of the purchasing power of environmental assets, i.e., an estimate of the capacity of a set of environmental assets to be used to acquire a given set of goods and services; and second, to assess whether there has been a change in the underlying aggregate physical stock of a number of different environmental assets. Both of these rationales may be important considerations when undertaking an aggregate analysis of the wealth of a country and considering the relative importance of environmental assets compared with other economic and social assets.

5.162 For estimating the purchasing power of a set of environmental assets, the volume measure is equal to the total value of environmental assets divided by an estimate of the general rate of inflation, for example, the consumer price index.

5.163 To estimate changes in the aggregate physical stock, a rough assessment may be completed through analysis of the change in the physical stock of each type of environmental asset. However, this approach does not permit aggregation across assets since each will be measured in different physical units, for example, hectares (for land) and tonnes (for coal).

5.164 A number of different measurement approaches can be considered in respect of obtaining a volume measure reflecting the aggregate physical stock. First, a volume measure can be compiled that is the aggregation of the changes in physical stocks of each asset weighted by their relative values at a given point in time. The point in time is often the beginning or end of the accounting period but the relative values may also be calculated based on an average of beginning- and end-of-period values.

5.165 A second approach to the compilation of the volume of the aggregate physical stock can be applied in cases where the NPV formula has been used. This approach is to re-estimate the NPV at the end of the period, for each environmental asset, using the same in situ resource price as was used at the beginning of the period. The sum of these re-estimated NPVs provides an estimate of the volume of environmental assets at the end of the period. This estimate can be compared with the value of the environmental assets at the beginning of the period to obtain an estimate of the change in volume. In effect, the physical stocks at the beginning and at the end of the period are all valued using the same set of prices; hence, any change reflects the volume change in environmental assets.

5.166 It is possible, with a time series of asset values, to use the in situ resource price from one reference period to re-estimate the value of assets at all other periods. This provides a time series of asset values at constant in situ resource prices. However, the use of constant prices may hide changes in prices and the associated resource rent that are due to changing technology and extraction costs. Hence, it is preferable to calculate the changes in volume between each period using in situ resource prices relevant to that period and then link the consecutive estimates of the changes in volume together to form a single time series.

5.167 A third approach to deriving asset volumes is to divide the individual asset values at the end of the period by an asset-specific price index. In many cases, this may be a price index relating to the sales of extracted products (e.g., a price index for coal used to deflate the value of stocks of coal). However, a more accurate result is obtained if the price index reflects changes in the in situ resource price. This requires taking into account not only the changing prices of the extracted products but also the changing costs of extraction. As for the second approach, the price index reflecting the changing costs of production should assume a constant technology so that these changes are captured in the volume change.

5.5 Asset accounts for mineral and energy resources

5.5.1 Introduction

5.168 Mineral and energy resources are a unique type of environmental asset in that they can be extracted and used in economic activity but cannot be renewed on any human timescale. Since they cannot be renewed, there is particular interest in understanding the rate at which these assets are extracted and depleted, the overall availability of these assets, and the sustainability of the industries that exploit them.

5.169 Asset accounts for mineral and energy resources organize relevant information, including the quantities and values of stocks of the resources and the changes in these over accounting periods. Flows of extraction, depletion and discoveries are central to the asset account and these, in turn, can provide valuable information regarding the availability of individual resources.

5.170 Valuing stocks and flows of mineral and energy resources allows important links to be made to monetary estimates of the value added and operating surplus of the extracting industries, such as through the derivation of depletion-adjusted value-added measures. Such measures provide a view of extraction activity that recognizes a more complete set of production costs. Monetary estimates of these assets may also be of interest in the determination of government taxation and royalty settings, given that, in many countries, the government is the collective owner of these assets on behalf of society.

5.171 The present section defines mineral and energy resources and the relevant measurement boundary for the Central Framework. It then presents asset accounts in physical and monetary terms, including a discussion on the estimation of resource rent. Further, this section discusses two specific measurement issues related to mineral and energy resources: (*a*) the allocation of income from the extraction of mineral and energy resources and (*b*) the recording of stocks and flows of energy from renewable sources.

5.5.2 Definition and categorization of mineral and energy resources

5.172 Mineral and energy resources include deposits of oil resources, natural gas resources, coal and peat resources, non-metallic minerals and metallic minerals. Since the resources are generally found underground (hence commonly referred to as subsoil assets), the quantity of resources that one might reasonably expect to be extracted is not known with any large degree of precision. Consequently, a key factor in the measurement of mineral and energy resources is the concentration and quality of the minerals and energy resources in the deposit, since this will influence the likelihood and cost of extraction and the degree of confidence regarding the quantity that can be extracted in the future.

5.173 ***Mineral and energy resources comprise known deposits of oil resources, natural gas resources, coal and peat resources, non-metallic minerals and metallic minerals.***

5.174 The framework used to define the scope of known deposits is the *United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009* (UNFC-2009) (United Nations, Economic Commission for Europe, 2010). The UNFC-2009 is a generic, flexible scheme for classifying and evaluating quantities of fossil energy and mineral resources.

5.175 Many countries have their own national classification systems based on, for example, systems developed by the Society of Petroleum Engineers (SPE, 2007), the Committee for Mineral Reserves International Reporting Standards (CRIRSCO, 2007) and the International Atomic Energy Agency/International Energy Agency (IAEA/IEA). Thus, it may be necessary to apply conversions to facilitate international comparisons.[56]

5.176 The UNFC-2009 categorizes mineral and energy resources through determining whether, and to what extent, projects for the extraction and exploration of the resources have been confirmed, developed or planned. The underlying resources are classified based on the maturity of the projects. UNFC-2009 is based on a breakdown of the resources according to three criteria affecting their extraction:

- Economic and social viability (*E*)
- Field project status and feasibility (*F*)
- Geological knowledge (*G*)

5.177 Criterion E designates the degree of favourability of economic and social conditions in establishing the commercial viability of the project. Criterion F designates the maturity of studies and commitments necessary to implement mining plans or development projects, extending from early exploration efforts occurring before it has been confirmed that a deposit or accumulation exists, to projects involving extraction and sale of a product. Criterion G designates the level of certainty of geologic knowledge and of potential recoverability of quantities of the resource concerned.

5.178 Known deposits are categorized in three classes, each defined according to combinations of criteria derived from UNFC-2009:

(*a*) *Class A: Commercially recoverable resources*. This class includes deposits for projects that fall in categories E1and F1 and where the level of confidence in the geologic knowledge is high (G1), moderate (G2) or low (G3);

56 To aid such conversions, mapping schemes have been developed showing the link between the UNFC-2009 and the SPE and CRIRSCO classifications. A reference to the UNFC documents, including examples of application of the UNFC in selected countries and descriptions of mapping between other systems and the UNFC, is http://www.unece.org/energy/se/reserves.html.

(*b*) *Class B: Potentially commercially recoverable resources.* This class includes deposits for those projects that fall in the category E2 (or eventually E1) and at the same time in F2.1 or F2.2 and where the level of confidence in the geologic knowledge is high (G1), moderate (G2) or low (G3);

(*c*) *Class C: Non-commercial and other known deposits*. These are resources for those projects that fall into category E3 and for which the feasibility is categorized as F2.2, F2.3 or F4 and where the level of confidence in the geologic knowledge is high (G1), moderate (G2) or low (G3).

5.179 deposits exclude potential deposits where there is no expectation of the deposits' becoming economically viable and there is a lack of information needed to determine the feasibility of extraction or to have confidence in the geologic knowledge. Table 5.6 gives an overview of how the classes of resources are defined based on the UNFC criteria. UNFC is explained in more detail in annex A5.3.

5.180 The scope of known deposits is broader than the scope of deposits that underpins the measurement of mineral and energy resources in the SNA. In the SNA, the scope is limited to deposits that are commercially exploitable given current technology and relative prices.[57] A broader scope of deposits is applied in the SEEA to ensure that as broad an understanding as possible is obtained on the availability of the stock of mineral and energy resources. Issues associated with the scope of the valuation of mineral and energy resources are discussed in section 5.5.4.

Classification of mineral and energy resources

5.181 There are a number of different types of mineral and energy resources, such as oil, natural gas, coal and peat resources, non-metallic minerals and metallic minerals; but there is no internationally agreed detailed classification for mineral and energy resources suitable for statistical purposes.

5.5.3 Physical asset accounts for mineral and energy resources

5.182 Physical asset accounts for mineral and energy resources should be compiled by type of resource and include estimates of the opening and closing stock of mineral and energy resource and changes in the stock over the accounting period.

5.183 The measurement units used to compile and present the relevant information will vary by type of resource. They are likely to be in tonnes, cubic metres or barrels. For accounting purposes, the same measurement unit should be used, for a single resource, to record the opening and closing stocks and the changes in the stocks over an accounting period.

5.184 It is noted that a total for each class of deposit across different resource types cannot be meaningfully estimated owing to the use of different measurement units for different resources. For certain subsets of resources, for example, energy resources, an aggregate across certain resource types may be possible using a common measurement unit such as joules or other energy units.

57 See para 10.179 of the 2008 SNA.

Table 5.6
Categorization of mineral and energy resources

	SEEA classes	Corresponding UNFC-2009 project categories		
		E Economic and social viability	F Field project status and feasibility	G Geologic knowledge
Known deposits	A: Commercially recoverable resources[a]	E1. Extraction and sale have been confirmed to be economically viable	F1. Feasibility of extraction by a defined development project or mining operation has been confirmed	Quantities associated with a known deposit that can be estimated with a high (G1), moderate (G2) or low (G3) level of confidence
	B: Potentially commercially recoverable resources[b]	E2. Extraction and sale are expected to become economically viable in the foreseeable future[c]	F2.1 Project activities are ongoing to justify development in the foreseeable future Or F2.2 Project activities are on hold and/or where justification as a commercial development may be subject to significant delay	
	C: Non-commercial and other known deposits[d]	E3. Extraction and sale are not expected to become economically viable in the foreseeable future or evaluation is at too early a stage to determine economic viability	F2.2 Project activities are on hold and/or where justification as a commercial development may be subject to significant delay Or F2.3 There are no current plans to develop or to acquire additional data at the time due to limited potential Or F4. No development project or mining operation has been identified	
Potential deposits (not included in SEEA)	Exploration projects Additional quantities in place	E3. Extraction and sale are not expected to become economically viable in the foreseeable future or evaluation is at too early a stage to determine economic viability	F3. Feasibility of extraction by a defined development project or mining operation cannot be evaluated due to limited technical data Or F4. No development project or mining operation has been identified	Estimated quantities associated with a potential deposit, based primarily on indirect evidence (G4)

Notes

[a] Including on-production projects, projects approved for development and projects justified for development.

[b] Including economic and marginal development projects pending and development projects on hold.

[c] Potential commercial projects may also satisfy the requirements for E1.

[d] Including unclarified development projects, non-viable development projects, and additional quantities in place.

Source: UNFC-2009, figures 2 and 3.

Measurement of opening and closing stocks

5.185 Ideally, opening and closing stocks of each mineral and energy resource should be classified by class of resource, i.e., class A: Commercially recoverable resources; class B: Potentially commercially recoverable resources; or class C: Non-commercial and other known deposits, following the structure in table 5.7.

Table 5.7
Stocks of mineral and energy resources

Type of mineral or energy resource	Class of known deposit A: Commercially recoverable resources	B: Potentially commercially recoverable resources	C: Non-commercial and other known deposits
Oil resources (thousands of barrels)	800	600	400
Natural gas resources (cubic metres)	1 200	1 000	1 500
Coal and peat resources (thousands of tonnes)	600	50	50
Non-metallic mineral resources (tonnes)	150	200	100
Metallic mineral resources (thousands of tonnes)	60	40	60

Note: Different physical units (e.g., tonnes, cubic metres and barrels) will be used for different types of resources.

5.186 It is not recommended that totals including all classes of individual types of resources be compiled. Because each class has a different likelihood of extraction, simple summation of the available resources for a specific resource (e.g., coal) may give a misleading indication of total available resources.

5.187 In this framework, it is important to specify those resources for which a monetary valuation is to be established. If this distinction is not made, a subsequent comparison between physical and monetary accounts for individual resources may provide misleading indicators of average prices and relative availability of individual resources.

Physical asset account for mineral and energy resources

5.188 A basic physical asset account for mineral and energy resources is provided in table 5.8.

Additions to and reductions in the stock of mineral and energy resources

5.189 The changes in the stock in physical terms should consider the following types of changes:

(*a*) *Discoveries*. Discoveries should incorporate estimates of the quantity of new deposits found during an accounting period. To be recorded as a discovery, the new deposit must be a known deposit, i.e., in class A, B or C. Discoveries should be recorded by type and by class of resource;

(*b*) *Reappraisals*. Reappraisals may be upward or downward. They should pertain only to known deposits. In general, reappraisals will relate to either additions or reductions in the estimated available stock of a specific deposit or to changes in the categorization of specific deposits between class A, B or C, based on changes in geologic information, technology, resource price or a combination of these factors;

(*c*) *Extraction*. Estimates of extraction should reflect the quantity of the resource physically removed from the deposit. It should exclude mining overburden, i.e., the quantity of soil and other material moved in order to extract the resource.

Further, the quantity should be estimated before any refinement or processing of the resource is undertaken. Estimates of extraction should include estimates of illegal extraction, either by residents or non-residents, as these amounts reduce the availability of the resource. It is noted that for the extraction of natural gas, the measurement of the quantity extracted may be more difficult owing to the nature of the extraction process for some deposits. In cases where natural gas is found with oil, it is the pressure exerted by the natural gas that causes the oil (and some natural gas) to be expelled from the oil well. Some of the natural gas that is expelled may be flared rather than put to direct use. Some natural gas, especially after extraction has been continuing for some time, may be reinjected to increase the pressure on the remaining oil and thereby allow more oil to be expelled. In such cases, if the natural gas associated with the oil is being accounted for, an allowance must be made for reinjection;

(*d*) *Catastrophic losses*. Catastrophic losses are rare in relation to most mineral and energy resources. Flooding and collapsing of mines do occur but the deposits continue to exist and can, in principle, be recovered: the issue is one of economic viability of extraction rather than actual loss of the resource itself. An exception to this general principle concerns oil wells that can be destroyed by fire or become unstable for other reasons, leading to significant losses of oil resources. Losses of oil and related resources in this situation should be considered catastrophic losses;

(*e*) *Reclassifications*. Reclassifications may occur if certain deposits are opened or closed to mining operations owing to government decisions concerning the access rights to a deposit. All other changes in the quantity of known deposits should be treated as reappraisals. Reclassifications may also be recorded if asset accounts for mineral and energy resources are being compiled by the institutional sector.

Table 5.8

Physical asset account for mineral and energy resources

	Type of mineral and energy resource (Class A: Commercially recoverable resources)				
	Oil resources (thousands of barrels)	Natural gas resources (cubic metres)	Coal and peat resources (thousands of tonnes)	Non-metallic minerals (tonnes)	Metallic minerals (thousands of tonnes)
Opening stock of mineral and energy resources	800	1 200	600	150	60
Additions to stock					
Discoveries					20
Upward reappraisals		200		40	
Reclassifications					
Total additions to stock		200		40	20
Reductions in stock					
Extractions	40	50	60	10	4
Catastrophic losses					
Downward reappraisals			60		
Reclassifications					
Total reductions in stock	40	50	120	10	4
Closing stock of mineral and energy resources	760	1 350	480	180	76

Note: Different physical units (e.g., tonnes, cubic metres and barrels) will be used for different types of resources.

5.190 Increasingly, there is interest in the capacity to supply various metals and other minerals through the recycling of produced goods (e.g., vehicles and computers). The implied stock of relevant metals and minerals within an economy is not within the scope of the asset accounts presented here. Nonetheless, depending on the extent of recycling undertaken in a country, information on recycled metals and other minerals may be compiled to provide a more complete picture of the availability of these resources and hence on the demands for the extraction of these resources from the environment.

5.5.4 Monetary asset accounts for mineral and energy resources

5.191 Asset accounts in monetary terms for mineral and energy resources are based on the availability of information on the physical stock of resources. The structure of the monetary asset accounts therefore largely parallels the structure of the physical asset accounts. The basic structure is shown in table 5.9.

Table 5.9
Monetary asset account for mineral and energy resources (*currency units*)

	Type of mineral and energy resource (Class A: Commercially recoverable resources)				
	Oil resources	Natural gas resources	Coal and peat resources	Non-metallic minerals	Metallic minerals
Opening value of stock of resources	24 463	19 059	41 366	1 668	6 893
Additions to value of stock					
Discoveries					1 667
Upward reappraisals		3 100		391	
Reclassifications					
Total additions to stock		3 100		391	1 667
Reductions in value of stock					
Extractions	1 234	775	4 467	98	333
Catastrophic losses					
Downward reappraisals			4 467		
Reclassifications					
Total reductions in stock	1 234	775	8 934	98	333
Revaluations	412	- 972	5 945	- 442	-4 287
Closing value of stock of resources	23 641	20 412	38 377	1 519	3 940

5.192 The additional entry in the monetary asset account relates to the recording of revaluations which occur due either to changes in resource prices over the accounting period or to changes to assumptions underlying the NPV approaches that are typically used to value mineral and energy resources.

5.193 While the measurement boundary extends to all known deposits in physical terms, it may not be possible to value all of these deposits in monetary terms owing to degrees of uncertainty regarding expected extraction profiles and incomes. Consequently, the resource rents for deposits in classes B and C cannot be determined with confidence. It is therefore recommended that valuation be undertaken only for deposits in class A: Commercially recoverable resources. If valuation of deposits in classes B and C is undertaken, the values for each class should be clearly distinguished. In valuing deposits in each class, it is important that the likelihood and timing of extraction be taken into account in determining expected patterns of extraction and resource rent.

Valuation of stocks of mineral and energy resources

5.194 Because there are few transactions in mineral and energy resources in situ, the valuation of these assets requires the use of NPV approaches, as introduced in section 5.4. The calculations should be undertaken at the level of an individual resource type, ideally for specific deposits of a resource, and then summed over the range of different resources in order to obtain a total value of mineral and energy resources.

5.195 Application of NPV approaches to the valuation of mineral and energy resources requires consideration of a number of specific factors, most pertaining to the estimation of the resource rent.

(a) Estimation of resource rent

5.196 In general, the resource rent will be estimated based on information about the income and operating costs for the extraction industry. The aim is to define a resource rent that is specific to a given resource type, for example, coal. In the effort to achieve this aim, several factors should be borne in mind.

5.197 ***Scope of operations.*** Consistent with the definition of quantities extracted, the scope of the income and operating costs to be considered in the derivation of resource rent should be limited to the extraction process itself and should not include any additional income earned or costs incurred through further refinement and processing of the extracted resource. The extraction process is considered to include the activity of mineral exploration and evaluation and these costs should be deducted in the derivation of resource rent.

5.198 For some mineral and energy resources, a single deposit may contain several types of resources. For example, an oil well often contains gas and, frequently, silver, lead and zinc are extracted together. In these situations, the resource rent used in the calculation of the value of the resources should be allocated by commodity. However, since data are generally available only for a single extracting unit, derivation of estimates of resource rent by type of resource based on known extraction costs for each type of resource may not be possible except by using detailed industry knowledge or general rules of thumb to allocate total extraction costs.

5.199 ***Price fluctuations.*** While operating costs for extracting resources may not fluctuate significantly, it is likely that income earned from sales of extracted resources will fluctuate. Consequently, the resource rent (which is derived as a residual), may entail a quite volatile time series. In addition, the aggregate amount of resource rent in any one period may be affected by extraction rates that in turn may be affected by one-off events, for example, mine collapse. Since the objective is to define a resource rent that can be forecast, it is recommended: first, that unit resource rents be derived by dividing total resource rent for an individual resource by quantities extracted in a period; and second, that, in the absence of other information on future resource prices, a proxy of unit resource rents (e.g., regression-based estimates and moving averages) may be used as the basis for the estimation of future resource rents. To aid interpretation of the information, all assumptions regarding future expected prices and costs should be made clear.

5.200 ***Treatment of mineral exploration and evaluation***. Mineral exploration is undertaken in order to discover new deposits of minerals and energy resources that may be exploited commercially. Such exploration may be undertaken on own account by enterprises engaged in mining activities. Alternatively, specialized enterprises may carry out exploration either for their own purposes or for fees. The information obtained from exploration and evaluation influences the production activities of those who obtain it over a number of years. Hence, the expenditures are considered to be a form of gross fixed capital formation resulting in the production of an intellectual property product, a type of produced asset.

5.201 Mineral exploration and evaluation consists of the value of expenditures on exploration for petroleum and natural gas and for non-petroleum deposits and subsequent evaluation of the discoveries made.[58]

5.202 These expenditures include pre-licence costs, licence and acquisition costs, appraisal costs and the costs of actual test drilling and boring, as well as the costs of aerial and other surveys, transportation costs, etc., incurred to make it possible to carry out the tests. Re-evaluations may be conducted after commercial exploitation of the resource has started and the cost of these re-evaluations is also included.

5.203 Consumption of fixed capital should be calculated for this asset, potentially using average service lives similar to those used by mining or oil corporations in their own accounts.

5.204 For the purpose of estimating resource rent, it is necessary to deduct the user costs of these produced assets, including both the consumption of fixed capital and a return to the produced asset.

5.205 It is recognized that an outcome from mineral exploration is the discovery of mineral and energy resources and hence the value of mineral and energy resources on the balance sheet may, in part, be considered to be due to mineral exploration. However, following the SNA, the output of mineral exploration activity is considered to be an intellectual property product, not a natural resource. The deduction of the user costs of mineral exploration and evaluation in the derivation of resource rent ensures that the recorded value of the mineral and energy resources reflects only the value of the non-produced environmental resource.

5.206 ***Mine and rig decommissioning costs***. Consistent with the treatment in the 2008 SNA, it is recognized that, in many cases, costs are incurred by extractors at the end of the productive life of a deposit, generally to restore the natural environment around the extraction site. These costs, where they can be reasonably anticipated or estimated, should be considered to reduce the resource rent earned by the extractor over the operating life of the extraction site, even though the actual expenditure is likely to take place at the end of the operation of the assets. Details on accounting for these costs are discussed in chapter IV.

5.207 ***Aggregation of the same resource over different deposits***. In the discussion so far, it has been implicitly assumed that the mineral and energy resources constitute a single deposit, so that any extractions and discoveries affect the resource life of all resources available to a country. In practice, of course, this is not the case: some oilfields will be exhausted in a relatively short time frame and extractors will then move to another.

5.208 Many reappraisals apply to established fields where extraction is already in progress. Upward revisions in quantities will extend the life of the resources and the addition to value will largely reflect the change between the previous and new resource lives, since without additional investment the extraction rate is likely to remain steady.

5.209 A somewhat different situation holds for a completely new discovery. Suppose a deposit is discovered with an expected life of, say, 20 years, equal by itself to the existing reserves of a country. It is not realistic to automatically assume that the resource in the new deposit will necessarily be extracted in years 21 to 40. On the other hand, neither is it realistic to automatically assume that it will be extracted in years 1 to 20 and thus double

58 See para. 10.106 of the 2008 SNA.

the total extractions in these years. For these reasons, it is desirable, if at all possible, to make projections of the impacts of discoveries and reappraisals separately and, ideally, on a deposit-by-deposit basis.

