Chapter 5: Asset accounts

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5.1 Introduction

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 that comprise the environment and the inputs the environment provides to society. The term environmental asset has been used to denote the source of these inputs which may be considered in both physical and monetary terms.
2. One motivation for considering environmental assets is the concern that the current patterns and practices of economic activity are depleting and degrading the available environmental assets more quickly than they can regenerate themselves and hence there are concerns about sustainability. Another motivation is that current generations can be seen as "stewards" for the range of environmental assets on behalf of future generations. Overall, 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.
3. Combined, these motivations are a key driver for the development of the System of Economic and Environmental Accounts (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.
4. For environmental assets, the physical and monetary changes over the period include additions to the stock of environmental assets (such as additions due to natural growth and discoveries) and reductions in the stock of environmental assets (such as those reductions due to extraction and natural loss).

Chapter structure

5. This chapter focuses on asset accounting for environmental assets. Section 5.2 defines environmental assets, describes the classification of environmental assets in the central framework and the relationship to economic assets. Section 5.3 articulates the accounting entries that are required to compile asset accounts including opening and closing stocks, additions to stock, reductions in stock and revaluations.
6. Section 5.4 describes two key areas in the compilation of asset accounting. First, there is description of the principles of defining depletion of environmental assets in physical terms with particular focus on the depletion of renewable environmental assets such as fish resources and timber resources. Second, in relation to monetary asset accounts, there is a discussion of approaches to the valuation of environmental assets and in particular the net present value (NPV) approach. An annex to the chapter provides additional material explaining NPV.

7. Sections 5.5 – 5.11 outline asset accounting for a range of individual environmental assets. Detail is provided on the measurement scope of each of these assets, the structure of the relevant 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 individual characteristics that must be taken into consideration.

5.2Assets in the System of Economic and Environmental Accounts

8. The assets considered in the SEEA are environment assets and economic assets. These are described in the following section noting that the distinction is not exclusive with some assets being classed as both environmental and economic assets.

5.2.1 Environmental assets

Definition of environmental assets

9. Environmental assets are the naturally occurring living and non-living components of the Earth that are used in production and that deliver ecosystem services through the interaction of the different components. Together these components comprise what is generally considered to be the biological (biotic) and physical (abiotic) environment.

10. Ecosystem services are of four types – provisioning services (such as the provision of timber from forests), regulatory services (such as when forests act as a sink for carbon), cultural services (such as the enjoyment provided to visitors to a national park) and supporting services (such as the formation of soils).

11. Some of these services, particularly provisioning services, are provided directly by an individual component but many of the services are delivered by various components working together. This joint delivery of services is a key characteristic of an ecosystem.

12. The joint delivery of ecosystem services by various components should also be conceptualised as being delivered from a particular area or space within the environment. Ecosystems are thus defined when a range of components interact as a functional unit within a particular space, for example within a forest or river basin.

13. Environmental assets deliver ecosystem services over a period of time and hence can be considered to be of benefit to both current and future generations beyond the current accounting period. Indeed, it is the change, often negative, in the capacity of environmental assets to deliver ecosystem services now and in the future that is core to the issue of sustainability.

14. With these considerations in mind, ***environmental assets are defined as the naturally occurring living and non-living components of the Earth, together comprising the bio-physical environment, that are used in production and that deliver ecosystem services to the benefit of current and future generations.***

Classification of environmental assets

15. Since it is the interaction between the various living and non-living components in a given area that leads to the delivery of ecosystem services, there is a significant amount of complexity that must be dealt with in order to undertake asset accounting by aggregating and valuing the services delivered by various ecosystems.

16. The degree of complexity means that at present, there are no generally accepted statistical standards for the measurement of ecosystem services and the construction of asset accounts for ecosystems. Nonetheless, there is a significant amount of relevant research and development of techniques and these are described in SEEA experimental ecosystem accounts.

17. Rather than focus on the ecosystem services, an alternative is to focus on the individual living and non-living components that deliver these services. Many of these components can be meaningfully measured in their own right and hence provide a basis for asset accounting. The key individual components in scope of the central framework are mineral and energy resources, soil resources, timber resources, fish resources, other biological resources, water resources and land in its role of delineating geographical areas.

18. This range of individual components covers, in physical terms, the bulk of the biological and physical environment of individual countries. Further, these individual components generally have strong connections to the economy in the provision of products to the economy through extraction or harvest. There is therefore a strong logic in considering these individual components in the broader framework of economic and environmental accounting.

19. Based on a focus on individual components a classification of environmental assets is presented in Table 5.2.1. For each of these environmental assets a measurement boundary in physical terms must be drawn for the purposes of asset accounting. This boundary is described in the relevant section for each asset type (see Sections 5.5 – 5.11).

Table 5.2.1: Central Framework Classification of Environmental Assets

Mineral and energy resources	
Land	
Soil resources	
Timber resources	Cultivated timber resources
	Natural timber resources
Fish resources	Cultivated fish resources
	Natural fish resources
Other biological resources	Cultivated livestock resources
	Cultivated crop resources
	Other cultivated animal and plant resources
	Other natural animal and plant resources
Water resources	

Environmental assets outside the central framework

20. The central framework excludes oceans and the atmosphere. These are environmental assets that are so vast that they are not clearly attributable to individual countries. Even if

measurement of them was possible, recording changes in the assets as a whole is unlikely to yield information of value.

21. At the same time, it is widely accepted that the quality of these environmental assets is changing and hence measurement of this change is of particular interest. The change in quality is, in effect, the change in the ability of these assets to deliver ecosystem services. The measurement of these changes and in changes to the ability of other environmental assets to deliver ecosystem services more generally, are considered in SEEA experimental ecosystem accounts.

22. As well, while excluded from the central framework classification of assets, the interactions between the oceans and the atmosphere and the economy are recorded in the central framework in various ways. For example, measures of precipitation, abstraction of sea water and evaporation are included in the asset accounts for water resources, and emissions from the economy to the atmosphere and oceans are recorded in physical flow accounts.

Land

23. For most environmental assets it is straightforward to conceptualise both a delivery of ecosystem services and physical inputs to economic activity – for example in the form of fish, timber and minerals. The exception to this is land[1].

24. The primary role of land in the SEEA is its provision of space which, in turn, defines the locations within which economic activity and other activity is undertaken and within which assets are situated. Although not physical, this location defining service is a fundamental input to economic activity and can have significant value. This is most commonly observed in the varying valuations given to similar dwellings in different locations that have different characteristics in terms of landscape, access to services, etc.

25. 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 terms of nutrients, groundwater and other matter. This distinction is discussed further in sections 5.6 and 5.7.

26. Land also plays a distinct role in the formation of the SEEA experimental ecosystem accounts. In these accounts land, by virtue of its role in delineating space, provides the statistical unit about which information is collected and is the focal point for the measurement of ecosystem services.

Timber, fish and other biological resources

27. Biological resources include timber and fish resources and a range of other animal and plant resources such as livestock, orchards, crops and wild animals. Like many

[1] The term land also encompasses areas of inland water such as rivers and lakes. However, the volume of water is considered a separate asset, water resources. Detail regarding land is contained in section 5.6 and detail regarding water resources is contained in section 5.11.

environmental assets they provide physical inputs to economic activity. However, for biological resources, a distinction is made between whether the resourcesare cultivated or natural. This distinction is based on the extent to which there is active management over the growth of the resource and follows the distinction made in the 2008 System of National Accounts (2008 SNA).

28. Maintaining this distinction in the central framework is important to ensure that clear links can be made to the treatment of these resources in the monetary production accounts and asset accounts of the 2008 SNA.

29. There is a wide range of ways in which biological resources can be cultivated. In some cases the management activity is very active such as in the case of battery farming of chickens or 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.

30. In other cases there may be relatively little active management for example in the case of broad acre cattle farming or the growing of plantation timber where the biological resource is exposed constantly to, and interacts as a part of, the broader biological and physical environment. Of course, there are cases between these two extremes.

31. In principle, cultivated biological resources that are managed in such a way that they never interact with the broader biological and physical environment should not be considered environmental assets since they do not deliver ecosystem services.

32. In practice, it may be difficult to distinguish between different types of cultivated biological resources by virtue of the manner of their production. Where countries are particularly interested in other biological resources, assessments will need to be made on a case by case basis.

Valuation

33. The monetary value of an environmental asset is equal to the economic benefits or series of economic benefits that accrue to the owner of the asset by holding or using the asset over a period of time[2]. Given this basis for the valuation of environmental assets, in many cases environmental assets also fulfil the definition of economic assets (see Section 5.2.2).

34. It is possible that for certain types of environmental assets there are instances of assets within scope of the definition that do not have a monetary value. Where this occurs, those assets without monetary value should be clearly distinguished.

[2] This definition is intended to align with the definition of economic assets in the 2008 SNA. The SEEA also applies the principles of valuation from the 2008 SNA that are described further in section 5.4.

5.2.2 Economic assets

35. Economic assets concern items (entities) that are owned and used by institutional units such as corporations, governments and households. By owning and using economic assets, institutional units derive economic benefits such as profits or interest.

36. ***An economic asset is a store of value representing an economic benefit or series of economic benefits accruing to the owner by holding or using an entity over a period of time***. Examples of economic assets include houses, office buildings, machines, computer software and financial assets. Many environmental assets are also economic assets.

Relationship between environmental and economic assets

37. Given that the valuation of assets is founded on the generation of economic benefits, estimates of the national wealth of a country may be based on a summation of the monetary values of all economic assets, including relevant environmental assets. The relevant concepts and measurement approaches to construct these estimates are fully described in the 2008 SNA. These concepts and approaches are adopted in the SEEA for the purposes of defining estimates of national and sector wealth and the construction of monetary asset accounts.

38. The set of economic assets includes a range of environmental assets and also includes a range of other assets. The structure of economic assets as defined in the 2008 SNA is presented in Table 5.2.2. Most environmental assets are part of natural resources.

39. Cultivated biological resources are considered to be produced assets and are either fixed assets or inventories depending on the nature of their role in the production process. Those resources that provide ongoing inputs (such as dairy cows providing milk) are considered fixed assets while those providing once-only inputs (such as trees for timber) are considered inventories.

Table 5.2.22008 SNA Economic assets

Non-financial assets			
	Produced assets	Fixed assets	
		Inventories	
		Valuables	
	Non-produced assets	Natural resources	
		Contracts, leases and licences	
		Purchased goodwill and marketing assets	
Financial assets and liabilities			

40. The overlap between economic assets and environmental assets is shown in Figure 5.2.1. The environmental assets outside the scope of economic assets include those environmental assets that do not accrue economic benefits to their owner such as oceans and the atmosphere. It is noted that whether or not cultivated biological resources are considered environmental assets, they remain economic assets irrespective of the manner in which they are cultivated.

Figure 5.2.1 Relationship between environmental and economic assets

Economic assets	Environmental assets		
	Central framework environmental assets		Other environmental assets
	Economic benefits	No economic benefits	
Produced assets (excl cultivated biological resources) Contracts, leases and licences Purchased goodwill & marketing assets Financial assets & liabilities	Mineral and energy resources Land Soil resources Timber resources Fish resources Other biological resources Water resources		Oceans Atmosphere

Environmentally related assets

41. There is also interest in economic assets that have a role in activities associated with the environment, so called environmentally related assets. These include assets relevant to the extraction and harvest of environmental assets such as oil rigs, water dams, cutting and drilling equipment, mineral exploration and evaluation expenditure; assets relevant to the undertaking of environmental protection and resource management activities and certain financial instruments. A discussion of environmentally related assets is included in Chapter 4.

5.3 The structure of asset accounts

5.3.1 Introduction

42. The recording of flows for environmental assets takes place in asset accounts. These accounts record both the opening and closing stock of assets and the changes over the accounting period. This 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

43. Physical asset accountsare 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 also means that aggregation across different assets in physical terms is not possible. While aggregation is only broadly possible in monetary terms, the physical asset account entries are essential in the compilation of monetary estimates.

44. Estimates of the opening or closing stock of an asset should always be constructed using information relating to the reference date of the specific opening or closing stock. From time to time, new information will arise that leads to a change in the assumptions underlying a set of estimates. When incorporating additional information it is important that the estimates continue to reflect the quantities and values that could reasonably be expected at the reference date.

45. The entries concerning the changes between opening and closing stocks of each asset are broadly divided into additions to the stock and reductions in the stock. However, within these broad categories there are many different types of flows and often the flows are 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 of them however relate to the activity of removing of environmental assets through processes of economic production.

46. Table 5.3.1 presents the range of accounting entries for physical asset accounts by type of asset. It gives an overview of the structure of physical asset accounts that are elaborated in detail for each asset in sections 5.5 – 5.11. In physical terms, each asset will be measured in different measurement units and hence aggregation across assets in physical terms is not possible.

47. The table provides a complete listing of possible flows for each asset type. In practice, only certain flows are likely to be important and not all cells that show the possibility of an entry in Table 5.3.1 should be shown separately in the published accounts for each type of asset.

Table 5.3.1Conceptual form of the physical asset account (physical units)

		Mineral & energy resources	Land (incl. forest land)	Timber resources	Fish resources	Water resources
Opening stock of resources		Yes	Yes	Yes	Yes	Yes
Additions to stock of resources						
	Growth in stock	na	na	Natural growth	Natural growth	Precipitation Returns Inflows
	Discoveries of new stock	Yes	na	na	Yes*	Yes*
	Upwards reappraisals	Yes	na	Yes*	Yes*	Yes*
	Reclassifications	Yes	Yes	Yes	Yes	Yes
	Total additions to stock					
Reductions in stock of resources						
	Extractions	Extractions	na	Removals	Gross catch / Landings	Abstraction
	Normal reductions in stock	na	na	Natural losses	Natural losses	Evaporation Outflows
	Catastrophic losses	Yes*	Yes*	Yes	Yes	Yes*
	Downwards reappraisals	Yes	na	Yes*	Yes*	Yes*
	Reclassifications	Yes	Yes	Yes	Yes	Yes
	Total reductions in stock					
Closing stock of resources		Yes	Yes	Yes	Yes	Yes

na – not applicable

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

48. There are four types of additions to the stock of a resource.

i. Growth in stock. These additions reflect increases in the amount of the stock of resources over an accounting period due to natural growth.For some assets, growth is often estimated net of normal losses of stock.

ii. Discoveries of new stock. These additions concern the arrival of new resources to a stock and commonly arise through exploration and evaluation.

iii. Upwards reappraisals. These additions reflect changes due to the use of updated information that permits a reassessment of the size of the stock.

iv. Reclassifications. Reclassifications of environmental assets will generally result from 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.

49. There are five types of reductions in the stock of a resource.

i. 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 dispersed to the environment after extraction because they are unwanted – for example by-catch in fishing.

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

iii. 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, exceptionally severe hurricanes, drought and other natural disasters; acts of war, riots and other political events; and technological accidents such as major toxic spills or release of radioactive particles into the air. Included here are major losses such as destruction of biological resources by drought or outbreaks of disease.

iv. Downwards reappraisals. These reductions reflect changes due to the use of updated information that permits a reassessment of the size of the stock.

v. Reclassifications. Reclassifications of environmental assets will generally result from situations in which an environmental asset is used for a different purpose or moves to a different category and will be reflected in an offsetting increased reclassification in another category of the same resource. Overall, reclassifications have no impact on the total physical quantity of an individual asset type.

50. The depletion of resources is related to the extraction of resources and the physical using up of the resource thus limiting 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 renewable resources that can regenerate over time. The definition of depletion in physical terms is covered in detail in section 5.4.

51. It may not be possible to directly estimate all of the accounting entries outlined in the conceptual form of the physical asset account in Table 5.3.1. Consequently, some entries may need to be estimated using appropriate models or derived on the basis of other accounting entries. Depending on the particular flow 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 constructing physical asset accounts for publication.

52. All of the details regarding the definition and measurement of these flows in relation to individual resources are contained in Sections 5.5-5.11.

Accounting entries for institutional sector accounts

53. The compilation of asset accounts by institutional sector may be of interest for particular types of environmental assets where the ownership of resources is of policy or analytical concern. Examples might include the attribution of mineral and energy resources between government units and extracting units and the assessment of ownership of land.

54. To construct institutional sector accounts there are two additional types of entries that are requiredcompared to those shown in Table 5.3.1 in order to account for transactions and other exchanges between sectors. These entries are

  i. <u>Acquisition and disposals of environmental assets</u>. These entries are recorded when transactions 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.

  ii. <u>Uncompensated seizures</u>. These changes in stock occur when institutional units take possession of or remove environmental assets without providing appropriate compensation to the 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.

55. It is also noted that reclassifications between sectors may be common entries in institutional sector accounts.

5.3.3Conceptual form of the monetary asset account

56. The general form of the monetary asset account is presented in Table 5.3.2. There are close links to structure of the physical asset account.

Table 5.3.2Conceptual form of the monetary asset account (monetary units)

Opening stock of resources		
Additions to stock of resources		
A1	Growth in stock	
A2	Discoveries of new stock	
A3	Upwards reappraisals	
A4	Reclassifications	
	Total additions to stock	
Reductions in stock of resources		
R1	Extractions	
R2	Normal loss of stock	
R3	Catastrophic loss	
R4	Downwards reappraisals	
R5	Reclassifications	
	Total reductions in stock	
Revaluation of the stock of resources		
Closing stock of resources		

57. The definitions of the flows presented in the monetary accounts align exactly with the same flows as defined in physical terms. Thus, the monetary account reflects, in large part, a valuation of the physical flows as recorded in the physical asset account. 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.

58. The only additional flow recorded in the monetary asset account compared to the physical asset account concerns revaluations. Revaluations relate to changes in the value of assets due to price changes and reflect nominal holding gains and losses on environmental assets. The nominal holding gain on a non-financial asset is the increase in value accruing to the owner of the asset as a result of a change in its price over a period of time.

59. As well as the nominal holding gain, it is interesting to know how the change in value compares with the general measure of inflation. If the value of an asset rises over an accounting period at the same rate as the general inflation rate this amount of 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 a real holding gain.

60. Revaluations should also incorporate changes in the monetary value of environmental assets due to changes in the assumptions made in the valuation models that are often used to estimate the value of environmental assets, in particular the Net Present Value model. The assumptions that should be taken in account are those regarding future rates of extraction and natural growth, the length of the asset/resource life and the discount rate.

