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DRAFT Measuring natural resources in the national accounts: a compilation guide

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This document contains the third draft of the guidelines that are being developed by the OECD Informal Expert Group on Natural Capital (EGNC) established to support implementation of the 2025 SNA.

It should be noted that this draft is a work-in-progress. It does not represent the views of the OECD Member countries and its content is without prejudice to the final text that will be published under the responsibility of the Secretary-General of the OECD.

The final version will be published later in 2025 after global consultation and final review by the Advisory Expert Group on National Accounts (AEG) and the EGNC.

This work is not to be cited in its current form.

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Foreword

The 2025 System of National Accounts (SNA) includes important changes compared with the 2008 SNA when it comes to the measurement and recording of natural capital. These changes aim to enhance the usefulness of the SNA to respond to data needs on the environment and the economy for analysis and policy making. However, they also present practical measurement challenges, in particular when it comes to the monetary valuation of natural resources and their depletion or regeneration.

In response and at the request of the Intersecretariat Working Group on National Accounts (ISWGNA), the OECD Committee on Statistics and Statistical Policy (CSSP) established the OECD informal Expert Group on Natural Capital (EGNC) in 2023. The main objective of the EGNC was to develop practical guidance for countries to implement the recommendations as included in the 2025 SNA in the area of natural capital. This compilation guide is the result of the work by the expert group.

The compilation guide was drafted by Bram Edens (OECD) with major contributions from Sarah Barahona (formerly OECD). The text boxes with country examples were provided by members of the EGNC, in alphabetical order (country example, author(s)): Austria: Sylvia Gierlinger (Statistics Austria); Canada: Matthew Hoffarth, Matthew Kelly, David Krochmalnek (Statistics Canada); Costa Rica: Silvia Arguedas (Central Bank of Costa Rica); France: Sylvain Larrieu (Institut national de la statistique et des études économiques); Indonesia: Zanial Firdaus (Statistics Indonesia); Netherlands; Sjoerd Schenau (Statistics Netherlands); Mexico: Cesar Cabrera, Raul Figueroa, Federico Gonzalez (Mexican National Institute of Statistics and Geography - INEGI); Norway: Trude Nygård Evensen, Sindre Midttun, Steinar Todsen (Statistics Norway); United Kingdom: Adam Dutton (formerly United Kingdom Office for National Statistics). Annex A was drafted by Timothy Na (University of Leiden) during his internship at the OECD.

The development of the guidelines was overseen by the EGNC, initially chaired by Sarah Barahona, later by Jorrit Zwijnenburg (OECD). Special thanks go to the members of the EGNC who discussed and reviewed successive drafts of the guidelines:

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The EGNC was coordinated by Bram Edens with support from Chloe Acas. The subgroups established under the EGNC were chaired and coordinated by Bram Edens. The final version of the report was edited by Chloe Acas.

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1 Introduction

1.1. What is this guide about?

1. The 2025 System of National Accounts (SNA) includes important changes compared with the 2008 SNA when it comes to the measurement and recording of natural capital. Natural capital is understood in the 2025 SNA as both natural resources and ecosystem assets, but ecosystem assets are outside the asset boundary of the 2025 SNA, so the scope of measurement is natural resources. Natural resources are defined as "assets that naturally occur, such as land, mineral and energy resources, water resources, and biological resources that have an economic value and over which ownership may be enforced and transferred" (2025 SNA 11.11).

2. The changes in the 2025 SNA consist of an explicit recognition of renewable energy resources such as wind and solar as economic assets, the splitting of natural resource assets between legal owner (e.g. government) and the extractor (producer) based on their shares of economic ownership, several changes to the treatment of biological resources that yield once-only products such as timber and fish resources, and recording the depletion of natural resources as a cost of production.

3. The national accounts measure economic activity, with Gross Domestic Product (GDP) being the most widely used measure of economic growth. Net Domestic Product (NDP) in the 2008 SNA measures growth after accounting for the depreciation of fixed capital; but it does not take into account that today's growth often comes at the expense of depleting natural resources, which may have implications for future growth. This changes as the depletion of natural resources is recorded as a cost of production – and therefore in NDP – in the 2025 SNA.

4. These changes have been necessary to ensure that the 2025 SNA continues to be well equipped as the statistical framework for measuring economic activity and continues to provide decision makers with the information they need in dealing with some of the pressing policy issues of our time such as addressing climate change, enabling the energy transition, and placing economies on a path to more sustainable growth.

5. While the valuation of natural resources and depletion is already part of the 2008 SNA, recording depletion as a cost of production in the 2025 SNA instead of another change in volume as in the 2008 SNA raises the importance of these estimates and thus it is recommended that all countries start compilation.

6. In the case of renewable energy resources, which are new types of assets in the 2025 SNA, this guide offers international guidelines to support compilation for national accounts purposes. Likewise, splitting of asset values between legal owner and extractor (producer) is already recommended in the System of Environmental-Economic Accounting Central Framework (SEEA CF, UN et. al 2014) but is a new topic for national accountants.

7. Together, these new recommendations will change some of the key macroeconomic aggregates that are derived within the 2025 SNA. In addition to net measures of production such as NDP, they will affect net measures of income and saving and net worth. It is of the utmost importance that countries compile these data in a comparable manner, based on similar methods and approaches, and thereby

ensure international comparability. For this purpose, *Measuring natural resources in the national accounts: a compilation guide* has been developed.

1.2. Who is this guide for and what will it provide?

8. The primary objective of the guide is to support implementation and compilation of the 2025 SNA when it comes to the measurement and recording of natural resources.[1] The guide frequently refers to other handbooks such as the SEEA CF or the EU Forest Accounts Handbook (EU 2024), to the extent these handbooks are consistent with the 2025 SNA concepts, as they usually provide more details on specific topics than the SNA does.

9. The compilation guide is primarily intended for national accounts compilers in all countries in the world. It may also be relevant for environmental accountants, compilers of energy or environmental statistics, and the research community at large. The guide assumes familiarity with basic national accounts terminology and concepts, but not with the measurement of natural resources. While the guide discusses the measurement of natural resources, it is important to emphasize that the resulting estimates are intended for usage in the context of macro-economic policy making. For instance, valuation of fish resources is not intended to be used directly for fisheries management, for which more detailed information would be required.

10. As countries differ in their data availability and resources for conducting measurement of natural resources, a Tiered approach is followed in this guide: Tier 1 describes basic methods for countries with limited data availability and/or resources; Tier 2 describes the standard approach which most countries would be expected to apply; Tier 3 covers advanced methods requiring high data availability and/or resources. This guide describes Tier 2 as the default, but also contains dedicated sections in Chapters 4 and 5 that describe the Tier 1 and Tier 3 approaches. The Tiers may also be useful for countries to communicate to users as part of the meta-data – for instance in their Gross National Income (GNI) inventories – or be used to set goals for improving methods over time.

11. Natural resources cover a diverse set of assets, including land, mineral and energy resources, biological resources, water resources, and other resources such as radio spectra. The focus of the guide is on those areas where the 2025 SNA advanced compared to the 2008 SNA and therefore will concentrate on mineral and energy resources (including renewables) and biological resources (especially those yielding once only products such as timber and fish resources). Some topics are not included as they are considered out of the scope of this guide, such as emission permits which are treated as financial assets in the 2025 SNA. For the measurement of land, specific guidelines already exist (Eurostat and OECD, 2015). This guide will therefore discuss land only in the context of forest land and its depletion. The valuation of water resources is also not discussed in detail in this guide: the topic was not specifically addressed during the 2008 SNA update process but will be included in the upcoming SEEA CF revision process.

12. Four Excel workbooks accompany this guide which contain hypothetical examples to illustrate the calculations and make it easier for countries to start compilation. These are: *Workbook: subsoil assets*[2]*; Workbook: renewable energy resources; Workbook: timber resources and forest land, and Workbook: fish resources.*

[1] The guide does not cover institutional aspects of accounts compilation such as the development of an implementation strategy, stakeholder engagement, or quality assurance, for which guidance exists elsewhere, see for instance: https://unstats.un.org/unsd/nationalaccount/impUNSD.asp

[2] Non-renewable mineral and energy resources.

1.3. The research process underpinning the guide

13. The United Nations Statistical Commission (UNSC) endorsed the programme to update the 2008 SNA in 2021. The process has been overseen by the Inter-Secretariat Working Group on National Accounts (ISWGNA), which consists of the five international organisations that are the co-publishers of the SNA: the European Commission, the International Monetary Fund (IMF), the Organisation for Economic Co-operation and Development (OECD), the United Nations, and the World Bank. The ISWGNA is assisted by the Advisory Expert Group on National Accounts (AEG), which consists of a group of highly experienced national accountants who are invited to serve as advisers.

14. The revision process started from the SNA Research Agenda[3], from which a list of issues was selected based on urgency and feasibility of resolving the issues (SNA Update (2021)). The issues were grouped into three priority areas: digitalisation, globalisation, and well-being and sustainability. Seven task teams were formed, of which five were organised jointly with the IMF Balance of Payments Committee that was working on a parallel update of the sixth Balance of Payment Manual (BPM6) in close coordination with the 2008 SNA update. For the measurement of natural resource, the most relevant was the Well-being and Sustainability Task Team (WSTT), which included an area group on environmental sustainability.

15. A total of 75 Guidance Notes[4] were produced as starting point for the SNA revision process. Each of the Guidance Notes focused on a specific part of the SNA Research Agenda and was drafted by experts tasked with analysing the issue and making recommendations. Each went through several iterations, including global consultation, before endorsement by the AEG. The recommendations contained in the endorsed Guidance Notes form the building blocks based on which the 2025 SNA was drafted.

16. In 2023, the ISWGNA asked the OECD to lead work to support implementation of the 2025 SNA's recommendations on measurement of natural capital by producing practical guidance for compilers. To do this, the OECD established an Expert Group on Natural Capital (EGNC) in July 2023. Specifically, the remit of the EGNC was to develop a compilation guide based on the recommendations in the following SNA Update Guidance Notes: WS.6 Accounting for the Economic Ownership and Depletion of Natural Resources (SNA Update 2023a); WS.8 Accounting for Biological Resources (SNA Update 2023b); WS.10 Valuation of Mineral and Energy Resources (SNA Update 2023d); and WS.11 Treatment of Renewable Energy Resources as Assets (SNA Update 2023e). Several other Guidance Notes with relevant elements were also used as inputs for the compilation guide: WS.9 Recording of Provisions (SNA Update 2023c), WS.12 Environmental Classifications (SNA Update 2023f), and AI.1 Valuation principles and methodologies (SNA Update 2023g).

17. An invitation to join the EGNC was sent to the following groups: countries that participate in the OECD Working Party on National Accounts (WPNA); countries that have participated in the SNA update process as part of the WSTT or have contributed to the Guidance Notes mentioned above; ISWGNA members, selected international experts. The UN Committee of Experts on Environmental-Economic Accounting (UNCEEA), the Joint OECD/United National Economic Commission for Europe (UNECE) Seminar on the Implementation of SEEA and the Government Finance Statistics community were also asked to nominate a representative. Several countries and organisations joined at a later stage because they expressed interest in participating; and some countries were also invited early 2024 to improve geographical and economic development balance in the EGNC. A total of 18 countries and 8 international organisations have participated in the EGNC (see Foreword).

18. The EGNC met virtually on a quarterly basis between October 2023 and January 2025. The kick-off meeting on 10-11 October reviewed the relevant recommendations for changes in the 2025 SNA in

[3] https://unstats.un.org/unsd/nationalaccount/Consolidated_SNA_RA.asp

[4] The full list is available at: https://unstats.un.org/unsd/nationalaccount/SNAUpdate/GuidanceNotes.asp

relation to natural capital, discussed high priority topics and the timetable for producing the compilation guide, and started to look at the existing guidelines and country compilation practices. After the meeting, a short survey was conducted amongst the members to further assess priorities. Based on the responses, and to facilitate technical discussions, five subgroups were formed, open to all EGNC members: subsoil assets, renewable energy, biological resources (split into timber and fish resources), and depletion.[5]

19. The subgroups met regularly between December 2023 and September 2024.[6] For each of the subgroups, the Secretariat prepared a discussion note structured in the form of draft guidance, with a list of issues requiring further discussion. In addition, Excel workbooks were prepared with examples to illustrate calculations. The discussion notes and workbooks have been revised based on the results of the group discussions and country testing and form the building blocks of this compilation guide.

20. The subgroups also served as a mechanism for countries to present initial results of testing and obtain feedback. The testing has also produced examples that are included in *this guide*.

21. The second meeting of the EGNC took place on 24-25 January 2024. Its main objectives were to discuss progress made in the subgroups, discuss a number of cross-cutting topics (discounting – based on a separate issues note; how to compile estimates for natural capital in constant prices / volume terms; and how to set the rate of return on fixed capital. The meeting also discussed an initial draft outline of the compilation guide. As a follow-up of the meeting, another survey was held to further assess member practices and preferences on discounting and rates of return on fixed capital.

22. The third meeting of EGNC was held on 29-30 May 2024. Its main objectives were again to discuss progress made in the subgroups and several cross-cutting topics including discounting and rates of return on fixed capital (continuing the previous discussion), taxes and subsidies and the split asset approach. Finally, the meeting also discussed a detailed annotated outline of the compilation guide.

23. The fourth meeting of EGNC was held on 9-10 October 2024. Its main objectives were to update on the outcomes of the final round of subgroups and relevant AEG discussions; review the first comprehensive draft of the compilation guide, and share selected results of country testing. The meeting discussed several remaining issues, agreed on the set of country examples that would be featured in the guide, as well the process towards finalization of the guidelines.

24. The fifth and final meeting of EGNC was held on 21 January 2025 to discuss the feedback received during the broad review of the second draft and agree on any remaining issues.

1.4. How this guide is structured

25. This guide consists of six chapters and an annex. Chapter 2 *Measurement of Natural Resources* starts by looking at the changes to the asset classification for natural resource in the 2025 SNA compared with the 2008 SNA. Second, it discusses fundamental differences between accounting approaches and welfare economics. Third, it clarifies the relationship between the SEEA as statistical standard for describing the interrelationship between economy and environment, and the SNA. The chapter then sets out in detail the key 2025 SNA recommendations pertaining to natural resources that form the point of departure of this compilation guide, including their rationale. The final section of the chapter explores in detail the 2025 SNA asset classification for natural resources.

26. Chapter 3 *Valuation of Natural Resources* describes suitable valuation methods for natural resource, as agreed in the context of the 2008 SNA update process and discussed by the EGNC, while

[5] The depletion group was later combined with the subsoil assets group as there was considerable overlap in terms of membership and topics.

[6] The fish resources group met twice, while the other groups met four or five times over this period.

Chapters 4 and 5 look at the practical applications for mineral and energy resources and biological resources. In Chapter 3, Section 3.2 discusses valuation methods that are suitable for compiling natural resource estimates for the national accounts and which are the preferred methods. Section 3.3 describes in detail the Net Present Value method that may be used to estimate asset values on the basis of future economic benefits (which are called resource rents in case of natural resources). Section 3.4 discusses the treatment of taxes and subsidies in deriving estimates of resource rent. Section 3.5 details how to measure and record depletion, Section 3.6 covers the split-asset approach, Section 3.7 provides guidance on the treatment of negative resource rents. A text box with a summary of key recommendations concludes the chapter.

27. Chapter 4 *Mineral and energy resources* covers both non-renewable mineral and energy resources and renewable energy resources. Sections 4.2 and 4.3 present guidance for the Tier 2 (standard or default) approach and follow the same structure. First, the scope and definition of the assets included in the national accounts is provided, as well as relevant classifications. Second, four compilation stages are presented and explained: identifying the types of assets to be included; collecting the physical data; building the monetary asset accounts; and integration of the results into the sequence of economic accounts. Third, specific compilation issues are discussed; and finally, modifications to the standard (Tier 2) approach. A text box with a summary of key recommendations concludes the chapter.

28. Chapter 5 *Biological resources* discusses the measurement of biological resources with a particular focus on resources yielding once-only products. Section 5.2 focuses on timber resources and forest land, and Section 5.3 on aquatic resources (especially fish). Both sections present guidance for the Tier 2 (standard or default) approach and follow the same structure in terms of subsections. First, the scope and definition of the assets to be included in the national accounts is provided, as well as relevant classifications. Second, four compilation stages are presented and explained: identifying the types of assets to be included and valuation methods; collecting the physical and price data; building the monetary asset accounts; and integration of the results into the sequence of economic accounts. Third, specific compilation issues are discussed; and finally, modifications to the standard (Tier 2) approach. Section 5.4 discusses (briefly) also the valuation of other classes of biological resources such as biological resources yielding repeat products, animals for slaughter and aquaculture, as well as treatment of wild animals. A text box with a summary of key recommendations concludes the chapter.

29. Chapter 6 *Volume measures, time series, quarterly estimates and recording natural resources* details how the various estimates of natural resources that have been discussed in previous chapters can be recorded in a full sequence of economic accounts. The chapter starts in Section 6.2 with discussing the compilation of stocks and flows of natural resource in volume terms. Section 6.3 looks at the compilation of a time series of natural resources especially how to backcast asset values. This is followed by a discussion in Section 6.4 of quarterly estimates of depletion required to compile Net Domestic Product (NDP) on a quarterly basis. Section 6.5 presents split-asset calculations (how to calculate the government's share of natural resource assets). Finally, Section 6.6 contains full sequences of accounts (T-accounts) for the four types of natural resource discussed in Chapters 4 and 5 – subsoil assets, renewable energy resources, timber resources and forest land, and fish resources - with the 2025 and 2008 SNA recordings to illustrate the differences. A text box with a summary of key recommendations concludes the chapter.

2 Measuring natural resources

2.1. Introduction

30. This chapter provides important background for understanding the measurement of natural resources in the national accounts and presents the main advancements included in the 2025 SNA. Measurement is used in this guide as a broad term covering the conceptualisation (definitions and classifications), physical measurement and monetary valuation of natural resources.

31. As a starting point, it is helpful to look at where natural resources are classified in the national accounts. As shown in Figure 2-1, the 2025 SNA brings together all natural resources es that were scattered across various non-financial asset classes into a single overarching class. This is intended to emphasize the importance given to natural resources in the 2025 SNA and make it easier for policy makers and other users to find information on this topic (i.e., in one place).

Figure 2-1 Classification of natural resource assets in the 2008 and 2025 SNA

2008 SNA
Produced non-financial assets (AN1)
Fixed assets (AN11)
Cultivated biological resources (AN 115)
Animal resources yielding repeat products (AN 1151)
Tree, crop and plant resources yielding repeat products (AN1152)
Inventories (AN12)
Work-in-progress on cultivated biological resources (AN1221)*
Valuables (AN13)
Non-produced non-financial assets (AN2)
Natural resources (AN21)
Land (AN211)
Mineral and energy resources (AN212)
Non-cultivated biological resources (AN213)
Water resources (AN214)
Other natural resources (AN215)
Contracts, leases and licenses (AN22)
Permits to use natural resources (AN222)

2025 SNA
Produced non-financial assets (excluding natural resources) (AN1)
Fixed assets (AN11)
Inventories (AN12)
Valuables (AN13)
Non-produced non-financial assets (excluding natural resources) (AN2)
Contracts, leases and licenses (AN21)
*CAWLMs** (AN22)*
Purchased goodwill and marketing assets (AN23)
Natural resources (produced and non-produced assets) (AN3)
Land (AN31)
Mineral and energy resources (AN32)***
Non-renewable mineral and energy resources (AN321)
Renewable energy resources (AN322)
Biological resources (AN33)
Biological resources yielding repeat products (AN331)
Biological resources yielding once-only products (AN332)
Work-in-progress on cultivated biological resources (AN333)
Water (AN34)
Other (AN39)
Permits to use natural resources (AN392)

Source: Author.

Notes: * Includes both work-in-progress on cultivated biological resources yielding once-only products (e.g. growing crops, immature animals for slaughter) and work-in-progress on cultivated biological resources yielding repeat products (e.g. immature orchards, immature milk-cows). ** CAWLM = crypto assets without a corresponding liability designed to act as a medium of exchange. *** Includes now also renewable energy resources.

32. In the 2008 SNA, cultivated biological resources (yielding repeat products) were under the heading produced non-financial assets along with fixed assets such as machinery and equipment, while work-in-progress on cultivated biological resources was grouped with inventories. All other natural resource classes, including non-cultivated biological resources, were presented under non-produced non-financial

assets. In the 2025 SNA, all natural resources are grouped together and shown separately from the other two non-financial asset classes, namely produced non-financial assets (excluding natural resources) and non-produced non-financial assets (excluding natural resources).

33. There are different possibilities when it comes to the ownership of natural resources, with the 2025 SNA splitting assets in case the economic ownership is shared (see Section 3.6). In all cases however, "the total value of the natural resource should be recorded against the relevant class of natural resource, such as land or mineral and energy resources" (2025 SNA 27.20). As a result, in the 2025 SNA there no longer exists a category for Permits to use natural resources under Contracts, leases and licenses. The value of permits to use natural resources is not separately recorded to avoid double counting, with the exception of radio spectra. To remain consistent with the 2008 SNA treatment of radio spectra, a class Permits to use natural resources (AN392) has been created under Other natural resources (AN39) to allow recording the value of permits related to radio spectra. Greenhouse gas emissions permits are not considered natural resources and are to be recorded as financial assets (other accounts receivable/payable) with taxes on production (recorded at surrender, valued at issuance prices) in the 2025 SNA. Emissions permits are therefore out of the scope of this guide.

34. Having established where natural resources will be classified in the SNA, it is important to consider the approach to measuring natural resources, which is an accounting approach. Other well-known approaches are cost-benefit analysis (that usually includes also an environmental dimension) and measuring natural resources in terms of their "total economic value". What these approaches have in common is that they analyse value in terms of welfare value. This is fundamentally different from the national accounts, which measure exchange value. Section 2.2 will therefore discuss fundamental differences between accounting approaches employed in the SNA and environmental or welfare economics.

35. Section 2.3 will clarify the relationship between the System of Environmental-Economic Accounting Central Framework (SEEA CF, UN et al. 2014) as statistical standard for describing the interrelationship between economy and environment, and the SNA. The chapter then discusses in detail the key recommendations pertaining to natural resources that form the point of departure of the compilation guide, including their rationale (Section 2.4). The final Section 2.5 of the chapter introduces the 2025 SNA asset classification in detail, which underpins this guide.

2.2. Accounting and welfare

36. When it comes to the measurement and more specifically the valuation of natural resource there are clear differences between environmental economics and national accounts.

37. Environmental economics has a foundation in utility theory and usually assesses the relationship between the economy and environment in terms of welfare. An important concept in thinking about the interrelationship is that of externalities. Externalities are the indirect costs or benefits caused by one person or entity (e.g. a business) but incurred by a third party. Externalities are not reflected in existing market transactions and can be negative (e.g. pollution) or positive (e.g. ecosystem services/natural resources provided for free). Environmental policies are sometimes designed with the objective of internalizing externalities. For instance, a negative externality can be internalized by setting taxes at the level of the externalities. Likewise, positive externalities can be internalized by introducing payments for ecosystem services schemes. When externalities are internalized, it is common to speak about valuation at shadow

prices.[7] Well-known examples of this approach are the inclusive wealth approach by UNEP (UNEP 2023) and the Dasgupta review on the economics of biodiversity (Dasgupta 2021).

38. Another (related) approach to measuring natural resources associated with, among others, Pearce and Turner (1989) consists of the total economic value (TEV) framework or taxonomy, which values a resource as a sum total of their use values (distinguishing between direct, indirect and option values), and non-use values (consisting of existence and bequest values).[8] For instance, a forest may be directly used for producing timber and indirectly for leisure, but its mere existence may also provide value to people who may never visit the forest.

39. The notion of externalities is however not part of national accounts frameworks. The national accounts are a bookkeeping system in which the same transaction (or flow) is recorded multiple times, but always with the same (exchange) value. This is evident in the supply and use tables where the value of the supply is equal to the use. Another way to describe this is to say that the accounts exclude any consumer surplus that may arise in transactions between units. They are restricted to measuring costs, the producer surplus (which essentially means value added), and total revenue (price times quantity). Likewise, "in applying the concept of exchange value, the SNA and the SEEA limit the scope of measurement to what are commonly called "use" or "instrumental" values" (2025 SNA, 35.102).

40. The SNA explains clearly that it should not be interpreted as a system for measuring welfare or well-being, rather its intent is to measure economic activity (2025 SNA, 1.9). Most economic activities may have a positive correlation with welfare, however some (commonly referred to as defensive expenditures such as defence, or health) may not. On the other hand, as explained in Chapters 2, 34 and 35, the 2025 SNA as accounting system contains a wealth of information that allows to support measurement of well-being and sustainability. Furthermore, while there are clear differences in the level of economic activity depending on whether one uses welfare values or exchange values, as shown by Fenichel et al. (2024) changes in the exchange value of real wealth (when using proper volume indices) can align with Hicksian welfare measures, allowing to bridge welfare and exchange value under certain circumstances.

41. Another key distinction between accounting and other measurement approaches is that accounting is always *ex post*: the accounts describe what actually happened. This is fundamentally different from many forms of (environmental) analysis that are *ex ante*: they assess different policy scenarios in terms of what would happen given certain assumptions, such as cost-benefit analysis. This is not to say that accounts never use projections: a common way to value natural resources consists in applying the Net Present Value (NPV) method of calculating asset values based on future economic benefits for which we need to come up with projections of resource rents[9]. However, these projections are always made based on past observations; they are not built up from models that include optimizing agents or other assumed behaviour.

[7] The theoretical green accounting literature (e.g. Dasgupta 2021) sometimes uses the term "accounting prices" instead of shadow prices, probably referring to a valuation of natural resources in which externalities are accounted for.

[8] Multiple versions of the TEV framework have been proposed that differ in some of the details such as the placement of option value.

[9] Resource rent is defined as the return to natural resources used in production, as will be further explained in Chapter 3.

2.3. Relationship between the SNA and the SEEA

2.3.1. Complementary standards

42. The SNA and SEEA can be considered as complementary statistical standards each with own purpose and policy uses. The main purpose of the SNA is to measure economic activity and to inform economic analysis and decision-making.[10] The main purpose of the SEEA is to measure the interrelationship between the economy and the environment in both directions (SEEA CF Figure 2.1): how the economy depends on inputs of natural resources (and ecosystem services in case of ecosystem accounting), and at the same time, how economic activities (production, consumption and accumulation) impact the environment in terms of exerting pressures through residuals such as emissions (to air, water and soil). The SEEA also measures environmentally related activities and transactions, by cross-classifying transactions in the SNA according to whether they have an environmental dimension, such as accounts for environmental taxes or subsidies.

43. Traditionally, the SEEA was primarily framed as measurement system for sustainable development with focus on monetary valuation of natural resources and adjusting macro-economic aggregates. In recent years (and due to a greater focus on accounts in physical units), the uses have broadened towards measuring the circular economy, climate change and biodiversity.

44. While Chapter 29 of the 2008 SNA referred to the 2003 version of the SEEA as having satellite account status, the SEEA CF (UN et. al 2014) has become meanwhile one of the “major macroeconomic statistical standards that complement the SNA” (2025 SNA 1.81) and therefore a system on par with the SNA. The 2025 SNA places greater emphasis on well-being and sustainability than the 2008 SNA, and discusses the SEEA in Chapters 2, 34 and 35. As will be discussed in Section 2.4, the 2025 SNA has adopted several of the recommendations of the SEEA CF, most importantly the treatment of depletion as a cost of production and the split asset approach.

45. Although the SNA and SEEA have their own purposes, the combined compilation of SNA and SEEA accounts provides several advantages. Physical asset accounts according to the SEEA asset boundary provide a foundation for the valuation of natural resources in the SNA. As the SEEA applies a broader asset boundary than the SNA, it therefore encompasses the required physical information for national accounts compilation. Moreover, SEEA accounts can also be used to improve the quality of the national accounts, as they satisfy the principle of material balancing (matter cannot be lost). For example, physical energy flow accounts (PEFA) describe the supply and use of energy products by economic activities and may provide an important data source for estimating intermediate consumption of energy products when multiplied with suitable prices.

46. It is important to note that the UN Statistical Commission endorsed the update of the SEEA CF in its 55th session in 2024. The process is expected to conclude in 2028. Alignment with the 2025 SNA is one of the revision issues, however the revised SEEA CF may deviate in some aspects from the 2025 SNA as it is developed to address different needs.

[10] “The accounting framework of the SNA allows economic data to be compiled and presented in a format that is designed for purposes of economic analysis, decision-taking and policymaking.” (2025 SNA 1.3). “The main objective of the integrated framework of national accounts is to provide a comprehensive conceptual and accounting framework that can be used to create a macroeconomic database suitable for analysing and evaluating the performance of an economy. The existence of such a database is a prerequisite for informed, rational policymaking and decision-taking.” (2025 SNA 1.48)

2.3.2. Measurement boundaries

47. In the 2025 SNA (11.178) natural capital is understood as the aggregation of natural resources and ecosystem assets (see Figure 2-2). The 2025 SNA defines natural resources as follows: “Natural resources are assets that naturally occur, such as land, mineral and energy resources, water resources, and animal, tree, crop and plant resources, that have an economic value and over which ownership may be enforced and transferred. Environmental assets over which ownership rights have not, or cannot, be enforced, such as high seas beyond national jurisdiction and most parts of the atmosphere, are excluded. A significant part of natural resources is non-produced, although biological resources are frequently the result of human involvement, and have thus come into existence as outputs from production processes.” (2025 SNA, 11.11)[11]

Figure 2-2 Components of four capitals

Type of capital	Main components	Links to SNA and SEEA measurement boundaries		
		SNA	SEEA	
Economic capital	Produced non-financial assets (excluding natural resources)	Assets in the integrated framework of national accounts		
	Non-produced non-financial assets (excluding natural resources)			
	Financial assets and liabilities			
Natural capital	Natural resources • Land • Mineral and energy resources (renewable and non-renewable) • Biological resources • Water resources • Other natural resources		Environmental Assets	Individual natural resources*
	Ecosystem assets			Ecosystem assets
Human capital				
Social capital				

* Note that the SEEA excludes the radio spectra and renewable energy resources.

Source: 2025 SNA Figure 35.1

48. As ecosystem assets are outside of the SNA asset boundary only natural resources are included in the asset classification and integrated sequence of accounts. However, ecosystem condition may be relevant insofar it yields monetary benefits within the scope of value measured by the SNA. The 2025 SNA explains this as follows: “Ecosystem assets are contiguous spaces of a specific ecosystem type characterized by a distinct set of biotic and abiotic components and their interactions. Ecosystem assets are not explicitly recognised as economic assets in the integrated framework of national accounts. However, part of the value of some ecosystem assets will be implicitly included in the value of some natural resources, particularly agricultural land and forest land, since the economic value of the provisioning

[11] The SNA and SEEA provide very specific definitions. The Dasgupta review (2021) uses the terms nature, natural capital, the natural environment, the biosphere, and the natural world interchangeably.

services and other ecosystem services supplied by these ecosystem assets will also be reflected in the values of the natural resources. The recording of data about ecosystem assets and the services they apply is at the heart of SEEA Ecosystem Accounting" (2025 SNA, 11.180). The 2025 SNA however does not explicitly record the value of ecosystem services which are considered to lie outside the SNA production boundary.

49. The SEEA CF does not define natural capital. It prefers the term environmental assets defined as "the naturally occurring living and non-living components of the Earth, together constituting the biophysical environment, which may provide benefits to humanity" (UN et al. 2014, para 2.17). The main reason why SEEA prefers environmental assets appears to be that the notion of asset in SEEA is first and foremost a physical concept, while capital has clear connotations of economic value.

50. The SEEA CF has a broader asset boundary in biophysical terms than the SNA, as environmental assets without current economic value or economic owner are also in scope. The SNA and SEEA CF however have the same asset boundary in monetary terms. For example, in case of oil and gas resources, both the SNA and SEEA asset boundary in monetary terms is restricted to resources with economic value over which ownership rights are exercised, i.e. to commercially viable resources, however the SEEA physical asset account will cover a wider set including potentially commercial or non-commercial resources. On the other hand, the 2025 SNA asset boundary for natural resources includes also assets not currently included as natural resources in the SEEA CF such as radio spectra and renewable energy assets.

51. The SEEA Ecosystem Accounting (UN et al. 2024) and SEEA CF have the same (biophysical) asset boundary, but a different classification of the assets that make-up the environment: "Within this broader asset boundary, the focus of accounting in the SEEA Central Framework is on the individual resources that make up the environment, such as minerals, timber, water, land and soil. This focus comprises those types of individual resources used in economic activity. The focus of accounting for environmental assets in the SEEA EA is on ecosystems and, in many senses, how individual components function together." (UN et al. 2024, A1.13) For instance, if we take a forest, the SEEA CF would describe this in terms of multiple assets: land (understood narrowly as the asset that provides space), soil resources, timber resources, and possibly also water resources and biological resources (e.g. wild animals). The SEEA EA, however, would describe the same forest as an integrated asset (a forest ecosystem) that generates a range of ecosystems services: provisioning services (in the form of timber), regulating services (such as carbon sequestration or retention; water purification and air filtration) and cultural services (using the forest for leisure).

52. When it comes to monetary valuation, the SEEA CF applies the same valuation principles as the SNA. The SEEA CF and 2025 SNA have the same production boundary. By contrast, the SEEA EA extends the SNA production boundary with the recognition of ecosystem services as outputs generated by ecosystem assets, although the valuation chapters in this manual were not approved as a statistical standard and remain experimental. As a result, the monetary value of ecosystem assets could be larger than the value of the individual assets measured by the SEEA CF or the 2025 SNA, if the market value of the assets outside of this boundary is positive. The value of the forest will be larger than the value of the individual assets such as timber resources (and land) as it will also include the value of non-marketed regulating and cultural ecosystem services which are outside the SNA production boundary.

53. Another important difference between the SEEA CF and the 2025 SNA is that they have a different definition of natural resources. The SEEA CF stipulates that "Natural resources include all natural biological resources (including timber and aquatic resources), mineral and energy resources, soil resources and water resources." (2.101, 5.18). Natural resources therefore exclude land and cultivated biological resources, although these assets are considered as environmental assets, whereas the 2025 SNA includes both produced (cultivated) and non-produced assets in natural resources. The SEEA EA (Table 11.2) contains a proposal for an extended balance sheet which integrates both the SEEA EA, SEEA CF

and SNA perspectives, where it is apparent that some 2025 SNA defined natural resources (e.g. forest land and timber) would be encompassed in ecosystem assets (e.g. terrestrial ecosystems).

54. The current situation where the SEEA CF and 2025 SNA have different definitions and classifications of natural resources is not ideal, which is why the treatment of land is placed on the post-2025 SNA research agenda. The issue of alignment between the SEEA and SNA asset classifications is also included as part of the SEEA CF update.

2.3.3. Physical and monetary estimates

55. The SEEA consist of accounts in physical units (such as physical flow accounts, and physical asset accounts); accounts in monetary units; and also hybrid accounts (accounts that combine physical and monetary information). For the physical accounts, a range of units is used including tons, joule, litres, km2 etc depending on the specific resource. On the other hand, the 2025 SNA consists of monetary values only. In most cases, the estimation of monetary asset values for natural resource and the cost of depletion requires SEEA-style physical asset accounts with information about stocks and changes in stocks during the accounting period. This physical information is typically a subset of the physical accounts of the SEEA, due to the broader asset boundary in physical terms of the SEEA and can be sourced from the SEEA accounts if countries already compile them. In case countries do not yet compile SEEA asset accounts, this guide recommends joint implementation to benefit from synergies. This is discussed further for mineral and energy resources in Chapter 4 and for biological resources in Chapter 5.

2.4. Changes from the 2008 SNA

56. In this section, we first outline the recommendations for the update of the 2008 SNA as endorsed by the UN Statistical Commission in 2024 (ISWGNA 2023a) with some modifications as described in ISWGNA (2024). Next, we explain the rationale for the key recommendations that are the starting point for this compilation guide.

2.4.1. Recommendations regarding natural resources

57. The recommendations for the update of the 2008 SNA were grouped together into eight categories (represented by letters in ISWGNA 2023a, further detailed with numbers). Here we list all relevant recommendations pertaining to natural resources by copy pasting the final text from Annex 4 of the 2025 SNA, but keeping the original letter and number designation, and adding supplemental reference to the relevant Guidance Notes in parenthesis for ease of reference:

A. Generic issues

<u>1. Giving more prominence to net measures (CM.4)</u>

Net income measures have been given more emphasis in the 2025 SNA. In this respect, the volume change of net domestic product (NDP) has been identified as the conceptually preferred measure of economic growth, not replacing but to be used alongside the volume change of gross domestic product(GDP). In the 2025 SNA, NDP is defined as GDP less depreciation and depletion of natural resources (in the 2025 SNA the term “depreciation” has replaced the term “consumption of fixed capital” used in the 2008 SNA)

<u>2. Valuation principles and methodologies (AI.1, X.24 and X.53)</u>

The principles and methodologies for valuing transactions and stocks/positions will not be changed in the 2025 SNA. However, more explicit guidance regarding the following issues will be added:

a. *Using the preferred term "exchange values", defined as "the values at which goods, services, labour or assets are in fact exchanged (between two independent parties) or else could be exchanged for cash", as the main principle for valuing transactions. The concept of "exchange values" and "exchange price" have been more clearly distinguished from the valuation methods to approximate this concept, by referring to observed exchange prices/market prices as the preferable method for valuing transactions;*

b. *Using the notion of (the present value of future) capital services as the current operational value for valuing non-financial assets. This can be approximated by using the perpetual inventory method (PIM) for most fixed assets and the present value of future resource rents for non-produced natural resources. In particular, there are more detailed recommendations for valuing mineral and energy resources.*

c. *Only using observed market prices to arrive at market-equivalent prices, if the appropriate market conditions are met. The latter concerns issues related to the maturity of the markets and/or related to the point that the market is not distorted by, for example, government interventions. It is not related to the structure of the market (competitive, monopolistic, oligopolistic, monopsonistic or other types of markets).*

C. Further specifications of the scope of transactions, including the production boundary

5. Household production of electricity and heat

The 2025 SNA provides guidance on the recording of production, by households, of electricity through the use of solar panels and wind power plants and the production of heat through geothermal heat or heat pumps is to be treated as own-account production of goods. Household production of electricity can be used directly by the producing household for own final consumption, can be sold to the local grid, or a mix of the two (with complicated price structures involved). Household production of heat through geothermal heat or heat pumps is normally used for own final consumption. The production of electricity and heat by households for own final consumption is also considered to be part of the production boundary applied in the integrated framework of national accounts.

D. Extensions and further specifications of the concepts of non-financial assets, capital formation and consumption of fixed capital/depletion, including changes related to other transactions in goods and services

4 Depletion of non-produced natural resources (WS.6, WS.10)

Depletion of non-produced natural resources is recorded as a cost of production in the 2025 SNA, instead of the 2008 SNA treatment as other changes in the volume of assets. Consequently, net domestic product is not only affected by depreciation (known as "consumption of fixed capital" in the 2008 SNA.

5. Accounting for mineral and energy resources (WS.6, WS.10 and WS.11)

In the 2025 SNA, the asset boundary for mineral and energy resources explicitly includes renewable energy resources (i.e., the exclusive use of solar, wind, etc., for the production of energy). If not already reflected in the value of land, these resources are explicitly accounted for, if they are viable in economic production under prevailing technological and economic conditions, to be valued using the present value of future resource rents (applying the residual value method). These renewable resources were not explicitly considered as assets in the 2008 SNA.

To facilitate the delineation and international comparability of non-renewable mineral and energy resources, the 2025 SNA uses the same three resource classes as in the SEEA Central Framework (i.e. commercial and other known deposits"). However, the measurement of monetary estimates is restricted to the first class, which in practice could be approximated by those resources for which permissions to *exploit have been granted, and/or those for which the existence is explicitly recognized by (past) monetary transactions.*

The 2025 SNA clarifies the calculation of present values of future resource rents for mineral and energy resources, which had been introduced in the 2008 SNA.

In allocating the value of mineral and energy resources, the split-asset approach is adopted in the 2025 SNA, in line with the appropriation of resource rents by both the legal owner (reflected as receipt of rents) and the extractor (reflecting the residual value of the resource rent). (In the 2008 SNA, the full value of the asset was allocated to the legal owner.) In relevant cases, transfers of parts of the resources by the legal owner to the extractor are recorded as other changes in the volume of assets and liabilities, and not as capital transfers. In the case of transferable rights to exploit the resources, double-counting should be avoided by not allocating both the value of the rights and the value according to the split-asset approach to the balance sheet of the extractor. The attribution of depletion costs to the legal owner and the extractor is recorded in line with chapter 5 of the SEEA central framework.

6 Accounting for biological resources yielding once-only products (WS8)

Although the asset boundary for biological resources has not changed, the 2025 SNA changes the distinction between cultivated (produced) and non-cultivated (non-produced) resources yielding once only products. It is recommended to distinguish between resources where the control, responsibility and management does not go beyond the establishment of quota regimes (e.g., migrating wild animals and fish) versus resources where one can observe a continuum from intensive to extensive forms of control, responsibility and management (e.g., the growth of trees for timber production). In respect of the latter, all growth of the relevant resources that in the future is intended to be used for the purpose of producing goods is considered as being under some form of management and control by economic agents, instead of applying a discretionary choice between either managed and controlled or not managed and controlled by economic agents. This only leads to a shift in the classification of assets, with no impact on the asset boundary.

The degradation of biological resources yielding once-only products, here to be understood as the income generating potential of the underlying asset (e.g., forest land), is recorded as depletion, with any regeneration recorded as negative depletion. Further clarification is also introduced regarding the compilation of work-in-progress for biological resources yielding once-only products, in particular the need to eliminate the possible inclusion of resource rents linked to the underlying asset. In this respect, it should be noted that forest land (i.e., the underlying asset for timber production) is treated as a non-produced non-financial asset, similar to agricultural land.

10 Revised classifications and definitions of assets (DZ.7, WS.11 and WS.12)

In the 2025 SNA, natural resources are treated as a separate asset class, next to produced non-financial assets (excluding produced natural resources), non-produced non-financial assets (excluding non-produced natural resources), and financial assets (and liabilities). Ecosystem assets, human capital and social capital are recognized as separate asset classes, albeit outside the asset boundary of the integrated framework of national accounts. For certain asset categories, "of which" items are included, as supplementary information, to separately identify certain investments that are considered highly relevant for the transition of the economy to cope with climate change.

F. Further specifications of the scope of transactions concerning government and public sector

1. Emission permits (WS.7)

It will be recommended to record emission permits as financial assets (other accounts receivable/payable), with taxes on production recorded at surrender, valued at issuance prices.

3. Distinction between taxes and services more generally (WS.14, AI.2)

The 2025 SNA provides clarification on the treatment of payments related to the use or extraction of natural resources. In particular, it is specified that rents received by the legal owner of a natural resource should include any payments from a user/extractor of that resource that are linked to the use/extraction or to the quantity and/or value of that resource (including royalties, surtaxes and permits).

2.4.2. Rationale for the main changes to 2008 SNA

Depletion as cost of production

58. The 2008 SNA included the recording of depletion of natural resources as an element in the other changes in volume of assets and liabilities account. The 2025 SNA recommends including depletion as a cost of production in the current accounts, thereby impacting net measures such as NDP, NNI and net saving.[12] The 2025 SNA recommends recording depletion for non-produced natural resources

59. The 2025 SNA essentially follows the SEEA CF (UN et al. 2014), which has standardized the definition and recording of depletion. Before the publication of the SEEA CF, the treatment of depletion as a cost of production had been extensively debated over many years, with several different approaches being put forward.[13] In the SEEA CF, it was agreed to treat depletion of natural resources like depreciation of fixed assets, as both types of assets are used up in the production process. The inclusion of depletion in NDP ensures consistency and symmetry of treatment between produced capital and relevant natural resources.

60. For non-cultivated biological resources yielding once-only products and forest land, whether or not depletion occurs depends on how they are managed. When they are managed in a fully sustainable manner , there is no depletion. It is possible that the opposite of depletion occurs, namely that the resource is allowed to regenerate. For instance, after a situation of overfishing, fishing quota may be reduced or the fishing ground closed, until the stock is sufficiently recovered.

61. When the 2025 SNA changes relating to natural resources are implemented in countries' accounts, policy makers should be able to compare, for example, the impact on net measures of production and income of using non-renewable *versus* renewable energy or of non-sustainable *versus* sustainably managed fishing. The inclusion of depletion as a cost of production provides clear signals to policy makers where the depletion of non-produced natural resources may jeopardize future economic growth.

Renewable energy resources as a new asset category

62. Guidance Note WS.11 (SNA Update 2023c) assesses the current treatment of renewable energy in the 2008 SNA and the SEEA CF. It notes that the 2008 SNA does not have much to say about this issue. The SEEA CF assumes that renewable energy asset values are captured in associated land values but does not address the valuation of renewable energy resources when this is not associated with land (e.g. offshore wind); or exists under ownership rights separated from land (e.g. hydro and most geothermal); or is associated with land that has no economic value (e.g. remote desert). The explicit recognition of

[12] Treatment of depletion as a cost of production may also have an effect om GDP to the extent production of natural resources is undertaken by government for its own final use (as a non-market production process), through the sum-of-cost approach for measuring output (2025 SNA 7.137). This would likely occur only infrequently.

[13] Edens (2013) contains a summary of these discussions, distinguishing between three main proposals. The proposal (associated with Vanoli) to see subsoil asset as "gifts from nature"; depletion would be seen as a withdrawal from inventories and equal to the full resource rent. A proposal (going back to Repetto and the United States Bureau of Economic Analysis work in the early 1990s) to see subsoil assets as assets that become produced through the act of discovery; depletion would hence be netted off by discoveries. El-Serafy's "user cost" approach which splits the resource rent into an income and depletion element; depletion was deducted both from GDP and NDP.

renewable energy as part of economic assets is therefore a change to the SNA and – if it is agreed as part of the update of that framework starting in 2024 – of the SEEA CF.

63. According to Guidance Note WS.11, there are several reasons why renewable energy resources should be explicitly recognized as assets as long as they satisfy the criteria of assets in terms of ownership and derivation of benefits.[14] First, as fossil fuel resources are already included in the SNA, not including renewable energy resources would lead to an imbalance, with the risk of sending distorted signals to decision-makers. Secondly, governments (for example in the United Kingdom) are already beginning to capture rents associated with renewable resources such as wind.