(b) Extraction rate

5.210 Independently of assumptions about the resource rent, an assumption must be made about the pattern of extraction to be followed in the future. The assumption most often used is that the extraction rate will stay constant in physical terms, but there is no reason why this should necessarily be so. As resources approach extinction, there may be a decline in output as some deposits become completely exhausted if there are no new deposits to take their place. Alternatively, an enterprise could adjust the rate of extraction to give the same total income every year, or could reduce the amount extracted as the resource diminishes, assuming that the price increased at the same time. There may be information available from government or from enterprises on projected levels of extraction that could be used, although these often tend to be based on conservative projections of the likely level of new discoveries and reappraisals.

5.211 In the absence of more precise information, a reasonable assumption is that the rate of extraction is kept constant in physical terms, which, effectively, is the assumption that the efficiency of the extraction process remains steady and the stock of extraction-related produced assets remains steady in proportion to the available stock of the resource.

(c) Resource life

5.212 At any point in time, the life of a resource is equal to the stock at that time divided by the expected extraction rate. In the course of a year, the resource life will diminish by one year owing to extractions and will change by the quantity of discoveries and reappraisals during the period divided by the average extraction rate. If, on balance, there are more downward reappraisals than upward reappraisals and discoveries, then the resource life is further reduced.

5.213 The quantity of the stock used to calculate the resource life must be consistent with the quantity to be valued. Since only class A resources are to be valued, then the resource's life must be calculated based only on class A resources and not on total known deposits for the resource (i.e., including also class B and class C resources).

Valuation of flows of mineral and energy resources

(a) Value of discoveries, reappraisals, extractions, depletion and catastrophic losses

5.214 The value of additions and reductions in the stock should be calculated using the average prices of the resource in situ over the period multiplied by the quantity discovered, reappraised, extracted, depleted or lost. This is consistent with the approach outlined in section 5.4 and explained in detail in annex A5.1.

(b) Acquisitions and disposals of mineral and energy resources

5.215 These transactions are likely to be rare but when they do occur they should be recorded. Estimates of the value of these transactions should take into account the costs of ownership transfer which should be recorded as the purchase of a produced asset: costs of ownership transfer on non-produced assets. On the balance sheet, this produced asset is considered to be incorporated into the value of the underlying mineral and energy resource.[59]

5.5.5 Other issues in the measurement of mineral and energy resources

Allocation of income from the extraction of mineral and energy resources

5.216 A general characteristic of mineral and energy resources is that the income earned from the extraction of the resources is shared between economic units. Most commonly, part of the income accrues to the extractor of the resources in the form of operating surplus and part of the income accrues to the government in the form of rent. The government earns this income, on behalf of the society, by allowing access to the resources.

5.217 Depending on the nature of the arrangements, often both the extractor and the government will have substantial assets in the form of expected future incomes from the extraction of the resources. Following the description in section 5.4, the expected incomes (which are equal in total to the resource rent) can be separated into two components: depletion and net return to environmental assets. Changes in the value of the assets for each unit will reflect declines due to depletion, while the return to environmental assets will be reflected in the generation and allocation of income accounts.

5.218 Within the SEEA, a specific objective is to show, within the general national accounts framework, how the incomes earned from the extraction of natural resources are impacted by the cost of depletion. In particular, the SEEA aims to define depletion-adjusted estimates of operating surplus, value added and saving at both an economy-wide level and for institutional sectors. Since there is only one amount of depletion for a given mineral and energy resource, it must be allocated between the relevant units within the accounting framework.[60]

5.219 In the circumstances outlined, accounting for these incomes and the associated depletion is problematic in the standard national accounts framework for two main reasons. First, the income flows are recorded in different accounts with the value added and operating surplus of the extractor recorded in the production and generation of income accounts, and the rent earned by the government recorded in the allocation of primary income account. Second, no cost of depletion is recorded against the income earned in the structure of the standard accounts (in contrast with the cost of produced assets, which is recorded as consumption of fixed capital). Instead, in the SNA, depletion is recorded in the other changes in the volume of assets account.[61]

5.220 The following accounting treatment is recommended for the SEEA:

(*a*) Record the total cost of depletion in the production and generation of income accounts of the extractor as deductions from value added and operating surplus. This ensures that the analysis of extractive activity and economy-wide aggregates of operating surplus and value added fully account for the cost of depletion. Further, since the government has no operating surplus in regard to the extraction activity, not recording depletion in the production account of the government ensures that estimates of government output (which are calculated based on input costs) are not increased owing to depletion;

59 See para. 10.97 of the 2008 SNA.

60 Note that in cases where a government-owned unit undertakes extraction, it should be treated as a non-financial corporation earning operating surplus distinct from the general government which earns income in the form of rent.

61 See para. 12.26 of the 2008 SNA.

(*b*) Record the payment of rent from the extractor to the government in the allocation of primary income account. This entry is the standard national accounts entry;

(*c*) Record an entry, entitled "Depletion borne by government", in the allocation of primary income account to reflect (i) that the rent earned by the government includes the government's share of total depletion which must be deducted to measure the depletion-adjusted saving of government; and (ii) that the depletion-adjusted saving of the extractor would be understated if the total amount of depletion were deducted in the extractor's accounts. Another way of viewing this entry is to consider that the rent earned by government must be recorded net of depletion (i.e., depletion-adjusted rent is derived) in the derivation of depletion-adjusted saving for government.

Table 5.10
Entries for allocating the income and depletion of mineral and energy resources

	Government		Extractor	
Transaction	Resources	Uses	Resources	Uses
Production account				
Output—sales from extraction			100	
Intermediate consumption				50
Gross value added			50	
Consumption of fixed capital			-15	
Net value added			35	
Depletion			-6	
Depletion-adjusted net value added			29	
Generation of income account				
Compensation of employees				20
Gross operating surplus			30	
Consumption of fixed capital			-15	
Net operating surplus			15	
Depletion			-6	
Depletion-adjusted operating surplus			9	
Allocation of primary income account				
Depletion-adjusted operating surplus				
Rent	5			5
Depletion borne by government		3	3	
Depletion-adjusted saving		2		7

5.221 These entries are shown in table 5.10. Importantly, they ensure that the sum of the institutional sector entries for depletion adjusted aggregates is equal to the same aggregates calculated at the economy-wide level.

5.222 The values of depletion shown for each unit should be consistent with the change in net worth of each unit in relation to the mineral and energy resources (assuming no other changes in the stock of resources such as discoveries). Thus, if government collects a 40 per cent share of the resource rent (through payment of rent by the extractor), then the depletion borne by government will be 40 per cent of the total measured depletion. In making this calculation, it is assumed that the government's share of future resource rent remains constant.

If this share is expected to change in the future, then the rent earned and depletion borne by government should be adjusted to reflect these changes.

5.223 The associated balance-sheet entries may be made in different ways depending on the nature of the analysis and on the institutional arrangements within a country. In any presentation, the allocation of assets and the resulting estimates of institutional sector net worth should reflect the expected future income streams for each unit from the extraction of the resources.

5.224 This approach to the allocation of income and depletion from the extraction of mineral and energy resources can also be applied in compiling accounts for other natural resources subject to depletion.

Treatment of energy from renewable sources

5.225 Energy from renewable sources is an important source of energy in many countries and, increasingly, is being seen as an alternative source of energy for those countries that have used energy primarily from non-renewable sources. Energy from renewable sources can be produced from many sources, including but not limited to, wind, hydropower (including run-of-river), solar and geothermal. A complete listing of renewable sources recognized in the SEEA is included in chapter III, table 3.2.

5.226 Renewable sources cannot be exhausted in a manner akin to fossil energy resources and, unlike biological resources, they are not regenerated. Thus, in an accounting sense, there is no physical stock of renewable sources of energy that can be used up or sold.

5.227 Therefore, the measurement scope of the SEEA in relation to these sources of energy relates to the amount of energy that is produced given current investment in relevant produced assets and associated technology. Excluded from scope are potential amounts of energy that could be produced from renewable sources if investment and technology were to increase in the future.

5.228 The presence of investments in renewable energy capture facilities and equipment affects the value of the land associated with those facilities. For example, land in a particularly windy area would be priced higher than similar land in a non-windy area, if investment was made in constructing windmills to capture the energy from the wind. Thus, opportunities to earn resource rent based on sources like wind, solar and geothermal should be expected to be reflected in the price of land.

5.229 In situations where the only income generated from the relevant land is from the generation of energy from renewable sources, the value of the land will, in theory, be equal to the net present value of the future income stream. However, it is also possible that other income is earned from the same area, for example, agriculture may be engaged in using wind farms. In these cases, the valuation of the land must also take into account the income generated from these other activities. Nonetheless, where possible, the value of the land should be partitioned to provide an estimate of the value of the land that is attributable to income arising from the generation of energy from renewable sources. The valuation of land with respect to energy from renewable sources is also discussed in section 5.6.

5.230 Special mention must be made of the valuation of future income streams from hydropower. In this case, it is more relevant to consider the income stream in relation to a stock of water rather than to an area of land. Thus, in the case of hydropower, it is the value of the water resource that should be partitioned to provide an estimate of the value of the water resource that is attributable to income arising from the generation of renewable energy from hydropower. The valuation of water resources with respect to hydropower is also discussed in section 5.11.

5.231 It is recognized that some investments in the capture of energy from renewable sources take place offshore (e.g., wind farms in the sea). By convention, the value of income streams from these sources are attributed to the value of land.

5.232 Generally, since the renewable sources themselves are not sold on markets, it is necessary to use NPV approaches for valuation purposes. In undertaking such valuations, all costs should be deducted, including the costs of fixed assets used in the capture of energy.

5.233 These accounting treatments do not apply in the case of energy sourced from timber and other biomass resources. Unlike the renewable sources of energy listed above, a stock of timber resources can be observed and measured. In concept, the volume and value of timber resources (considered in detail in sect. 5.8) encompasses all possible uses of the timber, including its use as an energy source. The recording of flows of energy from biomass is discussed further in section 3.4.

5.234 The various asset values related to the generation of energy may be combined to provide an overall value of environmental assets associated with energy production. Such an aggregate may include values of mineral and energy resources (e.g., coal, oil and natural gas), the value of land attributable to renewable sources of energy (e.g., wind, solar and geothermal), the value of timber resources used for energy, and the value of water resources used for hydropower.

5.6 Asset accounts for land

5.6.1 Introduction

5.235 Land is central to economic and environmental accounting. Some of the issues that can be considered in the context of land accounts, beyond an assessment of the ownership and use of land as part of economic production, include the impacts of urbanization, the intensity of crop and animal production, afforestation and deforestation, the use of water resources, and other direct and indirect uses of land.

5.236 While broad assessment of the changing shares of different land use and land cover within a country may provide useful indicators of change, increasingly the power of land accounts is reflected in the use of mapping technologies that can pinpoint areas of change. The classifications and structures outlined in the present section are designed to support work of this type.

5.237 Land also constitutes an important component in the assessment of national and institutional sector wealth. Land is bought and sold in combination with physical characteristics (buildings, soil, trees) and the composite value will incorporate a value for the space itself (location) as well as a value for the physical characteristics.

5.238 The present section is structured to define the scope of land accounts and define two primary aspects of land for environmental accounting purposes: land use and land cover. Categories and classes for the organization of data on land use and land cover are presented followed by a description of land accounts in physical terms. A particular focus is placed on physical land accounts for forest and other wooded land which complement the asset accounts for timber resources discussed in section 5.8. Land accounts in monetary terms are described next. The potential extension of land accounts towards ecosystem accounts building on the definitions of the land cover classes is discussed at the end of this section.

5.6.2 Definition and classification of land

5.239 ***Land is a unique environmental asset that delineates the space in which economic activities and environmental processes take place and within which environmental assets and economic assets are located.***

5.240 While the term “land” is commonly meant to refer only to terrestrial areas, in the SEEA, the term may also apply to areas covered by water. Thus, the SEEA land accounts encompass areas covered by inland water resources such as rivers and lakes and, in certain applications, the land accounts may be extended to include areas of coastal water and a country’s exclusive economic zone (EEZ). Together, the areas of land, inland water and coastal water constitute the area of a country. The total country area should be defined as the area enclosed by all inland borders and, if applicable, the normal baselines (low-water mark) and straight baselines on the seaward side.[62]

5.241 Land area is analysed in many different ways. Most often, statistical analysis will be conducted by compiling data for administratively defined regions within a country. From an economic viewpoint, there may be interest in determining the areas of land owned by different institutional sectors, such as areas of government land, and land used by different industries.

5.242 From the perspective of environmental and economic accounting, there are several other factors that are of interest including topography (e.g., mountains and plains), elevation and land zoning (e.g., residential, industrial and conservation). The additional foci in the SEEA are land use and land cover. Classifications for land use and land cover are described in this section. Particularly for statistics organized on land cover, traditional administrative boundaries become less relevant while the relationship among the different features of the environment and the interaction between these features and the economy and society assume greater significance.

5.243 The patterns of countries will exhibit considerable difference in respect of land use and land cover types. For example, forest land may be of major or minor importance for a particular country and some land types, for example, deserts, may not be present in a particular country. Consequently, the categorizations presented in the SEEA may require the addition of more details for national purposes in order that particular features may be highlighted and information requirements may be met.

5.244 Of particular interest in respect of statistics on land use and land cover is the means by which data are collected. Broadly, two methods are used; field surveys and satellite images. Field surveys are important, as they can provide a high level of specificity regarding the land cover and, in particular, the land use in a particular area. Satellite images are also important, as they enable a broader assessment of all areas in a country and, over time, more detailed resolutions of the images are permitting new forms of analysis. Increasingly, data based on combinations of field surveys and satellite images are being compiled. In the SEEA, the classifications and accounting structures are defined and described independently of the means by which data are collected. However, in practice, the type of data and the level of detail that can be compiled may depend on the means by which data have been collected.

62 The boundaries between the land and the sea vary considerably between countries depending on the different geographical features of a country. The conventions by which country area is determined, in particular the definition of baselines, focus on the boundary between land and sea and have been agreed internationally in the United Nations Convention on the Law of the Sea of 10 December 1982 (United Nations, 1998).

Land use classification

5.245 Estimates of area classified by type of land use may be of considerable interest in understanding issues of agricultural production, forestry management and the spread of built-up areas. Additional benefit is gained through analysis of changes in land use over time.

5.246 ***Land use reflects both (a) the activities undertaken and (b) the institutional arrangements put in place for a given area for the purposes of economic production, or the maintenance and restoration of environmental functions.*** In effect, "use" of an area implies the existence of some human intervention or management. Land in use therefore includes areas, for example, protected areas, that are under the active management of institutional units of a country for the purpose of excluding economic or human activity from that area.

5.247 Not all land in a country is used following the definition above. Some areas are "not in use", although they may have a use in supporting ecosystems and biodiversity. In order to provide a complete accounting for land use within a country, both land in use and land not in use must be included.

5.248 The scope of land use accounts comprises areas of land and inland water. For some analytical purposes, and depending on the composition of a country's economic territory, the measurement boundary for land use may be extended to include coastal waters and areas within a country's EEZ.[63] Such a broader boundary is likely to be of relevance in the management of fishing rights, offshore mining and exploration, the protection of coral reefs, and the understanding of other marine issues. Particularly in cases where the area of a country's coastal water and EEZ constitutes a large part of its economic territory, this extension of the analysis of land use is appropriate.

5.249 The SEEA land use classification is presented in table 5.11. At its highest level, it is classified by the primary types of surfaces: land and inland waters. The classification by type of surface reflects the primary use of the classification as a means of comparing alternative uses. Generally, the types of uses of inland water areas and land areas are quite distinct; and these different areas are likely to be managed in different ways.

5.250 For land, the classification consists of seven main categories of land use: agriculture, forestry, land used for aquaculture, use of built-up and related areas, land used for maintenance and restoration of environmental functions, other uses of land n.e.c. (not elsewhere classified), and land not in use. For inland waters, there are four main categories: inland waters used for aquaculture or holding facilities; inland waters used for maintenance and restoration of environmental functions; other uses of inland waters n.e.c.; and inland waters not in use.

5.251 Detailed descriptions for subcategories and classes of the land use classification are presented in annex I, including classes relevant for extended analysis of coastal waters and the EEZ. These descriptions provide a starting point for the compilation of relevant statistics. However, further testing and development of these classes are required. This work is part of the SEEA Central Framework research agenda (see annex 2).

5.252 Within each type of area, the classification comprises various categories of use. The categories are not defined on the basis of economic activity but rather pursuant to consideration of the general purpose and role of the user of the area. In many cases, this will align with the scope of the economic activity; but in some cases, particularly for forestry, the area considered to be in use may be larger than the area being used for economic production.

---

63 Following article 57 of the United Nations Convention on the Law of the Sea of 10 December 1982, a country's EEZ may extend up to 200 nautical miles from the country's normal baselines.

5.253 At the same time, for areas of forest not intended to be used for economic production (e.g., strictly demarcated nature reserves where there is no intention to harvest timber), their primary use is more likely to be maintenance and restoration of environmental functions or they may constitute land not in use, depending on the relevant designations associated with the area.

5.254 In some cases, an area may support multiple uses at the same time or, over an accounting period, the same area may have different uses at different times, and there may be interest in recording all uses for particular areas. In general, however, the principle of primary or dominant use should be employed to ensure that all of the area has been classified.

Table 5.11
Land use classification

1	**Land**
1.1	Agriculture
1.2	Forestry
1.3	Land used for aquaculture
1.4	Use of built-up and related areas
1.5	Land used for maintenance and restoration of environmental functions
1.6	Other uses of land n.e.c.
1.7	Land not in use
2	**Inland waters**
2.1	Inland waters used for aquaculture or holding facilities
2.2	Inland waters used for maintenance and restoration of environmental functions
2.3	Other uses of inland waters n.e.c.
2.4	Inland waters not in use

5.255 As there may be strong analytical interest in understanding the range of multiple uses, compilers should take this interest into account in developing accounts for land. In such cases, it may be possible to classify smaller areas that are used for particular purposes. For example, if trees are planted in defined areas on a farm to reduce water erosion or improve water quality (e.g., on river banks), then, instead of the entire farm area's being assigned to agriculture, the smaller area could be classified as an area used for the maintenance and restoration of environmental functions.

5.256 In some areas, particularly areas covered by water, there may be no clearly defined use for a given area; hence, a primary or dominant use will not be identifiable. For example, areas within harbours may be used to provide space for recreation, passenger and freight transport, and fishing. In order for an area to be defined as an area in use, there must be a significant degree of continuity in the use of the area. In general, areas of water will be considered "used" only where they have been clearly zoned or delimited for a specific use.

Land cover classes

5.257 ***Land cover refers to the observed physical and biological cover of the Earth's surface and includes natural vegetation and abiotic (non-living) surfaces.*** At its most basic level, it comprises all of the individual features that cover the area within a country. For the purposes of land cover statistics, the relevant country area includes only land and inland waters. The area of coastal waters is excluded.

5.258 The Food and Agriculture Organization of the United Nations (FAO) has developed an international standard classification system, the Land Cover Classification System, version 3 (LCCS 3) (FAO, 2009),[64,65] which can be used to systematically record the biophysical characteristics of all areas of land within any territory.

5.259 Current land cover is a function of natural changes in the environment and of previous and current land use, particularly in agricultural and forestry areas. Although characteristics of vegetation (such as whether it is natural or cultivated) influence the land cover within an area, they are not inherent features of the land cover. Thus, a clear and systematic description of classes of land cover allows the land cover classification to be compared with that for types of land use, while maintaining pure land cover criteria. The FAO LCCS provides a theoretical basis for this approach.

5.260 There is an enormous number of different land cover features that can be created with the LCCS approach. For the purposes of standardization and harmonization across statistical data sets, a classification comprising 14 classes has been established, as presented in table 5.12.

5.261 The 14 classes constitute a comprehensive set of land cover types with clear boundaries based on definitions from the LCCS that are mutually exclusive and unambiguous. This land cover classification can be used at all scales, independently of the method of observation, thus allowing cross-referencing of local and regional maps with continental and global maps without loss of information.

5.262 The land cover classification is complemented with a set of basic rules of classification to allow translation of national data sets. These rules are set out in annex I. The rules reflect the logical structure of the LCCS and determine, as the first step, the main object (the "basic object") to be considered when undertaking a translation of data. The basic objects are simple and intuitively discernible elements of land cover (such as trees, shrubs, buildings, etc.). The descriptions are supplemented by the inclusion of information on "properties" (such as height, cover, etc.) and "characteristics" (natural, cultivated, etc.) of the basic objects. Extended descriptions of the classes are also provided in annex I.[66]

64 The Land Cover Classification System (LCCS) provides a basis for defining and classifying any piece of land with a rigorous syntax and clear classification criteria, starting from a set of basic objects identified purely through physiognomic criteria, i.e., their overall appearance. When the land is vegetated, the basic objects described are the plants (divided into trees, shrubs and herbaceous vegetation). When the land has a non-vegetal cover, or no cover at all, the basic objects can be water, ice and snow, or the abiotic or artificial surface. The information in the LCCS can be supplemented with information on properties and characteristics of the basic objects. Properties are further physiognomic characterizations of basic objects such as height and cover. Characteristics are descriptive elements of the basic objects not directly related to their physiognomic aspects, which indicate, for example, whether an area is intended for agricultural purposes or is natural.

65 A higher level abstraction of the basic objects that compose land cover classes, as used in LCCS, the Land Cover Meta Language (LCML), has also been developed for use as a framework for classifying land cover and comparing systems internationally. This metalanguage allows the existing, well-established national and regional land cover systems to remain in place, while still allowing the data to be integrated into common world-level data sets following a common land cover standard. LCML is currently undergoing an approval process in order to become an ISO standard framework for classifying land cover and comparing systems internationally.

66 As part of the SEEA Central Framework research agenda (see annex II), the land cover classification presented in table 5.12 will be further tested to ensure its suitability for the standardization of statistical data sets at the international level.

Table 5.12
Land cover classification

	Category
1	Artificial surfaces (including urban and associated areas)
2	Herbaceous crops
3	Woody crops
4	Multiple or layered crops
5	Grassland
6	Tree-covered areas
7	Mangroves
8	Shrub-covered areas
9	Shrubs and/or herbaceous vegetation, aquatic or regularly flooded
10	Sparsely natural vegetated areas
11	Terrestrial barren land
12	Permanent snow and glaciers
13	Inland water bodies
14	Coastal water bodies and intertidal areas

5.6.3 Physical asset accounts for land

5.263 The objective of land accounts in physical terms is to describe the area of land and changes in the area of land over an accounting period. A range of different physical land accounts can be envisaged—for example, accounts for land use, land cover or landownership (by industry or institutional sector). The measurement units of land in physical terms are units of area such as hectares and square metres.

5.264 Generally, a country's total area of land will remain unchanged from one period to the next. Hence, the changes between the opening and closing stock of land in physical terms will primarily encompass changes between different classes of land, for example, classes relating to landownership, land use or land cover.

5.265 However, there are situations where the area of land for a country may change. It may increase, for example, owing to reclamation of land through the construction of dykes and other barriers. It may also decrease, for example, owing to land subsidence or higher water levels.