61. As for physical asset accounts it may not be possible to directly estimate all of the accounting entries outlined in the conceptual form of the monetary asset account in Table 5.3.2. Consequently, some entries may need to be estimated using appropriate models or derived on the basis of other accounting entries. Depending on the particular flow 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 constructing asset accounts for publication.

Relationship to SNA accounting entries[3]

62. Rather than a broad separation into additions and reductions in the stock, the 2008 SNA focuses on (i) changes due to transactions and (ii) other change in volume of assets. To support 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 as structured in the monetary asset account. These derivations are shown in Table 5.3.3.

63. The scope of the SNA accounting entries is different depending on whether the environmental asset is produced or non-produced. In the SEEA, this distinction is reflected in whether an environmental asset is cultivated or natural. For SNA purposes a further distinction needs to be considered as to whether the cultivated asset is a fixed asset or an inventory.

64. 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 between the monetary asset account in Table 5.3.2 and the SNA.

Table 5.3.3 Derivation of accounting aggregates (monetary units)

	Cultivated biological resources		**Natural environmental assets**
	Fixed assets	**Inventories**	
Accounting aggregates			
Gross fixed capital formation	A1 less R1	na	na
Changes in inventories	na	A1 less R1	na
Economic appearance	na	na	A1 + A2 + A3
Economic disappearance	na	na	R1 + R2 + R4

na – not applicable
A and R codes defined in Table 5.3.2

[3] The detailed description of the relevant accounting entries are contained in Chapters 10, 12 and 13 of the 2008 SNA.

65. In addition to the monetary accounting entries shown in Tables 5.3.2 and 5.3.3 there are two entries, depletion and consumption of fixed capital,thatrelate 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 losses of stock.

66. Depletion relates to the physical using up of natural environmental assets through extraction and in monetary terms represents the decline in future income that can be earned from a resource due to extraction. Details on the definition and measurement of depletion in physical and monetary terms are presented in Section 5.4.

Institutional sector accounts in monetary terms

67. Institutional sector asset accounts may also be compiled in monetary terms and indeed these accounts may be of particular interest since they can be connected directly to the full suite of institutional sector accounts as presented in the 2008 SNA. A key aggregate that can be compiled from a full recording of asset accounts by institutional sector is net worth by sector.

68. 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.

5.4 Principles of asset accounting

5.4.1 Introduction

69. The objective of accounting for assets to assess the stock of and changes in environmental assets presents a measurement challenge. The challenge commences in accurately measuring the physical stock of environmental assets which all have their own unique characteristics including, in some instances, the capacity to regenerate over time. Understanding the biological dynamics is therefore important in making a reasonable assessment of certain environmental assets.

70. The next challenge is to take the estimates in physical terms and determine appropriate valuations in monetary terms. Since few environmental assets are actively traded before they are extracted determining their in situ valuation is not straightforward.

71. 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 describesakey challenge in physical asset accounting – the measurement of depletion in physical terms. This is followed in section 5.4.3 by a discussion on valuation approaches and, in particular a presentation of the net present value approach. The section concludes with a discussion on the potential uses and limitation of valuation approaches and a description of the relationship in monetary terms between resource rent and depletion. The application 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

72. In principle, the physical estimates of the accounting entries described in Section 5.3 can be made through direct observation. In practice however, these observations are very difficult to make in part due to the size of the resources and in part due to the location and inaccessibility of the resources – for example mineral resources under ground.

73. Consequently, various models, techniques and conventions have been developed for the estimation of physical stocks and flows of individual environmental assets. These are described in more detail in sections 5.5 - 5.11.

74. Of particular importance in the context of asset accounting are the approaches used to estimate the stocks and flows of renewable environmental assets, notably timber resources and fish resources. The interest in these resources is because they naturally regenerate and grow and hence there is interest in the balance between the growth and the extraction of these resources. A similar interest may arise with water or soil resources where natural renewal and regeneration also occurs. The same interest does not arise in the case of mineral and energy resources that do not regenerate on human time scales.

75. Part 5.4.2 focuses on the definition of depletion in physical terms particularly as it relates to renewable environmental assets. It is clear that the definition must take into account the ongoing regenerative capacity of an environmental asset such that extraction in possible into

the future. This part concludes with a discussion on the relationship between depletion and degradation in physical terms.

Depletion of environmental assets

76. The depletion of environmental assets relates to the physical using up of environmental assets through extraction and harvest by economic units, including households, such that there is a reduced availability of the resource in the future at current extraction rates. Depletion is not recorded when there is a reduction in the quantity of an environmental asset due to unexpected events such as losses due to extreme weather or pandemic outbreaks of disease. Thus depletion must be seen as a consequence of the normal, year on year, interaction between economic units and the environment.

77. In this context, depletion of mineral and energy resources can be directly related to the amount of resource that is extracted since a given stock of resources at the beginning of a period cannot regenerate itself. Ignoring other possible changes in the quantity of mineral and energy resources over a period due to discoveries and reappraisals, the quantity of resource depleted will equal the quantity of resource extracted.

78. For biological resources, primarily timber resources and fish resources, this relationship between depletion and extraction/harvest does not hold. The ability for the resources to regenerate naturally means that under certain management and extraction situations, the quantity of resources extracted may be matched by a quantity of resources that are regenerated and hence there is no overall physical using up of the environmental asset.

79. While these paragraphs provide an overall logic for the consideration of the depletion of environmental assets, the measurement of the depletion of biological resources requires more in depth consideration and is not a purely quantitative assessment of numbers or volumes at the beginning and end of a period.

Depletion of biological resources

80. The key element in understanding measures of depletion of biological resources is that the ongoing regeneration of the resource is dependent on the structure of the particular population of interest. For extraction to occur over the long term there must remain sufficient quantities of reproductively active individuals (in the case of animals) and sufficient rates of replanting or natural expansion (in the case of plants) to ensure that the age structure of the population is maintained in a state that contains a sufficient number of individuals that are of reproductive age. Where the structures are not sustainable within individual populations of biological resources, the extraction rate cannot continue indefinitely and ongoing extraction will result in depletion of the resource in physical terms.

81. In recording data on biological resources in physical terms it is therefore not sufficient to look purely at the quantity extracted by species. There must also be an understanding of the age and sex structures (cohorts) of the extracted resource to determine the extent to which extraction is occurring from particular cohorts to a greater degree than others.

82. In the case of animal resources it is necessary to apply relevant biological models that take age and sex structures and other factors affecting population dynamics into account. The link between these biological models and asset accounts is in the concept of maximum sustainable yield. A sustainable yield is a level of harvest that ensures that the population being harvested is not driven to extinction. Maximum sustainable yield is the largest harvest that can be sustained in perpetuity. In physical terms harvest in excess of the maximum sustainable yield represents depletion of the biological resource.

83. For plant resources the same principles apply but because the life cycles for plant resources, primarily timber resources, can be quite long relative to those for animal resources and because the regenerative process is different, the considerations taken into account in the models are different.

84. Because of their regenerative capacity the recording of depletion for biological resources may not happen on an ongoing basis. It is possible for extraction rates to be reduced to allow populations of individual species to regenerate. Even while some extraction may continue, depletion may not be in evidence in those periods in which such recovery is being allowed. The increase in stock associated with such recovery is recorded in the asset accounts as natural growth.

The relationship between depletion and degradation

85. The focus in measuring depletion is on the availability of individual environmental assets in the future and changes in the availability due to extraction and harvest by economic units. There is particular focus on the provisioning services of individual environmental assets and the capacity of the extraction of the resources to generate income for the extractor.

86. Degradation considers the broader capacity of environmental assets to deliver the full suite of ecosystem services 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 as a specific form of degradation.

87. The measurement of degradation is complicated because the capacity of environmental assets to deliver ecosystem services is not completely attributable to individual assets. Rather, many ecosystem services are delivered by individual assets functioning together. Further, while individual environmental assets, such as water and soil resources, may have been degraded over time, separating the extent of degradation of the individual asset from the broader degradation of the related ecosystem may not be straightforward.

88. The measurement of degradation in physical terms is also complicated as it generally relies on a detailed assessment of the internal characteristics of environmental assets rather than the relatively simpler quantities of an environmental asset 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 amounts of various pollutants in the water. While individual accounting for each of these pollutants might be undertaken it will not be directly related to the volume of water in m^3 that is used to account for water resources in an asset account.

89. For these reasons the measurement of degradation is not pursued in the central framework. Rather it is considered as part of SEEA experimental ecosystem accounts.

5.4.3Principles of asset valuation

90. Since many environmental assets are not purchased in a market place and have not been produced in a manner like buildings and equipment 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.

91. It should be recognised that 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 to the development of meaningful valuations. At the same time, there are complexities in the models that compilers and users should be aware of before applying the models in practice.

92. The following parts explain the principles for the valuation of assets and outline the approaches that can be used to estimate the values in monetary terms[4]. Specific measurement issues relevant to individual environmental assets are addressed in later sections of this chapter.

General principles of valuation

93. The prices at which assets may be 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.

94. 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 allows the formation of opening and closing values of stocks that can be used to assess national and sector based estimates of wealth in monetary terms.

95. 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 market place will often be less than the value that the current owner places on the utility and flexibility of car ownership. At the same time, the car's value may not reflect the impact of emissions from operating the car on the environment. Thus while the use of market prices allows comparison across asset

[4] The principles of valuation explained here align fully to the 2008 SNA. See 2008 SNA paragraphs 13.16-13.25

types they may not reflect the full value of the asset from an individual or society's perspective. This limitation of market based prices is often referred to in respect of the valuation of environmental assets.

96. An additional and important 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. This objective means that care needs to be taken in the application of market based approaches.

97. The approaches described in the SEEA, in particular the Net Present Value approach, provide reasonable proxies for observable market prices but do not take into account the full range of benefits (and costs) that might be considered relevant. The potential uses and limitations of NPV approaches are outlined later in this section.

Approaches to the valuation of assets

98. The ideal source of price observations for assetsare values observed in marketsin 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 quantity in order to compute the total market value of different classes of assets. These types of price observation are available for most financial assets, newly purchased produced assets including many types of transport equipment (such as cars and trucks) and livestock.

99. 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 in particular areas may be used to estimate the value of houses and land in other areas that have not been sold.

100. 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 market existed were the assets to be acquired on the date to which the estimate of the stock relates.

101. An alternative approach is to use values obtained by accumulating and revaluing transactions. Most non-financial assets change in value year by year reflecting changes in market prices. In most cases the value of an asset will decline over time as the initial acquisition cost is reduced by consumption of fixed capital, in the case of fixed assets, or other forms of depreciation over the asset's expected life. Furthermore, the acquisition prices of equivalent new assets will change. Thus, in theory, the value of such an asset at a given point in its life is given by the current acquisition price of an equivalent new asset less the accumulated depreciation. This valuation is sometimes referred to as the "written-down replacement cost". 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.

102. 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.

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

104. The discounted value of future returns approach, commonly referred to as the Net Present Value approach – or simply NPV – 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 from 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 future returns is then discounted back to reflect values in the current period.

105. The next section outlines the key components of the NPV approach followed by a discussion of the uses and limitations of the approach for environmental accounting. Additional detail, including the relevant mathematical derivations related to the NPV approach, is contained in an annex to the chapter.

5.4.4 The Net Present Value (NPV) approach

106. There are five key aspects of NPV that require explanation: the measurement of future returns on environmental assets, the estimation of the asset life, the determination of the pattern of resource rents based on future extraction profiles and prices, the selection of a rate of return on produced assets and the choice of discount rate.

The measurement of future returns on environmental assets

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

108. The surplus value, referred to as resource rent in the context of environmental assets, can be considered as the return attributable to the asset itself. The logic of NPV 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.

109. 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

i. differential rent – where one firm earns more than another with the same inputs due to differences in the underlying quality of the resource endowment
ii. scarcity rent – where a firm earns more than a normal rate of return because the underlying resource is of limited supply and hence, as it is extracted or used, the decreasing future supply pushes up output prices relative to extraction or use costs
iii. entrepreneurial rent – where a firm earns more than another through investments in

training, research and development, high quality management, etc and hence lowers the operating costs of production or creates a new product.

110. These sources of resource rent are not mutually exclusive and any single amount of resource rent may be due to any of these sources to varying degrees. Consequently, the estimates of resource rent that underpin the NPV estimates in the SEEA should not be considered as emerging from any particular source of resource rent.

111. One common aspect in the definition of resource rent is that the amount of rent is always derived relative to the returns earned by other firms on average over time – i.e. normal returns. It is also observed that resource rent, as a residual may be positive or negative. Economic theory would suggest that over the long term resource rents should not be negative.

112. The framework for the derivation of resource rent is shown in Table 5.4.1. It is based on some key national accounts variables. The table shows that resource rent can be derived residually based on knowledge of all of the other variables and very often a residual approach is used to estimate resource rent. However, direct estimation methods are also available working within the same national accounts based framework.

Table 5.4.1 Relationships between different flows and income components

<table>
<tr><td colspan="4">Output (sales of extracted environmental assets)</td></tr>
<tr><td colspan="4">LessOperating costs
Intermediate consumption (input costs of goods and services)
Compensation of employees (input costs for labour)</td></tr>
<tr><td rowspan="4">Equals Gross Operating Surplus (GOS)*</td><td colspan="2">Consumption of fixed capital (CFC)</td><td rowspan="2">User cost of produced assets</td></tr>
<tr><td rowspan="3">Net Operating Surplus (NOS)</td><td>Return to produced assets</td></tr>
<tr><td rowspan="2">Resource Rent</td><td>Depletion</td></tr>
<tr><td>Return to environmental assets</td></tr>
</table>

* Strictly 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 here.

113. In this model there are three key elements in the derivation of resource rent:

i. The value of Output – in this case sales of extracted environmental assets
ii. Operating costs defined as Intermediate consumption plus Compensation of employees
iii. The costs of using produced assets – here referred to as the User costs of produced assets (defined as Consumption of fixed capital plus Return to produced assets)

114. Using these variables resource rent can be seen to be equal to: Output less Operating costs (equal to Gross Operating Surplus (GOS)) less User costs of produced assets.

<u>Approaches to estimating resource rent</u>

115. In practice, there are three primary approaches to estimating resource rent: the residual value method, the appropriation method and the market price method.

116. The most commonly applied method is the residual value method. Under this method amounts of resource rent are estimated by deducting user costs of produced assets from gross operating surplus and assumptions are made regarding the future flows of resource rent based on factors such as extraction rates. Once the future flows of resource rent have been estimated the general NPV method can be applied to obtained an estimate of the value of the environmental resource.

117. Estimates of the value of gross operating surplus are obtained from national accounts datasets. Estimates of user costs of produced assets are not generally available and have to be constructed so as to obtain each period's resource rent. It is recommended that future estimates of resource rent should be set equal to current estimates of resource rent assuming no price increases beyond the general level of inflation and a realistic rate of resource extraction. In general, there is too much volatility in unit resource prices for meaningful assumptions about future resource price changes to be incorporated.

118. In their simplified form, estimates of the user costs of produced assets are composed of two elements – the consumption of fixed capital of the produced assets; and the normal return on produced assets. Estimates of consumption of fixed capital may be obtained based on national accounts calculations. The normal rate of return on produced assets should be set as a real exogenous rate consistent with the assumption made above concerning asset-specific price changes[5].

119. One difficulty in estimating resource rents following this method is that it is rare for the source information to be able 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 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 a pure extraction and single resource component is not always straightforward. All efforts should be made to isolate the specific GOS for the extraction activity of individual resources in the underlying data.

120. The appropriation methoduses actual payments made to owners of environmental assets. In many countries, governments are the primary owners of the national environmental assets. As landlords, governments could in theory collect the entire resource rent derived from extraction of the resources they own. This amount would, in principle be equal to GOS less user costs of produced assets of the extractor, as defined.

121. Resource rent is generally collected by governments through mechanisms such as fees, taxes and royalties. In practice, the fees, taxes and royalties 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 adoption of the appropriation method.

[5] The OECD Manual on Measuring Capital (2009) provides detailed guidance on the estimation of user costs.

122. The market price methodis based on the fact that access to resources may be controlled through the purchase of licences and quotas – 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 asset (after deducting all costs including user costs of produced assets).

123. 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, say entitlements for one year, this can provide a direct estimate of the resource rent for that year.

124. However, in many cases the government give the rights direct to extractors for free or do so at a price less than the true market value and trading of the rights may be restricted or prohibited. In these cases there is no directly observable market valuation.

125. The application of the market price method in the case of renewable resources needs careful consideration of the underlying sustainable yield of the environmental asset. Where the resource access rights that have been allocated are not consistent with maintenance of the environmental asset in perpetuity, the market prices of the access rights may not adequately enable assessment of possible depletion of the resource.

126. 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 market price method are more heavily influenced by institutional arrangements in a country. For these reasons, the compilation of estimates of resource rent based on the residual value method should be compiled and reconciled with estimates obtained using the other methods where possible. Indeed, there may be particular analytical interest in comparing the estimates of resource rent based on the different methods.

Estimates of the asset life

127. Estimates of the asset life are required such that the time frame over which the NPV approach is applied can be determined. In practice, depending on the choice of discount rate, if asset lives are longer than around 20 years, the NPV estimates are relatively stable. That is, there is little additional value estimated under the NPV approach once the asset life has reached around 20 years. This effect has implications for the interpretation of NPV results that are discussed in the section on limitations of the NPV approach.

128. Estimates of the asset life must be based on consideration of the 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 may be calculated as the existing physical stock divided by the excess of expected annual extractions over expected annual growth. However, especially for renewable resources such as fish resources, it is necessary to consider biological models and

associated sustainable yields of renewable resources such that 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.

Determination of the pattern of resource rents

129. Estimates of the pattern of resource rent are needed such that the discounting of income can be undertaken in an effective way. For example, if it was known that the majority of the future income was to be earned in years 5 – 10 over a total asset life of 30 years, then this should be taken into account in the derivation of the NPV estimates.

130. It is recommended that the future patternod resource rent be based on consideration of the physical stock and associated information on the rates of extraction and harvest as discussed in section 5.4.2. Often, past extraction rates are used as a starting point. 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 have been acquired.

131. Special consideration is needed in situations where the extraction rates in any particular period fall to zero, or close to zero. In practice this is possible in any given accounting period for example, if economic circumstances change such that extraction is no longer cost effective or if natural disasters make the resource inaccessible or un-harvestable.

132. If changes in the expected extraction schedule that underpin the NPV estimates occur the resulting NPV estimates may produce results that are difficult to interpret. However, this only highlights 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 it reflects a valuation based on all of the information available at that point in time.