64. It should be emphasized that the asset we are trying to value in the national accounts is the renewable resource itself, not the value of the equipment used in capturing the renewable resource. For instance, in case of solar panels, we need to distinguish between the value of the solar panel (a fixed asset) and the value of the renewable energy asset (a non-produced asset).

65. Some accountants have struggled to see how energy resources such as wind or hydro can be considered as stocks, as they seem to be flows. Here, it is important to realize that for subsoil assets, reserves are also based not only on geological considerations ("how much is available?") but also on technical ("can we extract it?"), legal ("do we have permission to extract?") and economic considerations ("is it profitable to extract?"). Likewise, in the case of renewable resources, we can conceive of stocks in physical units as the total amount that can be extracted over time given existing technology and price or cost levels; stocks in monetary units consist of aggregated (discounted) flows of future flows of benefits. This similarity is why the United Nations Framework Classification for Resources applies to both non-renewable and renewable mineral and energy resources (see Section 4.2.1).

66. A second objection to treatment of renewable energy resources as assets is that they cannot be seen as scarce. Here it should be clarified, as mentioned in 2025 SNA (A4.54)), that in the national accounts only "the exclusive use of solar, wind, etc. for the production of energy" gives rise to recording of assets. First of all, renewable resources that are not used (e.g. a river without hydropower installation, or solar radiation not captured by solar panels) do not constitute assets. Secondly, the installation of equipment such as wind turbines, hydropower dams, or solar installation almost always requires permits, and is not allowed everywhere.[15] The situation with solar panels installed by households is more nuanced; for instance, balcony panels (i.e. smaller panels detached from the grid) are not considered to give rise to renewable energy assets, but panels fixed to the roof do.[16]

67. All things considered, the inclusion of renewable energy assets should enable the 2025 SNA to remain a policy-relevant measurement framework for economies facing climate change. In addition to showing the impact of different types of energy use on net measures of production and income (with implications for future economic growth, as discussed above), the national accounts will also be able to

[14] 2025 SNA (1.68) states: "Natural resources such as land, mineral deposits, fuel reserves, renewable energy resources, uncultivated forests or other vegetation and wild animals are included in the balance sheets provided that institutional units are exercising effective ownership rights over them, that is, are actually in a position to be able to benefit from them.

[15] The 2025 SNA (11.200) states: "Although these resources as such are generally not scarce, the exploitation of these resources may be restricted to certain economic agents, for example by needing permissions to put wind turbines on land, or having ownership of particular pieces of land which are highly favourable for exploiting renewable resources."

[16] Eurostat (2024) discusses the treatment of electricity production by households and recommends that "for practical reasons the households' production of electricity with so-called balcony solar panels (also known as mini solar systems) does not need to be recorded. This assessment might change when this type of production reaches significant amounts." The 2025 SNA however seems to support the exclusion of balcony panels on conceptual grounds as their use of renewable energy resources is not exclusive, as these panels can be moved to a different location.

provide estimates of stocks of renewable energy, allowing for comparisons of renewable energy assets and non-renewable energy assets.

Clarifications to biological resources

68. The 2025 SNA contains several changes regarding the conceptualization, measurement and recording of biological resources. More specifically, as neither biological resources yielding repeat products nor biological resources yielding once-only products in agriculture are considered problematic in terms of measurement as they are typically cultivated and market prices are often available[17], the scope of the recommendations is restricted to the treatment of biological resources yielding once-only products (other than agriculture) such as timber and fish resources.

69. The 2008 SNA made a distinction between cultivated and non-cultivated biological resources depending on whether "the growth process is directly controlled by, managed by and under the responsibility of an economic agent" (UN et al. 2009; para 6.136 and 10.88). In practice it is often difficult to make this distinction, and there was a risk that countries draw the line differently, thus leading to a potential lack of international comparability.

70. There is no change for biological resources yielding repeat products, which are always cultivated. The 2025 SNA maintains the distinction between cultivated and non-cultivated biological resources yielding once only products, but draws the line slightly differently. The distinction is between "resources regarding which the human involvement is very limited, such as the establishment of quota regimes [non-cultivated], and resources where one can observe a continuum from intensive to extensive forms of control, responsibility and management [cultivated]." (2025 SNA 11.207).

71. The asset boundary for biological resources of the 2008 SNA is not changed: for instance, timber resources in remote or non-logged areas of the Amazon will continue to be outside the asset boundary. The overarching criteria remains whether the biological resources fulfil the definition of economic assets (SNA 11.10) and hence included within the SNA asset boundary.

72. Finally, the 2025 SNA sets out to clarify various treatments of biological resources in the 2008 SNA[18] by distinguishing clearly between work-in-progress of cultivated biological resources (e.g. standing timber) and what it describes as the underlying asset (e.g. forest land). The underlying asset captures the capacity of assets to yield also future benefits. It is therefore the underlying asset that can be subject to depletion or regeneration, not the work-in-progress. This is explored further in Chapter 5.

Economic ownership employing the split-asset approach

73. The 2008 SNA specified that asset ownership is in principle determined based on economic ownership. But "when a natural resource is the subject of a resource lease, the asset continues to appear in the balance sheet of the lessor [e.g., a government] even though most of the economic risks and rewards of using the asset in production are assumed by the lessee [e.g., a resource company]" (2008 SNA, 13.3). Therefore, there was an inconsistency in the SNA's approach to asset ownership, which created an imbalance between value recognized in the balance sheet and the income measured in the current accounts of the legal owner and extractor (producer).

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[17] Presentation 'Accounting for Biological Resources', 26th Advisory Expert Group (AEG) on National Accounts, 2022: https://unstats.un.org/unsd/nationalaccount/aeg/2022/M19/M19_6_WS8_Accounting_Biological_Resources_Pres.pdf

[18] Some confusion may have been created in the 2008 SNA, by using less precise terminology (SNA Update 2022b para. 58).

74. A common thread underpinning several of the natural resource recommendations is the general idea that using a natural resource in production always gives rise to a “resource rent”, and that this resource rent is generally not fully captured in the rent paid to the legal owner of the resource (usually the government).[19]

75. The SEEA CF (UN et al. 2014) specifies that “Economic value of mineral and energy resources should be allocated between the extractor and the legal owner” (para 33) and that “the allocation of assets and the resulting estimates of institutional sector net worth should reflect the expected future income streams for each unit from the extraction of the resources” (5.223). The 2025 SNA follows the SEEA CF treatment applying it generally to natural resources. The upshot is that depletion is also shared based on economic ownership.

76. In general, the split asset approach is not only relevant for the government sector (S.13) and extractor (S.11), but also for the household sector (S.14) or non-profit institutions serving households (S.15) that may also be the legal owner of natural resources e.g. churches that own standing timber and forest land.

77. Aside from the key accounting reason to restore consistency between income (and depletion) streams with the underlying assets giving rise to the flows, splitting assets provides highly policy-relevant information. First, it provides an indicator of how much natural resource wealth is given away by government to the private sector, which is especially relevant in resource rich countries.[20] Second, the allocation of the assets to legal owner and extractor within the national accounts is consistent with the aspiration of the 2025 SNA to assess distributions of income and wealth across groups of economic units (2025 SNA 1.10).

2.5. 2025 SNA asset classification

78. In the 2025 SNA, natural resources are split into five classes: land; mineral and energy resources, biological resources, water resources; and radio spectra and other natural resources. We will discuss each of these in greater detail, including the classes not covered in the remainder of this compilation guide: land, water resources and other natural resources. Figure 2-3 also indicates for each of the natural resource classes whether they consist of produced or non-produced assets. This is important as this will determine their treatment in the integrated framework of national accounts, which is indicated in the additional columns on the recording of their generation and rundown. For example, biological resources yielding repeat products such as orchards are fixed assets (produced natural resources) and subject to depreciation and gross fixed capital formation.

[19] SNA Update (2023h, section II) discusses the use of the terms “resource rent” and “rent” in the various statistical standards. In the 2008 SNA, GFSM 2014 and ESA 2010 these terms are synonyms (D.45). It was called “resource rent” or simply “rent” as it concerned a resource lease. By contrast, the OECD Measuring capital handbook (OECD 2009) and the SEEA CF understand resource rent as a different concept, namely capital services, which is also followed in the 2025 SNA (see Chapter 3 in this guide for a more detailed discussion of rent and resource rent).

[20] There is a whole literature investigating the so-called resource curse, i.e. the paradoxical situation where countries rich in natural resources such as mineral or oil and gas appear to have poor development outcomes.

Figure 2-3 2025 SNA natural resource asset classification

	Type	Generation	Rundown
AN3 Natural resources			
AN31 Land	Non-produced*	Negative depletion	Depletion
AN32 Mineral and energy resources			
AN321 Non-renewable mineral and energy resources			
AN321S1 Coal and lignite resources	Non-produced	OCV	Depletion
AN321S2 Oil and natural gas resources	Non-produced	OCV	Depletion
AN321S21 Oil resources	Non-produced	OCV	Depletion
AN321S22 Natural gas resources	Non-produced	OCV	Depletion
AN321S3 Mineral resources	Non-produced	OCV	Depletion
AN321S4 Other non-renewable mineral and energy resources	Non-produced	OCV	Depletion
AN322 Renewable energy resources			
AN322S1 Wind energy resources	Non-produced	OCV	OCV
AN322S2 Solar energy resources	Non-produced	OCV	OCV
AN322S3 Water energy resources	Non-produced	OCV	OCV
AN322S4 Geothermal energy resources	Non-produced	OCV	OCV
AN322S4 Other renewable energy resources	Non-produced	OCV	OCV
AN33 Biological resources			
AN331 Biological resources yielding repeat products			
AN3311 Animal resources yielding repeat products	Produced	GFCF	Depreciation
AN3312 Tree, crop and plant resources yielding repeat products	Produced	GFCF	Depreciation
AN332 Biological resources yielding once-only products			
AN3321 Cultivated biological resources yielding once-only products	Produced	OCV	Depreciation
AN3322 Non-cultivated biological resources yielding once-only products	Non-produced	Negative depletion	Depletion
AN333 Work-in-progress on cultivated biological resources			
AN3331 Work-in-progress on cultivated biological resources yielding repeat products	Produced	Additions to invent	Withdrawals from i
AN3332 Work-in-progress on cultivated biological resources yielding once-only products	Produced	Additions to invent	Withdrawals from i
AN34 Water resources	Non-produced	OCV	OCV
AN39 Other natural resources			
AN391 Radio spectra	Non-produced	OCV	OCV
AN392 Permits to use natural resources	Non-produced	OCV	OCV
AN399 Other			

Source: *Author*

Notes: Cells in orange are supplementary items (also indicated with S). * Land improvement is classified separately as fixed assets (AN1123).

2.5.1. Land

79. The 2025 SNA (11.194) defines land (AN31) as follows[21]: "Land consists of the ground, including the soil covering and any associated surface waters, over which ownership rights are enforced and from which economic benefits can be derived by their owners by holding or using them. The value of land excludes any buildings or other structures situated on it or running through it; cultivated crops, trees and animals; mineral and energy resources; non-cultivated biological resources and water resources below the ground. The associated surface water includes any inland waters. (reservoirs, lakes, rivers, etc.) over which ownership rights can be exercised and that can, therefore, be the subject of transactions between institutional units. However, water bodies from which water is regularly extracted, against payment, for use in production (including for irrigation) are included not in water associated with land but in water resources."

80. Land is in principle a non-produced asset. According to the 2025 SNA (11.238) "Bare land .. [is] not subject to depletion. However, in the case the value of land is combined with another asset, the combined asset may be subject to depreciation or depletion... In the case of cultivated biological resources yielding once-only products, the growth and decline of the regenerative potential of the underlying asset (mainly relating to forest land in the case of the growth of trees for the production of timber) is also to be

[21] No change compared to the 2008 SNA.

recorded as (negative) depletion." Although the 2025 SNA does not define bare land specifically, it is to be understood in a land cover sense, as land predominantly without vegetation.[22]

81. The SNA definition of land differs from the SEEA CF, which defines land as "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" (UN et al. 2014, paragraph 5.239). According to the SEEA CF, land should be understood as the mere provision of space and is different from natural resources. Another difference is that according to the SEEA CF, soil should be considered as a separate asset, whereas soil is part of the value of land in the SNA.

Table 2-1 Classification of land

1. Land underlying buildings and structures
1.1 Land underlying dwellings
1.2 Land underlying other buildings and structures
2. Land under cultivation
2.1 Agricultural land
2.2 Forestry land
2.3 Surface water used for aquaculture
3. Recreational land and associated surface water
4. Other land and associated surface water

Source: Eurostat and OECD (2015, Table 3.3), suppressing the classification codes.

82. Reference is made here to the Eurostat-OECD compilation guide on land estimation (Eurostat and OECD 2015). The compilation guide contains a classification of land (see Table 2-1) that goes beyond the detail provided in the SNA. Eurostat and OECD (2015) also describe a range of valuation methods for land consisting of direct methods (such as transactions in land) and indirect methods (such as the residual value method; land to structure ratio; and hedonic pricing).

83. This guide will not discuss the measurement and valuation of land in detail, apart from the valuation of forest land[23] which will be discussed in relation to the valuation of timber resources (Chapter 5). This guide is, however, consistent with the Eurostat and OECD (2015) compilation guide.

84. The 2025 SNA defines land improvements as "major improvements in the quantity, quality or productivity of land, or prevent its deterioration. Such improvements are recorded as capital formation and the additional value is shown as a separate asset within produced non-financial assets (excluding natural resources). Activities such as land clearance, land contouring, creation of wells and watering holes that are integral to the land in question are to be treated as resulting in land improvements. Activities such as the creation of seawalls, dykes, dams and major irrigation systems which are in the vicinity of the land but not integral to it, which often affect land belonging to several owners and which are often carried out by government, result in assets that are to be classified as structures." (2025 SNA, 11.88) Land improvements continue to be recorded as AN11 fixed assets (2025 SNA 11.89) separate from land (which is a non-

[22] More precisely, the SEEA CF contains a description of land cover classes which includes Class 11 Terrestrial barren land, defined as: "This class includes any geographical area dominated by natural abiotic surfaces (bare soil, sand, rocks, etc.) where the natural vegetation is absent or almost absent (covers less than 2 per cent). The class includes areas regularly flooded by inland water (lake shores, river banks, salt flats, etc.). It excludes coastal areas affected by the tidal movement of saltwater".

[23] Note that slightly different terminology can be found: the Guidance Note WS 8 (SNA Update 2023b) uses forest land; the EFA uses wooded land; Eurostat and OECD (2015) use forestry land.

produced asset). It has been mentioned by some that “land improvement” is a misleading term as some of these activities may have detrimental environmental outcomes. This issue has been included in the post 2025 SNA/BPM research agenda.

2.5.2. Mineral and energy resources

85. *Mineral and energy resources* (AN32) are split between non-renewable (AN 321) and renewable resources (AN 322). All minerals are considered non-renewable, so they are included in the first category (AN321) while energy resources may be renewable or non-renewable. Mineral and energy resources are considered non-produced assets. Their generation is recorded as other changes in volume, while their run-down is recorded as depletion for non-renewable resources and as other changes in volume for renewable resources.

86. Non-renewable mineral and energy resources (AN321) are disaggregated into coal and lignite, oil and natural gas (which itself is further broken down between oil and natural gas), minerals, and other. These classes are all labelled as supplementary in the 2025 SNA, which means that it is up to countries and international organizations to decide what they consider relevant for inclusion in national publications and international questionnaire. Their scope and treatment are further discussed in Section 4.2.

87. Renewable energy resources (AN322) are disaggregated into wind energy resources; solar energy resources; water energy resources; geothermal energy resources; and other renewable energy resources (2025 SNA 11.202). These classes are also labelled as supplementary in the 2025 SNA, which means that it is up to countries and international organizations to decide what they consider relevant for inclusion in national publications and international questionnaire. Their scope and treatment are further discussed in Section 4.3.

2.5.3. Biological resources

88. *Biological resources* (AN33) are disaggregated into AN331 Biological resources yielding repeat products, AN332 Biological resources yielding once-only products and AN333 Work-in-progress on cultivated biological resources.

AN331 Biological resources yielding repeat products

89. AN331 are considered fixed assets and further divided into AN3311 Animal resources yielding repeat products and AN3312 Tree, crop and plant resources yielding repeat products. According to the 2025 SNA (11.214) “Animal resources yielding repeat products cover animals whose natural growth and regeneration are under the direct control, responsibility and management of institutional units.” They are therefore considered as cultivated assets. Their generation is recorded as gross fixed capital formation measured by the value of acquisitions less disposals, with depreciation measured as the decline in value due to aging of animals (for more details see 11.215). AN3311 is a broad category that consists of various groups of animals which can be illustrated based on the functions they fulfill in production (based on 11.214 with examples added):

- Breeding stocks i.e. animals kept for controlled reproduction, including aquatic resources.[24]
- Dairy cattle, sheep or other animals used for production of wool or milk. Cattle raised for slaughter is excluded here as this is included under AN333 Work-in-progress on cultivated biological resources.

[24] “In all but exceptional cases, though, [aquatic resources maintained for reproduction] will be small and may be ignored unless of significant importance.” (11.215)

- Draught animals i.e. animals such as oxen, or bulls that are used to do work such as plowing fields.
- Animals used for transportation such as horses or guide dogs.
- Animals used for racing such as horses or dogs.
- Animals used for entertainment such as circus animals.

90. AN 3312 are also considered fixed assets defined according the 2025 SNA (11.217) as "Tree, crop and plant resources yielding repeat products cover plants whose natural growth and regeneration are under the direct control, responsibility and management of institutional units." They are therefore considered as cultivated assets. Their generation is recorded as gross fixed capital formation measured by the value of acquisitions less disposals, with depreciation measured as the decline in value due to aging of these assets. The class consists of "Trees (including vines and shrubs) cultivated for fruits and nuts, for sap and resin and for bark and leaf products." (11.217) The class excludes "Trees grown for timber that yield a finished product once only, just as cereals or vegetables that produce only a single crop." (11.217).

AN332 Biological resources yielding once-only products

91. AN332 Biological resources yielding once-only products consist of AN3321 Cultivated biological resources yielding once-only products and AN3322 Non-cultivated biological resources yielding once-only products. Their generation is recorded as negative depletion while their run-down is recorded as depletion. AN3321 Cultivated biological resources yielding once-only products is in principle an empty category which is only included for completeness of the classification structure. The class is empty because timber resources are always recorded as AN333 work-in-progress, while forest land is always recorded under AN31 Land.

92. The main example of non-cultivated biological resources yielding once-only products consist of fish resources in open seas (see Section 5.2 for a detailed discussion of definition and scope). Other examples are wild animals (e.g. game) that are hunted for commercial purposes (i.e. not for own final consumption).

AN333 Work-in-progress on cultivated biological resources.

93. According to the 2025 SNA (11.223) Work-in-progress on cultivated biological resources covers both work-in-progress on biological resources yielding repeat products and once-only products. Specifically, it defines (11.224) "work-in-progress on cultivated biological resources yielding repeat products consists of output that is not yet sufficiently mature to be in a state in which it is normally supplied to other institutional units, or to be used in production." Furthermore (11.225), "Work-in-progress related to cultivated biological resources yielding once-only products represents the accrual accounting of the growth of single-use animals, crops and plants as well as trees intended for the future production of timber." Aquaculture resources would be recorded in this class as well.

94. Generation and run-down is recorded as additions and withdrawals from inventories.

2.5.4. Water resources

95. The measurement and valuation of *Water resources* (AN34) as assets is a complex area that sits at the intersection of SNA, SEEA CF and SEEA EA. The 2025 SNA (11.203) defines water resources as follows[25]: "Water resources consist of surface and groundwater resources used for extraction to the extent that their scarcity leads to the enforcement of ownership or use rights, market valuation and some measure

[25] No change compared to the 2008 SNA.

of economic control. If it is not possible to separate the value of surface water from the associated land, the whole should be allocated to the category representing the greater part of the total value."

96. The SEEA Water (UN 2012) contains detailed guidelines for the measurement of water resources, covering a range of water accounts, with Chapter VIII discussing the valuation of water resources. The SEEA EA (UN et al. 2021, 11.41) distinguishes between freshwater ecosystems (such as rivers or lakes) and the provisioning of water (water supply): "The value of water supply is treated as an abiotic flow and hence is recorded as part of other environmental assets – as water resources - rather than associated with the terrestrial or freshwater ecosystem asset to which they are most directly connected (e.g., based on the location of a bore or well). In this context, the value of water resources is limited to its use as input to economic activity and human consumption.". Aquifers require specific attention, in some cases they are confined and in others unconfined[26]; when confined they are treated as distinct ecosystems (UN et al. 2021, 3.17).

97. Some water resources can be understood as non-renewable: "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 during the human lifespan. It should be noted that the concerns about non-renewable water apply not only to groundwater, but also to other bodies of water: for example, lakes may be considered non-renewable when their replenishment rate is very slow compared with their total volume of water." (SEEA Water 6.16). For non-renewable water resources, it would seem logical to measure the cost of depletion (or value of regeneration).[27] This issue has not been discussed in the context of the SNA (or the SEEA) and therefore the valuation of depletion of water resources is not recommended in the national accounts, and any value changes are to be recorded as other changes in volume.

98. Water resources can be used in economic activity in different ways: they can be used directly (for instance water abstraction for use as drinking water), indirectly (to absorb heat when used for cooling water or to dilute pollutants), in situ (used for transportation or recreation) or for their kinetic energy (hydropower). Importantly, the SNA restricts the scope of valuation as asset to the first category: use for extraction (hydropower is discussed under renewable energy). This restricted focus is consistent with the SEEA EA, which considers water resources as distinct assets from ecosystem assets.

99. Even with such a limited focus, the valuation of water resources can be challenging. The SEEA Water mentions several unique characteristics of water including that "water is a heavily regulated commodity for which the price charged (if any) often bears little relation to its economic value or even to its cost of supply." (UN 2012, para 8.1). Valuation of water resources could be undertaken based on the resource rent of the water supply sector. However, as the provisioning of water is often not for profit, the resulting rents may be low or even negative.

100. In light of the definitions of land and water resources in the SNA, in practice valuation of the water resource only occurs in the SNA when payment is taking place for the rights to extract the resource. There are actually few countries that value water resources as asset in the national accounts. According to the 2025 SNA, the asset value should be recorded under water resources, not under contracts, leases and licenses.

[26] "A confined aquifer is an aquifer below the land surface that is saturated with water. Layers of impermeable material are both above and below the aquifer, causing it to be under pressure so that when the aquifer is penetrated by a well, the water will rise above the top of the aquifer. A water table--or unconfined--aquifer is an aquifer whose upper water surface (water table) is at atmospheric pressure, and thus is able to rise and fall. Water table aquifers are usually closer to the Earth's surface than confined aquifers are, and as such are impacted by drought conditions sooner than confined aquifers" see https://www.usgs.gov/faqs/what-difference-between-a-confined-and-unconfined-water-table-aquifer#:~:text=A%20confined%20aquifer%20is%20an,the%20top%20of%20the%20aquifer)

[27] Arguably, renewable water resources may also be subject to depletion.

101. In light of these complexities and challenges, the valuation of water is included in the list of issues for the SEEA CF revision starting in 2024 and is not further discussed in this compilation guide.[28] Water resources are in general considered non-produced, but whether water behind dams is to be considered a produced asset has been debated in the SEEA community and is also included as an issue for the revision of the SEEA CF.

2.5.5. Other natural resources

102. The 2025 SNA (11.204) specifies that: "The category other natural resources currently includes radio spectra and permits to use natural resources.. Given the increasing move to carry out environmental policy by means of market instruments, it may be that other natural resources will come to be recognized as economic assets. If so, this is the category to which they should be allocated." Other natural resources AN39 consist of Radio spectra AN391, Permits to use natural resource AN392 and Other AN399. To remain consistent with the 2008 SNA treatment of radio spectra, a class Permits to use natural resources (AN392) has been created which is solely to be used for recording the value of permits related to radio spectra.

103. The radio spectrum is the part of the electromagnetic spectrum which is used for communication. There are important differences in treatment between SNA and SEEA. The 2025 SNA (35.35) says: "the radio spectrum is not considered part of the biophysical environment and hence is not included as part of natural resources but, in the integrated framework of the SNA, it is included as part of natural resources."

104. The radio spectrum cannot be subject to depletion or degradation. Its treatment is discussed in detail in Chapter 27 of the 2025 SNA and will not be further discussed in this compilation guide. There are many outstanding issues in the treatment of radio spectra, thus it is included as an issue on the post 2025 SNA/BPM research agenda.

[28] The revision of the SEEA CF was decided during the 55th session of the UN Statistical Commission in 2024. A list of issues has been put together for global consultation. This is available at: https://seea.un.org/sites/seea.un.org/files/area_b1_table_of_central_framework_update_topics_0.xlsx

3 Valuation of natural resources

3.1. Introduction

105. This chapter describes suitable valuation methods for natural resources, as agreed in the context of the SNA update process and discussed by the EGNC, while Chapters 4 and 5 look at the practical applications in more detail for mineral and energy resources and for biological resources. The outline of this chapter is as follows. Section 3.2 will discuss suitable valuation methods for the purposes of national accounts compilation including a preference order. Section 3.3. discusses the Net Present Value method of resource rents. Section 3.4 discusses the treatment of taxes and subsidies in deriving resource rent. Section 3.5 details how to measure and record depletion, Section 3.6 covers the split-asset approach, Section 3.7 provides guidance on the treatment of negative resource rents. A text box with a summary of key recommendations concludes the chapter.

3.2. SNA valuation methods

106. The general principle when it comes to valuation is described by 2025 SNA (3.60) as follows: "Transactions are valued at the actual price agreed upon by the transactors. Exchange values, or the observed market prices, are thus the basic reference for valuation in the integrated framework of the SNA." Exchange value is defined as follows: "the current exchange value, often labelled as the "market price", refers to the value at which goods, services, labour or assets are exchanged, or else could be exchanged, for cash (currency or transferable deposits). Exchange prices are the basis for valuation of transactions in the integrated framework of the SNA." (2025 SNA 4.131)

107. Given the principal objective to measure exchange values, a range of methods can be applied for measurement. We will first discuss methods for valuing transactions and stocks including a preference order drawing from Chapter 4 of the 2025 SNA (especially its Annex). Then we will discuss valuation of natural resources in greater detail.

Methods for valuing transactions and stocks

108. Regarding transactions the preferred valuation method is based on observed exchange values (or observed market prices). Exchange prices for transactions are defined in the 2025 SNA (4.142) as "amounts of money that willing buyers pay to acquire something from willing sellers; the exchanges are made between independent parties and on the basis of commercial considerations only, sometimes called "at arm's length." The SNA places no restrictions on the type of market or the functioning of markets when observing prices to measure exchange values (e.g. markets need not be competitive), but notes that in some cases such as transfer pricing or concessional pricing, the accountant may deviate from observed market prices.

109. In the absence of observed market prices (2025 SNA A4.3), it is recommended to apply prices for similar goods, services and assets, or market equivalent prices. When such markets do not exist, alternative valuation methods that approximate the main SNA valuation principles should be applied such

as a sum-of-costs approach in case of non-market production. This approach is commonly used for the measurement of education and health services, and measures output by adding all costs that are incurred for providing these services, including intermediate consumption, compensation of employees, and the depreciation of assets (e.g. school buildings).[29]

110. There exist also various valuation methods commonly used in welfare economics based on measuring the Willingness-to-Pay or Willingness-to-Accept which are not appropriate for national accounts purposes, as they include the consumer surplus which should be excluded from exchange values (see Chapter 2).

111. The preference order for valuing assets (2025 SNA A4.15-40) consists of observed market prices, market-equivalent prices, valuation based on past expenses (such as the written down replacement costs), nominal value[30], indirect valuation, and finally based on the present value of future economic benefits.

Valuation of natural resources

112. The 2025 SNA mentions (A4.30) that the present value method is typically used for valuing natural resources, in which case "the method comes down to estimating the present value of future economic benefits derived from these assets (i.e., the resource rents), which often need to be approximated by the so-called "residual value method"." (A4.32). It emphasizes that the method requires making several assumptions and therefore is considered a last resort (A4.33). Finally, a reference is made to the SEEA CF for more detailed guidance.

113. The SEEA CF (UN et al. 2014, para 5.109) observes that for many non-produced natural resources (such as oil and gas deposits), observable market prices for the assets themselves *in situ*[31] are not available (nor prices for which they were acquired), what is observable are the outputs derived from the natural resources through harvest (e.g. of timber) or extraction (oil or gas). Under these circumstances, the asset *in situ* can be valued based on the NPV method of future returns, where these returns are measured as resource rents.

114. For some types of natural resources observable market prices may be available, such as transactions in (forest) land or transactions in standing timber. There are also instances where the value of a natural resource can be obtained indirectly through observed transactions in associated assets such as land or dwellings. In such cases, where observable market prices are available this would be the preferred valuation method.

115. The Eurostat and OECD compilation guide on land estimation (Eurostat and OECD 2015, see chapter 6) discusses several indirect approaches for valuing land: the residual approach, the land-to-structure ratio approach and the hedonic approach, that may also be relevant for valuing natural resources other than land. The residual approach estimates the value of land by deducting the value of structures (such as dwellings, which can be derived from a perpetual inventory model) from the combined asset value of land and structures (which is typically observed in market transactions). The same method can also be applied specifically for valuing forest land, starting from transactions in forest estates by deducting the value of standing timber, as further discussed in Section 5.2. In the case of renewable energy

[29] In fact, one of the changes in the 2025 SNA is to include also a return on capital used in production as an additional cost element in the sum of costs method (A4.6).

[30] Nominal value and indirect valuation only apply to financial assets.

[31] The SEEA CF (5.157) uses *in situ* to describe the price of the asset before extraction, as opposed to the price received for the sale of the resource after extraction.

resources, one could compare the price of land without structures with the price of land with solar panels or wind turbines installed and use the price difference as a way to value the renewable energy resource.[32]

116. Hedonic approaches are discussed in the 2025 SNA primarily in relation to price measurement (18.86-18.92) but may also be used for valuing natural resources such as standing timber or renewable energy resources (as further discussed in Chapters 4 and 5).

117. While markets for natural resources *in situ* may not exist, in many countries markets for permits or rights to access natural resources exist (e.g. fish quota or rights to extract oil or gas). Using market prices for the value of these rights as a means to value the resource itself, is referred to as an access price method (UN et al. 2014 para 5.128) in SEEA CF. Such values may provide a correct valuation of the natural resource, especially when the right (permit or license) was purchased during an open competition and is transferable i.e. it may be sold to other economic agents (2025 SNA para 11.210).

118. However, the value of the right will depend on the duration for which access is granted: if this period is shorter than the expected asset life of the resource, the value of the right may only provide a partial value of the natural resource. Moreover, "in practice, in many cases governments may give the access rights to extractors for free or do so at a price that is less than the true economic value. Further, trading of the rights may be restricted or prohibited. In these cases, there is no directly observable market valuation, and the present value of future resource rents should be used." (2025 SNA 11.211)

119. The 2025 SNA summarizes (A4.40) that "For non-financial assets, in the absence of observed market prices or market equivalent prices, two valuation methods are applied most frequently, either the written-down replacement cost method or the present value of future earnings. The former method is typically applied to fixed assets used in the production of goods and services, while the latter method is often the only alternative for arriving at an approximation of the value of natural resources."

120. In the next section we will therefore discuss in greater detail the NPV of future resource rents method, which is the recommend method for valuing natural resources in the absence of market transactions that can be used for a direct or indirect valuation.

3.3. Net Present Value of future resource rents

121. As markets for transactions in natural resources *in situ*[33] are often thin or absent and permits (or quota) to access a resource oftentimes will only reveal a partial value of the resource, it is recommended to apply the Net Present Value (NPV) method to estimate asset values on the basis of future resource rents. The NPV method requires 1) estimation of resource rents in current and previous reference years as well as projection of future resource rents 2) an estimation of the asset life (which can be infinite in case of renewable resources), and 3) discounting to convert future resource rents (flows) into a current period estimate of value (stock).

[32] SNA Update (2023e) surveyed the literature but concluded that the evidence was mixed: "Overall, the farmland and residential property price studies we reviewed support the SEEA's contention that renewable energy production can positively influence land values where the benefits of that production accrue to the owners of the land. However, they also support our contention that even on private land, the size (and even direction) of this change is unpredictable today because markets are not yet in equilibrium. These studies point to the importance of real-world buying and selling decisions, which are influenced by both policy contexts and market participants' knowledge, both of which continue to evolve within and among countries."

[33] In situ resources primarily consist of AN32 Mineral and energy resources, and AN3322 Non-cultivated biological resources yielding once-only products

122. The NPV method relies on several assumptions and is therefore only to be used if market prices are not available. As a general principle, it is important to ensure comparability across countries by standardising the assumptions used to the extent possible. If this is not feasible, it is recommended to be transparent about the assumptions that are used in the metadata (accompanying documentation) and provide insights into the impact of any assumptions used.

123. We will start by discussing resource rent, and how it is recommended to be measured by the residual value method (RVM), including a discussion of key inputs such as the rate of return to capital. This will be followed by a discussion of the NPV method, including the choice of asset life of the resource, the role of expectations and the choice of the discount rate. The role of taxes and subsidies in deriving resource rent is discussed in Section 3.4.

3.3.1. Resource rent

124. First, it is important to clarify terminology. The 2025 SNA (8.166) explains that “Rent should be clearly distinguished from “resource rent” or “natural resource rent”. The latter represents the surplus value accruing to the extractor of an asset after all costs have been taken into account.”[34] The resource rent is therefore equal to the concept of capital services for natural resources (2025 SNA 17.45). Capital services can be understood in this context as the benefits that are derived from using an asset in production, noting that the word “service” has a different meaning than usual, when it is understood as the output of a production process.

125. The resource rent should be distinguished from rent on natural resources (D42) as defined in national accounts (2025 SNA, para 8.115) as “the income receivable by the owner of a non-produced natural resource or another non-produced non-financial asset (the lessor or landlord) for putting the asset at the disposal of another institutional unit (a lessee or tenant) for use in production”. One possible valuation method discussed in the SEEA CF is to use rent payments as proxy for resource rent, referred to as an appropriation method. However, as stated in SEEA CF (para 5.217), *“in many instances fees, taxes and royalties actually collected tend to understate total resource rent, as the rates may be set with other priorities in mind, for example, encouraging investment and employment.”* Use of the appropriation method for deriving the full natural resource value is therefore not recommended.[35]

126. The recommended method for estimating resource rent is the residual value method (RVM) (2025 SNA A4.32). The main intuition behind this method is that we can understand value added (for instance in oil extraction) as a return on the use of labour and a combination of capital assets in production: produced assets (such as machinery) and natural resources. The return to labour is measured through renumeration of employees;[36] the return to produced assets is estimated based on information about the capital stock and depreciation; the return to natural resources can then be obtained as a residual (hence the name of the method). These calculated resource rents are subsequently used to project future resource rents.

Residual value method

127. It is useful to make a distinction between a top-down method and a bottom-up method for applying the RVM. Both methods are examples of an ‘activity-based’ (ISIC) approach. Figure 3-1 explains the

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[34] The 2025 SNA follows the terminology of the SEEA CF. Economic rent (as defined in the SEEA CF para. 5.113-114) measures “the surplus value accruing to the extractor or user of an environmental asset (e.g. natural resource) calculated after all costs and normal returns have been taken into account”. If we are dealing with environmental assets, the SEEA CF uses the terminology “resource rent”.

[35] However, in the split asset approach the appropriation method is *de facto* used in order to partition the value between legal owner and exploiter of the resource.

[36] The 2025 SNA uses renumeration of employees instead of compensation of employees in the 2008 SNA.

derivation of resource rent in greater detail according to the top-down method. The bottom-up method is discussed below.

Figure 3-1 Calculating resource rent – residual value method (top-down method)

Output at producer prices (related to the extracted resources)
Less Taxes on products
Plus Subsidies on products
Equals **Output at basic prices** (related to the extracted resources)
Less Operating costs
Intermediate consumption (input costs of goods and services at purchasers' prices, including taxes on products)
Remuneration of employees
Other taxes less subsidies on production
Equals **Gross Operating Surplus** and **Gross Mixed Income**
Less Specific subsidies on extraction
Plus Specific taxes on extraction
Equals Gross Operating Surplus for derivation of resource rent
Less **User cost of capital (excl. extracted resource)**
Depreciation
Return to capital used in production (excl. extracted resources)
Equals **Resource rent**
Depletion
Net return to natural resources

Source: Adapted from 2025 SNA (A4.32) and Table 5.5 of the SEEA Central Framework.

128. The point of departure for the top-down method is information readily available in the national accounts in the form of gross operating surplus (GOS) by an economic activity (ISIC rev.5), which is obtained by deducting intermediate consumption, compensation of employees and other taxes on production from output at basic prices and adding other subsidies on production[37]. The GOS is more or less the same thing as business operating profits, and measures what a business retains as a surplus after paying certain production-based taxes[38] and receiving subsidies. If we wish to value coal and lignite resources, for example, we would use the GOS of ISIC division 05 (mining of coal and lignite). The precise delineation of economic activities when applying the RVM will be further discussed for individual resources in Chapters 4 and 5.

129. Gross mixed income (GMI) is recorded for unincorporated enterprises when it is not possible to separate compensation of employees from return to capital. In ISIC Section B Mining and quarrying, GMI is expected to be insignificant which is why the SEEA CF labels the row GOS (with an accompanying footnote about GMI). However, according to the 2025 SNA (para 7.154 and 7.155) household production of electricity and heat will be classified as output by an unincorporated enterprise owned by households.

130. When measuring the value of renewable energy resources, the inclusion of GMI will therefore be relevant. Also in case of the valuation of biological resources, mixed income may be relevant for instance

[37] In the national accounts, Taxes on production and imports (D.2) = Taxes on products (D.21) + Other taxes on production (D.29), while Subsidies (D.3) = Subsidies on products (D.31) + Other subsidies on production (D.39). For details, see 2025 SNA Chapter 8.

[38] GOS does not include income taxes, interest payments, property income (like e.g. investment income), or rents. Entrepreneurial income (B.4g) as defined in the SNA provides a better alignment with the concept of profits in business accounting.

in case of fishing activities or timber harvesting that go beyond own final consumption (i.e. commercial purposes) to value the natural resource (2025 SNA 13.24). However, it is really only the GOS element of mixed income (equivalent to the profits of the unincorporated enterprise in the households sector) that we would wish to use as the starting point.[39]

131. Second, we need to deduct specific subsidies related to production (D21 and D29) and add specific taxes related to production (D31 and D39) yielding what Figure 3.1 calls *GOS and GMI for the derivation of resource rent*. The reason behind is that if the resource is owned by government, and we want to assess what the resource is worth to society, we should neutralize the specific taxes and subsidies as they constitute mere distributions. Specific taxes and subsidies will be further discussed in section 3.4.

132. The final step to obtain resource rent in Figure 3.1 is to subtract the user costs of capital (excl. natural resources), consisting of two elements:

- depreciation; and
- a return to capital used in production

133. An alternative is to derive resource rent using the bottom-up method towards RVM. This may be useful in cases where the national accounts and economic activity/industrial classification breakdowns do not provide a 1-1 link[40] to the asset that the compiler is trying to estimate, and detailed source data is available which would produce a better result. For example, for renewable energy resources, the ISIC Rev 4 classification does not distinguish between renewable and non-renewable resources, let alone provide a breakdown between different types of renewable resources such as solar, wind or hydro power. Therefore, GOS or GMI (the starting point for the top-down approach) are unlikely to be available from the national accounts at the required level of detail.

134. This will change in future as countries implement ISIC Rev 5, which shows *electric power generation activities from renewable sources* in class 3512 separately from non-renewable sources (class 3511). If the figures at ISIC class level feed through into the national accounts, it may become feasible to use the top-down method for renewables in future. However, breakdowns by type of renewable energy (solar, wind, hydro etc) will still not be available, so some compilers may still prefer the bottom-up approach for estimating resource rent from renewables.

135. The bottom-up method follows the same recipe as shown in Figure 3.1 but uses other data sources (e.g. business surveys of industries engaged in a specific economic activity) to derive GOS/GMI that is specific to the activity in question. The same steps are then followed to derive resource rent as for the top-down method, namely deducting specific subsidies on production and adding specific taxes on production; and then subtracting the user costs of capital excluding the extracted resource (depreciation and return to capital). In this method, these items may also be calculated specifically for the activity in question, rather than using information in the accounts.

136. A challenge of a bottom-up method may lie in proxying national accounts concepts as best as possible. For instance, business survey data may provide figures for depreciation, but these may be based on historic costs and may need to be adjusted to better reflect exchange value / written-down replacement cost.

[39] If the remuneration of employees component in GMI is not negligeable, one may try to use techniques described in 2025 SNA Chapter 17 Capital Services to disaggregate GMI and attribute part as return to labour (remuneration of employees).

[40] 2025 SNA (A4.33) emphasizes the importance of a direct link: "In the case of non-financial assets, using the method of the present value of future economic benefits can only be used if there is a direct link between the future economic benefits and the asset in question, in the sense that one can assume that there are no other assets which may have generated the residual income."

User costs of capital

137. Whichever approach is followed to apply the RVM (top-down or bottom-up), we need to estimate the user costs of capital in deriving resource rent. These user costs consist of two elements: depreciation and a return to capital (excl. the extracted resource)[41] used in production. One may ask: why do we include return on capital used in production in the user costs (see Figure 3-1), rather than just depreciation costs? The generally agreed principle across all standards and guidelines is that a return on capital used in production also needs to be included in the user costs, as there are costs involved with investing in and/or owning assets either in the form of financing costs (e.g. interest paid on loans), or, in case of assets already in possession, because one could have made a return by investing the capital elsewhere (opportunity costs).

138. Capital used in production may consist of AN1 produced capital (excluding natural resources) and AN2 non-produced capital (excluding natural resources) such as purchased goodwill and marketing assets as these assets also play a role in generating the operating surplus. For the exploitation of some natural resources brand names (e.g. of oil companies) may be relevant. It should be noted here that the 2025 SNA only recognizes marketing assets under specific circumstances (2025 SNA 11.20) "when a unit is purchased in its entirety, or an identifiable marketing asset is sold to another unit" so in practice the return to capital will predominantly consists of produced assets.

139. Depreciation (2025 SNA para 7.267) is "the decline, during the course of the accounting period, in the current value of the stock of fixed assets, including (cultivated) biological resources yielding repeat products, owned and used by a producer as a result of physical deterioration, normal obsolescence or normal accidental damage". Depreciation is commonly measured through the application of a perpetual inventory model (PIM). A PIM (OECD 2009) requires as inputs the investments made in various types of fixed assets, their service lives (i.e. number of years), and depreciation profiles (e.g. linear or geometric), as well as appropriate price indices for the various types of assets.[42]

140. In order to value natural resources, it is therefore important to first estimate depreciation for a sufficient number of fixed assets used in production. In terms of sequencing, it is therefore generally recommended to first implement capital measurement using a PIM (see OECD 2009 for further guidance).[43]

141. The return to capital is usually described as measuring the opportunity cost of money tied up in these assets. The SEEA CF 6.105 notes: "The estimation of capital costs should include both the consumption of fixed capital and the opportunity cost of investing in the assets which is equivalent to estimating a rate of return on the assets." To calculate the return to capital (excluding natural resources), we need the net stock of produced assets (i.e. the gross stock minus depreciation) form national accounts by an economic activity (ISIC) and choose a suitable rate of return. The chosen rate of return is then multiplied by the net stock of produced assets. Because of differing risk premia in different countries, it is not feasible to recommend a common rate of return for produced capital to be used across countries for

[41] In some cases, one type of natural resource may be used in the exploitation of another. If so, also a return needs to be applied to the supporting natural resource.

[42] Includes depreciation of decommissioning costs, which are in SNA capitalized (see section 4.3.3)

[43] Guidance and a supporting tool for countries is being developed by the IMF using the simplified PIM set out in Annex C of Measuring Capital (OECD 2009).

market producers.[44] Nevertheless, in the interests of enhancing consistency in the compilation of the national accounts, this guide provides recommendations on selecting an appropriate rate of return.

142. What is the scope of the produced assets for which the return should be calculated? Produced assets cover: AN11 Fixed assets (excluding produced natural resource); AN12 Inventories (excluding produced natural resource); and AN13 Valuables. However, for estimating the return to produced capital, it is sufficient to include only the fixed assets or "fixed capital". Valuables represent a store of value and therefore do not contribute to production. Inventories may consist of unsold output or goods stored before use in production.[45] The former are the result of production, not a means of production, and can be excluded on conceptual grounds. It is proposed to exclude also the latter on practical grounds as it is challenging to distinguish inventories of goods before use from unsold output and the amounts are expected to be relatively small. Therefore, in this compilation guide we refer to the "rate of return to fixed capital" rather than the "rate of return to produced assets".

143. It is important to emphasize that the rate of return for fixed capital is different from the rate used in the discounting of future resource rents ("the discount rate"). The discount rate should ideally be a risk-free and stable rate (see Section 3.3.2 Discounting future flows of resource rent), and a common rate across countries may be chosen in the interests of international comparability. By contrast, the rate of return on fixed capital reflects risk, which differs according to countries' specific financial and economic circumstances.

144. According to SEEA Central Framework and OECD (2009 Section 8.3 Rates of return – conceptual considerations), two approaches can be taken to estimating rates of return on produced assets for a specific economic activity: an endogenous approach and an exogenous approach. In the endogenous approach the rate would be equal to the net operating surplus divided by the value of the net stock of produced assets. This approach implicitly assumes that there is no return attributable to non-produced assets, including natural resources, and hence it is not recommended. It should, however, form an upper bound of the estimated rate of return on produced assets. The exogenous approach assumes that the expected rate of return on produced assets is equal to an exogenous rate of return, which is recommended in the SEEA and also recommended here. How should we set the exogenous rate?

145. Different options for calculating an exogenous rate of return to fixed capital exist:

a) **Activity-specific rate of return**: the return that an investor actually gets when investing. As remarked in SEEA CF (5.143), while an activity-specific return may be preferred in theory, it is unlikely that direct measures (e.g. in financial markets) of this risk premium can be found in many countries.[46]

b) **Economy-wide rate of return.** The main reasoning behind selecting an economy wide return (i.e. all ISIC sections or total economy S.1) is based on opportunity costs: one would look for the return one could have obtained by investing elsewhere in the economy. Using an economy-wide return can also be understood as an expression of a normal or average rate of return (as mentioned in SEEA CF 5.144). A disadvantage of the economy-wide approach is that the net operating surplus of S.1 includes also returns to natural resources, which we are trying to measure, and the approach is therefore conceptually unsuitable.