5.266 Further, changes in the total area of land may occur owing to political factors. For example, the total area may increase or decrease as a result of war and associated events; in addition, commonly, there are areas of disputed territory, which can be responsible for change. The area that is within scope of land cover and land use statistics should be clearly defined to prevent confusion.

Physical accounts for land cover

5.267 In the first instance, it is recommended that countries develop estimates of the total land area classified by land cover at the beginning and the end of each accounting period. This is because data on land cover from remote sensing (either aerial photography or satellite images) are usually available and require less interpretation than land use. It is noted that land cover and land use are interrelated. For example, agricultural production is closely aligned to crop area. However, while land use and land cover are closely related, this is not always the case. For example, tree-covered areas can be used for forestry, or for the maintenance and restoration of environmental functions, or may not be used at all (constituting "land not in use").

5.268 With data structured in an accounting format, it is possible to link land cover to land use, including through the presentation of matrices showing the changes in land cover and land use over an accounting period. In assessing land cover and land use change, it may be useful to determine the proportion of the opening stock of land whose cover or use has remained unchanged. To undertake this type of analysis, the data must be based on spatially referenced data sources.

Scope of land cover accounts

5.269 The land area of a country defines the scope of the land cover account. For most purposes this will be the area of land and associated inland waters, as defined in the land cover classification shown in table 5.12. The account could be extended to coastal water bodies and intertidal areas.

5.270 A physical account for land cover is presented in table 5.13. It shows the opening and closing areas for different land cover types and various additions and reductions in those areas over the accounting period. The different additions and reductions are explained in the following paragraphs.

Table 5.13
Physical account for land cover (*hectares*)

	Artificial surfaces	Crops	Grassland	Tree-covered area	Mangroves	Shrub-covered area	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies	Coastal water and inter-tidal areas
Opening stock of resources	12 292.5	445 431.0	106 180.5	338 514.0	214.5	66 475.5	73.5	1 966.5		12 949.5	19 351.5
Additions to stock											
Managed expansion	183.0	9 357.0									
Natural expansion			64.5								1.5
Upward reappraisals			4.5								
Total additions to stock	183.0	9 357.0	69.0								1.5
Reductions in stock											
Managed regression		147.0	4 704.0	3 118.5	9.0	1 560.0	1.5				
Natural regression					1.5	64.5					
Downward reappraisals						4.5					
Total reductions in stock		147.0	4 704.0	3 118.5	10.5	1 629.0	1.5				
Closing stock	12 475.5	454 641.0	101 545.5	335 395.5	204.0	64 846.5	72.0	1 966.5		12 949.5	19 353.0

Note: Crops include herbaceous crops, woody crops, and multiple or layered crops.

5.271 ***Managed expansion*** represents an increase in the area of a land cover type due to human activity. For example, crop areas may be converted to tree-covered areas as a result of silvicultural measures such as planting and seeding, or tree-covered areas may be converted to crop or grassland following tree clearing. Generally, the managed expansion of one land cover type will also lead to the recording of a matching entry for managed regression of the reducing land cover types. A matching entry is not recorded if there is a managed expansion in the total area of land within scope of the account (e.g., in the case of land reclamation).

5.272 ***Natural expansion*** is an increase in area resulting from natural processes, including seeding, sprouting, suckering or layering. In the case of sparse natural vegetation and terrestrial barren land, the natural loss of vegetation from other vegetation types would lead to increases in these areas. Changes in the extent of permanent snow, glaciers and inland water bodies can also be due to natural variation, in rainfall, for example. Generally, the natural expansion of one land cover type will also lead to the recording of a matching entry for natural regression of the reducing land cover types. A matching entry is not recorded if there is a natural expansion in the total area of land within scope of the account (e.g., in the case where land is created through volcanic activity or landslide).

5.273 ***Managed regression*** represents a decrease in the area of a land cover type due to human activity. As for managed expansion, a matching entry is recorded in all cases of managed regression, except in cases where there is a managed regression in the total land area.

5.274 ***Natural regression*** should be recorded when the area of a land cover type reduces for natural reasons. As for natural expansion, a matching entry is recorded in all cases of natural regression, except in cases where there is a natural regression in the total land area (e.g., the loss of land due to erosion by the sea).

5.275 ***Reappraisals*** can be upward or downward and can reflect changes due to the use of updated information that permits a reassessment of the size of the area of different land covers, for example, from new satellite imagery or interpretation of satellite imagery. The use of updated information may require the revision of previous estimates to ensure a continuity of time series.

5.276 The land cover change matrix set out in table 5.14 shows land cover at two different points in time. It shows the area of different land cover types at the beginning of the reference period (opening area), the increases and decreases of this area according to the land cover type it was converted from (in the case of increases) or the type it was converted to (in the case of decreases) and, finally, the area covered by different land cover types at the end of the reference period (closing area).

5.277 Table 5.14 shows net changes, which may mask important information. For example, when natural forest is lost in one place but plantation forest is added elsewhere, no net change of tree-covered area would be shown. Similarly, when high-quality agricultural land is converted into built-up land, but, at the same time, less productive agricultural land is added through deforestation, total agricultural land cover will not change. Where these phenomenon are relevant, the format of table 5.14 can be extended to show increases and decreases in separate tables and thus allow more detailed analysis.

5.278 An additional step in the analysis of land cover change might be the construction of tables showing reasons for land cover change. For example, changes in land cover might be classified to show whether the change relates to urban growth and development of infrastructure (through conversion of crops or tree-covered area), intensification and industrialization of agriculture (through conversion of family farming and mosaic landscapes), extension of agriculture in general (through conversion of tree-covered land), drainage of regularly flooded areas (wetlands) for crops or artificial surfaces (urban land), deforestation (of tree-covered areas for timber production or agriculture development), and desertification (at the expense of formerly vegetated areas).

5.279 The structure of land use accounts could be similar to that of land cover accounts. An example of land use accounts for forest and other wooded land is contained in the next subsection.

Table 5.14
Land cover change matrix (*hectares*)

Land cover	Opening area	Increases (positive numbers) and decreases (negative numbers) from other land covers											Net change (increase-decrease)	Closing area
		Artificial surfaces	Crops	Grassland	Tree-covered area	Mangroves	Shrub-covered area	Regularly flooded areas	Sparse natural vegetated areas	Terrestrial barren land	Permanent snow, glaciers and inland water bodies	Coastal water and intertidal areas		
Artificial surfaces	12 292.5		147.0	27.0		9.0							183.0	12 475.5
Crops	445 431.0	-147.0		4 677.0	3 118.5		1 560.0	1.5					9 210.0	454 641.0
Grassland	106 180.5	- 27.0	- 4 677.0				69.0						- 4 635.0	101 545.5
Tree-covered area	338 514.0		- 3 118.5										- 3 118.5	335 395.5
Mangroves	214.5	-9.0										-1.5	-10.5	204.0
Shrub-covered area	66 475.5		-1 560.0	-69.0									-1 629.0	64 846.5
Regularly flooded areas	73.5		-1.5										-1.5	72.0
Sparse natural vegetated areas	1 966.5													1 966.5
Terrestrial barren land														
Permanent snow, glaciers and inland water bodies	12 949.5													12 949.5
Coastal water and intertidal areas	19 351.5					1.5							1.5	19 353.0

Note: Including herbaceous crops, woody crops and multiple or layered crops.

5.6.4 Physical asset accounts for forest and other wooded land

Introduction

5.280 For particular land uses or types of land cover, it is also possible to construct basic physical asset accounts as established for other resources. The most developed example is for forest and other wooded land. Often, the compilation of physical asset accounts for forest and other wooded land is undertaken in conjunction with the compilation of asset accounts for timber resources as described in section 5.8. However, in principle, accounts for forest and other wooded land are a type of land account.

5.281 A key distinction between the physical asset account for forest and other wooded land and the asset account for timber resources is that the scope of timber resources is not limited to timber from forest and other wooded land. Thus, for example, depending on their significance, orchards would fall within scope of timber resources but are not considered areas of forest and other wooded land.

5.282 Another key distinction is that the asset account for timber resources is focused on the volume of timber resources rather than on the area of land covered by forests and other wooded land. Thus, the focus of the forest and other wooded land account is on changes in the area of land, for example, due to deforestation and afforestation, rather than on the quantity and value of timber removed from areas of forest and other wooded land.

5.283 Notwithstanding these clear distinctions in purpose and scope, there are strong connections between asset accounts for timber resources and asset accounts for forest and other wooded land. This is because the majority of timber resources are found in areas of forest and other wooded land. Consequently, there are links between the two sets of accounts which should be considered in their compilation.

Scope of the forest and other wooded land account

5.284 The scope of the forest and other wooded land account is defined consistent with the definition of this land in the FAO Global Forest Resources Assessment 2010.[67] Forest land is defined as land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 per cent, or trees able to reach these thresholds in situ. The scope of the forest and other wooded land account follows a land use perspective. Thus, it does not include land that is predominantly under agricultural or urban land use and is not strictly defined on the basis of changes in tree-covered areas.

5.285 Forest land is classified according to different types of forest. The primary distinction is between naturally regenerated forest and planted forest. ***Naturally regenerated forest is forest that is predominantly composed of trees established through natural regeneration. In this context, "predominantly" means that the trees established through natural regeneration are expected to constitute more than 50 per cent of the growing stock at maturity.***

5.286 Two broad types of naturally regenerated forest are distinguished:

(*a*) ***Primary forest*** is naturally regenerated forest of native species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed. Key characteristics of primary forests are that: (*a*) they show natural forest dynamics, such as natural tree species composition, occurrence of dead wood, natural age structure and natural regeneration processes; (*b*) the area is large enough to maintain its natural characteristics; and (*c*) there has been no known significant human intervention or the last significant human intervention occurred long enough in the past to have allowed the natural species composition and processes to have become re-established;

(*b*) ***Other naturally regenerated forest*** is naturally regenerated forest with clearly visible indications of human activities. These include: (*a*) selectively logged-over areas, areas regenerating following agricultural land use and areas recovering from human-induced fires, etc.; (*b*) forests where it is not possible to distinguish whether they are planted or naturally regenerated; (*c*) forests with a mix of naturally regenerated trees and planted/seeded trees and where the naturally regenerated trees are expected to constitute more than 50 per cent of the growing stock at stand maturity; (*d*) coppice from trees established through natural regeneration; and (*e*) naturally regenerated trees of introduced species.

5.287 ***Planted forests*** are predominantly composed of trees established through planting and/or deliberate seeding. Planted/seeded trees are expected to constitute more than 50 per cent of the growing stock at maturity, including coppice from trees that were originally planted or seeded.

5.288 ***Other wooded land*** is land not classified as forest land, spanning more than 0.5 hectares; with trees higher than 5 metres and a canopy cover of 5-10 per cent, or trees able to reach these thresholds in situ; or with a combined cover of shrubs, bushes and trees above 10 per cent. It does not include land that is predominantly under agricultural or urban land use.

---

67 The following definitions are sourced or adapted from the "Global Forest Resources Assessment, 2010: specification of national reporting tables for FRA 2010" (FAO, 2007).

5.289 Where possible, accounts should be compiled reflecting these distinctions between types of forest and other wooded land. In addition, countries may be interested in compiling accounts based on the total area of different species of tree.

5.290 A physical asset account for forests is presented in table 5.15. It shows the opening and closing stock by area and changes in the area of forest and other wooded land. The area of forest and other wooded land should be measured inclusive of relevant access roads, rivers and streams.

Table 5.15
Physical asset account for forest and other wooded land (*hectares*)

	Type of forest and other wooded land				
	Primary forest	Other naturally regenerated forest	Planted forest	Other wooded land	Total
Opening stock of forest and other wooded land	20	100	150	130	400
Additions to stock					
Afforestation		2	5		7
Natural expansion		3			3
Total additions to stock		5	5		10
Reductions in stock					
Deforestation	2	10		5	17
Natural regression				3	3
Total reductions in stock	2	10	0	8	20
Closing stock of forest and other wooded land	18	95	155	122	390

Additions to and reductions in the stock

5.291 ***Afforestation*** represents an increase in the stock of forest and other wooded land either due to the establishment of new forest on land that was previously not classified as forest land, or as a result of silvicultural measures such as planting and seeding. In particular, land previously classified as other wooded land may be converted to forest land as a result of silvicultural measures.

5.292 ***Natural expansion*** is an increase in area resulting from natural seeding, sprouting, suckering or layering. Where the expansion is into the area of another type of forest or other wooded land (e.g., natural expansion of other naturally regenerated forest into other wooded land), a corresponding entry for natural regression should be recorded.

5.293 ***Deforestation*** represents a decrease in the stock of forest and other wooded land due to the complete loss of tree cover and transfer of forest land to other uses (e.g., use as agricultural land, land under buildings or roads) or to no identifiable use. Removals of standing timber do not lead to decreases in forest and other wooded land if the use of the land does not change after felling.

5.294 ***Natural regression*** should be recorded when the stock of forest and other wooded land reduces for natural reasons. An entry for natural regression should be recorded together with an entry for natural expansion when there are natural changes in the areas of different types of forest and other wooded land (e.g., natural expansion of other naturally regenerated forest into other wooded land—i.e., a natural regression of other wooded land).

5.295 In the next subsection, monetary asset accounts for forest and other wooded land are not separately described but are covered as part of the monetary asset accounts for land.

5.6.5 Monetary asset accounts for land

5.296 The monetary asset account for land follows the structure outlined in table 5.16. Changes in the overall value of land will relate primarily to the revaluation of land, since the total area of land will remain largely unchanged. However, since at a more detailed level there will be changes in the purposes for which land is used (often due to purchases and sales of land between economic units), there are likely to be notable changes in the value of different types of land due to transactions and reclassifications.

5.297 Table 5.16 shows the value of land by type of land use. It may also be of interest to estimate the total value of land by institutional sector of ownership. In this case, transactions and reclassifications between sectors are likely to be important accounting entries.

Table 5.16
Monetary asset account for land (*currency units*)

	Type of land use								
	Agriculture	Forestry	Land used for aquaculture	Use of built-up and related areas	Land used for maintenance and restoration of environmental functions	Other uses of land n.e.c.	Land not in use	Inland water	Total
Opening value of stock of land	420 000	187 500		386 000	2 000				995 500
Additions to stock									
Acquisitions of land	3 500								3 500
Reclassifications		200		2 500					2 700
Total additions to stock	3 500	200		2 500					6 200
Reductions in stock									
Disposals of land		3 500							3 500
Reclassifications		1 250			200				1 450
Total reductions in stock		4 750			200				4 950
Revaluations	18 250	15 350		65 000					98 600
Closing value of stock of land	441 750	198 300		453 500	1 800				1 095 350

Valuation of land

5.298 While this is not the case for most environmental assets, there is, in most countries, an active market in the purchase and sale of land of all types, including residential, industrial and agricultural land. However, determining the value of the land itself is a complex task.

5.299 Generally, the market values of land encompass the value of the location, the value of the physical attributes of the land and the produced assets that may be located on the land (e.g., buildings). Separating these different components may be difficult. Further, although there is a market in land, a relatively small proportion of land is transacted in any year and thus observed prices may not be representative. Therefore, a comprehensive set of prices to cover all land types in all locations is seldom, if ever, available. Finally, some land will never be exchanged on the market. This may include designated public areas, land under traditional patterns of common ownership, and remote and inhospitable areas.

(a) Composite assets

5.300 Several common situations in which assets are bundled with land need to be described and relevant accounting treatments defined.

5.301 ***Soil resources.*** Although land and soil are distinguished as separate environmental assets, in terms of valuation, land and soil are always considered jointly. Thus, the value of all land, especially agricultural land, implicitly includes the value of any associated soil.

5.302 ***Buildings and structures.*** The opening and closing values of the stock of land should be recorded excluding the value of buildings and structures on the land.

5.303 For land underlying buildings, the market will, in some instances, furnish data directly on the value of the land. More typically, however, such data are not available and a more usual method is to calculate ratios of the value of the site to the value of the structure (often using administrative data). Another approach is to use estimates of the depreciated value of the stock of dwellings and other buildings and structures which are often compiled for the purposes of the core national accounts and deduct this amount from the value of the composite asset.

5.304 When the value of the land cannot be separated from the building or structure sitting on it, the total value of the composite asset should be classified to the asset category representing the greater part of its value.

5.305 ***Land improvements.*** In addition to the effect of buildings and structures, there may be improvements to land due to activities such as land clearance, land contouring or the creation of wells and watering holes for agriculture that are integral to the land in question. These activities, collectively referred to as "land improvements", are characterized by their outcome: they lead to major improvements in the productivity of a given area of land, potentially through the prevention of a deterioration in the quality of land. In principle, the value of land improvements should be recorded as a separate produced asset distinct from the value of the land as it existed before improvement.

5.306 If the value of the land improvements cannot be separated from the value of land in its natural state, the value of the land may be allocated to one category or the other depending on which is assumed to represent the greater part of the value. (For details regarding the accounting treatment for land improvements, refer to the 2008 SNA, paras. 10.79-10.81.)

5.307 ***Biological resources.*** As with the treatment of buildings and structures, the value of these environmental assets should, in principle, be separated from the land on which they are grown. For example, for forest land, the separation should be based on the value of the stock of timber resources (for details, see sect. 5.8). For cultivated biological resources other than timber resources, the range of techniques for making the distinction made for buildings and structures are also relevant.

5.308 ***Land under roads and public land.*** In principle, the land under roads, railways and other transportation routes should be valued in the same way as other land. However, given the shared characteristics of these assets, determining appropriate valuations may be difficult.

5.309 It is recommended that the valuations adopted for the purposes of government finance statistics be used to value land under roads and public land more generally. The value of the roads and rail lines, etc., should be determined separately, possibly on the basis of construction costs as required for the purposes of capital stock estimation in the national accounts.

5.310 ***Energy from renewable sources.*** As described in section 5.5, the value of some land may be influenced by the income earned from the generation of renewable energy (e.g., land on which wind farms are based). The value arises due to the scarcity of the sites used for energy generation. Where possible, the value of the land should be partitioned to provide an estimate of the value of the land that is attributable to income arising from the generation of energy from renewable sources. The valuation should be based on calculation of expected income streams using standard NPV approaches, including deductions for the costs of fixed assets utilized to capture the energy.

(b) Changes in value due to changes in the quality of land

5.311 Changes in the value of land may be due to many factors, including changes in the quality of land. At times, there may be catastrophic losses in land quality, for example, as a result of contamination by radioactive waste or major flooding. Changes in the quality of land that lead to changes in the value of the land should not be recorded as revaluations even though the area of land does not change. Rather, the changes in value should be recorded as reclassifications (where the land use changes), reappraisals (where the land use remains the same) or catastrophic losses, as most appropriate.

Accounting for transactions in land

5.312 Generally, all transactions in land are between resident economic units. In situations in which a non-resident purchases land, the accounting convention is to establish a notional resident unit that purchases the land and to show the non-resident as having the full financial ownership of the notional unit. There are at times exceptions to this treatment, such as when governments purchase land from other countries. These should be recorded as acquisition and disposals between countries.

The treatment of costs of ownership transfer

5.313 Whenever land is sold, there are transaction costs involved. Typically, these arise from the involvement of the lawyers registering the change of ownership of the land and of the estate agents who bring the buyer and seller together. There may also be taxes payable in connection with the land purchase. The SNA refers to these expenses as the "costs of ownership transfer". These costs are not recoverable by the new owner: any further sale will cover the underlying value of the land itself plus a new set of costs of ownership transfer. In the context of the transaction, the costs to the purchaser of the land are treated as the purchase of a fixed asset and they are written off over time by means of consumption of fixed capital.

5.314 In general, because they are treated as a separate asset, the costs of ownership transfer on land are not included in the valuation of land in the asset account. However, some refinements in respect of this general position need to be clarified. Where the transaction involves only land and land improvements (e.g., where the sale of buildings or forests is not involved), the costs of ownership transfer are allocated to the produced asset land improvements. Where the transaction involves both land and produced assets (such as buildings or cultivated biological resources), the costs are allocated to the specific produced assets involved. In both of these situations, the costs are also recorded against the opening and closing stock values for the relevant produced asset.

5.315 It is also noted that, where the costs of ownership transfer relate to a non-produced asset other than land (e.g., to the sale of mineral and energy resources or natural timber resources), the costs are capitalized against the produced asset "costs of ownership transfer on non-produced assets" but they are recorded on the balance sheet against the non-produced asset in question.

5.6.6 Links to ecosystem accounting

5.316 Ecosystem accounts are founded on consideration of the capacity of the environment to deliver ecosystem services as described in chapter II. It is the interactions between different environmental assets within a given area that generates ecosystem services.

5.317 To the extent that meaningful groupings of land areas can be defined, these areas may be used to provide a measurement basis for ecosystem accounting in a similar way to which statistical units, such as establishments, provide a basis for measurement in economic statistics. SEEA Experimental Ecosystem Accounting develops these ideas in detail to provide a framework for assessing the capacity of ecosystems to deliver ecosystem services.

5.7 Accounting for soil resources

5.7.1 Introduction

5.318 Soil resources are a fundamental part of the environment. They provide the physical base required to support the production and cycling of biological resources, provide the foundation for buildings and infrastructure, are the source of nutrients and water for agriculture and forestry systems, provide a habitat for diverse organisms, play an essential role in carbon sequestration, and fulfil a complex buffering role against environmental variability (ranging from dampening diurnal and seasonal change in temperature and water supply to the storage and binding of a range of chemical and biological agents).

5.319 Accounting for soil resources, therefore, has many dimensions. At one level, accounting for soil resources can provide information on the area and volume of soil resources lost due to soil erosion, or made unavailable by changes in land cover (e.g., soil covered by buildings or roads) and other causes (e.g., changes in soil structure due to compaction, acidity or salinity). More broadly, accounting for soil resources in terms of their types, nutrient content, carbon content and other characteristics is relevant for more detailed examination of the health of soil systems, and the connections between soil resources and production in agriculture and forestry.

5.320 The focus of asset accounting for soil resources in the SEEA is on the top layers (horizons) of soil that form a biological system. Thus, quantities of soil that are extracted for construction, land reclamation, engineering and similar purposes are not considered, except to the extent that such extraction reduces the area and volume of soil resources available to operate as a biological system. Quantities of soil extracted for landscaping and similar purposes, where the soil continues to operate as a biological system, are considered to be within the accounting framework.

5.321 Research into the quantity and quality of soil has been a long-standing undertaking in many countries. At an international level, there has been substantial effort to create harmonized systems for recording information on different soils; and more recently, there has been work carried out to facilitate a more complete record of information on soils in all countries, in recognition of the fundamental role that soil resources play in environmental and economic systems.[68]

5.322 At the same time, there have been few research findings that relate the changes in the physical volume and characteristics of soil to measures of economic activity using accounting frameworks like the SEEA. Work is advancing that considers changes in soil resources

68 See, for example, the Harmonized World Soil Database (FAO and others, 2009) and, at finer scale, the GlobalSoilMap (www.globalsoilmap.net) (International Union of Soil Sciences, 2009).

from a natural capital perspective,[69] but up to now this work has not been translated into the SEEA framework.