Rate of return on produced assets

133. An expected rate of return on produced assets is required to fully estimate the cost of the produced assets used in the extraction of the asset. If this cost is not incorporated the resulting estimates of resource rent will overstate the future earnings.

134. Two approaches can be taken to forming expected 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 divided by the value of produced assets. This approach implicitly assumes that there is no income attributable to non-produced assets, including environmental assets and hence is not recommended.

135. The exogenous approach is recommended in the SEEA. This approach assumes that the expected rate of return on produced assets is equal to an external (exogenous) rate of return. Ideally, the expected rate of return should take into account industry or activity specific returns thus implicitly 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.

136. For this reason a realistic approach is to use an economy wide rate of return perhaps based on government bond rates where these exist.[6] In all cases a real rate of return should be used. Experience suggests that over time the real rate of return in many countries is between 3 and 5 per cent per annum.

137. 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.

Choice of discount rate

138. Discount rates are required to convert the future stream of resource rents into a current period estimate of the overall value. A discount rate expresses a time preference – the preference for 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 businesses will have higher rates of time preference than governments. That is, individuals and businesses will tend to demand a quicker return from ownership of an asset than will governments. Higher rates of time preference translate into higher discount rates.

139. The use of a discount rate 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 on produced assets should be equal. This is because the enterprise should only invest if the rate of return is aligned to its own time and risk preferences for receiving income.

140. The choice of discount rate has been a controversial issue for many years. It is recommended that a market-based discount rate should be used set equal to the assumed rate of return on produced assets. The use of a market based discount rate is intended to ensure that the valuation of environmental assets aligns as closely as possible to observable market prices.

141. At the same time, there is strong 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. Social discount rates take into account inter-generational issues with, at the extreme, a zero social discount rate implying that there is no preference between whether the current or future generations receive the income for the assets.

142. Section 5.4.5 discusses the potential uses and limitations of the NPV approach including discussion on the choice of discount rate.

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[6] It is also the case for technical reasons that a general rate of return is appropriate. If an industry specific rate of return is used it is also necessary to include industry specific expectations in the derivation of the revaluation term in the NPV formula and in doing this the impact of using industry specific rates of return is offset.

Calculation of Net Present Values

143. Using these various elements estimates of the value of an environmental asset are obtained using the following basic steps assuming the use of the residual value method to calculate resource rent. More details are contained in Annex A5.1.

i. Estimates of GOS for the extractive activity are obtained from relevant sources, most likely based on national accounts data
ii. Estimates of the User cost of produced assets may be obtained directly from national accounts data. Where there are no available data, estimates can be derived by multiplying the rate of return on produced assets by an estimate of the value of the stock of relevant produced assets and adding an estimate of depreciation.
iii. Estimate Resource rent as GOS less User cost of produced assets
iv. Estimate the asset life based on physical assessment of the stock and projected extraction rates.
v. Project the estimate of Resource rent over the life of the asset taking into account any expected changes in extraction pattern.
vi. Apply the NPV formula using an appropriate discount rate

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

144. Experience in the compilation of NPV has shown that the choice of discount rate generally has the largest effect on the resulting overall value. Put differently, NPV valuations are sensitive to the choice of discount rate. Thus consideration of the choice of discount rate is an important step for compilers.

145. Where possible, compilers are also encouraged to compare results of NPV calculations that would be obtained using 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 into the general NPV formulation to derive alternative valuations.

146. A more complete articulation of the derivation and application of the NPV approach is presented in an annex to Chapter 5.

5.4.5 Potential uses and limitations of NPV based estimates

147. Through this section a number of limitations of the NPV approach to the valuation of environmental assets have been referred to. This part discusses the ways in which NPV based valuations may be used and limitations on their interpretation.

148. The measurement of the depletion of an individual resource must be defined in reference to physical data as discussed in section 5.4.2. This physical information is an essential ingredient in the assessment of sustainability of environmental assets and it also underpins the estimates of the value of environmental assets obtained using NPV approaches.

149. One general advantage of applying valuation approaches is that different environmental assets can be compared using a common numéraire, a comparison that cannot be made using purely physical data. Further, environmental assets can be compared against other assets in

order to assess relative returns, national wealth and other similar types of analysis. Since it is commonly the case that governments have a high degree of ownership or influence over the extraction of environmental assets, monetary valuation of resources may be a useful approach to assessing future streams of income for government, for example in the estimation of future government revenue from the extraction of oil and gas.

150. It is also the case that in business accounts, enterprises involved in extraction make assessments of their own in terms of future income streams and it is relevant to be able to place these individual enterprise based valuations in a broader, national perspective. There is also increasing use of market based mechanisms such as quotas to allocate access rights to environmental assets and the use of NPV based valuations allows such markets to be effectively established.

151. At the same time, valuations established using NPV approaches have been strongly criticized. There are two specific arguments against the use of NPV. Both are related to the choice of discount rate.

152. First, irrespective of the length of the asset life, the use of a market-based discount rate will tend to place very little weight on income earned by future generations and indeed the value of income streams earned beyond about 20 years from the assessment date are quite small. This is interpreted in two ways. First that NPV market-based approaches do not value future generations and second, that the total values obtained are too small since they do not place sufficient value on these future incomes.

153. From this it is often implied that the use of NPV for environmental assets under-values environmental assets relative to other assets and hence may give a misleading picture of the investment options available to a nation.

154. The second concern is that NPV valuations are especially sensitive to choice of discount rate and choices of rates can make a large difference to the final valuation.

155. Despite this sensitivity it is the case that real rates of return are not volatile and generally well aligned over time and across countries (usually between 3-5 per cent). NPV market-based approaches may therefore at least be used to compare change between two points in time even if not used for overall valuations.

156. Indeed, assessments of sustainable use are typically undertaken in terms of the overall change in wealth rather than its level. Thus, it remains relevant to consider changes in the value of individual resources, often caused by depletion, in addition to changes in their physical quantity.

157. Overall, while NPV market-based approaches have some limitations as valuation tools, they can be used effectively, in combination with assessment of the physical data, to consider a broader range of policy questions than is possible by looking at physical data alone.

5.4.6 Relationship between resource rent and depletion

158. Table 5.4.1 shows that the estimate of resource rent can be decomposed into an element of depletion and an element of return to environmental assets. The ability to

decompose resource rent in this way is an important conceptual relationship as it permits the development of estimates of depletion adjusted operating surplus and other related aggregates within the framework of the traditional national accounts.

159. This section describes the nature of the relationship between resource rent and depletion. Section, 5.4.2, explains the basis for measuring depletion in physical terms which underpin the monetary estimates discussed in this section. The annex to Chapter 5 explains in detail how monetary estimates of depletion can be derived within the NPV approach. Chapter 6 describes the full sequence of accounts including adjustments for depletion.

160. The gross operating surplus of an enterprise represents the benefit accruing to the owner of using all assets in the year in question. It can equally be described as the value of the flow of services rendered by the assets, referred to as capital services, in the same period plus a possible residual profit or loss. The value of all assets can, in principle, be estimated by calculating the NPV of the gross operating surplus (or capital services) to be generated for all future years in which the assets will be still in service.

161. The value of capital services is composed of two elements. First, there is an element that reflects the change in the value of the asset due to the using up of the asset over an accounting period. In effect, after each accounting period there are fewer capital services available to be delivered by the asset. Second, there is an income element, or return on assets, that reflects the fact that the owner receives a net benefit from undertaking investment in the assets. That is, if there was no income element the owner should have invested in an alternative asset.

162. In relation to produced assets, the cost of using up the asset's capital services is referred to as consumption of fixed capital in the SNA. More generally it is referred to as depreciation. The difference between gross operating surplus and consumption of fixed capital is net operating surplus. Net operating surplus incorporates the return on produced assets and the full value of capital services provided by non-produced assets.

163. For environmental assets a similar logic can be applied. The value of capital services provided by environmental assets is referred to as resource rent and can be partitioned into two components. The first component, depletion, reflects the decline in the value of the asset due to the physical extraction of the asset. The second component, the return to environmental assets, reflects the income accruing to the extractor of the asset through the use of the extracted resource in production.

164. If an environmental asset has characteristics such that no amount of use in a year leads to a decline in its value, then there is no depletion and the entire value of the capital service represents a return to the environmental asset and is considered income. The implication of assuming no decline in the value of the resource is that natural growth must always keep pace with harvesting or that the item should be sufficiently abundant as to render it free, with no cost arising from using up the resources. This assumption is not made in the SEEA.

165. In the case of non-renewable resources, which by definition have a finite life (even if quite

long in some instances), the recognition of a depletion element is relatively straightforward since each year the total amount of income that can be earned from the resource in the future reduces due to the physical extraction of the resource.

166. In the case of renewable resources the recognition of depletion is less obvious. It is quite possible that the amount extracted is replaced through natural growth of the resource such that the income that can be earned from the resource in the future is unchanged despite the physical extraction.

167. Where the amount extracted does not impact on the long term viability of the environmental resource, taking into account the age and reproductive structures of the resource, then estimated depletion is zero and all resource rent should be considered as a return to the extractor of the resource.

168. Where the amount extracted does impact on the long term viability of the resource then depletion should be estimated. The relevant considerations and measurement approaches are explained in detail in Section 5.4.2 and also in Annex A5.1.

169. Where growth in the resource is greater than extraction leading to an overall increase the long term structure of the resource this should be recorded as an addition to the stock of the resource in the asset account.

5.5Asset accounts for mineral and energy resources

5.5.1 Introduction

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

171. Asset accounts for mineral and energy resources organise relevant information including the levels 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 in turn these can provide valuable information regarding the sustainability of individual resources.

172. The capacity to value 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 the derivation of depletion adjusted value added measures. Such measures provide a more holistic view of extraction activity recognising 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 the community.

173. This 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. A final part of this section discusses two specific measurement issues related to mineral and energy resources – (i) accounting for the ownership of mineral resources, and (ii) the recording of renewable energy resources.

5.5.2 The definition and categorization of mineral and energy resources

174. Mineral and energy resources include deposits of petroleum resources (primarily crude oil and natural gas), coal & peat resources, non-metallic minerals and metallic minerals. Since the resources are generally found under the ground (and hence commonly referred to as subsoil assets) it is often not known with a great deal of precision the quantity of resources that might be reasonably extracted. Consequently, a key factor in the measurement of mineral and energy resources is the likelihood of extraction and the degree of confidence that exists regarding the quantity that can be extracted in the future.

175. Mineral and energy resources are defined as known deposits of petroleum resources, coal & peat resources, non-metallic minerals and metallic minerals.

176. 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). The UNFC-2009 is a generic and flexible scheme for classifying and evaluating quantities of fossil energy and mineral resources.

177. The 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. Based on the maturity of the projects the underlying natural resources are classified. The 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)

178. 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 geological knowledge and potential recoverability of the quantities.

179. Known deposits are categorised into three classes each defined according to combinations of criteria from the UNFC-2009.

i. Class A: Commercially Recoverable Resources. This class includes deposits for projects that fall in the categories E1and F1 and where the level of confidence in the geological knowledge is either high (G1) or moderate (G2). Class A resources are also termed "proven".

ii. Class B: Potentially Commercially Recoverable ResourcesThis 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 geological knowledge is either high (G1) or moderate (G2).Class B resources are also termed "probable".

iii. Class C: Non-Commercial and Other Known Deposits are resources for those projects that fall in E3 and for which the feasibility is categorised as F2.2, F2.3 or F4and where the level of confidence in the geological knowledge is either high (G1), moderate (G2) or low (G3).Class C resources are also termed "possible".

180. Known deposits exclude potential deposits where there is no expectation of the deposits becoming economically viable and there is a lack of information to determine feasibility of extraction or to have confidence in the geological knowledge.

181. Table 5.5.1 gives an overview of how the classes of resources are defined based on the UNFC criteria. The UNFC is explained in more detail in Annex A5.2.

Table 5.5.1: 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** **Geological knowledge**
Known deposits	**A. Commercially Recoverable Resources**[1] **(Proven)**	E1. Extraction and sale has 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) or moderate (G2) level of confidence
	B. Potentially Commercially Recoverable Resources[2] **(Probable)**	E2. Extraction and sale is expected to become economically viable in the foreseeable future[3]	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	Quantities associated with a known deposit that can be estimated with a high (G1) or moderate (G2) level of confidence
	C. Non-Commercial and other known deposits[4] **(Possible)**	E3. Extraction and sale is 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	Quantities associated with a known deposit that can be estimated with a high (G1), moderate (G2) or low (G3) level of confidence
Potential deposits (not included in SEEA)	Exploration projects Additional quantities in place	E3. Extraction and sale is 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
1. Includes on-production projects, projects approved for development and projects justified for development
2. Includes economic and marginal development projects pending and development projects on hold
3. Potential Commercial Projects may also satisfy the requirements for E1.
4. Includes unclarified development projects, non-viable development projects, and additional quantities in place
Source: UNFC-2009, Figures 2 and 3

Classification of mineral and energy resources

182. There a number of different types of mineral and energy resources such as petroleum resources, coal and peat resources, non-metallic minerals and metallic minerals, but there is no internationally agreed classification of the full range of mineral resources suitable for statistical purposes.

183. At the same time, many countries that have mineral and energy resources have developed relevant classifications suited to their own resource endowments and countries are encouraged to use these classifications for statistical purposes. This will help ensure an alignment between statistical outputs and the physical and geological data available in a country. As well, use of country based classifications should ensure broad coverage of resources and connection to key resource and sustainability issues within the country.

5.5.3 Physical asset accounts for mineral and energy resources

184. 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.

185. The units used to compile and present the relevant information will vary by type of resource. They are likely to be in tonnes, m3, or barrels. For accounting purposes the same unit should be retained for a single resource to record the opening and closing stocks and the changes in the stocks over an accounting period.

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

Measurement of opening and closing stocks

187. Ideally, opening and closing stocks of each mineral and energy resource should be classified by category of resource – i.e. proven, probable or possible – following the structure in Table 5.5.2. In this framework it is also important to clarify 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.

Table 5.5.2 Stocks ofmineral and energy resources (physical units)

	Class of known deposit			
	Class A: Proven	Class B: Probable	Class C: Possible	**Total known deposits**
Type of mineral and energy resource				
Petroleum resources				
Coal & peat resources				
Non-metallic minerals				
Metallic minerals				

Physical asset account for mineral and energy resources

188. A basic physical asset account for mineral and energy resources is shown in Table 5.5.3.

Table 5.5.3 Mineral and energy resource account (physical units*)

		Type of mineral and energy resource			
		Petroleum resources	Coal & peat resources	Non-metallic minerals	Metallic minerals
Opening stock of mineral and energy resources					
Additions to stock					
	Discoveries				
	Upwards reappraisals				
	Reclassifications				
	Total additions to stock				
Reductions in stock					
	Extractions				
	Downwards reappraisals				
	Reclassifications				
	Total reductions in stock				
Closing stock of mineral and energy resources					

* Different physical units will be used for different types of resources

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

189. The changes in the stock in physical terms should consider the following types of changes.

i. <u>Discoveries.</u> Discoveries should incorporate estimates of the quantity of new deposits found during an accounting period. To be regarded as a discovery the new deposit must be proven, probable or possible. Thus, in situations in which the quantity of potential deposits becomes known to a higher degree of confidence such that they are re-categorized as known deposits,this increase should be treated as discoveries. Discoveries should be recorded by type of resource and by category of resource.

ii. <u>Reappraisals.</u> Reappraisals may be upwards or downwards. They should only pertain to existing known deposits or to speculative deposits that have previously been categorized as known deposits. In general, reappraisals will relate to either additions or reductions in the estimated available stock of a known deposit or to changes in the categorization of specific deposits between proven, probable and possible resources based on changes in information, technology, resource price or a combination of these factors.

iii. 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. As well the quantity should be estimated before any refinement or processing of the resource is undertaken.

It is noted that for the extraction of gas the measurement of the quantity extracted may be more difficult due to the nature of the extraction process. Gas is often found with oil and it is the pressure exerted by the gas that causes the oil (and some gas) to be expelled from the oil well. Some of the gas that is expelled may be flared rather than being put to direct use. Some gas, especially after extraction has been continuing for some time, may be re-injected to increase the pressure on the remaining oil and so allow more oil to be expelled. In such cases, if the gas associated with the oil is being accounted for, an allowance must be made for the decrease in the amount of gas available for other uses due to flaring and re-injection.

iv. Catastrophic losses. Catastrophic losses are unlikely in relation to most mineral and energy resources. Flooding and collapsing of mines does occur but the deposits continue to exist and can, in principle, be recovered and 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.

v. Reclassifications. Reclassifications may occur if certain deposits are opened or closed to mining operations due to government decision 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 institutional sector.

5.5.4 Monetary asset accountsfor mineral and energy resources

190. 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 5.5.4.

Table 5.5.4Mineral and energy asset account (monetary unit)

		Type of mineral and energy resource				Total
		Petroleum resources	Coal & peat resources	Non-metallic minerals	Metallic minerals	
Opening value of stock of resources						
Additions to value of stock						
	Discoveries					
	Upwards reappraisals					
	Reclassifications					
	Total additions to stock					
Reductions in value of stock						
	Extractions					
	Downwards reappraisals					
	Catastrophic losses					
	Reclassifications					
	Total reductions in stock					
Revaluations						
Closing value of stock of resources						

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

192. While the measurement boundary extends to all known deposits it may not be possible to value all of these deposits in monetary terms. Where it is possible it is recommended that the valuation be undertaken separately for proven, probable and possible resources.[7] It is likely to be the case that for deposits in the different classes there are different assumptions that should be applied in relation to the extraction costs and technologies and also in relation to the time of extraction. These differences must be taken into account in the derivation of estimates of resource rent and net present value.

193. If an aggregate value across classes of resources is to be estimated it is further recommended that a weighting pattern based on the likelihood of extraction be applied to the different classes.

194. Of importance is the valuation of extractions which is comprised of a depletion component and an income component. While the distinction between income and

[7] The recommendation of the 2008 SNA is to limit the valuation of mineral and energy resources to only proven resources.

depletion is not always shown in the asset account its presentation in the asset account assists in reconciling the asset and income flows in relation to these resources.

Valuation of stocks of mineral and energy resources

195. Because there are few transactions in mineral and energy resources 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 and then summed over the range of different resources in order to obtain a total value of mineral and energy resources.

196. 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.

<u>Estimation of resource rent</u>

197. 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 meeting this aim several factors should be borne in mind

198. <u>Scope of operations</u>: 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.