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[44] The situation for non-market producers is different, see Guidelines for estimating the net return to capital for non-market production (ISWGNA 2025).

[45] Inventories of products that increase in value may in some cases be recorded as production such as aging cheese and wine (2025 SNA A7.8). These situations however can be neglected for the purpose of estimating the rate of return.

[46] It is also not clear how one could isolate the return to the natural resources from the overall return to the activity.

c) **“Everything but” the natural resource extraction activities rate of return**. This approach suggested by Liu (2016, 2023) can be seen as an improved way of estimating an economy-wide return which avoids the above-mentioned inconsistency. It estimates an economy wide return but excludes the natural resource extraction / harvesting activities in doing so. It should be remarked that for countries that do not have a large extractive sector, the difference between the economy wide and the “everything but” approach will be minimal.

d) **A rate based on cost of financing.** This method looks not at the actual cost of financing (which is captured in national accounts), but at what it would cost to finance such an investment (e.g. based on average cost of borrowing). However, the cost of financing would provide only a lower bound (if cost of financing were higher than the rate of return, a project would not get off the ground). Also, it may be volatile, which could make the calculations more difficult.

146. The economy-wide return and “everything but” approach resemble the endogenous approach in deriving a rate of return implicitly by dividing the operating surplus by stock of produced assets, however they are considered exogeneous methods as they use information external to the activity in question. While all methods have pros and cons, based on general criteria of conceptual soundness and practicality to implement, it is recommended to apply the “Everything but” approach. The activity–specific rate of return method is considered as a Tier 3 approach.

147. When applying the “Everything but” approach, the rate of return is obtained by dividing the net operating surplus of all economic activities minus the activities of the natural resources industry, by the net fixed assets of the same set of activities. It is recommended to use the following scope of activities (in ISIC Rev.5): Total economy minus ISIC A (Agriculture, Forestry and Fishing), minus B (Mining and Quarrying), minus D3512 (Electric power generation activities from renewable sources).[47] With the 2025 SNA, the net operating surplus for non-market production will no longer be zero, as a net return to capital will be included when estimating output (using the sum of costs approach). Therefore, industries producing also non-market output should be included when estimating the “Everything but” approach.

148. Based on the various elements described in this section it is possible to derive resource rents for the current and previous accounting periods. As discussed in the next section, these resource rents are averaged/smoothed for the last 3-10 years and used to estimate future resource rents. The projected future resource rents are then used as input for the NPV method of calculating asset values.

3.3.2. Net present value method

149. The asset value of the natural resource can be measured by applying the NPV method which converts future resource rents (flows) into a current period estimate of value (stock) by discounting:

$$V^t = \sum_{\tau=1}^{N} \frac{RR^{t+\tau-1}}{(1+r)^{\tau}} \quad [1]$$

with V^t the opening stock value at time *t*; RR^t the resource rent generated during year *t*; *r* the discount rate, and *N* the asset life of the natural resource.

The main theory (2025 SNA Chapter 17; OECD 2009) behind using NPV is that the value of an asset should be equal to the benefits (capital services, described here as resource rents) that we expect to derive from its use over its expected lifetime.

150. While resource-specific recommendations are discussed in Chapters 4 and 5, a number of general recommendations for applying the NPV method are made in this section. We start by looking at the physical

[47] If we assume that the return falls in the middle of the accounting period (reflecting the average price level of the period), it is recommended to calculate the return by taking the average of net opening and net closing stocks (both in current prices), with the result that this represents a real rate of return.

asset accounts that underpin the calculation. We then examine each part of the NPV calculation: the estimation of the asset life, projections of future resource rents, and discounting to convert future resource rents (flows) into a current period estimate of value (stock) using the discount rate. Finally, we include a brief discussion of the impact of any new information or changes in assumptions on the NPV estimates when compiling a time series of asset values.

The physical asset accounts

151. It is recommended to underpin the estimates by first compiling a physical asset account for the natural resource. Having a physical foundation is important as it allows deriving separate projections for the levels of future extraction, removals, gross catch[48] or harvest (depending on the type of resource, see Table 3-1) and for the development of prices as reflected in the unit resource rent (see Subsection Projections of resource rent).

152. This guide recommends compilation of physical asset accounts according to the SEEA. As the SEEA applies a broader asset boundary than the SNA, it encompasses the required physical information for national accounts compilation (as a subset). The physical asset account should provide at minimum information about opening and closing stocks and the level of extraction (or removal/harvest, catch/landings), and preferably also further details of changes during the accounting period due to discoveries (if applicable), reappraisals, reclassifications and catastrophic losses (see Table 3-1). The precise definitions and interpretations of each of these terms will be discussed in Chapters 4 and 5.

Table 3-1 Physical asset accounts for natural resources

	Non-renewable mineral and energy resources	**Renewable energy resources**	**Timber resources**	**(Forest) land**	**Aquatic resources (non-produced)**
Opening stock of resources	Yes	Yes	Yes	Yes	Yes
Additions to stock of resources					
Growth in stock	na	na	Growth	Yes*	Natural growth
Discoveries of new stock	Yes	na	na	na	Yes*
Upward reappraisals	Yes	Yes	Yes*	Yes	Yes*
Reclassifications	Yes	Yes	Yes	Yes	Yes
Reductions in stock of resources					
Extractions	Yes	na	Removals	na	Gross catch
Normal reductions in stock	na	na	Natural losses	na	Natural losses
Catastrophic losses	Yes	Yes	Yes	Yes*	Yes
Downward reappraisals	Yes	Yes	Yes*	Yes	Yes*
Reclassifications	Yes	Yes	Yes	Yes	Yes
Closing stock of resources	Yes	Yes	Yes	Yes	Yes

Source: Adapted from SNA Table 35.1, by splitting mineral and energy resources into renewable and non-renewable. "na" means not applicable. * An asterisk indicates that this entry is usually not significant for the resource or is typically not separately identified in the source data. In practice, not all cells that reflect the possibility of an entry here should be shown.

The asset life

153. Regarding the setting of the asset life of the resource ("N" in the NPV equation), in case of non-renewable energy and mineral resources, the asset life of the resource is obtained indirectly based on

[48] Gross catch is the total live weight of fish caught (gross removal less pre-catch losses) – see Section 5.3.2.

opening stocks and the projected levels of extraction (see Section 4.2.2 Stage 3 (subsoil assets): Building the monetary asset accounts). A key restriction is that the total projected extraction over the asset life of the resource at the start of the accounting period should be equal to the total physical opening stock. It is not common to allow for projections of future discoveries and/or reclassifications.

154. In the case of renewable energy resources, intuitively it might be thought that an infinite asset life is appropriate. However, due to the uncertainty caused by technological developments, climate change and political uncertainty, this is not recommended and default asset lives are proposed for different types of resources (see Section 4.3.2 Stage 3 (renewable energy): Building the monetary asset accounts).

155. In the case of forest land, the asset life will depend on the rate of removals compared to (net) growth. Here also a default asset life is suggested (see Section 5.2.2 Stage 3 (forest land): Building the monetary asset accounts).

156. In the case of fish resources (non-cultivated resources yielding once-only products) (see Section 5.3.2 Stage 2 (fish resources): Collecting physical data), the assumption about asset life of the resource is derived from an assessment of fish stocks and whether or not they are sustainably managed.

Projections of resource rent

157. To calculate resource rent for each year of the asset's life in the future, the recommended method is first to calculate a "unit resource rent". This is done by dividing the resource rent for each past accounting period (year), which is the result of the steps described in section 3.3.1, by the physical amount of the resource that has been produced or extracted.

158. It is recommended in the standard approach to use an average of actual unit resource rents (called smoothing), as resource rents can fluctuate due to volatility in commodity prices (embodied in output), as a result of which the current unit resource rent will likely not be a good predictor of future resource rents.[49] The number of years used for the average will depend on the type of resource, but typically would range from 3-10 years.[50] It should be noted that although this smoothing is done using past resource rents, it is to be used for projecting future resource rents (not for reporting of resource rents).

159. In order to apply smoothing of unit resource rents, we need to first bring the unit resource rent of the previous years to the same price level as the current accounting period by applying a price deflator.

160. Projections of future resource rent are then calculated as the average unit resource rent multiplied by the physical extraction/(net) growth expected in each future year. It is recommended:

- To assume that the unit resource rent remains constant in future unless specific policies have been implemented which would allow to estimate a specific unit resource rent path.

[49] A disadvantage of smoothing is that a change in market conditions (e.g. prices shift higher or lower for the long term) is picked up with a delay. However, it is difficult to tell whether a change in price is temporary or structural, and in general the advantages of smoothing (less volatility, better predictor of future prices) are considered to outweigh the drawbacks. ISWGNA (2023b) mentioned "the importance of using long-term averages of resource rents (applying the residual value method), to avoid volatility in the value of mineral and energy resources as a result of short-run price fluctuations of commodity prices."

[50] Under certain circumstances there may be good reasons not to smooth, for instance when futures markets provide a different signal compared to the long-term price trend or due to expected changes in the regulatory regime, but this should be the exception not the rule.

- To assume a constant level of extraction/(net) growth equal to the last period's, unless a specific extraction profile is available.[51]

Discounting future flows of resource rent

161. The last part of the NPV calculation involves discounting to convert future resource rents (flows) into a current period estimate of value (stock) (see Table 3-2). The choice of a particular discount rate has a major impact on estimates of natural resources value and some impact on estimates of depletion of (relevant) natural resources, which in turn – in the 2025 SNA – feed into net estimates of production and income. As regards options for a discount rate, a set of recommendations is set out in this section, after a brief discussion of discounting.

162. The role of discounting in creating a current period estimate of asset values reflects the finding (e.g. from behavioural economics) that people put a lower value on income they expect to receive in the future than on income they receive now. The further into the future the income will be received, the lower its perceived value in the current period. However, peoples' perceptions of the value of something in the future differ depending on their views of the importance of the asset being valued as well as factors such as whether they are naturally risk averse or risk takers, their consumption patterns and inflation.

163. A high discount rate will imply that resource rents in future years will not contribute much to the current asset value; therefore the use of higher discount rates will produce lower estimates of the asset value.

Table 3-2 Example of discounting

Real discount rate						
2%		**n=0**	**n=1**	**n=2**	**n=3**	**n=4**
	Discount factor	1	1.02	1.04	1.06	1.08
	Resource rent (current prices)	100	90	98	101	100
	Resource rent (discounted)	100	88	94	95	92
	Net Present Value	470				

164. A choice always needs to be made about whether to express the discount rate in real or nominal terms. The real rate is the underlying rate expressing the value over time in a world of constant prices, while the nominal rate includes inflation and is equal to the real discount rate plus inflation. This is more a practical than a conceptual issue: if resource rent is recorded in current prices, then the discount rate used must be nominal (including inflation); whereas if the resource rent is expressed in constant prices, the discount rate must be 'real' (excluding inflation)[52].

165. Other important choices concern whether the rate used is stable (understood to mean that it is fixed at an agreed rate which stays the same over several reference periods) or varying, for example to reflect changes in markets; and whether the rate is a single rate for the whole of the forecast period, or "declining" (for example, the rates used by the United Kingdom are 3.5% for the first 30 years of the forecast period; 3.0% for 31-75 years ahead and 2.5% for 76-125 years ahead).

166. A survey was conducted of EGNC members, to which ten countries that produce valuations of natural resources responded. The survey found that most use real discount rates (although two countries

[51] This recommendation is consistent with existing guidelines such as provided by the SEEA Energy (para 6.41) which notes that "…If extraction profiles are available from experts, energy agencies, geologic institutes, etc., those profiles should be used."

[52] To avoid confusion, it is essential for any discussion of this topic that all references to discount rates (proposed or in use) should make clear whether they are expressed in real or nominal terms.

use nominal rates); and most use stable discount rates in the form of a single rate for the whole forecast period, while one country (the UK) uses a stable and declining discount rate. For those countries using real discount rates, the rates used were around 3.5% to 4%, except in the case of the United States which uses 7% real.

167. The rationales for the choice of discount rate vary between countries: several countries have selected rates based on long-term government bond yields, while the UK refers to a social rate of time preference (SRTP), see Box 3.1. Both of these approaches adopt the view that the discount rate for valuing natural resources should be **risk-free**. On the other hand, the US uses a discount rate based on the rate of return on capital in the private sector and some countries in Latin America use rates based on the cost of borrowing in (private) markets. These approaches are **market-based**, including the risks faced by private companies extracting or exploiting the natural resources.

Box 3.1. Social rate of time preference

A common starting point in economics when discussing discount rates is the so-called Ramsey formula for the SRTP expressed as consisting of several components (OECD, 2009):

$$STRP = (1+g)^{e} * \left(\frac{1}{pw}\right) - 1$$

with *g* the trend of the growth in real per capita household consumption; *e* the elasticity of marginal utility of consumption, i.e. it indicates the percentage change in utility from an additional percent of consumption; *P* is the survival probability of an individual – it captures the risk that an individual in society is not able to benefit from future returns on an investment – which conceptually is supposed to capture a 'rate of pure time-discounting'; *w* a coefficient that reflects the degree of 'selfishness' of present generations vis-à-vis future generations.

Often a simpler version of the equation is applied: *STRP* = *d* + *e*g* although different specifications of these terms can be found. For instance, in the UK's Green Book (HM Treasury 2023) *d* is interpreted as the rate of time preference consisting itself of the pure rate of time preference and an allowance for unpredictable risk together estimated at 1.5%. The *e*g* part is called the wealth effect and estimated as 2% leading to a STRP of 3.5 %.

OECD (2018; Section 8.2) refers to the right-hand side of the equation as the welfare-preserving rate of return to consumption, with *d* interpreted as the utility discount rate.

168. A key difference in rationale behind the choice of the discount rate is whether the chosen rate for valuing natural resource should be a "risk-free" rate or should include a measure of market-related risk of the activity. It is recommended that market-related risk should be captured by the rate of return on fixed capital (see Section 3.3.1) rather than by the discount rate used for valuing natural resource assets.

169. A consequence of the NPV method is that if different discount rates are used by compilers, the results will not be comparable. A compromise approach is therefore suggested consisting of two elements:

- A common, stable discount rate agreed by the EGNC which would serve as the central rate against which countries would do sensitivity analysis (and could also be applied by countries that wish to apply this discount rate); and
- For countries that wish to select their own rate(s), recommendations on acceptable methods for selecting rates.

170. For the common stable real discount rate for calculating natural resource assets and depletion, it is proposed to use 2%. The main rationale being that the rate should be a risk-free rate based on the yields

of long-term government debt securities. The rate may seem low compared with current country practices, but the yields of long-term government debt securities (over 20 years) have on average decreased significantly over the past decades.

171. A rate of 2% for the common stable real discount rate to be used in calculating natural resource assets and depletion is also consistent with the work of Drupp et al. (2015) on social discount rates; and it would be consistent with the rate agreed in the European Ageing Working Group that is used to estimate pension entitlements in the national accounts. It is proposed to review the common rate every 5 years under the auspices of the ISWGNA, but it should be noted that the review would not necessarily lead to a change in the rate.

172. As the 2025 SNA recommends the split asset approach (see Section 3.6), it would be possible to apply different discount rates for the extractor (producer) (usually in the private sector) and for the legal owner (usually government). This would suppress the relative value of the asset of the producer compared with its share in rents captured. However, applying different discount rates for different units when valuing the same asset is hard to justify and would make the balance sheets more volatile. It is therefore not recommended.

173. In case countries prefer to choose their own rates, the following recommendations are made:

- If a government-prescribed discount rate for valuing natural resources exists (such as the United Kingdom's Green Book (HM Treasury 2023)), apply this rate.
- Otherwise, the rate used should be a stable rate.
- The preferred option is an average yield of government debt securities (real), representing a risk-free rate; in light of the long asset lives of natural resources, the securities should have a maturity of at least 10 years; the average should be taken over the last 10 years (minimum).
- Another alternative would be to apply a SRTP; here it is recommended to apply the so-called Ramsey formula as expressed in OECD (2009) – see Text Box 3.1.

174. Countries would be free to set their own discount rates as long as they also include a valuation using the common agreed rate as part of the sensitivity analysis. It is recommended that countries also provide an estimate of the cost of depletion using the common agreed rate. The common agreed rate can also be considered as a default (or Tier 1) approach for countries that wish to use it.

175. In all cases, countries should strive for transparency and provide metadata (including the specific rate applied; real or nominal; stable; single rate for the whole forecast period (non-declining) or declining; and rationale for the choice of the rate) when disclosing their results.

Monetary asset accounts

176. The previous section explained how an asset value for a specific year is derived. For national accounts compilation it is also important to describe how to obtain a time series of asset values. For this purpose, it is recommended to compile what SEEA CF calls a monetary asset account for individual natural resources. Recommendations on how to compile such accounts for energy and mineral resources, timber and forest land and fish resources are included in Chapters 4 and 5.

177. The monetary asset account that is used in the NPV of future resource rents method (Table 3-3)[53] depicts how asset values change during the accounting period as a result of any discoveries, depletion or regeneration of the asset, catastrophic losses, reclassifications and reappraisals. Another possible cause for changes in asset values consists in changes in expected prices, a revision of the discount rate, or due

[53] The monetary asset account for timber resources: work-in-progress is slightly different, as it shows growth, removals and natural losses rather than regeneration/depletion. This is discussed in Section 5.2.

to changes in the extraction path: this is to be recorded as a revaluation during the year in question, so that the balance at the end of the year is affected but not the opening balance.

Table 3-3 Basic form of the monetary asset account

Opening stock of resources
Additions to stock of resources
Discoveries (for subsoil assets)
Regeneration (for forest land and fish)
Upward reappraisals
Reclassifications
Reductions in stock of resources
Depletion (for subsoil, forest land and fish)
Catastrophic losses
Downward reappraisals
Reclassifications
Revaluation of the stock of resources
Closing stock of resources

Source: Adapted from SEEA CF Table 5.3

178. The various elements of the monetary asset account are subsequently included in various parts of the sequence of economic accounts. The monetary asset account forms also the basis for the estimation of depletion, as will be further discussed in Section 3.5 and in the relevant sections of Chapters 4 and 5.

179. In order to compile a monetary asset account, the NPV is applied twice: first to obtain the value of the opening stocks and (a year later) to obtain the value of opening stocks of the next year (which is by definition equal to the closing stock of the period in question).

180. The NPV estimate is to be considered a best estimate at the time it is made and is always forward looking. For instance, if the monetary asset account is compiled for the calendar year 2020 (opening stock 1 January 2020, closing stock 31 December 2020) *as of November 2021* the closing stock estimate would be based on all information as of November 2021. It would include the actual extraction (or removals, gross catch or harvest) that took place and hence the resource rent generated during the accounting period as well as any other changes that may have occurred during 2020. The opening stock of 2020, which was estimated a year earlier in November 2020), should not be revised in retrospect as a result of changes in physical estimates[54], as the intention of the monetary asset account is precisely to explain how the asset value changed over time. However, it is recommended to always use the most up-to-date national accounts data when calculating resource rent, as is further discussed in Section 6.3.

3.4. Taxes and subsidies

181. The treatment of taxes and subsidies related to production in the derivation of resource rent deserves consideration. We will first clarify terminology by placing the definition of taxes and subsidies by the SNA in a broader context. Then we will discuss specific taxes and subsidies. Finally, we will discuss a number of examples to provide further illustration as to how these should be treated.

[54] As explained in Section 6.3 the monetary value may be updated following regular revision process of national accounts data that are used for estimating resource rents for instance during benchmark revisions.

3.4.1. SNA subsidies in broader perspective

182. There exists no international agreement regarding the definition of subsidies among international organisations:

- The World Trade Organisation [55] defines a subsidy as:

  "a1) there is a financial contribution by a government .. where: (i) a government practice involves a direct transfer of funds (e.g. grants, loans, and equity infusion), potential direct transfers of funds or liabilities (e.g. loan guarantees); (ii) government revenue that is otherwise due is foregone or not collected (e.g. fiscal incentives such as tax credits); (iii) a government provides goods or services other than general infrastructure, or purchases goods (iv) a government makes payments to a funding mechanism, or entrusts or directs a private body to carry out one or more of the type of functions illustrated in (i) to (iii) above which would normally be vested in the government and the practice, in no real sense, differs from practices normally followed by governments;

  Or

  (a)(2) there is any form of income or price support in the sense of Article XVI of GATT 1994; and

  (b) a benefit is thereby conferred."

- The OECD adheres to the same definition but calls this "support".
- The IMF[56] distinguishes between explicit and implicit subsidies, where the latter not only includes foregone tax revenue but also unpriced externalities.
- The IEA[57] distinguishes energy subsidies and consumption subsidies where the latter are measured based on the 'price-gap' approach i.e. as the difference between the price paid by consumers and the competitive market price.

183. The SNA definition of subsidies (sometimes called explicit subsidies) is much narrower than the definitions of subsidies / support employed above. It only covers subsidies related to production (which can be broken down into subsidies on products (D31) and other subsidies on production (D39). The SNA distinguishes the following concepts:

- Subsidies on products are subsidies payable per unit of a good or service. (8.106).
- Other subsidies on production consist of subsidies other than subsidies on products that resident enterprises may receive as a consequence of engaging in production (8.112).

The SNA definition of taxes follows a similar approach, covering taxes related to production (which can be broken down into taxes on products (D21) and other taxes on production (D29):

- Taxes on products are taxes payable per unit of a good or service (para 8.93).
- Other taxes on production consist of taxes on production other than taxes on products that enterprises incur as a result of engaging in production. Such taxes do not include any taxes on the profits or other income received by the enterprise and are payable regardless of the profitability of the production (para 8.102).

Sometimes also the shorthand "(net) taxes" is used, meaning taxes minus subsidies.

[55] Agreement on Subsidies and Countervailing Measures, Article 1: Definition of a Subsidy. Available at: https://www.wto.org/english/docs_e/legal_e/24-scm_01_e.htm

[56] https://www.imf.org/en/Topics/climate-change/energy-subsidies

[57] Energy Subsidies – Topics - IEA

184. The SEEA CF (4.138) uses the notion of “environmental subsidies and similar transfers” to include also social benefits to households consisting of: current transfers to households; investment grants consisting of capital transfers to finance all or part of the acquisition of fixed assets; other current transfers consisting of all current transfers other than current taxes on income, wealth, etc., social contributions and benefits, and social benefits in kind; other capital transfers consist of all capital transfers except capital taxes and investment grants (examples are legacies, large gifts and donations by households or enterprises intended to finance the purchase of fixed assets).

185. To avoid confusion, in this guide we will use the term “subsidies” as defined in the 2025 SNA, and we will use “similar transfers” as understood in the SEEA, and “support” as a broad term for subsidies as defined by the WTO.

186. Government revenue foregone or not collected is excluded in the SNA definition as these support measures do not consist of actual transactions, but often require the use of counterfactuals, and are therefore difficult to quantify (which is why these are sometimes called off-budget subsidies).

187. Interest payments for loans are split in the national accounts into a payment for a service component (which is measured as financial service on loans and deposits [58]– recorded as intermediate consumption i.e. as a cost in the production account) and a residual called interest which is recorded as property income in the allocation of earned income account. Again, the national accounts record the actual payments made, not whether the loan conditions are more advantageous than expected based on industry practice and therefore might be considered as a subsidy from a policy perspective. In any case, the non-service-fee interest component would not be considered in the derivation of resource rent using the top-down RVM method (see para 127), as the GOS is obtained from the generation of income account (i.e. before allocation of income takes place).

188. In summary, we see that the SNA definition of subsidies is narrow in the sense that it is linked only to the production and generation of income, and subsidies can only be received directly by producers. Other support measures such as current or capital transfers are recorded in the SNA as long as they are transactions, but outside the production and generation of income accounts.

189. While arguments can be made for taking a wider view in considering support measures when estimating natural resource asset values, there are also two additional drawbacks to consider. First, the sectoral accounts do not have a breakdown by economic activity but by institutional sector, which would make it difficult to assign (some) of these support measures to economic activities to estimate natural resources asset values (and hence complicate the use of a top-down estimation method). Second, off-budget types of support require modelling and may have lower reliability.

190. Therefore, for the guidelines we will stick to the SNA (and SEEA CF) definitions and recommendations, recognizing that there is a policy interest for standardized broader measures of support. It is suggested that these issues will be further assessed as part of the SEEA CF revision.

3.4.2. Specific taxes and subsidies

191. In the SNA, output is typically recorded at basic prices which are the prices that a producer actually receives. Likewise, intermediate consumption is valued at purchaser’s prices of inputs with the difference resulting in value added at basic prices. This leads to “a measure of gross value added that is particularly relevant for the producer.” (2025 SNA para 7.85)[59]. To get to GOS and GMI we would deduct renumeration of employees and net other taxes on production (D29-D39). Hence, the GOS/GMI measures what the producer retains as surplus or “profit” after all net taxes have been deducted. For the derivation of resource

[58] Which was known as FISIM (financial intermediation services indirectly measured) in the 2008 SNA.

[59] NB: The purchaser’s price excludes any VAT (value added tax) deductible by the purchaser.

rent (Figure 3-1) the 2025 SNA recommends correcting for specific taxes less subsidies, consistent with the SEEA CF.

192. The SEEA CF reasons (para 5.119) that if taxes (both on products and other taxes on production) are considered specific i.e. applying only to this specific industry or products produced by the industry and not to a wider set of economic activities, they should be added back when deriving the resource rent. According to the SEEA CF (UN et al. 2014 para 5.119): "…The deduction of specific subsidies from and the addition of specific taxes to the standard national accounts measures of gross operating surplus are such that the resulting measure of resource rent is neutral to these flows; that is to say, while these flows affect incomes of the extracting industries, they are effectively redistributions within the economy and should not influence the estimated return to the underlying environmental asset". The situation is completely symmetrical in case of subsidies: we would deduct these subsidies (on products and other subsidies on production) when deriving the GOS/GMI for the derivation of resource rent.

193. The rationale for doing so is that the resource rent should capture the economic value that is generated by using the natural resource in production without redistributions by government. As an extreme example, suppose the extraction of a natural resource generates a lot of output; in case all of this is taxed, we would have a zero GOS, and hence, if we would not adjust the GOS by adding these specific taxes, also a zero asset value, which would be counterintuitive. In case certain economic activities are not (yet) profitable, society may decide to subsidise them (e.g. renewable energy production). As a result, it will be profitable for companies to engage in them, which will be reflected in the national accounts, as these specific subsidies will be included in the GOS. However, the resource rent that is generated (obtained through deducting these specific subsidies from GOS) may well be low (or even negative), and as a result the economic value of the natural resource will be zero (see country example from the Netherlands).

194. The notion of specific taxes and subsidies related to production should be operationalized as follows. First, check if it is clearly a specific tax/subsidy using the following criteria: is it a **tax/subsidy related to exploitation** of a specific, named natural resource? Examples are: pollution taxes imposed by government on coal mining companies and for subsidies, amounts payable by government to producers (this may include households in their capacity as producers of renewable energy) of solar panels for each panel sold or to compensate producers for losses due to price caps.

195. If it is still unclear whether it is a specific tax/subsidy related to production (examples = carbon tax, mining, North Sea activities), then use the following approach: by evaluating its scope at ISIC Section level and by applying a threshold of 90 % of the total value of the tax / subsidy. For instance, a tax levied only within ISIC Section B (say on Division 05 - Mining of coal and lignite and Division 06 - Extraction of crude petroleum and natural gas) but not outside ISIC Section B would be considered a specific tax for both of these Divisions.

196. Specific taxes related to production used in the derivation of resource rent are a subset of taxes on production and imports (D21+D29) in the national accounts, and specific subsidies used in the derivation of resource rent are a subset of subsidies (D31+D39). We would expect the numbers for specific taxes and subsidies to be lower than the numbers for taxes on production and subsidies on production respectively.

197. As well as specific standalone taxes/subsidies on natural resources production, we may also have variants of more generic taxes levied on natural resource producers at different rates than non-natural resource producers (called sur-taxes). In these instances, the amount of the specific tax can be calculated as the difference between the value of the tax at the specific rate less the value at the generic rate. It is possible that the specific rate could be lower than the generic rate and hence form an implicit subsidy.

Country example: derivation of resource rent for offshore wind resources in the Netherlands

Introduction

Renewable energy resources are becoming more and are important for the Netherlands. Renewable energy production has increased from 35 PJ in 2000 to 308 PJ in 2023. Fossil energy extraction (natural gas, oil) on the other hand has sharply decreased over the last year as for most reserves the extraction is no longer socioeconomically feasible. Statistics Netherlands has started to investigate how to monitor and value renewable energy resources. Here the results of a pilot project are presented for the valuation of wind resources on the Dutch part of the North Sea (Statistics Netherlands 2024).

Methodology

The method applied to value wind resources on the North Sea is based on the net present value of future resource rents. In this example we focus on the derivation of resource rent. A top-down approach is not possible, as no comprehensive data is available for all wind projects at sea. Therefore, a bottom-up approach was applied, which uses multiple data sources including data from separate wind projects to approximate national accounts concepts as best as possible.

The first step is to determine the monetary value of annual electricity production from wind energy resources. This involves multiplying the physical production in kWh from the energy statistics with the basic prices for electricity plus related subsidies on products. In the Netherlands the major subsidy to stimulate renewable energy production is the so called SDE++ subsidy. The subsidy that is provided is calculated as the difference between the cost of the technology that reduces CO_2 (the ‘base rate’) and the market value of the product that is generated by the technology (the ‘corrective amount’). The base rate is fixed for the entire subsidy period, but the corrective amount is set annually. The unprofitable component decreases when the market value rises, as does the amount of the subsidy you receive. This subsidy for renewable energy is classified in the SNA as a subsidy on products and thus should be included in output in basic prices.

We also need to make a correction for the profile and imbalance costs of wind energy, which refer to the difference between the average electricity price received by the wind producer and the average electricity price on the wholesale market. Intermediate costs include operation and management costs (O&M), such as fixed costs (e.g., insurances) and variable costs (e.g., warranty and maintenance contracts for turbines). These costs thus also include compensation of employees. After subtracting these costs, we arrive at the gross operating surplus.

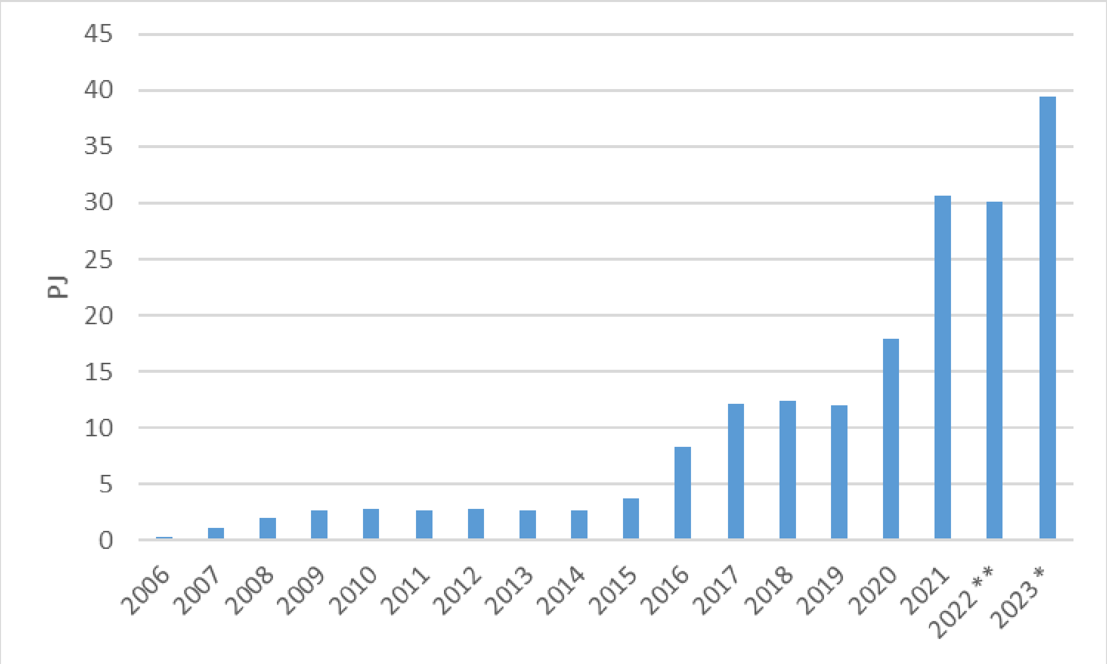
We consider the SDE++ subsidy as specific subsidy, as this scheme is dedicated to renewable energy generation. In addition, there are certain investment grants that are received by the producers of wind energy, which we also consider as specific subsidies. These subsidies should be subtracted to calculate the resource rent (see also discussion below).

To calculate the capital services (or user costs of fixed assets), we have compiled the capital stock by analyzing annual investments in newly installed wind turbine capacity (in MW) and multiplying it by the investment costs per MW of that particular year. These costs include expenditures on foundations, turbines, electric infrastructure, mains connection, construction interest, land acquisition costs and civil engineering. Since investments take place some years before the completion, the investments are spread over multiple years. We then construct the fixed capital stock using the perpetual inventory method and assume a linear depreciation of 20 years. This fixed capital stock is necessary to calculate the return to capital and the depreciation, which together form the capital services rendered by an asset. The return on capital can be measured using the weighted average cost of capital (WACC), which the PBL Netherlands Environmental Assessment Agency publishes for wind energy in general (PBL, 2022). Subtracting from the output (including subsidies on products), intermediate costs, specific subsidies and capital services, results in the resource rent estimates.

Results

Renewable energy production from wind resource has increased significantly over the past years (Figure 2-1). The construction and operationalization of new wind parks resulted in upward shifts of the annual production.

Figure 3-2 Energy production form wind resources on the Dutch part of the North Sea



The results for the resource rent calculation for wind energy on the Dutch part of the North Sea are shown in Table 3-4. After subtracting for the specific subsidies (SDE++ and investment grants) the resource rent is negative for all the years. This is not an unexpected result as the main purpose of these subsidies is to subsidize the unprofitable component of different renewable energy technologies.

We have also calculated what is sometimes called a "social resource rent" (Section 3.4.2) namely the resource rent that would be obtained by not correcting for specific taxes / subsidies. Here, the idea is that the distribution of income function of the government indicates that society as a whole has a certain preference for in this case renewable energy production. The reduction in negative externalities inherent in the use of wind energy will be expressed in the valuation and this valuation will be closer to the social preferences regarding energy production. Not correcting for the specific subsidies results in a positive resource rent for wind energy at sea, except for the last year. This is to be expected as wind turbine operators need to be able to generate profits to stay in business.

Another observation is that the calculated resource rents are very volatile. Between 2019 and 2021 the production (in KWh) of offshore wind energy increased sharply, but this also leads to an increase in intermediate consumption, which is based on the physical production and capacity as described in the methodology. However, as a result of higher electricity prices less subsidies have been provided, which has caused the social resource rent to decline and become negative in 2021.

Table 3-4 Derivation of resource rent for Dutch offshore wind, time series

million euro	**2017**	**2018**	**2019**	**2020**	**2021**
Output (sales of environmental assets at basic prices, includes all subsidies on products, excludes taxes on products)	564	551	559	699	569
Less Operating costs					
Intermediate consumption (input costs of goods and services at purchasers' prices, including taxes on products)	133	132	131	301	289
Compensation of employees (input costs for labour)					
Other taxes on production plus other subsidies on production					
Equals Gross operating surplus (GOS) and gross mixed income (GMI)	431	419	427	398	280
Less Specific subsidies on production	*428*	*406*	*388*	*453*	*234*
Plus Specific taxes on production					
Equals GOS and GMI for the derivation of resource rent	3	13	39	-55	46
Less User costs of produced assets, specifically:					
Value of fixed assets	2576	4067	5222	6191	7656
Consumption of fixed capital (depreciation)	129	203	261	310	383
Return to fixed capital	96	104	56	85	21
***Equals* Resource rent (with substraction of specific subsidies)**	**-222**	**-295**	**-278**	**-449**	**-358**
***Equals* Resource rent (with no substraction of specific subsidies)**	**206**	**112**	**110**	**4**	**-124**

3.5. Depletion

198. The 2008 SNA already included depletion of natural resources (as an economic disappearance of non-produced assets, K21) in the other changes in volume of assets account. The 2025 SNA includes depletion as a cost of production in the current accounts, thereby impacting net aggregates such as net domestic product, net national income and net saving. This is an important change as the 2025 SNA will place greater focus on net measures. Countries are encouraged to show depletion of natural resources in addition to depreciation, so that users can understand its impact on net measures. It is therefore important to obtain accurate measures of depletion.

3.5.1. Defining depletion

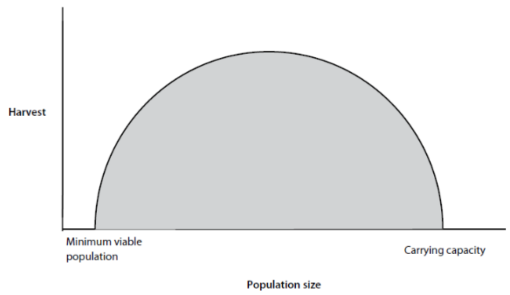
199. The 2025 SNA (7.283) defines depletion (as in the SEEA CF) as follows: "Depletion, in physical terms, represents the decrease in the quantity or value of the stock of a non-produced natural resource over an accounting period that is due to the extraction of the natural resource by economic units occurring at a level greater than that of regeneration; in monetary terms, it corresponds with the decline in future income, due to extraction, that can be earned from a resource, the value of which is based on the physical flows of depletion using the price of the natural resource in situ." This definition covers both non-renewable resources such as minerals and oil as well as biological resources that are able to reproduce and grow such as fish resources. However, as shown in Figure 2-3 it should be noted that renewable energy resources and radio spectra are not subject to depletion. The depletion of water resources is not addressed in the 2025 SNA and hence not recommended to value. Depletion also does not apply to produced biological resources, which are subject to depreciation, and bare land.

200. It is important to distinguish between depletion and degradation. The 2025 SNA notes (13.32) “All degradation of land, water resources and other natural assets due to less predictable erosion and other damage to land from deforestation or improper agricultural practices should also be considered as a quality change, and thus recorded in the other changes in the volume of assets and liabilities account”. For example, improper agricultural practices may consist in use of chemicals of fertilizers leading to a reduction in quality of surrounding natural resources such as water or land, which may be picked up in associated market prices. This reduction in value would not be considered as a cost of depletion and hence is to be recorded as other changes in volume.

201. In case of non-renewable (mineral and energy) resources, the 2025 SNA (7.287) is clear that while discoveries may permit the ongoing extraction of the resources, these increases in volume are not considered regeneration and cannot be used to offset depletion.

202. In the case of forest land used for timber production or non-cultivated fish stocks that are not sustainably managed, depletion is assessed by comparing removals (for timber) or catch (for fish) with the natural growth of the resource. SNA 2025 (7.288) states: “Only the amount of extraction that is above the level of growth is recorded as depletion; in the case the amount of extraction is below the level of growth (for example, to allow the resource to regenerate and thus allow higher future extraction), it is recorded as negative depletion.” As further detailed in Section 5.2, when it comes to timber resources the 2025 SNA distinguishes between work-in-progress (the standing timber) and the underlying asset (the forest land), which captures the capacity of the land to continue providing timber into the future. Overharvesting may have two effects: a net withdrawal from work-in-progress and a reduction in the value of the non-produced forest land in case future growth of timber is reduced, which is recorded as a cost of depletion. Depletion can therefore only arise as a result of overharvesting, which is assessed by comparing the removals (or catch in case of fish resources) with the growth of the resource. Likewise, regeneration only applies in case of underharvesting, ensuring a symmetric treatment.

Figure 3-3 Stylized sustainable yield curve



Source: SEEA CF Figure 5.2.

203. The 2025 SNA provides further details on how to measure the growth of biological resources directly drawing on the SEEA CF: “While the rates of extraction can be observed directly, measurement of the rates of growth can be complex and usually requires consideration of biological models. These models will usually account for both the structure and the size of biological resource populations; and exhibited by their general form, when the stock or population of the specific type of resource is small, the rate of growth will be small but, as the population increases, the rate of growth will also increase. Eventually, as the population within a given area reaches the carrying capacity of the area, i.e., as the density reaches a maximum, the rate of growth in the population will slow substantially.” (2025 SNA 7.289) The 2025 SNA continues to explain that depletion (and regeneration) can be assessed by comparing the harvest with the sustainable yield instead of the mere growth, as illustrated in Figure 3-3: “Based on this general model, for any given population, it is possible to calculate the number of animals or volume of plants by age or size class that may be removed from the population without affecting the capacity of the population to reproduce

itself (i.e., opening stock equals closing stock). In effect, there is a “surplus” or excess that can be harvested from the existing stock. In biological models, this surplus is known as the sustainable yield. The level of the sustainable yield rises and falls in line with the overall size and structure of the population. For example, in populations where the growth rates are low, the sustainable yields are also low. It is noted that the same level of extraction will have a different relationship to the sustainable yield depending on the population size” (2025 SNA 7.290.) In these guidelines, as further discussed in Chapter 5, we treat the use of population models for deriving depletion (and regeneration) as advanced methods.

3.5.2. Deriving depletion

204. A key innovation introduced by the SEEA CF and followed in the 2025 SNA is to anchor the cost of depletion in the changes in physical units: when there is no physical extraction there can be no depletion.

205. The SEEA CF method for estimating depletion consists of the following steps (based on Annex A5.1). First it is important to see that the resource rent can also be written as the physical extraction multiplied with the unit resource rent:

$$RR^t = p_E^t E^t \qquad [2]$$

with E^t the physical extraction (in tonnes or cubic meters) and p_E^t the unit resource rent

206. Next, we estimate the so-called price of the resource in situ by expressing the asset value as follows: $V^t \equiv p^t X^t$

[3]

with p^t the price of the resource in situ, which is obtained by estimating the asset value V^t by X^t the total physical stock of the resource at that point in time.

207. This allows us to decompose the change in asset values into two components: 1) a change in the price of the *resource in situ* (multiplied with the average of the opening and closing stocks) and 2) changes in physical stocks (due to extraction, discoveries etc.) multiplied with the average in situ resource price. To see this, we can write:

$$V^t - V^{t-1} = p^t X^t - p^{t-1} X^{t-1} = p^t X^t + \boldsymbol{p^t X^{t-1}} - \boldsymbol{p^t X^{t-1}} - p^{t-1} X^{t-1} =$$

$$p_{\square}^{t}(X^t - X^{t-1}) + X_{\square}^{t-1}(p^t - p^{t-1}) \qquad [4a]$$

However, we could have also decomposed this (see orange instead of blue) as

$$V^t - V^{t-1} = p^t X^t - p^{t-1} X^{t-1} = p^t X^t + \boldsymbol{p^{t-1} X^t} - \boldsymbol{p^{t-1} X^t} - p^{t-1} X^{t-1} =$$

$$p_{\square}^{t-1}(X^t - X^{t-1}) + X_{\square}^{t}(p^t - p^{t-1}) \qquad [4b]$$

As both decompositions are equally valid, following SEEA CF we average them whereby we obtain:

$$V^t - V^{t-1} = \frac{(p^t + p^{t-1})}{2}(X^t - X^{t-1}) + \frac{(X^t + X^{t-1})}{2}(p^t - p^{t-1}) \equiv$$

$$p_{avg}^{\square}(X^t - X^{t-1}) + X_{avg}^{\square}(p^t - p^{t-1}) \qquad [5]$$

where $p_{avg}^{\square}$ denotes the average of the price in situ during the accounting period, and $X_{avg}^{\square}$ the average physical stock during the accounting period.

It is important so see that this is an exact decomposition, the opening stock value plus the changes in stocks equal the closing stock value. Finally, to obtain the cost of depletion, we can further disaggregate the first element as

$$p_{avg}^{\square}(X^t - X^{t-1}) = p_{avg}^{\square}(G^t - E^t + D^t + A^t) \qquad [6]$$

with G^t = growth (in case of biological resources able to reproduce) at time *t*, D^t = discoveries at time *t*; A^t = reappraisals at time *t*, E^t = extraction / harvest at time *t*.

The cost of depletion then becomes:

$$Depletion = p_{avg} (E^t - G^t) \qquad [7]$$

In case $E^t - G^t < 0$ we have a situation of regeneration or negative depletion. In case of non-renewables equation 7 simplifies to the physical extraction during the accounting period, multiplied with the average price of the resource in situ:

$$Depletion_{nr} = p_{avg} E^t \qquad [8]$$

208. It is important to realize (as discussed in Section 3.5) that the point of departure for estimating depletion are the two NPV estimates that are made at different points in time with different information including different assumptions about the future flow of resource rents.

209. It can be readily seen that due to discounting, in principle: $p_{avg} < p_E^t$. This supports the interpretation that the resource rent consists of an income (net return to natural asset) and a depletion element as shown in Figure 3-1. By subtracting the cost of depletion, only the income element of the resource rent is included in net measures.

210. However, due to smoothing and averaging (between beginning and end of accounting period), in some cases $p_{avg} > p_E^t$ leading to a situation in which depletion is higher than resource rent implying a negative net return to the natural asset. If this arises, no adjustment is suggested, as a negative net operating surplus (after deducting depreciation – and in this case also depletion) can occasionally happen. For example, farmers may have negative value added in some years, one does not introduce adjustments for such instances either.

3.5.3. Recording of depletion in the sequence of economic accounts

211. The 2025 SNA recommends (1.26) recording depletion of natural resources as a cost of production in the production and income accounts. The attribution of the costs to the legal owner and the extractor is recorded in line with the split asset approach (2025 SNA, A4.34), and illustrated in 2025 SNA Table 27.1, and consistent with the reasoning of Chapter 5 of the SEEA CF. Paragraph 5.220 of the SEEA CF says:

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

- "Record the payment of rent from the extractor to the government in the allocation of primary income account. This entry is the standard national accounts entry;

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

212. Regeneration is recorded in full in the production and generation of earned income account of the extractor (as negative depletion), with part of the negative costs allocated to the legal owner in the allocation of earned income account (in line with their respective shares of the asset value).