5.323 Some aspects of accounting for soil resources fit easily into the broader asset accounting framework described in the Central Framework. Also, some of the physical flows associated with soil resources, for example, flows of nutrients, are within the framework of physical flows described in chapter III. More broadly, accounting for soil resources as a system providing multiple benefits is a part of the broader subject of ecosystem accounting and is described in SEEA Experimental Ecosystem Accounting.

5.324 The present section presents a brief characterization of soil resources and the associated information on soil. It then describes how the volume and area of soil resources can be accounted for within the asset accounts of the Central Framework. The section concludes by introducing the aspects of soil measurement that can be taken into consideration in other parts of the SEEA, including nutrient balances and measurement of soil resources as a system.

5.7.2 Characterization of soil resources

5.325 Different types of soil are defined in reference to their components and properties. Soil components reflect the biogeochemical composition of the soil: the minerals, liquids, gases and organic matter that are present in the soil. Soil properties reflect the physical, chemical and biological characteristics of the soil, e.g., porosity, texture, pH level and microbial biomass.

5.326 Various soil types can be defined using information on different combinations of soil components and properties. It is these various soil types (groupings) that can provide the basis for a generalized accounting for soil resources—not because soil types change, but because soils have different baselines and potentials. Soil types are necessary categories for understanding the importance of measured change and the potential for improvement. The Harmonized World Soil Database describes 28 major soil groupings that can be used to categorize and map soils at a broad global scale. Various national and regional groupings of soil types may be appropriate for national and subnational measurement.

5.327 Soil resources are measured through a series of inventory processes, known collectively as a soil survey. Typically, a soil survey produces maps of soil types, soil suitability for various purposes and hazard and degradation potential and, in some cases, maps of specific soil properties. Other important and complementary activities associated with soil resource accounting include site- or area-based measures of soil loss or erosion processes, and simulation modelling of the way in which soil types relate to various climate and land use settings.

5.328 Measures of soil quality or soil value can also be developed using a range of approaches. In most cases, soil suitability for specific purposes is assessed through a standardized indexing procedure. Most countries and regions have similar procedures optimized for implementation of their approach to soil mapping and soil classification. Soils are generally ranked in terms of their properties (e.g., carbon content), productive capacity (e.g., for agriculture) and/or their tendency towards degradation over time. Simulation models that take into account local conditions may then be used to extrapolate from well-studied sites across the landscape to produce quantitative measures of yield, run-off and soil erosion.

5.329 The availability of this suite of measurements varies between and within countries. Overall, while most soil information has not been placed in an accounting framework, there

69 For an examination of this issue from a soil science perspective, see, for example, Dominati, Patterson and Mackay "A framework for classifying and quantifying the natural capital and ecosystem services of soils", Ecological Economics, vol 69, No.9 (15 July 2010, pp.1858-1868).

is a strong potential for aggregate accounting frameworks to be populated using the data available.

5.7.3 Accounting for the area and volume of soil resources

5.330 A first stage of accounting for soil resources entails measurement of the area of different soil types within a country. This type of accounting is an extension of the land accounting described in section 5.6. An example of how an asset account for the area of soil resources can be structured is presented in table 5.17. The table presents the opening and closing stock of soil resources by type of soil and the additions and reductions in area of soil resources. In order for there to be a focus on soil resources that are available as a biological system, the scope of this account should be restricted to land used for agriculture and forestry and also volumes of soil extracted to be used as a biological system. In certain circumstances, there may be a focus on particular landscapes or land use systems that are under pressure.

Table 5.17
Physical asset account for area of soil resources (*hectares*)

	Type of soil resource	Total area
Opening stock of soil resources		
Additions to stock		
Due to changes in land cover		
Due to changes in soil quality		
Due to changes in soil environment		
Total additions to stock		
Reductions in stock		
Due to changes in land use		
Due to changes in soil quality		
Due to changes in soil environment		
Total reductions in stock		
Closing stock of soil resources		

5.331 In terms of accounting entries, the focus is on the area of different soil types at the beginning and end of an accounting period and on changes in the availability of different soil types used for agriculture and forestry. Different scopes of soil resources may be measured depending on the purpose of analysis. For example, for the analysis of carbon sequestration in soil, a very extensive coverage of soil resources within a country may be appropriate.

5.332 A distinction is made between additions and reductions due to changes in land cover (e.g., loss of soil resources for agriculture as a result of urban expansion, also known as soil alienation or soil sealing); those due to changes in soil quality (e.g., after compaction or acidification); and those due to changes in the soil environment (e.g., due to desertification or land clearing). In practice, distinguishing between these different types of changes may be difficult and the structure of the account should be based on highlighting the primary reasons and the changes of most environmental, economic or social interest.

5.333 In addition to an asset account such as presented in table 5.17, there may be interest in tabulating types of soil resources by type of land use or land cover at a particular point in time. Such information may help in determining whether various types of land use are being undertaken on high-quality or marginal soil and may hence provide a basis for assessment of alternative land uses. Considerable analytical benefits would also be derived from mapping information on soil types, land use and land cover using data that are spatially referenced.

5.334 A second stage in accounting for soil resources entails measuring the volume of soil resources. Accounting for changing volumes of soil may enable assessment of the extent of erosion and the impact of major disasters such as flooding or drought, as well as provide information relevant to the assessment of soil depletion, i.e., the loss of soil resources due to economic activity.

5.335 An asset account for the volume of soil resources is shown in table 5.18. It is structured to show the opening and closing volumes of soil and the changes in the volume of soil. Increases in the volume of soil by natural processes (soil formation) are assumed to be very slow and, in this sense, soil may be considered a non-renewable resource. However, the movement of soil through natural means (e.g., wind and water) may mean that soil lost from one area of a country may be deposited in another area or in another country, or in the sea and ocean. The deposition is often deleterious (e.g., covering infrastructure or polluting coral reefs) but there are situations where a region benefits from sediment movement. Where benefits from soil deposition can be established, the flow should be considered part of the additions to stock; at the same time, soil erosion should be considered a reduction in stock.

Table 5.18
Physical asset account for volume of soil resources (*cubic metres*)

	Type of soil resource
Opening stock of soil resources	
Additions to stock	
Soil formation and deposition	
Upward reappraisals	
Reclassifications	
Total additions to stock	
Reductions in stock	
Extractions	
Soil erosion	
Catastrophic losses	
Downward reappraisals	
Reclassifications	
Total reductions in stock	
Closing stock of soil resources	

5.336 The soil resources in table 5.18 are classified by type of soil, but it may also be meaningful to structure the changes in the volume of soil resources by geographical region or by type of land use or land cover. It is likely that different regions and land uses will have different impacts on and be differently impacted by soil erosion and soil deposition.

5.337 Changes in the volume of soil resources should also be recorded when soil is excavated and moved for various reasons. For example, soil may be excavated to build levies and dykes, for land reclamation, or for road and other construction. Since the intent of the soil resources account is to record changes in the volume of soil resources that can operate as a biological system, the loss of the top layers of soil resource due to this extraction should be recorded as permanent reductions in soil resources, unless the purpose is to create new biological soil systems in other locations. Losses in the accessibility of soil resources due to changing land cover (e.g., as a result of urban expansion or permanent flooding, as is the case in the creation of artificial reservoirs) should be recorded as extractions.

5.338 Catastrophic losses of soil resources may occur in cases of major floods and other severe weather events. This may also lead to soil deposition, depending on the quality of soil transferred. Reappraisals of soil volume should be recorded when additional information is available, as for reappraisals of other environmental assets.

5.7.4 Other aspects in accounting for soil resources

5.339 In addition to the physical asset accounts proposed in this section, soil resources are accounted for in the physical supply and use tables described in chapter III. There are two main aspects to the PSUT entries for soil resources. First, the movement of soil resources for construction, land reclamation, landscaping and other such uses in the economy should be recorded as a natural resource input of soil resources from the environment to the economy. These entries should also record movement of soil as part of dredging operations in rivers and ports and movements of contaminated soil for treatment or disposal.

5.340 Second, the flows of individual elements in the soil, such as soil carbon and soil nutrients (nitrogen (N), phosphorus (P) and potassium (K)), can be recorded as part of material flow accounting. An introduction to net nutrient balances in the context of the SEEA is described in section 3.6.

5.341 The recording of nutrient balances considers issues related to the overall functioning of soil resources as a biological system and, further, those issues related to valuing soil resources and associated measures of soil depletion and soil degradation. However, the accounting framework presented in the Central Framework does not fully describe the overall state or condition of soil resources, changes in the health of soil resources, or their capacity to continue to provide the benefits that soil resources generate.

5.342 In the Central Framework, the value of soil resources is tied directly to the value of land, as described in section 5.6. In this context, connections may be made between changes in the combined value of land and soil and changes in the associated income earned from use of the soil resources.

5.8 Asset accounts for timber resources

5.8.1 Introduction

5.343 Timber resources are important environmental assets in many countries. They provide inputs for construction and the production of paper, furniture and other products, and are both a source of fuel and an important sink for carbon.

5.344 The compilation of timber resource asset accounts is one measurement tool that provides information for use in assessing and managing changes in timber resources and the services they provide. For a complete assessment of timber resources it is also relevant to construct asset accounts regarding the stock of land associated with timber resources, primarily forest and other wooded land. The changes in the stock of forest and other wooded land due to afforestation and deforestation may be of particular interest. These asset accounts are described in section 5.6.

5.345 The present section is structured to provide details on the definitions of timber resources and associated classification and boundary issues, including the relationship between timber resources and forest and other wooded land. An important aspect in this regard is the delineation of the distinction between cultivated and natural timber resources. The section then presents a physical asset account and a monetary asset account for timber resources and concludes with an introduction to accounting for carbon in timber resources. This is an extension of the physical asset accounting for timber resources.

5.8.2 Scope and definition of timber resources

5.346 Timber resources may be found in a wide variety of places and may or may not be available to be felled and used as wood supply, i.e., to produce timber products or as fuelwood. Timber resources may not be available for wood supply due to the fact that the trees (i) are in areas in which logging operations are restricted or prohibited; (ii) are in areas that are inaccessible or remote and hence where logging is not economically viable; or (iii) do not, from a biological perspective, belong to a commercially useful species.

5.347 While the timber resources that are not available for wood supply do not have an economic value, these timber resources remain in scope of timber resources in the SEEA in physical terms, as they fulfil the definition of environmental assets and may provide benefits. However, since these timber resources do not have an economic value, they are not recorded in the asset accounts for timber resources in monetary terms. Consequently, the volume of these timber resources in physical terms should be clearly identified so that appropriate alignment can occur between asset accounts in physical and monetary terms.

5.348 Most commonly, timber resources are found in areas of forest land or other wooded land, which may often provide a good starting point for the compilation of data on timber resources. The areas that are classified as forest land and other wooded land for the purposes of measuring timber resources should be defined consistently with those same areas in the physical asset accounts for forest and other wooded land, as described in section 5.6.4.

5.349 Timber resources are also found in other areas such as in orchards, rubber plantations, along roadsides and train tracks, and in city parks. Conceptually, the timber resources in all of these areas are also within the measurement scope of the SEEA. In practice, countries should determine the scope of their timber resource accounts based on the relative importance of the types of areas that provide timber resources. Timber resources from different types of areas should be clearly differentiated.

5.350 Within the relevant areas, ***timber resources are defined by the volume of trees, living or dead, and include all trees regardless of diameter, tops of stems, large branches and dead trees lying on the ground that can still be used for timber or fuel.*** The volume should be measured as the stem volume over bark at a minimum breast height from the ground level or stump height up to the top. Excluded are smaller branches, twigs, foliage, flowers, seeds and roots.[70]

5.351 The thresholds for minimum breast height, tops of stem and branches may vary across countries. This variation reflects the variety of species, growing conditions and forestry management and harvesting practices that take place in different parts of the world. The precise specification of the volume of a conifer in northern Europe, for example, will differ from that of a teak tree in a tropical rainforest. The general principle that should be considered in determining the volume of timber resources is the volume that is commercially usable. All estimates of timber resources, including estimates of the monetary value of timber resources, need to take into account country-specific conditions and practices.

5.352 The volume of timber resources is often referred to as the volume of standing timber. This definition includes trees on the ground either because they have been felled but not

70 See "Global Forest Resources Assessment 2010: specification of national reporting tables for FRA 2010" (FAO, 2007).

yet removed from the area, or because they have fallen through natural causes (e.g., disease or lightning strike) but are still useful for timber products or fuel. The volume of standing timber also includes dead trees remaining standing. The volume of standing timber should be distinguished from the growing stock which relates to living trees and forms the basis for the calculation of the natural growth in timber resources over a period.

The boundary between cultivated and natural timber resources

5.353 Determining whether timber resources are cultivated or natural is important in the application of the appropriate accounting treatment. The growth in cultivated timber resources is considered to be a process under the direct control, responsibility and management of institutional units. Consequently, the growth is recorded as occurring within the production boundary on an ongoing basis as an increase in inventories of those enterprises undertaking the cultivation. (The removal of cultivated timber resources is recorded as a decrease in inventories of timber resources and an equivalent amount of sales.) The growth of natural timber resources, on the other hand, is not considered to take place within the production boundary and is recorded as entering the production boundary only at the time the tree is removed from the forest or other land area.

5.354 The treatment of timber resources as either cultivated or natural depends on the management practices applied to the areas in which timber resources are found. For timber resources to be classed as cultivated, the management practices must constitute a process of economic production. This is likely to include activities such as (*a*) control of regeneration, for example, seeding, planting of saplings, thinning of young stands; and (*b*) regular and frequent supervision of trees to remove weeds or parasites, or to attend to disease. The level of these types of activity should be significant relative to the value of the timber resources and should be directly connected with the growth of the timber resources in question.

5.355 In practice, a common initial basis for the determination of whether timber resources are cultivated or natural is the type of land on which the timber resources are found. For example, for forest land, those timber resources within primary forests would generally be considered natural timber resources, whereas those timber resources in plantations would be generally considered cultivated timber resources.

5.356 However, the rules by which different areas of forest land are differentiated may not align neatly to the production boundary of the SEEA. For example, pursuant to applying the definitions of different forest land as presented in section 5.6.4: as soon as primary forest is logged for the first time, it becomes other naturally regenerated forest and hence falls into a category of forest land that is likely to be a mixture of land under active management and control, and land in which human intervention is relatively infrequent. Also, in some countries, there are large areas of planted forests that are not managed directly or frequently where the trees are left to grow until ready to harvest. These trees would be considered natural timber resources following the SEEA production boundary, even though the term “planted forests” may immediately suggest a high level of economic activity.

5.357 Given the potential for forestry management practices to vary considerably across and within countries, it is recommended that countries determine the status of their timber resources as either natural or cultivated based on application of the production boundary considerations listed above. This process is likely to require assessment by type of area in which timber resources are found, including forest land, other wooded land and other land with wood supply.

5.8.3 Physical asset accounts for timber resources

5.358 The physical asset account for timber resources records the volume of timber resources at the beginning and end of an accounting period and the change in this stock over the accounting period. Of particular interest is the analysis of the natural growth of timber resources compared with the removals.

5.359 A basic structure for a physical asset account for timber resources is presented in table 5.19. The asset account should distinguish between the types of timber resource, most importantly between cultivated timber resources and natural timber resources. For natural timber resources, a distinction should be made between those timber resources available for wood supply and those not available for wood supply, so as to ensure that the different scopes of the asset accounts in physical and monetary terms can be reconciled. Depending on the purpose of analysis and available data, accounts by species of tree may be compiled.

Table 5.19
Physical asset account for timber resources (*thousands of cubic metres over bark*)

	Type of timber resource		
	Cultivated timber resources	Natural timber resources	
		Available for wood supply	Not available for wood supply
Opening stock of timber resources	8 400	8 000	1 600
Additions to stock			
Natural growth	1 200	1 100	20
Reclassifications	50	150	
Total additions to stock	1 250	1 250	20
Reductions in stock			
Removals	1 300	1 000	
Felling residues	170	120	
Natural losses	30	30	20
Catastrophic losses			
Reclassifications	150		150
Total reductions in stock	1 650	1 150	170
Closing stock of timber resources	8 000	8 100	1 450
Supplementary information			
Fellings	1 250	1 050	

5.360 The focus of the asset accounts presented in the SEEA is on the timber resources found in areas of forest and other wooded land. There may be interest, however, in developing estimates of the volume of timber resources in other areas, depending on country circumstance.

Additions to the stock

5.361 The stock of timber resources will increase due to *natural growth*. This is measured in terms of the gross annual increment, i.e., the volume of increment over the reference period of all trees with no minimum diameter.

5.362 The calculation of natural growth should be based on the timber resources available at the beginning of the accounting period. Increases in the area of forest land, other wooded land and other areas of land that lead to increases in the volume of available timber resources should not be considered natural growth but should, instead, be recorded as *reclassifications*. Reclassifications may also occur as a result of changes in management practice that shift timber resources from cultivated to natural or vice versa.

Reductions in the stock

5.363 The stock of timber resources will decrease over an accounting period through the removal of timber resources and natural losses. ***Removals*** are estimated as the volume of timber resources removed from forest land, other wooded land and other land areas during the accounting period. They include removals of trees felled in earlier periods and the removal of trees killed or damaged by natural causes. Removals may be recorded by type of product (e.g., industrial roundwood or fuelwood) or by species of tree (e.g., coniferous or broadleaved).

5.364 Removals constitute the relevant variable for measuring the extraction of timber resources because the definition of the stock of timber resources includes trees that have been felled and are on the ground but have not yet been removed.

5.365 To fully account for the change in the volume of timber resources over an accounting period, it is necessary to deduct ***felling residues***. These residues are associated with the fact that, at the time of felling, a certain volume of timber resources is rotten, damaged or in excess in terms of the size requirements. Felling residues exclude small branches and other parts of the tree that are also excluded from the scope of timber resources. Estimates of felling residues may also provide important information on the nature of forestry practice.

5.366 ***Natural losses*** are the losses to the growing stock (i.e., living, standing trees) during an accounting period due to mortality from causes other than felling. Examples include losses due to natural mortality, insect attack, fire, wind throw or other physical damages. Natural losses should include only those losses that can be reasonably expected when considering the timber resources as a whole. Natural losses should be recorded only when there is no possibility that the timber resource can be removed. All timber removed should be recorded as removals.

5.367 ***Catastrophic*** losses should be recorded when there are exceptional and significant losses of timber resources due to natural causes. Catastrophic losses should be recorded only when there is no possibility that the timber resource can be removed. All timber removed should be recorded as removals.

Depletion

5.368 Following the general definition of depletion, the depletion of natural timber resources is related to the sustainable yield of timber resources from the forest land, other wooded land and other land on which natural timber resources are found. More precisely, the sustainable yield of timber resources is the quantity of timber that can be harvested at the same rate into the future while ensuring that the productive potential is maintained. The sustainable yield will be a function of the structure of the growing stock and needs to take into account both the expected natural growth and the natural losses of trees. Various biological and forestry models will need to be taken into account in estimating sustainable yield.

5.369 Depletion of natural timber resources, in physical terms, is equal to removals less sustainable yield. As explained in section 5.4, some variation from year to year is to be expected in the relationship between estimates of sustainable yield and actual quantities of natural growth (less natural losses). Hence, depletion should be recorded only when removals are beyond normal year-on-year variations in quantities of natural growth.

5.370 It is noted that the concept of sustainable yield used to define depletion does not take into account the broader ecological sustainability of the surrounding ecosystems which may be affected by the felling and removal of timber resources.

Fellings

5.371 While these entries fully account for the change in the volume of timber resources over an accounting period, there may be specific interest in the volume of trees felled during the period relative to the volume of timber resources removed. Annual fellings are equal to the volume of timber resources that is felled during an accounting period. Fellings include silvicultural and pre-commercial thinnings and cleanings. Where available, estimates of the volume of fellings may be added as supplementary information in the physical asset account.

Timber resources as a source of energy

5.372 Timber resources are often used as a source of energy. The inputs of energy from both natural and cultivated timber resources are recorded in the physical supply and use table for energy (sect. 3.4). The basis for the recording is the measurement of the amount of energy actually sourced from timber resources rather than the measurement of the total energy that might be sourced from timber resources. In concept, the stock of timber resources measured in the asset accounts incorporates the volume and value of timber resources that may be used for energy purposes, but no separate estimates are made. Where there is analytical interest and where data are available, it would be possible to construct asset accounts for timber resources with a focus on timber resources used for energy purposes. In this context, the focus may be placed on those timber resources that are considered renewable sources of energy.

5.8.4 Monetary asset accounts for timber resources

5.373 Monetary asset accounts for timber resources consist in measuring the value of the opening and closing stock of timber resources and the changes in the value of the stock over an accounting period. The monetary asset account for timber resources is presented in table 5.20.

5.374 Most of the changes in the stock relate directly to changes recorded in the physical asset account; but there are also entries relating to the revaluation of timber resources, which are recorded when the prices for timber change during an accounting period.

5.375 It may be that not all timber resources are available for harvest because of forest legislation and/or for environmental and economic reasons. It is recommended that the volume of timber resources that cannot be harvested be separately identified and not form a part of the overall calculations of the value of timber resources.

5.376 Estimates are made for the value of natural growth and the value of removals. For cultivated timber resources, the natural growth is considered an increase in inventories and the removal of trees is treated as a decrease in inventories. Following the SNA, only the change in inventories would normally be recorded, but the entries are recorded on a gross basis in the SEEA.

5.377 For natural timber resources, the natural growth is not considered an increase in inventories, since the growth in the trees is not considered to be part of a production process. The removal of the timber resources represents the point at which the timber resources enter the economy and output is recorded at that point.

Table 5.20
Monetary asset account for timber resources (*currency units*)

	Type of timber resource		
	Cultivated timber resources	Natural timber resources (available for wood supply)	Total
Opening stock of timber resources	86 549	82 428	168 977
Additions to stock			
Natural growth	12 364	11 334	23 698
Reclassification	515	1 546	2 061
Total additions to stock	12 879	12 879	25 759
Reductions in stock			
Removals	13 395	10 303	23 698
Felling residues	1 752	1 236	2 988
Natural losses	309	309	618
Catastrophic losses			
Reclassification	1 546		1 546
Total reductions in stock	17 001	11 849	28 850
Revaluations		16 692	16 692
Closing stock of timber resources	82 428	100 150	182 578

Valuing the stock of timber resources

5.378 In line with its general definition (see sect. 5.4), resource rent on timber resources can be derived as the gross operating surplus from the harvest of timber resources (after taking into account specific taxes and subsidies) less the value of the user costs of produced assets used in the harvesting process.

5.379 Defined in this way, the resource rent will implicitly include a share that should be attributed to the land on which the timber stands. This reflects the composite nature of the overall asset as discussed in section 5.6. In many cases, owing to the location of the land or the quality of the soil, the return to the land may not be large compared with the return to the timber resource; but where relevant (e.g., where the land may be potentially of value for other purposes), an estimate of the resource rent attributable to land should be deducted for the purpose of deriving the estimate of resource rent on timber resources.

5.380 Resource rent can be estimated more directly by using estimates of the stumpage price, which is the amount paid per cubic metre of timber by the harvester to the owner of the timber resources. The stumpage price itself may also be derived by deducting various harvesting costs from roadside pickup prices (also called wood-in-the-rough or raw wood prices). The harvesting costs should include felling costs as well as costs of thinning (net of any receipts), other management costs and rent on land. For natural timber resources, these additional costs may be very low or even zero. Where timber resources are sold prior to felling, relevant contract prices may also be used, with appropriate adjustments for the scope and coverage of the prices to align them with the concept of resource rent.