199. For some mineral and energy resources, a single deposit may contain several types of resources. For example, often an oil well contains gas and, frequently silver, lead and zinc can only be 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 only available 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.

200. <u>Price fluctuations:</u>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 be 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, eg mine collapse. Since the objective is to define a resource rent which 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 moving average of unit resource rents be used as the basis for the estimation of future resource rents.

201. 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.

202. 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.[8]

203. These expenditures include prelicence 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 take place after commercial exploitation of the resource has started and the cost of these re-evaluations is also included.

204. 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 the own accounts.

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

206. 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. 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.

207. 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

[8] See 2008 SNA paragraph 10.106

the operation of the assets. Details on accounting for these costs are discussed in Chapter 4.

208. 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 oil fields will be exhausted in a relatively short time frame and extractors will then move to another.

209. 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.

210. 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 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.

Extraction rate

211. Independent of assumptions about the unit 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.

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

Resource life

213. At any point in time, the life of a resource is equal to the stock at that time divided by the average extraction rate. In the course of a year, the resource life will diminish by one

year due 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 life is further reduced.

214. The quantity of the stock used to calculate the resource life must be consistent with the quantity to be valued. For example, if a value is to be placed on proven reserves only, then the resource life will be appreciably shorter, and the value of the stock lower, than if probable reserves are also to be valued.

Valuation of flows of mineral and energy resources

Value of discoveries, reappraisals, extractions, depletion and catastrophic losses

215. The value of additions and reductions in the stock should be calculated using the average prices 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.

Acquisitions and disposals of mineral and energy resources

216. These transactions are likely to be rare but when they occur they should be recorded. Estimates of the value of these transactions should take into account the costs of ownership transfer that 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.

5.5.5 Other issues in the measurement of mineral and energy resources

Accounting for the ownership of mineral and energy resources

217. A general characteristic of mineral and energy resources is that they are often owned by general government on behalf of a country but they are commonly extracted by either private corporations or market based public corporations. As a consequence of this general legal framework there is usually a difference between the recognised legal owner of the resource and economic user and extractor of the resource.

218. The existence of separate legal and economic owners leads to various arrangements by which the legal owner, generally the government, seeks to recover the resource rent accruing to that legal ownership out of the total benefits earned by the extractor. Commonly, some of the rent (often referred to as royalties) is payable by the extractor to the government calculated based on the amount of resource extracted. Rent may also be recovered through various income tax arrangements or other mechanisms. The legal framework also gives rise to a range of permits and leases to access resources.

219. Where there is particular relevance in considering mineral and energy resources from an institutional sector perspective there may be interest in clearly articulating the relevant net worth positions of each sector and showing the complete sequence of accounting entries in the relevant accounts.

220. Unfortunately, following standard national accounting principles outlined in the 2008 SNA there is no ideal approach to the recording of the relevant accounting entries. The following are the key outcomes of the treatment in the SEEA.

i. The value of the mineral and energy resource should be split between the two owners based on their share of the future stream of resource rent. The share accruing the government should be based on the expected stream of payments of rent (royalties, special taxes, etc) by the extractor to the government.

ii. All of the depletion estimated in relation to the mineral and energy resource should be attributed, in the first instance, to the extractor in their production and generation of income accounts such that measures of depletion adjusted value added and depletion adjusted net operating surplus can be derived where the full cost of the depletion is shown against the extractor.

iii. In the allocation of primary income account in addition to the flow of rent from the extractor to the government a return transfer should be shown – a depletion transfer – representing the amount of depletion incurred by the government on their share of the resource. This transfer ensures that the net saving of each unit aligns with the change in their future income stream following extraction of the resource.

221. It is noted that this approach to the partitioning of assets and the associated entries for depletion can also be applied to other assets subject to depletion.

Table 5.5.5: Entries to account for split ownership of mineral and energy resources

	Legal owner		**Extractor**	
Transaction	**Resources/ assets**	**Uses/ Liabil.**	**Resources/ assets**	**Uses/ Liabil.**
Opening value of stock				
Mineral deposit	432		340	
Cash	0		0	
Net worth	432		340	
Production account				
Output – sales from extraction			1000	
Intermediate consumption				500
Gross Value Added			500	
Consumption of fixed capital			-150	
Net Value Added			350	
Depletion			-61	
Depletion adjusted Net Value Added			289	
Generation of income account				
Compensation of employees				200
Gross operating surplus			300	
Consumption of fixed capital			-150	
Net operating surplus			150	
Depletion			-61	
Depletion adjusted operating surplus			89	
Allocation of primary income account				
Rent	56			56
Depletion transfer		34	34	
Depletion adjusted saving		22		67
Capital account				
Depletion adjusted saving	22		67	
Depletion	-34		-27	
Consumption of fixed capital			-150	
Net Lending		56		244
Financial account				
Increase in cash	56		244	
Other changes in the volume of assets a/c				
Closing value of stock				
Mineral deposit	398		313	
Cash	56		244	
Net worth	454		557	

Treatment of renewable energy resources

222. Energy from renewable resources (renewable energy) has been an important source of energy in many countries and increasingly is being seen as an alternative source of energy for those countries that have primarily used energy from non-renewable sources. Renewable energy can be produced in various ways, including but not limited to wind energy, hydropower

energy (including run of river resources), solar energy, biomass including wood, and geothermal energy.

223. Setting aside energy sourced from the use of timber resources, other renewable energy sources cannot be exhausted in a manner akin to fossil energy resources and neither are they regenerated as is the case with biological resources. Thus in an accounting sense there is no physical stock of energy resources that can be used up or sold.

224. Therefore, the measurement scope of SEEA in relation to these resources relates to the amount of energy that is captured given current levels of fixed assets and associated capture technology. Excluded from scope are amounts of potential energy that could be captured based on available renewable energy resources if investment and technology were to increase in the future.

225. The presence of investments in renewable energy capture facilities and equipment impacts on the value of the land on which those facilities stand. For example, the land in a particularly windy area would be priced more highly than similar land in a non-windy area if investment is made to construct windmills to capture the energy from the wind resource. Thus, opportunities to earn resource rent based on resources like wind, solar radiation and geothermal energy are expected to be reflected in the price of land and are likely to be difficult to identify separately.

226. Given this difficulty of decomposition a separable asset of renewable energy resources is not incorporated into the central framework asset classification. At the same time, for countries in which there is particular interest in the value of renewable energy resources and a decomposition of the value of relevant land is undertaken these estimates should be recorded.

227. These accounting treatments do not apply in the case of energy sourced from timber and other biomass resources. Unlike other renewable energy sources a stock of timber resources can be observed and measured. In concept thevolume and value of timber resources (considered in detail in Section 5.8) encompasses all possible uses of the timber including its use as an energy source.

5.6 Asset accounts for land

5.6.1 Introduction

228. The consideration of land is central to economic and environmental accounting. Beyond an assessment of the ownership and use of land as part of economic production, some of the issues that can be considered in the context of land accounts include the impacts of urbanisation, the intensity of crop and animal production, afforestation and deforestation, the use of water resources and other direct and indirect uses of land.

229. 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 pin-point areas of change. The classifications and structures outlined in this section are designed to support work of this type.

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

231. This section is structured to define the scope of land accounts and define two primary views of land for environmental accounting purposes - land use and land cover. Categories and classes for the organisation 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

232. 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.

233. The measurement boundary for land accounts is defined by a country’s land area including all inland waters. The land area should be defined as the surface enclosed by all inland borders and, if applicable, the normal base-line (low-water mark) on the seaward side.

234. 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 a more specifically economic view point there may be interest in knowing the area of land owned by different institutional sectors, such as areas of government land, and regarding data on land used by different industries.

235. From the perspective of economic and environmental accounting there are two additional views that are of primary importance – land use and land cover. Classifications for land use and land cover are described in this section. Particularly for statistics organised on land cover, traditional administrative boundaries become less relevant and more interest is in the relationship of the different features of the environment and the interaction between these features and the economy and society.

236. Countries will have considerably different patterns of land use, land cover and landscape types. For example, forests may be of major or minor importance for a particular country and some land types, for example deserts, may not be present in all countries.Consequently, the categorizations reflected in the SEEA may require more detailed to be added for national purposes in order to highlight particular features and meet information requirements.

<u>Land use classification</u>

237. Land use reflects the activities undertaken in a certain land area. Estimates of land area classified by 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.

238. The land use classification is composed of four broad categories and 11 high level classes as shown in Table 5.6.1. The four categories are cultivated, forest and aquacultural land, built-up and related land, inland water areas and land not in use. The land use classification provides additional breakdowns of agricultural, forest and aquaculturalareas. The full classification with a description of classes is presented in Annex A5.3.

Table 5.6.1 Land Use Classification

Code	**Level 1**	**Level 2**
	Agricultural, Forest and Aquacultural land	
		Agricultural land
		Forest and other wooded land
		Land with aquaculture facilities
	Built-up and related land	
		Land used for mining and quarrying
		Land used for construction
		Land used for manufacturing
		Land used for technical infrastructure
		Land used for transport and storage
		Land use for commercial, financial and public services
		Land developed for recreational purposes
		Residential areas
	Inland waters	
	Land not in use	

239. The area of land classifiedto "land not in use" should be calculated to ensure that the aggregate area of land classified according to the land use classification aligns with the total area of land within a given country.

240. Usually, "land in use"can be related to economic activity of some type, including the ownership of dwellings. "Land not in use" may include land that has been set aside for conservation and environmental protection purposes. It is noted that the area of "Forest and other wooded land" includes areas other than those used exclusively for logging purposes and hence may include areas such as national parks that have been set aside for conservation purposes.

241. In some cases the land may support multiple uses at the same time or, over an accounting period the same area of land may be used for different uses at different times. In these cases the principle is that the primary or dominant use should be recorded in terms of ensuring that all of the land area within a territory has been attributed. At the same time there may be strong analytical interest in understanding the range of multiple uses and compilers should take this interest into account in developing land accounts.

Land cover classes

242. 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 is comprised of all of the individual features, known as basic objects, that cover the area within a country.

243. The UN Food and Agriculture Organisation (FAO) has developed an international standard classification system, the Land Cover Classification System, version 3 (LCCS 3)[9], that can be used to systematically record the biophysical characteristics of all areas of land within the national territory. The LCCS 3 provides a basis for any basic objects within any area of land to be defined and classified on a consistent basis starting from a set of characteristics (eg grass, shrub, tree, mineral, water, etc); properties (tree-type, managed growth, etc) and spatial patterns that reflect the way these basic objects are arranged on the land.

244. Even at this level of detail it is important to recognise some aspects of the property of the basic object such as whether a tree is cultivated or not. Thus at this basic level the classification is not strictly "pure" land cover. This reflects the fact that current land cover is, particularly in agricultural and forestry areas, a function of previous and current land use and not only of natural changes in the environment.

245. There are of course an enormous number of different basic objects and thus for the purposes of organising the different basic objects a set of basic land cover types is defined

[9] A higher level abstraction of the basic objects that compose land cover classes, as used in LCCS, called the "LCML" (for Land Cover Meta Language) has also been developed for use as a framework to classify land cover and compare systems internationally. This meta language 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.

as shown in Table 5.6.2. These different types are uniquely defined using the LCCS 3 structures and may be used to organise basic land cover information on a consistent basis across countries.

Table 5.6.2Land Cover Types

Code	Category
	Herbaceous crop
	Tree or shrub crop
	Multiple or layered crop
	Tree covered area
	Shrub covered area
	Herb covered area
	Sparse natural vegetation (terrestrial/aquatic/regularly flooded)
	Aquatic or regularly flooded tree covered area
	Aquatic or regularly flooded shrub or herb covered area
	Bare areas (terrestrial or regularly flooded)
	Artificial surfaces and associated areas
	Inland water bodies
	Glacier and perennial snow

246. The land cover types in Table 5.6.2 simply represent groupings of similar basic objects. They are not necessarily spatially related in a way that helps define a mappable area of land. For example it may be that within a given small area of land (such as a farm) there may be a combination of herbaceous crops, tree covered areas and inland water bodies.

247. Therefore, to define areas of land for analytical purposes it is necessary to group together the different land cover types. While there are a number of ways in which this might be achieved, the set of mappable land cover classes shown in Table 5.6.3 has been developed. It is noted that in a number of cases there is fairly close correspondence between the land cover type and the mappable land cover class, for example for glaciers and perennial snow and artificial surfaces and associated areas. In other cases, there are varying degrees to which the use of the land, particularly agricultural use, is taken into account in defining the mappable areas.

Table 5.6.3 Mappable land cover classes*

01	Urban and associated developed areas
02	Medium to large fields rainfed herbaceous cropland
03	Medium to large fields irrigated herbaceous cropland
04	Permanent crops, agriculture plantations
05	Agriculture associations and mosaics
06	Pastures and naturalgrassland
07	Forest treecover
08	Shrubland, bushland, heathland
09	Sparselyvegetated areas
10	Barren land
11	Permanent snow and glaciers
12	Open wetlands
13	Inland water bodies
14	Coastal water bodies

* Provisional set of classes

5.6.3 Physical asset accounts for land

248. 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. The measurement units of land in physical terms are units of area such as hectares or m^2.

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

250. However, there are situations where the area of land for a country may change for example due to rising sea levels or due to reclamation of land through the construction of dykes and other barriers.

251. As well, changes in the total area of land may occur due to political factors. For example, the total area may increase or decrease due to war and associated events and there are commonly areas of disputed territory. The area that is within scope of land cover and land use statistics should be clearly defined to avoid confusion.

Types of physical land accounts

252. In the first instance it is recommended that countries develop estimates of the total land area classified by land use and separately by mappable land cover class at the beginning and end of each accounting period.

253. With data structured in this way it is possible to construct tables showing land use by land cover and matrices showing the changes in land cover (or 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.

254. An additional step 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 infrastructures (through conversion of agriculture and natural land), intensification and industrialisation of agriculture (through conversion of family farming and mosaic landscapes), extension of agriculture in general (through conversion of forest land), drainage of wetlands, deforestation (for timber production and or agriculture development), and desertification (at the expense of formerly vegetated areas).

5.6.4 Physical asset accounts for forest and other wooded land

255. For particular land uses or land covers it is also possible to construct basic physical asset accounts as established for other resources. The most developed example of this is for forest and other wooded land. Most often the compilation of physical asset accounts for forest and other wooded land are 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. Section 5.8 covers in more depth the relationship between timber resources and forest and other wooded land.

256. The scope of the forest and other wooded land account is defined consistently with the definition of in the FAO Forest Resource Assessment 2010.[10]Forest landisdefined as land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use.

257. Forest land is divided into three types of forest.

i. Primary forests are naturally regenerated forest of native species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed. These forests usually show natural forest dynamics, such as natural tree species composition, occurrence of dead wood, natural age structure and natural regeneration processes. There has been no known significant human intervention or the last significant human intervention was long enough ago to have allowed the natural species composition and processes to have become re-established.

ii. Other naturally regenerated forests include naturally regenerated forest with clearly visible indications of human activities. These are selectively logged-over areas, areas regenerating following agricultural land use and areas recovering from human-induced fires, etc. These are also forests where it is not possible to distinguish whether they are

[10] The following definitions are sourced or adapted from the Global Forest Resources Assessment 2010: Specification of National Reporting Tables for FRA 2010. Forestry Department, Food and Agriculture Organization of the United Nations. Forest Resources Assessment Programme Working paper 135, Rome 2007

planted or naturally regenerated, and forests with a mix of naturally regenerated trees and planted/seeded trees.

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

258. 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 percent, or trees able to reach these thresholds in situ; or with a combined cover of shrubs, bushes and trees above 10 percent. It does not include land that is predominantly under agricultural or urban land use.

259. Where possible accounts should be compiled using these distinctions between types of forest and other wooded land. In addition, countries may be interested to compile accounts based on the total area of different species of tree.

260. A physical asset account for forests is presented in Table 5.6.6. 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, lakes, rivers and streams as appropriate

Table 5.6.6Physical asset account for forests (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						
Additions to stock						
	Afforestation					
	Natural expansion					
	Total additions to stock					
Reductions in stock						
	Deforestation					
	Natural regression					
	Total reductions in stock					
Closing stock of forest and other wooded land						

Additions to and reductions in the stock

261. All changes in the area of forest and other wooded land are reclassifications either between different types of forest and other wooded land or where there are changes in the are of land between forest and other wooded land and other land types, such as agricultural land. Following are the definitions of the particular types of reclassification that apply in the case of forest and other wooded land.

262. Afforestation represents an increase in the stock of forest and other wooded land due to either the establishment of new forest on land that was previously not classified as forests 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 or natural restoration, including restoration after transition from cultivation.

263. Natural expansion is an increase in area resulting from natural seeding, sprouting, suckering or layering.

264. Forest renewal by natural or silvicultural measures after clear-cutting does not qualify as an increase in forests. This land remains classified as forest land except when clear-cutting is preliminary to putting the land to an alternative use such as agriculture or construction.

265. 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 (as agricultural land, land under buildings, roads etc.) or to no identifiable use. Removals of standing timber by felling do not lead to decreases in forest and other wooded land if the use of the land does not change after felling.

266. Natural regression should be recorded when the stock of forest and other wooded land reduces for natural reasons.

267. 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 in the next part.

5.6.5Monetary asset accounts for land

268. The monetary asset account for land follows the structure outlined in Table 5.6.7. 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.

269. Table 5.6.7 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 5.6.7Monetary asset account for land (monetary unit)

		Type of land use				Total
		Agricultural land	Forest and other wooded land	Built up and related land	Other land and water areas	
Opening value of stock of land						
Additions to stock						
	Acquisitions of land					
	Reclassifications					
	Total additions to stock					
Reductions in stock						
	Disposals of land					
	Reclassifications					
	Total reductions in stock					
Revaluations						
Closing value of stock of land						

Valuation of land

270. Unlike 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 rural land. However, determining the value of the land itself is a complex task.

271. Generally, the market values of land encompass both the value of the location and the value of the physical properties on the land and separating these two values may be difficult. Further, although there is a market in land, relatively little land changes hands 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 land.

<u>Composite assets</u>

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

273. 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.

274. 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) and to deduce the value of the land from the replacement cost of the buildings or from the value on the market of the combined land and buildings. Another approach is to use estimates of the depreciated value of the stock of dwellings and other buildings and structures that is often compiled for the purposes of the core national accounts and deduct this amount from the value of the composite asset.

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

276. Land improvements.In addition to 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 characterised by the outcome that 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.