213. The recording of depletion will be illustrated in Chapter 6.

3.5.4. Depletion and tiers

214. In the absence of physical asset accounts (Table 3-1) to estimate depletion in physical and then monetary terms (as in the standard Tier 2 approach described above), the recommended Tier 1 basic method consists in measuring depletion based on the asset value divided by the asset life (for opening and closing values). The asset value would need to be obtained, in the absence of suitable market prices, by applying the NPV of future resource rents, without use of physical data. This implies that the resource rent is not split into a unit resource rent and extraction (equation 2) but that projecting of future resource rents needs to be undertaken directly in monetary terms.

215. This should provide in general a good approximation of the standard method. To see this, if we are assuming a constant level of extraction (or removal or catch), the asset life consists of the total physical stock divided by the extraction level. Therefore, we can write:

$$Depletion_{Tier1} = p^t_{avg} {*} E^t = \left(0.5 * \frac{V^t}{X^t} + 0.5\frac{V^{t-1}}{X^{t-1}}\right) * E^t = 0.5\frac{V^t}{X^t} * E^t + 0.5\frac{V^{t-1}}{X^{t-1}} * E^{t-1} = 0.5\frac{V^t}{n^t} + 0.5\frac{V^{t-1}}{n^{t-1}} \cong \frac{V}{n}$$

216. This Tier 1 approach is relatively easy to apply, it requires in addition to the asset value a (default) asset life. An example is shown in Chapter 5 for fish resources. However, when there are significant changes during the accounting period (e.g. discoveries, reclassifications, price changes) that cause the extraction level to change, the depletion estimate derived in this manner will deviate from the standard (Tier 2) approach, which is preferred.

217. An advanced method (Tier 3) for estimating depletion for renewable resources such as forest land underlying timber production and non-cultivated fish resources may consist in applying a biophysical model. Such a biophysical model would describe the population in terms of different age brackets in order to estimate the sustainable yield and would allow for making dynamic projections of stocks. The assessment of depletion would be based on a comparison of harvest with the sustainable yield. This will be further discussed in Chapter 5.

3.6. Split-asset approach

218. Chapter 27 section C (27.15-27.19) specifies that there are 3 types of treatments when it comes to rights to use a natural resource:

- The legal owner may permit the resource to be used to extinction. In this case, the economic ownership is transferred which is recorded as the sale of the resource.
- The legal owner can extend or withhold permission for the use of the resource from one year to the next. In this case, the legal owner retains economic ownership which is recorded as a resource lease (with rent payment).
- The legal owner may allow the resource to be used for an extended period of time in such a way that in effect the user controls the use of the resource during this time with little if any intervention from the legal owner. In this situation the economic ownership of the natural resource is shared, leading to the so-called split asset approach.

219. What is important is that "Under all three options the total value of the natural resource should be recorded against the relevant natural resource class, such as land or mineral and energy resources. The exception to this treatment concerns radio spectra." (2025 SNA 27.20). This implies that while permits (or quota) to use the natural resources may exist that could qualify as assets in their own right (for instance when transferable and valid for more than 1 year), they would not lead to a separate registration under

AN21 Contracts, leases and licenses (with the exception of radio spectra where the permit would be recorded as a separate asset from the value of the radio spectra itself).[60]

220. In case of the third situation described above, the 2025 SNA recommends (A4.34) the split-asset approach i.e. to apportion the value of the asset to the legal owner and the extractor (producer) of a natural resource based on their shares of the resource rent (see example in Box 3.1). The difference between the resource rent and relevant payments received by the legal owner (to be recorded as rent, see below) provides the foundation of the split-asset approach, where the asset is split based on how much of the resource rent is captured by the legal owner (usually government but may also be households for instance in case of indigenous peoples that receive royalties from extractors).

221. If rights to access the natural resource are tradeable, one would expect the value of the permit to be equal to (net present value of) the difference between resource rent and rent payments, as this would be the surplus value that the permit provides to the extractor.

Box 3.2. Example of split asset approach

Suppose the resource rent is calculated as 100 and that the part appropriated by the legal owner, in this case the government, is 40. Assume further an asset life of 100 years and discount rate of 5%. Therefore, the total asset value = 2,000.

The respective shares of resource rent are therefore: 60 for the producer/extractor and 40 for the government (i.e. part appropriated by government = 40%). The total asset value will therefore be split based on these respective shares of resource rent (60 vs. 40) as follows:

Producer: 1200 Government: 800

The cost of depletion will be attributed accordingly. Assume depletion cost of 80. The full 80 will be recorded in the production and generation of income account of the producer; 32 will be allocated to the government in the transfer of earned income account, with 48 remaining with the producer.

It is important to realize that where the legal owner is the government, total government revenue from exploitation of the natural resource can be larger than the resource rent, for instance due to the application of general taxes. Here we are interested in estimating only the part of the resource rent appropriated by government.

222. How should the share of the resource rent to the legal be measured? The EGNC considered initially the following 5 components which were mentioned in earlier Eurostat guidance (Eurostat 2003):

- Specific taxes on products
- Specific other taxes on production
- Rent (royalties)
- Specific taxes on income
- Dividend payments.

223. A wide range of different types of royalties or natural resource related taxes may exist in countries, oftentimes not explicitly referred to as royalties in source data. When compiling national accounts, it is

[60] As this appears to be inconsistent with the general approach followed in the 2025 SNA, the treatment of radio spectra has been added to the post 2025 SNA/BPM research agenda.

therefore recommended to apply wide search criteria.[61] The 2025 SNA stipulates that "any payments made by the user/extractor of a non-produced natural resource to the owner of the natural resource, which are linked to the use/extraction of that resource, in particular to the quantity and/or value of that resource, should be recorded as rent. These would include, for example, royalties, sur-taxes, and permits." (8.173) This implies that such payments that may be classified as taxes (product, production, or income) in other frameworks should be recorded as D.45 in national accounts, as long as government is the legal owner of the natural resource.[62]

224. The inclusion of dividend payments was considered as in many countries government has a stake in companies managing or investing in extraction activities. However, this could cause complications as mentioned in Liu (2023): "For instance, if part of dividends from the oil and gas companies are also sent to their foreign shareholders as resources in the rest of the world account of primary incomes and current transfers, it leads to a creation of foreign ownership of Norwegian oil and gas resources in proportion to their respective share in the total resource rent, if the split-asset approach is strictly respected." The inclusion of dividend payments in the estimate of government's share of resource rent is therefore not recommended.

225. Therefore, in principle, in case government is the legal owner of the resource, it should be sufficient to use rent payments (D42) to separate the government's share.

226. In case government is not the legal owner, but households or the private sector, specific taxes may occur that would be recorded under D21 or D29 in the national accounts. This could lead to a situation where the value of the resource to the legal owner and extractor would not align with the asset value obtained through application of the residual value method. Therefore it is recommended when government is not the owner (in full or in part), not to correct for specific taxes less subsidies when deriving the resource rent (see Figure 3-1.) Likewise, in case of specific subsidies, these should not be deducted when deriving resource rent, as long as government is not the legal owner (in full or in part).

227. The main rationale for this recommendation is that such a valuation approach better measures the exchange value of the asset to the owner. For instance, in case an extractor (or investor) foresees having to pay specific taxes, he would subtract the specific taxes as costs when calculating his profit i.e. not treat specific taxes different from other production taxes. As a result, in concept, the value would be equal to the value measured by a tradable license or permit to extract.[63]

228. Resource rents and the part of resource rents captured by the legal owner will change from year to year, and this would make the resulting split asset values volatile. It has already been recommended to smooth the unit resource rent used for projecting the resource rent flows required to calculate asset values by the NPV method (see Section 3.3.2); and here it is recommended to use average resource rent shares to split asset values as well. For the averaging, it is recommended to be consistent with the averaging (smoothing) that is used in estimating the asset value itself (e.g. between 3 and 10 years)[64]. This implies that the average share will be updated on an annual basis, but due to the smoothing is expected to change

[61] Please note that the recording of specific taxes as D42 instead of D29 does not change the resource rent, as these specific taxes are not part of the GOS but are added back again for deriving resource rent.

[62] This is also the recommendation contained in Eurostat (2022) on the delineation between resource taxes and rent.

[63] It should be noted here, that a drawback of this recommendation is that we may overstate or understate total wealth. For instance, in case of specific net subsidies, this would then raise the value of the natural resource to the extractor and private owner and overstate total national wealth unless these (expected) subsidies are somehow counter booked as a (contingent) liability for the government. The treatment of (contingent) liabilities is an item on the post 2025 SNA/BPM research agenda.

[64] As noted in the section on Projections of resource rent, actual flows of resource rents (for past reference periods) are not to be changed.

very little. Any resulting changes in split asset values due to changes in the share are to be recorded as OCV.

229. The same average share is to be used to split the cost of depletion, revaluation and other changes in volume of assets and liabilities elements.

230. The 2025 SNA recommends recording ownership changes of parts of the resources as OCVs of assets and liabilities, and not as capital transfers. Likewise, changes in royalty regimes should be recorded as OCV. Application of the split-asset approach will be further illustrated in Chapter 6 for different natural resources.

3.7. Negative resource rents

231. Existing compilation experience by countries has shown that negative resource rents often occur. They can arise due to a number of reasons, but it is always important to further investigate, as, in theory, negative resource rents imply that there is no economic rationale for engaging in a specific activity. It is recommended to ask the following questions to ensure that they are "genuine" negatives:

- Standard assumptions of the PIM such as average service lives should be checked. The service life being used can be compared with the range and recommended average service life (as stated in UNECE 2024) and possibly adjusted to a longer service life thereby reducing user costs.
- Would the resource rent still be negative if (net) specific subsidies were not deducted? In some situations, negative rents can exist if an economic activity is (heavily) subsidized by government for other socio-economic reasons, such as maintaining employment or due to positive impacts on related economic activities (see Section 3.4.2). An example could be small scale (e.g. artisanal) fishing, where government may decide to subsidise the activity because of its positive impacts. If the resource rent would still be negative if (net) specific subsidies were not deducted, there may be a problem with the data or estimation process.
- Would the resource rent still be negative when using a price at the upper range of the prices observed in the past 10 years? Even after smoothing (say of 3-10 years), negative resource rents can occur due to a prolonged slump in commodity prices, but if resource rents are always negative there may be an error somewhere in the compilation process.
- What is the ratio between depreciation (CFC) costs (coming from a PIM model) and depreciation costs as reported in business accounts (e.g. company reports)? It is important to realize that depreciation costs are not actually incurred, they are estimated. In case depreciation costs from national accounts are significantly above depreciation costs from business accounts (e.g. by more than 50%), it may be necessary to make a downward adjustment for the calculation of resource rent.
- Do stranded assets exist? CFC may also be overestimated due to the existence of stranded assets. Equipment linked to stranded assets should be excluded when estimating the user costs of produced assets.
- Is the rate of return used for fixed capital realistic? The rate applied (based on the "everything but" approach (see Section 3.3.1), could be compared with the rate of return in ISIC Section C Manufacturing. If the difference is more than 2 percentage points, the rate should be reassessed.

If after all these checks, negative resource rents still persist, it is recommended for the purpose of projecting future resource rents to set the unit resource rent to zero. This means that the asset value becomes zero.

232. In case the asset value is set to zero, this implies that there will also be no cost of depletion. In fact, allowing for negative asset values could lead to a situation where the physical running of the asset to the ground would lead to negative depletion (hence regeneration) which is clearly counterintuitive.

Summary of key recommendations Chapter 3

Valuation methods (section 3.2)

- The preferred valuation method for natural resources is using market prices or market-equivalent prices. When these are not available, it is recommended to apply the Net Present Value (NPV) method of future resource rents.
- Resource rent measures the surplus value accruing to the extractor of a natural resource and is equal to the SNA concept of capital services. Resource rent should be clearly distinguished from the concept of rent (D42).
- The recommended method for estimating resource rent is the residual value method (RVM). The RVM measures resource rent by deducting from output all costs related to the extraction of the resource. These costs include the user costs of capital (excluding the natural resource one is trying to value) used in production. A distinction can be made between a top-down method and a bottom-up method for applying the RVM.

User costs of capital (section 3.3)

- User costs of capital consist of two elements: depreciation and a rate of return to capital used in production.
- Capital used in production may include both produced capital and non-produced capital such as purchased goodwill and marketing assets. The scope of produced assets is restricted to fixed assets on practical grounds.
- It is important to derive high-quality estimates for the fixed capital used in production - as input for deriving the costs of capital - by using the Perpetual Inventory Method (see OECD 2009)).
- For estimating the rate of return to capital, it is recommended to apply the “Everything but” approach, which derives the rate of return by dividing the net operating surplus of all economic activities except the natural resource and harvesting industries by the value of net fixed assets of the same set of activities.

Projecting future resource rent (section 3.3)

- Projections of future resource rent are calculated as the average unit resource rent (a price) multiplied by the physical extraction or (net) growth (in physical units) expected in each future year.
- The average unit resource rent should be based on the observed unit resource rents for a number of years (called ‘smoothing’). The exact number of years will depend on the type of resource, but typically would range from 3-10 years.
- It is recommended to assume that unit resource rents remain constant in the future unless specific policies have been implemented which would allow to estimate a specific path of future unit resource rents.
- Furthermore, it is recommended to assume a constant level of extraction or (net) growth equal to the last period’s, unless a specific extraction path is available.

Discounting (section 3.3)

- Market-related risk should be captured by the rate of return on fixed capital rather than by the discount rate used for valuing natural resource assets.

- For the common stable real discount rate for calculating natural resource assets and depletion, it is proposed to use 2%.
- In case countries prefer to choose their own rates, the following applies:
    - If a government-prescribed discount rate for valuing natural resources exists, apply this rate.
    - Otherwise, the rate used should be a stable rate.
    - The preferred option is an average yield of government debt securities (real), representing a risk-free rate; in light of the long asset lives of natural resources, the securities should have a maturity of at least 10 years; the average should be taken over the last 10 years (minimum).
    - Another alternative would be to apply a social rate of time preference; here it is recommended to apply the so-called Ramsey formula as expressed in OECD (2009).

Asset valuation (section 3.3)

- It is encouraged to compile monetary asset accounts for individual natural resources, which depict opening and closing stocks and a full reconciliation of how asset values change during the accounting period as a result of any discoveries, depletion or regeneration of the asset, catastrophic losses, reclassifications and reappraisals.

Specific taxes and subsidies (section 3.4)

- Specific taxes less subsidies (both on products and production) should be included in the calculation of resource rent. The main criteria to identify them is whether it is clearly a tax/subsidy related to exploitation of a specific, named natural resource.

Depletion of non-produced natural resources recorded as cost of production (section 3.5)

- Depletion in physical terms consists of the extraction of a natural resource by economic units occurring at a level greater than that of regeneration.
- Physical asset accounts according to the SEEA encompass the required physical information for national accounts compilation. Due to various synergies, this guide recommends compilation of SEEA accounts for relevant natural resources in case these do not yet exist.
- In the standard approach, depletion in monetary terms (i.e., cost of depletion) is derived by multiplying the physical depletion with the average price of the asset in situ (the price of the asset before extraction, as opposed to the price received for the sale of the resource after extraction).
- Degradation refers to changes in the quality of natural resources, which is to be recorded as ‘other changes in the volume of assets’, not under depletion.

Split asset approach (section 3.6)

- The value of natural resources, should be split between the legal owner (usually government) and the extractor in line with the appropriation of resource rent.
- In case the government is the legal owner of the resource, it should be sufficient to use rent payments (D42) to estimate the government’s share. In case the government is not the legal owner, no correction should be made for specific taxes less subsidies when deriving the resource rent.
- In order to split the asset values, compilers should use an average of the calculated shares by applying the same period as the one used for smoothing unit resource rents.

Negative resource rents (section 3.7)

- When applying the RVM method, negative resource rents may occur. A check list is provided to assess whether negative resources rents are “genuine” negatives.
- If after all these checks, negative resource rents persist, it is recommended - for the purpose of projecting future resource rents - to set the unit resource rent to zero. This means that the asset value becomes zero, and that there will be no cost of depletion.

4 Mineral and energy resources

4.1. Introduction

233. This chapter covers the valuation of mineral and energy resources, distinguishing between non-renewable energy and mineral resources (Section 4.2) and renewable energy resources (Section 4.3). Subsoil assets will be used in this chapter as shorthand for mineral and non-renewable energy resources (AN3121 in 2025 SNA classification of assets).

234. The 2008 SNA already required valuation of subsoil assets as well as their cost of depletion (as an economic disappearance of non-produced assets, K21). In the 2025 SNA, however, the depletion of natural resource will be recorded as a cost of production, no longer as other changes in the volume of assets.

235. Guidelines for measuring and valuing subsoil assets already exist in the form of the Eurostat guidelines (2003), the SEEA Central Framework (CF) (UN et al. 2014), SEEA Energy (UN 2019). IMF Guide to Analyzing Natural Resources in National Accounts (IMF 2017) and results of the OECD Taskforce on SEEA Implementation (Pionnier and Yamaguchi 2018). In addition, there is quite some country experience: about a dozen countries regularly compile estimates for mineral and/or energy resources. This chapter structures the existing guidance and country experiences, and when necessary, updates it to take the 2025 SNA recommendations into account. It also contains a number of concrete compilation steps, as well as recommendations to enhance international comparability. In addition, two accompanying workbooks (one for subsoil assets and another for renewable energy resources) are included to facilitate and illustrate compilation.

236. The situation regarding renewable energy is different from that of subsoil assets. The 2025 SNA for the first time, explicitly recognizes renewable energy resources such as hydro, wind, geothermal and solar resources as economic assets. The changes will primarily affect the balance sheet. They will have no impact on the production or income accounts.[65] In the case of renewable energy, it is assumed that no depletion takes place because such resources do not (at least in the relevant time frame) decrease due to their use, nor do they regenerate.

237. The point of departure for the guidance on renewable energy resources provided in this Chapter is the 2025 SNA, complemented by Guidance Note WS.11 (SNA Update 2023e) which provides a lot more detail and the results from early implementation by countries participating in the EGNC. While Guidance Note WS.11 restricted its discussion of renewable energy resources to solar, wind, hydro (water) and geothermal sources for electricity production, the guidance provided here widens the treatment towards all possible renewable energy sources within the 2025 SNA asset boundary including assets for the production of heat and cold.

238. A three-tier approach (basic, standard, advanced) is used in the chapter to provide different options for compilers depending on their data availability and resources. The standard approach will be described

[65] The 2025 SNA also includes specific guidance on the measurement of household production of electricity and heat (7.154-7.155) which may lead to changes in the estimation of output.

as the “default”, with a specific section dedicated to describing modifications in case a basic or advanced method is preferred by countries.

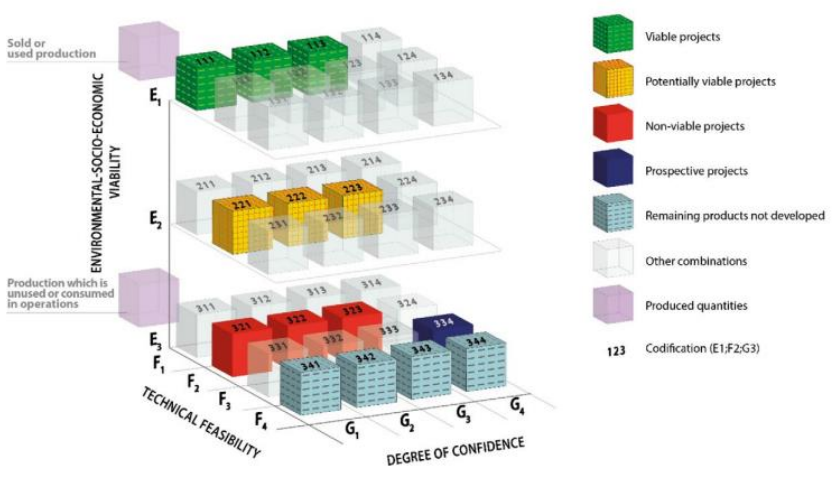
239. The outline of the chapter is as follows. Sections 4.2 and 4.3 follow the same structure. First, the scope and definition of the assets to be included in the national accounts is provided, as well as relevant classifications. Second, four compilation stages are presented and explained: identifying the types of assets to be included; collecting the physical data; building the monetary asset accounts; and integration of the results into the sequence of economic accounts. Third, we discuss specific compilation issues; and finally, modifications to the standard approach. A text box with a summary of key recommendations concludes the chapter.

4.2. Subsoil assets

4.2.1. What to include in the national accounts

240. The choice of subsoil assets to include in national accounts estimates is based on the United Nations Framework Classification for Resources - Update 2019 or “UNFC-2019” (UNECE, 2020), which is a standardized classification system for defining the environmental-socio-economic viability and technical feasibility of projects to develop resources (both renewable and non-renewable). The classification categorizes mineral and energy resources through determining whether, and to what extent, projects for the extraction and exploration of the resources have been confirmed, developed or planned. The underlying resources are classified based on the maturity of the projects in terms of economic and social viability (E), field project status and feasibility (F) and geological knowledge (G), see Figure 4-1.

Figure 4-1 UNFC Categories and examples of classes



Source: UNECE (2020)

241. In the SEEA CF, the known deposits are categorized in three classes, while each is defined according to combinations of criteria derived from UNFC-2019:

- Class A: commercially recoverable resources
- Class B: potentially commercially recoverable resources
- Class C: non-commercial and other known deposits.

242. To facilitate the delineation and international comparability of mineral and non-renewable energy resources in 2025 SNA, only Class A resources are to be included (11.186): “The measurement of monetary estimates is typically restricted to the first class, which in practice could be approximated by those resources for which permissions to exploit have been granted, and/or those for which the existence is explicitly recognised by (past) monetary transactions. Potential mineral and energy resources where it is not foreseen that they will be exploited in the near future are thus explicitly excluded.”

243. Class A is equal to the class of viable projects defined according to the UNFC consisting of classes E1, F1, G1-3 (see Table 4-1).

Table 4-1 Viable projects as defined by UN Framework Classification for Resources

Category	Definition	Supporting Explanation
E1	Development and operation are confirmed to be environmentally-socially-economically viable.	Development and operation are environmentally-socially-economically viable on the basis of current conditions and realistic assumptions of future conditions. All necessary conditions have been met (including relevant permitting and contracts) or there are reasonable expectations that all necessary conditions will be met within a reasonable timeframe and there are no impediments to the delivery of the product to the user or market. Environmental-socio-economic viability is not affected by short-term adverse conditions provided that longer-term forecasts remain positive.
F1	Technical feasibility of a development project has been confirmed.	Development or operation is currently taking place or, sufficiently detailed studies have been completed to demonstrate the technical feasibility of development and operation. A commitment to develop should have been or will be forthcoming from all parties associated with the project, including governments.
G1	Product quantity associated with a project that can be estimated with a high level of confidence.	Product quantity estimates may be categorized discretely as G1, G2 and/or G3 (along with the appropriate E and F Categories), based on the degree of confidence in the estimates (high, moderate and low confidence, respectively) based on direct evidence. Alternatively, product quantity estimates may be categorized as a range of uncertainty as reflected by either (i) three specific deterministic scenarios (low, best and high cases) or (ii) a probabilistic analysis from which three outcomes (P90, P50 and P10)3 are selected. In both methodologies (the “scenario” and “probabilistic” approaches), the estimates are then classified on the G Axis as G1, G1+G2 and G1+G2+G3 respectively. In all cases, the product quantity estimates are those associated with a project. The G axis Categories are intended to reflect all significant uncertainties (e.g. source uncertainty, geologic uncertainty, facility efficiency uncertainty, etc.) impacting the estimate forecast for the project. Uncertainties include variability, intermittency and the efficiency of the development and operation (where relevant). Typically, the various uncertainties will combine to provide a full range of outcomes. In such cases, categorization should reflect three scenarios or outcomes that are equivalent to G1, G1+G2 and G1+G2+G3.
G2	Product quantity associated with a project that can be estimated with a moderate level of confidence.	
G3	Product quantity associated with a project that can be estimated with a low level of confidence.	

4.2.2. Compilation stages

244. Regarding the measurement of subsoil assets, four compilation stages are distinguished: identifying the types of assets to be included; collecting the physical data; building the monetary asset accounts; and integration of the results into the sequence of economic accounts.

Stage 1 (subsoil assets): Identifying types of assets

245. In the first step, the different types of subsoil assets that fall within Class A, and are therefore "in scope", need to be clearly identified. The 2025 SNA asset classification distinguishes four categories: AN321S1 coal and lignite, AN321S2 oil (petroleum) and natural gas (further disaggregated into oil and natural gas), AN321S3 minerals, and AN321S4 other non-renewable mineral and energy resources (see Section 2.5). Although these are supplementary items, countries are encouraged to provide this breakdown (as a minimum) for the dissemination of asset values. However, production of the estimates for these categories following the recommendations set out in this chapter will be at the level of more specific subsoil asset categories. A more detailed break-down (see country example of Canada) such as the one proposed in the SEEA CF[66] could be disseminated as part of the environmental-economic accounts (either in physical or monetary units); but this goes beyond the 2025 SNA requirements.

246. The SNA is exhaustive, implying that all assets with economic value (the Class A resources discussed above) within the asset boundary and should be estimated. However due to the resource intensive nature of the work required to value subsoil assets, it is proposed to apply a materiality threshold. It is therefore suggested that it would be reasonable to focus on valuation of subsoil assets that contribute more than 5% of output in ISIC Section B: Mining and quarrying (see Table 4-2) and for which the long-term average contribution of mining and quarrying to GDP is at least 0.1 %. When a reasonable estimate can be made of how much of the asset value is missed, it is recommended to gross up the asset value.

247. In the absence of an internationally agreed detailed classification for mineral and energy resources suitable for statistical purposes (as noted in SEEA CF paragraph 5.181), it is recommended to use the following list of commodities as a checklist to assess which energy and mineral resources are available in the country and are above the materiality threshold in terms of output and contribution to GDP:

- **Coal and lignite:** Hard coal; Lignite[67] (ISIC Division 5).
- **Crude oil (petroleum) and natural gas:** Crude oil; Natural gas (ISIC Division 6).
- **Minerals:** Iron ore; Bauxite; Copper; Tin; Zinc; Lead; Nickel; Gold; Silver; Uranium and other metal ores used as nuclear fuels (ISIC Division 7); and Phosphate (ISIC Division 8).

This list of subsoil assets has been selected based upon economic and environmental significance. However, if other commodities are significant in a particular country, they should also be considered.[68]

[66] The SEEA CF distinguishes 5 broad classes, while the SEEA Energy (2019) separately identifies uranium (and other nuclear fuels) for its importance in energy production.

[67] Lignite is also known as brown coal.

[68] The asset category Other could consist of assets such as stone, sand or clay, salt or peat which may be significant in certain countries.

Table 4-2 ISIC Section B

Section B
Mining and quarrying

Division	Group	Class	Description
Division 05			**Mining of coal and lignite**
	051	0510	Mining of hard coal
	052	0520	Mining of lignite
Division 06			**Extraction of crude petroleum and natural gas**
	061	0610	Extraction of crude petroleum
	062	0620	Extraction of natural gas
Division 07			**Mining of metal ores**
	071	0710	Mining of iron ores
	072		Mining of non-ferrous metal ores
		0721	Mining of uranium and thorium ores
		0729	Mining of other non-ferrous metal ores
Division 08			**Other mining and quarrying**
	081	0810	Quarrying of stone, sand and clay
	089		Mining and quarrying n.e.c.
		0891	Mining of chemical and fertilizer minerals
		0892	Extraction of peat
		0893	Extraction of salt
		0899	Other mining and quarrying n.e.c.
Division 09			**Mining support service activities**

Note: There has been no change in Section B of the ISIC between Rev. 4 and Rev. 5.

Stage 2 (subsoil assets): Collecting the physical data

248. Once the relevant subsoil assets are identified, the following stage is to compile a physical asset account for the individual resources in scope (see Table 4-3). The physical asset account provides information on stocks and changes in stocks which are important for the estimation of the asset life, cost of depletion and other entries in the non-financial accounts and the financial accounts and balance sheets.

249. A full physical asset account distinguishes between additions due to discoveries, upward reappraisals and reclassifications, and deductions distinguishing between extraction, downward reappraisals, reclassifications as well as catastrophic losses[69]. It would be ideal to obtain or compile a full physical asset account for all the individual resources in scope of the national accounts, as this allows to make a clear distinction between revaluation and other changes in volume (see Stage 4: Integration). However, as a minimum, information is needed about opening stocks, extraction, and closing stocks.

[69] The SEEA CF (paragraph 5.189) explains that in case of subsoil assets: "reappraisals .. pertain only to known deposits .. based on changes in geologic information, technology, resource price or a combination of these factors.. Catastrophic losses are rare in relation to most mineral and energy resources… Flooding and collapsing of mines do occur but the deposits continue to exist and can, in principle, be recovered: the issue is one of economic viability of extraction rather than actual loss of the resource itself. An exception to this general principle concerns oil wells that can be destroyed by fire or become unstable for other reasons, leading to significant losses of oil resources… Reclassifications may occur if certain deposits are opened or closed to mining operations owing to government decisions concerning the access rights to a deposit."

Table 4-3 Physical asset account for Class A subsoil assets – example for oil, natural gas and coal

	Oil resources (thousands of barrels)	Natural gas resources (cubic metres)	Coal (thousands of tonnes)
Opening stock of resources	800	1200	600
Additions to stock		200	
Discoveries			
Upward reappraisals		200	
Reclassifications			
Reductions in stock	40	50	120
Extractions	40	50	60
Catastrophic losses			
Downward reappraisals			60
Reclassifications			
Closing stock of resources	760	1350	480

Source: Based on SEEA CF Table 5.8

250. An issue may be that these data sources may not align fully with the UNFC classes in which case a crosswalk (mapping) needs to be undertaken between the national classification of resources and the UNFC classes, such as the one shown in Figure 4-2. A full mapping is undertaken for all resources, but in the UK case only those coloured in dark blue in the mapping, which correspond to Class A, would be included in the national accounts. Other examples of crosswalks (mappings) can be found in the correspondence tables of the OECD dataset on Mineral and Energy Resources.[70]

[70] https://stats.oecd.org/wbos/fileview2.aspx?IDFile=c7f5f4ad-9b66-4b8c-a8b9-7a6775bd2a28

Figure 4-2 Coverage of mineral and energy resources in the UK

Fundamental Characterization	CRIRSCO (minerals)	UNFC-2009 (mineral and energy resources): Class	Sub-class	UNFC E axis	UNFC F axis	UNFC G axis: Proved / Measured / 1P/1C Low Estimate	Probable / Indicated / 2P/2C Best Estimate	Possible / Inferred / 3P/3C High Estimate	
Discovered and Commercially Recoverable	Mineral Reserves	Commercial Projects	On Production	1	1.1	1	2	3	Class A
			Approved for Development	1	1.2	1	2	3	
			Justified for Development	1	1.3	1	2	3	
Discovered and Not Commercially Recoverable	Mineral Resources	Potentially Commercial Projects	Development Pending	1.1	2.1	1	2	3	Class B
				2	1.3	1	2	3	
				2	2.1	1	2	3	
			Development On Hold	2	2.2	1	2	3	
	Inventory (not defined in template)	Non-Commercial Projects	Development Unclarified	3.2	1.3	1	2	3	Class C
				3.2	2.1	1	2	3	
				3.2	2.2	1	2	3	
			Development Not Viable	3.3	1.3	1	2	3	
				3.3	2.1	1	2	3	
				3.3	2.2	1	2	3	
				3.3	2.3	1	2	3	
		Additional Quantities in Place		3.3	4	1	2	3	
Undiscovered	Exploration Results	Exploration Projects	(No sub-classes defined)	3.2	3.1	4.1	4.2	4.3	
				3.2	3.2	4.1	4.2	4.3	
				3.3	3.3	4.1	4.2	4.3	
	Unrecoverable	Unrecoverable		3.3	4	4.1	4.2	4.3	

Reported Categories for the United Kingdom — E axis, F axis, G axis

Discovered Reserves (Expected: sum of proven and probable reserves)

Contingent resources (proven)

Source: Adapted from Pionnier and (2018).

251. In the absence of national data on reserves or extraction rates (or in case of difficulties obtaining the national data) Table 4-4 describes several databases with global coverage that may contain relevant information on extraction / production, physical proven reserves (and how they change over time), as well as unit prices and costs of commodities.

Table 4-4 Selected global data sources

Publisher	Description	Link
US Geological Survey / National Minerals Information Center	Information about production and reserves of around 90 frequently occurring minerals (by country).	https://www.usgs.gov/centers/national-minerals-information-center/commodity-statistics-and-information
International Energy Agency	World Energy Statistics and Balances database. Statistics on 16 energy topics for over 170 countries and regions.	https://www.iea.org/data-and-statistics
The Energy Institute Statistical Review of World Energy	Data about production and reserves (including a time series) of oil, gas, coal, cobalt, lithium, graphite, rare earth by country. Information about renewable energy generation (a.o. wind, solar, hydro, geothermal)	https://www.energyinst.org/statistical-review

World Bank - GEM Commodities	The World Bank collection of monthly commodities prices and indices from 1960 to present, updated each month, as presented in the Commodity Price Data (a.k.a. Pink Sheet), published continuously for more than half a century.	http://databank.worldbank.org/data

Stage 3 (subsoil assets): Building the monetary asset accounts

252. Once the physical asset accounts have been compiled for each resource, the next stage is to compile the monetary asset accounts. These provide information on stocks and changes in stocks that are needed to populate the relevant accounts in the 2025 SNA, including estimates of the cost of depletion and various entries in the capital accounts and balance sheets as explained in Stage 4.

253. Eight steps are required to compile the monetary asset accounts, as shown in the example for the year 2023 in the *Workbook: subsoil assets*, which is discussed below. The eight steps are:

1. Calculate resource rents (past and present).
2. Project the physical asset account and physical output until end of the asset life of the resource.
3. Calculate the unit resource rent.
4. Smooth unit resource rents to address price volatility.
5. Project future resource rents.
6. Calculate NPV for the opening stocks.
7. Calculate NPV for the closing stocks.
8. Put together the monetary asset account.

254. It should be noted that when valuing subsoil assets, it is preferrable to use observable market prices for transactions. As discussed in Chapter 3, such markets are often very thin or do not exist at all, and valuation based on permits may only be feasible in certain circumstances. Therefore, in most cases, the recommended valuation method is to calculate asset values as the Net Present Value (NPV) of future resource rents, which are projected from actual (past and present periods) resource rents calculated with the Residual Value Method (RVM).

Step 1: Calculate resource rents (past and present)

255. When using the RVM to calculate resource rents (see Section 3.3), a distinction can be made between a top-down approach using information included in the national accounts or a bottom-up approach applying information from other data sources such as business statistics. For valuing subsoil assets, Chapter 3 recommended applying the top-down approach.[71] Table 4-5 presents an example, which follows the steps of the RVM top-down approach set out in Figure 3-1. The calculation is shown in the *Workbook: subsoil assets* in rows 6-25 of the Year 1 and Year 2 worksheets.

[71] In case a bottom-up approach is preferred, the specific recommendation is to use actual labour costs in the resource rent calculation (rather than opportunity cost of labour), following the SEEA Central Framework (CF) recommendation.

Table 4-5 Calculating resource rents for subsoil assets – an example

	2020	2021	2022	2023
Output (producer prices)	106	107	108	109
Less Taxes on products	4	4	4	4
Plus Subsidies on products	2	2	2	2
Output (basic prices)	**104**	**105**	**106**	**107**
Less operating costs, specifically:	31	34	36	37
Less Intermediate consumption	8	10	11	11
Less Renumeration of employees	24	25	26	27
Less Other taxes on production	2	2	2	2
Plus Other subsidies on production	3	3	3	3
Gross operating surplus (GOS)	**73**	**71**	**70**	**71**
Less Specific subsidies on products	0	0	0	0
Plus Specific taxes on products	0	0	0	0
Less Specific other subsidies on production	1	1	1	1
Plus Specific other taxes on production	0	0	0	0
GOS for the derivation of resource rent	**72**	**70**	**69**	**70**
Less User costs of capital, specifically:	51	49	47	45
Less Consumption of fixed capital (depreciation)	33	32	31	29
Less Return to fixed capital	18	17	17	16
Resource rent	**21**	**21**	**22**	**25**

Source:. *Workbook: subsoil assets*, Year 2 worksheet

Notes: Cells in green indicate input data; blue indicates calculated data. Specific taxes on products / specific other taxes on production should be recorded as rent payment (D42) when government is the legal owner. Depreciation includes decommissioning costs (see Section 4.2.3).

256. The main difficulty here is the aggregated nature of the top-down information. In some cases there may not be a one-to-one link between the physical data (which may be for an individual resource such as iron or bauxite) and the monetary data which will probably be at ISIC group or class level, as shown in Table 4-2 and may cover multiple resources. There are two ways to proceed.

257. The first option is to aggregate the physical data so that it matches the available national accounting aggregates (e.g. aggregate hard coal and lignite reserves). This would only work for resources that are measured in the same units and have similar prices per unit, which is unlikely in most cases.

258. The second option – which is recommended in this guide – is to compile the monetary estimates to the same level of disaggregation of the physical data. A partitioning of the national accounts aggregates by individual natural resource should be made based on relevant data on output, costs and capital stocks for each resource. While this may introduce some uncertainty regarding resource rents of specific resources and eventually also asset values, the advantage is that it would not affect the total value of subsoil assets which is based on the national accounts data. As a result, one should obtain a time series of actual (past and present) resource rents for each of the individual resources in scope.

259. Countries that extract subsoil assets already compile figures for the production and generation of income account and therefore have estimates of gross operating surplus (GOS) for the relevant industries as a starting point for the top-down approach, thus it is not necessary to elaborate on compilation of these figures in this guide. However, some guidance may be helpful for estimating specific taxes/subsidies. This is discussed in detail in Chapter 3 (see Specific taxes and subsidies).

260. As explained in Section 3.3.1 the user costs consist of two elements: depreciation and a return to produced assets, specifically fixed capital. The value of depreciation (consumption of fixed capital) is usually derived from a perpetual inventory model (PIM) and available by industry as part of the national

accounts. The asset life of the fixed assets could differ from the asset life of the natural resource, but in principle it should not be longer than the life of the natural resource.

261. The return to fixed capital is estimated by multiplying the value of fixed assets (including mineral exploration and evaluation) (row 22) with the rate of return, which is specified in cell H24. The rate of return is assumed to be 6% real in the example, but countries should apply their own rate of return.

262. After deducting both elements – depreciation and the return to fixed capital – from GOS for the derivation of resource rent, we obtain the resource rent (consisting of depletion and net return to subsoil assets).

Step 2: Project the physical asset account and physical output until end of the asset life of the resource

263. In the *Workbook: subsoil assets* (Year 1 worksheet, rows 34-44) and Table 4-6, we assume that in 2023 we have an opening stock of 1000 physical units (e.g. tonnes of coal), and an expected extraction of 100 units per year, which is based on the last year and is assumed to remain constant (see Chapter 3). Alternatively, it is possible to use a specific extraction profile when available, for instance when prescribed by government. When making projections, we only project extractions, as by definition we do not have information about discoveries, reappraisals or reclassifications. The assumption of a constant extraction of 100 units implies that the resource will be exhausted by the end of 2032 (see orange column). When making projections, the key restriction is that the total projected extraction over the asset life at the start of the accounting period should be equal to the total physical opening stock (Class A) as included in the physical asset account for the resource in question.

Table 4-6 Physical asset account as of 2023 (start of period)

			PROJECTION AS OF 2023 (start of period)								
	2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Opening stock	1100	1000	900	800	700	600	500	400	300	200	100
Additions											
Discoveries											
Upward reappraisals											
Reclassifications											
Reductions											
Extraction	100	100	100	100	100	100	100	100	100	100	100
Catastrophic losses											
Downward reappraisals											
Reclassifications											
Revaluation											
Closing stock	1000	900	800	700	600	500	400	300	200	100	0

Source: *Workbook: subsoil assets*, Year 1 worksheet.

Note: Cells in green indicate actual data; yellow indicates projections; orange indicates end of asset life.

264. The use of a constant level of extraction is also supported by findings of the OECD Task Force on SEEA CF implementation (Pionnier and Yamaguchi 2018) which investigated this issue, looking also at the scientific literature. One of the basic models describing the extraction and valuation of subsoil assets is the so-called Hotelling (or net price) model which assumes producers can optimize when they extract (e.g. the extraction rate is endogenous) in which case the valuation of the resource simplifies to the unit resource rent times the total physical stock (the unit resource rent of optimizing producers would increase at the discount rate). Empirical evidence however supports the assumption of constant output along mines' service lives, as there often times are capacity constraints on production (it is not possible to all of a sudden extract more due to restrictions in capacity of machinery; extracting less also does not happen much due investments in fixed capital which can be seen as sunk costs). This supports the recommendation to

assume extraction will continue at the same level as in the (recent) past since this is the level for which an appropriate amount of produced assets have been acquired.[72]

Box 4.1 What data do I need?

For Steps 1-2, the following data are required:

- Physical information on stocks and extraction: this may already be available as part of the energy statistics or may need to be collected from agencies such as the natural resources department or technical agencies.
- Monetary information from national accounts including GOS, consumption of fixed capital (depreciation) and value of fixed assets.
- Monetary information from environmental-economic accounts or government finance statistics to assess specific taxes and subsidies (for different economic activities)

Step 3: Calculate the unit resource rent

265. The unit resource rent is the resource rent (from Step 1) divided by the physical amount extracted during the same accounting period. It can be considered a price measure. The unit resource rent needs to be calculated for several years, as this is required for the next step. This is done in row 49 of the workbook.

266. In the workbook it is assumed (as a convention) that the resource rent is generated in the middle of the accounting period and therefore reflects the average price level of the accounting period[73].

267. In order to apply smoothing of unit resource rents in Step 4, we need to first bring the unit resource rent of the previous years to the same price level as the current accounting period (in this case 2023). This is done in the Year 1 worksheet by applying a price deflator in row 50 to the unit resource rent figure (row 43), obtaining – for each past year - the unit resource rent in mid-2023 prices (row 51). We use a fixed price deflator of 2% in the example but countries should apply their own price index (which may differ from year to year).

Step 4: Smooth unit resource rents to address price volatility

268. We recommend assuming that the unit resource rent will remain constant in the projection period unless specific policies have been implemented which would allow us to estimate a specific path of future unit resource rents. As discussed in Chapter 3, it is recommended to project future unit resource rents based on an average of actual unit resource rents for several years. Due to volatility in commodity prices for several natural resources, if we were to use only the unit resource rent of the last year, asset values would become highly volatile and hard to cope with in the national accounts. The number of years used for smoothing will depend on the type of resource, but typically would range from 3 to 10 years.

269. Under certain circumstances there may be good reasons not to smooth, for instance when futures markets provide a different signal compared with the long-term price trend or if there are expected to be changes in the regulatory regime.

[72] Guidance Note WS 10 alludes to this same issue when it mentions the importance of paying attention to a.o. “Constraints imposed on mineral production at the micro level by initial investments in physical capital”. (para 18)

[73] It would be possible to make a different choice (e.g. that it falls at the end of the accounting period) as this is merely a convention. However, in order to standardise the approach, a decision had to be made and this was the recommendation of the EGNC (and is consistent with 2025 SNA (18.117) which mentions that for flow variables the desired valuation point is usually the mid-point of the period).

Step 5: Project future resource rents

270. We now multiply the smoothed unit resource rent in mid-2023 prices (cell F55) by the projected physical extraction for the year in question (Year 1 worksheet row 38). This results in projections of future resource rents in mid-2023 prices in row 60.

271. Next, we project discounted future flows of resource rents using a discount factor for each projected year (Year 1 worksheet row 61). The discount factors are calculated from a real discount rate (cell B60). The opening stock is to be calculated (in Step 6) for the start of the accounting period (1 January) and the resource rents are assumed to arise in the middle of the accounting period as these activities occur mid-year on average, so we halve the discount factor in the first period (in this case 2023).

As the resource rent in future periods is expressed in constant prices, the discount rate used must be 'real' (excluding inflation), as noted in Section 3.3.2. The *Workbook: subsoil assets* example uses the real discount rate of 2% that is recommended as the common, stable rate by the EGNC. The resulting discounted projections of future resource rents is shown in the Year 1 worksheet row 63.

272. Countries may prefer to use a real discount rate that is higher or lower than the common, stable rate agreed by the EGNC. As noted in Section 3.3.2, countries are free to set their own discount rates as long as they also include a valuation using the common agreed rate as part of sensitivity analysis. This is simple to do as part of Step 5: compilers need only change the figure in cell B61 from 0.02 (2%) to the desired rate.

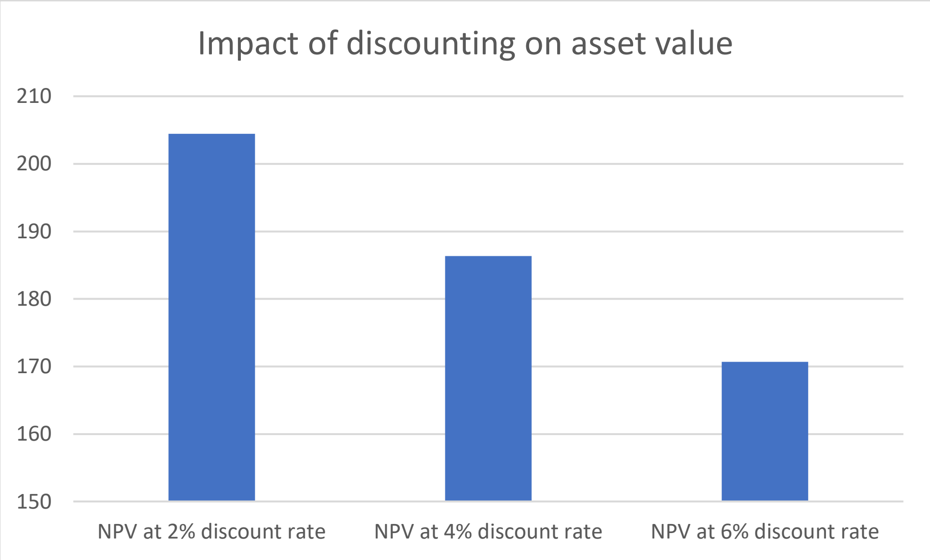
273. Countries may also prefer to project resource rents including future price increases (e.g. price of a barrel of oil will increase with X percent per year). If so, a nominal discount rate which includes price changes must be used. However, it is easier to assume that the price of the resource remains constant and apply a real discount rate, and this is the method recommended in this compilation guide.