5.381 Stumpage prices can then be multiplied by estimates of the expected volume of standing timber per hectare at the expected harvesting age to yield estimates of future receipts. These future receipts are then discounted (over the time from the current period to the expected harvest period) for the purpose of estimating a value per hectare for each age class. In turn, these values are multiplied by the total area of each age class and added to give the value of the total stock of standing timber. This approach should ensure that trees harvested after reaching maturity are separately accounted for. A simplifying approach is to use the current age structure and assume that each tree of a particular age grows to maturity and is harvested at maturity.

5.382 The primary difficulty in applying these NPV approaches lies in the extent to which information is available on the age structure of the trees and how these trees will mature into the future. Where the necessary detail is available, these NPV approaches should be used, taking into account modelling of future timber resources.

5.383 If detailed information on the future age structure is not available, two methods are commonly applied. The stumpage value method multiplies the average stumpage price across all maturities of felling by an estimate of the current volume of timber resources. The consumption value method requires information on the current age structure of the timber resources and stumpage prices for different maturities of standing timber.

5.384 While these two methods are variants of the basic NPV approaches, the assumptions underpinning them may be restrictive, particularly in the case of a changing age structure of timber resources due either to over-exploitation or to active afforestation.

5.385 Other data sources for the price of timber resources may also be available. For timber resources in young forests, there may be valuations for insurance purposes, since at a young age there is a higher likelihood that forests will be destroyed. Also, in some countries, there are well-developed markets in the acquisition and disposal of forests. In these situations, pricing models have been established to provide appropriate valuations, taking into account the location, type and age structure of the trees, etc. Care should be taken in using these pricing models for the purpose of valuing timber resources, as the value of the forest may include estimates of the value of alternative land uses rather than estimates of only the future income stream from the timber resources.

Valuation of removals, natural growth, depletion and other flows

5.386 In general terms, the valuation of flows of timber resources (including removals, natural growth, depletion and other flows) should be undertaken using the same in situ resource prices underlying the valuation of the opening and closing stock of timber resources. The relevant approaches are described in annex A5.1.

5.387 With respect to catastrophic losses, for example, due to wind throw or forest fire, when a catastrophic event does not fully destroy the wood, it is necessary to take into account the value of the wood that will be salvaged. Prices may rise following destruction of timber resources due to fire or they may fall if trees are killed but not destroyed in storms. The price changes will reflect the changes in the pattern of timber available to be supplied. Further, the stumpage value of the salvaged timber has to be accounted for in the value of the stock for the period until its removal from the forest, which, in some cases, may take a number of years.

5.388 Other changes that affect the value of stocks of standing timber as a resource for the logging industry are changes in use or status, for example, when forests are protected and logging is prohibited. In this case, the value of the standing timber, in terms of income from the sale of timber resources, is reduced to zero.

5.8.5 Carbon accounts for timber resources

5.389 The assessment of carbon sequestration is an increasingly important consideration. As part of a broader accounting of carbon sequestration and other carbon stocks and flows, estimates of the amount of carbon bound in timber resources and the changes in these amounts over an accounting period can be derived using information on opening and closing volume of standing timber and the changes in volume. Estimates can be derived by applying relevant average coefficients for both the relationship between the volume of standing timber and the total biomass (including above- and below-ground biomass) and the relationship between the biomass and the quantity of carbon. These coefficients will vary with the species of the tree and other factors.[71]

5.390 A carbon account for timber resources can be developed based on the structure of the physical asset account for timber resources (see table 5.19).

5.391 It is noted that references to reductions in the stock of carbon in timber resources, for example, due to removals, do not imply that carbon has been released into the atmosphere. In general, carbon will remain bound in timber until the timber is burned or decomposes naturally and these releases of carbon will not be recorded in a carbon account for timber resources.

5.392 A complete articulation of carbon accounting, including, for example, carbon sequestration in soils, is beyond the scope of the Central Framework but is discussed in SEEA Experimental Ecosystem Accounting. This reflects the fact that calculation methods are still developing and that an ecologically grounded accounting approach is required to fully account for stocks and flows of carbon and provide information for policy in this area. At the same time, it is noted that the underlying accounting models in the Central Framework are sufficiently well developed for use in carbon accounting for timber and other stores of carbon.

5.9 Asset accounts for aquatic resources

5.9.1 Introduction

5.393 Aquatic resources are an important biological resource. They include fish, crustaceans, molluscs, shellfish and other aquatic organisms such as sponges and seaweed, as well as aquatic mammals such as whales. Aquatic resources are subject to harvest for commercial reasons as well as in the context of subsistence and recreational fishing activities. The abundance and health of natural aquatic resources in inland and marine waters are also increasingly affected by water pollution and by the degradation of habitats through the damming and diversion of rivers, restricted water release from reservoirs to rivers, clearance of mangroves, sedimentation, coral mining, deforestation in the hinterland, urbanization, and other activities. The dual impacts of high exploitation levels and habitat degradation result in the loss, or reduction, of the economic value of the goods and services provided by the aquatic ecosystems and a loss of biodiversity and genetic resources.

5.394 In most parts of the world, fishing capacity has reached a level where unrestricted fishing will result in over-exploitation and lead to smaller catches and economic benefits than would be possible if the catch was managed in such a way as to prevent over-exploitation. In extreme cases, there is the risk of commercial extinction of some aquatic resources with attendant impacts on the aquatic ecosystem.

5.395 Asset accounts for aquatic resources organize information on the stocks and changes in stocks of the quantity and value of aquatic resources within a country's economic territory, including stocks within a country's EEZ or on the high seas over which the country holds ownership rights. In principle, all aquatic resources are in scope of the asset accounts in the

71 See Good Practice Guidance for Land Use, Land Change and Forestry (IPCC, 2003); and Updated UNFCCC reporting guidelines on annual inventories following incorporation of the provisions of decision 14/CP.11(United Nations Framework Convention on Climate Change, 2006).

Central Framework; but in practice, the scope is limited to those aquatic resources that are subject to commercial activity. Asset accounts cover both cultivated aquatic resources and natural aquatic resources, thus enabling a comparison of trends in both resources.

5.396 The asset accounts presented in the present section do not cover the assessment of general aquatic ecosystems that support the various resources and provide a wide range of ecosystem services. The measurement of ecosystems is described in SEEA Experimental Ecosystem Accounting.

5.397 The present section provides a definition and classification of aquatic resources, including a discussion of the boundary between cultivated and natural aquatic resources. A physical asset account is then described with a particular focus on the measurement of resources of natural aquatic resources. The section concludes with the presentation of a monetary asset account, incorporating a discussion on the role of quotas and licences in estimating the value of aquatic resources.

5.9.2 Definition and classification of aquatic resources

5.398 The aquatic resources for a given country comprise those resources that are considered to live within the exclusive economic zone (EEZ) of a country throughout their life cycles, in both coastal and inland fisheries. Migrating and straddling fish stocks are considered to belong to a country during the period when those stocks inhabit its EEZ.

5.399 When exploitation control over migrating and straddling fish stocks, and fish stocks that complete their life cycle in international waters (high seas), has been established and the access rights of a country to them are defined in international agreements, that portion of agreed access rights to those aquatic resources can be considered to belong to the country.

5.400 In some cases, international agreements specify explicitly the share of total catches that should be allocated to each country. When this is the case, each country's share of the stock of the common aquatic resource can be determined on the same basis. In the absence of specific information about the share of the common aquatic resource, the catch realized by a given country can be used as an indicator of the country's share.

5.401 These aspects of the measurement boundary are defined with reference to the United Nations Convention on the Law of the Sea, and in particular to the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (United Nations, 2004) and the Code of Conduct for Responsible Fisheries (FAO, 1995). Together, these agreements create a legal framework for international fisheries management.

Classification of aquatic resources

5.402 The high-level classification of aquatic resources is shown in table 5.21.

Table 5.21
Classification of aquatic resources

Aquatic resources
Cultivated aquatic resources
For harvest (inventories)
For breeding (fixed assets)
Natural aquatic resources

5.403 The Food and Agriculture Organization of the United Nations (FAO) and other fishery and aquaculture related institutions have collected data on capture and aquaculture production of aquatic resources, itemized at species level to the extent possible. The data include harvests of freshwater, brackish-water and marine species of fish, crustaceans, molluscs and other aquatic animals and plants, for all commercial, industrial, recreational and subsistence purposes.

5.404 The Aquatic Sciences and Fisheries Information System (ASFIS) list of species contains over 11,500 species, and is commonly used as the standard reference for fisheries production. It is linked to the FAO International Standard Classification for Aquatic Animals and Plants (ISCAAP) which divides commercial species into 50 groups on the basis of their taxonomic, ecological and economic characteristics.[72]

5.405 Aquatic resources can be further grouped into the following nine divisions.

1. Freshwater fishes
2. Diadromous fishes
3. Marine fishes
4. Crustaceans
5. Molluscs
6. Whales, seals and other aquatic mammals
7. Miscellaneous aquatic animals
8. Miscellaneous aquatic animal products
9. Aquatic plants

5.406 Diadromous fish are either those that normally live in salt water and spawn in freshwater (e.g., salmon) or those that normally live in freshwater and spawn in the sea (e.g., eels). Miscellaneous aquatic animal products encompass pearls, mother-of-pearl, shells, corals and sponges.

Harvesting aquatic resources and the production boundary

5.407 Aquatic resources may be either cultivated or natural biological resources. Treatment depends on the degree to which the growth and regeneration of the biological resource are under the direct control, responsibility and management of an institutional unit.

5.408 The production boundary includes all activities carried out under the responsibility, control and management of a resident institutional unit in which labour and assets are used to transform inputs of goods and services into outputs of other goods and services. In the case of aquatic resources, the growth of fish in fish farms and other aquaculture facilities is treated as a process of production.

5.409 Aquaculture is defined by FAO as follows:

> Aquaculture is the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms that are harvested by an individual

72 The ISCAAP is maintained by the Coordinating Working Party on Fisheries Statistics (CWP). Details on CWP and ASFIS are available at www.fao.org/fishery.

or corporate body that has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms that are exploitable by the public as a common property resource, with or without appropriate licences, are the harvest of the fisheries.

5.410 Following the FAO definition of aquaculture, all aquatic resources produced within aquaculture facilities are considered cultivated biological resources. All other aquatic resources harvested as part of capture production processes are considered natural biological resources. In some cases, the life cycle of aquatic resources may start in an aquaculture establishment before transfer to the wild. In other cases, fish are captured in the wild for further growth in aquaculture facilities. Following standard methods, the proportion of growth in the wild and the proportion of growth in aquaculture facilities should be separated and classified appropriately.

5.411 While all aquatic resources in aquaculture facilities are cultivated biological resources, not all aquaculture is undertaken in the same way. Some aquaculture is undertaken using netted areas in rivers or offshore; hence, there is an interaction between the fish and the aquatic environment in which it is situated. Other forms of aquaculture involve raising fish in tanks where they are entirely removed from a natural environment. Therefore, it may be the case that some cultivated aquatic resources should not be considered environmental assets. Nonetheless, information on this distinction between types of cultivated aquatic resources would be useful, given that the interactions between the environment and the economy are likely to be quite different. In practice, it may not be possible to distinguish between cultivated aquatic resources on the basis of the farming practice.

5.9.3 Physical asset accounts for aquatic resources

5.412 A physical asset account for aquatic resources shows the total biomass of all species that are subject to harvesting activity or cultivated within the national boundary, including within the country's EEZ, and a portion of shared resources biomass to which a country has access rights either through traditional practice, international agreement or provision of part of the distribution areas. The scope of harvesting includes commercial sea- and freshwater operations, aquaculture, and subsistence and recreational harvesting of aquatic resources. Aquatic resources that exist within other countries' EEZ but are harvested by operators that are resident in the reference country should not be included in the asset accounts. The physical asset account also shows the changes due to harvest, normal loss, growth (in size and in number) and other changes.

5.413 A basic asset account for aquatic resources in physical terms is presented in table 5.22.

5.414 In all cases, the units that are used to record the stock and changes in stock should be the same, although the measurement unit may vary by type of aquatic resource. It may be necessary to convert some estimates of the mass into number and vice versa. Conversion factors by species and size are required for this purpose.

Cultivated aquatic resources

5.415 In the case of cultivated aquatic resources, it is reasonable to assume that the stock and changes in the stock can be estimated by the operator or owner of the resource. Accounts should be structured by species, as appropriate. Increases come from ***growth in stock*** (in both size and numbers) and decreases from harvesting and ***normal losses.***

5.416 When natural aquatic resources are introduced either as seeds or as breeding stock, this should be recorded as a ***reclassification*** from natural to cultivated resources. In the case of ranching and enhancement of aquatic resources, cultured seeds released into the wild should be recorded as a reclassification from cultivated to natural resources. A risk for aquaculture undertaken in rivers and marine environments is that the fish may escape into the external environment. These escapes should also be considered a reclassification from cultivated to natural aquatic resources in cases where the fish are able to integrate into natural fish stocks. Where this is not possible, the escapes should be recorded as normal or catastrophic losses.

Table 5.22
Physical asset account for aquatic resources (*tonnes*)

	Type of aquatic resource		
	Cultivated aquatic resources—fixed assets	Cultivated aquatic resources—inventories	Natural aquatic resources
Opening stock of aquatic resources	406	150	1 393
Additions to stock			
Growth in stock	19	192	457
Upward reappraisals			33
Reclassifications	40		11
Total additions to stock	59	192	501
Reductions in stock			
Gross catch/harvest		183	321
Normal losses	37	5	183
Catastrophic losses	4	2	9
Uncompensated seizure			7
Downward reappraisals	5		
Reclassifications	9		35
Total reductions in stock	55	190	555
Closing stock of aquatic resources	410	152	1 339

5.417 Unexpectedly large losses due to disease or natural catastrophic events should be considered *catastrophic losses*.

5.418 The majority of changes in the stock of cultivated aquatic resources should be accounted for as changes in inventories. However, there will be a proportion of the cultivated aquatic resources that are considered to be breeding stock. In principle, these resources should be considered fixed assets rather than inventories and their growth should be recorded as gross fixed capital formation with associated entries for consumption of fixed capital.

Natural aquatic resources

(a) Measuring stocks and changes in stocks of natural aquatic resources

5.419 Asset accounts for natural aquatic resources should be compiled separately for freshwater aquatic resources, and marine aquatic resources within a country's EEZ or that over which the country has ownership rights. A distinction between freshwater and marine aquatic resources may also be compiled.

5.420 Fishery biologists define a "stock" as a group of individuals from the same species that constitute a unit in breeding new offspring. If mating between members of different groups occurs to the level required to modify their gene pools in the long term, those groups should be regarded as belonging to one stock. The resource management should be based on this concept of stock. The boundary of a stock in this sense does not correspond to national boundaries and when aquatic resources belonging to a stock move around multiple countries' boundaries, international collaboration in management is needed and the national asset account of such stock can be defined based on the share of access to the stock.

5.421 There are several dimensions that should be considered in measuring the size of the resources. An important one is the measurement of the sexually mature part of the stock (i.e., the spawning stock or parental biomass). It is important because, commonly, a primary purpose of fishery management is to maintain an adequate level of spawning stock so as to be able to generate natural growth and to minimize the probability of collapse. Measures of the sexually mature stock should be complemented with measures of the immature stock to obtain a complete assessment of the stock.

5.422 Another relevant measurement dimension is the exploitable stock size. This corresponds to the proportion of the stock that is subject to harvesting activity, which ignores the cohorts that are younger than those being harvested about which little is known. In this regard, it is important to record separately the catch of mature resources and the catch of immature resources within the same species. Similarly, in cases where stocking with cultured seeds is regularly conducted, as commonly observed in freshwater resources, it is important to include the amount of released seeds as a reclassification from cultivated aquatic resources in order to assess their potential impacts on wild ecosystems and gene pools.

5.423 Various methods can be used by fishery biologists to estimate the absolute size of natural aquatic stocks, including virtual population analysis (VPA), tag-recapture analysis, and direct and indirect measurement with line-transect surveys or at randomly sampled areas (e.g., echo-sounders, trawl surveys and sighting surveys), according to the behaviour and distribution of the target species, the harvesting patterns, and available data.

5.424 However, estimates of the absolute size of stocks can be imprecise. In practice, little can be done to estimate the variability in births and survivals before the recruitment to the stock, the effects of environmental factors affecting the growth of the individual fish, or the rate of natural death from accidents, sickness, age, predators and so on. Further, small modifications in such parameters within assessment models and equations may result in substantial differences in the estimated size of a stock. It is therefore important to record the impact of changes in model parameters as reappraisals in the asset accounts to distinguish these changes from other physical changes in the stock size.

5.425 When scientific assessment of the absolute stock size is not available, an alternative approach is to measure the gross catch for a certain harvesting operation in relation to the amount of effort required to obtain the catch for a given species (e.g., days at sea, number and type of fishing gear, size and power of vessel, and expenditure on catch effort, including wages and fuel). The ratio of catch per unit effort (CPUE) may provide a good indicator of the relative change in stock size, assuming that population density and population size are closely correlated and that CPUE is higher at higher population densities. Importantly, not all species have the same ratios between population structure and the associated CPUE and this needs to be taken into account in using this technique. Further, CPUE measures may be affected by changes in quota and other administrative arrangements, and changes in technology. These types of factors should also be taken into account. Since the CPUE is derived based on information about activity over an accounting period, it provides an indicator of the stock at the midpoint of the accounting period.

5.426 Estimates may be available of stocks for individual species, since this is often the basis on which quotas are determined. However, it may be more applicable to focus on the size of the stock within a given area (or fishery), regardless of the number of species harvested in that area. Commonly, particularly in tropical areas, multiple species may be harvested at one time, and accessing relevant indicators and models of the overall stock size consisting of multiple species that supports this harvest may be the most appropriate measurement approach.

(b) Accounting for the harvest of natural aquatic resources

5.427 In physical terms, all aquatic resources harvested and all efforts used to realize the harvest (e.g., in terms of fishing days multiplied by vessel power) should be recorded. Records should differentiate between species and the type of fishing/harvesting fleet (i.e., vessels operating in a similar way with similar gear). Further, the aquatic resources harvested in the open seas, coastal waters or inland waters by commercial, subsistence or recreational fishing should be counted as production at the time they are harvested, regardless of whether they are sold in the market or used for own consumption.

5.428 FAO has defined the different stages of the catch, extending from when fish encounter fishing gear to when they are landed. They are summarized here, with a complete depiction of the relationships presented in a diagram in annex A5.4.

(*a*) ***Gross removal:*** the total live weight of fish caught or killed during fishing operations;

(*b*) ***Gross catch:*** the total live weight of fish caught (gross removal less pre-catch losses);

(*c*) ***Retained catch:*** the total live weight of fish retained (gross catch less discarded catch);

(*d*) ***Landings:*** the net weight of the quantities landed as recorded at the time of landing;

(*e*) ***Nominal catch:*** the live weight equivalent of the landings.

5.429 The most common catch concept used in practice is that of “landings”. Landings are directly linked to the economic value of the product. However, this measure excludes the discards of organisms incidentally caught through harvesting activity (discarded catch) as well as the amount of the catch used for own consumption. For the SEEA, the measurement of discarded catch is an important contributory factor to a full understanding of the linkages between economic activity and the impact on aquatic resources. For this reason, it is recommended that the concept of “gross catch” be used to measure the extraction of fish resources.

5.430 Conceptually, “gross removal” is the most appropriate concept for measuring the impact on aquatic resources and the damage to aquatic ecosystems, e.g., to coral reefs, as a result of fishing activity. However, the measurement of gross removal is not possible in practice.

(c) Depletion

5.431 In principle, depletion of natural aquatic resources is derived following the approach outlined in section 5.4 and annex A5.1, where depletion for renewable resources is shown to be equal to gross catch less sustainable yield. Since the drivers for changes in populations of aquatic resources can only be modelled, it may be difficult to obtain precise and consistent measures of sustainable yield over time. In these cases, it is recommended that estimates from biological models be compared with indicators of stock size, such as CPUE, and also that estimation be carried out on an ongoing basis so that the dynamics of the various populations (natural growth, natural losses, etc.) can be better understood.

5.432 With this information, a sustainable yield may be established to which the gross catch in any given period can be compared. As noted in section 5.4, some year-on-year variation in the actual changes in the population must be accepted as part of the accounting, and depletion should therefore be recorded only when the extraction is beyond a normal level of natural growth (less natural losses).

(d) Capture fishing by non-residents

5.433 Given the nature of aquatic resources and harvesting activity, there will be capture fishing undertaken by non-residents within another country's EEZ. Following the principles of the SNA, the location of the aquatic resource is not the key determinant of the attribution of economic production. Production is allocated instead to the country of residence of the harvesting operation.

5.434 Therefore, in the assessment of the change in the aquatic resources belonging to a country over an accounting period, it is not sufficient or accurate to focus only on the catch by operations of residents of that country. This estimate will exclude changes in the national aquatic resource due to catch by non-residents and will include catch by residents in other countries. For the purposes of accounting for the national aquatic resource, the focus must be on the total catch from the country's aquatic resources, including any resources on the high seas over which ownership rights exist, regardless of the residency of the harvesting operation.

(e) Illegal fishing

5.435 If residents harvest aquatic resources beyond the scope of their licence, they are harvesting illegally. Nonetheless, following the principles of the SNA, this harvest should still be recorded as production with an income accruing to the fisherman.

5.436 In cases where non-residents harvest aquatic resources illegally, either without a licence or by taking catch in excess of their allocated quota, the physical removals should be recorded. These flows should be recorded as uncompensated seizures. In recording such flows, care must be taken to exclude them from estimates of gross catch of the country in whose EEZ the fish were caught.

(f) Other physical flows

5.437 It is unlikely that direct information can be separately obtained regarding the growth and normal loss in natural aquatic resources. Consequently, the estimates of growth and normal loss should be derived based on estimates of the opening and closing stock of aquatic resources and the extent of harvest when estimates of the absolute stock size are available. Otherwise, the change in CPUE over accounting periods should provide an indication of whether the overall change (i.e., growth less gross catch less normal loss) is positive or negative.

5.438 It is also likely that reappraisals of the quantity of aquatic resources, both upward and downward, will occur, most commonly owing to revisions in the parameters used in stock measurement models.

5.9.4 Monetary asset accounts for aquatic resources

5.439 A monetary asset account for aquatic resources records the opening and closing values of aquatic resources in an accounting period and the changes over the period in the form of additions to the stock, reductions in the stock and revaluations. Aside from revaluations, all of the monetary flows in the asset account have a direct parallel with the physical flows recorded in the physical asset account.