277. 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 full accounting treatment for land improvements refer to the 2008 SNA.)

278. 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 land under forests, the separation should be based on the value of the stock of timber resources (for details see section 5.8) For cultivated biological resources other than timber resources, the range of techniques for making this distinction outlined for buildings and structures are also relevant for these assets.

279. 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 for other land. However, given the shared characteristics of these assets, determining appropriate valuations may be difficult.

280. 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.

The treatment of costs of ownership transfer

281. Whenever land is sold, there are transaction costs involved, arising, typically, 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. As a 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.

282. 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 on this general position need to be clarified. Where the transaction involves only land and land improvements (for example where the sale of buildings, forests, is not involved), the cost of ownership transfer are allocated to the produced asset land improvements. Where the transaction involves land and other fixed assets (such as buildings or cultivated biological resources) the costs are allocated to the specific fixed asset involved. In both of these situations the costs are also recorded against the opening and closing stock values for the relevant produced asset.

283. It is also noted that where the costs of ownership transfer relate to a non-produced asset other than land (such as when related to the sale of mineral and energy resources or natural timber resources) the costs are capitalised against the item "costs of ownership transfer on non-produced assets" but they are recorded on the balance sheet against the non-produced asset in question.

5.6.6Linkages to ecosystem accounting

284. Ecosystem accounting is founded on consideration of the capacity of the environment to deliver ecosystem services. Importantly, it is interactions between different environmental assets within a given area of land that generates ecosystems services.

285. A parallel can be drawn between (i) the areas that deliver ecosystem services through the interaction of environmental assets and (ii) the producing units defined in economic statistics that use a combination of assets, including human capital, to produce goods and services. In economic statistics these producing units also form a basis of observation for the collection of data and can be grouped according to those units that produce similar outputs and undertake similar activities.

286. Using this parallel, the construction of ecosystem accounts can be commenced by defining areas of land that deliver similar ecosystem services. In this regard the mappable land cover classes shown in Table 5.6.4 can be used for this purpose. In the context of ecosystem accounts these areas of land are effectively statistical units that are classified on the basis that they produce a similar primary ecosystem service. In this sense they may be referred to as land cover functional units.

287. Ecosystem accounting must go one step beyond this however. Ultimately, the delivery of ecosystem services by functional units is also dependent on the surrounding topography including elevation and slope, whether the unit is part of a river basin and the location of the different functional units.In short, the assessment of ecosystem services makes most sense within the context of a landscape. The land cover functional unit should therefore be aggregated to form landscape units.

288. Five primary types of landscape unit can be considered in the development of ecosystem accounts: mountain ecosystem landscapes, highland ecosystem landscapes, lowland ecosystem landscapes, coastal landscapes and river systems. The ways in which these landscape units are defined in relation to the various land cover functional units and the broader issue of the construction of ecosystem accounts (including measures of ecosystem services) is covered in detail in SEEA experimental ecosystem accounts.

5.7 Accounting for soil resources

5.7.1 Introduction

289. Soil resources form a fundamental part of the environment. They provide the physical base to support both the growth of biological resources and, particularly in agricultural and forestry areas, soil resources are the source of nutrients to plants and provide an essential store of water.

290. Accounting for soil resources in purely quantitative terms provides information on the amount of soil lost due to soil erosion and other causes. More broadly, accounting for soil resources in terms of their types, volumes, nutrient content, and other characteristics is relevant for a more detailed examination of agricultural production and the impact of changing land uses, in particular the impact of urbanization.

291. Research into the quantity and quality of soil by soil scientists has been a longstanding undertaking in many countries. This section explains how research on soil can be combined with accounting for environmental assets.[11] A characterization of soil resources is provided together with discussion on accounting for soil resources in physical and monetary terms.

5.7.2 Characterization of soil resources

292. Soil resources are a form of environmental asset providing a range of ecosystem services. A key feature of soils is their delivery of supporting services including the formation of soils, nutrient cycling and water cycling.

293. In the central framework the focus of accounting for soil resources is on the volume of soil and the various components and properties of soil. Soil components reflect the biogeochemical composition (eg. mineral, organic, liquid or gas). Soil properties reflect the physical, chemical and biological characteristics of the soil – eg porosity, texture, pH level, microbial biomass.

294. Using information on different combinations of components and properties various soil types can be defined. It is these various soil types that can provide the basis for a generalised accounting for soil resources.

295. Soil resources are distinguishable from land and associated water areas in physical terms since land is defined through its delineation of space. In monetary terms however, separating the values of these two environmental assets may be very difficult since it is unlikely that the soil resources can be physically removed from a given area except at the margin. Thus by convention, the value of land and soil is combined.

[11] For material examining this issue from a soil science perspective see, for example, Dominati et al, 2010, “A framework for classifying and quantifying the natural capital and ecosystem services of soils”, Ecological Economics, Vol 69.

5.7.3 Accounting for soil resources in physical terms

296. A first stage of accounting for soil resources provides an articulation of the quantity of different soil types available within a country, either in terms of area or, ideally, in terms of depth and volume. 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.

297. Most benefit from information on soil types is gained by spatially mapping this information and cross classifying it with information on land use to analyse the ways in which different soil types are being used. Such an analysis may also consider the extent to which soil of different types are being effectively lost through urbanisation and other changing land uses.

298. It is likely that the focus of accounting for soil resources in the first instance would be on soil in agricultural areas. Using the link between soil types and detailed agricultural land use statistics, connections can be made to the productivity of soil over time. Thus the question may be answered as to whether a particular soil type has the capacity to generate the same quantity of output of agricultural products over time. In this regard analysis in combination with flows of fertilisers and pesticides and other agricultural inputs may be of interest.

299. A second stage in accounting for soil resources is to consider more directly the ecosystem services that are produced by soil. Such an accounting approach would lead to the assessment of soil degradation and examine issues such as salinization, acidification and eutrophication of soils. This aspect of accounting for soil resources is considered as part of SEEA experimental ecosystem accounts.

5.7.4 Accounting for soil resources in monetary terms

300. Since, by convention, the values of land and soil resources in monetary terms are combined, a general monetary accounting approach for soil resources only is not considered here. However, for certain areas, such as agricultural areas, it may be meaningful to consider the relationship between changes in soil resources in physical terms and the derivation of income from the production of agricultural outputs. Indeed, if agricultural land could be broken down into different soil types, meaningful monetary indicators might be derived concerning the capacity of the soil to support different agricultural activities.

301. For these areas a monetary estimate of depletion could be obtained by assessing the loss in the capacity to generate income in the future due to declining volumes of certain soil types that are caused by agricultural activity and other changes described above. This would then take into account losses of soil due to erosion and where the soil type has changed due to changes in soil components or soil properties. Changes in soil components or properties and hence changes in soil types may be positive or negative depending on the agricultural activities and practices being undertaken. For example, the replenishment of organic material to the soil would be one factor to incorporate.

302. To the extent that the soil is being used in a fashion that its volume and characteristics remains stable over time then depletion would be zero. Where soil quality was improved over

time through careful management this would represent an addition to the stock of soil resources and should be reflected in higher future incomes and higher land and soil values.

5.8Asset accounts for timber resources

5.8.1 Introduction

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

304. The compilation of timber resource asset accounts is one measurement tool in providing information to assess and manage 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:Asset accounts for land.

305. This 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 is the delineation between cultivated and natural timber resources. The section then presents a physical asset account and a monetary asset account for timber resources. The final part of this section outlines a physical asset account for carbon in timber resources. This is a simple extension of the physical asset accounting for timber resources.

5.8.2 Definition of timber resources

306. Following definitions from the UN Food and Agriculture Organisation (FAO)[12] timber resources are defined as the volume of standing 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. It should be measured as the stem volume over bark at a minimum breast height from the ground level or stump height up to a top. Excluded are smaller branches, twigs, foliage, flowers, seeds and roots. The thresholds for minimum diameter of breast height, top and branches may vary across countries. This volume is often referred to as standing timber.

307. Timber resources may be found in a wide variety of places and may or may not be available to be felled and used to produce timber products or as fuel. For example some timber resources will be found in national parks and in many cases these areas are not open to logging activity.

308. Table 5.8.1 provides a breakdown of the possible areas in which timber resources are found classified by the availability of the timber to be used as inputs to production. Conceptually, the timber resources in all of these areas are within scope (i.e. boxes A – F).

[12] See Global Forest Resources Assessment 2010: Specification of National Reporting Tables for FRA 2010. Forestry Department, Food and Agriculture Organization of the United Nations. Forest Resources Assessment Programme Working paper 135, Rome 2007

In practice, countries should determine the scope of their timber resource accounts depending on the relative importance of the type of area in supporting timber resources.

Table 5.8.1 Scope of timber resources

	Areas with timber resources		
	Forest land	Other wooded land	Other land with wood supply (eg orchards)
Trees available for timber supply	A	B	C
Trees not available for timber supply	D	E	F

The boundary between cultivated and natural timber resources

309. The determination as to 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. This growth is recorded as production as it takes place. The growth of natural timber resources, on the other hand, is only recorded at the time the timber is removed from the forest or other land area and enters the production boundary.

310. 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. There are three key aspects to consider:

i. Control over and undertaking of harvesting is not sufficient to establish that the timber resources are cultivated. Thus if the only control exercised over the resources is legislative control over access and harvest this should not be sufficient to consider that the timber resources are cultivated.

ii. For the timber resources to be considered cultivated they should be producing or in the process of producing economic benefits for their owners. Those trees that may have been planted and managed for the purposes of re-establishing natural areas but where there is no current intention of logging should not be considered cultivated.

iii. The processes involved in cultivation must constitute a process of economic production 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, attend to disease. The level of this production activity should be significant relative to the value of the timber resources and should be directly connected with the timber resources in question.

311. In practice, the determination of whether timber resources in a given area are cultivated or natural is usually based on the type of forest land. Thus, timber resources from planted forests and other naturally regenerated forests are considered cultivated and timber resources from primary forests are considered natural. Definitions of these types of forest are found in section 5.6.

312. The same considerations are applicable in determining the treatment of timber resources on other wooded land as either cultivated or natural. That is, other wooded land can be considered to be planted, other naturally regenerated or primary in nature.

5.8.3 Physical asset accounts for timber resources

313. 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 rate of natural growth of timber resources compared to the rate of removals.

314. The physical asset account for timber resources should distinguish between the type of timber resource particularly between cultivated and natural timber resources and if possible by type of regeneration – planted or naturally regenerated. Depending on the purpose of analysis accounts by species of tree may be compiled.

315. 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.

316. A physical asset account for timber resources is presented in Table 5.8.2.

Additions to the stock

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

318. 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 and other wooded land that lead to increases in the volume of available timber resources should not be considered as natural growth but instead should be recorded as reclassifications. Reclassifications may also occur due to changes in management practice that shifts timber resources from cultivated to natural or vice versa.

Table 5.8.2Physical asset account for timber resources (cubic metres over bark)

		Type of timber resource			
		Cultivated		Natural	Total
		Planted	Other naturally regenerated	Primary	
Opening stock of timber resources					
Additions to stock					
	Natural growth				
	Reclassifications				
	Total additions to stock				
Reductions in stock					
	Removals				
	Natural losses				
	Catastrophic losses				
	Reclassification				
	Total reductions in stock				
Closing stock of timber resources					
Supplementary information					
Fellings					
Felling residues					

Reductions in the stock

319. The stock of standing timber 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 forests 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 – eg industrial roundwood and woodfuel or by species of tree – eg coniferous, broadleaved.

320. Removals are the relevant variable for measuring the extraction of timber resources because the definition of the stock of timber resources includes timber that has been felled and is on the ground but not yet removed.

321. Natural losses are the losses to the growing stock during an accounting period due to mortality from other causes than cutting by man. Examples include losses due to natural mortality, insect attack, fire, wind throw or other physical damages.

322. Natural losses should only include those losses that would reasonably be expected when considering the timber resources as a whole. Exceptional and significant losses due to natural causes should be accounted for as catastrophic losses.

323. The volume of natural losses and catastrophic losses should only be recorded against these categories when there is no possibility that the timber resource can be removed.

Fellings and felling residues

324. 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 standing volume of trees that are felled during an accounting period. Fellings include silvicultural and pre-commercial thinnings and cleanings left in the forest.

325. In addition there may be interest in the volume of fellingsthat are not removed, i.e. felling residues.Estimates of felling residues may provide important information on the nature of forestry practice.

326. Where available estimates of fellings and felling residues may be added as supplementary information in the physical asset account.

Timber resources as a renewable resource

327. A broader discussion on renewable energy is presented in Section 5.5. It is noted that unlike other renewable energy sources a stock of timber resources can be observed and measured. Thus, in concept the volume and value of timber resources will encompass all possible uses of the timber including its use as an energy source.

5.8.4Monetary asset accounts for timber resources

328. Monetary asset accounts for timber resources consist of 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 5.8.3.

329. 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.

330. Since the scope of timber resources includes those resources that are not available to supply inputs to production it is possible that some timber resources have low or zero values in monetary terms. In these situations countries may limit the scope of timber resources included in their monetary asset accounts. Whatever scope is chosen for the monetary asset account it is important to clearly identify the corresponding scope of physical resources such that meaningful indicators of timber resources in physical and monetary terms can be produced.

331. 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 2008 SNA only the change in inventories would normally be recorded but the entries are recorded on a gross basis in the SEEA.

332. For natural timber resources the natural growth is not considered an increase in inventories since the growth in the trees is not considered as 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 5.8.3Monetary asset account for timber resources (monetary unit)

		Type of timber resource			
		Cultivated		Natural	Total
		Planted	Other naturally regenerated	Primary	
Opening stock of timber resources					
Additions to stock					
	Natural growth				
	Reclassification				
	Total additions to stock				
Reductions in stock					
	Removals				
	Natural losses				
	Catastrophic losses				
	Reclassification				
	Total reductions in stock				
Revaluations					
Closing stock of timber resources					

Valuing the stock of timber resources

333. In line with the general definition of resource rent (see Section 5.4), resource rent on timber resources is derived as the gross operating surplus from the harvest of timber resources less the value of the user cost of produced assets used in the harvesting process.

334. Defined in this way the resource rent will implicitly includes 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 due to the location of the land and the quality of the soil the return to the land may not be large compared to the return to the timber resource but where relevant an estimate of the resource rent attributable to land should be deducted to derive the estimate of resource rent for timber resources.

335. Estimates of resource rent may be also 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 forest. 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 costs should include thinning (net of any receipts), other forest management costs and rent on the forest land. For natural forests, the management costs may be very low or even zero.

336. As well as stumpage prices, ideally, estimates of the volume of standing timber per hectare at the harvesting age are also needed. These volumes are multiplied by the stumpage price to estimate future receipts, and discounted to estimate a value per hectare for each age class. 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.

337. A slightly simplified approach is to consider the current age structure and assume that each tree of a particular age grows to maturity and is harvested at maturity. Then the application of age specific prices generates an income flow for each age of tree that can be discounted back to the current period.

338. The primary difficulty in applying these NPV approaches is 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.

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

340. While these two methods are variants of the basic NPV approaches the assumptions underpinning them are restrictive and should be carefully considered before being used to value timber resources. It is noted that particularly in the case of a changing age structure of timber resources due to either overexploitation or active afforestation, the stumpage value method and the consumption value method will not provide robust valuations estimates.

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

Valuation of natural growth,removals and other flows

342. In general terms the valuation of flows of timber resources should be undertaken using the same assumptions underlying the valuation of the opening and closing stock of timber resources.

343. The value ofremovals is always given by the stumpage value of the timber removed from the forest. When the stumpage prices are not available, harvesting costs must be deducted from the value of the wood in the rough.

344. The value of catastrophic losses is given by the difference between the value of the stock of timber just before the catastrophic event and its value immediately after. When a catastrophic event does not destroy the wood, it is necessary to take into account the value of the wood that will be salvaged. 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.

345. It is noted that there may also be revaluation effects following large catastrophic events. Prices may rise following a destruction of timber resources due to fire or 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.

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

5.8.5 Carbon accounts for timber resources

347. The assessment of carbon binding is an increasingly important consideration. Estimates of the amount of carbon bound in timber resources**s**and the changes in these amounts over an accounting periodcan be derived from information on opening and closing volume of standing timber and the changes in volume by applying relevant average coefficients.[13]

348. A carbon account for timber resources can be developed based on the structure of the physical asset account for timber resources (Table 5.8.2).

349. It is noted that references to reductions in the stock of carbon in timber resources, for example due to removals, does not imply that carbon has been released to the atmosphere. In general, carbon will remain bound in timber until the timber is burnt or decomposes naturally.

350. A complete articulation of carbon accounting, including for example carbon binding in soils, is beyond the scope of the central framework but will be discussed in SEEA experimental ecosystem accounts. This is mainly because calculation methods are still developing and are not mature enough to provide sufficiently reliable information. At the same time it is noted that the underlying accounting models such as asset accounting and physical flow accounting are sufficiently well developed to be able to used for carbon accounting purposes.

[13]See Intergovernmental Panel on Climate Change (IPCC): Good Practice Guidance for LULUCF and UNFCCC Guidelines on annual inventories.

5.9Asset accounts for fish resources

5.9.1 Introduction

351. Fish resources (including all aquatic resources) are an important biological resource. Fish resources are subject to harvest for commercial as well as through recreational and subsistence fishing activities. The abundance and health of wild fish resources in inland and marine waters are also increasingly affected by water pollution and by the degradation of fish habitats through, damming and diversion of rivers, restricted water release from reservoirs to rivers, clearance of mangroves, sedimentation, coral mining, deforestation in the hinterland and other activities. The dual impacts of excessive 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.

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

353. Asset accounts for fish resources aim to organise information on the quantity and value of fish resources within a national boundary and their changes, in order to assess the sustainable use of national fish resources. Asset accounts cover both cultured fish resources and wild fish resources thus enabling a comparison of trends in both resources.

354. This section provides a definition and classification of fish resources including discussion of the boundary between cultured fish and wild fish. Then a physical asset account is described with a particular focus on the measurement of resources of wild fish. Finally a monetary asset account is presented incorporating discussion on the role of quotas and licences in estimating the value of fish resources.

5.9.2 Definition and classification of fish resources

355. The key features of fish resources distinct from other environmental assets are the capacity for the population to regenerate over time and the free movement of the resources across national boundaries.

356. The fish resources for a given country comprise those fish that are considered to live within the Exclusive Economic Zone (EEZ) of a country throughout their lifecycles, both coastal and inland fisheries, and also those fish stocks, such as migrating and straddling stocks and stocks that complete their life cycle in international waters (high seas), over which exploitation control has been established and to which the access rights of a country are defined in international agreements.