Step 6: Calculate NPV for the opening stocks

274. Now we are able to estimate the opening stock value (in this case of the year 2023) by applying the NPV equation (see Section 3.3.2 Equation 1).

275. In the *Workbook: subsoil assets* (Year 1 worksheet cell F67), we sum the discounted future resource rents to give the opening stock of assets. We obtain an opening asset value as of 1 January 2023 of 204. If a country were to change the discount rate from 2% to 4%, the resulting value would be 186. In this case, the value of 186 would be used by the country in its accounts, and the value of 204 would also be reported (as part of sensitivity analysis).

Figure 4-3 NPV of subsoil assets – an example of sensitivity analysis



Source: *Workbook: subsoil assets.*

Step 7: Calculate NPV for the closing stocks

276. A year goes by, after which we redo compilation steps 1-6 using information now available (Year 2 worksheet in the *Workbook: subsoil assets*) in order to estimate, in Step 7, the opening stock value of the year 2024 (which gives us the closing stock value of the year 2023).

Table 4-7 Physical asset account as of 2024 (start of period)

			PROJECTION AS OF 2024 (start of period)									
	2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**
Opening stock	1100	1000	926	824	722	620	518	416	314	212	110	8
Additions												
Discoveries		20										
Upward reappraisals		10										
Reclassifications												
Reductions												
Extraction	100	102	102	102	102	102	102	102	102	102	102	8
Catastrophic losses												
Downward reappraisals		2										
Reclassifications												
Revaluation												
Closing stock	1000	926	824	722	620	518	416	314	212	110	8	

Source: *Workbook: subsoil assets*, Year 2 worksheet.

Note: Cells in green indicate actual data; yellow indicates projections; orange indicates end of asset life.

277. Suppose during the accounting period we had some discoveries of 20 physical units, as well as reappraisals of +10 and -2, and a slightly higher extraction level than anticipated (102 units), resulting in a closing stock of 926 units in 2023 (Table 4-7). The column for 2023 is now coloured green as the figures are all actuals. Using the same assumptions of constant extraction, we now have revised projections as shown in the table above, with extraction continuing into 2033 (albeit with only 8 units).

278. For the year 2023 we now also have measured data on output and user cost of fixed assets (included in column F of the Year 2 worksheet). We again estimate the resource rent, unit resource rent, but now expressed in mid-2024 prices. Again, we do smoothing, and we have an opening stock value for 2024 of 200, which is also the 2023 closing stock value. This figure can be found in cell G71 of the Year 2

worksheet. The opening stock for 2023 (cell G66) is not re-calculated in the Year 2 worksheet, but instead taken from the Year 1 worksheet. This is because of the forward-looking (or ex ante) nature of balance sheets: their main purpose is to describe how the value of assets change over time, for instance due to discoveries, extractions and reclassifications.

279. It would also be possible to revise the discount rate when calculating the 2024 opening stock value: if so, the resulting change should be recorded as a revaluation during the year in question, so that the balance at the end of the year is affected but not the opening balance. The value of this change can be estimated as the difference between the asset value based on the old discount rate and the new rate (all else remaining equal).

Step 8: Put together the monetary asset account

280. We now have the NPV of the subsoil asset at the start of the accounting period (204 as of 1 January 2023) and end of the accounting period (200 as of 1 January 2024, or end of 2023). It is important to realize that these NPV estimates represent the value of the assets in current prices. The compilation of the monetary asset account in constant prices in discussed in Chapter 6.

281. Table 4-8 shows how this can be used to calculate the price of the resource[74] at the beginning and end of 2023, as well as the 2023 average price and average physical stock.

Table 4-8 Estimating 2023 average stock and price of the resource

	NPV of asset in current prices, opening balance	**Physical assets, opening balance**	**Price of resource (in the ground)**
1 Jan 2023 (2023 opening)	204	1000	0.20
1 Jan 2024 (2023 closing)	200	926	0.22
Average physical stock		**963**	
Average price			**0.21**

Source: *Workbook: subsoil assets*, Year 2 worksheet.

282. Depletion in 2023 (Table 4-9) can then be calculated as the average price from Table 4.8 multiplied by the physical amount extracted during the year from Table 4.7 (see also country example from Norway). As part of the sensitivity analysis we can also look at the impact of changing the discount rate on the depletion figure. In this example, if a country were to change the discount rate from 2% to 4%, the resulting value for depletion would be 20.6 instead of 21.5.

283. In the monetary asset account (Table 4-9), depletion replaces the “extraction” row in the physical asset account. The other rows of the physical asset account retain the same labels and, like depletion, can be calculated by multiplying the average price from Table 4-8 by the estimates in physical units from Table 4-7.Revaluation can be calculated by multiplying the average physical stock with the change in the price of the resource in situ. Revaluation will pick up both the effect of changes in the resource rent as well as changes in the extraction path to the extent they lead to changes in asset value. In the *Workbook: subsoil assets*, a check is included to ensure that the sum of opening stock value + all changes results in a closing stock equal to the opening stock estimate of the next year.

[74] The price being estimated is price in the ground (“in situ”) before any processing has taken place.

Table 4-9 Monetary asset account for 2023 (current prices)

	Monetary value, 2023	Monetary value, 2024
Opening stock	204	200
Additions		
Discoveries	4.2	
Upward reappraisals	2.1	
Reclassifications	0.0	
Reductions		
Depletion	21.5	
Catastrophic losses	0.0	
Downward reappraisals	0.4	
Reclassifications	0.0	
Revaluation	11.3	
Closing stock	200	

Source: *Workbook: subsoil assets*, Year 2 worksheet.

Stage 4 (subsoil assets): Integration

284. The information from the monetary asset account for subsoil assets will be used in the sequence of economic accounts (standard SNA presentation), see Table 4-10.

285. In the 2025 SNA, depletion of subsoil assets is recorded as a cost of production, similar to depreciation (instead of other changes in the volume of assets and liabilities as it was in the 2008 SNA). This will be recorded in the production account, in the earned income, the transfer of income account, and the capital account.

286. Discoveries and reclassifications (upward or downward) and catastrophic losses are recorded as other changes in volume. Reappraisals (upward and downward) are also treated as other changes in volume. Revaluation is to be recorded in the revaluation account (see also Stranded assets). Finally, opening and closing stocks are part of the national accounts balance sheets (opening and closing balance sheet).

Table 4-10 Integration in SNA sequence of economic accounts

Items from monetary asset account	Where to put these items in the national accounts
Opening stock	Balance sheet
Additions	
Discoveries	Other changes in volume
Upward reappraisals	Other changes in volume
Reclassifications	Other changes in volume
Reductions	
Depletion	Production and generation of income account, capital account
Catastrophic losses	Other changes in volume
Downward reappraisals	Other changes in volume
Reclassifications	Other changes in volume
Revaluation	Revaluation
Closing stock	Balance sheet

4.2.3. Specific issues

Mineral exploration and evaluation

287. Before the extraction of subsoil assets can take place, companies first engage in mineral[75] exploration and evaluation to assess possible prospects. These expenditures can be significant and are treated as follows: 2025 SNA (para 7.258): "Expenditures on mineral exploration and evaluation are not treated as intermediate consumption. Whether successful or not, they are needed to acquire new reserves and so are all classified as gross fixed capital formation." Mineral exploration and evaluation (AN1172) are classified under intellectual property products (AN17), i.e. as a component of fixed assets AN11.

288. Consistently, the SEEA CF (para 5.201 – 5.205) says that mineral exploration is to be treated as an intellectual property product (IPP). Thus, the user costs implicitly include both depreciation (consumption of fixed capital) and a return to these fixed assets (IPPs) when deriving the resource rent. Compilers may find it useful to include them as *of which* items when calculating resource rent for subsoil assets in Step 1, Table 4-5. Such a presentation is shown in Table 4-11.

Table 4-11 User costs of produced assets – *of which* mineral exploration and evaluation

	2020	2021	2022	2023
Less User costs of produced assets, specifically:				
Value of fixed assets	300	287	275	264
Of which, value of mineral exploration and evaluation	*50*	*50*	*50*	*50*
CFC (depreciation)	33	32	31	29
Of which, CFC of mineral exploration and evaluation	*3*	*3*	*3*	*3*
Return to fixed capital	18	17	17	16
Of which, return to mineral exploration and evaluation	*3*	*3*	*3*	*3*

Notes: Value of mineral exploration and evaluation is input data (green cells); depreciation and return to mineral exploration and evaluation (blue cells) are estimated in the same was as for depreciation and return to fixed capital generally (see Step 1), although the specific assumptions used may be different.

289. The 2025 SNA describes mineral exploration and evaluation in para 11.108 -11.111, while para 14.40 explains that mineral exploration and evaluation should be valued either on the basis of the amounts paid under contracts awarded to other institutional units for this purpose or on the basis of the costs incurred for exploration undertaken on own account.[76] These costs should include a return to the fixed capital used in the exploration activity. That part of exploration undertaken in the past that has not yet been fully written off should be revalued at the prices and costs of the current period.

290. UNECE (2024, p.12-13) recommends applying the same service life for mineral and energy exploration as that used for the associated subsoil assets, with 30 years as recommended average service

[75] The term "mineral" in this context includes all non-renewable energy and mineral resources, not only minerals.

[76] If capitalization of mineral exploration and evaluation still needs to be undertaken, the following applies: intermediate costs (e.g. of surveying) would be recorded as gross fixed capital formation (GFCF). If exploration is undertaken for own purposes, any labour costs (compensation of employees) would need be recorded as additional output (used by GFCF). Intuitively, the capitalisation increases output and therefore GOS, at the same time there is also an increase in user costs of produced assets (as the fixed capital stock increases with the IPP). The resource rent will reflect the net effect.

life, while 2025 SNA 11.110 notes that “depreciation may be calculated for such assets by using average service lives similar to those used by mining or oil corporations in their own accounts”.

Decommissioning costs

291. 2025 SNA para 11.58 explains the importance of considering costs associated with the decommissioning of assets such as oil rigs and nuclear power at the end of their productive lives. The SEEA CF contains an elaborate discussion of the treatment of decommissioning costs (para 4.194 – 4.209; para 5.206) distinguishing between **terminal costs** and **remedial costs**. “Terminal costs are costs that can and should be anticipated during the production periods prior to closure; provision should be made for meeting them during the life of the fixed asset. Remedial costs are incurred when production has already ceased, with no provision having been made for the taking of remedial action while production was in progress. Examples are the rehabilitation of sites contaminated by past activities, for example, fuel storage sites, and former landfill and abandoned mining sites.” (SEEA CF, para 4.195)

292. According to the 2008 SNA terminal costs should be included in the estimates of depreciation (leading to a negative asset). The European System of Accounts (ESA) 2010 has a different treatment of terminal costs: they are booked when they occur and directly depreciated (as a result of which there can never be a negative asset in the balance sheet) (EC, 2014 p. 33).

293. The treatment of terminal costs changes in the 2025 SNA towards including the expected terminal costs in the value of fixed assets upfront (this is consistent with IAS 37/IPSAS 19 on recording of provisions). With the new SNA (as detailed in Chapter 17, D.6 – Terminal costs), these estimates will be part of the fixed assets estimate and hence be automatically included when estimating the user costs of produced assets using the same assumptions for service life and rate of return. CFC of terminal costs and return to terminal costs may be shown as *of which* items under User costs of produced assets when calculating resource rent for subsoil assets in Step 1, Table 4-5 (similar to the treatment for mineral exploration and evaluation shown in Table 4-11).

294. Contrary to 2025 SNA which does not explicitly deal with remedial costs, the SEEA CF has an extensive discussion on this issue. Paragraphs 4.207-9 of the SEEA CF set out the recommendations:

> *4.207 “Costs of a remedial nature are often incurred after a site has been closed and the operator has left. There are two main types of remedial costs: (a) expenditures to restore land to allow its use for some other purpose; and (b) expenditures to ensure that no harmful emissions from deposits of pollutants and other residuals from past activity are able to leach into the surrounding environment and cause environmental damage. In both cases, the relevant expenditures should be treated as gross fixed capital formation and give rise to a fixed asset: land improvement.*
>
> *4.208 For remedial costs, there is no special consideration required regarding the timing of reporting nor are there questions regarding whether the costs are anticipated, since, by definition, these costs are incurred after the operations at the site have ceased and are not incurred by the operator of the site who caused the need for the remediation.*
>
> *4.209 In cases where environmental protection expenditures are incurred on an ongoing basis so that environmental damage is either inhibited or reduced on a continuing basis, then these expenditures should be treated as intermediate consumption or gross fixed capital formation of the owner at the time they are incurred and not recorded as either terminal or remedial costs.”*

Stranded assets

295. Stranded assets are mineral and non-renewable energy resources that were at one point considered assets but are now no longer likely to be extracted due to for instance changes in regulations and/or changing energy markets.

296. Stranded assets should be recorded as (downward) reappraisals in the physical asset account (see Year 2 worksheet in the *Workbook: subsoil assets*, Step 7). This will impact the life length of the asset and hence the asset value. The 2025 SNA (13.28) (see also the discussion in Guidance Note WS.9 Recording of Provisions, SNA Update 2023c) recommends recording such downward reappraisals as other changes in volume (Step 8). It is helpful to clarify that there can be different types of situations that require a different recording in the national accounts:

- In case of a change in relative prices, this could have both a volume effect (lower reserves considered as economically viable to exploit) and a price effect (the reserves extracted generate a lower price). It is recommended to split these two impacts when compiling the monetary asset account.
- In case of a change in the extraction path: if the total amount of reserves that is extracted remains the same, this is not a volume effect but (due to the effect of discounting) a value effect, which should be recorded as a revaluation.
- In case there is more (or less) of the resource accessible (e.g. due to legal changes), this should be recorded as an ‘other change in the volume of assets’.

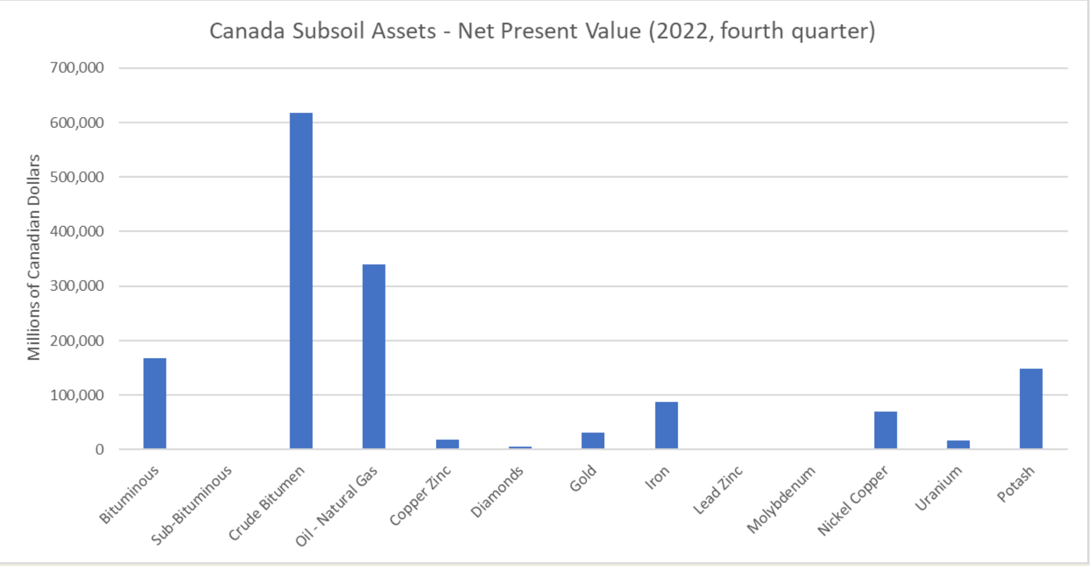
Country example: valuation of Canada's subsoil assets

Statistics Canada's Natural Resource Asset Accounts (NRAA) provide a broader dimension to our national wealth by reporting the stocks of natural resources such as energy resources (e.g., oil and gas), mineral resources (e.g., zinc, potash), and timber. These accounts form the basis of the estimates of Canada's quarterly natural resource wealth that are integrated into the National Balance Sheet. Integrating natural resource assets with other income-generating assets, such as buildings, machinery and equipment, and intellectual property products, is essential for tracking the national wealth of a resource-based economy like Canada's.

The calculation of subsoil asset wealth (Figure 4-4) involves myriad data sources to calculate the net present value of thirteen different commodities, including crude bitumen, iron, potash and gold. Data relating to the costs and value of production are obtained from annual surveys of the resource-producing industries. The total value, or wealth, associated with the stock is calculated as the present value of all future annual resource rent that the stock is expected to yield. In each year, it is assumed that the physical depletion of energy and mineral stocks will continue at the current rate until the stock is fully depleted. Statistics Canada produces quarterly estimates by projecting forward annual data using a selection of quarterly indicators. These projections are calculated using price and production data for the respective commodities along with wages and salary estimates and establishment based operating cost survey data.

In the compilation of these estimates, one challenge that Canada has encountered is that of negative resource rent, which occurs in each period the resource extraction is not economically viable and, as a result, the resource has no value (or carries a cost). This implies that the surplus generated does not exceed the return to capital and depreciation of produced capital. There is some evidence that stranded assets may exist in the capital stock of certain resource industries in Canada, which would inflate the return to capital and depreciation estimates used in the net present value calculation.

Figure 4-4 Canada's Net Present Value of Subsoil Assets

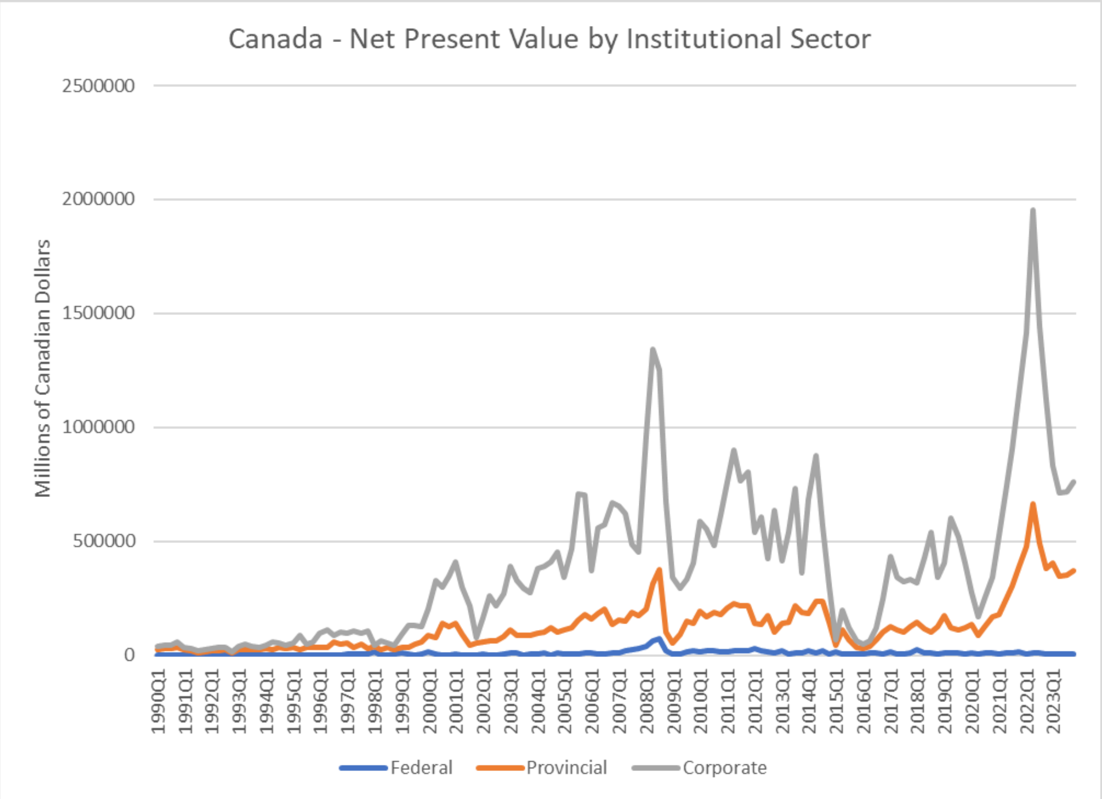


In Canada, the current treatment for negative resource rent is to, instead of attributing negative wealth to this commodity, set the commodity's wealth to zero. Because Canada's estimates are calculated on a commodity-by-commodity basis, negative resource rent can arise more frequently than if all commodities were aggregated together. Additionally, negative resource rent poses a related issue when it comes to depletion. If depletion is calculated as the quantity of extraction by the average in-situ price then the implied price resulting from negative resource rent would either be zero, if this is the chosen treatment, or negative.

Presently, Canada's calculation of resource rent does not include any smoothing of unit resource rent, while international guidance recommends considering some degree of smoothing. This is something that the team at Statistics Canada plans to reconsider based on emerging guidance, which could serve to mitigate issues arising from negative resource rent. At the moment, Canada compiles quarterly estimates of wealth and resource rent that give a more volatile series that aligns more closely with operating surplus of resource extractors.

Canada was the first country to sector natural resource wealth using a split-asset approach (Figure 4-5). The stocks of natural resource wealth are allocated between the government (federal, provincial) and the extractor (corporate sector), using the royalty receipts of government as the resource rent captured by the government sector, while the remaining resource rent would be captured in the economic sector extracting the asset (mostly private non-financial corporations). This treatment is also impacted by negative resource rent in situations where royalties are received by government despite having no wealth attributed to the commodity.

Figure 4-5 Value of Subsoil Assets by Institutional Sector in the National Balance Sheet Accounts



Country example: measuring natural capital in the Norwegian national accounts

Norway has historically been a country with abundant natural resources. Among these are biological resources, such as fish and timber, and non-biological renewable resources, such as hydropower. Since the discovery of offshore petroleum resources in 1969 however, the stock of crude oil and natural gas has been the paramount contributor to Norwegian national wealth. The Norwegian Government regulates extraction licenses which are only distributed to legal units registered in Norway. All corporations involved in extraction on the Norwegian Continental Shelf are therefore obliged to pay taxes to the Norwegian government.

The Norwegian Offshore Directorate[77] was established in 1972. The main tasks of the Directorate are to manage extraction and exploration licenses and analyzing petroleum resource deposits. As such, they publish annual data on extracted petroleum of different categories, as well as the monthly production/extraction of the different petroleum products in physical units. They also estimate and publish figures for expected future extraction from the Norwegian Continental Shelf, as well as estimates of the physical assets based on a national classification. These asset categories however can be easily mapped onto the SEEA CF classes (Liu and Midttun 2024a). Only the category "commercially recoverable resources" would be regarded as assets within the 2025 SNA framework. These resource estimates are updated on an annual basis.

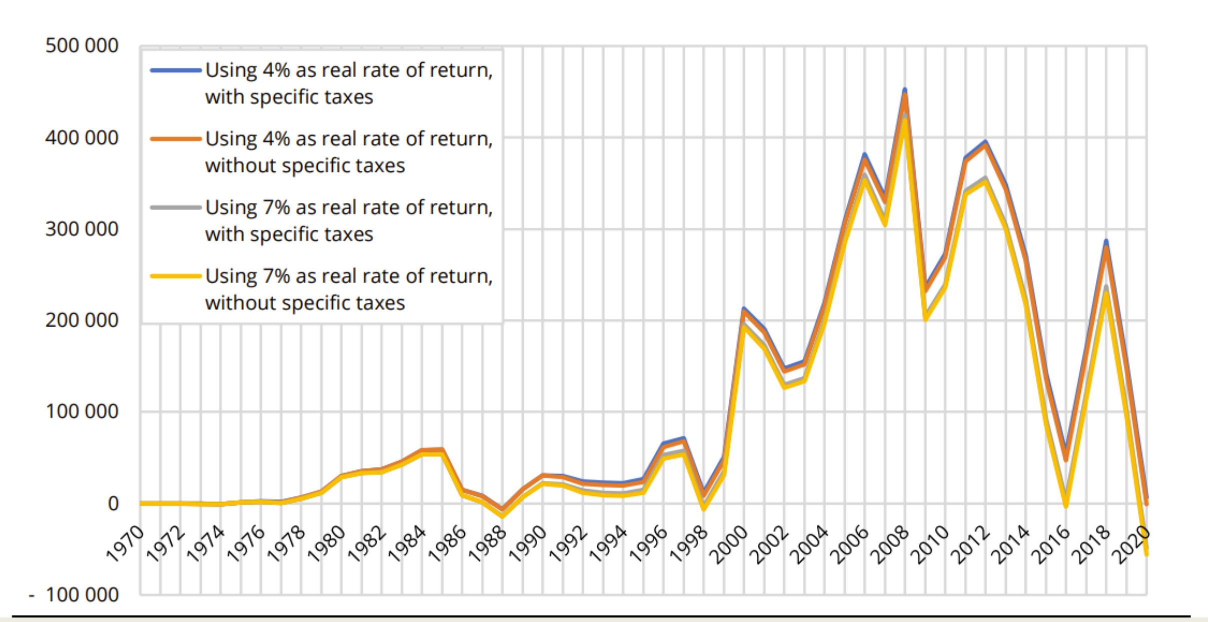
Statistics Norway has historically made several estimates on the value of natural capital, in particular of petroleum resources, however with different approaches. Calculations of resource rents have been used for policy analysis, such as analyzing whether the taxation of the industry captures a "reasonable" part of the resource rent. Updated calculations based on the most recent international recommendations have now been carried out, financed with grants from Eurostat. To estimate the resource rent stemming from petroleum deposits on the Norwegian continental shelf, different data sources must be combined. The data on extraction and estimated deposits are available on a disaggregated level, i.e. per oil and gas field. On many fields oil, different petroleum liquids and natural gas are extracted together. Also, multiple license holders can operate simultaneously on a given field, and each license holder can operate on several fields. The main operator on any given field is responsible for reporting extraction per product, such as natural gas and crude oil. These companies report their annual income, investments and compensation of employees on a company-wide basis, not per field or per petroleum product extracted. All these factors make it difficult to estimate resource rent per field, and per petroleum product. Consequently, a top-down approach is the only feasible method, given the data sources currently available in Norway. Even though a bottom-up approach would be favored, it can be shown that under reasonable assumptions, a top-down approach will yield the same result (Liu and Midttun, 2024b).

In addition to taxes applied on all companies, legal units involved in extraction are obliged to pay higher taxes on their net income. This is a way for the government to capture a share of the resource rent derived from extraction. The government also has a direct financial interest in the oil and gas fields. As this data is readily available, applying a split asset approach on the Norwegian petroleum deposits is feasible (Liu, 2023).

The real rate of return to fixed assets favored by the Norwegian Ministry of Finance is 4 per cent per year. Additionally, a resource rent using a rate of return estimated by the net operating surplus divided by the net stock of produced assets in Mainland Norway is used.[78] The reasoning behind this last choice of the rate of return is that, in equilibrium, any investor should expect the same asset return from the market-oriented sector in Mainland Norway (excluding government assets) (Liu, 2023).

Even if the extraction, measured in physical assets, is relatively stable over time, there might be substantial fluctuations in monetary values from one year to another, caused by extremely volatile energy prices.

Figure 4-6 Estimated nominal resource rent (current prices, NOK million), using 4% as real rate of return vs estimated rate of return



Source: Liu and Midtun (2024c). Authors' own calculation based on data from Statistics Norway

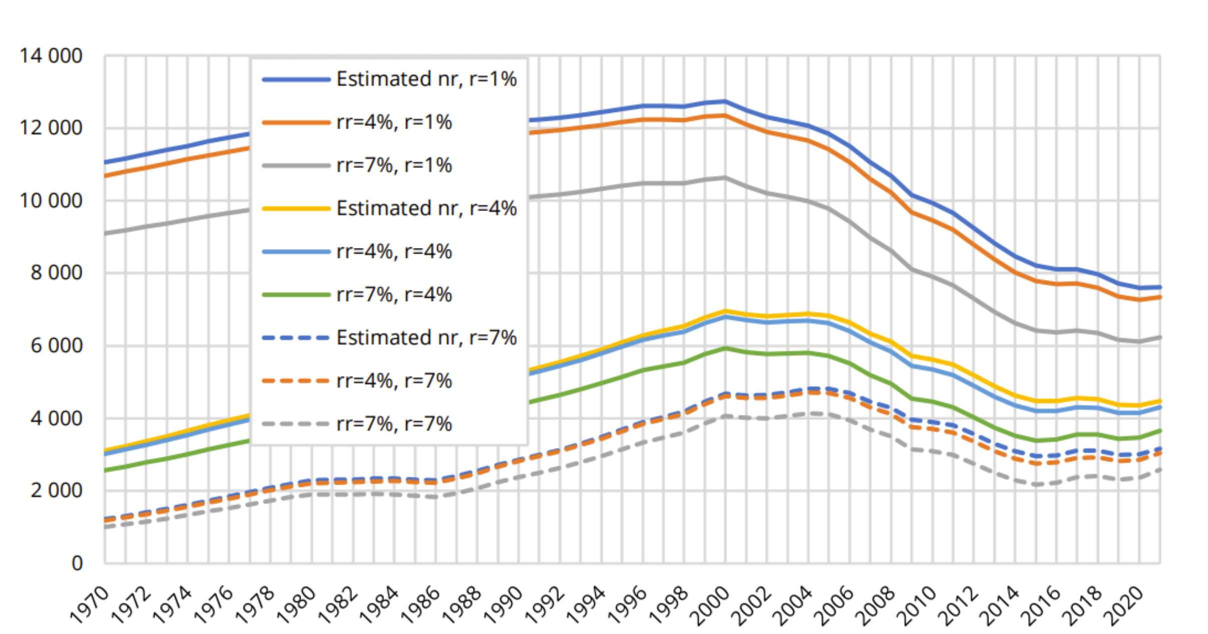
Estimated nominal resource rent does not differ significantly whether one applies a 4 per cent real rate or an estimated rate of return as a basis for the calculation (Figure 4-6). Whether the calculations include specific taxes or not, also has limited influence on the final results.

The asset value of Norwegian petroleum resources is, however, more sensitive to the choice of variables used in the NPV calculations. In Figure 4-7 below (Liu and Midttun, 2024c), one can see that for example in 2020, the asset value, measured in constant 2021 prices, will vary considerably depending on the choices made on nominal rate of return, annual real rate of return and real discount rate one applies to the calculation.

[77] https://www.sodir.no/en/

[78] Referred to in these guidelines as the "everything but" the activity approach. Mainland Norway consists of all domestic production activity except exploration of crude oil and natural gas, transport via pipelines and ocean transport.

Figure 4-7 Estimated asset value of Norwegian petroleum resources (in constant 2021 prices, NOK billion. 1970-2021



Source: Liu and Midttun (2024c). Authors' own calculation based on data from Statistics Norway

This rather large variation in estimates is consistent whether one makes the calculation in constant 2021 prices, constant 1970 prices or current prices (Liu and Midttun, 2024).

Statistics Norway has also made some experimental calculations of depletion of oil and gas resources, in line with the recording proposed in the 2025 SNA.

The value of depletion is calculated as recommended in this guide, i.e. using the physical extraction multiplied with the average price of the resource in situ. The calculations are based on Norwegian time series data for the value of the resources from Liu and Midttun (2024a), assuming an estimated nominal annual rate of return to produced capital for Mainland Norway, and an annual real discount rate of 4%.

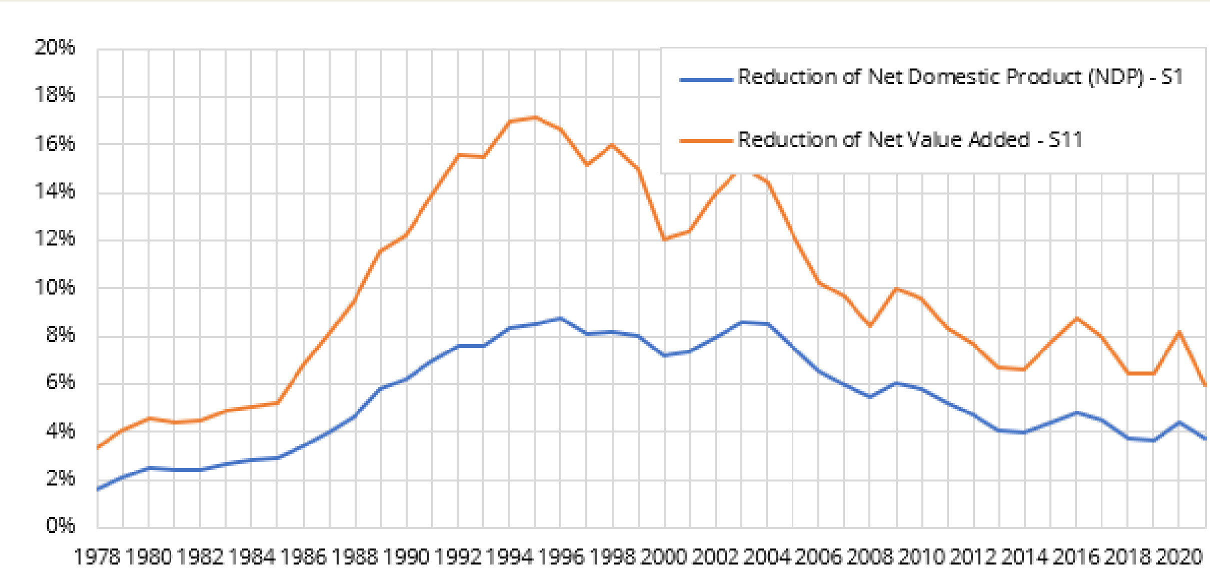
Figure 4-8 below shows the impact, based on the preliminary experimental calculations, of including depletion as a production cost on the Net Domestic Product (NDP) for Total economy (S1) and on the net value added for non-financial corporations (S11) over the period 1978-2021.

The impact of depletion on NDP and net value added according to these experimental calculations was most significant during the 1990s and early 2000s, with a reduction in NDP of up to 9%. In recent years, the reduction in NDP is around 4%, while net value added in S11 is reduced by 6-8%.

Even though the Norwegian authorities possess comprehensive data sets regarding extraction of crude oil and natural gas, it should be noted that some of the components in the calculations might be uncertain. Especially we will draw attention to the large fluctuations in crude oil and gas prices, which might have large impact on expectations of future resource rents. Even when using historic resource rents backward, for more than one year (smoothing), instead of the last observed value, as a basis for expectation of future rents, there are no guarantees that this will reduce the uncertainty. The calculations also depend on other assumptions, where different "sets" of assumptions might give different results.

Some assumptions, like the discount rate and rate of return, might be harmonised between countries, but the compatibility between countries is still blurred when countries have different sets of data. Some countries have scarcer data than others and might apply the data differently.

Figure 4-8 Impact on net value added and net domestic product (NDP), %, 1978-2021



Source: Experimental calculations based on data from Statistics Norway and Offshore Directorate.

It should also be noted that so far only annual calculations have been carried out, with a time lag of two years. For quarterly and preliminary annual figures, the available date is more scare. Timely information about the development in the prices and incomes is available, as well as quarterly information about gross fixed capital formation. However, timely information about extraction costs, taxes paid, etc., is not available. If we would compile quarterly (and preliminary annual figures), these figures would contain even more uncertainty than the annual figures.

4.2.4. Modifications to the standard approach

297. The approach described in Section 4.2.2 is to be understood as the Tier 2 (default) method. As countries differ in their in their data availability and resources for conducting valuation of natural resource, this section describes also a Tier 1 (basic) approach that would typically be followed in case of limited data availability and/or resources, as well as Tier 3 (advanced) methods requiring high data availability and resources.

Basic approach

298. A Tier 1 method would consist of applying a product-based application of the RVM for deriving resource rent in Step 1, instead of the top-down method that is used for the default approach. The product-based method does not use national accounts data or business statistics data for estimating resource rent for activities (e.g. oil and gas extraction). Rather, it estimates all elements required for calculating resource rent (e.g. revenues, costs, user cost of fixed capital, taxes / subsidies) directly for specific products (e.g.

oil, copper) from a range of data sources including commodity market prices, industry reports on cost to revenue ratios etc.

299. A good example of this method is the World Bank methodology used for the Changing Wealth of Nations (World Bank 2021) which estimates mineral and energy asset values for all 14 individual resources mentioned in Section 4.2.1, for a large portfolio of countries (> 140), including a time series (1995-2021). CWON uses a range of global data sources for the estimates, including from commercial providers (Table 4-12). When applying the product-based approach, it is recommended to use national data whenever possible instead of the global data sources.

Table 4-12 Data Sources for Fossil Fuel Energy and Mineral Resources in CWON

Resource	Indicator	Data sources and notes
Oil and natural gas	Production	• Rystad Energy, UCube (upstream database), https://www.rystadenergy.com/energy-themes/oil--gas/upstream • International Energy Agency (IEA), "World Energy Statistics," IEA World Energy Statistics and Balances database, https://www.iea.org/data-and-statistics • IEA, "World Conversion Factors," IEA World Energy Statistics and Balances database • BP, Statistical Review of World Energy, https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html • US Energy Information Administration, International Energy Statistics, https://www.eia.gov/international/data/world#/? • UN Statistics Division, UN Monthly Bulletin of Statistics, https://unstats.un.org/unsd/mbs/app/DataSearchTable.aspx Production data from different sources are selected following a few decision rules, such as best coverage over time and median values among estimates.

Oil and natural gas	Unit rent	• Rystad Energy, UCube (upstream database) Country data from Rystad Energy on unit revenues and costs for oil and natural gas are used to calculate average rental rates by region. Average rental rates are weighted by production.
Oil and natural gas	Proven reserves	• BP, Statistical Review of World Energy • US Energy Information Administration, International Energy Statistics
Coal	Production	• IEA, "World Energy Statistics" • US Energy Information Administration, International Energy Statistics • UN Statistics Division, UN Monthly Bulletin of Statistics Coal production is standardized on the basis of heat content and is broken down into two general categories: hard coal and brown coal.
Coal	Unit cost	• Wood Mackenzie, Global Economic Model database, https://www.woodmac.com/research/products/upstream/global-economic-model • Case studies from various sources • World Bank, Manufactures Unit Value Index, Global Economic Monitor Commodities database, https://databank.worldbank.org/source/global-economic-monitor-(gem)
Coal	Unit price	• World Bank, Global Economic Monitor Commodities database, • Government of Australia, Office of the Chief Economist, Department of Industry, Innovation and Science, Resources and Energy Quarterly database, https://www.industry.gov.au/data-and-publications/resources-and-energy-quarterly • IEA 1995, *Coal Information* Country-level estimates of unit production costs and prices are used to calculate average rental rates by region for thermal and metallurgical (coking) coal. Average rental rates are weighted by production.
Coal	Proven reserves	• US Energy Information Administration, International Energy Statistics • BGR (German Federal Institute for Geosciences and Natural Resources) 2015, *Reserves, Resources, and Availability of Energy Resources*
Metals and minerals	Production	• US Geological Survey (USGS), Minerals Yearbook and Mineral Commodity Summaries, https://www.usgs.gov/centers/nmic/minerals-yearbook-metals-and-minerals • British Geological Survey, World Mineral Statistics, https://www2.bgs.ac.uk/mineralsuk/statistics/worldStatistics.html
Metals and minerals	Unit cost	• S&P Global Market Intelligence for copper, gold, iron ore, lead, nickel, silver, and zinc, https://www.spglobal.com/marketintelligence/en • Country-specific case studies from various sources (assumed to be representative for the region) and cost index based on global average production costs from S&P for bauxite, phosphate rock, and tin.
Metals and minerals	Unit price	• World Bank, Global Economic Monitor Commodities database
Metals and minerals	Proven reserves	• USGS, Mineral Commodity Summaries and Minerals Yearbook, various years, https://www.usgs.gov/centers/nmic/mineral-commodity-summaries

Source: World Bank (2021) – Table A.6

300. A disadvantage of the Tier 1 method is that the estimates may not fully align with national accounts concepts and therefore differences in results are to be expected. For instance, by using market prices for resources, it is not entirely clear to what extent taxes / subsidies are taken into account.

Advanced methods

301. Several more advanced methods exist compared with the default approach. One advanced method involves applying more advanced modelling of future prices and/or extraction rates. For example, SEEA Energy (UN, 2019), para 6.41 notes that "…If extraction profiles are available from experts, energy agencies, geologic institutes, etc., those profiles should be used."

302. For projecting future prices, instead of assuming that the smoothed unit resource rent remains constant, an interesting possibility that deserves further research is to use information from futures markets. This could especially be relevant in case of extreme events or major societal issues (e.g. wars) that are likely to cause upheaval in markets in the short to medium term but not necessarily the long term. Futures markets cover multiple commodities (but not all) and there exist multiple exchanges. A possibility could be to use futures market prices as a point on the horizon (to understand what prices will do say X years from now); an alternative could be to use their information to assess how long it will take for prices

to return to their long-term average trend. However, before we can turn this into a more specific recommendation, future research would be needed to assess how accurate these predictions tend to be.

303. It is also possible to compile the value of mineral and energy deposits at a disaggregated level, ideally at the individual deposit level. Guidance Note WS.10 recommends this. The main reason is the heterogeneity of extraction costs across space, which would be problematic if deposits with low extraction costs are extracted first, as a result of which current costs would be poor predictors of future costs.

304. This approach could consist in applying a micro-level bottom-up approach (e.g. using deposit level data) allowing to estimate values for a larger number of individual resources. This approach would allow to capture heterogeneity in revenues and costs across deposits; but it is highly resource intensive.

305. The implementation of a deposit level approach may prove difficult for countries in the following circumstances: if they have a very large number of mines (e.g. a country like Canada produces 60 minerals and metals at almost 200 mines and 6,500 sand, gravel and stone quarries); when mining takes place to a large extent in the informal sector (a country like Ghana); or due to a lack of sufficient information at deposit level that would permit a resource rent calculation at that level (see Liu and Midttun 2024). A further challenge arises when multiple minerals are mined in the same operation (e.g. mixed ore mines).

4.3. Renewable energy

4.3.1. What to include in the national accounts

306. Renewable energy resources are shown separately in the 2025 SNA classification of assets as AN322.

307. As for subsoil assets, their scope is grounded in the United Nations Framework Classification for Resources (UNFC; United Nations Economic Commission for Europe, 2020) a standardized classification system for all mineral and energy resources (both renewable and non-renewable). The 2025 SNA states: “In the case of mineral and energy resources, SEEA Central Framework distinguishes three classes based on the United Nations Framework Classification (UNFC) for Fossil Energy and Mineral Resources: class A: commercially recoverable resources; class B: potentially commercially recoverable resources; and class C: non-commercial and other known deposits. The measurement of monetary estimates is typically restricted to the first class, which in practice could be approximated by those resources for which permissions to exploit have been granted, and/or those for which the existence is explicitly recognised by (past) monetary transactions. Potential mineral and energy resources where it is not foreseen that they will be exploited in the near future are thus explicitly excluded” (11.186) Based on the UNFC, the 2025 SNA update Guidance Note WS.11 (SNA Update 2023e) defines renewable energy resources as comprising “the cumulative quantities of kinetic, heat or radiative energy recoverable from moving water (hydro and ocean energy), moving air (wind energy), hot underground and surface rock and water (geothermal resources) and incident solar radiation (solar resources).”

308. Renewable energy assets to be included in the national accounts correspond to a subset of renewable energy resources, namely those resources “viable for use in economic production under prevailing technological and economic conditions” (Smith and Peszko 2022). This means that the treatment of renewable energy is consistent with that of non-renewable energy and mineral resources (subsoil assets), where the scope of measurement is restricted to SEEA Class A which also corresponds with the class of viable projects. Viable projects (called commercial projects in Guidance Note WS.11) are defined according to the UNFC as consisting of classes E1, F1, G1-3 (see Section 4.2), however as shown in Box 4.1 there are some differences with respect to the interpretation of the Geological or G-axis.

Box 4.1 Interpreting the G axis (degree of confidence) for renewables

According to UNFC (2016) "it is recognized that the reference to "geological knowledge" [the interpretation applied for subsoil assets] is not generally applicable to Renewable Energy Resources. Therefore, when applied to Renewable Energy Resources, the G axis should be understood to reflect the "level of confidence in the potential recoverability of the quantities".

Thus, the G axis categories shown in Figure 4-1 are intended to reflect all significant uncertainties impacting the estimated Renewable Energy Resources quantities that are forecast to be produced by the Project and typically would include (but not be limited to) areas such as meteorology, climatology, topography and other branches of geography, ecology and, for geothermal Projects, geology. Uncertainties include both variability in the Renewable Energy Source and the efficiency of the extraction and conversion methodology (where relevant).

The level of confidence for quantities that are classified on the G axis as G1, G2 and G3 is defined as "high", "moderate" and "low", respectively. In order to maintain alignment between different Renewable Energy Resources, as well as with non-renewable fossil energy and mineral reserves and resources, specifications for application of the G-axis categories to Renewable Energy Resources are:

1. Where the "probabilistic" approach is used, the cumulative probability levels associated with G1, G1+G2 and G1+G2+G3 shall be 90%, 50% and 10% respectively, where each probability level reflects the probability of exceeding the estimated Renewable Energy Resource quantities for that level.
2. Where the "scenario" approach is used, the low, best and high estimates shall reflect the same principles, and approximately the same probabilities, as would be associated with estimates derived from a probability analysis as described above for the "probabilistic" approach." "

309. UNFC (2016) makes a helpful distinction between products and sources: "Products of the project may be bought, sold or used, including electricity, heat, hydrocarbons, hydrogen, minerals, and water. It is noted that with some projects, such as for renewables, the products (electricity, heat etc.) are different from the sources (wind, solar irradiation etc.). In other projects the products and sources may be similar e.g. in petroleum projects both the sources and products are oil and/or gas, although the fluid state and properties may change from reservoir to surface conditions." In other words, we can draw a clear conceptual distinction between the source (such as the oil in the ground; or wind), and the product (the oil produced; electricity generated). It is the source that we seek to capture when measuring natural resource assets (in this case, renewable energy resources),

310. Renewable energy resources consist of the cumulative quantity of renewable energy resources harvestable by viable renewable energy projects. This means for instance that the energy of a river without hydroelectric generation (existing or planned at a point in time) does not constitute an asset, and that only the solar radiation capturable by (existing or planned) solar panels is considered an economic asset. Physical stocks of renewable energy resources may increase over time due to additional equipment being installed or due to better technology – these would be recorded as (upward) reappraisals in a physical asset account.