5.440 A basic monetary asset account for aquatic resources is presented in table 5.23.

Table 5.23
Monetary asset account for aquatic resources (*currency units*)

	Type of aquatic resource			
	Cultivated aquatic resources—fixed assets	Cultivated aquatic resources—inventories	Natural aquatic resources	Total
Opening stock of aquatic resources	3 250	1 125	9 750	14 125
Additions to stock				
Growth in stock	150	1 440	3 200	4 790
Upward reappraisals	0	0	250	250
Reclassifications	280	0	75	355
Total additions to stock	430	1 440	3 525	5 395
Reductions in stock				
Gross catch/harvest	0	1 375	2 250	3 625
Normal losses	275	35	1 460	1 770
Catastrophic losses	30	15	70	115
Uncompensated seizure	0	0	50	50
Downward reappraisals	35	0	0	35
Reclassifications	75	0	280	355
Total reductions in stock	415	1 425	4 110	5 950
Revaluations	160	50	480	690
Closing stock of aquatic resources	3 425	1 190	9 645	14 260

Valuation of cultivated aquatic resources

5.441 Aquatic resources farmed in an aquaculture facility are produced assets, either inventories or fixed assets (in the case of breeding stocks). In most cases, market prices can be obtained and used to estimate the value of the resources and the value of the flows of resources over an accounting period.

Valuation of natural aquatic resources

5.442 Valuation of natural aquatic resources is complex. There are two main options. One is to value the aquatic resource using the value of long-term fishing licences and quotas where realistic market values are available. The other is to base the value on the net present value of the resource rent of the aquatic resources. Under the NPV approach, there are two principal means of estimating the resource rent: using information on annual licences, and using information from the national accounts following the residual value method (see sect. 5.4 for details).

5.443 If there is a perfectly functioning market for licences, if these licences cover the whole stock, and if resource rent can be accurately estimated, then these different valuation approaches should give the same result. However, because of market imperfections (barriers to entry in the form of specialized fixed assets, knowledge of fishing grounds, etc.), a lack of liquidity in the markets, and uncertainties in the statistical assumptions required for net present value calculations, this is unlikely to be exactly the case in practice.

Valuing natural aquatic resources using licence and quota information

5.444 In many countries, a licence issued by government is required in order to practise either freshwater or marine fishing. A licence may be issued for a right to fish in general, a right to fish with specific gear, or a right to catch specific species. If these licences apply for a period not exceeding one year, they are recorded in the SNA as taxes. For enterprises, they are treated as taxes on production; for private individuals fishing for pleasure, they are recorded as taxes on income.

5.445 Issuing quotas is an increasingly common approach to controlling marine aquatic resources so as to prevent over-harvesting. Quotas are portions of an overall allowable catch, either specified as percentages or as absolute quantities. They are usually issued by government (which is also responsible for ensuring their enforcement) and may apply both to harvesting within the waters of the country's EEZ and to fishing on the high seas. Quotas typically apply to a particular species.

5.446 Quotas may be sold or assigned to certain designated enterprises, people or communities (e.g., people in locations where fishing is the main source of livelihood), or other groups. A quota may be valid for one year only or for a longer period—sometimes for the lifetime of the quota-holder. It may or may not be tradable to third parties. Even if not tradable, in certain circumstances, it may still be transferable, say, from one generation to the next.

5.447 If a quota can be sold by the holder to a third party, then the quota is recorded as an asset quite separately from the aquatic resources to which it relates.

5.448 When fishing/harvesting rights, evidenced by the existence of licences and quotas, are freely traded, it is possible to estimate the value of the aquatic resources from the market prices of these entitlements. In many cases, where the government hands the access rights to fishermen, trading in these access rights is prohibited and there is therefore no directly observable market valuation. In some cases, fishing rights may be tied to some asset (often a fishing vessel and, in some cases, land) that is freely traded. In these cases, it may be possible to infer market valuation of the access rights by comparing the prices of the associated assets when fishing rights are attached to them with prices of similar assets that do not encompass any such rights.

5.449 Two types of individual transferable quota (ITQ) systems are common. The most common type provides entitlement to a fixed share of a total that may itself be variable from year to year in accordance with, for example, international agreements. The other type provides entitlement to an absolute level of catch.

5.450 In theory, the value of the quota represents the NPV of the owner's expected income using the quota over its period of validity. If the aquatic resource is managed with such quotas and the quotas are valid in perpetuity, then the value of all quotas, at the market price, should be equal to the value of the aquatic resource.

5.451 If the quotas are valid for a single year only, the total should give an approximation of the resource rent in that year. By projecting an estimate of the value of a single year quota, estimating the resource life, and applying an appropriate discount rate, an overall value of the aquatic resource can be derived using the NPV approach.

5.452 However, in most of those cases where ITQs and similar arrangements are used to manage aquatic resources, the markets in the quotas are not perfect and there may be various restrictions on the quotas (e.g., the quotas may be for a limited duration). Consequently, the access rights may not reflect the full value of the resource. Licences and quotas are often introduced when considerable excess capacity exists in the fishing/harvesting industry. Unless those setting the total level of the quotas do so based on knowledge of the maximum catch consistent with preserving stocks, the earnings from the catch will not correspond to the level of income that maintains the aquatic resource intact. A total permissible catch resulting in earnings that are higher than this level will mean that some of those earnings should be regarded as depletion of the aquatic resources and not as income.

Valuing natural aquatic resources using the NPV of expected resource rents

(a) Estimating resource rent

5.453 Following the approaches outlined in section 5.4 and annex A5.1, the operating surplus from harvesting natural aquatic resources can be used as a basis for the calculation of the resource rent of the resources. The total amount of gross operating surplus must be partitioned between that part representing the user costs of produced assets such as the ship, nets and other equipment used; and the part representing the resource rent of the aquatic resource.

5.454 There are a number of complications particular to the fishing industry that must be taken into account. One arises from the fact that artisanal fishing is very common, especially in developing countries. Here the generation of income account yields an item called "mixed income" as the balancing item rather than operating surplus. This item is so named because it represents not only a return to the produced assets used and the natural aquatic resources but also an element of remuneration to the self-employed fisherman. In this situation, an adjustment to remove this element of labour remuneration must be made.

5.455 It may also be difficult to separate harvesting and processing activities, both with respect to factory vessels and in cases where companies whose primary activity is land-based processing (that is, manufacturing) also have some harvesting operations. Although it is desirable to allocate the production and cost data to the relevant activity, this may be difficult in practice.

5.456 In addition, besides permitting harvest in excess of a sustainable level of catch, governments may sometimes subsidize fishing so that fishing continues even when the expected resource rent is negative. Following the treatment outlined in section 5.4, in these cases, the value of the aquatic resource should be assumed to be zero, as the income to the extractor is primarily a redistribution from within the economy rather than a return from the underlying natural resource.

(b) Estimating the asset life

5.457 Estimating the asset life of aquatic resources presents a difficult measurement challenge. If the aquatic resource is to be preserved in perpetuity, harvest should not exceed the renewal rate of a stable population, i.e., the sustainable yield. In general, questions regarding the sustainable yield of an aquatic resource are answered using biological models (as described in sect. 5.4) or through analysis of trends in relevant indicators such as gross catch, CPUE, and the species and size of the fish caught. In particular, a declining trend in the CPUE may be a signal that the rate of harvest is exceeding the renewal rate of the fish stock,[73] and thus the asset life may be estimated by extrapolating the declining pattern of the CPUE to the point where the population is zero. More generally, focus should be placed on understanding the expected trajectories of population size relative to past and expected rates of harvest.

73 This may not be the case during the initial harvesting of a stock from carrying capacity down to a population size considered suitable for sustaining long-term yields.

Valuation of depletion and other changes in aquatic resources

5.458 The value of aquatic resources may change due to a wide range of factors. When it is not possible to identify separate reasons for changes in the size or value of stocks and to attribute the changes to natural causes or harvesting activity, it will be possible to prepare only a minimal asset account. For example, the physical asset accounts may consist of extractions (based on catch data) for a number of species but without corresponding stock estimates for all of the species.[74] Thus, it may not be possible to value the stocks of individual species; hence, only a regional or national aggregate resource value will be produced.

5.459 The value of aquatic resources harvested should be based on the average price of the opening and closing stock of the relevant aquatic resources. Ideally, changes due to growth, normal loss, depletion and other changes should also be measured directly using the same prices. However, owing to data limitations, these flows may often be available only as a composite entry either measured as the difference between the value of resources harvested and the change between opening and closing stocks, or based around trends in CPUE.

5.10 Accounting for other biological resources

5.10.1 Introduction

5.460 Other biological resources are largely represented by cultivated animals and plants including livestock, annual crops such as wheat and rice, and perennial crops such as rubber plantations, orchards and vineyards. Together, these biological resources form the basis of food production in all countries.

5.461 While the vast majority of other biological resources are cultivated, there is a range of natural biological resources that provide inputs to the economy and also form an important part of local biodiversity. These resources may include wild berries, fungi, bacteria, fruits and other plant resources that are harvested for sale or own consumption. Alternatively, they may include wild animals such as deer, boar or moose that are killed for sale or own consumption.

5.462 Since the majority of other biological resources are cultivated, estimates relating to the production and accumulation of these resources are an integral part of estimates of gross domestic product. The asset accounting for these resources is covered in detail in the SNA.

5.463 The present section introduces asset accounting for natural biological resources. No tables are proposed because the compilation of accounts for these resources depends entirely on the resources of relevance in an individual country.

5.10.2 Accounting for natural biological resources

5.464 Natural biological resources are distinguished from cultivated biological resources because their natural growth and regeneration are not under the direct control, responsibility and management of an institutional unit.

5.465 As a consequence of not being under direct control of institutional units, natural biological resources are not easily accounted for. Aside from natural aquatic and natural timber resources, most animals and plants that provide significant economic benefits have become cultivated. Thus, while there are a range of animal and plant resources that are harvested that are not cultivated, there is typically active measurement only of the animals, plants

74 Further, many fishing operations harvest multiple species at the same time and it may not be possible to attribute CPUE to individual species.

and other biota for which access rights are controlled (e.g., through hunting licences) or for which there are other management or conservation arrangements in place. Further, many of the examples that might be considered pertain to harvest for own consumption or as part of subsistence farming.

5.466 At the same time, in certain countries there are particular species that support reasonably significant commercial operations, possibly illegal, and where there is significant extraction of animals and plants from the wild. Examples in this regard include the hunting of elephants for ivory (illegal) and hunting of kangaroos for meat (legal). There may therefore be interest in the organization of data and other information on the quantity and value of the available resources, the extraction rates and the possible extent of loss in animal or plant populations due to over-harvesting.

5.467 The structure and logic of the accounting for these resources are consistent with the accounting presented in sections 5.8 and 5.9 on timber resources and fish resources.

5.468 As natural biological resources form an important part of biodiversity and ecosystems in particular regions, there may be interest in compiling data on the availability and extraction of these resources at subnational spatial levels. Further, information on these resources may be able to form an input into broader measures of ecosystems that are discussed in SEEA Experimental Ecosystem Accounting.

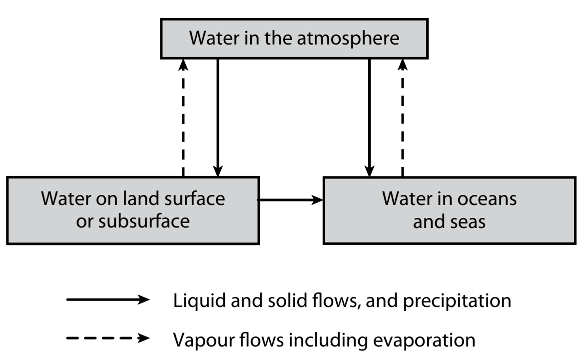
5.11 Asset accounts for water resources

5.11.1 Introduction

5.469 Unlike other environmental assets, such as timber resources or mineral resources that are subject to slow natural changes, water is in continuous movement through the processes of precipitation, evaporation, run-off, infiltration and flows to the sea. The natural cycle of water, the hydrological cycle, involves connections between the atmosphere, the oceans, and land surface and subsurface, as shown in figure 5.3.

5.470 Asset accounts for water resources focus on the inflows and outflows of water to and from the land surface and subsurface, and on the destination of these flows. In conjunction with information on instream uses of water (e.g., fish breeding and run-of-the-river hydropower generation), seasonal variation of flows of water, and other factors, such a focus allows assessment of the availability of water to meet demands from the economy and to assess whether those demands are consistent with the longer-term sustainability of water supply.

Figure 5.3
Elements of the global hydrological system



5.471 The asset accounts themselves present information on the stock of water at the beginning and end of an accounting period, whether it is in artificial reservoirs, lakes or rivers, or stored as groundwater or soil water. The accounts then record the flows of water as it is abstracted, consumed, added to through precipitation, or changed through flows to and from other countries and returns to the sea.

5.472 The subject of water resources as assets is included in two places in the Central Framework environmental asset classification: as part of "Land and other areas" and as part of "Water resources". As a component of land, it is the in situ or passive use of water that is being considered, for example, in the provision of space for transportation and recreation. Consequently, it is the area of water that is of interest. In the context of water resources, the focus is on the amount of water in the environment, its abstraction, and the use of water through the economy; hence, in this case, it is the volume of water and the changes over time that are of interest.

5.473 The present section defines water resources and the classes of water resources that are within scope of the asset accounts; presents the physical asset account for water resources and describes the relevant entries; and concludes with a discussion of related measurement issues, such as the measurement of the value of water resources.

5.11.2 Definition and classification of water resources

5.474 ***Water resources consist of fresh and brackish water in inland water bodies, including groundwater and soil water.*** Inland water bodies are classified as shown in table 5.24.

5.475 Freshwater is naturally occurring water having a low concentration of salt. Brackish water has salt concentrations lying between those of freshwater and marine water. The definition of brackish and freshwater is not clear-cut, as the salinity levels used in the definition vary among countries.[75] Brackish water is included in the asset boundary on the grounds that this water is often used, with or without treatment, for some industrial purposes, for example, as cooling water, for desalination or irrigation of some crops. Countries may choose to present accounts by salinity levels or for freshwater only.

Table 5.24
Classification of inland water bodies

Inland water bodies	
1	Surface water
1.1	Artificial reservoirs
1.2	Lakes
1.3	Rivers and streams
1.4	Glaciers, snow and ice
2	Groundwater
3	Soil water

5.476 The definition of water resources excludes water in oceans, seas and the atmosphere. At the same time, flows of water in oceans, seas and the atmosphere are recorded in the accounts in a number of places. For example, abstraction from the ocean and outflows to the ocean are recorded in the asset account and evaporation to the atmosphere from inland water

75 For further details, see International Glossary of Hydrology, 2nd ed. (United Nations Educational, Scientific and Cultural Organization and World Meteorological Organization, 1993).

resources is also recorded there. Flows to and from inland water resources are also recorded in the physical flow accounts for water (see chap. III).

5.477 ***Surface water*** comprises all water that flows over or is stored on the ground surface regardless of its salinity levels. Surface water includes water in ***artificial reservoirs***, which are purpose-built reservoirs used for storage, regulation and control of water resources; ***lakes,*** which are, in general, large bodies of standing water occupying a depression in the earth's surface; ***rivers and streams,*** which are bodies of water flowing continuously or periodically in channels; ***snow and ice,*** which include permanent and seasonal layers of snow and ice on the ground surface; and ***glaciers,*** which are defined as accumulations of snow of atmospheric origin, generally moving slowly on land over a long period. Overland flows, i.e., the flows of water over the ground before entering a channel, are also part of surface water but the stock of these flows at any one time is small and hence not separately recorded.

5.478 Although artificial reservoirs are not natural components of the earth's surface, once in place, the stocks and flows of water are treated in the same way as the stocks and flows associated with natural stores of water, in particular natural lakes. Thus, flows of precipitation, abstraction and evaporation affect artificial reservoirs in the same way as they affect natural lakes, and artificial reservoirs therefore form one part of the hydrological system. They are separately identified in the classification of inland water resources, since, in many cases, the flows associated with artificial reservoirs, in particular evaporation, are of particular analytical interest.

5.479 ***Groundwater*** is water that collects in porous layers of underground formations known as aquifers. An aquifer is a geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs. It may be unconfined, by having a water table and an unsaturated zone, or may be confined when it is between two layers of impervious or almost impervious formations.

5.480 ***Soil water*** consists of water suspended in the uppermost belt of soil, or in the zone of aeration near the ground surface. Soil water can be discharged into the atmosphere by evapotranspiration (the process whereby a quantity of water is transferred from the soil to the atmosphere by evaporation and plant transpiration), absorbed by plants, flow to groundwater, or flow to rivers (run-off). Some part of transpiration and absorption of water by plants is used in production (e.g., the growing of crops).

5.11.3 Physical asset accounts for water resources

5.481 Physical asset accounts for water resources should be compiled by type of water resource and should account for both the stock of water at the beginning and end of the accounting period and the changes in the stock of water. The accounts are generally compiled in terms of millions of cubic metres of water.

5.482 Changes in the stock of water should consider additions to the stock, reductions in the stock and other changes in the stock. The structure of the physical asset account for water resources is shown in table 5.25.

Defining the stock of water

5.483 The concept of a stock of surface water is related to the quantity of water in a territory of reference measured at a specific point in time (usually the beginning or end of the accounting period). The stock level of a river is measured as the volume of the active riverbed determined on the basis of the geographical profile of the riverbed and the water level. This quantity is usually very small compared with the total stock of water resources and the annual flows of rivers.

Table 5.25
Physical asset account for water resources (*cubic metres*)

	Type of water resource						
	Surface water				Groundwater	Soil water	
	Artificial reservoirs	Lakes	Rivers and streams	Glaciers, snow and ice			Total
Opening stock of water resources	1 500	2 700	5 000		100 000	500	109 700
Additions to stock							
Returns	300		53		315		669
Precipitation	124	246	50			23 015	23 435
Inflows from other territories			17 650				17 650
Inflows from other inland water resources	1 054	339	2 487		437	0	4 317
Discoveries of water in aquifers							
Total additions to stock	1 478	585	20 240		752	23 015	46 071
Reductions in stock							
Abstraction	280	20	141		476	50	967
for hydropower generation							
for cooling water							
Evaporation and actual evapotranspiration	80	215	54			21 125	21 474
Outflows to other territores			9 430				9 430
Outflows to the sea			10 000				10 000
Outflows to other inland water resources	1 000	100	1 343		87	1 787	4 317
Total reductions in stock	1 360	335	20 968		563	22 962	46 188
Closing stock of water resources	1 618	2 950	4 272		100 189	553	109 583

Note: Dark grey cells are null by definition.

5.484 Stocks of groundwater and soil water are measured consistent with the definitions above. The measurement of soil water may extend to cover all soil but may also be limited (e.g., to soil water in agricultural and forestry areas), depending on the analytical purposes of the water account. The measurement scope of soil water should be clearly articulated in any asset account for water resources.

5.485 In countries where there is a consistent and regular hydrological year with a distinct dry period, the stock of soil water at the end of the hydrological year may be negligible in comparison with groundwater or surface water. While soil water can be distinguished from groundwater and surface water in theory, it may be difficult to measure it directly, although it can be estimated indirectly using a variety of data.[76]

Additions to and reductions in the stock of water resources

5.486 Additions to the stock of water resources consist of the following flows:

(*a*) *Returns,* which represent the total volume of water that is returned to the environment by economic units into surface water, soil and groundwater during the accounting period. Returns can be disaggregated by type of water returned, for example, irrigation water, and treated and untreated wastewater. In this case, the

76 See International Recommendations for Water Statistics (United Nations, 2012a), para. 4.29.

breakdown should mirror that used to disaggregate the returns in the physical supply and use tables in chapter III;

(*b*) *Precipitation,* which consists of the volume of atmospheric precipitation (rain, snow, hail, etc.) on the territory of reference during the accounting period before evapotranspiration takes place. The major part of precipitation falls on the soil. A proportion of this precipitation will run off to rivers or lakes and is recorded as an addition to surface water. Amounts retained in the soil should be recorded as additions to soil water. Some precipitation also falls directly onto surface-water bodies. It is assumed that water would reach aquifers after having passed through either the soil or surface water (rivers, lakes, etc.), thus no precipitation is shown in the asset accounts for groundwater. The infiltration of precipitation to groundwater is recorded in the accounts as an inflow from other water resources into groundwater;

(*c*) *Inflows,* which represent the amount of water that flows into water resources during the accounting period. The inflows are disaggregated according to their origin: (i) inflows from other territories/countries; and (ii) inflows from other water resources within the territory. Inflows from other territories occur with shared water resources. For example, in the case of a river that enters the territory of reference, the inflow is the total volume of water that flows into the territory at its entry point during the accounting period. If a river borders two countries without eventually entering either of them, each country could claim a percentage of the flow to be attributed to its territory. If no formal convention exists, a practical solution is to attribute 50 per cent of the flow to each country. Inflows from other resources include transfers, both natural and man-made, between the resources within the territory. They include, for example, flows from desalination facilities and flows of infiltration and seepage;

(*d*) *Discoveries of water in new aquifers*. These flows should be recorded in terms of the quantity of water in the newly discovered aquifer as distinct from the overall capacity of the aquifer. Increases in the volume of water in a known aquifer should be included as an inflow of water resources to groundwater.

5.487 Reductions in the stock of water resources consist of the following flows:

(*a*) *Abstraction*, which is the amount of water removed from any source, either permanently or temporarily, in a given period of time. It includes the abstraction of water by households for own consumption, water used for hydroelectric power generation and water used as cooling water. Given the large volumes of water abstracted for hydroelectric power generation and for cooling purposes, these flows are separately identified as part of the abstraction of water. Abstraction also includes the abstraction of soil water by plants in areas of rain-fed agriculture and cultivated timber resources in line with the definition of abstraction for the water PSUT (see sect. 3.5). The water abstracted from soil water is either absorbed by the plants or returned to the environment through transpiration;

(*b*) *Evaporation and actual evapotranspiration,* which constitute the amount of evaporation and actual evapotranspiration that occurs in the territory of reference during the accounting period, excluding amounts already recorded as abstracted from soil water. Evaporation refers to the amount of water evaporated from water bodies such as rivers, lakes, artificial reservoirs, etc. Actual evapotranspiration refers to the amount of water that evaporates from the land surface and is transpired by the existing vegetation/plants when the ground is at its natural moisture content as determined by precipitation and soil properties. Actual evapotranspiration will typically be estimated using models;[77]

(*c*) *Outflows,* which represent the amount of water that flows out of water resources during the accounting period. Outflows are disaggregated according to the destination of the flow; i.e., (i) other water resources within the territory, (ii) other territories/countries and (iii) the sea/ocean.

5.11.4 Other water resource measurement issues

Monetary asset accounts for water resources

5.488 The measurement of the stock of water in monetary terms is particularly difficult. The main problem is that, historically, water has often been made available free of charge as a public good supplied at less than the cost of production in order to support agricultural production; or supplied for a flat charge because it has been perceived not to be subject to scarcity. The monetary prices, therefore, have tended to be related to the fixed infrastructure costs of collecting and transporting water to designated outlets rather than to actual volume of water used, which may vary considerably.

5.489 Given this situation, the standard approaches to valuation of environmental assets, and in particular the net present value approach (described in sect. 5.4), do not work because the resource rent that is derived following standard definitions is negative. Estimates of negative resource rent arise when the income earned from the sale of abstracted water does not cover the costs of maintaining the produced assets required to distribute the water. Consequently, the value of the water resources themselves is considered to be zero.

5.490 There is a trend towards water pricing that reflects the full costs of managing, abstracting and distributing water resources. Consequently, there may be some instances where approaches such as the NPV approach can be applied. In these cases, these values should be incorporated as part of the overall monetary value of environmental assets and as part of the value of economic assets.