357. The actual fish resource of a given country with regard to migratory, straddling and high seas stocks is considered to be a proportion of the access rights of that country to the

shared resources. 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 fish resource can be determined on the same basis. In the absence of specific information about the share of the common fish resource, the realised catch by a given country can be used as an indicator of the country's share.

358. This measurement boundary is defined with reference to the United Nations Convention on the Law of the Sea (see United Nations, 1997a), in particular the Agreement for the Implementation of the Provision 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, 1998, sect. I; see also A/CONF.164/37) and the Code of Conduct for Responsible Fisheriesof the FAO(ibid., sect. III). Together these agreements create a legal framework for international fisheries management.

Classification of fish resources

359. Fish resources include fish, crustaceans, molluscs, shellfish and other aquatic organisms such as sponges and seaweed, as well as aquatic mammals such as whales. The high level classification of fish resources is shown in Table 5.9.1.

Table 5.9.1 Classification of fish resources

	Level 1	**Level 2**	**Level 3**
	Fish resources		
		Culturedfish resources	
			For harvest (inventories)
			For breeding (fixed assets)
		Wild fish resources	

360. FAO and other fishery and aquaculture related institutions have collected capture and aquaculture production of fish, itemized at species level as much as possible. The data includes 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.

361. The ASFIS list of species currently contains 11,562 species, is commonly used as the standard reference of fish. It is linked to the FAO "International Standard Classification for Aquatic Animals and Plants" which divides commercial species into 50 groups on the basis of their taxonomic, ecological and economic characteristics. [14]

[14] The ISCAAP is maintained by the Co-ordinating Working Party on Fisheries Statistics (CWP). Details on CWP and ASFIS are available at www.fao.org/fishery

362. Fish resource can be further grouped into the nine divisions below.

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.

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

Harvesting fish and the production boundary

364. Fish resources may be either cultivated or natural biological resources. The treatment depends on the degree to which the natural growth and regeneration of the biological resource is under the direct control, responsibility and management of an institutional unit and is linked to the production boundary.

365. 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 fish resources, the growth of fish in fish farms and other aquacultural facilities is treated as a process of production.

366. 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 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".

367. Following the FAO definition of aquaculture, all cultured fish are considered to be cultivated biological resources and all types of wild, enhanced and ranched fish are considered to be natural biological resources.

368. While all cultured fish are cultivated biological resources not all farming of fish is undertaken in the same way. Some aquaculture is undertaken using netted areas in rivers or off-shore and 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 the fish are entirely removed from the natural environment. Therefore, it may be the case that some cultured fish should not be considered environmental assets following the principles outlined in Section 5.2.

369. However, the measurement of all fish is important to give a complete coverage of fish resources. In practice it may not be possible to distinguish between cultured fish resources on the basis of the farming practice but this may provide useful information given that the interaction with the environment and the nature of flows within the economy are likely to be different.

5.9.3 Physical asset accounts for fish resources

370. A physical asset account for fish resources shows the total biomass of all species that are harvested either within the national boundary or by vessels whose flag belong to the reference country (where applicable), and that are kept in cultivation. It also shows the changes due to harvest, natural loss, natural growth (increase in size), recruitment (growth in numbers) and other changes.

371. A basic asset account for fish resources in physical terms is presented in Table 5.9.2

Table 5.9.2Fish resources physical asset account (tonnes/numbers)

		Type of fish resource		
		Cultured fish – fixed assets	Cultured fish - inventories	Wild fish
Opening stock of fish resources				
Additions to stock				
	Natural growth			
	Reclassifications			
	Total additions to stock			
Reductions in stock				
	Gross Catch			
	Natural losses			
	Catastrophic losses			
	Uncompensated seizure			
	Reclassifications			
	Total reductions in stock			
Closing stock of fish resources				

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

Cultured fish resources

373. In the case of cultured fish it is reasonable to assume that estimates of the volume of stock and changes in the stock are able tobe estimated by the operator or owner of the resource. Accounts should be structured by species as appropriate. Increases come from natural growth and decreases from harvesting (gross catch) and natural losses.

374. When wild fish are introduced either as seeds or breeding stock this should be recorded as a reclassification from wild to cultured fish. A risk for aquaculture undertaken in rivers and marine environments is that the fish may escape into the external environment. These escapes should be considered a reclassification from cultured fish to wild fish.

375. Unexpectedly large losses due to disease or natural catastrophe should be consideredcatastrophic losses.

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

Wild fish resources

Measuring stocks of wild fish resources

377. While asset accounts for wild fish resources may be compiled separately between freshwater and marine fish resources, the measurement issues are closely aligned. The primary difficultly is the measurement of opening and closing stocks.

378. Fishery biologists define a fish “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 considered to belong 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 fish belonging to a stock move around multiple countries’ boundaries, the international collaboration in management is needed and the national asset account of such stock can be defined as a proportion of share to access to the stock.

379. There are several definitions that can be used in measuring the size of the resources. The most important concept is to measure the sexually mature part of the stock (i.e. the spawning stock or parental biomass), as it is believed that the main purpose of fishery management is to maintain adequate level of spawning stock to be able to generatenatural growth and to minimize the probability of collapse.Generally, little is known about the cohorts that are younger than those being harvested. However, in the case where stocking with cultured seeds is regularly conducted, as the case commonly observed in freshwater

resources, it is important to include the amount of released seeds into the asset account as reclassification from cultured fish in order to assess their potential impacts on wild ecosystems and gene pools.

380. Like all living creatures, wild fish form a part of a complex ecological system where some fish are predators and others are prey, some are both. To be able to understand the dynamics of the biological system, estimate its productive potential, and avoid serious overfishing, it is important to gather information on all species harvested as well as being affected by fishery activities.

Virtual population analysis

381. Physical data on stocks are usually compiled by biologists who use different methods to estimate the size of the stocks. Virtual population analysis (VPA) is commonly used and is the most reliable method when data on the proportions of different cohorts in the catch and data on catch per unit effort (eg fishing days) are available. This method is more effective in relatively long lived species and in the estimation of the stock size of a single species.

382. When this information is not available, biologists rely on other models that relate the size of the stock to the amount of effort (eg fishing days) required to realize a certain type of catch. These methods may not be very precise, partly because it is difficult to estimate the volume of effort in homogeneous units, but they are still useful to obtain rough estimates of stock condition as well as being applicable to the cases where the harvesting of several species is undertaken simultaneously with various types of equipment.

383. Stocks of bigger aquatic animals like seals and whales can be estimated by direct enumeration of the number of animals in randomly sampled areas if animals can be spotted outside water.

384. Estimates of the absolute size of fish stocks can be imprecise. 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, and the rate of natural death from accidents, sickness, age, predators and so on, which makes it difficult to estimate the productive potential of the fish stock. However, the above mentioned procedures can at least provide reasonable indicators on relative changes in fish stock sizes.

Measuring changes in wild fish stocks

Accounting for the harvest of wild fish

385. In physical terms, all fish harvested and expenditure used to realize the harvest (eg in terms of fishing days multiplied by vessel power) should be recorded. Further, the fish harvested in the open seas, coastal waters or inland waters by commercial or recreational fishing count as production at the time they are harvested regardless of whether they are

sold in the market or used for own consumption. This scope includes the activity of subsistence fishing.

386. There may be differences between measures of quantities harvested using different definitions of catches. The different catch concepts that may be recorded are:

i. *Gross removal.* The total live weight of fish caught or killed during fishing operations.

ii. *Gross catch.* The total live weight of fish caught (Gross removal less pre-catch losses)

iii. *Retained catch.* The total live weight of fish retained (Gross catch less discarded catch)

iv. *Landings.* The net weight of the quantities landed as recorded at the time of landing

v. *Nominal catch.* The live weight equivalent of the landings.

387. For the asset accounts the concept of gross removal is most appropriate. Subsequent changes to the weight of fish should be considered the result of processing of the fish catch. In practice, the most common catch concept is landings but this measure excludes the discards of incidentally caught organisms through fishing activity as well as the damage done to aquatic ecosystems, eg to coral reefs, due to fishing activity. For environmental accounting the measurement of by-catch is an important element in fully understanding the linkages between economic activity and the impact on fish stocks.

Capture fishing by non-residents

388. Given the nature of fish resources and fishing activity there will be capture fishing undertaken by non-residents within another country's EEZ. Following the principles of the 2008 SNA, the location of the fish resource is not the key determinant of the attribution of economic production. Rather production is allocated to the country of residence of the extractor. Therefore, in the assessment of the change in the fish resources belonging to a country over an accounting period, it is not sufficient or accurate to focus only on the catch by fishing operations undertaken by residents of that country. This estimate will exclude changes in the national fish resource due to catch by non-residents and will include catch by residents in other countries. For the purposes of accounting for the national fish resource the focus must be on the total catch from the country's fish resource irrespective of the residency of the fishing operator.

Illegal fishing

389. If a resident fishes beyond the scope of his licence, he is fishing illegally. Nonetheless, following the principles of the 2008 SNA, this harvest should still be recorded as production with an income accruing to the fisherman, even though he is acting illegally.

390. In cases where non-residents fish illegally, either without a licence or by taking catch in excess of their allocated quota, the physical removals should be recorded and valued. These flows should be recorded as uncompensated seizures. In recording such flows care must be taken to exclude these flows from estimates of gross catch.

Other physical flows

391. It is unlikely to be the case that direct information can be separately obtained regarding the growth in wild fish resources. Consequently, the estimates of natural growth should be derived based on estimates of the opening and closing stock of fish resources and the extent of harvest.

392. It is also likely that reappraisals of the size of the fish resource, both upwards and downwards, will occur and these changes to the resourcewill most likely be reflected in improved estimates of other flows.

5.9.4 Monetary asset account for fish resources

393. A monetary asset account for fish resources records the opening and closing values of fish 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.

394. A basic monetary asset account for fish resources is presented in Table 5.9.3.

Valuation of cultured fish resources

395. Fish farmed in an aquaculture establishment are produced assets, either as inventories or fixed assets in the case of breeding stocks. In most cases, market prices are obtainable and can be used to estimate the value of live fish owned by the establishment and the value of the flows of fish over an accounting period.

Valuation ofwild fish resources

396. Monetary valuation of wild fish resources is complicated. There are two primary options. One possibility is to value the fish resource via 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 fish resources. Under the NPV approach there are two main approaches to estimating the resource rent – using information on annual fishing licences or using information from the national accounts under the residual value method (see section 5.4 for details).

Table 5.9.3 Monetary asset account for fish resources (monetary units)

		Type of fish resource			
		Cultured fish – fixed assets	Cultured fish - inventories	Wild fish	**Total**
Opening stock of fish resources					
Additions to stock					
	Natural growth				
	Reclassifications				
	Total additions to stock				
Reductions in stock					
	Gross catch				
	Natural losses				
	Catastrophic losses				
	Uncompensated seizure				
	Reclassifications				
	Total reductions in stock				
Revaluations					
Closing stock of fish resources					

397. If there is a perfectly functioning market for fishing licences and 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 and uncertainties in the statistical assumptions required for net present value calculations, this is unlikely to be exactly the case in practice.

Valuing fish stocks using licence and quota information

398. In many countries, a fishing licence issued by government is required in order to practise either fresh water or marine fishing. 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.

399. An increasingly common approach to controlling marine fishing so as to prevent overfishing is to issue fishing quotas. These are usually issued by government (which is also responsible for ensuring their enforcement) and may apply both to fishing within the waters of the country's EEZ and to fishing on the high seas. Quotas typically apply to a particular species of fish.

400. Quotas may be given away free to certain designated persons (for example, people in locations where fishing is the main source of livelihood) or sold. 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.

401. 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 fish stocks to which it relates.

402. When fishing rights, evidenced by the existence of licences and quotas, are freely traded, it is possible to estimate the value of the fish resource 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.

403. Two forms of individual transferable quotasystems are common. An individual transferable quota (ITQ) provides entitlement to an absolute level of catch. An individual transferable share quota (ITSQ) 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.

404. 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 fishery 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 use of the fish resource.

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

406. However, in most of those cases where ITQs, ITSQs and similar arrangements are used to manage fisheries, the market in these quotas is far from perfect and so the access rights do not reflect the full value of the resource. Fishing licences and quotas are often introduced when considerable excess capacity exists in the fishing 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 capital intact. A total permissible catch resulting in fishermen's earnings that are higher than this level will mean that some of those earnings should be regarded as depletion of the fish resources and not as income.

Valuing fish stocks using the NPV of future resource rents

Estimating resource rent

407. Following the approaches outlined in Section 5.4 and Annex A5.1, the operating surplus from fishing of wild fish resources can be used as a basis for the calculation of the resource rent of the wild fish. 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 fish resource.

408. 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 production 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 fish stocks 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.

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

410. In addition, besides permitting fishing in excess of the sustainable level of catch, Governments may sometimes subsidize fishing so that fishing continues even when the resource rent is negative.

Estimating the asset life

411. Estimating the asset life of fish resources presents a difficult measurement challenge. If the fish stock is to be preserved in perpetuity, harvest should not exceed the renewal rate of a stable fish population. In general, questions regarding the degree of sustainable use of a fish resource can only be answered through consideration of biological models. These models provide a basis for estimates of the numbers of fish and the renewal rate based on information about the fish catch. (A discussion on this topic is presented in Section 5.4.2)

Valuation of changes in fish resources

412. A change in the value of fish resources may be brought about by a wide range of factors. When it is not possible to identify reasons for changes in the size or value of stocks and to attribute the changes to natural causes or fishing activity, it will be possible to prepare only a minimal asset account. The physical asset accounts may consist of catch data for a number of species but without corresponding stock estimates for all of the

species. Thus, it may not be possible to value the stocks of individual species, so that only a regional or national aggregate resource values will be produced.

413. Increasingly, though, estimates are available of stocks for individual species, since this is the basis on which quotas are determined. Even when stock estimates are not available, it is necessary to consider the causes of increases and decreases in the stock in order to determine how to record these in monetary accounts. Ideally, recruitment, natural growth and natural loss could all be estimated and recorded separately. Owing to data limitations, this category is often available only as a composite “other changes” measured as the residual difference between the amount harvested and the change between opening and closing stocks.

5.10 Accounting for other biological resources

5.10.1 Introduction

414. 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.

415. 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 bio-diversity. These resources may include wild berries, fungi, fruits and other plant resources that are harvested for sale or own consumption. Alternatively they may relate to wild animals such as deer, boar or moose that are killed for sale or own consumption.

416. 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 2008 SNA.

417. This 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

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

419. As a consequence of not being under direct control of institutional units natural biological resources are not easily accounted for. Aside from wild fish 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 has not tended to be active measurement of the available resource. As well, many of the examples that might be considered pertain to use for own consumption or as part of subsistence farming.

420. At the same time there are particular species in certain countries where reasonably significant commercial operations operate, possibly illegally, and where there is significant extraction of animals and plants from the wild. Examples include the hunting of elephants for ivory and hunting of kangaroos for meat. There may therefore be interest in the organisation 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.

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

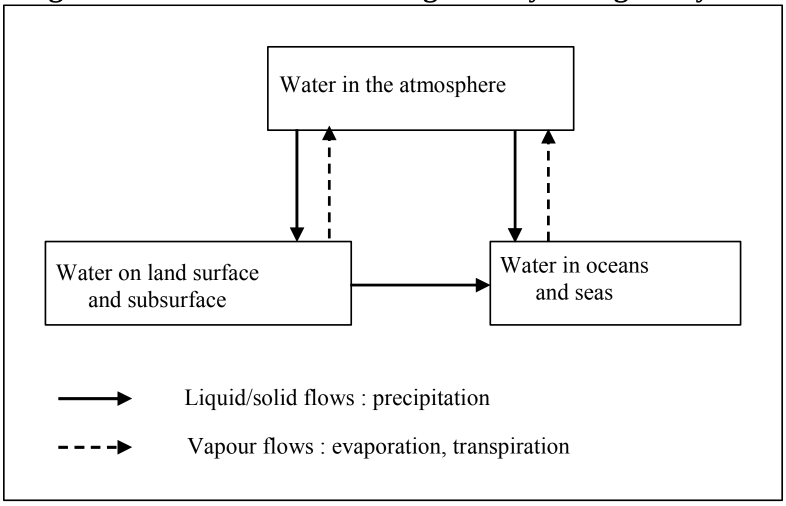
422. As natural biological resources may form an important part of bio-diversity and ecosystems in particular regions, there may be interest in compiling data on the availability and extraction of these resources at sub-national spatial levels. Further, information on these resources may be able to form an input into broader measures of ecosystem health that are discussed in SEEA experimental ecosystem accounts.

5.11 Asset accounts for water resources

5.11.1 Introduction

423. 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 evaporation, precipitation and other flows. The natural cycle of water, the hydrological cycle, involves connections between the atmosphere, the oceans and land surface and sub-surface as shown in Figure 5.11.1.

Figure 5.11.1: Elements of the global hydrological system



424. Within the hydrological cycle, asset accounts for water resources focus on the inflows and outflows of water to and from the land surface and sub-surface. 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.

425. The asset accounts themselves present information on the availability of water at the beginning and end of an accounting period whether it is in lakes or rivers or stored as ground or soil water. The accounts then record the flows of water as it is abstracted, it evaporates, is added to through precipitation, or via flows to and from other countries and returned to the sea.

426. This section proceeds to define water resources and the classes of water resources that are within scope of the asset accounts. It then presents the physical asset account for water resources and describes the relevant flows. A final part discusses related measurement issues such as the measurement of the value and quality of water resources.

5.11.2 Definition and classification of water resources

427. ***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 5.11.1.

428. Freshwater is naturally occurring water having a low concentration of salt. Brackish water

has salt concentrations between that of fresh and marine water. The definition of brackish and freshwater is not clear cut as the salinity levels used in the definition vary between countries. 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.

429. The definition of water resources excludes water in oceans, seas and 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 resources is also recorded there. Flows to and from inland water resources are also recorded in the physical flow accounts for water (see Chapter 3).

Table 5.11.1 Classification of water resources

Code		
	Surface water	
		Artificial reservoirs
		Lakes
		Rivers and streams
		Glaciers, snow and ice
	Groundwater	
	Soil water	

430. Surface watercomprises 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 man-made 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 seasonal layers of snow and ice on the ground surface; and *glaciers* which are defined as an accumulation of ice of atmospheric origin, generally moving slowly on land over a long period.