311. The scope for renewable energy resources includes resources that generate electricity and/or heat and cold. As we have seen in Section 2.5.2 the 2025 SNA asset classification of renewable energy resources consist of wind, solar, water, geothermal and other renewable energy resources. Additionally, the following recommendations regarding what resources to include in the national accounts are made:

- **Biomass / solid biofuel** is in many countries an important source of energy (either in the form of heat or electricity production or combined heat and electricity production). However, the value of biomass should in principle be captured under timber resources if it pertains to fuelwood. Other biomass used for energy production such as crop residue or felling residues can be considered as being produced within the economy (SEEA Energy, UN 2019) and would therefore be considered as products not sources (following the earlier UNFC categorization). It is therefore recommended not to account for biomass under renewable energy assets.

- **Other biofuels (e.g. renewable municipal waste, biogas, liquid biofuels)** can also be considered as produced within the economy (SEEA Energy, UN 2019) constituting products (or sometimes residuals in case of waste(water) or sewage), not as sources and hence would be out of scope as renewable energy assets.

- **Geothermal energy resources**. A distinction is commonly made between deep subsoil sources (e.g. in the Dutch context > 500 m) and shallow sources (e.g. used for heat pumps) – although there does not appear to be an internationally standardized depth / classification. Heat-pumps can be used both for heating and cooling with heat (or cool air) as main product. Both deep and shallow sources are in scope, as is hot surface water (e.g. from geysers).

- **Aerothermal energy** is captured by heat-pumps but using outside air rather than geothermal energy. These devices seem to be predominantly used by households. Aerothermal energy is also in scope of measurement.

- **Solar thermal** may be captured either by a small installation that warms water directly or a large installations like concentrated solar power plants. Solar thermal is also in scope.

- Water energy resources, more generally known as hydropower, can be understood as the use of moving water (either natural or artificial, after storage behind a dam) to generate electricity. **Wave and tidal** energy are in scope but probably insignificant in most countries.

4.3.2. Compilation stages

312. For renewable energy resources, we will distinguish four compilation stages: identifying the types of assets to be included; collecting the physical data; building the monetary asset accounts; and integration of the results into the accounts. The four compilation stages follow the same approach as for non-renewable energy and minerals; but they are simpler than for non-renewables and there is (by definition) no cost of depletion to be recorded in the accounts at the end of the compilation process.

Stage 1 (renewable energy): Identifying types of assets

313. In the first stage, the types of renewable energy assets for which accounts are to be compiled need to be identified. The 2025 SNA asset classification distinguishes between wind energy resources (AN3221), solar energy resources (AN3222), water energy (hydro) resources (AN3223), geothermal energy resources (AN3224) and other renewable resources (AN3229). Countries are encouraged to provide breakdowns at least at this level of detail, because they are of considerable policy interest. A more detailed break-down could be disseminated as part of the environmental-economic accounts (either in physical or monetary units) but this goes beyond the 2025 SNA requirements.[79]

[79] The SEEA Energy (UN 2019) contains a breakdown of renewable sources that is very similar, only wave and tidal are separately identified. The International Renewable Energy Agency (IRENA) commonly distinguishes between renewable hydro, wind, solar energy, bioenergy (e.g. solid biofuels, biogas, renewable municipal waste), geothermal energy, and marine energy.

314. The SNA is exhaustive, implying that all assets with economic value (the in-scope Class A resources discussed above) should be estimated. Due to the resource intensive nature of the valuation of renewable energy assets, it is proposed to apply a materiality threshold and focus on the valuation of those renewable energy resources that contribute more than 5% of the national energy supply. The easiest way to assess this is by looking at the generation of energy by source (in physical units) based on energy statistics. However, data and resources permitting, countries are encouraged to compile accounts for any renewable resources that are likely to grow and become economically important in future. When a reasonable estimate can be made of how much of the asset value is missed, it is recommended to gross up the asset value.

315. The materiality threshold should be applied at a slightly more detailed level of resources than the five categories mentioned above. In the absence of an internationally agreed detailed classification for renewable energy resources suitable for statistical purposes[80], it is recommended to use the following list as a checklist to assess which renewable energy resources are available in the country and would be above the threshold in terms of energy generation:

- Wind (off-shore), wind (on-shore), solar photovoltaic, solar thermal, hydro, geothermal (deep), geothermal (shallow), aerothermal, wave and tidal.

This list has been drawn up based upon existing country practices, taking into account the exclusion of biomass as discussed in the previous section.

Stage 2 (renewable energy): Collecting the physical data

316. The next stage is to collect the physical data for the renewable energy resources that have been identified and are above the materiality threshold. In the case of renewable energy, it is necessary to obtain information on renewable energy generation in physical units. No information is required about installed capacity. This information may already be available as part of energy statistics, in some cases it would need to be collected and estimated in order to express various energy resources in the same units.[81]

317. The use of renewable energy resources is growing in most if not all countries. This raises the question how one should make projections of future production in physical terms. Some projects (such as the construction of a hydropower dam) may take several years. If you know when the dam would start producing (say five years from now with an expected lifetime of 50 years), it would be possible to take this into account when making future projections of electricity generation. While this may be feasible for a technology such as hydropower with a limited number of locations, for other resources such as wind or solar PV this may pose significant information demands

318. While in theory plants or installations that are not yet producing energy (to the extent they are considered viable projects according to the UNFC) should be included, in the standard approach they are therefore excluded for pragmatic reasons.

Stage 3 (renewable energy): Building the monetary asset accounts

319. Once the physical data has been collected for each renewable energy resource, the next stage is to compile the monetary asset accounts. These provide information on stocks and changes in stocks that

[80] This may change in the near future, for instance the SIEC (Standard International Energy Product Classification (SIEC) is at the time of writhing these guidelines under revision; the International Renewable Energy Agency (IRENA) has also prepared a new system to classify different energy sources.

[81] For instance, in the EU context detailed protocol exist for the estimation of the share of renewable energy in total electricity or heat end-use (SHARES tool).

are needed to populate the relevant accounts in the 2025 SNA, such as various entries in the capital accounts and balance sheets as explained in Stage 4.

320. When valuing renewable resource assets, as discussed in Chapter 3, the preferred valuation method would be to use observable market prices for transactions. Under some circumstances, the valuation of renewable energy will already be captured in associated land values; for instance, in the case of onshore wind energy or in the value of dwellings equipped with solar panels. This issue is recognized in the 2025 SNA (11.197): "The value of land may be higher due to the availability of subsoil resources, or the possibility to exploit renewable energy by having permission to put, for example, wind turbines or fields of solar panels on the land." In such cases a hedonic pricing method could be followed, which may provides a direct estimate of the renewable energy asset value (e.g. a house with solar panels fetches a higher market price). However, care would need to be taken to obtain separate values for the land or dwelling, the equipment (e.g. the solar panel) and the renewable energy asset value itself to avoid double counting. Furthermore, the use of hedonic pricing methods is highly resource intensive, requiring extensive micro-data. For these reasons, the use of hedonic pricing is not recommended as the standard approach, but as an advanced method (see Section 4.3.4). As explained in SNA update Guidance Note WS.11, in many instances no associated land exists (e.g. in case of off-shore wind) or installations are placed on land that is not recognized as economic asset in the SNA (e.g. desert areas / wastelands), which would rule out the possibility of doing hedonic pricing.

321. In some instances, permits to access the natural resource exist but as discussed in Chapter 3, valuation based on permits may only be feasible in certain circumstances. Therefore, in most cases, the recommended valuation method is to calculate asset values as the Net Present Value (NPV) of future resource rents, which are projected from actual (past and present periods) resource rents calculated with the Residual Value Method (RVM). This has the additional advantage also of consistency in treatment with the valuation of subsoil assets.

322. However, Guidance Note WS.11 indicated concerns about using the NPV method in cases where markets are immature or heavily distorted: "Though we recommend the RVM in most instances, we acknowledge that the least-cost alternative (LCA) method is worthy of consideration in cases where subsidies remain significant and markets are likely still far from long-term equilibrium (mainly for solar and wind energy assets)." The EGNC has investigated how the LCA method could be operationalized for different technologies based on Levelized Cost of Electricity Estimates (LCOEs), see Annex 1. The investigation concluded that the LCOE is not suitable for use in compiling the national accounts.

323. *Stage 3: Building the monetary asset accounts* therefore focuses on demonstrating how to calculate asset values for renewable energy resources as the NPV of future resource rents, which are projected from actual (past and present periods) resource rents calculated with the RVM (see also country examples from Costa Rica and Indonesia). While most renewable electricity and heat is generated by companies, we will also include a discussion of the production of electricity and heat by households.

324. As in the case of subsoil assets, eight steps are required to compile the monetary asset accounts for renewable energy resources, as shown in the example for the year 2023 in the *Workbook: Renewable energy*, which is discussed below. The eight steps are:

1. Calculate resource rents (past and present).
2. Project the physical asset account and physical output until end of the asset life of the resource.
3. Calculate the unit resource rent.
4. Smooth unit resource rents to address price volatility.
5. Project future resource rents.

6. Calculate NPV for the opening stocks.
7. Calculate NPV for the closing stocks.
8. Put together the monetary asset account.

Step 1: Calculate resource rents (past and present)

325. The calculation of resource rents is shown in the *Workbook: Renewable energy* in rows 4-20 of the Year 1 and Year 2 worksheets. Table 4-13 presents an example.

Table 4-13 is similar to Table 4-5 used for subsoil assets. However, it also includes gross mixed income (GMI) of the household sector to allow for the inclusion of the profits associated with renewable energy production by households (as unincorporated enterprises).

Table 4-13 Calculating resource rents for renewable energy resources – an example

	2020	2021	2022	2023
Output (producer prices)	70	75	80	85
Less Taxes on products	1	1	1	1
Plus Subsidies on products	10	10	10	10
Output (basic prices)	**80**	**85**	**90**	**95**
Less operating costs, specifically:	23	23	25	26
Less Intermediate consumption	10	10	11	11
Less Renumeration of employees	12	12	13	14
Less Other taxes on production	2	2	2	2
Plus Other subsidies on production	1	1	1	1
Gross operating surplus (GOS) and gross mixed income (GMI)	**57**	**62**	**65**	**69**
Less Specific subsidies on products	0	0	0	0
Plus Specific taxes on products	0	0	0	0
Less Specific other subsidies on production	7	7	7	7
Plus Specific other taxes on production	0	0	0	0
GOS and GMI for the derivation of resource rent	**50**	**55**	**58**	**62**
Less User costs of capital, specifically:	17	18	18	19
Value of fixed assets	200	206	212	218
Less Consumption of fixed capital (depreciation)	5	5	5	5
Less Return to fixed capital	12	12	13	13
Resource rent	**33**	**37**	**39**	**43**

Source: *Workbook: renewable energy assets*, Year 2 worksheet.

Notes: Cells in green indicate input data; blue indicates calculated estimates. Specific taxes on products / specific other taxes on production should be recorded as rent payment (D42) when government is the legal owner.

326. For calculating resource rents associated with renewable energy production, it is recommended to use a bottom-up approach rather than the top-down approach recommended for sub-soil assets.[82] There are a number of reasons for this recommendation. First, as discussed in Section 3.3.1 on the Residual value method for calculating resource rent, the national accounts (and most economic statistics) currently do not distinguish between renewable and non-renewable energy production as separate economic activities. This is expected to change with ISIC Rev 5, which will have a breakdown of electricity into two new classes (3511 and 3512 respectively) for electric power generation activities from non-renewable

[82] An exception may arise in case a country's energy supply predominantly is generated from renewable energy resources.

sources and renewable sources. But even with the implementation of ISIC Rev 5, compilers would still need a further disaggregation between different types of renewables (solar, wind etc.).

327. The overall intent in applying the bottom-up method lies in proxying national accounts concepts as best as possible. For instance, business survey data may provide figures for depreciation, but these may be based on historic costs and may need to be adjusted to reflect exchange value / written-down replacement cost required for the national accounts.

328. The bottom-up approach uses a range of data sources, where we will distinguish between companies and households. Large-scale renewable energy production is undertaken by companies, but households are important for solar energy (both PV and thermal), aerothermal, and geothermal energy.

329. For **companies**, the recommended approach consists of collecting micro-data of businesses engaged in different types of renewable energy production such as hydro, wind, solar (e.g. business surveys). Depending on the national market, it may be sufficient to focus on the biggest companies (e.g. the main wind farms) and impute unit resource rents for the smaller companies in Step 3 below based on their respective shares in electricity generation, assuming similar unit resource rents. A challenge may arise in case companies are active in different kinds of renewable energy (or even fossil energy). In such cases, it is recommended to apply a product-based approach (see Section 4.3.4, Basic approach), where for instance output is based on physical output multiplied with relevant energy prices. Energy and electricity markets are however quite complex and care should be taken to apply a valuation consistent with national accounts principles, see Box 4.3.

330. In order to apply the RVM, the starting point for corporations in Step 1 is gross operating surplus (GOS). Information about taxes and subsidies and depreciation is also relevant. Business surveys typically do not contain information about the value of stocks of fixed assets (e.g. equipment), which is needed for the estimation of user costs of produced assets. This would need to be obtained from other sources (such as business accounts) or estimated based upon information about gross investment in tangible goods (which is similar to the concept of gross fixed capital formation in national accounts).[83]

331. As explained in Section 3.3.1 the user costs consist of two elements: depreciation and return to produced assets, specifically fixed capital. The value of depreciation (consumption of fixed capital in the 2008 SNA) is usually derived from a perpetual inventory model (PIM) and available as part of the national accounts but probably not in the required disaggregation that allows to distinguish between renewable and non-renewable energy generation. The asset life of the fixed assets could differ from the asset life of the natural resource , but in principle it should not be longer than the life of the natural resource.

[83] Beginners:Structural business statistics - Statistics Explained (europa.eu)

Box 4.3 Electricity markets and national accounts

Electricity markets are complex. Electricity is sold across two main markets: the wholesale market and the retail market. In the wholesale market, electricity generators sell electricity in bulk to large buyers, such as utilities, at prices influenced by supply conditions and demand forecasts. The wholesale market itself consists of forward markets (up to years ahead of physical delivery), the spot market (up to minutes), and the balancing market (real time to avoid black-outs).[84]

The spot price - the current price for electricity traded for immediate delivery - reflects the value of electricity at a given moment. Fluctuations in the spot price are influenced by real-time supply and demand, particularly for renewable sources, which are often weather-dependent. For instance, on a sunny or windy day, in a country where electricity mainly is used for lighting and heating, renewable electricity generation may surge, leading to lower spot prices due to excess supply. In such situations even negative prices for renewable electricity may occur. The marginal cost of the electricity producers usually drives price formation.

In the retail market, energy suppliers then sell electricity to end consumers (households and businesses), where the final price includes additional costs like distribution and retailing, as well as taxes & levies.

The design of electricity markets differs a lot between countries, ranging from highly centralized to decentralized markets, and from closed to open markets.

Government policies, such as feed-in tariffs (FiTs), also play a key role in price formation. FiTs ensure that renewable energy producers receive a guaranteed price for the electricity they generate, smoothing out the volatility of spot prices. Similarly, power purchase agreements (PPAs), which are long-term contracts between producers and buyers, set fixed prices for electricity over time. As a result, a significant part of renewable energy can be sold outside the competitive electricity markets. This poses a major challenge for estimating the value of output for purposes of the national accounts.

The national accounts measure output which for an electricity producer consist of the transactions in electricity produced. This value may be quite different from the average wholesale electricity spot price times physical generation, in case PPAs (or FiTs) are in place. The valuation of output for wholesale or retail traders generally consists of the wholesale and retail margins.

332. The return to fixed capital is estimated by multiplying the value of fixed assets (row 22) with the rate of return, which is specified in cell H24. The rate of return is assumed to be 6% real in the example, but countries should apply their own rate of return, based on the recommendations provided in Section 3.3.1 by applying the “everything but” the activity method to be consistent with the estimation of subsoil assets.

333. After deducting both elements – depreciation and the return to fixed capital – from GOS and GMI for the derivation of resource rent, we obtain the resource rent.

334. Plants that are not yet producing renewable energy (e.g. a hydropower dam being constructed) are recorded under work-in-progress (AN12). As discussed in Section 3.3.1 the user cost of capital is restricted to fixed assets and therefore excludes a return to the work-in-progress.

335. For **households**, the 2025 SNA is clear (7.27) that electricity and heat production by households should be recorded. Eurostat (2024) provides more detailed guidance on the treatment. First, the output is

[84] 20211021_Factsheet_Power market design_EN.pdf (epexspot.com)

recorded as production of an unincorporated enterprise owned by household sector, either in ISIC 35.12 'Production of electricity from renewable sources' or ISIC 68.20 'Rental and operating of own or leased real estate', with the second option "best justified [when] electricity production is small compared to total electricity production and small compared to the production of owner-occupied dwelling services." (Eurostat, 2024). Electricity produced by so-called balcony solar panels i.e. smaller panels usually not connected to the grid may be excluded for practical reasons of data availability. Furthermore, both the production of electricity provided to other units and for own final use is included, the latter only when "significant, i.e. when it is quantitatively important in relation to the total supply of that good in a country" (Eurostat, 2024).

336. When it comes to valuation of electricity the following recommendations apply (Eurostat, 2024). "When households sell own-account production of electricity to the grid, this amount of electricity should be valued with the price the household receives. The price to be used should be a weighted average of the different Feed-in-Tariffs (FiT) for households." (Eurostat, 2024) The FiTs are usually contractual arrangements between the household and the energy company.[85] Secondly, "The own final consumption of electricity produced by households themselves, should be valued at the basic price which incorporated producers receive for electricity intended for sale to households. This price should exclude any charges for transmission or distribution of electricity. As it has to be valued at basic prices, taxes less subsidies on products applicable to incorporated electricity producers need to be deducted" (Eurostat, 2024). In case charges apply to households for delivering energy back to the grid, these charges need to be treated as intermediate consumption. Finally, "renewable energy installations, which fulfil the criteria of being fixed assets, should be classified as GFCF in electricity production, or as GFCF in dwellings" (Eurostat, 2024).

337. While Eurostat (2024) does not discuss the generation of heat, similar treatment would apply. It should be noted (as discussed in Stage 1) that biomass is not considered as a renewable energy resource, hence use of wood or charcoal for heating or cooking is excluded from the valuation of renewable energy resources.

338. In order to derive resource rent for unincorporated enterprises in the household sector, the following recommendations apply:

- GMI will be broadly equivalent to profit (GOS for corporations) because compensation of employees can be neglected as no labour is usually involved (after the installation of the solar panels or heat-pumps) in the production of electricity.
- According to Eurostat (2024) "Taxes less subsidies on production, if applicable at all for households, also need to be taken into account." In case households are subsidized for the production of electricity (by government)[86] this is to be recorded as D3 and treated as (specific) subsidies on products and hence deducted in the derivation of the resource rent.
- The user costs of produced assets need to be estimated based on estimates of the value of the installations. Countries are recommended to include solar panels and heat pumps as two additional and separate assets in their perpetual inventory models (PIMs). The assumed service life should not necessarily be the same as the life of the resource. Unless more specific information is available, it is recommended to apply 25 years as default for solar panels with an assumed loss of 0.5% annually in efficiency.[87] For other equipment used by households a default asset life of 15

[85] In addition to FiTs, a range of other policy instruments may exist such as Feed-in-Premiums (that pay a difference compared to the electricity market price).

[86] These may be in addition to the renumeration households receive through the FiT.

[87] Solar Panel Efficiency Over Time (Plus Tips to Improve It) (2024) - EcoWatch

years is assumed with an assumed loss of 1% annually in efficiency.[88] The loss in efficiency can be used to estimate suitable depreciation profiles for these assets.

- It is recommended to use an "everything but" the activity approach to estimate the return to fixed capital to be consistent with the estimation of resource rent for companies.

339. As many countries will be compiling estimates for household production of renewable energy the first time, it may be helpful to note that the estimation of output (and value added) of household production can be undertaken based on a variety of data sources: information collected from network operators, from energy companies (e.g. information obtained through smart meters) or through household surveys, (See also Box 4.4). The output is recorded in the production account; the income generated is recorded as GMI in the earned income account.

340. In line with the recommendations of Guidance Note WS.11, Variable Renewable Energy (VRE) grid integration costs such as cost made by to connect wind turbines and solar panels to the network are likely to be modest and therefore may be excluded when estimating renewable energy resource rents.

Step 2: Project the physical asset account and physical output until end of the asset life of the resource

341. In the *Workbook: Renewable energy* (Year 1 worksheet, rows 33-46), we have included a physical asset account table because it is helpful for compilers when going through steps recommended by this guide. Below the table there is a line for generation of energy (physical output), in row 46 of the worksheet.

342. It should be noted that that there are some key differences between this physical asset account and the one for subsoil assets:

- There is no "extraction" or "discoveries" lines, as these are not applicable for renewable energy.
- The opening and closing stock of physical renewable energy assets is calculated as the current generation of energy (in MW) times the asset life and is therefore expressed in energy units (MW).

343. The choice of the asset life (of the natural resource) should not be based on the expected lifetime of the equipment used in capturing energy, as we are valuing the resource itself. Similar to the exploitation of other natural resources, it is reasonable to assume that equipment will be replaced when there are still economic benefits that can be derived from the natural resource.

344. It is not recommended to use an infinite life either due to uncertainties in technology and climate considerations. For example, water levels in Lake Mead in the United States have dropped significantly in recent years, reducing electricity generation by the Hoover Dam.[89] The dam was completed in 1936, less than 100 years ago, and uncertainties as a result of exacerbating climate change will only increase.[90]

345. It is recommended to use the average (or median) licensed lifetime of projects as asset life of the resource, and if such data is not available to apply a default asset life of the resource of 30 years for wind and solar and 50 years for hydro.

346. In Table 4-14, we assume that in 2023 we have energy generation of 83 units per year, which is based on the last year and is assumed to remain constant (see Chapter 3) Alternatively, it is possible to use a specific projection for future energy generation when available. In order to use such a projection, in light of the UNFC (as discussed in Section 4.1), it is important that clear evidence is available of future

[88] Based on UNECE (2014) recommendation for AN1139 Other machinery and equipment, specifically CPA 27: electrical equipment.

[89] Hoover dam power capacity by month 2020-2024 | Statista

[90] A practical advantage of using a finite asset life is that the total physical stock also remains finite.

renewable energy projects, hence the existence of policy goals for increasing renewable energy production alone is not sufficient.

347. When making projections, we only project energy generation, as by definition we do not have information about reappraisals or reclassifications. We also make an assumption (in cell B31 of the Year 1 worksheet) that the asset life of the resource is 50 years (e.g. for a hydro project), giving an opening stock of 4150 physical units (MW). This remains constant if the amount of energy generated remains constant.

Table 4-14 Physical asset account as of 2023 (start of period)

	PROJECTION AS OF 2023 (start of period)										
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Opening stock	4150	4150	4150	4150	4150	4150	4150	4150	4150	4150	4150
Additions											
Upward reappraisals											
Reclassifications											
Reductions											
Catastrophic losses											
Downward reappraisals											
Reclassifications											
Revaluation											
Closing stock	4150	4150	4150	4150	4150	4150	4150	4150	4150	4150	4150
Generation of energy (physical output)	83	83	83	83	83	83	83	83	83	83	83

Source: *Workbook: Renewable energy*, Year 1 worksheet.

Note: Cells in green indicate actual data; blue indicates modelled estimates; yellow indicates projections. Projections continue up to 2072.

Box 4.4 What data do I need?

For Steps 1-2, the following data are required:

- Physical information about the amount of renewable energy generation for different technologies Data on renewable energy production is usually not collected / compiled by NSIs but rather by the Ministry of Energy or an Energy Agency.
- For companies, micro-data of businesses engaged in different types of renewable energy production such as hydro, wind, solar (e.g. business surveys).
- For households, information about FiTs, number (and value of) solar panels and heat pumps for instance through household surveys.
- Data may also be collected from network operators, from energy companies (e.g. information obtained through smart meters). Information about the energy market (e.g. average wholesale electricity prices) may also be useful either to estimate output (by multiplying with physical data about generation), or to corroborate information from other sources.
- Average (or median) licensed lifetime of wind and/or solar projects.

Step 3: Calculate the unit resource rent

348. The unit resource rent is the resource rent (from Step 1) divided by the physical amount of energy generated during the same accounting period. It can be considered a price measure. The unit resource rent needs to be calculated for several years, as this is required for the next step. This is done in row 50 of the workbook.

349. In the workbook it is assumed (as a convention) that the resource rent is generated in the middle of the accounting period and therefore reflects the average price level of the accounting period[91].

350. In order to apply smoothing of unit resource rents in Step 4, we need to first bring the unit resource rent of the previous years to the same price level as the current accounting period (in this case 2023). This is done in the Year 1 worksheet by applying a price deflator in row 51 to the unit resource rent figure (row 50), obtaining – for each past year - the unit resource rent in mid-2023 prices (row 52). We use a fixed price deflator of 2% but countries should apply their own price index (which may differ from year to year).

Step 4: Smooth unit resource rents to address price volatility

351. It is assumed that the unit resource rent will remain constant unless specific policies have been implemented which would allow us to estimate a specific path of future unit resource rents. An example of such a specific policy would be if there is solid evidence that subsidies for renewable energy will change over the period of the projection (see Box 4.5).

Box 4.5 Projecting future taxes/subsidies

A key input in projecting future unit resource rent for renewable resources is the level of taxes/subsidies. Guidance Note WS.11 proposed to assume a linear decline of subsidies from their current level to zero over a reasonable time horizon, and a linear increase of taxes from zero to 25% over the same time horizon.[92] However, further research in support of these guidelines has indicated that there is large uncertainty regarding the future development of subsidies/taxes on renewables. In addition to FiTs, a wide variety of policy instruments has been developed which makes it difficult to predict the aggregate future development. Also, the arguably optimistic outlook that existed when the Guidance Note was written about the competitiveness of renewable energy seems to have changed somewhat in recent years with consulted experts questioning whether any taxes (rents) will be levied on renewables in the foreseeable future. Another issue that has become increasingly clear is that with a larger percentage of electricity being provided by renewables, the competitiveness of renewable energy not only depends on cost but also on a range of other factors such as the ability to address peak demands, flexibility in supply and their computability with the electricity system.[93]

If there is no evidence to support a different scenario, the standard approach recommends assuming that the (smoothed) unit resource rent stay constant i.e. it assumes that the current (net) subsidy levels remain constant when projecting resource rent into the future.

352. As discussed in Chapter 3, it is recommended to project future unit resource rents based on an average of actual unit resource rents for several years. Due to volatility in commodity prices for several natural resources, if we were to use only the unit resource rent of the last year, asset values would become

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[91] It would be possible to make a different choice (e.g. that it falls at the end of the accounting period) as this is merely a convention. However, in order to standardise the approach, a decision had to be made and this was the recommendation of the EGNC (and is consistent with 2025 SNA (18.117) which mentions that for flow variables the desired valuation point is usually the mid.-point of the period.

[92] The rationale for the 25% was based on data from the Canadian balance sheets being the only country at the time of writing that applied the split-asset approach (WS.11 – p.36).

[93] This is why in addition to LCOE (as discussed in Box 4.2) currently VALCOE (value adjusted LCOE) is used as a metric designed to also take additional issues such as flexibility and grid stability into account.

highly volatile, which is hard to cope with in the national accounts. The number of years used for smoothing will depend on the type of resource, but typically would range from 3 to 10 years.

353. Under certain circumstances there may be good reasons not to smooth, for instance when futures markets provide a different signal compared with the long-term price trend or if there are expected to be changes in the regulatory regime.

Step 5: Project future resource rents

354. We now multiply the smoothed unit resource rent in mid-2023 prices (cell F56) by the projected electricity generation for the year in question (Year 1 worksheet row 61). This results in projections of future resource rents in mid-2023 (constant) prices.

355. Next, we project discounted future flows of resource rents using a discount factor for each projected year (Year 1 worksheet row 63). The discount factors are calculated from a real discount rate (cell B62). The opening stock is to be calculated (in Step 6) for the start of the accounting period (1 January) and the resource rents are assumed to arisein the middle of the accounting period as these activities occur mid-year on average, so we halve the discount factor in the first period (in this case 2023).

356. As the resource rent in future periods is expressed in constant prices, the discount rate used must be 'real' (excluding inflation), as noted in Section 3.3.2 on Discounting future flows of resource rent. The *Workbook: Renewable energy* example uses the real discount rate of 2% that is recommended as the common, stable rate by the EGNC (see Chapter 3). The resulting discounted projections of future resource rents is shown in the Year 1 worksheet row 64.

357. Countries may prefer to use a real discount rate that is higher or lower than the common, stable rate agreed by the EGNC. As noted in 3.3.2 Discounting future flows of resource rent, countries are free to set their own discount rates as long as they also include a valuation using the common agreed rate as part of sensitivity analysis. This is simple to do as part of Step 5: compilers need only change the figure in cell B62 from 0.02 (2%) to the desired rate.

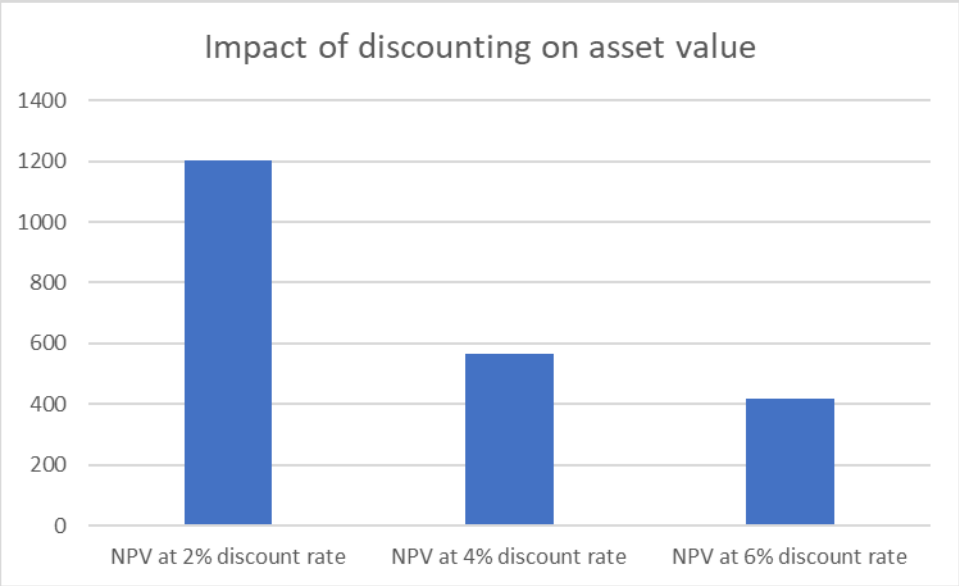
358. Countries may also prefer to project resource rents including future price increases. If so, a nominal discount rate which includes price changes must be used. However, it is easier to assume that the price of the resource remains constant and apply a real discount rate, and this is the method recommended in this compilation guide.

Step 6: Calculate NPV for the opening stocks

359. Now we are able to estimate the opening stock value (in this case of the year 2023) by applying the NPV equation (see Section 3.3.2 on Net present value method).

360. In the *Workbook: Renewable energy* (Year 1 worksheet, cell F60), we sum the discounted future resource rents to give the opening stock of assets. We obtain an opening asset value as of 1 January 2023 of 1205. If a country were to change the discount rate from 2% to 4%, the resulting value would be 565. In this case, the value of 565 would be used by the country in its accounts, and the value of 1205 would also be reported (as part of sensitivity analysis).

Figure 4-9 NPV of renewable energy assets – an example of sensitivity analysis



Source: *Workbook: Renewable energy workbook.*

Step 7: Calculate NPV for the closing stocks

361. A year goes by, after which we redo compilation steps 1-6 using information now available (Year 2 worksheet in the *Workbook: Renewable energy*) in order to estimate, in Step 7, the opening stock value of the year 2024 (which gives us the closing stock value of the year 2023).

Table 4-15 Physical asset account as of 2024 (start of period)

	PROJECTION AS OF 2024 (start of period)											
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Opening stock	4150	4150	4179	4179	4179	4179	4179	4179	4179	4179	4179	4179
Additions												
Upward reappraisals		31										
Reclassifications												
Reductions												
Catastrophic losses												
Downward reappraisals		2										
Reclassifications												
Revaluation												
Closing stock	4150	4179	4179	4179	4179	4179	4179	4179	4179	4179	4179	4179
Generation of energy	83	85	85	85	85	85	85	85	85	85	85	85

Source: *Workbook: Renewable energy workbook*, Year 2 worksheet.

Note: Cells in green indicate actual data; blue indicates modelled estimates; yellow indicates projections. Projections continue up to 2073.

362. Suppose during the accounting period we had net reappraisals of 29 physical units (for instance due to increases in efficiency of the solar panels), resulting in a closing stock of 4179 units in 2023 (Table 4-15). The column for 2023 is now coloured green as the figures are all actuals. Using the same assumptions of constant production, we now have revised projections as shown in the table above, with projection period continuing into 2073.

363. For the year 2023 we now also have measured data on output and user cost of fixed assets (included in column F of the Year 2 worksheet, Step 1). We again estimate the resource rent, unit resource

rent, but now expressed in mid-2024 prices. Again, we do smoothing, and we have an opening stock value for 2024 of 1334 (with a 2% real discount rate), which is also the 2023 closing stock value. This figure can be found in cell G72 of the Year 2 worksheet. The opening stock for 2023 (cell F68) is not re-calculated in the Year 2 worksheet, but instead taken from the Year 1 worksheet. This is because of the forward-looking (or ex ante) nature of balance sheets: their main purpose is to describe how the value of assets change over time, for instance due to revaluation.

Step 8: Put together the monetary asset account

364. We now have the NPV of the renewable energy asset at the start of the accounting period (1205 as of 1 January 2023) and end of the accounting period (1334 as of 1 January 2024, or end of 2023). It is important to realize that these NPV estimates represent the value of the assets in current prices. The compilation of the monetary asset account in constant prices in discussed in Chapter 6.

365. Table 4-16 shows how this can be used to calculate the price of the resource[94] at the beginning and end of 2023, as well as the 2023 average price and average physical stock.

Table 4-16 Estimating 2023 average stock and price of the resource

	2023	**2024**
Physical assets, opening balance	4150	4179
NPV of asset in current prices, opening balance	1205	1334
Price of resource	0.29	0.32
Average physical stock	**4165**	
Average price	**0.30**	

Source: *Workbook: Renewable energy workbook*, Year 2 worksheet.

366. In the monetary asset account (Table 4-17), there is no depletion row for renewable energy resources. The other rows of the physical asset account retain the same labels and are calculated by multiplying the average price from Table 4-16 by the estimates in physical units from Table 4-15. Revaluation can be calculated by multiplying the average physical stock with the change in the price of the resource in situ. Revaluation will pick up both the effect of changes in the resource rent as well as changes in the extraction path to the extent they lead to changes in asset value. In the *Workbook: Renewable energy*, a “check” is included to ensure that the sum of opening stock value + all changes results in a closing stock equal to the opening stock estimate of the next year.

[94] The price being estimated is price in the ground (“in situ”) before any processing has taken place.

Table 4-17 Monetary asset account for 2023 (current prices)

	Monetary value, 2023	Monetary value, 2024
Opening stock	1205	1334
Additions		
Upward reappraisals	9.4	
Reclassifications	0.0	
Reductions		
Catastrophic losses	0.0	
Downward reappraisals	0.6	
Reclassifications	0.0	
Revaluation	120.5	
Closing stock	1334	

Source: *Workbook: Renewable energy workbook,* Year 2 worksheet.

Note: Discoveries and depletion are not applicable for renewable energy.

Stage 4 (renewable energy): Integration

367. The information from the monetary asset account for renewable energy assets will be used in the sequence of economic accounts (standard SNA presentation), see Table 4-18.

368. Reclassifications (upward or downward) and catastrophic losses (for example extreme weather events destroying plants) are recorded as other changes in volume. Reappraisals (upward and downward) are treated as revaluation and together with the direct estimate for revaluation are to be recorded in the revaluation account. Opening and closing stocks are part of the national accounts balance sheets (opening and closing balance sheet).

Table 4-18 Integration in SNA sequence of economic accounts

Items from monetary asset account	Where to put these items in the national accounts
Opening stock	Balance sheet
Additions	
Upward reappraisals	Other changes in volume
Reclassifications	Other changes in volume
Reductions	
Catastrophic losses	Other changes in volume
Downward reappraisals	Other changes in volume
Reclassifications	Other changes in volume
Revaluation	Revaluation
Closing stock	Balance sheet

4.3.3. Specific issues

Return to Intellectual Property Products

369. The advent of renewable energy is primarily driven by technology. An issue that was discussed during the EGNC was whether the resource rent captures a return to Intellectual Property Products (IPP) embedded in the equipment used to capture renewable energy, such as wind turbines or solar panels., If so, this would necessitate estimating a return to the IPP and deduce this when calculating resource rent.

370. However, as explained in 2025 SNA (11.97) it is reasonable that the product embodying the knowledge has an increased price relative to a similar product without this embodied knowledge.

371. User cost (depreciation and net return to capital) related to this equipment used to capture renewable energy are thus implicitly already included in the resource rent.

372. It could be argued that rents from renewable resources are embodied in the market prices of the fixed assets used to abstract value, when such assets are scarce. In case evidence exists that rents are internalised in this way (for instance if the RVM method generates negative resource rents), countries could make adjustments to split this market price between the fixed asset and the natural resource.

Aggregating negative and positive resource rents

373. When following the bottom-up approach, it is possible that for an individual renewable energy resource (e.g. solar), some renewable energy installations would generate a negative resource rent, while others would generate a positive resource rent. This raises an issue of aggregation when projecting future resource rents (for the resource as a whole): should the negative resource rents be set to zero before aggregating, or should we aggregate the sum total of negative and positive rents?

374. As national accounts compilation should be scale invariant (that is, we should obtain the same result independent from the level of disaggregation), and we would obtain a different result when putting negative resource rents to zero before aggregating, it is recommended to aggregate positive and negative rents. If the resulting rent is negative, it is recommended to follow the checklist for negative rent (Stage 3 (subsoil assets): Building the monetary asset accounts). After these checks, if the rent remains negative it should be set to zero for making projections implying zero economic value of that natural resource.

Taxes and subsidies

375. Section 3.4 on Taxes and subsidies explains in general terms what types of support are to be included or excluded when calculating resource rent. Essentially, resource rent excludes taxes on products (D21) and other taxes on production (D29) that are not specific; and includes subsidies on products (D31) and other subsidies on production (D39) unless they are specific. Here we will discuss several examples in more detail.

- **Support for manufacturers**. Guidance Note WS 11. Discusses the situation where support is provided to manufacturers of solar and/or wind energy equipment (e.g. capital transfers D9). It concludes that these should not be taken into account when estimating resource rent as “Market forces will tend to ensure that renewable energy producers pay fair market value for their equipment and these subsidies are not especially large in the global context. Cost structures of renewable energy producers are not likely to be any more distorted by manufacturing subsidies than are the structures of any capital-intensive sector of the economy..” (SNA Update 2023e).

- **Concessionary loans**. Guidance Note WS.11 states that “a concessionary loan received by a solar electricity producer to finance purchase of solar panels would be considered a specific subsidy.” However, the AEG conclusion regarding debt concessionality (based on Guidance Note F.15) is to “never record a transfer element for concessional lending in the sequence of economic accounts, except for concessional loans provided by employers to employees (to be recorded as current transfers)”. The 2025 SNA (14.112) states “Institutional units may lend to other units under conditions in which the contractual interest rate is intentionally set below the market interest rate that would otherwise apply. The degree of “concessionality” can be enhanced with grace periods, frequencies of payments and a maturity period favourable to the debtor. Since the terms of a concessional loan are more favourable to the debtor than market conditions would otherwise permit, concessional loans effectively include a transfer from the creditor to the debtor. In the sequence of economic accounts, adjustments are only made for concessional loans provided by employers to employees, whereby the difference between the market interest rate and the concessional rate is recorded as remuneration of employees.” This implies that concessional loans are not treated as subsidies and therefore would not be deducted in calculating the resource rent.

Country example: valuation of renewable energy resources in Costa Rica

Costa Rica stands out internationally for its renewable electricity matrix. During the decade from 2014 to 2023, 97,9% of the country's electricity production was generated from renewable sources, with hydro energy resources being its main source (72,8%), followed by geothermal (12,5%), wind (12%), solar and biomass (0,6%). The remaining 2,1% of electrical energy was produced from thermal sources.

According to information from the national accounts, published by the Central Bank of Costa Rica[95], the country's electricity industry accounted for 2% of total value added in 2021.

Due to the importance of hydro, geothermal and wind energy sources within the country's electricity generation (99,4% of electricity generation is from renewable sources), these sources are included within the preliminary valuation of renewable energy resources in Costa Rica.

For the construction of the monetary asset account for the year 2021, information on production, intermediate consumption, compensation of employees, and other taxes less subsidies on production was used. This information was taken from the estimates made by the National Accounts Unit of the Central Bank of Costa Rica. It is important to note that the national accounts make estimates for several economic activities, including the activity of electricity supply. This activity includes information in monetary terms of the electrical energy generated by all sources without distinguishing between electrical energy from renewable and non-renewable sources.

Based on the information published by the Costa Rican Electricity Institute[96] on the production of renewable energy in physical units per year and with information from the national accounts, each component of the production and the generation of income account was estimated, obtaining as a balance item the gross operating surplus for each of the hydro, wind and geothermal resources.

Costa Rica is making important efforts focused on having a valuation of its fixed assets. As an approximation of the value of the renewable energy fixed assets, we have taken the information estimated by the national accounts related to the gross fixed capital formation of electric energy assets. To determine the value corresponding to the gross fixed capital formation of renewable energy assets, a disaggregation was made according to the installed capacity by type of energy.

From the value of fixed assets, fixed capital consumption was estimated by applying an asset life of fixed assets of 50 years for hydro power assets and 40 years for wind and geothermal power assets. The return on capital of the fixed assets was estimated using a 6% rate of return on capital.

Deducting from the gross operating surplus, the components of fixed capital consumption and the return on fixed capital, the resource rent associated with the production of renewable energy was obtained.

From the resource rent and the amount of energy generated per year in physical terms, the unit resource rent is estimated, which is used to obtain the projected resource rent flows during the asset life of the different assets.

A discount rate of 2% was used to convert the projected resource rent flows into an estimate of the total value corresponding to the current period; this rate expresses the asset owner's preference to receive the income in the present rather than in the future.

Given the projected resource income flows, the value of the asset as of January 1, 2021, and January 1, 2022, is estimated by the net present value. The estimated values represent the initial and final stock of the monetary account of renewable energy assets for the year 2021.

Changes in the stock of renewable energy resources have been valued at the average resource price. The average price is estimated using the net present value at current prices and the initial stock in physical terms for the years 2021 and 2022. The upward reappraisals during 2021 were due to an increase in installed capacity of 1,6% compared to the previous year, while the revaluation was due to a decline in the general level of electricity prices (-13%).

The monetary renewable energy asset account presented in Table 4-19 shows aggregated information for hydro, wind and geothermal energy resource assets. This is a preliminary account; it is expected that future publications will present disaggregated information for the three different renewable energy resources included in this table.

Table 4-19 Monetary renewable energy asset account Costa Rica, 2021

Monetary asset account (current prices)	Million dollars [1/]
Opening stock	21.781
Additions	-
Upward reappraisals	1.939
Reclassifications	-
Reductions	-
Catastrophic losses	-
Downward reappraisals	-
Reclassifications	-
Revaluation	-2.257
Closing stock	21.463

Source: Central Bank of Costa Rica

[1/] Preliminary information

[95] Central Bank of Costa Rica.

[96] Costa Rican Electricity Institute

Country example: experimental valuation of renewable energy resources in Indonesia

BPS-Statistics Indonesia regularly publishes Natural Capital Accounts in a publication entitled Indonesia System of Integrated Environmental-Economic Accounting (BPS, 2023). This publication presents data on environmental asset accounts in both physical and monetary units. The compilation activities are undertaken based on the BPS Regulation No 3 of 2023 concerning the Compilation Guidelines of Natural Resources and Environmental Accounts, which is in accordance with the System of Environmental-Economic Accounting (SEEA).

Renewable energy plays an important role in reaching the target of Net Zero Emission (NZE) in Indonesia. More than half of the greenhouse gas emissions released to the atmosphere come from the energy sector, which is mainly caused by fuel combustion activities. As the demand of energy is expected to increase over time, the strategy toward NZE will be highly dependent on the shifting of energy supply from non-renewable energy resources to non-emitting renewable energy resources. Indonesia is estimated to have a huge potential of renewable energy-based power plants. In accordance with the commitment to reduce greenhouse gas emissions, the Government of Indonesia has set a target for renewable energy in the primary energy supply of 23 percent in 2025.

The Government of Indonesia has demanded that renewable energy resources has its own classification in the environmental asset accounts, in which the value of renewable energy resources could be differentiated from the value of land or the value of water resources. Hereto, BPS (BPS, 2024) has conducted an experimental study to value its renewable energy resources, summarized here.

Data sources and methodology

Indonesia has a state-owned company which is specialized in electricity supply activities, namely PT Perusahaan Listrik Negara (PLN). However, the electricity generation activities were not only carried out by PLN, but also by Independent Power Producers (IPPs) and Private Power Utilities (PPUs). Nonetheless, both IPP and PPU power plants sell their electricity to PLN as PLN controls the electricity distribution network. Meanwhile, there are also some off grid power plants, which usually operate in isolated islands and rural areas, but its production only constituted 7.63 percent of total electricity production in 2022.

The study used Electricity Statistics from PLN as the main data source to estimate the monetary value of renewable energy resources in Indonesia. It presents data on the electricity production and operating cost by type of power plant. While the data on electricity production covered five types of renewable energy resources, the operating cost data was limited to hydroelectric, geothermal, and solar energy.

The source data were not able to differentiate the revenue of electricity sales by type of power plant which produced them. Therefore, the value of output for each type of renewable energy power plant was calculated by multiplying the quantity of produced electricity and the highest benchmark price for purchasing electricity. Those prices were regulated in the Presidential Regulation Number 112 of 2022 concerning the Acceleration of Renewable Energy Development for Electricity Supply.

The valuation of renewable energy resources was carried out by using the NPV approach of future resource rents. The asset life of hydroelectric resources was set to 50 years because the use of a lifetime beyond 50 years has a small impact on the result of NPV calculation. Meanwhile, the asset life of geothermal and solar energy resources was set to 25 years as the future revenues and costs of such power plants were assumed to be less certain than for hydroelectric power plants.