5.491 A specific case where there is potential for using NPV approaches effectively to value water resources is that where water is being used to generate energy using hydropower. For these water resources, future income streams from the sale of energy can be estimated following the standard NPV approaches outlined in section 5.4. Where such valuations can be made, the resulting asset values should be attributed to water resources.

5.492 Another approach to the valuation of water resources is to consider the value of water access entitlements which, in some countries, are traded in distinct markets. Often, the value of these entitlements may be closely connected to the value of the associated land, and determining the relevant proportion of the total value of land that can be attributed to the access entitlements may be a means of determining the value of the associated water. These approaches to valuation are likely to be most relevant in agricultural contexts where access to water by farmers is a significant consideration.

Spatial and temporal detail

5.493 Water statistics can provide data for water management at many geographical levels, ranging from local levels and the level of river basins, to national and multinational levels.

---

77 Actual evapotranspiration differs from potential evapotranspiration, which is the maximum quantity of water capable of being evaporated in a given climate from a continuous stretch of vegetation that covers the whole ground and is well supplied with water.

The choice of spatial reference for the compilation of water accounts ultimately depends on the data needed by users and the resources available to data producers. The choice of spatial scale is important, as countries may experience significant geographical variation in the availability of water (e.g., areas of very high or very low rainfall) and national aggregates may not accurately reflect the issues facing particular countries.

5.494 It is recognized internationally that a river basin is the most appropriate spatial reference for integrated water resource management (see, e.g., Agenda 21 (United Nations, 1993); and the European Water Framework Directive (European Parliament and Council, 2000)). This is because the people and economic activities within a river basin will have an impact on the quantity and quality of water in the basin, and conversely the water available in a basin will affect the people and economic activities that rely on this water. In areas where groundwater is an important source of water, aquifers may also be appropriate spatial references for the compilation of water statistics.

5.495 Although data for specific spatial scales within a country are often more appropriate for the analysis of water resources, integration of physical data on water at relevant spatial levels, e.g., river basins, may not align with the available spatial detail for economic data (which are more commonly compiled based on administrative boundaries). In these situations, common areas of observation, accounting catchments, should be defined.[78]

5.496 When integrating or collecting water data, it is important that the reference periods for the different data items be aligned. In water and economic statistics, the calendar year is the recommended temporal reference. However, in practice, water and economic data may not be available for calendar years. For example, for national accounts some countries use a financial year, while for water statistics, they may use a hydrological year. Financial and hydrological years may be the same as or different from calendar years. It is also noted that in some cases high seasonal variability in the relationship between the demand and supply of water may mean that annual data (either on a financial or hydrological year) are insufficient and, instead, sub-annual data are required.

78 For details, see *SEEA Water: System of Environmental-Economic Accounting for Water* (United Nations, 2012b), paras. 2.90-2.91.

This page intentionally left blank

Annex A5.1

The net present value method for valuation of stocks and the measurement of depletion and revaluation for natural resources

Introduction

A5.1 The present annex explains, in some detail, the assumptions and mathematical underpinnings relevant to the use of the net present value (NPV) approach in an accounting context, with a view to deriving valuations of the stock of natural resources and consistent flow measures of depletion, income and revaluation. In particular, the latter element is often neglected in presentations of the NPV approach. Also, it must be accepted that the NPV approach is not applied under conditions of perfect foresight. Hence, revisions in the set of information available to the compiler over an accounting period need to be accounted for. This annex does not describe a step-by-step guide to compilation although the logic and coherence of the method outlined here should underpin practical applications.

Defining the unit resource rent

A5.2 Consider an enterprise that harvests and sells timber resources from an uncultivated natural forest. The enterprise uses produced assets in the extraction process (lorries, saws, etc.) as well as labour and intermediate inputs (e.g., fuel). The enterprise receives income from the sale of timber and pays input costs for labour, produced assets and intermediate inputs.

A5.3 The enterprise must also take into account the timber resources to be extracted. This variable is best understood as the price per unit of timber resources extracted that the enterprise would be charged if the timber resources were owned by another unit (e.g., the government). While in principle, this amount is observable, often it is not available in practice, in particular when the extracting enterprise is itself the owner of the resource.

A5.4 This amount is commonly referred to as the resource rent (RR_t) and is equivalent to the total value of the natural resource input into the production process during an accounting period. It consists of two parts: (a) the quantity of timber extracted (S_t) and (b) the price per unit of timber extracted (P_{St}). The variable P_{St} is equivalent to the unit resource rent, i.e., the resource rent per extracted unit of timber resource.

A5.5 Empirically, the resource rent can be measured ex post (i.e., at the end of the accounting period) as a residual, provided there is only one type of natural resource per enterprise or per industry. In this case, RR_t equals gross operating surplus plus the non-labour component of mixed income less the user costs of produced assets. Alternatively, RR_t may be observable from rent payments that extraction enterprises pay to the owners of a natural resource. (The various methods for estimating RR_t are discussed in sect. 5.4.) Given RR_t and S_t, computation of the unit resource rent (P_{St}) is straightforward.

A5.6 Once the unit resource rent has been estimated, two important tasks remain to be completed: first, the value of the stock of the natural resource needs to be established; and second, the period-to-period gross income attributed to the resource, RR_t, needs to be split up into a part that represents the value of depletion and a part that represents net income. These tasks are directly related and need to be addressed consistently.

Valuing the stock of a natural resource

A5.7 To tackle the valuation of the stock of a natural resource, start with the fundamental asset market equilibrium condition or NPV that the value of an asset (the timber resources, in this example) at the end of period t, V_t, equals the discounted flow of future resource rents $RR_{t+\tau}\ (\tau = 1,2,\ldots N_t)$ over N_t periods. The estimate of the number of remaining periods of extraction may vary over time; therefore, N_t depends on t. In the simplest case, and for a fixed finite period of exploitation, N_t declines by one period as t progresses. If the exploitation of a natural resource is judged to be sustainable, N_t will take an infinite value. It is assumed here that the resource rent accrues at the end of the accounting period.[a] The standard NPV condition is shown in equation (1).

$$V_t = \sum_{\tau=1}^{N_t} \frac{RR_{t+\tau}}{(1+r_t)^{\tau}} \qquad (1)$$

where r_t is a nominal discount rate valid at time t, but not necessarily constant over time.

A5.8 $RR_{t+\tau}\ (\tau = 1,2,\ldots N_t)$ is a nominal value of expected future resource rents and the projected time profile of the resource rent $\{RR_{t+1}, RR_{t+2},\ldots\}$ may be non-constant. Note that the sequence of resource rents $\{RR_{t+1}, RR_{t+2},\ldots\}$ is an expected sequence and that the expectation is formed at the end of period t.

A5.9 As time goes on, information may change and a different sequence of resource rents may be expected. Similarly, the value of the stock at the beginning of period t may have been constructed with a different set of expectations about future resource rents or discount rates. Such a change in the set of information needs to be allowed for and will be addressed later.

A5.10 V_t is the value of the stock at the end of period t. In concept, this value is composed of a price and a quantity component: call them P_t and X_t. Indeed, without this price-quantity distinction, the meaning of "V" would be unclear. In the timber example, if V_t is the value of the timber resource, P_t equals the price per cubic metre of the timber resources at the end of period t, and X_t is the number of cubic metres of timber resources at the end of period t. (In the case of an oil field, X_t would be the estimated quantity of oil in the ground.) Therefore, one has

$$V_t = P_t X_t \qquad (2)$$

A5.11 To obtain an estimate of the price P_t and consequently of V_t, use the NPV condition from equation (1) together with the definition of the resource rent $RR_t = P_{St} S_t$:

$$V_t = P_t X_t = \sum_{\tau=1}^{N_t} \frac{P_{s,t+\tau} S_{t+\tau}}{(1+r_t)^{\tau}} \qquad (3)$$

A5.12 Next, a hypothesis has to be formed concerning the future profile of extractions and the expected price change of P_{St}. One simple possibility is to assume that the most recent *quantity of extraction* is the best estimate of future extractions so that $S_{t+\tau} = S_t\ (\tau = 1,2,3,\ldots N_t)$. This is only one possibility and different assumptions could be made, for instance, if the extraction in year t was unusually large or small and unlikely to be occurring again in the future. Another possibility is to assume a constant *rate of extraction*, so that $S_{t+\tau}/X_{t+\tau}$ is constant

a Preferably, resource rent should be assumed to accrue to the midpoint of the accounting period. The assumption made here is used to simplify the explanation and the associated notation and has no impact on the underlying relationships described.

for $\tau = 1,2,3,\ldots N_t$. For the expositional purpose at hand, a constant quantity of extraction is assumed.

A5.13 Similarly, a hypothesis needs to be formed regarding the evolution of the price P_{St} and the proposal here is to consider the long-run trend in the unit resource rent or, even more straightforwardly, to assume that P_{St} evolves in line with an expected general rate of inflation, ρ_t.

A5.14 Using these two hypotheses, the NPV condition can then be rewritten as

$$V_t = P_t X_t = \sum_{\tau=1}^{N_t} \frac{P_{s,t+1} S_{t+1} \left(1+\rho_t\right)^{\tau-1}}{\left(1+r_t\right)^{\tau}}$$

$$= P_{s,t} S_t \sum_{\tau=1}^{N_t} \frac{\left(1+\rho\right)^{\tau}}{\left(1+r_t\right)^{\tau}} = P_{s,t} S_t \Omega_t = RR_t \Omega_t \qquad (4)$$

$$\Omega_t = \sum_{\tau=1}^{N_t} \frac{\left(1+\rho\right)^{\tau}}{\left(1+r_t\right)^{\tau}} \qquad (5)$$

A5.15 Ω_t is a discount factor which links future resource rents to the present value of the asset. Equation (4) provides the desired estimate for the value of the stock, V_t, as well as the price level for the unit value of the resource in/on the ground, $P_t = RR_t \Omega_t / X_t$. The above expression also shows the relationship between the unit resource rent P_{St} and the price of the asset in/on the ground P_t: the latter is the discounted value of the former, multiplied by the current extraction rate S_t / X_t:

$$P_t = \frac{P_{S,t} \Omega_t S_t}{X_t} \qquad (6)$$

A5.16 One conclusion from this relationship is that it is incorrect to use the unit resource rent, P_{St} as the price of the asset, i.e., for valuation of the stock of the resource. It is also useful to note that with the simplifying hypotheses made above, the main element of Ω_t, $\left(1+\rho_t\right)/\left(1+r_t\right)$ is the inverse of a real interest rate. In many countries, real interest rates tend to be relatively stable and should not be difficult to estimate.

A5.17 The real interest formulation also relates to Hotelling's rule for non-renewable resources. Hotelling's rule states that under certain market conditions, non-renewable resource rents will rise at the rate of the nominal discount rate as the resource becomes scarce. Under these circumstances, the value of the resource stock can be calculated simply as the unit resource rent times the size of the stock. Because nominal resources rent rises over time at a rate that is exactly sufficient to offset the nominal discount rate, there is no need to discount future resource income. In terms of the notation at hand, this corresponds to a situation where $\rho_t = r_t$ so that and $P_t = N_t P_{St} S_t / X_t$, the unit resource rent multiplied by the number of extraction periods. The application of Hotelling's rule is not recommended for the valuation of environmental assets in the SEEA.

Estimating the value of depletion, discoveries and losses for non-renewable natural resources

A5.18 The next task consists in valuing the changes to the natural resource over the accounting period. The present section considers the flows associated with non-renewable natural resources. The following section considers accounting for renewable natural resources.

A5.19 As before, it is assumed that the quantity of natural resources at the end of period t, X_t, is known and that there is a projected sequence of extractions, based on the information available at the end of period t. At the end of period t, the quantity at the end of the preceding period, X_{t-1} is also known. Ex post, the difference between X_t and X_{t-1} can be decomposed into three components: depletion, discoveries and other additions (referred to below as "discoveries") and catastrophic losses and other reductions (referred to below as "catastrophic losses"). Ex ante, i.e., based on the information at the end of the preceding period t-1, discoveries and catastrophic losses will not be known.

A5.20 To operationalize the measurement of these three components, it is necessary to distinguish between the information and expectations present at the end of period t-1 and those present at the end of period t. The notation used for this purpose is such that X'_t relates to the quantity of the natural resource at the end of period t, given the information available at the end of period t-1. Thus, for example, using this notation, $X'_{t-1} = X_{t-1}$, as no new information arises during period t about the stock at the end of period t-1. However, in general, it is not the case that $X'_t = X_t$ or $P'_t = P_t$, since over the course of period t, unforeseen events and additional information will arise. In this context, X'_t and P'_t represent expected quantities and prices.

A5.21 With this notation it is now possible to define depletion, discoveries and catastrophic losses. Depletion, i.e., the regular and expected reductions from the stock of the asset, is defined as $S_t = X'_{t-1} - X'_t$ where S_t is the extraction during period t. (As we are dealing with a non-renewable resource, depletion equals extraction.) Thus, depletion is the difference between the quantity of resource at the end of period t-1, X_{t-1} less the quantity of resource expected to be remaining in the ground at the end of period t, X'_t (i.e., setting aside discoveries or catastrophic losses).

A5.22 Discoveries constitute an unexpected addition to the natural resource during the accounting period. The main body of chapter V described, for each type of natural resource, which types of discoveries should be recognized as such. Catastrophic losses relate to unexpected and significant reductions in the natural resource during the period. They constitute exceptional and significant losses. The combined effect of discoveries and catastrophic losses can now be measured as $X_t - X'_t$, i.e., the difference between actual and expected quantities at the end of the period.

A5.23 To separately account for discoveries and catastrophic losses, let I_t be the physical amount of discoveries and let L_t be the physical amount of catastrophic losses, such that $X_t - X'_t = I_t - L_t$. Recall that $X'_{t-1} = X_{t-1}$, as no new information arises during period t about the natural resource at the end of period t-1. The same holds for prices and values of the asset: $P'_{t-1} = P_{t-1}$ and $V'_{t-1} = V_{t-1}$. With these remarks in mind, the total physical changes in the non-renewable resource between the beginning and the end of the accounting period are:

$$\left(X_t - X_{t-1}\right) = \left(X_t - X'_{t-1}\right) \equiv \Delta X_t = \left(X_t - X'_t + X'_t - X_{t-1}\right) = I_t - L_t - S_t \qquad (7)$$

A5.24 Using equations (2) and (7), the change in the value of the natural resource between the beginning of period t, given the available information at that time, and the value of the natural resource at the end of the period, given the available information then, can be decomposed as follows:

$$\left(V_t - V_{t-1}\right) = \left(V_t - V'_{t-1}\right) = \left(P_t X_t - P_{t-1} X_{t-1}\right) = P_{t-1}\Delta X_t + X_t \Delta P_t \qquad (8)$$

A5.25 In equation (8), the change in value of the natural resource $\left(V_t - V_{t-1}\right)$ has been decomposed into a quantity effect and a revaluation effect. The quantity effect $P_{t-1}\Delta X_t$ measures the change in the quantity of the resource valued at the price of the beginning of the period; the revaluation effect $X_t \Delta P_t = X_t\left(P_t - P_{t-1}\right)$ captures the price change of the resource, multiplied by the quantity at the end of the period.

A5.26 There is an alternative way to decompose the term $\left(P_t X_t - P_{t-1} X_{t-1}\right)$, namely, with a quantity $P_t \Delta X_t$ effect and a revaluation effect $X_{t-1}\Delta P_t$. As neither is a priori superior to the other, an arithmetic average of the two effects can be employed:

$$\begin{aligned}\left(V_t - V_{t-1}\right) &= 0.5\left[\left(P_{t-1} + P_t\right)\Delta X_t + \left(X_{t-1} + X_t\right)\Delta P_t\right] \\ &= 0.5\left(P_{t-1} + P_t\right)\left(X_t - X'_t\right) + 0.5\left(P_{t-1} + P_t\right)\left(X'_t - X'_{t-1}\right) + 0.5\left(X_{t-1} + X_t\right)\Delta P_t \\ &= 0.5\left(P_{t-1} + P_t\right)\left(I_t - L_t\right) - 0.5\left(P_{t-1} + P_t\right)S_t + 0.5\left(X_{t-1} + X_t\right)\Delta P_t \qquad (9)\end{aligned}$$

A5.27 The final expression for the value of discoveries is then $0.5\left(P_{t-1} + P_t\right)I_t$; for the value of catastrophic $0.5\left(P_{t-1} + P_t\right)L_t$ losses, ; for the value of depletion, $0.5\left(P_{t-1} + P_t\right)S_t$; and for revaluation, $0.5\left(X_{t-1} + X_t\right)\Delta P$. It is of note that the valuation of depletion with the average price of the period is consistent with the rules in the SNA for the valuation of consumption of fixed capital. Also, discoveries and catastrophic losses are valued with mid-period prices, implying an assumption about these events occurring mid-year on average. Finally, it should be pointed out that P_t, when estimated by applying the NPV method (4) at the end of period t, takes into account any modifications in the expected extraction profile $\{S_{t+\tau}\}\left(\tau = 1,2,\ldots,N_{t+1}\right)$ that may have arisen as a consequence of discoveries or catastrophic losses during the accounting period. P_t thus constitutes the correct valuation of the balance-sheet entry for the asset under consideration. P_t will also reflect any other informational changes, for example, changes in the discount rate.

Estimating the value of depletion for a renewable asset

A5.28 Unlike non-renewable resources, natural plant and natural animal resources have the potential to reproduce and grow over time; and this natural growth enters as an additional flow which determines the evolution of the natural resource over the accounting period. Depletion, in physical terms, is the decrease in the quantity of a natural resource that is due to the extraction of the resource occurring at a rate that will not permit the same amount of resource to be extracted in all future periods. Depletion is thus determined as a relationship between extraction or harvest and sustainable yield, i.e., the largest amount that can be harvested for a given population size without reducing the long-term viability of the resource. In its simplest form, sustainable yield equals the natural growth of the asset. These issues are discussed in more detail in section 5.4.

A5.29 For the purpose of this annex, it is assumed that an estimate of sustainable yield can be made and hence an estimate of depletion in physical terms is available. In what follows, sustainable yield in period t will be called G_t. Physical depletion D_t is then estimated as $D_t = S_t - G_t$ and consequently, $X'_t - X'_{t-1} = -S_t + G_t$ the (expected) change in the stock that is not due to discoveries or catastrophic losses. Note that the depletion for non-renewable resources can be seen as a special case, where $G_t = 0$.

A5.30 It is now possible to enhance expression (7) for the case of renewable natural resources:

$$(X_t - X_{t-1}) = (X_t - X'_{t-1}) \equiv \Delta X_t = (X_t - X'_t + X'_t - X_{t-1}) = I_t - L_t - S_t + G_t \quad (10)$$

A5.31 Following the derivations for non-renewable natural resources, monetary depletion is physical depletion valued at average prices of the period, $0.5(P_{t-1} + P_t)D_t$.

A5.32 In summary, the entries between the beginning and end of the accounting period, t, are as follows:

Closing balance-sheet item of period t-1 based of information available at end of period t-1:	$V'_{t-1} = P'_{t-1}X'_{t-1}$
+ Discoveries (and other additions):	$0.5(P_{t-1} + P_t)I_t$
- Depletion:	$-0.5(P_{t-1} + P_t)(S_t - G_t)$
Of which due to natural growth:	$0.5(P_{t-1} + P_t)G_t$
Of which due to extraction:	$-0.5(P_{t-1} + P_t)S_t$
- Catastrophic losses (and other reductions):	$-0.5(P_{t-1} + P_t)L_t$
+ Revaluation due to price changes:	$0.5(X_{t-1} + X_t)\Delta P_t$
= Closing balance-sheet item of period t based on information available at end of period t:	$= V_t = P_t X_t$

Net income and depletion

A5.33 As a final step, the value of depletion can be subtracted from the resource rent to yield an expression for the depletion-adjusted resource rent:

$$\text{Depletion-adjusted resource rent} = RR_t - 0.5(P_{t-1} + P_t)(S_t - G_t) \quad (11)$$

A5.34 The depletion-adjusted resource rent represents the net income generated by the natural resource. Putting aside any changes in expectations or differences between expected and realized variables, it corresponds to a return to capital or return to natural resources. This can be demonstrated as follows. Multiplying V'_{t-1} by $(1+r_t)$, subtracting V'_t (the expected value of the asset at the end of the period) and applying the NPV condition (1) yields

$$V'_{t-1}(1 + r_t) - V'_t = RR'_t \quad (12)$$

A5.35 Note that all expressions are in terms of the information set at the end of period t-1 and therefore discoveries and catastrophic losses are ignored. Combining (12) with (9), one obtains

$$RR'_t = r_t V'_{t-1} - (V'_t - V'_{t-1}) = r_t V'_{t-1} - 0.5(X'_{t-1} + X'_t)\Delta P'_t + 0.5(P'_{t-1} + P'_t)(S_t - G_t) \quad (13)$$

A5.36 The depletion-adjusted resource rent is then

$$RR'_t - 0.5(P'_{t-1} + P'_t)(S_t - G_t) = r_t V'_{t-1} - 0.5(X'_{t-1} + X'_t)\Delta P'_t \quad (14)$$

A5.37 Thus, net income consists of the nominal return to capital, $r_t V'_{t-1}$ less (expected) revaluation of the asset. This does not imply that revaluation enters the measurement of income. It should be remembered that r relates to the returns that an investor or shareholder would expect from the use of an asset in production, i.e., it is a forward-looking rate. Whether, ultimately, these returns come from normal business operations or from holding gains/losses is irrelevant to the (financial) investor. Hence, conceptually, the expected rate of return r includes expected holding gains or losses. Therefore, to arrive at an income measure consistent with the definition of income in the national accounts,[b] revaluations must be subtracted. After subtraction, expression (14) shows the return from "normal business operations" excluding holding gains or losses.

A5.38 The derivations above are valid for both renewable resources and the limiting case of non-renewable resources. When there is depletion, the term $S_t - G_t$ will increase in absolute terms with a rising rate of depletion. In general, the quicker the resource is depleted, the higher will be the price change of the resource in the ground. When natural growth exceeds extraction, depletion should be recorded as zero and the excess amount added to additions of stock.

A5.39 It should be noted that the specifications above leave no ambiguity about the valuation of stocks and flows, i.e.:

- The input of natural resources into production, the extractions, should be valued at the unit resource rent P_{St}
- The value of the stock of natural resources, and flows concerning depletion, should be valued using the price of the asset in situ (P_t)

Volume measures

A5.40 With the price, quantity and value of the natural resource in situ in hand, it is fairly straightforward to compute a volume measure of the stock of natural resources. In the case of a single homogeneous asset, the volume measure simply equals the evolution of the physical quantity in the ground, $\{X_t\}$. In the case of different types of natural resources, an aggregation procedure must be identified to construct a volume index across different types of natural assets.

A5.41 The balance-sheet entry for the value of natural resources at the end of year t-1 in end-year prices of t-1 is simply $\sum_{i=i}^{z} P_{t-1}^{i} X_{t-1}^{i}$ if there are z different types of assets. Assuming a chain Laspeyres index as is customary in the national accounts, the volume change between t-1 and t is then given by:

$$\text{Volume change} = \frac{\sum_{i=1}^{z} P_{t-1}^{i} X_{t}^{i}}{\sum_{i=1}^{z} P_{t-1}^{i} X_{t-1}^{i}} \qquad (15)$$

b See *Measuring Capital: OECD Manual; 2nd ed.* (OECD, 2009), sect. 8.3.2, for a more detailed discussion in the context of produced assets.