431. Groundwatercomprises 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. Depending on the recharge rate of the aquifer, groundwater can be fossil (or non-renewable) in the sense that water is not replenished by nature in human life spans. Note that the concerns of non-renewable water applies not only to groundwater, but also to other water bodies: for example, lakes may be considered non renewable when the replenishment rate is very small compared to the total volume of water.

432. Soil waterconsists of water suspended in the uppermost belt of soil, or in the zone of aeration

near the ground surface, that can be discharged into the atmosphere by evapotranspiration.

The relationship between land and water

433. Water is included in two places in the central framework environmental asset classification – as part of “Land” 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 abstraction and active use of water through the economy and hence it is the volume of water that is of interest.

5.11.3 Physical asset accounts for water resources

434. Physical asset accounts for water resources should be compiled by type of water resource and should account for both the stock of water at 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.

435. 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 5.11.2.

Table 5.11.2Physical asset account for water resources (cubic metres)

		Type of water resource		
		Surface water	Groundwater	Soil water
Opening stock of water resources				
Additions to stock				
	Returns			
	Precipitation			
	Inflows – from other territories			
	- from other national water resources			
	Discoveries of water in aquifers			
	Total additions to stock			
Reductions in stock				
	Abstraction			
	Evaporation/Actual evapotranspiration			
	Outflows – to other territories			
	- to other national water resources			
	Total reductions in stock			
Closing stock of water resources				

Defining the stock of water

436. The concept of a stock of water is related to the quantity of surface and groundwater in a territory of reference measured at a specific point in time (usually the beginning or end of the accounting period). While for lakes, reservoirs and groundwater the concept of a stock of water is straightforward, for rivers a stock is not always easy to define.

437. To keep consistency with the other water resources, the stock level of a river is measured as the volume of the active riverbed determined on the basis of the geographic profile of the riverbed and the water level. This quantity is usually very small compared to the total stocks of water resources and the annual flows of rivers. However, the river profile and the water depth are important indicators for environmental and economic considerations. There might be cases, however, in which the stocks of river water may not be meaningful either because the rate of the flow is very high or because the profile of riverbed changes constantly due to topographic conditions. In these circumstances, computing the stock of rivers is not realistic and can be omitted from the accounts.

Additions to and reductions in the stock of water resources

438. Additions to the stock of water resources consist of the following flows.

i. Returnsrepresent the total volume of water that is returned to the environment into surface and groundwater during the accounting period. Returns can be disaggregated by type of water returned, for example, irrigation water, treated and untreated wastewater. In this case, the breakdown should mirror that used to disaggregate the returns in the physical supply and use tables in chapter 3.

ii. Precipitation consists of the volume of atmospheric wet precipitation (e.g. rain, snow, hail etc.) on the territory of reference during the accounting period before evapotranspiration takes place. The majority of precipitation falls on the soil and would thus be recorded in the column of soil water in the asset accounts. Some precipitation also falls into the other water resources e.g. surface water. It is assumed that water would reach aquifers after having passed through either the soil or surface water (e.g. 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.

iii. Inflowsrepresent the amount of water that flows into water resources during the accounting period. The inflows are disaggregated according to their origin: (a) inflows from other territories/countries; and (b) 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 their 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 of infiltration and seepage as well as channels built for water diversion.

iv. 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. Changes in the volume of water in an aquifer should be included as an inflow of water resources to groundwater.

439. Reductions in the stock of water resources consist of the following flows.

i. Abstractionrepresents the amount of water removed from any resource, either permanently or temporarily, during the accounting period for final consumption and production activities. Water used for hydroelectric power generation is considered part of water abstraction. Given the large volumes of water abstracted for hydroelectric power generation, it is advisable to separately identify the abstraction and returns from hydroelectric power generation. Abstraction also includes the use of precipitation for rain-fed agriculture as this is considered a removal of water from the soil as a result of human activity (e.g. agriculture). Water used in rain-fed agriculture is thus recorded as an abstraction from soil water.

ii. Evaporation/Actual evapotranspirationis the amount of evaporation and actual evapotranspiration that occurs in the territory of reference during the accounting period. Note that evaporation refers to the amount of water evaporated from water bodies such as rivers, lakes, artificial reservoirs, etc. Evapotranspiration refers to the amount of water that is transferred from the soil to the atmosphere by evaporation and plant transpiration. Evapotranspiration can be “potential” or “actual” depending on the soil and vegetation conditions: potential evapotranspiration refers to the maximum quantity of water capable of being evaporated in a given climate from a continuous stretch of vegetation covering the whole ground and well supplied with water. Actual evapotranspiration, which is reported in the accounts, 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 that is determined by precipitation. Note that actual evapo-transpiration can only be estimated through modeling and may be a rough approximation.

iii. Outflowsrepresent the amount of water that flows out of water resources during the accounting period. Outflows are disaggregated according to the destination of the flow, namely (a) to other water resources within the territory, (b) to other territories/countries and (c) to the sea/ocean. Outflows to other water resources within the territory represent water exchanges between water resources within the territory. In particular, they include the flows of water going out of a water body and reaching other water resources within the territory. Outflows to other territories represent the total volume of water that flows out of the territory of reference during the accounting period. Shared rivers are a typicalexample of water flowing from one upstream country to a downstream country. Outflows to the sea/oceans represent the volume of water that flows into the sea/oceans.

5.11.4 Other water resource measurement issues

Monetary asset accounts for water resources

440. The measurement of the stock of water in monetary terms is particularly difficult. There are two primary reasons. The first is that, historically, water has often been made available free as a public good or for a flat charge because it has been seen to be freely available and not subject to scarcity. The monetary prices, therefore, have tended to be related to the cost of transporting water by pipe to designated outlets rather than to the volume of water consumed.

441. Given this situation the standard approaches to valuation of environmental assets, and in particular the NPV approach, generally do not work because the resource rent that is derived following standard definitions is commonly negative. There is a trend towards better water pricing reflecting the full costs of the water resources. Consequently, there may be some instances where approaches such as NPV can be applied. In these cases these values should be incorporated as part of the overall monetary value of environmental asset and as part of the value of economic assets.

Spatial and temporal detail

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

443. It is recognized internationally that a river basin is the most appropriate spatial reference for integrated water resource management (e.g., Agenda 21 (United Nations, 1992)and European Water Framework Directive, 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.

444. 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 many 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.

Annex A5.1: The Net Present Value method for valuation of stocks and the measurement of depletion and revaluation

Introduction

1. This annex explains, in some detail, the assumptions and computations needed to implement the net present value method (NPV) with a view to deriving valuations of the stock of environmental assets and consistent flow measures of depletion, income, and revaluation. In particular the latter element is often neglected in presentations of the NPV. Also, it must be accepted that the NPV 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.

Defining the unit resource rent

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

3. The enterprise must also pay for the standing timber to be extracted. This variable is best understood as the price per unit of extraction that the enterprise would be charged if the timber were owned by another unit (for example 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.

4. This amount is commonly referred to as the resource rent, RR_t and is equivalent to the total value of the resource input into the production process during an accounting period. It is comprised of two parts the quantity of timber extracted, S_t, and 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 extract unit of timber.

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 natural asset per unit or per industry. In this case, RR_t equals gross operating surplus plus the non-labor 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 RRt are discussed in more detail in Section 5.4.3). Given RR_t and S_t, it is straightforward to compute the unit resource rent, P_{St}.

6. Having estimated the unit resource rent, two important tasks remain to be completed: first, the value of the stock of the environmental asset 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 into a part that represents net income. It will be clear that the two tasks are directly related and need to be addressed consistently.

Valuing the stock of an environmental asset

7. To tackle the valuation of the stock of the environmental asset, start with the fundamental asset market equilibrium condition or NPV that the value of an asset (the standing timber resources in the case at hand) at the end of year t, V_t, equals the discounted flow of future resource rents $RR_{t+\tau}$ (τ=1,2,…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 resource is judged to be sustainable, N_t will take an infinite value. It is assumed here that the resource rent is paid at the end of the accounting period. The standard NPV condition is shown in equation (1).

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

8. r_t is a nominal discount rate valid at time t, but not necessarily constant over time. Similarly, $RR_{t+\tau}$ (τ=1,2,…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}, …} may be non-constant. Note that the sequence of resource rents {RR_{t+1}, RR_{t+2} …} is an *expected* sequence and that the expectation is formed at the end of period t.

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 be 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.

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 standing timber resource, P_t equals the price per m3 of the timber resources at the end of period t, and X_t is the number of m3 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

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

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 $RR_t = P_{st} S_t$:

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

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 *level of extraction* is the best estimate of future extractions so that $S_{t+\tau} = S_t$ (τ=1,2,3,…N_t). This is only one possibility and a different assumption 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* such that $S_{t+\tau}/X_{t+\tau}$ is constant for τ=1,2,3,…N_t. For the expositional purpose at hand, a constant level of extraction is

assumed. Similarly, a hypothesis needs to be formed regarding the evolution of the price P_{st} and the proposal here is 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. The NPV condition can then be re-written as

$$V_t = P_t X_t = \sum_{\tau=1}^{N_t} P_{St+1} S_{t+1} (1+\rho_t)^{\tau-1} / (1+r_t)^{\tau}$$
$$= P_{St} S_t \sum_{\tau=1}^{N_t} (1+\rho_t)^{\tau} / (1+r_t)^{\tau} = P_{St} S_t \Omega_t = RR_t \Omega_t \qquad (4)$$

$$\Omega_t \equiv \sum_{\tau=1}^{N_t} (1+\rho_t)^{\tau} / (1+r_t)^{\tau} \qquad (5)$$

13. Ω_t is a 'discount' factor that 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.

$$P_t = P_{St} \Omega_t \frac{S_t}{X_t} \qquad (6)$$

14. One conclusion from this relationship is that it is incorrect to use the unit resource rent as the price of the asset in the ground, 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, $(1+r_t)/(1+\rho_t)$, is a real interest rate. In many countries, real interest rates tend to be relatively stable and should therefore not be too difficult to estimate. The real interest formulation also relates to Hotelling's rule for non-renewable resources. It 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 rent rises over time at a rate that is exactly sufficient to offset the discount rate, there is no need to discount future resource income. In terms of the notation at hand, this corresponds to a situation where $\rho_t = r_r$ so that $\Omega_t = 1$ and $P_t = P_{st} S_t / X_t$, the unit resource rent.

Estimating the value of depletion

15. The next task consists of estimating the value of depletion. As before, it is assumed that the stock of resources X_t is known and that there is a projected sequence of extractions from the stock. It will also be assumed that the expected rate of natural growth of the resource at hand is known (zero in the case of a non-renewable resource, non-zero otherwise). Let $\{S_{t+1}, S_{t+2}, \ldots\}$ be the expected sequence of extractions and let $\{G_{t+1}, G_{t+2}, \ldots\}$ be the expected profile of natural growth, then depletion of the resource is the difference between extraction and natural growth:

$$-(X_t - X_{t-1}) \equiv -\Delta X_t = -(G_t - S_t) \quad (7)$$

16. It is important to note that this expression is a simplification of the relationship between growth and extraction that needs to be considered in the case of renewable resources. For renewable resources the relationship between extraction/harvest, natural growth and sustainable yields needs to be taken into account, and this requires the use of an appropriate biological model and relevant assumptions. This issue is discussed in more detail in section 5.4.2. For the purpose of this annex however, it is assumed that an estimate of the difference between extraction and sustainable yield can be made and hence an estimate of depletion in physical terms can be incorporated into equation (7).

17. Using equations (2) and (7), the value of the asset between the beginning and the end of period t can be decomposed as follows:

$$-(V_t - V_{t-1}) = -(P_t X_t - P_{t-1} X_{t-1}) = -P_{t-1}\Delta X_t - X_t \Delta P_t \quad (8)$$

18. In (8), the change in value of the asset $-(V_t\text{-}V_{t-1})$ has been decomposed into a depletion effect and a revaluation effect. The depletion 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 $-X_t\Delta P_t$ captures the price change of the asset, multiplied by the stock at the end of the period.

19. There is an alternative way to de-compose the term $-(P_tX_t\text{-}P_{t-1}X_{t-1})$, namely with a depletion effect $-P_t\Delta X_t$ and a revaluation effect $-X_{t-1}\Delta P_t$. None is *a-priori* superior to the other so an arithmetic average of the two effects can be employed:

$$-(V_t - V_{t-1}) = -\tfrac{1}{2}\left((P_{t-1} + P_t)\Delta X_t + (X_{t-1} + X_t)\Delta P_t\right) \quad (9)$$

20. The final expression for the value of depletion is then $-\tfrac{1}{2}(P_{t-1} + P_t)\Delta X_t$ and the expression for the price effect is $-\tfrac{1}{2}(X_{t-1} + X_t)\Delta P_t$. (It is of note that the valuation of depletion ΔX_t with the average price of the period is consistent with the rules in the SNA for the valuation of consumption of fixed capital.) The decomposition in (9) was established at the end of period t, with $V_{t-1}=P_{t-1}X_{t-1}$ based on the information and assumptions at the end of period t. However, this value of V_{t-1} may differ from the valuation of V_{t-1} recorded at the end of the year t-1, which was based on the information set at the end of year t-1, call it V'_{t-1}. This difference in valuation, V_{t-1} - V'_{t-1}, must be accommodated by adding an additional item to the decomposition of flows between the opening and closing balance sheet. It is of note that one source of changes in information is a new set of projected extractions, for example because the earlier sequence of expected extractions turned out not be sustainable. A case could be made to add such a revision to the value of depletion

21. 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 on information available at end of t-1:	V'_{t-1}
- Depletion:	$\frac{1}{2}(P_{t-1}+P_t)\Delta X_t$
Of which due to natural growth	$\frac{1}{2}(P_{t-1}+P_t)G_t$
Of which due to extraction	$-\frac{1}{2}(P_{t-1}+P_t)S_t$
- Revaluation due to price changes:	$\frac{1}{2}(X_{t-1}+X_t)\Delta P_t$
+ Revaluation due to changes in information set:	V_{t-1}-V'_{t-1}
Equals closing balance sheet item of period t based on information available at end of t:	V_t

Net income and depletion

22. 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:

$$RR_t + \tfrac{1}{2}(P_{t-1}+P_t)\Delta X_t\,. \qquad (10)$$

23. The depletion-adjusted resource rent represents the net income generated by the resource. It corresponds to a real return to capital, adjusted for a residual profit or loss. This can be demonstrated as follows. Multiplying V_{t-1} by $(1+r_t)$, subtracting V_t and applying the NPV condition (1) yields

$$V_{t-1}(1+r_t) - V_t = RR_t \qquad (11)$$

24. Combined with (9), one obtains

$$RR_t \approx r_t V_{t-1} - (V_t - V_{t-1}) = r_t V_{t-1} - \tfrac{1}{2}(X_t + X_{t-1})\Delta P_t - \tfrac{1}{2}(P_t + P_{t-1})\Delta X_t \qquad (12)$$

25. A complication arises here. Equation (12) will only hold exactly if the actual rate of change in the resource rent RR_t/RR_{t-1} exactly corresponds to the assumed rate of change ρ_t. Thus, where the actual rate of change in resource rent is different from ρ_t, an extra residual term must be included, call it M_t that balances equation (12). Therefore:

$$RR_t = r_t V_{t-1} + M_t - \tfrac{1}{2}\big((X_{t-1}+X_t)\Delta P_t + (P_{t-1}+P_t)\Delta X_t\big) \qquad (13)$$

26. The depletion-adjusted resource rent in (10) is then

$$RR_t + \tfrac{1}{2}\left((P_{t-1} + P_t)\Delta X_t\right) = r_t V_{t-1} + M_t - \tfrac{1}{2}\left((X_{t-1} + X_t)\Delta P_t\right) \quad (14)$$

27. Thus, net income consists of the nominal return to capital, $r_t V_{t-1} + M_t$, less 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 get to an income measure consistent with the definition of income in the national accounts[15], revaluations must be subtracted. After subtraction, expression (14) shows the return from 'normal business operations' excluding holding gains or losses.

28. The derivations above are valid for both renewable resources and the limiting case of non-renewable resources. When there is depletion, the term $-\Delta X_t = S_t - G_t$ will be negative and 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 recorded as zero.

29. It should be noted that the specifications above leave no ambiguity about the valuation of stocks and flows:

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

References

United Nations, European Commission, IMF, OECD (2003); Integrated Environmental and Economic Accounting 2003, Final Draft.

OECD (2009); *Measuring Capital* 2nd edition, Paris.

[15] See OECD (2009) section 8.3.2 for a more detailed discussion in the context of produced assets.

Annex A5.2:Description of the UN Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC 2009)

1. The 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. Based on the maturity of the projects the underlying natural resources are classified. The 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)

2. 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 geological knowledge and potential recoverability of the quantities.

3. Each criteria, E, F and G, is sub-divided into categories characterizing the projects for exploring and extracting the resource. The categories for the economic and social criteria are numbered from E1- E3.

   - The category E1 includes projects where extraction and sale is 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 has 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 is not expected to become economically viable in the foreseeable future or evaluation is at too early a stage to determine economic viability.

4. The categories for project status and feasibility are numbered F1 – F4 with further sub-categories in some cases.

   - The category F1 includes projects where extraction is currently taking place (F1.1); or capital funds have been committed and implementation of the development project or mining operation is underway (F1.2); or sufficiently detailed studies have been completed to demonstrate the feasibility of extraction by implementing a defined project or mining operation (F1.3).

- Both F2.1 and F.2.2 includes 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 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 due to limited potential.
- F3 indicates that the feasibility of extraction by a defined development project or mining operation cannot be evaluated due to limited technical data.
- F4 indicates that no development project or mining operation has been identified.