Results

Table 4-20 shows the results that were obtained. The valuation of renewable energy resources in Indonesia only managed to obtain a monetary value of hydroelectric and geothermal resources for electricity generation purposes only. It excluded the direct use of geothermal as well as other types of renewable energy power plant due to limited data availability. Also bioenergy used as fuel was not taken into consideration.

In 2022, the hydroelectric resources in Indonesia were estimated to have a monetary value around IDR 113,884 billion. Meanwhile, the monetary value of geothermal energy resources was IDR 106,986 billion. By considering the monetary value of non-renewable energy resources, comprising of coal, oil, and natural gas; the share of the monetary value of Indonesia renewable energy resources in 2022 was only 1.07 percent.

Table 4-20 Monetary Value of Energy Assets in Indonesia, 2022

No	Type of Energy Asset	Monetary Value (billion IDR)	Share (percent)
1	Coal	15,178,689	73.35
2	Natural Gas	3,019,090	14.59
3	Crude Oil	2,275,564	10.99
	Sub-Total of Non-Renewable Energy	**20,473,343**	**98.93**
4	Hydroelectric	113,884	0.55
5	Geothermal	106,986	0.52
6	Solar Energy	-	-
	Sub-Total of Renewable Energy	**220,869**	**1.07**
	Total Energy Resources	**20,694,212**	**100.00**

Conclusions

Even though the potential of renewable energy resources in Indonesia is enormous, the monetary value of renewable energy resources in Indonesia was highly dependent on the installed capacity of renewable energy power plants as well as on the quantity of electricity generation. The high operating cost may also influence the derivation of resource rent from the residual value method. For solar energy resources in Indonesia, the resource rent had a negative value due to high consumption of fixed capital. The net present value of renewable energy resources was also impacted by the choice of asset life and discount rate for each type of renewable energy resources.

The valuation of renewable energy resources might be better carried out by applying a bottom-up approach or site-by-site basis. The calculation based on macro data would not be able to take into account the remaining lifespan of renewable energy generation equipment of certain power plants. An in-depth study to the electricity generation establishment was recommended in order to obtain sufficient data, particularly on operating cost, to derive resource rent and to apply NPV method on the valuation of other types of renewable energy resources, such as wind and biomass energy.

4.3.4. Modifications to the standard approach

376. The approach described in Section 4.3.2 is the default. As countries differ in their in their data availability and resources for conducing valuation of natural resource, this section describes a Tier 1 (basic) approach that would typically be followed in case of limited data availability and/or resources, as well as Tier 3 (advanced) methods requiring more detailed data availability and more resources.

Basic approach

377. A Tier 1 method would consist of applying a product-based application of the RVM for deriving resource rent in Step 1, instead of the bottom-up method that is used for the default approach. The product-based method does not use national accounts data or business statistics data. Rather, it estimates all elements required for calculating resource rent (e.g. output, costs, user cost of fixed capital, taxes / subsidies) from a range of other data sources including commodity market prices, industry reports on cost to revenue ratios etc.

378. A good example of this method is the World Bank methodology used for the Changing Wealth of Nations (World Bank 2021, Chapter 14) which estimates resource rent for renewable energy for hydro, wind and solar for the 15 largest producers. The method is based upon the following steps and assumptions (Smith et al. 2021, section 4.2.1):

- Multiply annual quantities of electricity generated for each technology / resource type with relevant market price.
    - For hydro it is assumed that the price received is the average country-wide spot price in a given year. For solar and wind, prices were estimated from a range of data sources.
- Estimate subsidies received by electricity producers.

    Hydro was assumed not to receive any subsidies as it a well-established technology. In the absence of readily available data on subsidies, the amount of (net) subsidies for solar and wind was estimated as the difference between actual revenues (e.g. the FiT) and the average electricity spot price.
- Estimate operation and maintenance costs.
    - In the absence of readily available data, assumed as fixed proportion of value of investment flows: assumed 1 % for onshore wind; 1.3 % for solar; 1.75% for hydroelectric generation and 2 % for offshore wind and Concentrated Solar Power.
    - Country specific investment flows were obtained by multiplying yearly physical additions to capacity by average annual investment costs (from a range of sources).
- Estimate cost of produced capital
    - Country specific economy wide real rate of returns were applied (e.g. 4 % for OECD countries)
    - In order to measure depreciation, for hydro an asset life of 50 years was assumed, for solar and wind 25 years.
    - The stock value of produced capital of wind and solar related infrastructure was calculated by assuming that no investment was done before 1990; the stock in later years then being equal to accumulated investments minus depreciation. For hydro a more complex approach based on OECD (2009) was followed according to which the value of the stock in the base year is obtained "by dividing the value of investment in the base year by the sum of the asset's deprecation rate plus the long-term growth rate of real GDP" (Smith et al. 2021).

- Obtain the resource specific resource rent by deducting subsidies, operation and maintenance costs and user costs from revenue.

379. When applying a Tier 1 product-based approach, it is recommended to use national data whenever possible instead of global data sources or generic assumptions.

Advanced methods

380. If projections of future energy generation (quantities) are available and/or specific projections of specific taxes and subsidies, such results could be used to refine projections of future resource rents in Step 4 of the default method and thereby improve the estimates in the monetary asset account (Step 8).

Summary of key recommendations Chapter 4

Non-renewable mineral and energy resources (section 4.2)

- The SNA asset boundary is restricted to 'Class A: commercially recoverable resources', as defined in SEEA CF based on the UN Framework Classification of Resources.
- A materiality threshold should be applied with a focus on valuation of subsoil assets that contribute more than 5% of output in ISIC Section B: Mining and quarrying and for which the long-term average contribution of mining and quarrying to GDP is at least 0.1 %. When a reasonable estimate can be made of how much of the asset value is missed, it is recommended to gross up the asset value. A default list of energy and mineral resources is proposed to assess which resources are available in the country and are above the materiality threshold in terms of output and contribution to GDP.
- For valuing subsoil assets, the preferred valuation method is to use observable market transactions. When such markets are very thin or do not exist at all, and valuation based on permits is not feasible, the recommended valuation method is to apply the Net Present Value of future resource rents, calculated with the Residual Value Method (RVM).
- When using the RVM to calculate resource rents, a top-down approach is recommended.
- Monetary estimates should be compiled at the same level of disaggregation as the physical data.
- When making projections of future extraction, the key restriction is that the total projected extraction over the asset life at the start of the accounting period should be equal to the total physical opening stock (Class A) as included in the physical asset account for the resource in question.
- Extraction should be assumed to continue at the same level as in the (recent) past.
- It is recommended to assume that unit resource rents remain constant in the future unless specific policies have been implemented which would allow to estimate a specific path of future unit resource rents.
- Stranded assets should be recorded as (downward) reappraisals in the physical asset account. There can be different types of situations that require a different recording in the national accounts:
    - In case of a change in relative prices, this could have both a volume effect (lower reserves considered as economically viable to exploit) and a price effect (the reserves extracted generate a lower price). It is recommended to split these two impacts when compiling the monetary asset account.
    - In case of a change in the extraction path: if the total amount of reserves that is extracted remains the same, this is not a volume effect but (due to the effect of discounting) a value effect, which should be recorded as a revaluation.
    - In case there is more (or less) of the resource accessible (e.g. due to legal changes), this should be recorded as an 'other change in the volume of assets'.
- A Tier 1 (basic) method would consist of applying a product-based application of the RVM for deriving resource rent, instead of the top-down activity-based method that is used for the default approach. The product-based method does not use national accounts data but estimates all elements required for calculating resource rent from a range of data sources. When applying the product-based approach, it is recommended to use national data whenever possible instead of the global data sources.

- Several Tier 3 methods exist such as applying more advanced modelling of future prices and/or extraction rates or compiling the value of mineral and energy resources at a disaggregated (ideally individual deposit) level.

Renewable energy resources (section 4.3)

- Renewable energy resources are shown separately in the 2025 SNA classification of assets as AN322. Renewable energy assets to be included in the national accounts correspond to a subset of renewable energy resources, namely those resources “viable for use in economic production under prevailing technological and economic conditions”, similar to Class A for subsoil assets.
- The scope for renewable energy resources includes resources that generate electricity and/or heat and cold. Specifically, biomass or other biofuels (e.g. renewable municipal waste, biogas, liquid biofuels) are excluded from scope. In scope are: geothermal energy resources including hot surface water, aerothermal energy (e.g. captured by heat-pumps), solar thermal, and wave and tidal resources.
- A materiality threshold should be applied with a focus on valuation of those renewable energy resources that contribute more than 5% of the national energy supply. The easiest way to assess this is by looking at the generation of energy by source (in physical units) based on energy statistics. When a reasonable estimate can be made of how much of the asset value is missed, it is recommended to gross up the asset value. A default list of renewable energy resources is proposed to assess which resources are available in the country and are above the materiality threshold.
- For valuing renewable resource assets, the preferred valuation method is to use observable market prices for transactions. Under some circumstances, the valuation of renewable energy will already be captured in associated land values; for instance, in the case of onshore wind energy; or in the value of dwellings equipped with solar panels. In such cases a hedonic pricing method could be followed, which may provides a direct estimate of the renewable energy asset value. However, as the use of hedonic pricing methods is highly resource intensive, requiring extensive micro-data, it is recommended as an advanced method. In some instances, permits to access the natural resource exist but valuation based on permits may only be feasible in certain circumstances. Therefore, in most cases, the recommended valuation method is to calculate asset values as the Net Present Value (NPV) of future resource rents, calculated with the Residual Value Method (RVM).
- When using the RVM to calculate resource rents, a bottom-up approach is recommended.
- The Least Cost Alternative method for valuing renewable energy resources is considered not suitable for use in compiling national accounts.
- The user costs of produced assets required for the RVM need to be estimated based on estimates of the value of the installations. Countries are recommended to include solar panels and heat pumps as two additional and separate asset classes in their perpetual inventory models (PIMs). The assumed service life should not necessarily be the same as the life of the resource. Unless more specific information is available, it is recommended to apply 25 years as default for solar panels with an assumed loss of 0.5% annually in efficiency. For other equipment used by households a default asset life of 15 years is assumed with an assumed loss of 1% annually in efficiency. The loss in efficiency can be used to estimate suitable depreciation profiles for these assets.
- Variable renewable energy grid integration costs such as costs made to connect wind turbines and solar panels to the network are likely to be modest and therefore may be excluded when estimating renewable energy resource rents.

- It is not recommended to use an infinite asset life when applying the NPV method due to uncertainties in technology and/or climate considerations. Instead, it is recommended to use the average (or median) licensed lifetime of projects as asset life of the resource, and, if such data is not available, to apply a default asset life of the resource of 30 years for wind and solar, and 50 years for hydro.
- If there is no evidence to support a different scenario, the standard approach recommends assuming that the (smoothed) unit resource rent stays constant i.e. it assumes that the current (net) subsidy levels remain constant when projecting resource rent into the future.
- As national accounts compilation should be scale invariant, it is recommended to aggregate positive and negative rents before assessing whether their total is negative or not.
- A Tier 1 (basic) method would consist of applying a product-based application of the RVM for deriving resource rent, instead of the bottom-up activity-based method that is used for the default approach. The product-based method does not use national accounts data but estimates all elements required for calculating resource rent from a range of data sources. When applying the product-based approach, it is recommended to use national data whenever possible instead of the global data sources.
- A Tier 3 method would consist in using projections of future energy generation (quantities) and/or specific projections of specific taxes and subsidies when projecting future resource rents.

5 Biological resources

5.1. Introduction

381. The term “biological resources” in the 2025 System of National Accounts refers to naturally occurring assets in the form of biota (trees, vegetation, animals, birds, fish, etc.) (para 11.206). The 2025 SNA makes a distinction between cultivated biological resources yielding repeat products (AN331), biological resources yielding once only products (AN332), which can be cultivated or non-cultivated and work-in-progress on cultivated biological resources (AN333) (either on repeat or once-only biological resources).

382. The 2025 SNA contains several changes regarding the measurement and recording of biological resources compared to the 2008 SNA. As cultivated biological resources yielding repeat products (fixed assets) and work-in-progress on cultivated biological resources in agriculture are considered relatively straightforward, the scope of the revised recommendations is focused on the measurement of timber resources AN333 (and forest land AN311) and non-cultivated fish resources (AN3322). The accounting treatment of timber resources and forest land is complex as they constitute a composite asset. The resulting estimates for forest land are to be recorded as land in the 2025 SNA and not as biological resources; but as the calculation is bound up with that of timber resources, we include it in this chapter.

383. A key distinction is between non-cultivated and cultivated biological resources. In the 2025 SNA, this will be defined slightly compared to the 2008 SNA as: “Resources where the control, responsibility and management does not go beyond the establishment of quota regimes (e.g. migrating wild animals and fish in open waters) *versus* resources where one can observe a continuum from intensive to extensive forms of control, responsibility and management (e.g., the growth of trees for timber production).” As a result, fish in open water such as the sea, rivers or lakes (but excluding aquaculture which are cultivated assets) will be treated as non-cultivated assets, while timber resources will be treated categorically as cultivated.

384. There are already quite a few countries that regularly compile asset accounts for timber and forest land in monetary terms whose compilation experiences can be drawn upon.[97] The FAO’s Forest Resource Assessment (FRA) has been assessing timber resources since 1990 (5-yearly), and provides standardized concepts, definitions and classifications for measurement in physical units. The same definitions underpin the SEEA CF, which contains a discussion of forest accounts (in physical and monetary units). The upcoming expansion of the EU environmental economic accounts directive to include forest accounts will make compilation of forest accounts a legal requirement for all EU member states. To support compilation,

[97] Within the EU area, existing forest statistics are already pretty comprehensive. For instance the Eurostat dataset: Volume of timber over bark (source: EFA questionnaire) [for_vol_efa__custom_8898628] (https://ec.europa.eu/eurostat/databrowser/view/for_vol_efa/default/table?lang=en) contains estimates of the net annual increment in physical and monetary terms, as well as volume of timber over bark and wooded / forest land in physical and monetary units (although not for all EU countries).

a revised European Forest Accounts (EFA) handbook (Eurostat 2024c) has been released[98] which contains detailed guidelines for measuring and valuing timber resources and forest land consistent with the 2008 SNA/2010 ESA. The World Bank (2017) has also published a guide entitled “Forest Accounting Sourcebook. Policy applications and basic compilation”. The recommendations presented in this chapter build upon these guidelines, and regarding valuation are aligned with the EFA (apart from any changes arising between the 2008 SNA and 2025 SNA).

385. The situation regarding aquatic resources is quite different, with only a handful of countries currently compiling monetary asset accounts. The SEEA-Fisheries (UN et al. 2007) contains useful conceptual guidance, but its status is unclear[99] and some of the guidance appears outdated. The SEEA for Agriculture, Forestry and Fisheries (SEEA AFF, FAO and UN 2020) contains useful guidance on physical and monetary flow accounts but refers to the SEEA CF for the monetary asset accounts, and the SEEA CF only provides general guidance.

386. Non-cultivated aquatic resources, especially fish, pose specific measurement challenges compared with other biological resources such as timber or livestock. Fish stocks are usually not directly observable; some of the assets move in and out of national boundaries (which are described as Exclusive Economic Zones - EEZs) and require a global approach; and depletion of fish stocks can be caused by non-residents on the national territory (or by residents abroad). Also, in many countries subsistence and artisanal fishing are important activities, which overlaps with the measurement of the informal economy. The recommendations presented in this chapter build on existing materials to the extent possible, but in several instances go beyond existing treatment.

387. As in Chapter 4, the three-tier approach (basic, standard, advanced) will be used in this chapter to provide different options for compilers depending on their data availability and resources. The standard approach (Tier 2) will be described as the default. The chapter will also outline a Tier 1 (basic) approach that would typically be followed in case of limited data availability and/or resources and Tier 3 (advanced) methods requiring high data availability and resources.

388. The outline of the chapter will be as follows. Section 5.2 will focus on timber resources and forest land, and Section 5.3 on non-cultivated aquatic resources, both following the same structure in terms of subsections. First, the scope and definition of the assets to be included in the national accounts is provided, as well as relevant classifications. Second, four compilation stages are presented and explained: identifying the types of assets to be included and valuation methods; collecting the physical and price data; building the monetary asset accounts; and integration of the results into the sequence of economic accounts. Third, we discuss specific compilation issues; and finally, modifications to the standard approach. Section 5.4 discusses (briefly) also the valuation of other classes of biological resources such as the treatment of biological resources yielding repeat products (AN331), biological resources yielding once only products other than fish resources such as wild animals (AN332), and work-in-progress on cultivated biological resources other than timber such as animals for slaughter, agricultural crops and aquaculture (AN333). A text box with a summary of key recommendations concludes the chapter.

389. Two accompanying Excel workbooks have been developed: *Workbook: timber resources and forest land*, and *Workbook: fish resources*. These facilitate and illustrate compilation according to the 2025 SNA and are referred to in Sections 5.2 and 5.3.

[98] The EFA replaces the European Framework for Integrated Environmental and Economic Accounting for Forests (IEEAF) (EC 2002a; b) and is consistent with the 2010 ESA.

[99] The SEEA-Fisheries was available at the UNSD website as white cover version prior to official editing but seems never to have been officially released; it is no longer available online.

5.2. Timber resources and forest land

5.2.1. What to include in the national accounts

390. As noted above, the 2025 SNA (para 11.208) defines cultivated biological resources as a "continuum from intensive to extensive forms of control, responsibility and management"**.** The results of various global consultations for the SNA update suggest that the continuum wording has been interpreted as implying that any forest area (including inaccessible/remote areas) would need to be treated as cultivated in the 2025 SNA. This is not the intention. It is important to clarify that in the 2025 SNA, timber in remote or non-logged areas (such as the Amazon or Siberia) will continue to be outside the asset boundary, as in the 2008 SNA. The overarching criteria remains whether the assets are economic i.e. they are used for deriving economic benefits.

391. It is clear that all instances of timber harvesting activity whether undertaken for own use or for commercial purposes are recorded as part of production and consumption as this clearly falls within the SNA production boundary. The 2025 SNA (para 13.24) further clarifies the conditions under which an asset would be recognized: "For other (non-produced) natural resources, the first substantial market appearance, generally involving commercial exploitation, is the reference point for recording in this account. For forests, gathering firewood is not commercial exploitation, but large-scale harvesting of a forest for timber is and brings the forest into the asset boundary." Thus, the key criteria for recognition as economic asset is whether the extraction activity is of commercial scale. Commercial activities would consist of logging activities that are not primarily for own use and this would be a sufficient condition to bring the asset within the asset boundary. By extension, situations of common pool resources, firewood collection or indigenous use of resources, would not draw these assets into the asset boundary, unless their use can be considered commercial (as evidenced through payments for the harvested resources).

392. The 2025 SNA (11.220; 11.238; 14.62) makes a key distinction between what it calls the **underlying asset** (e.g. forest land) and the **inventories** (work-in-progress of standing timber on the land), together forming a combined asset. This idea is aligned with the European Forest Accounts (EFA) handbook (Eurostat 2024c) which refers to the composite asset as the forest estate, and further distinguishes between wooded land and timber stocks. Likewise, the SEEA CF speaks about biological resources as composite assets.[100]

393. In this chapter, we will use the terminology of timber resources (the work-in-progress) and forest land (the underlying asset), as two distinct parts of a composite asset. For the purposes of national accounts compilation, both timber resources and forest land need to be valued. The timber resources capture the value of standing timber as work-in-progress (inventories), whereas the forest land captures the potential of the land to continue providing timber in future, its regenerative potential. As noted above, timber resources will be classified under biological resources (work-in-progress) while forest land will be classified under land resources.

394. It is particularly important to note that as the 2025 SNA treats all timber resources as cultivated, it is necessary to follow an accrual reporting of output. This means that the growth of all timber resources which are included in the SNA asset boundary (whether formerly treated as cultivated or non-cultivated stocks) is to be recorded as output instead of the value of the timber at the moment of harvest (for formerly non-cultivated resources). This places clear demands on compilers in terms of the physical data underpinning the monetary valuation, as will be discussed in Section 5.2.2 Stage 2.

[100] "As with the treatment of buildings and structures, the value of these environmental assets should, in principle, be separated from the land on which they are grown. For example, for forest land, the separation should be based on the value of the stock of timber resources" SEEA CF: 5.307.

5.2.2. Compilation stages

395. As discussed above, timber resources and forest land are two distinct parts of a composite asset. Regarding the measurement of both assets, four compilation stages are distinguished: identifying the types of assets to be included and valuation methods; collecting the physical data; building the monetary asset accounts; and integration of the results into the sequence of economic accounts.

Stage 1 (timber resources and forest land): Identifying types of assets and valuation methods

Identifying types of assets

396. In the first stage, the types of timber resources for which accounts are to be compiled need to be identified. The 2025 SNA provides a generic definition of timber resources as "a type of biological resource that are valued in terms of the expected harvesting of timber .. most commonly present in areas of forest land but the harvesting of timber, and hence the stock of timber resources, can occur in other areas of land, in particular agricultural land, for example through agro-forestry production systems." (27.33). For a more specific definition, they are defined here consistent with the SEEA CF[101]: "Within the relevant areas, timber resources are defined by the volume of trees, living or dead, and include all trees regardless of diameter, tops of stems, large branches and dead trees lying on the ground that can still be used for timber or fuel. The volume should be measured as the stem volume over bark at a minimum breast height from the ground level or stump height up to the top. Excluded are smaller branches, twigs, foliage, flowers, seeds and roots" (SEEA CF para. 5.350).

397. The FRA provides in some cases more specific guidance on definitions. For instance, the growing stock of timber resources is defined in the 2020 FRA as: "Volume over bark of all living trees with a minimum diameter of 10 cm at breast height (or above buttress if these are higher). Includes the stem from ground level up to a top diameter of 0 cm, excluding branches." (FAO 2020).

398. In order to estimate the volume of timber resources, it is recommended to first compile an account for forest land (expressed in hectares). This is suggested by the SEEA CF and in line with the proposed amendment to the EU directive on EEA concerning forest accounts, which requires information about the area of wooded land, broken down by:

– forest available for wood supply;

– forest not available for wood supply;

– other wooded land

– other land available for wood supply (e.g. agricultural land)

This is discussed further in Stage 2.

399. Here forests available for wood supply are understood as "Forests where any environmental, social or economic restrictions do not have a significant impact on the current or potential supply of wood. These restrictions can be established by legal rules, managerial/owner's decisions or because of other reasons." (Eurostat 2024c). Other wooded land is defined as "land not classified as forest, spanning more than 0.5 hectares; with trees higher than five metres and a canopy cover of 5-10% or trees able to reach these thresholds in situ; or with a combined cover of shrubs, bushes and trees greater than 10%. It does not include land that is predominantly under agricultural land use or trees in urban settings, such as city parks, alleys and gardens." (Eurostat 2024c)

[101] Which itself is consistent with FAO's Forest Resources Assessment

400. The SNA is exhaustive implying that all assets with economic value within the asset boundary should be estimated. However, due to the resource intensive nature of the valuation of biological assets, it is proposed that in the standard approach, timber resources on other wooded land may be omitted. Regarding forests not available for wood supply, it is possible that illegal logging takes place: when these illegal activities are structural and at commercial scale they would give rise to recognition of assets and would need to be measured, as further discussed in Section 5.2.3. The situation of other land available for wood supply is complex: the standing timber would be in scope of work-in-progress, but when estimating the value of forest land care should be taken to avoid double counting with agricultural land. As will be further discussed in Stage 2 (timber resources): Collecting physical and price data, for national accounts purposes we would be including only those timber resources expected to be used in (future) economic activities, providing a further restriction on the scope of resources to be included both in terms of measurement of output and as economic assets.

Figure 5-1 Different activities within forestry and logging

Source: Author.

401. The accrual recording of output for cultivated assets implies that the growth of timber stocks is recorded as additions to work-in-progress.[102] Formally, when the timber is mature, the cumulated value of work-in-progress is converted to inventories of finished goods (of mature standing timber). When the timber is logged it would become a different finished good (roundwood), which is then run down as it is used by the producer or sold or lost. In practice, the distinction between mature and immature timber stocks will usually not be made, and a withdrawal from work-in-progress recorded when timber is felled and/or removed from the forest. Accrual recording allows for a continuous recording of output as inventories of standing timber grow, instead of a one-off recording of output concurrent with the actual harvest (used previously in 2008 SNA for non-cultivated timber resources). For a single asset (e.g. a specific logging site which is say harvested every five years) the implication will be that output is recorded earlier and more continuously, however when averaging over a large number of sites these effects may be expected to disappear (unless in situations of significant dynamics within the forestry sector).

[102] In the 2008 SNA (10.140), work-in-progress for timber production was defined in the following manner: "Work-in-progress on cultivated biological resources consists of output that is not yet sufficiently mature to be in a state in which it is normally supplied to other institutional units." In the 2025 SNA, the maturity of the trees is no longer part of the definition, which is: "Work-in-progress related to cultivated biological resources yielding once-only products represents the accrual accounting of the growth of trees intended for the future production of timber" (2025 SNA 11.221).

Valuation methods

402. As part of Stage 1, in addition to identifying the assets it is important to consider what method will be used to produce monetary values. In the case of timber resources and forest land, the approach is more complex than for the other biological resources; therefore, we have included a specific discussion here. We will first discuss valuation methods for timber, then methods for valuing forest land.

403. For timber resources (work-in-progress), this compilation guide recommends, consistent with the valuation hierarchy discussed in Section 3.2, using observed market transactions. There are in case of timber resources however various methods that fall into this category.

Country example: timber output and forest valuation in French national accounts

Primary data sources available

The *French national geographical institute* (IGN) is the main primary data source for:

- The areas of forests and other wooded land in hectares.
- The volumes of standing timber in cubic meters, thanks to the annual forest inventory. The forest inventory is conducted as a sample survey, combining aerial photography analysis and field observation. Definitive results are obtained as 5 years moving averages of annual sample results.
- Statistics on prices of standing timber and wood in the rough come from the *National forests office* (ONF), from private associations of forest owners and from the ministry in charge of forests.

Forests accounts

All these primary sources of information are put together in the *Forest accounts*, which are compiled according to the SEEA recommendation. More precisely, France complies with the European regulation on *European forest accounts* (EFA), which describes the data tables and compilation methods required. The transmission of the EFAs to Eurostat used to be on a voluntary basis but will become compulsory for all Member States starting in 2025.

The *Forest accounts* provide a synthesis of the state of French forests and forestry activity. Compared to the raw data source mentioned above, they introduce significant advantages:

- Definitions and concepts from the primary sources are harmonized to conform to the Eurostat standard (for example, include the volume of large branches into the volume of standing timber);
- Physical and economic tables are built based on the same perimeters;
- Potential inconsistencies in primary data sources are analysed and reconciled as much as possible;
- Important statistics are produced during the compilation of the accounts. In particular, the average price of harvest cannot be directly observed in the primary sources. It has to be reconstructed, considering the structure of harvest: different prices apply to round wood for construction, for other use, fire wood directly gathered by households etc.

For all these reasons, the *Forest accounts* are taken as a starting point when building the SNA accounts related to forestry activities or forest value.

Accounting under 2008 SNA

To account for forest output, two sub-industries are distinguished: *Silviculture and other forestry activities* (02.1) and *Logging* (02.2).

The output of *Silviculture and other forestry activities* (02.1) is standing timber. It is valued as the “Net annual increment of timber”, that is the average annual volume growth of live trees less the average annual mortality. This key figure is extracted directly from the forest accounts.

The output of *Logging* (02.2) is wood in the rough. Conceptually, it is simply the sales of wood in the rough, excluding all taxes (basic price). A practical difficulty is that the sales can be made by purely logging companies (NACE 02.2) but also by combined logging / sawmilling companies (NACE 16.1). The total output of raw wood must cover these two sources.

The French SNA balance sheet for forests is built in three steps:

- Total forest land including standing timber is valued directly based on market transactions in forest estates.
- Standing timber is then valued separately (as a national aggregate), based on the forest accounts;
- The value of the "underlying asset" (in French "*fonds forestier*") is finally deduced as a residual, by taking the difference between the total value of the land and the value of the standing timber.

This approach is possible because the French forest is largely privately held (75%), with many observed transactions (around 20.000 yearly, representing between 0.5% and 1.0% of the total surface). It is however possible that this valuation is biased, because some plots are rarely or never traded.

What is planned for the next benchmark revision and the adoption of 2025 SNA

For the next national accounts benchmark revision, the first improvement will be to aim for a full consistency with the new forest accounts which will be transmitted to Eurostat. Currently, some series are not fully consistent between the two sets of accounts.

A second possible improvement will be to improve the modelling of the stock values in the balance sheet:

- The standing timber could be valued using a "consumption value method" rather than the current "stumpage value method". This would require the use of more detailed price information, specific to species and age groups.
- The stock value of forest estates could be estimated using more detailed plot characteristics, combined in a stratified or hedonic pricing model.

More importantly, in order to estimate depletion / net regeneration in the new SNA accounts, the French national accounts will now measure the resource rent of silviculture (NACE 02.1) and project it into the future to obtain the net present value (NPV) of timber resource rent. This new valuation approach will need to be articulated with the current (market based) approach to forest land valuation.

404. Regarding the valuation of the timber resources, the EFA explains the importance of distinguishing between mature and immature trees (Eurostat 2024c; 4.68): "For trees that are ready to harvest, the general assumption is that they will be harvested in the current accounting period and hence the value will be equal to what the unharvested timber can be sold for in the current period." The EFA continues to explain that the "relevant price for undertaking this valuation is the current stumpage price" and it refers to the original definition of the stumpage price contained in the IEEAF as "the value of, or price paid for, timber as it stands uncut in the woods" (IEEAF, 2002, para 3.130)."

405. Discussions in the EGNC have indicated that countries use the term "stumpage" differently. For example, in Canada it is common to speak about stumpage fees, which can be understood as "the fee paid by an individual or company for the timber they harvest from public forests or privately owned forest

land."[103] There appear to be therefore different interpretations of what stumpage means: the price that somebody would be willing to pay now to cut trees now, or giving somebody the right to harvest now or at a later time of their liking after the trees have matured. For sake of clarity, in the guidelines, the stumpage price is understood as the former, the latter is referred to as a stumpage fee. This is important, as stumpage fees may be used as one of the elements to split the asset between producer and government (as discussed in Chapter 3).

406. In some countries directly observable stumpage prices exist due to transactions in standing timber. In the majority of countries, stumpage prices need to be derived indirectly based on road-side pick-up prices for logs (i.e. after harvesting) which are commonly available. To arrive at the stumpage price, the following costs need to be deducted:

- Harvesting costs: these costs also include cutting off of branches etc.
- Transport costs: the costs of hauling the felled logs to the road and stacking them
- User cost of fixed capital: this includes both depreciation and a return for the use of machinery involved in logging and transportation such as chainsaws, tractors etc.[104]

407. The indirect method to arrive at a stumpage price relies on many assumptions. The price will depend on what the timber is to be used for (e.g. construction wood or firewood), and there may be a need to take this into account by weighting the volume based on expected uses.

408. For trees that are not yet mature (i.e. work-in-progress), valuation is more complicated. The EFA specifies three elements that need to be considered: "First, the volume of the stock will be less than the volume at harvest and the value must be calculated based on the current volume. Second, the revenue to be earned from harvesting will not occur in the current accounting period but at some point in the future. Thus even if the current stumpage price remains the same, since the revenue will not be received until later, it is necessary to discount the expected price to the current period. Third, since the trees are still growing there will be some costs incurred to bring the trees to maturity, for example, costs of thinning and other management costs. These costs need to be deducted in estimating the relevant price recognising that the costs will vary depending on the age of the tree and the time to maturity, and indeed for trees that are closer to harvest these costs may be relatively small."

409. The EFA distinguishes between four valuation methods for timber resources that differ in how they address these three issues (EFA section 4.3; see also IEEAF Annex III):

- The **stumpage value method** values timber resources by multiplying the total physical stocks (i.e. of both mature and immature standing timber) with the stumpage price of mature timber.[105]
- The **consumption value method** values timber resources by distinguishing between stocks of different age classes (and hence different sizes / diameters). The value of timber resources is obtained by multiplying the physical stocks of those age classes with their respective stumpage prices.

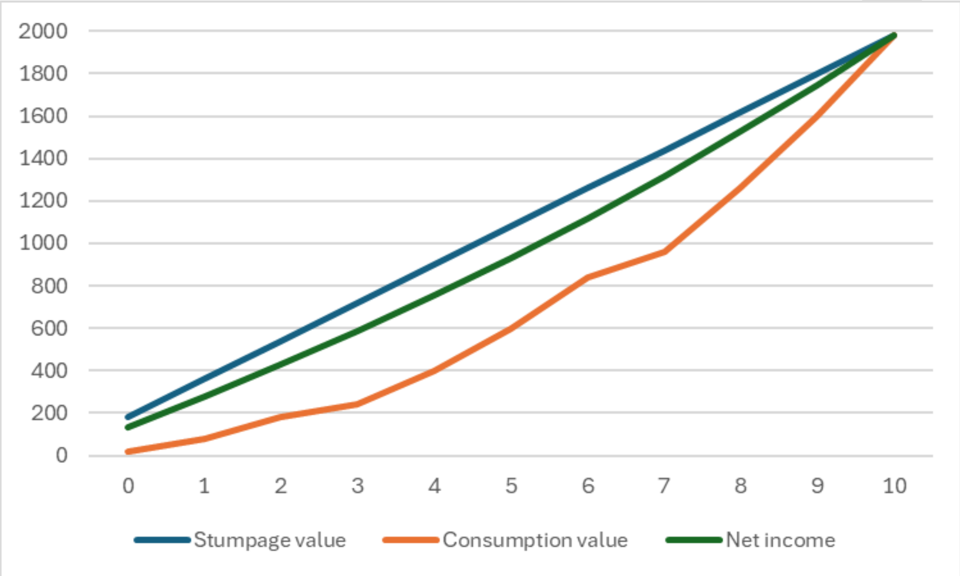
[103] Forestry glossary | Natural Resources Canada (nrcan.gc.ca)

[104] To see why it is necessary to also deduct the user costs of fixed capital consider the situation where the silviculture company hires a logging company to harvest the trees and bring them to the road. The logging company would also want to include depreciation and opportunity cost for its equipment in the cost its charges for its services.

[105] The original stumpage value method assumes that the natural growth rate of timber stocks is equal to the discount rate and therefore that the current inventory can be used as proxy for the combined asset value (of standing timber and the underlying asset). IEEAF (Eurostat 2002b, p.102) In this compilation guide, we take a different approach where we value the timber resources (work-in-progress) and forest land (the underlying asset) separately.

- The **net income method** distinguishes between stocks of different age classes and values them with the stumpage price of mature timber, but discounted taking into account how long it will take for each age class to reach maturity, and if possible the expected costs to bring the trees to maturity.
- The **age constant method** also distinguishes between stocks of different age classes and values each class by multiplying the expected felling value with an age factor. The age factor can take several aspects into accounts such as costs, as well as discounting. As the method is less clearly developed than the others (and can also be seen as an example of the net income method), it is not further considered.

Figure 5-2 Illustration of value of timber resources over time by different valuation methods



Source: Author's illustration

Notes: the example is based on a single forest stand with trees that have been planted at year 0 and grow linearly over time, assumed to reach maturity after 10 years.

410. As illustrated by Figure 5-2, in case of the assumed hypothetical situation of a single forest stand, these methods will result in a different value of timber resources over time, with the stumpage value giving the highest value and the consumption value method giving the lowest value. There are two ways to evaluate these methods: in terms of the sequence of additions to work-in-progress or in terms of the value of standing timber (stocks). For the national accounts, it is particularly important to obtain a correct sequence of additions to work-in-progress and withdrawals from inventories because these (i.e. the growth expected to be harvested, less natural losses) are what will be included in GDP.

411. The consumption value method is the only method that recognizes that timber stocks get more valuable the larger their size and arguably provides the correct sequence of work-in-progress and is therefore the conceptually preferred method. The net income method can be understood as an improved version of the stumpage value method that is less demanding in terms of data availability than the consumption value method.

412. However, in practical applications, we would always have a large number of forest plots. Under these circumstances, the differences in annual flows would mostly disappear: all three methods – as long

as we assume equal distribution of ages of the trees – would give the same (constant) time sequence for work-in-progress.[106] The inventory values (stocks) however would still be different.

413. A second perspective on evaluating these different methods consists in their data requirements. The stumpage value method can be considered a rather simple method with lowest demand on data availability. It is the method that most widely applied by countries. The consumption value method depends on the availability of stumpage prices for different age classes which may not be availability for many countries. The net income method and age constant method also depend on granularity of data on timber stocks. In this compilation guide, the stumpage value method is recommended as default approach, with the other methods considered as advanced methods. Its application is discussed in Stage 2.

414. We will now turn to the discussion of valuation methods for forest land (the underlying asset), for which different valuation methods exist.

415. For calculating the value of forest land (the underlying asset), the preferred approach would be to start from observed market transactions in forest estates (i.e. composite assets of timber resources and forest land) if such data is available. This data can subsequently be used for conducting a hedonic pricing analysis to separate the value of the forest land. Hedonic pricing analysis is considered an advanced method and is discussed in Section 5.2.4.

416. If a sufficient and representative amount of transactions are observed, the value of the composite asset can be obtained by multiplying the total surface area times the average price (per hectare) of the transactions observed during the accounting period (see example France). The value of the forest land is then calculated as a residual by deducting estimates of the value of work-in-progress, as illustrated in the country example from France.

417. If insufficient market transactions are available (for instance when land is mostly government owned), the recommended method to calculate the composite asset is to apply the NPV of future resource rents, as in the cases discussed in Chapter 4. This produces an asset value representing the whole of timber production, including work-in-progress and the potential to generate future production. As in the case of market transactions, the asset value of the forest land can be estimated as a residual by subtracting the estimates of work-in-progress, as also described in the 2025 SNA: “Exchange prices for forest land are usually not available, and need to be approximated using the present value of future economic benefits, after deduction of the value of the work-in-progress “ (11.220).[107] This method is described in Stage 3 and illustrated in the *Workbook: timber resources and forest land.*

[106] To see why this is the case, an analogy may help. Let’s consider runners of a 10 km course. The stumpage value method assumes that all runners keep the same speed throughout the race. In the consumption value method, runners start slowly and run faster every kilometre. They finish however at the same time as the stumpage runners. If you ask at each point in time “what is the speed?”, you get a different answer (and hence different additions to work-in-progress i.e. output) depending on whether we look at a stumpage runner or a consumption runner. However, if we organize multiple 10km races simultaneously of consumption runners (i.e. they run faster each kilometre) that start at different points in time (i.e. they overlap), and now ask the question “what is the average speed?”, we would approximate the average speed of the stumpage runners (as we average across runners that are early in the race and hence have a low speed with runners that are near the end of the race and have a high speed). However, in terms of (average) distance, the consumption runners are always behind the stumpage runners as each of them follows the orange line instead of the blue line (and hence the asset value of timber resources based on consumption value will be lower).

[107] It should be noted that other valuation methods also exist. For instance, in Germany the Faustmann formula is applied, and in Austria forest land is valued based on (part of) the value of grassland (which can be considered an opportunity cost approach). The Faustmann method (see Eurostat 2024c) is highly similar to the NPV of resource rent method: the main difference is that it departs from the assumption of unstocked land, and then projects income flows from the timing of future harvests and rotations.

418. It should be mentioned here that the NPV method of future resource rents primarily values the provisioning service of timber generated off the land. This should be considered a lower bound estimate of the value of forest land, as in some instances the land is also used for other purposes (such as hunting or collecting of non-timber forest resources such as berries and mushrooms) which may yield additional economic benefits. A related issue is that transactions in forest land commonly show that parcels closer to urban areas fetch a higher market price, which may be due to their proximity to people or due to some option value for possible conversion to other land uses being priced in (e.g. land speculation). This additional value would in part reflect what SEEA CF describes as the “provision of space” (UN et al. 2014 1.49). Therefore, we can think of the composite asset as consisting of three separate assets: a) work-in-progress of timber production; b) the underlying asset for timber production; and c) additional value such as the provision of space. The third element is recommended to be measured directly through application of the hedonic pricing method or indirectly as a residual of the market transactions of land and the NPV of resource rents. In the 2025 SNA, both the value of the underlying asset and any additional value due to for instance the provision of space are classified under AN311 Land Resources. For the valuation of depletion, only the value of the underlying asset should be used, as it is this value that is directly related to future timber production.

Country example: timber output and forest valuation in French national accounts

Primary data sources available

The *French national geographical institute* (IGN) is the main primary data source for:

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- The volumes of standing timber in cubic meters, thanks to the annual forest inventory. The forest inventory is conducted as a sample survey, combining aerial photography analysis and field observation. Definitive results are obtained as 5 years moving averages of annual sample results.
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- The stock value of forest estates could be estimated using more detailed plot characteristics, combined in a stratified or hedonic pricing model.

More importantly, in order to estimate depletion / net regeneration in the new SNA accounts, the French national accounts will now measure the resource rent of silviculture (NACE 02.1) and project it into the future to obtain the net present value (NPV) of timber resource rent. This new valuation approach will need to be articulated with the current (market based) approach to forest land valuation.

Stage 2 (timber resources): Collecting physical and price data

419. The second stage of the compilation process is to collect the physical and price data that will be needed to produce the physical asset accounts and monetary asset accounts for timber and to project future resource rents. This stage is illustrated in the *Workbook: timber resources and forest land* in the *work-in-progress* worksheets, for which two examples are provided: 2022 and 2023. There are three steps:

1. Collect data on areas of forest land
2. Collect physical data on timber
3. Collect price data

420. **Step 1** is to collect data on areas of forest land. The workbook shows an example in rows 5-12 of the work-in-progress worksheets, and this is also shown in Table 5-1. For the purposes of the SNA, the

focus of measurement usually lies on timber resources within forests available for wood supply (which includes plantations), which is the assumption used in the example, however as discussed under Stage 1 there are situations where the measurement scope needs to be extended for instance in case of illegal logging or extensive agro-forestry practices. Between 2022 and 2023, Table 5-1 shows that see that the forest available for wood supply (FAWS) increases by 4 hectares. As recommended by EFA (EC 2024c), the account for forest land should be disaggregated by (main) species, as different species may have different timber density, growth and mortality rates etc. The increase in FAWS in the example is associated with Species A.

Table 5-1 Data for areas of forest land

Area (ha)	**2022**	**2023**
Forest available for wood supply (FAWS)	100	104
Species A	30	34
Species B	70	70
Forest not available for wood supply (FNAWS)	80	76
Other wooded land	10	10
Other land	1000	1000
Total land area	1190	1190

Source: *Workbook: timber resources and forest land*, work-in-progress worksheets, Step 1.

421. Table 5-2 available in rows 14-19 of the work-in-progress worksheets (**Step 2**), contains the other physical input variables used for the two species. Density (m^3/ha) expresses the average density of each species in their respective wooded areas. The growth rate and mortality rate of the trees is also required, as this will be needed to calculate the net increment of timber, which is defined as growth (or gross increment) less natural losses. This type of information is typically available from a forest inventory or scientific reports (See Box 5.1).

422. The EFA (EC 2024c) also recommends that density should be expressed over bark (i.e. including bark). Reference is made to EFA Chapters 3 and 4 which contain more detailed information about the compilation of physical asset accounts, including conversion between units, disaggregation by species, as well as a detailed discussion of possible data sources and how they can be integrated.

Table 5-2 Physical data on timber, 2022

	Species A	***Species B***	**Average**
Density (m3 over bark / ha)	3.0	4.0	3.7
Proportion expected to be harvested	60%	70%	67%
Growth rate	5%	4%	4%
Mortality rate	*0.5%*	*0.5%*	0.5%

Source: *Workbook: timber resources and forest land*, work-in-progress worksheets.

423. For each species a percentage expected to be harvested also needs to be estimated. This is a little more complex, as explained below. Forest available for wood supply, density and the proportion expected to be harvested are multiplied in row 37 of the work-in-progress workbook to produce the initial opening balance of the physical asset account at the start of Stage 3 (2022) in our example.

424. The challenge for national accounts compilation is that the net annual increment in the timber resources available covers both actual and potential wood supply. However, for the accrual recording for output we need to estimate the net increment that is expected to be harvested in the future, so we need to

exclude the growth which will not be harvested. This is an important distinction between the SNA and the EFA (and the SEEA CF) which has a broader asset boundary. Estimating this proportion may seem difficult but, as argued in the Guidance Note WS.8, it is not much different from the projections that already need to be made according to the 2008 SNA when applying a NPV method for estimating the monetary value of non-cultivated biological resources based on current and future harvests: in both cases we need to estimate how much timber will be eventually harvested, the main difference is one of timing.

425. To estimate the percentage of growth that will be harvested in the future, it is recommended to use land-use planning information and/or information about licenses provided to forest companies. In the absence of such detailed (spatially explicit) information, a coefficient may be applied based on an analysis of historical records of net annual increment and removals.

426. For example, the coefficient could be estimated as: removals: 90 / net annual increment: 100 = 0.90. As the amount of removals is likely to vary year by year, for instance as a result of damages, it is recommended to average removals for at least 3 years when estimating the coefficient.

427. Another illustration is the OECD indicator "intensity of use of forest resources" (which is part of a dataset called "Depletion and growth of forest resources in terms of volume"[108]) which is calculated as the ratio of fellings to annual productive capacity (gross increment) covering about 35 (OECD) countries. The indicator averages over a long time period between 0.5 and 0.9 for countries.