Annex A5.2

Discount rates

Introduction

A5.42 In the SEEA, a discount rate is a rate of interest used to adjust the value of a stream of future flows of revenue, costs or income so that the value of future flows can be compared with the value of flows in the current period.

A5.43 Underpinning the use of discount rates is the concept that the value of money in the future is not the same as the value of money now. A common explanation of this concept entails considering how much money would be needed now to purchase a given amount of goods and services in one year's time.

A5.44 This question may be answered by considering the interest rate at which a consumer should invest his or her money now in order to earn sufficient interest over one year to purchase the goods and services in one year's time. The consumer may then make a choice as to whether he or she consumes the goods and services in the current period or waits, earns the interest from investing the money, and purchases the goods and services in one year's time. In making this choice, the consumer indicates a time preference and the extent of the preference is given by the interest rate, or discount rate. A lower discount rate will apply if the consumer is relatively indifferent as regards receiving the benefits of consumption now or in one year's time. A higher discount rate will apply if the consumer has a stronger preference for consumption in the current period.

A5.45 When time preferences are seen from the perspective not of an individual consumer but of society as a whole, they call for comparisons of welfare across different generations. There is no immediate reason why the time preferences of individuals and society should coincide.

A5.46 Discount rates are also affected by risk preferences, which raises the question whether consumption forgone in the current period will induce more or less utility in future periods. Again, these two factors may be valued differently by the individual and society as a whole.

A5.47 The application of the general concept of a discount rate to economic issues has generated much discussion (as yet unresolved) by many economists (Arrow, Nordhaus and Stiglitz, among others). The choice of discount rate has become a focus of discussion in environmental economics because of the impact that the choice of discount rate has on models of economic outcomes over long periods of time, and because the choice of discount rates and the nature of the assumed preferences may be perceived as having ethics-related underpinnings.

A5.48 The present annex explains, in broad terms, the key aspects of the discussion on discount rates and the logic of the choice of discount rate that aligns with the SEEA's approach to valuation in monetary terms.

Types of discount rates

A5.49 There are two broad types of discount rates: individual discount rates and social discount rates, which are quite distinct in concept. An individual discount rate entails consideration of preferences from the perspective of an individual consumer or firm and is directly related to the prices for goods, services and assets confronting the individual. In addition, the preferences are generally considered within the normal decision-making time frames of an individual consumer or firm. Finally, the discount rate relevant to an individual consumer or firm needs to take into account the likelihood of earning interest (or, more generally, a return) so that consumption can be undertaken in the future. Put differently, if an individual faces a smaller likelihood of earning a return, then he or she should seek a higher discount rate to compensate for this risk.

A5.50 A social discount rate reflects the time and risk preferences of a society as a whole. Unlike individuals, societies must consider future generations to a greater extent and must also balance the benefits accruing to different sections of society in current and future periods (i.e., the distribution of income and consumption). In addition, the risks of earning returns are far more dispersed and balanced at a societal than at an individual level and therefore the compensation for risk will usually be lower for a society as a whole. Often, social discount rates are applied in the context of a government in relation to its decision-making on behalf of a society.

A5.51 The difference between individual and social discount rates may be characterized in terms of preferences with respect to both efficiency and equity. Generally speaking, individual discount rates take into account only aspects of efficiency in the allocation of resources over time from the perspective of an individual consumer or producer. On the other hand, social discount rates may consider only aspects of efficiency or they may take into consideration aspects of both efficiency and equity between societies or between generations. Most discussion on discount rates revolves around the equity aspects, either because they may not be taken into account at all (e.g., in individual discount rates) or because the philosophical basis for the assumptions concerning equity that underlie a social discount rate can be contested.

A5.52 The difference between individual and social discount rates can also be characterized in terms of descriptive and prescriptive discount rates. A discount rate determined on a descriptive basis is based only on prices faced by individuals and governments or other measureable factors, whereas a prescriptive discount rate incorporates assumptions regarding the preferences of individuals and societies, particularly in respect of equity between and within current and future generations.

Individual discount rates

A5.53 The determination of discount rates for individuals requires a focus on information concerning the return needed by the individual consumer or firm to justify investment in the current period with the aim of receiving income or other benefits in the future. Relevant considerations are the expected returns that an individual may earn by investing in different assets and the degree of risk associated with different investments. Under pure market conditions, it would be expected that the price of an asset (e.g., a building) would reflect the expected returns to the purchaser over the life of the asset and would take into account the likelihood of earning the income (i.e., the degree of risk). Thus, there is a link between the choice of discount rates and the concept of market prices for assets.

A5.54 In the SEEA, as in the SNA, the application of discount rates is to the valuation of assets not traded on markets. For these assets, market prices are not available and the technique of net present value (see annex A5.1) can be used to estimate market prices. This technique requires the choice of a discount rate. The selection of a descriptive discount rate that considers only the prices faced by an individual consumer or firm, relates to the expected returns, and accounts for the degree of risk associated with the investment, is the most appropriate discount rate in respect of aligning with the market price valuation principle used in the SEEA.

A5.55 For individual consumers and firms, the relevance of a discount rate may be reflected in the cost of funds to the individual. Thus, the interest rate needed to finance an investment either through loans, equity issues or the issue of corporate bonds may be a discount rate appropriately reflecting the rate of return needed by the individual and also the degree of risk in the investment as assessed on the market. However, at the more aggregate level at which the SEEA operates, taking into account the variety of ways in which investment is financed and targeting the financing method with respect to the valuation of specific non-traded assets makes the financing cost approach difficult to apply across individual firms within an industry, particularly if financial markets are not well developed within a country. It is also noted that returns to financial instruments, particularly equities, may be influenced by many external factors, thus limiting their appropriateness in the valuation of non-traded assets.

A5.56 The other approach to the estimation of a discount rate is to consider information on the actual returns accruing to specific activities, for example, mining activity, where the related income streams all have similar risk profiles. This may be done by considering national accounts information on the operating surplus of relevant firms and the associated stock of produced assets. Underpinning this approach is the idea that the total operating surplus is the return to the firm for its use of a combination of produced assets, for example, mining equipment, and non-traded natural resources.

A5.57 Ideally, if the value of the relevant natural resources was known, the implied rate of return (total operating surplus divided by total value of assets) would apply to both produced assets and natural resources. However, since the value of the natural resources is unknown, two alternatives must be considered. First, for a specific activity (e.g., coal mining), a rate of return equal to the total operating surplus divided by the value of the stock of produced assets can be calculated and the rate of return on natural resources and the discount rate can be set equal to this rate. By its very construction, this rate will overstate the rate of return, since the denominator (the value of the stock of produced assets) excludes the value of natural resources. At the same time, this rate of return does take into account the returns accruing to the specific activity and hence the associated risks.

A5.58 The other alternative entails the assumption that the rate of return on produced assets should be equal to an external rate of return that the firm would have received if it had invested in alternative assets. This rate is then assumed to apply also to the natural resources. Since this rate of return takes into account investment in a broader range of assets across the economy, the industry-specific risks of investment are less likely to be taken into account.

A5.59 Although neither of these relatively direct methods generates a discount rate that completely measures the desired concept, a comparison of both rates may yield useful information. In particular, a useful approach may be to use a general, external rate of return as a base rate and to adjust it utilizing industry-specific information to account for specific investment risk. Adjustments may be made on the basis of relative financing costs or of the relative difference in the return to produced assets in the target industry compared with an economy-wide return to produced assets.

A5.60 It is noted that, in the valuation of assets owned by individual firms, the choice of external rate under the second approach should take into account some degree of risk, even if only general economy-wide risks of investment. Often, the use of relatively risk-free rates of return is suggested, such as the rate of return on long-term government treasury bonds, but these rates take no account of individual risks that are faced in determining consumption and investment preferences.

Social discount rates

A5.61 Social discount rates are used in the context of evaluating actions and assets that have value from the perspective of a society as a whole. Often, this is applied in the assessment of government decisions, and social discount rates are used to evaluate the costs and benefits of investment in public infrastructure since both the benefits and the costs are usually spread across many individuals and over long periods of time. However, social discount rates can also be used to provide social valuations of assets owned and operated by individuals and firms.

A5.62 As noted above, both descriptive and prescriptive approaches may be taken to the determination of an appropriate social discount rate. A descriptive approach follows the same logic as that governing the determination of individual discount rates, in that the rate is determined through a focus on the prices and returns relevant to the society rather than through any explicit consideration of equity issues.

A5.63 Prescriptive social discount rates that take into account equity considerations cannot be determined following the logic applied to individual discount rates. Rather, consideration must be given to the relative preferences of current and future generations and, ideally, to the relative preferences of different sections of society. A common approach used by economists to determining prescriptive social discount rates is the application of the Ramsey growth model (Ramsey, 1928) which takes specific account of consumption and saving choices for an economy as a whole. This model has underpinned many recent works on evaluating the impacts of environmental issues, in particular the 2006 Stern review in the United Kingdom of Great Britain and Northern Ireland of the economic impacts of climate change.

A5.64 The formula for a prescriptive discount rate that emerges from the Ramsey model requires information or assumptions regarding (a) the "pure" rate of time preference, (b) the rate of growth in per capita consumption and (c) the extent to which the extra benefits to people from consumption decrease as their income increases (the marginal utility of income). The second and third terms are multiplied together and then added to the first term to derive the discount rate.

A5.65 Much discussion on prescriptive social discount rates has focused on the first term, which asks the question whether the preferences of current generations are more important than those of future generations. If the value of the first term is set at zero, then the assumption is that all generations' preferences have equal weight. This assumption is distinctly at odds with the underlying premise of individual discount rates in which there is an underlying assumption that it is the present year (let alone the present generation) that is always preferable (unless there is suitable return). The implications of choices for the pure rate of time preference are discussed in the next section.

A5.66 A common misconception is that setting a zero "pure" rate of time preference implies a discount rate of zero. In fact, following the Ramsey model, there are two other assumptions that need to be considered. Generally, it is understood that as income rises, the extra or marginal benefits that a person receives from spending additional income decline. Put differently, someone on a low income gains greater benefit from spending a dollar than someone on a higher income. When the same concept is considered over time: if an individual in the future is assumed to have a higher level of income than someone today, then it would be the case that they would get relatively lower benefit from spending that additional income compared with someone spending the same amount today. Thus, even assuming that all peoples' preferences are the same, there may still be an overall preference in consumption now because the marginal benefits from undertaking the same consumption in the future are lower (assuming growth in incomes). Different choices for the rates of growth in income and consumption and in the marginal utility of income will lead to different (non-zero) estimates of the social discount rate following the Ramsey model.

A5.67 A different approach to taking into account the preferences of future generations is the use of declining discount rates. Different models may be used and there is mention in the literature of hyberbolic discount rates, gamma discounting and geometrically declining rates.

Simple step functions have also been proposed whereby the discount rate is set at progressively lower levels as one moves away from the current period. The general aim of declining discount rates is to counter an impact of constant rate discounting which implicitly fixes the relationship of the preferences across generations. Declining rates effectively give relatively larger preferences to future generations than would otherwise be implied (although the preferences of future generations generally have less weight than those of current generations). The exact relationship depends on the function assumed for the pattern of decline.

Estimates of discount rates

A5.68 In practice, the approaches to the selection of discount rates vary widely. Both prescriptive and descriptive approaches are often used, and within both approaches, a wide variety of solutions are adopted. While it seems generally to be the case that those rates determined on a more prescriptive basis are lower than rates determined on a descriptive basis, this is not always the case.

A5.69 An important consideration is whether the discount rate should be in real or in nominal terms. A real discount rate is one that has been adjusted to remove the impact of inflation, whereas a nominal discount rate has not undergone any such adjustment. The choice depends on the assumptions made in relation to the future flows. If the future flows, say, of income, are measured in terms of the prices of the period to which they relate (e.g., an income flow for 2050 is in terms of 2050 prices), then the flow is said to be in nominal terms and a nominal discount rate should be used.

A5.70 However, if the flows are expressed in terms of prices of the current period, then a real discount rate should be used. Since it is very difficult to project prices into the future, a common assumption is that the future flows are the same as the flows in the current period; and if this assumption is made, then a real discount rate should be used.

A5.71 The choice of discount rate—however determined—can have a significant impact on the value of an asset. Table A5.1 illustrates the differences in the value of an asset at different discount rates for a different length of asset life. Assuming that the income flow is $100 per year, then over 10 years, the net present value (see annex A5.1) can range from $614 for a discount rate of 10 per cent to a value of $853 for a discount rate of 3 per cent. Over 100 years, the differences are even more stark, with an NPV of $1,000 for a discount rate of 10 per cent but an NPV of $3,160 for a discount rate of 3 per cent.

A5.72 Of particular note is that for higher discount rates, increasing the asset life has little impact on the total current net present value of the asset; that is, there is relatively little difference in the NPV for an asset that has a life of 30 years and one of 100 years at higher discount rates.

Table A5.1

Net present value (*dollars*) **for constant income flow of 100 dollars over varying asset lives and at varying discount rates**

Discount rate (percentage)	Asset life (years)			
	10	30	50	100
3	853	1960	2573	3160
5	772	1537	1826	1985
8	671	1126	1223	1249
10	614	943	991	1000

Analytical implications of the choice of discount rate

A5.73 The implications of the choice of a discount rate may be discerned in a number of ways. First, the choice of approach to selecting a discount rate may provide an area of concern for users. The selection of a descriptive approach consistent with market valuations may generate concern that equity issues—especially those across generations—are not being adequately considered. At the same time, the selection of a prescriptive approach may raise concern about the role of statisticians in selecting implicit societal preferences.

A5.74 Second, various interpretations may be made concerning the estimates derived based on particular discount rates. For example, there may be concerns about the use of relatively high discount rates (usually attributed to the use of market-based approaches), since these give relatively lower values to long-lived assets, such as many natural resources, and this may imply a preference either for immediate use of the resources or for substitution with produced assets.

A5.75 At the same time, the use of market-based approaches to the determination of the discount rate permits a stronger parallel to be drawn to the valuation of produced assets and therefore trade-offs between assets can be more consistently considered. In this regard, the estimation of concepts like national net worth can be consistently estimated across all asset types. Also, the use of market-based descriptive approaches does not necessarily ignore intergenerational and equity issues. They imply that the current generation's attitudes to time preference and income inequality, as reflected in observed investment and saving rates, will continue into the future.

A5.76 A general concern in respect of the use of market-based discount rates is that they tend to be relatively higher rates, which in turn tend to provide relatively low values in absolute terms beyond normal planning time frames, say, 30 years. Thus for long-lived and potentially everlasting resources, the use of relatively lower rates will tend to reflect the recognition of values for these resources into the future to a greater extent. Independent of any implied societal preferences, lower discount rates may therefore better reflect the likely values of these resources. Also, especially for environmental resources, the recognition of values over a longer time period may assist in understanding the problem that, while the benefits received from the environment tend to be received immediately, the costs to the environment may be evidenced only much later. The use of declining discount rates may be a way to deal with these issues.

Conclusions

A5.77 For the purposes of the SEEA, it is recommended that a discount rate be determined that is consistent with the general approach to valuation in the SEEA and the SNA, i.e., consistent with valuation at market prices. This suggests the choice of an individual discount rate that reflects the return needed by those undertaking an activity to justify investment in that activity. Consequently, the relevant rate should be descriptive and, ideally, should include any activity-specific risks.

A5.78 The derivation of an activity-specific rate of return is difficult in the case of natural resources because the value of the natural resources is not known. Nonetheless, it should be possible to determine relevant discount rates on the basis of national accounts data and financial sector information.

A5.79 Because judgements are required regarding societal preferences, it is not recommended that prescriptive approaches to the determination of discount rates be used for the purposes of official statistics.

A5.80 Different discount rates can be selected under any approach to the determination of discount rates for valuing environmental assets. Given the significance of the choice of discount rate, it is recommended that sensitivity analysis using different discount rates be undertaken in the compilation of valuations of environmental assets utilizing the net present value approach. The varying estimates may be published to provide users with information on the impact of the choice of discount rate.

Annex A5.3

Description of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC 2009)

A5.81 United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009) categorizes mineral and energy resources by looking at whether, and to what extent, projects for the extraction or exploration of the resources have been confirmed, developed or planned. The underlying natural resources are classified based on the maturity of the projects. UNFC-2009 is based on a breakdown of the resources according to three criteria affecting their extraction:

- Economic and social viability (*E*)
- Field project status and feasibility (*F*)
- Geologic knowledge (*G*)

A5.82 The first criteria (E) designates the degree of favourability of economic and social conditions in establishing the commercial viability of the project. The second criteria (F) designates the maturity of studies and commitments necessary to implement mining plans or development projects. These extend from early exploration efforts before a deposit or accumulation has been confirmed to exist through to a project that is extracting and selling a product. The third criteria (G) designates the level of certainty in the geologic knowledge and potential recoverability of the quantities.

A5.83 Each of the three criteria is subdivided into categories characterizing the projects for exploring and extracting the resource. The categories for the economic and social criteria are numbered from E1 to E3:

- Category E1 includes projects where extraction and sale are economically viable, i.e., the extraction is assumed to be economic on the basis of current market conditions and realistic assumptions of future market conditions. It includes considerations of prices, costs of the legal and fiscal framework, and various environmental, social and other non-technical factors that could directly impact the viability of a development project. The economic viability is not affected by short-term adverse market conditions provided that longer-term forecasts remain positive
- For projects falling into category E2, extraction and sale have not yet been confirmed to be economic but on the basis of realistic assumptions of future market conditions, there are reasonable prospects for economic extraction and sale in the foreseeable future
- For E3, extraction and sale are not expected to become economically viable in the foreseeable future or evaluation is at too early a stage to determine economic viability

A5.84 The categories for project status and feasibility are numbered from F1 to F4 with further subcategories in some cases:

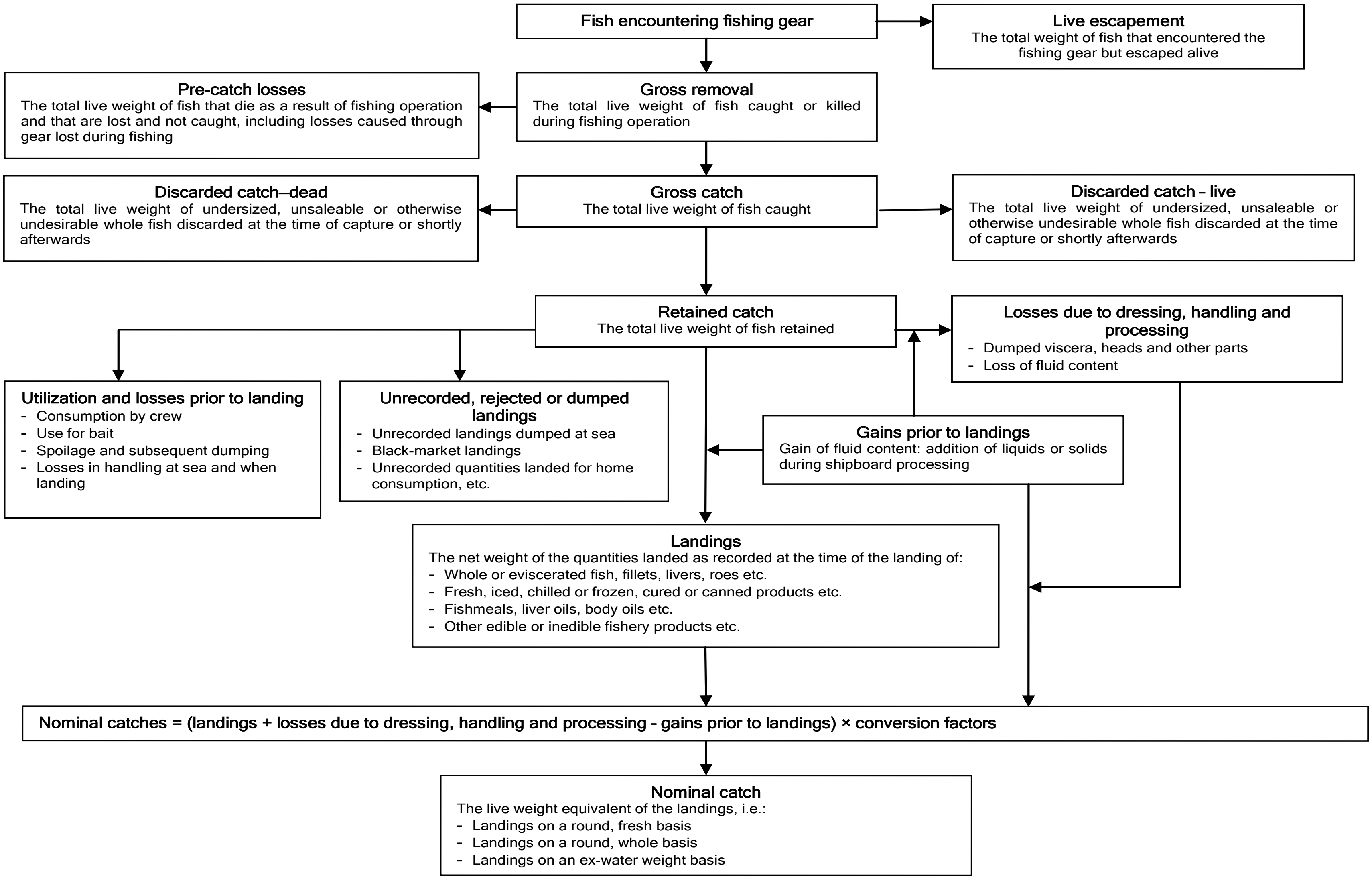
- Category F1 includes projects where extraction is currently taking place (*F*1.1); or where capital funds have been committed and implementation of the development project or mining operation is under way (F1.2); or where sufficiently detailed studies have been completed to demonstrate the feasibility of extraction through implementation of a defined project or mining operation (F1.3)

- Both F2.1 and F.2.2 include projects where the feasibility of extraction is subject to further evaluation. For F2.1, project activities are ongoing to justify development in the foreseeable future; and for F2.2, project activities are on hold and/or justification is on hold, as commercial development may be subject to a significant delay. F2.3 indicates that there are no current plans to develop or to acquire additional data at the time owing to limited potential
- F3 indicates that the feasibility of extraction by a defined development project or mining operation cannot be evaluated owing to limited technical data
- F4 indicates that no development project or mining operation has been identified

A5.85 The categories for geologic knowledge are numbered from G1 to G4. Quantities associated with a high level of confidence (or low level of uncertainty) are classified as G1, quantities associated with a moderate level of confidence are classified as G2 and quantities associated with a low level of confidence as G3. Quantities associated with a potential deposit based primarily on indirect evidence are classified as G4.

Annex A5.4

Catch concepts: a diagrammatic presentation[a]



[a] Derived from "Handbook of national accounting: integrated environmental and economic accounting for fisheries" (United Nations and Food and Agriculture Organization of the United Nations, 2004).

This page intentionally left blank