5. The categories for geologic knowledge are numbered G1-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 A5.3 Land classifications

Land Use Classification (Definitions and Descriptions)

CATEGORY	DEFINITION
A. Agricultural land	The total of areas under "Land under temporary crops," "Land under temporary meadows and pastures," "Land with temporary fallow," "Land under permanent crops," "Land under permanent meadows and pastures," and "Land under protective cover". Thus, this category includes tilled and fallow land, land under grass used for agricultural purposes. Scattered land under farm buildings, yards and their annexes, permanently uncultivated land, such as uncultivated patches, banks, footpaths, ditches, headlands, and shoulders are traditionally included.
A1. Land under temporary crops	Land used for crops with a less than one-year growing cycle, which must be newly sown or planted for further production after the harvest. Some crops that remain in the field for more than one year may also be considered as temporary crops. Asparagus, strawberries, pineapples, bananas and sugar cane, for example, are grown as annual crops in some areas. Such crops should be classified as temporary or permanent according to the custom in the country. Excludes: - Herbaceous forage crops.
A11. Cereals	Land used for the related activities of Classes: - 0111 - Growing of cereals (except rice), leguminous crops and oil seeds - 0112 - Growing of rice as in ISIC Rev.4.
A12. Vegetables and melons	Land used for the related activities of Classes: - 0113 - Growing of vegetables and melons, roots and tubers as in ISIC Rev.4.
A13. Temporary oilseed crops	Land used for the related activities of Classes: - 0111 - Growing of cereals (except rice), leguminous crops and oil seeds as in ISIC Rev.4.
A14. Root/tuber crops with high starch or inulin content	Land used for the related activities of Classes: - 0113 - Growing of vegetables and melons, roots and tubers as in ISIC Rev.4.
A15. Temporary spice crops	Land used for the related activities of Classes: - 0128 - Growing of spices, aromatic, drug and pharmaceutical crops as in ISIC Rev.4.
A16. Leguminous crops	Land used for the related activities of Classes: - 0111 - Growing of cereals (except rice), leguminous crops and oil seeds as in ISIC Rev.4.
A17. Sugar crops	Land used for the related activities of Classes: - 0113 - Growing of vegetables and melons, roots and tubers - 0114 - Growing of sugar cane as in ISIC Rev.4
A18. Other temporary crops	Land used for the related activities of Classes: - 0119 - Growing of other non-perennial crops as in ISIC Rev.4.
A2. Land under	Land cultivated with temporary herbaceous forage crops for mowing or pasture.

temporary meadows and pastures	A period of less than five years is used to differentiate between temporary and permanent meadows.
A3. Land with temporary fallow	Agricultural land that is not seeded for one or more growing seasons. The maximum idle period is usually less than five years. Land remaining fallow for too long may acquire characteristics requiring it to be reclassified, such as “Land not in use” (K). This land may be in the form sown for the exclusive production of green manure.
A4. Land under permanent crops	Land cultivated with long-term crops which do not have to be replanted for several years (such as cocoa and coffee); land under trees and shrubs producing flowers (such as roses and jasmine); and nurseries (except those for forest trees, which should be classified under "Forest land"). Land under permanent meadows and pastures are excluded from “Land under permanent crops.” Excludes: - Herbaceous forage crops.
A41. Fruit and nuts	Land used for the related activities of Classes: - 0121 - Growing of grapes - 0122 - Growing of tropical and subtropical fruits - 0123 - Growing of citrus fruits - 0124 - Growing of pome fruits and stone fruits - 0125 - Growing of other tree and bush fruits and nuts as in ISIC Rev.4.
A42. Permanent oilseed crops	Land used for the related activities of Classes: - 0126 - Growing of oleaginous fruits as in ISIC Rev.4.
A43. Beverage and permanent spice crops	Land used for the related activities of Classes: - 0127 - Growing of beverage crops - 0128 - Growing of spices, aromatic, drug and pharmaceutical crops) as in ISIC Rev.4.
A44. Other permanent crops	Land used for the related activities of Classes: - 0129 - Growing of other perennial crops as in ISIC Rev.4.
A5. Land under permanent meadows and pastures	Land used to grow permanent (five years or more growth cycle) herbaceous forage crops through cultivation or naturally (wild prairie or grazing land). Permanent meadows and pastures on which trees and shrubs are grown should be recorded under this heading only if the growing of forage crops is the most important use of the area. Measures may be taken to keep or increase productivity of the land (i. e. use of fertilizers, mowing or systematic grazing by domestic animals.) This category includes: - Grazing in wooded areas (agro-forestry areas, for example). - Grazing in shrubby zones (heath, maquis, garigue). - Grassland in the plain or low mountain areas used for grazing: land crossed during transhumance where the animals spend a part of the year (approximately 100 days) without returning to the holding in the evening: mountain and sub-Alpine meadows and similar; steppes and dry meadows used for pasture.
A51. Cultivated permanent meadows and pastures	Land under permanent meadows and pastures that is managed and cultivated.
A52. Naturally	Land under naturally grown permanent meadows and pastures used for grazing,

grown permanent meadows and pastures	animal feeding or agricultural purpose.
A6. Agricultural land under protective cover	Surfaces occupied by dwellings on farms etc.: dwellings, operating buildings (hangars, barns, cellars, green houses, silos), buildings for animal production (stables, cow sheds, pig sheds, sheep pens, poultry yards), family gardens, farmyards. Excludes - Buildings in rural areas for exclusive residential purpose (J) - Buildings for agro-food manufacture (E)
B. Forest and other wooded land	Land spanning more than 0.5 hectares with trees higher than 5 m and a canopy cover of at least 5 percent, or trees able to reach these thresholds *in situ*; or with a combined cover of shrubs, bushes and trees above 10 percent. It does not include land that is predominantly under agricultural or urban use.
B1. Forest	Land spanning more than 0.5 hectares with trees higher than 5 m and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use. Explanatory notes 1. Forest land is determined both by the presence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5 m *in situ*. 2. Includes areas with young trees that have not yet reached but which are expected to reach a canopy cover of 10 percent and tree height of 5 m. It also includes areas that are temporarily unstocked due to clear-cutting as part of a forest management practice or natural disasters, and which are expected to be regenerated within 5 years. Local conditions may, in exceptional cases, justify that a longer time frame is used. 3. Includes forest roads, firebreaks and other small open areas; forest in national parks, nature reserves and other protected areas such as those of specific environmental, scientific, historical, cultural or spiritual interest. 4. Includes windbreaks, shelterbelts and corridors of trees with an area of more than 0.5 hectares and width of more than 20 m. 5. Includes abandoned shifting cultivation land with a regeneration of trees that have, or is expected to reach, a canopy cover of 10 percent and tree height of 5 m. 6. Includes areas with mangroves in tidal zones, regardless whether this area is classified as land area or not. 7. Includes rubber-wood, cork oak and Christmas tree plantations. 8. Includes areas with bamboo and palms provided that land use, height and canopy cover criteria are met. 9. Some agroforestry systems such as the "Taungya" system where crops are grown only during the first years of the forest rotation should be classified as forest. Excludes tree stands in agricultural production systems, such as fruit tree plantations, oil palm plantations and agroforestry systems when crops are grown under tree cover.
B11. Naturally regenerated forest	Forest 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% of the growing stock at maturity. Includes:

	- Coppice from trees established through natural regeneration. - Naturally regenerated trees of introduced species. o Primary forest: i.e. naturally regenerated forest of native species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed. Some key characteristics of primary forests are: o They show natural forest dynamics, such as natural tree species composition, occurrence of dead wood, natural age structure and natural regeneration processes. o The area is large enough to maintain its natural characteristics. o There has been no known significant human intervention or the last significant human intervention was long enough ago to have allowed the natural species composition and processes to have become re-established. - Other naturally regenerated forest: i.e. forest where there are clearly visible indications of human activities. Includes: o Selectively logged-over areas, areas regenerating following agricultural land use, areas recovering from human-induced fires, etc. o Forests where it is not possible to distinguish whether planted or naturally regenerated. o 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% of the growing stock at stand maturity.
B12. Planted forest	Forest predominantly composed of trees established through planting and/or deliberate seeding. In this context, predominantly means that the planted/seeded trees are expected to constitute more than 50% of the growing stock at maturity. Includes: - Coppice from trees that were originally planted or seeded. Excludes: - Self-sown trees of introduced species. - Tree stands in agricultural production systems, such as fruit tree plantations, oil palm plantations and agroforestry systems when crops are grown under tree cover. - Land that is predominantly under agricultural or urban use.
B2. Other wooded land	Land not classified as “Forest”, spanning more than 0.5 hectares; with trees higher than 5 meters and a canopy cover of 5-10 percent, or trees able to reach these thresholds *in situ*; or with a combined cover of shrubs, bushes and trees above 10 percent. It does not include land that is predominantly under agricultural or urban land use. The definition above has two options: - The canopy cover of trees is between 5 and 10 percent; trees should be higher than 5 meters or able to reach 5 meters *in situ*. or - The canopy cover of trees is less than 5 percent but the combined cover of shrubs, bushes and trees is more than 10 percent. Includes areas of shrubs and bushes where no trees are present. Includes:

	- Areas with trees that will not reach a height of 5 meters *in situ* and with a canopy cover of 10 percent or more, e.g. some alpine tree vegetation types, arid zone mangroves, etc. - Areas with bamboo and palms provided that land use, height and canopy cover criteria are met.
C. Land with aquaculture facilities	Land used for aquaculture facilities including supporting facilities. Aquaculture refers to the farming of aquatic organisms: fish, molluscs, crustaceans, aquatic plants, crocodiles, alligators, turtles, and amphibians. Farming implying some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Aquaculture facilities include ponds and tanks (artificial units of varying sizes constructed above or below ground level capable of holding and interchanging waters), raceways and silos (artificial units constructed above or below ground level capable of high rate of water interchange in excess of 20 changes per day) and hatcheries (housing facilities for breeding, nursing and rearing seed of fish, invertebrates or aquatic plants to fry, fingerlings or juvenile stages).
C1. Hatcheries	Housing facilities for breeding, nursing and rearing seed of fish, invertebrates or aquatic plants to fry, fingerlings or juvenile stages.
C2. Managed grow-out sites	Land with aquaculture facilities other than “Hatcheries.”
Built-up and related land	Land affected or adapted by man, under buildings, roads, mines and quarries and any other facilities, including their auxiliary spaces, deliberately installed for the pursuit of human activities. Included are also certain types of open land (non- built- up land), which are closely related to these activities, such as waste tips, derelict land in built-up areas, junk yards, city parks and gardens. Land under closed villages or similar rural localities are included.
D. Land used for mining and quarrying	Land mainly occupied by mines and quarries including installations for the extraction of solid fuels, petroleum, natural gas, minerals, salt, construction stone, and sand and clay; including their associated areas (slag heaps, dumps and storage areas, loading and unloading sites, shafts or head gear).
E. Land used for construction	Land mainly occupied by construction building sites including abandoned areas (residential, industrial, commercial, infrastructures and burned areas) tips and man-made wasteland.
F. Land used for manufacturing	Land occupied by activities of manufacturing including heavy industries. This category includes coking plants, cracking and refining of petroleum, installations for producing and processing of metals, installations producing non-metallic minerals; industrial installations in the field of basic chemistry, agro-chemistry, the production of synthetic and artificial fibres and other products; installations working in the fields of agro-food products, beverages and tobacco, textile manufacturing, leather, footwear and clothing manufacturing, wood, paper and production of paper articles, rubber and transformation of plastics, as well as construction companies and public works. Excludes - Actual construction sites (D). - Harbour areas and their storage facilities (G).
G. Land used for technical infrastructure	Land occupied by technical installations for the generation, distribution, and transmission of electrical energy; the distribution of hydro-carbons, including oil and gas pipelines, and water; the recovery and purification of water; the collection and treatment of waste; Land occupied by telecommunications networks, such as relay stations, TV aerials, radio telescopes, radars, and major protective works, e.g. water retention dams, protective dykes. Included is also the land used for related offices and other service buildings and installations, as well as any space needed, according to national practices, for the operation of such technical infrastructure.
H. Land used for transport and	Land occupied by infrastructures and service enterprises in the field of transport and storage. Includes transport infrastructures for road traffic; rail networks;

storage	airport installations; installations connected with river and maritime transport. Included is also the land used for transport-related offices and other service buildings and installations, such as stations, airport buildings, storage facilities for equipment and repair workshops, space used for sidewalks, grass slopes along railways, windshelter belts along roads, open noise abatement areas round airports as well as any other space needed, according to national practices, for the provision of the related infrastructure. This category does not include: - military aerodromes (H) - dockyards (E) - waterways (L)
I. Land used for commercial, financial, and public services	Land mainly used for commerce, trade, and related services, public administrations and judicial services, public order and safety services, social security and social work services, professional and trade associations; including private roads and other auxiliary spaces located in the areas concerned. This category includes wholesale and retail trade; hotel and catering services; banks and insurance; personal services; installations for national defence; education and research/development; land occupied by religious buildings.
J. Land developed for recreational purposes	Land developed for and occupied by leisure or recreational purposes, including cultural sites: archaeological sites; historic sites, classified monuments, ruins and stately homes; museums, libraries, media centres; concert halls and theatres; cemeteries, and associated areas (water, wooded areas, lawns, gardens) sport facilities: public beaches and swimming pools, gymnasiums, sports halls; stadiums and games fields; assembly and dancing halls; golf courses; riding tracks; car racing circuits; green or leisure areas: urban parks, public gardens, zoological and botanical gardens, hobby gardening; major burial grounds used as walking places with considerable vegetation; facilities for tourism: camping and caravanning sites; amusement parks, circuses, youth hostels and country centres; marinas; secondary residences or vacation houses; and casinos. This category does not include areas that can be used for recreation but this is not the main utilization: - agricultural areas (A) - forests and other wooded land (B) - secondary dwellings (J) - natural or semi-natural areas not specifically developed (K) - ski runs (K) - beaches (K)
K. Residential areas	Land mainly covered by residential buildings, irrespective of whether they are actually occupied or temporarily vacant, including residential land attached private gardens and small green areas and parking facilities and small playgrounds mainly reserved and used by the inhabitants of the buildings. This category includes: - continuous and dense residential areas (dense to very dense urban core where a large proportion of the buildings are higher than three stories) - continuous residential areas of moderate density (suburban kind, found commonly in old villages attached to a town.) - discontinuous residential areas of moderate density ("housing area" type, formed by individual houses) - isolated residential areas (hamlets, groups of a few houses, small villages, isolated buildings) - collective residential areas (collective dwellings generally higher than three

	stories) This category does not include: - land used for purposes specified elsewhere, even if it is mainly used by the local population.
L. Inland water	This relates to the part of the national territory to be reported, which is covered by inland waters. Areas corresponding to natural or artificial water courses, serving to drain natural or artificial bodies of water, including lakes, reservoirs, rivers, brooks, streams, ponds, inland canals, dams, and other land-locked (usually freshwater) waters. The banks constitute limits whether the water is present or not. This category does not include: - industrial bodies of water (D) - hydro-electric dams (F) - marinas (I) - moats (I) - swimming pools (I)
L1. Areas with aquaculture or holding facilities	Inland bodies of water used for fish farming activities (aquaculture).
L2. Other inland water areas	Other natural or artificial water courses (rivers, canals), serving to drain natural or artificial bodies of water (lakes, ponds, reservoirs). The banks constitute limits whether the water is present or not.
L21. Enhanced areas	Areas with enhancement including stocking, fertilization, engineering, predator control, habitat modifications, and/or access limits.
L22. Open access waters without enhancement	Area without any enhancements and access limitation.
M. Land not in use	Land where there are no clearly visible indications of human activities and ecological processes are not significantly disturbed. <u>Includes</u> - Land with trees not used for the purpose of agriculture and not classified as Forest and other wooded land; - Bushes and shrub not used for the purpose of agriculture and not classified as Other wooded land; - Open areas with low vegetation of the herbaceous type, not used for agricultural purposes; - Natural and non-built-up land surface with little or no vegetation, which precludes its inclusion in other categories of the classification; included are old quarries and abandoned sandpits. - Bare soils (areas where bedrock crops out) including rocks and scree, and dunes and sand and pebble beaches. - Land covered by glaciers (generally measured at the time of their greatest expansion in the season) or eternal snow; and burned areas. - Land under water or areas covered by wet land, which are flooded or likely to be so over a large part of the year by fresh, brackish or saline, or stagnating water, bearing a vegetation cover of the low shrub, semi-woody or herbaceous type (bogs and marshes); and occupied by intermediate zones between the solid and liquid state, among which blanket or raised peat lands, such as peat bogs (moors). <u>Excludes</u> - Peat bogs in use for fuel harvesting (D).

Sources: FAOSTAT Resources Questionnaire; WCA2010; and Specification of National Reporting Tables for FRA 2010; and CWP Handbook; ECE (1993), Eurostat (1993); and Article 8 of the Informal Composite Negotiating Text/Revision 2 (A/CONF.62/WP.10/Rev.2, 11 April 1980) of the United Nations Third Conference on the Law of the Sea.

Definitions of land cover types

CATEGORY	DEFINITION
A. HERBACEOUS CROP	The class is composed of a main layer of **cultivatedherbaceous plants**.
B. TREE OR SHRUB CROP	The class is composed of a main layer of **cultivated tree or shrub plants**.
C. MULTIPLE OR LAYERED CROP	This class is composed of at least two layers of **cultivatedwoody and herbaceous plants** or different layers of **cultivated plants** combined with **natural vegetation**.
D. TREE COVERED AREA	The class is made of a main layer of **natural trees** with a cover from 10 to 100 %.
E. SHRUB COVERED AREA	The class is composed of a main layer of **natural shrubs** with a cover from 10 to 100 %.
F. HERB COVERED AREA	The class is composed of a main layer of **natural herbaceous vegetation** with a cover from 10 to 100 %.
G. SPARSE NATURAL VEGETATION (TERRESTRIAL OR AQUATIC OR REGULARLY FLOODED)	The class is made of **any type** of **naturalvegetation** **(all the growth forms)** with a cover from 2 to 10 %. Sparse natural vegetation aquatic or regularly flooded with a water persistence of 2 to 12 months/year may also be included in this category.
H. AQUATIC OR REGULARLY FLOODED TREE COVERED AREA	The class is made of **naturaltrees** with a cover from 10 to 100 % aquatic or regularly flooded with water. The water persistence can go from 2 to 12 months/year.
I. AQUATIC OR REGULARLY FLOODED SHRUB OR HERB COVERED AREA	The class is made of **naturalshrubs or herbs** with a cover from 10 to 100 % aquatic or regularly flooded with a water persistence of 2 to 12 months/year.
J. BARE AREAS (TERRESTRIAL OR REGULARLY FLOODED)	The class is made of **abioticnatural** surface and include also bare areas regularly or tidal related flooded.
K. ARTIFICIAL SURFACES AND ASSOCIATED AREAS	The class is composed of any type of **artificial surfaces** with a cover from 10 to 100 %.
L. INLAND WATER BODIES	This class is composed of any type of inland **water body** with a water persistence of 12 months/year.
M .GLACIER AND PERENNIAL SNOW	This class is composed of any type of **glacier and perennial snow** with persistence of 12 months/year.