[108] "The objective of this dataset is to trace net changes in terms of volume in the growing stock of standing wood on forest land. It shows data underlying the indicator on the intensity of use of forest resources. This indicator relates actual fellings to annual productive capacity (i.e. gross increment). Forest depletion and growth describe balances or imbalances in different types of forests. The intensity of use of forest resources reflects various forest management methods and their sustainability. These data should be read in connection with other indicators of the OECD Core Set, in particular with indicators on land use changes and forest quality (species diversity, forest degradation), and be complemented with data on forest management practices and protection measures. In interpreting these data, it should be borne in mind that definitions and estimation methods vary among countries", see: https://stats.oecd.org/OECDStat_Metadata/ShowMetadata.ashx?Dataset=FOREST&ShowOnWeb=true&Lang=en

Box 5.1 Data sources

Several data sources commonly exist in countries for the compilation of physical asset accounts for timber resources. These include:

- **Forest Inventories**. Forest inventories usually contain detailed information such as forest area, timber stocks, annual increment, stocking densities, management types (commercial and protective forests), ownership type (private small scale, private large scale, public), age classes, growing classes based on average diameter at breast height, tree species, dead trees and damaged trees, removals including harvest and natural losses. Data is for national level and/or subnational areas. Frequency of data collection is usually low, only once in every 5-10 years.
- **Felling statistics**: Provide annual data on the volume of wood in the rough harvested on forest land. [109]
- **Forest enterprise surveys**: Cover usually agricultural and forestry holdings with a certain minimum area.
- **Agricultural census data**: Provides information on 'other land with tree cover', most importantly short rotation coppices and Christmas tree plantations.
- **Geospatial information**: Earth Observation data can be used to provide information about areas of forest land and changes over time.

In principle, both the timber felling reports and the inventory provide aggregated data on stock removals in productive forests with an annual periodicity. However, it should be noted that there are several methodological differences between these data sources and as a result there may be considerable differences in outcomes. These differences are due to: annual observation in surveys versus interpolation when using less frequent inventories; existence of minimum thresholds in areas when surveying; use of different units (e.g. over/under bark) requiring conversion; volatility in annual data due to natural variability or damages.

Different data sources can be compared to enhance consistency.

A lot of the variables required for the physical asset account are collected by the FAO from countries every 5 years, the latest being 2020, see https://fra-data.fao.org/

428. The final step in Stage 2 (**Step 3**) is to collect price data and calculate stumpage prices. This is illustrated in rows 21-30 of the work-in-progress worksheets and in Table 5-3. Information is required for roadside pickup prices and cost of harvesting and transport for the two species, as well as user costs of fixed capital involved in logging. Stumpage prices are then calculated as roadside pickup prices *less* total costs.

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[109] Felling statistics may underestimate actual fellings and may need to be corrected by confronting with other data sources on demand / use of roundwood. For an example, see: https://www.thuenen.de/en/institutes/forestry/projects-1/recalculation-of-fellings

Table 5-3 Price data and stumpage prices, 2022

	per m3		
	Species A	Species B	Average
Roadside pickup price	15.0	14.0	14.3
Cost (transport / felling) to bring to road	3.0	3.0	3.0
Felling	1.0	1.0	1.0
Transport	1.0	1.0	1.0
User costs of fixed capital	1.0	1.0	1.0
Stumpage price	12.0	11.0	11.3

Source*: Workbook: timber resources and forest land,* work-in-progress worksheets.

Stage 3 (timber resources): Building the monetary asset accounts for work-in-progress

429. The third stage of the compilation process for timber resources (work-in-progress) is to compile the physical and monetary asset accounts for timber. This stage is illustrated in the *Workbook: timber resources and forest land* in the *work-in-progress* worksheets, for which two examples are provided: 2022 and 2023. There are two steps:

1. Compile the physical asset account for timber
2. Compile the monetary asset account for timber

430. Using the physical data collected in Stage 2, it is straightforward to compile a physical asset account for timber resources as shown in Table 5-4 and illustrated in rows 34-49 of the *work-in-progress* worksheets. This is done for each species. The opening stocks of 2022 are calculated as described above: FAWS * density * proportion expected to be harvested. Gross increment and mortality can be calculated based on growth and mortality rates, and these rates can be adjusted from year to year. Also the percentage expected to be harvested can be adjusted from year to year.

Table 5-4 Physical asset account for timber, 2022 (volume of timber over bark - million m3)

Physical asset account for timber, 2022 (volume of timber over bark - million m3)			
	Species A	Species B	Total
Opening stock	54	196	250
Additions			
Growth (gross increment)	2.7	7.8	10.5
Upward reappraisals			
Reclassifcation			
Reductions			
Natural losses	0.3	1.0	1.3
Removals	2.0	6.0	8.0
Downward reappraisals			
Reclassification			
Catastrophic losses			
Closing stock	54	197	251
Net increment	2.4	6.9	9.3

Source*: Workbook: timber resources and forest land, Work-in-progress (2022) worksheet.*

431. However, some additional items are required at this stage. The most important of these is the volume of removals, which will feed into the calculation of depletion of forest land in Stage 3 (forest land): Building the monetary asset accounts. Within forestry statistics, an important distinction is between removals[110] (which may include also trees that were felled in earlier periods or were lying dead on the ground) and fellings (i.e. trees that are cut down in the accounting period). It is common practice for felled trees, after removal of branches, to be temporarily stored within the forest (e.g. close to forest roads). It is important to realize that stocks of timber resources include not only living trees (i.e. the growing stock or work-in-progress), but also dead trees (called deadwood) and felled timber (which may be stacked and stored within forest areas).[111] While the difference between removals and fellings is important, especially for compiling forestry statistics and accounts, for national accounts compilation (in the standard approach described here) it is sufficient to focus on the measurement of removals.

432. Other important items within the physical asset account are the estimates for growth and natural losses, as these will provide the underlying information required for the accrual recording of output, which feeds into GDP. The EFA talks of "Net annual increment of timber", defined as "the average annual volume growth of live trees less the average annual mortality" (EC 2022).

433. Average losses should be distinguished from "catastrophic losses" (as described in the SEEA) which captures other reductions in inventories due to exceptional and significant losses from natural causes such as windthrow, forest fires, pests or insect infestations.

434. Finally, the physical asset account includes any reappraisals or reclassifications. Reappraisals can arise due to for instance a change in the forest area available for wood supply or in the percentage expected to be harvested.

435. For monetary valuation of work-in-progress the 2025 SNA specifies the following. "Additions to, and withdrawals from, work-in-progress are treated in the accounts in the same way as entries to, and withdrawals from, inventories of finished goods. They must be recorded at the times they take place and at the basic prices prevailing at those times." (7.123) "For inventories of work-in-progress, the value for the closing balance sheet should be consistent with the value of the opening balance sheet, plus any work put in place during the current period, less any work completed and reclassified as finished goods. In addition, an allowance for any necessary revaluation for changes in prices in the period must be included." (14.45).

436. Therefore, once the physical asset account for timber is complete, it is straightforward to compile the monetary asset account for timber (see rows 52-66 of the *work-in-progress* worksheets), see also the country example from Austria. This is done for all but one line by multiplying the physical units by the stumpage price for each species of tree. The exception is revaluations: if there is a change in the price of Species A or B during the accounting period, this should be included (multiplying the average physical stock by the price change).[112] In the example for 2023 shown in the workbook and in Table 5-5, the opening stock of timber resources is valued at 2917 (this is the closing stock from 2022). The closing stock is

[110] Removals are defined as in EFA (4.15) as "the volume of all trees, living or dead, that are felled and removed from the forest, other wooded land or other felling sites. It includes unsold roundwood stored at the forest roadside. It also includes natural losses that are recovered, removals during the year of wood felled in an earlier period, removals of non-stem wood (such as stumps and branches), and removal of trees killed or damaged by natural causes (known as natural losses), e.g. fire, wind, insects, and diseases. It does not include non-woody biomass or any wood that is left in the forest and not removed during the year, e.g. stumps, branches, tree tops and felling residues (harvesting waste) (Regulation (EU) 691/2011 Annex VII, based on the Joint Forest Sector Questionnaire T&D 2020)."

[111] If the felled timber temporarily remains in the forest, it is recorded as inventories of finished products such as wood-in-the-rough or roundwood. The moment the wood is removed from the forest, this is recorded as a withdrawal from inventories of finished products (which is then used by for instance manufacturing),

[112] Revaluations may also result from a change in the extraction path (due to the effect of discounting).

calculated as the opening balance plus additions less reductions plus revaluations, and is 2971 in this example.

437. In the case of the monetary asset account, the net increment (now expressed in monetary terms – row 67 of the *work-in-progress* worksheets and the last line in Table 5-5) is recorded as output of timber. This figure not only feeds into GDP but is also the starting point for the calculation of actual and future resource rents in the accounts for the underlying asset: forest land.

Table 5-5 Monetary asset account for timber, 2023

	Species A	**Species B**	**Total**
Opening stock	**653**	**2264**	**2917**
Additions			
Growth	32.7	90.6	123.2
Upward reappraisals	86.4	0	86.4
Reclassifcation	0	0	0
Reductions			
Natural losses	3.3	11.3	14.6
Removals	36.0	97.8	133.8
Catastrophic losses	0	103.5	103.5
Downward reappraisals	0	0	0
Reclassification	0	0	0
Revaluation	0	95.8	95.8
Closing stock	**733**	**2238**	**2971**
Net increment (output of timber)	29.4	79.2	108.6

***Source**: Workbook: timber resources and forest land, Work-in-progress (2023) worksheet.*

Country example: the monetary and physical asset account for timber resources in Austria

This example describes how physical and monetary asset accounts (stages 1 to 3) are compiled in Austria based on the work carried out for the compilation of the European Forest Accounts EFA. The issues discussed include main data sources used, identification of types of assets, compilation of forest land accounts and valuation of timber resources based on the stumpage value method.

Stage 1: (timber resources and forest land): Identifying types of assets and valuation methods

In order to estimate the volume of timber resources, forest land accounts are compiled first. For the case of Austria, the national forest inventory (NFI) serves as the primary source of information on forest land. While the data from the inventory is consistent with FAO's thresholds for forest area, the challenge here is the allocation of the said forest area to the various woodland assets. The NFI differentiates between several silvicultural management types which can be used for the allocation These include commercial and protective forests with and without yield. Each of these types may be composed of various sub-types: productive and non-productive forest land as well as bush areas. All these elements in their respective management types provide the basis (building blocks) for the allocation of the forest area and wooded land to the categories FAWS, FNAWS and OWL.

To differentiate between FAWS and FNAWS, the harmonized reference definitions proposed by Alberdi et al. (2016) (Forest Policy and Economics) is followed. The authors suggest a number of criteria for the allocation of forest area to FAWS or FNAWS. These include environmental, economic and social factors that severely impact or restrict the use of forest resources in economic activities. The assessment of the criterion profitability is challenging. Alberdi et al. 2020 suggest to not consider short-term market fluctuations. It would still be a FAWS even if current harvesting is not taking place or if it is done only for own consumption. Environmental (protective functions) and economic restrictions (accessibility, slope, soil conditions) are the most important factors in Austria to distinguish FNAWS.

For the valuation of timber resource, the stumpage value method has been chosen. Directly observable stumpage prices do not exist in Austria. Instead, the road-side pick-up price minus harvesting and transport costs are used. So far, the user cost of fixed capital is not deducted.

For the EFA Austria does not compile the monetary value of the forest land yet. For the Austrian balance sheets, valuation of the forest land is carried out based on current market prices and assuming that the value of forest land is 50% of the value of grassland in the same region. In the balance sheets standing timber is currently accounted for as part of the inventory.

Stage 2: (timber resources): Collecting physical and price data

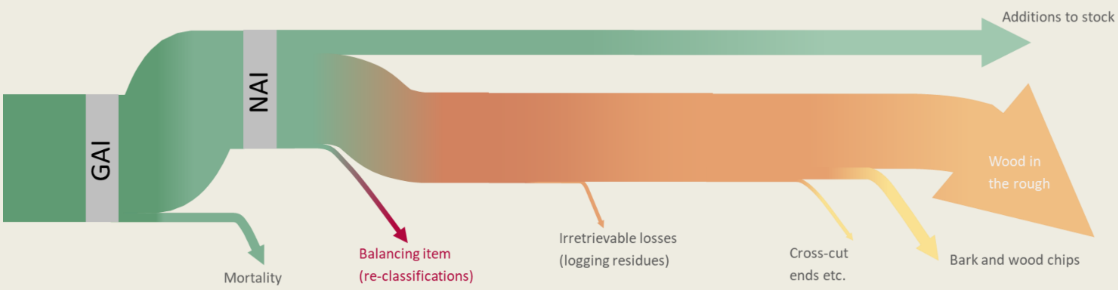
The NFI is the main source for Information on timber volume. It provides information on stocks as period averages in intervals of several years and on flows as averages between two inventory periods (observation period). Hence, additional work has been carried out to develop accounting principles and modelling approaches in order to derive annual stock and increment data from the NFI.

To derive annual stock data and to fill data-gaps on stocks between the inventory periods, an interpolation approach is used by allocating period averages to the NFI median years. This is supplemented by a more detailed method to obtain annual flow data on increment and mortality from dendrochronological surveys.

Additional primary and secondary sources, including surveys and literature (annual felling reports as the most important source), are used to gather information on timber removals and irretrievable losses, which serve as building blocks for an integrated accounting model. This model brings all the information together and provides comprehensive understanding of the flows of timber, from increment to withdrawal through harvests and irretrievable losses, while ensuring coherence among different data sources.

To get to the physical stocks, no adjustment for the % of annual increment that is expected to be harvested is made.

Figure 5-3 Model for timber flows in FAWS



Source: Statistics Austria

Since there are no statistics on stumpage prices in Austria, the value of standing timber is estimated by deducting harvesting costs and transport costs for the prices of harvested timber (roadside pick-up price). Timber prices are taken from the agricultural producer price statistics of Statistics Austria. Harvesting and transport costs (transport to the roadside) applied to derive the stumpage prices for FAWS correspond to the annual average value recorded by the accountancy network of large-scale forest enterprises (>200 ha).

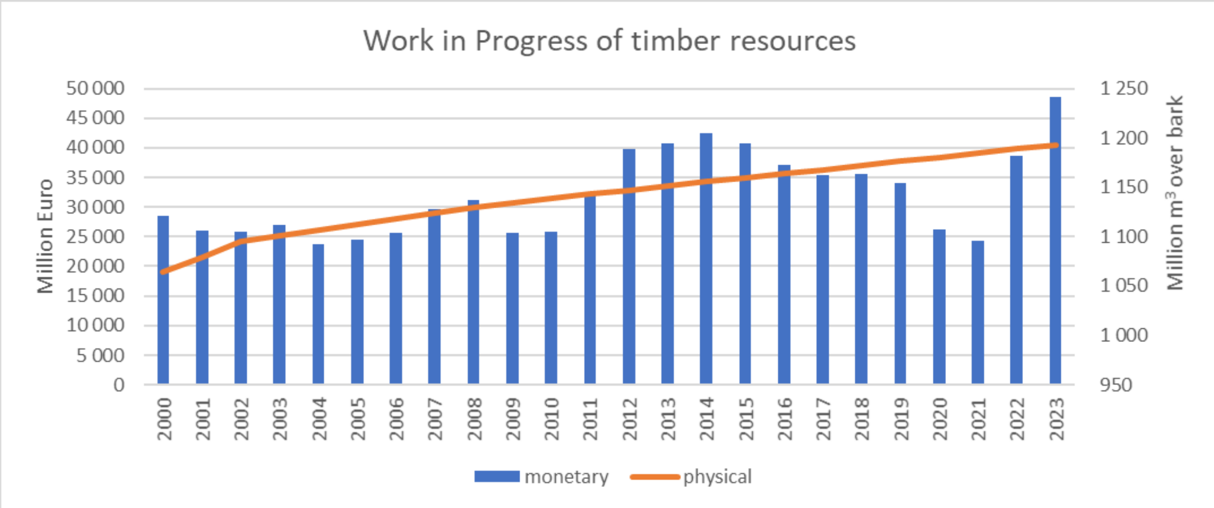
Stage 3: Building the monetary asset accounts for work-in-progress

Physical stock and flow data build the foundation for the monetary asset accounts of standing timber. The stumpage value method is used for the monetary valuation.

Disaggregation of the annual increment and timber stock into the product groups of coniferous and non-coniferous wood is based on the assumption that the composition of standing timber corresponds to a 15-year moving average of the assortment composition of loggings. In order to value both the increment and the stock using stumpage prices, conversion of the volumes of the stock and increment to m^3 under bark is necessary. This is done by means of deducting the potential losses that take place in the course of felling, shaping, measuring saw logs etc.

The resulting physical and monetary asset accounts for Austria are presented in the following figure and tables. Figure 5-4 shows a comparison of work-in-progress of standing timber in monetary and physical terms for the years 2000 to 2023. The two tables show the compilation of the physical and monetary asset accounts for timber using the Workbook on timber resources.

Figure 5-4 Work-in-progress of standing timber between 2000 and 2023, monetary and physical



Source: European Forest Accounts, Statistics Austria.

Physical and monetary asset accounts for timber for the year 2023 in the Workbook on timber

Step 1: Compile the physical asset account for timber

Volume of timber over bark - million m3			
	Total		
Opening stock	1 188,8		
Additions			
Growth (gross increment)	29,2		
Upward reappraisals			
Reclassifcation	0,7		
Reductions			
Natural mortality	2,3		
Removals	23,5		
Downward reappraisals			
Reclassification			
Catastrophic losses			
Closing stock	1 193,0		
Net increment	*26,9*		

Note: Net increment of timber is defined as natural growth (or gross increment) less natural mortality.

Step 2: Compile the monetary asset account for timber

Million Euro			
	Total		
Opening stock	38 591,0		
Additions	1 198,2		
Growth	1 170,3		
Upward reappraisals			
Reclassifcation	27,9		
Reductions	- 8 834,8		
Natural mortality	91,7		
Removals	982,8		
Catastrophic losses			
Downward reappraisals			
Reclassification			
Revaluations	- 9 909,3		
Closing stock	48 624,1		
Net increment (output of timber)	***1 078,6***		

Note: Net increment of timber is defined as natural growth (or gross increment) less natural mortality.

Stage 3 (forest land): Building the monetary asset accounts

438. Once the monetary asset accounts have been compiled for timber, the next stage is to compile the monetary asset accounts for the underlying asset: forest land. This means calculating the value of the composite asset comprising standing timber (work-in-progress) and the underlying asset (forest land), and then deducting work-in-progress from the composite asset value. This is preferably undertaken by using a direct market-based valuation of forest land (see country example France). When market values or not available, valuation of the composite asset can be based on the NPV of future resource rents. The latter is the method described below for 2023 and illustrated in the *Workbook: timber resources and forest land* in the worksheets *Underlying asset Year 1* and *Underlying asset Year 2.*

439. For this method, the following eight steps are required:

1. Calculate resource rents (past and present).

2. Project the physical asset account and physical output until end of the asset life of the resource.

3. Calculate the unit resource rent.

4. Smooth unit resource rents to address price volatility.

5. Project future resource rents.

6. Calculate NPV for the opening stocks.

7. Calculate NPV for the closing stocks.

8. Put together the monetary asset account.

It is worth noting that although these steps are illustrated in the *Underlying asset* worksheets, it is only in Step 8 that the estimates become those of forest land. Steps 1-7 are designed to calculate the NPV of future resource rent for the whole of timber production i.e. the composite asset value.

440. **Step 1: Calculate resource rents (past and present).** To calculate the resource rent for timber production, the residual value method (RVM) should be applied, as described in Chapter 3. It is recommended to apply a top-down approach starting from national accounts aggregates for ISIC Division 2: Forestry and logging. As we are valuing timber resources and forest land for the provision of timber, it is important to restrict the scope of ISIC Division 2 to commercial timber harvesting and logging activities, hence excluding ISIC 2.3 Gathering of non-wood forest products.[113] Table 5-6 presents an example, which follows the steps of the RVM top-down approach set out in Figure 3.1 in Section 3.3.1. The calculation is shown in the *Workbook: timber resources and forest land* in rows 4-20 of the Underlying asset Year 1 and Year 2 worksheets.

[113] The output of ISIC 2.3 is likely to be small compared with the total output of ISIC 2 and typically would not include use of fixed assets. In case gathering of non-timber forest resources is done on a commercial scale (and hence likely not be negligible) it would give rise to a separate asset (AN3322 Non-cultivated biological resources yielding once-only products). In such instances, it is recommended to separately identify the output as well as the value of fixed assets involved in this activity.

Table 5-6 Calculating resource rents for timber

	2020	2021	2022	2023
Output (producer prices)	105	105	105	109
Less Taxes on products	0	0	0	0
Plus Subsidies on products	1	1	1	1
Output (basic prices)	**106**	**106**	**106**	**110**
Less operating costs, specifically:	21	21	21	30
Less Intermediate consumption	8	8	8	12
Less Renumeration of employees	12	12	12	17
Less Other taxes on production	2	2	2	2
Plus Other subsidies on production	1	1	1	1
Gross operating surplus (GOS) and gross mixed income (GMI)	**85**	**85**	**85**	**80**
Less Specific subsidies on products	0	0	0	0
Plus Specific taxes on products	0	0	0	0
Less Specific other subsidies on production	1	1	1	1
Plus Specific other taxes on production	0	0	0	0
GOS and GMI for the derivation of resource rent	**84**	**84**	**84**	**79**
Less User costs of capital, specifically:	8	8	8	8
Value of fixed assets	90	90	90	95
Less Consumption of fixed capital (depreciation)	2	2	2	2
Less Return to fixed capital	5	5	5	6
Resource rent	**76**	**76**	**76**	**71**

Source: *Workbook: timber resources and forest land, Underlying asset Year 2 worksheet*

Notes: Cells in green indicate input data; blue indicates calculated estimates. Specific taxes on products / specific other taxes on production should be recorded as rent payment (D42) when government is the legal owner. Depreciation includes decommissioning costs (see Section 4.2.3).

441. Output in this table should be based on the accrual recording of output of timber, i.e. on the natural growth expected to be harvested (as derived in Table 5-5), not on actual revenues generated from harvesting. This can be seen in the *Underlying asset* worksheets, row 6, where the value of output of timber for 2022 and 2023 needed for the calculation of resource rents comes from the calculation of net increment (output of timber) at the end of the work-in-progress worksheets.

442. Operating costs are linked to the cost elements used in compiling the physical asset account for timber, including the costs used to derive the stumpage prices. In the workbook, you can follow the links back to these calculations in the work-in-progress worksheets. Operating costs should be at least equal to the average costs (per species) times the removals (per species) in the work-in-progress worksheets.

443. Gross mixed income (GMI) is recorded for unincorporated enterprises when it is not possible to separate compensation of employees from return to capital. In some countries, removals of timber for use as firewood will be important. When measuring the value of forest land, the inclusion of GMI may therefore be relevant. As discussed in Section 5.2.1 the key criteria for recognition as economic asset would be whether the extraction activity is of commercial scale. Firewood collection or indigenous use of resources, which is undertaken for commercial purposes, would therefore need to be included in the estimation of resource rent, but output generated for own use would need to be excluded. Unlike the situation of renewable energy production by households, renumeration of labour would likely not be negligible and it is recommended to make a suitable estimate (for instance by using the minimum or median wage in the forestry sector in combination with hours worked).

444. As explained in Section 3.3.1 the user costs consist of two elements: depreciation and a return to capital, specifically fixed assets. The value of depreciation (consumption of fixed capital in the 2008 SNA) is usually derived from a perpetual inventory model (PIM) and available as part of the national accounts. The asset life of the fixed assets could differ from the asset life of the natural resource, but in principle it should not be longer than the life of the natural resource.

445. The return to fixed capital is estimated by multiplying the value of fixed assets (row 22) with the rate of return, which is specified in cell H24. The rate of return is assumed to be 6% real in the example, but countries should apply their own rate of return.

446. After deducting both elements – depreciation and the return to fixed capital – from GOS and GMI for the derivation of resource rent, we obtain the resource rent.

447. **Step 2: Project the physical asset account and physical output until end of the asset life of the resource**. In the *Workbook: timber resources and forest land, Underlying asset Year 1* rows 24-37) and Table 5-7, we simply project forward the opening and closing balances from the physical asset account for timber compiled in the work-in-progress worksheet. In 2022, we have an opening stock of 250 physical units, and a closing stock of 251 units. These figures are based on the last year and are assumed to remain constant in future.

448. We also project the net annual increment based on the ratio of the last period's observed net annual increment to last period's opening stocks (i.e. the closing stocks of the last period). This ensures that in case there are reappraisals or reclassifications that occur during the current accounting period (as is the case in our example), the expected growth for the next period takes these changes into account, ensuring consistency. We assume that the projected net annual increment remains constant for the remainder of the asset life of the resource. It is recommended to apply as a default asset life 100 years.[114]

449. More advanced methods (see Section 5.2.4) may consist in the use of a biophysical model which would allow for dynamic projections of future growth taking into account the current state of the forest (is the forest young or old), harvesting patterns, as well as risks due to fire etc.

Table 5-7 Physical asset account for timber as of start of 2023

	2020	2021	2022	2023	2024	2025	2026	2027	2028
Opening stock			250	251	251	251	251	251	251
Additions									
Growth			10.5						
Upward reappraisals			0.0						
Reclassifications			0.0						
Reductions									
Natural mortality			1.3						
Removals			8.0						
Catastrophic losses			0.0						
Downward reappraisals			0.0						
Reclassifications			0.0						
Closing stock			251	251	251	251	251	251	251
Net increment	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3

Source: *Workbook: timber resources and forest land, Underlying asset Year 1 worksheet*

114 Discussion in the EGNC indicated that some countries apply a 200 years asset life. However, in light of climate change (and an increasing incidence of forest fires,) shortening the asset life to 100 years was deemed appropriate.

450. **Step 3: Calculate the unit resource rent**. The unit resource rent is the resource rent (from Step 1) divided by the net annual increment during the same accounting period. It can be considered a price measure. The unit resource rent needs to be calculated for several years, as this is required for the next step. This is done in row 43 of the workbook.

451. It is important to emphasize that the unit resource rent is not the same as the stumpage price: "A stumpage price is an output price related to a finished, unharvested tree. A resource rent price reflects the overall return to the economic owner of a resource per unit of output. Estimating a resource rent price therefore requires deducting all relevant costs from the measure of output, including the user costs of produced capital involved in growing / maturing trees. For a forest resource as a whole, the costs will include silvicultural and other establishment costs" (EFA, para 4.72).

452. In the workbook it is assumed (as a convention) that the resource rent is generated in the middle of the accounting period and therefore reflects the average price level of the accounting period[115].

453. In order to apply smoothing of unit resource rents in Step 4, we need to first bring the unit resource rent of the previous years to the same price level as the current accounting period (in this case 2023). This is done in the Year 1 worksheet by applying a price deflator in row 50 to the unit resource rent figure (row 49), obtaining – for each past year – the unit resource rent in mid-2023 prices (row 51). We use a fixed price deflator[116] of 2% in the example but countries should apply their own price index (which may differ from year to year).

454. **Step 4: Smoothing of unit resource rents to address price volatility**. We recommend assuming that the unit resource rent will remain constant in the projection period unless specific policies have been implemented which would allow us to estimate a specific path of future unit resource rents. As discussed in Chapter 3, it is recommended to project future unit resource rents based on an average of actual unit resource rents for several years. Due to volatility in commodity prices, if we were to use only the unit resource rent of the last year, asset values would become highly volatile, which should be avoided because the main use of these values is to assess long-term macro-economic trends. The number of years used for smoothing will depend on the type of resource, but typically would range from 3 to 10 years.

455. Under certain circumstances there may be good reasons not to smooth, for instance when futures markets provide a different signal compared with the long-term price trend or if there are expected to be changes in the regulatory regime.

456. **Step 5: Project future resource rents**. We now multiply the smoothed unit resource rent in mid-2023 prices (cell F55) by the projected physical annual increment for the year in question (Underlying asset Year 1 worksheet row 45). This results in projections of future resource rents in mid-2023 (constant) prices in row 60.

457. Next, we project discounted future flows of resource rents using a discount factor for each projected year (Underlying asset Year 1 worksheet row 61). The discount factors are calculated from a real discount rate (cell B61). The opening stock is to be calculated (in Step 6) for the start of the accounting period (1 January) and the resource rents are assumed to arise in the middle of the accounting period as these activities occur mid-year on average, so we halve the discount factor in the first period (in this case 2023).

[115] It would be possible to make a different choice (e.g. that it falls at the end of the accounting period) as this is merely a convention. However, in order to standardise the approach, a decision had to be made and this was the recommendation of the EGNC (and is consistent with 2025 SNA (18.117) which mentions that for flow variables the desired valuation point is usually the mid-point of the period.

[116] Preferably a producer price index for the forestry industry.

458. As the resource rent in future periods is expressed in constant prices, the discount rate used must be 'real' (excluding inflation), as noted in Section 3.3.2 on Discounting future flows of resource rent. The *Workbook: timber resources and forest land - Underlying asset* worksheets use the real discount rate of 2% that is recommended as the common, stable rate by the EGNC (see Chapter 3). The resulting discounted projection of future resource rents is shown in the Year 1 worksheet row 63.

459. Countries may prefer to use a real discount rate that is higher or lower than the common, stable rate agreed by the EGNC. As noted in Section 3.3.2 Discounting future flows of resource rent, countries are free to set their own discount rates as long as they also include a valuation using the common agreed rate as part of sensitivity analysis. This is simple to do as part of Step 5: compilers need only change the figure in cell B61 from 0.02 (2%) to the desired rate.

460. Countries may also prefer to project resource rents including future price increases (e.g. stumpage price will increase with X percent per year). If so, a nominal discount rate which includes price changes must be used. However, it is easier to assume that the price of the resource remains constant and apply a real discount rate, and this is the method recommended in this compilation guide.

461. **Step 6: NPV calculation for the opening stocks**.

462. Now we are able to estimate the opening stock value (in this case of the year 2023) by applying the NPV equation (see Section 3.3.2).

463. In the *Workbook: timber resources and forest land* (Underlying asset Year 1 worksheet cell F67), we sum the discounted future resource rents to give the opening stock of assets. We obtain an opening asset value of the combined asset of 3458.

464. **Step 7: NPV calculation for the closing stocks – redo compilation 1-7 above**

465. A year goes by, after which we redo compilation steps 1-6 using information now available (Underlying asset Year 2 worksheet in the *Workbook*) in order to estimate, in Step 7, the opening stock value of the year 2024 (which gives us the closing stock value of the year 2023).

Table 5-8 Physical asset account for timber as at start of 2024

	2020	2021	2022	2023	2024	2025	2026	2027	2028
Opening stock			250	251	247	247	247	247	247
Additions									
Growth			10.5	10.6					
Upward reappraisals			0.0	7.2					
Reclassifications			0.0	0.0					
Reductions									
Natural mortality			1.3	1.3					
Removals			8.0	11.5					
Catastrophic losses			0.0	0.0					
Downward reappraisals			0.0	0.0					
Reclassifications			0.0	9.0					
Closing stock			251	247	247	247	247	247	247
Net increment	9.3	9.3	9.3	9.3	9.2	9.2	9.2	9.2	9.2

Source: *Workbook: timber resources and forest land, Underlying asset Year 2 worksheet*

466. From the physical asset account of timber resources, we know that during the accounting period we had some upward reappraisals of 7.2 physical units, as well as reductions due to reclassifications of 9, and a higher harvest level than anticipated (11.5 units), resulting in a closing stock of 247 units in 2023 (Table 5-8). The column for 2023 is now coloured green as the figures are all actuals.

467. For the year 2023 we now also have measured data on output and user cost of fixed assets (included in column F of the Underlying asset Year 2 worksheet). This data is consistent with the changes assumed for roadside pickup prices. We again estimate the resource rent, unit resource rent, but now expressed in mid-2024 prices. Again, we do smoothing, and we have an opening stock value of the combined asset as at 1 January 2024 of 3323. This is also the 2023 closing stock value. This figure can be found in cell G65 of the Underlying asset Year 2 worksheet.

468. The opening stock for 2023 (cell F67) is not re-calculated in the Underlying asset Year 2 worksheet, but instead taken from the Year 1 worksheet. This is because of the forward-looking (or ex ante) nature of balance sheets: their main purpose is to describe how the value of assets change over time, for instance due to growth, removals and reclassifications.

469. **Step 8: Put together the monetary asset account**. We can now subtract the value of work-in-progress obtained earlier to obtain the NPV of the underlying asset (forest land): 3613 minus 2917 = 251 at the start of 2023 and 3323 minus 2971 = 247 at the start of 2024 (or the end of 2023). It is important to realize that these NPV estimates represent the value of the assets in current prices. The compilation of the monetary asset account in constant prices in discussed in Chapter 6.

470. It is possible to arrive at a negative asset value for the underlying asset, in case the value of work-in-progress is larger than the value of composite asset. This is an indication that the work-in-progress is overvalued. To be consistent with the valuation of other natural resources, it is recommended to limit the value of the composite asset to the net present value of resource rents (or the market value of land in case market prices are used) and reassess the value of work-in-progress. This would entail checking the stumpage price (e.g. is the user cost of machinery used in transporting and logging included) and whether all (physical) stocks of standing timber expected to be logged etc.

471. Table 5-9 – from rows 70-75 of the Underlying asset Year 2 worksheet – shows how this can be used to calculate the price of the resource[117] at the beginning and end of 2023, as well as the 2023 average price and average physical stock.

Table 5-9 Estimating 2023 average stock and price of the resource

	2023	**2024**
Physical assets (timber), opening balance	251	247
NPV of underlying asset (forest land) in current prices, opening balance	541	353
Price of resource	2.2	1.4
Average physical stock	249	
Average price	1.8	

Source*: Workbook: timber resources and forest land, Underlying asset Year 2 worksheet*

472. Table 5-10 is the monetary asset account for forest land (see rows 78-92 of the Underlying asset Year 2 worksheet). This is produced by:

- Opening and closing balances = NPV estimates in Table 5-9
- Depletion and regeneration = the effect of removals minus the net increment on the underlying asset. If the result is positive, it is recorded as depletion; if the result is negative, it is recorded (as a positive number) in regeneration, and no value recorded in depletion.

[117] The price being estimated is price in the ground (“in situ”) before any processing has taken place.

- Revaluation = Average physical stock * (Price of resource (2024) less Price of resource (2023)) from Table 5-9. Revaluation will pick up both the effect of changes in the resource rent as well as changes in the extraction path to the extent they lead to changes in asset value.
- All other rows = Estimate from physical asset account (Table 5-8) * Average price (Table 5-9)

In the worksheet, a check is included to ensure that the sum of opening stock value + all changes results in a closing stock equal to the opening stock estimate of the next year.

Table 5-10 Monetary asset account for forest land 2023 (current prices)

	Monetary value, 2023	Monetary value, 2024
Opening stock	541	353
Additions		
Regeneration		
Upward reappraisals	13	
Reclassifications	0	
Reductions		
Depletion	4	
Catastrophic losses	16	
Downward reappraisals	0	
Reclassifications	0	
Revaluation	-182	
Closing stock	353	

Source*: Workbook: timber resources and forest land, Underlying asset Year 2 worksheet*

473. As expected (based on our assumptions), we find as key elements: upward reappraisals due to the increase in forest area available for wood supply. This has a direct effect on the value of timber resources, but also an effect on the forest land value as this area will continue to generate timber resources into the future. We also see a reduction in value due to catastrophic losses in the case of species B. There is a cost of depletion as we have overharvested during the accounting period. Then there is revaluations: we see a positive amount for revaluations in the monetary asset account for timber resources due to the assumed increase in roadside pickup price of species B. However, for forest land there is a negative value in the monetary asset account for revaluations. This is driven by the drop in the resource price due to the reduction in asset value (which is driven by the profitability of the resource extraction, which may or may not move in the same direction as the output price itself (the costs of extraction can have a dynamic of their own).

Stage 4: (timber resources and forest land): Integration

474. In Stage 4, the estimates compiled for the monetary asset accounts for work-in-progress: timber resources and for the underlying asset: forest land in Stage 3 are recorded in the sequence of economic accounts (standard SNA presentation), see Table 5-11. The description of the rows in the two accounts follows those in the monetary asset account for timber (Table 5-5) and the monetary asset account for forest land (Table 5-10). In the monetary asset account for timber, we refer to growth and removals, while in the monetary asset account for forest land we have estimates of depletion (positive or negative) of the natural resource.

475. The value of (net) natural growth expected to be harvested should be included as output in the production account (and hence GDP). This output is supplied by the forestry sector and used as additions

to work-in-progress of cultivated biological resources. Compared with the 2008 SNA, there may be an impact on GDP due to the accrual recording of output for forest areas that previously were treated as non-cultivated (this will be further discussed in Chapter 6).

Table 5-11 Integration of monetary asset accounts of timber resources and forest land in the sequence of economic accounts

Items from monetary asset account for timber resources	Where to put these items in the national accounts	Items from monetary asset account for forest land	Where to put these items in the national accounts
Opening stock	Balance sheet	Opening stock	Balance sheet
Additions		Additions	
Growth	Production account (additions to work-in-progre	Regeneration	Production, capital account (record as negative depletion), as relevant allocation of earned income *
Upward reappraisals	Other changes in volume	Upward reappraisals	Other changes in volume
Reclassifications	Other changes in volume	Reclassifications	Other changes in volume
Reductions		Reductions	
Natural mortality	Withdrawals from work-in-progress		
Removals	Withdrawals from work-in-progress	**Depletion**	Production, capital account (record as depletion), as relevant allocation of earned income **
Catastrophic losses	Other changes in volume	Catastrophic losses	Other changes in volume
Downward reappraisals	Other changes in volume	Downward reappraisals	Other changes in volume
Reclassifications	Other changes in volume	Reclassifications	Other changes in volume
Revaluations	Revaluation	Revaluation	Revaluation
Closing stock	Balance sheet	Closing stock	Balance sheet
Net increment (=growth minus natural losses)	See "growth" and "natural losses"		See "growth" and "natural losses"

Notes: * if split asset: part of the regeneration (recorded as negative depletion) allocated to the legal owner; ** if split asset: part of the cost of depletion allocated to the legal owner.

476. Depletion of the underlying asset is recorded as a cost of production, similar to depreciation (instead of other changes in the volume of assets and liabilities as it was in the 2008 SNA). This will be recorded in the production account, the capital account (and in the allocation of earned income account for the part of the depletion born by the legal owner as negative imputed rent). Net regeneration of biological resources yielding once-only products is to be recorded as negative depletion. Due to natural variability, it is recommended to apply a bandwidth approach (e.g. if ratio of removals to net increment is within 95-105% assume sustainable use (hence no depletion). Any value difference is to be recorded as other changes in volume.

477. The revaluation elements are recorded in national accounts in other changes in assets accounts (specifically the revaluation account) and changes in balance sheets. Reappraisals (and catastrophic losses) are recorded in other changes in assets account (as other changes in volume) and changes in balance sheets.

478. Opening and closing stocks are part of the national accounts balance sheets (opening and closing balance sheet).

5.2.3. Specific topics

Damages and catastrophic losses

479. In some countries, removals due to damages can be significant in some years. In such cases it will be important to assess to what extent these are better described as catastrophic losses. Also, fellings due to damages (e.g. in case of pests) are likely worth less than planned fellings. This may cause issues when the net increment would be valued based on prices of healthy timber alone. It is therefore recommended when estimating a stumpage price to take an average of all timber eventually sold (i.e. a weighted average across different wood types and wood uses).

Deforestation and depletion

480. The SNA does not discuss land cover change, which is the domain of SEEA CF and SEEA EA. The SNA is not a spatial framework, and the focus of analysis is on classic natural resources such as timber and fish. As a result, the 2025 SNA does not disaggregate land into different assets based on land use.[118] The effects of land cover change will be recorded in the capital accounts and balance sheets as economic appearance (K1) or as reclassifications (K6) depending on whether the land was already recognized as economic asset or not.

481. That said, deforestation and depletion are interrelated to the extent that depletion as a result of timber harvesting practices may result (eventually) in deforestation. However, this need not be the case for a number of reasons: depletion may occur in forests that remain forests (called forest degradation in the IPCC[119]); deforestation may be caused by population pressures (e.g. due to fire wood collection) however these practices may not be sufficient to bring the forest within the SNA asset boundary and thus depletion will not be recorded; deforestation may result from pressures not caused by timber harvesting activities (e.g. agricultural practices or urbanisation); deforestation may result from indirect pressures (e.g. climate change).

482. Thus, while the SNA does not include land cover and land use accounts which provide the proper framing for assessing deforestation (and/or afforestation), the SNA would be expected to record cost of depletion due to timber harvesting which is one of the drivers of forest loss.

Other uses of forests

483. Forests are not only used for the provisioning of timber but may generate a range of other benefits such as non-timber forest resources (e.g. gathering of berries and mushrooms) which are included as output in the SNA. As discussed, only in case of commercial use would these lead to recognition of AN3322 AN3322 Non-cultivated biological resources yielding once-only products.

484. In addition, forests may also generate a range of non-material benefits such as water purification, carbon retention, or recreation services, usually described as regulating and/or cultural ecosystem services. As discussed in Section 2.3.2 ecosystem services lie outside the SNA production boundary and ecosystem assets lie outside the SNA asset boundary. In some cases, the value of ecosystem services may already be reflected in the observed market price of assets, for instance in case of amenity services provided by an urban park leading to higher real estate values. The treatment of ecosystem services is described in detail by the SEEA EA.

485. In some cases, payments take place for ecosystem services generated by forests, such as for carbon sequestration or and/or carbon retention. Examples are REDD+ projects[120] which are recognized under the Paris agreement. In addition, there are also private standards such as the Voluntary Carbon Standard that generate carbon credits from forestry projects that can be traded on markets.[121]

[118] Although the 2025 SNA does mention agricultural land and forest land on several occasions.

[119] The IPCC explains as follows: "Forest degradation is land degradation in forest remaining forest. In contrast, deforestation refers to the conversion of forest to non-forest that involves a loss of tree cover and a change in land use.", based on https://www.ipcc.ch/site/assets/uploads/sites/4/2022/11/SRCCL_Chapter_4.pdf

[120] REDD+ stands for reducing emissions from deforestation and forest degradation. "Under the framework with these REDD+ activities, developing countries can receive results-based payments for emission reductions when they reduce deforestation." Based on https://unfccc.int/topics/land-use/workstreams/redd/what-is-redd

[121] REDD+ FAQ: Explaining the ins and outs of forestry climate projects - Carbon Market Watch

Country example: valuation of timber resources in Canada

Canada has a substantial stock of forest land (Table 5-12) and extensive timber operations across numerous geographical regions. Beginning in 2015, Statistics Canada began producing estimates of Canadian natural resource wealth estimates on a quarterly basis[122] back to 1990 as part of the National Balance Sheet[123]. With the increasing focus on natural capital as part of the update to the System of National Accounts (2025 SNA) Canada has revisited our current methodologies to ensure the comparability and relevance of our estimates.

Table 5-12 Area, Gross Total Volume, Total Above-Ground Biomass by Forest/Non-forest, Ownership in Canada

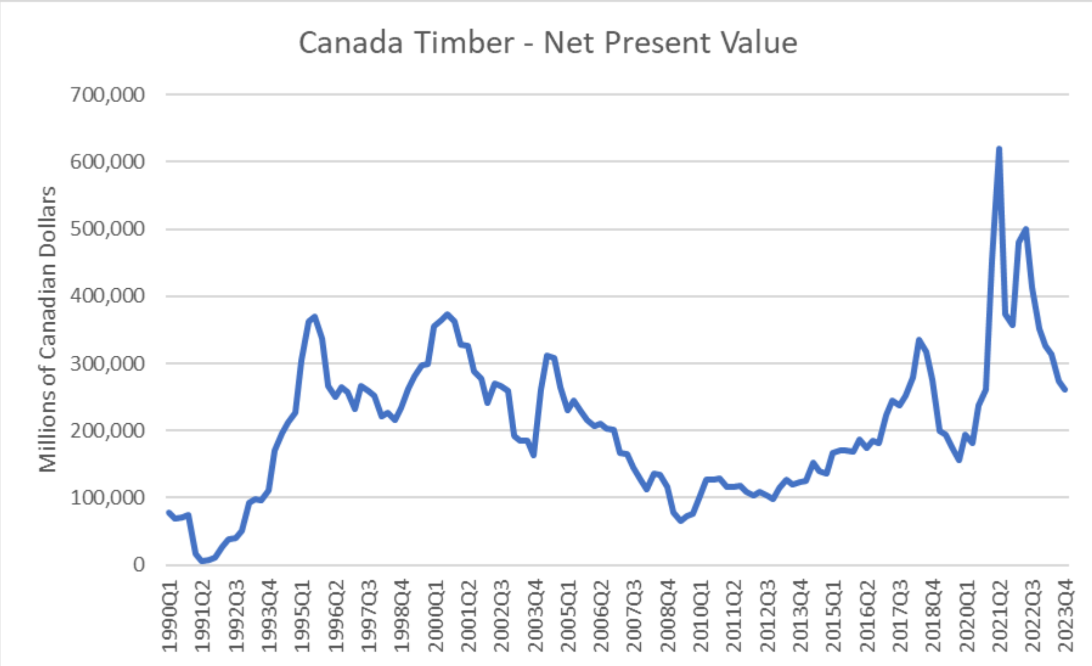
Forest land	Ownership	Area (1000 ha)	Tree Volume (million m3)	Tree Biomass (million t)
Forest land	Indigenous	7590.8	901.18	515.36
Forest land	Provincial	278808.26	38964.49	23437.38
Forest land	Federal	6158.22	1102.85	644.55
Forest land	Municipal	980.63	163.1	104.68
Forest land	Private	24271.11	3607.58	2343.82
Forest land	Missing	2879.63	396.37	241.54
Forest land	Territorial	46893.38	5749.31	3157.14
		367582.02	50884.89	30444.48

Notes: The Arctic ecozones (Arctic Cordillera, Northern Arctic, Southern Arctic), and the Taiga Plains and Hudson Plains ecozones located in Nunavut, are not inventoried. These non-inventoried areas total 262,189.89 thousand ha.
Generated: 9/20/2024
Source: Canada's National Forest Inventory, first remeasurement 2022

Statistics Canada's physical timber asset account, discontinued for some time, provides data up to 2003. However, a wide variety of statistics relating to timber are tabulated by Natural Resources Canada, including the National Forest Inventory and the National Forestry Database. Unfortunately, testing has indicated that it is not currently possible to estimate the growing stock of standing timber or the net annual increment without additional work. Currently, Statistics Canada produces a monetary timber asset account primarily using establishment surveys of forest product companies. The revenue and cost data are compiled to produce estimates of resource rent for the extracted timber in each period which is described as a Tier 1 method in the guide.

As with other natural resources, a net present value calculation is applied to these resource rent estimates (Figure 5-5) for the life of the resource, which is assumed to be infinite given sustainable harvesting practices and based on the sheer volume of timber assets in Canada. This differs from the treatment of other commodities in Canada, which have a finite reserve life. In more recent years, concerns relating to the impact of climate change, including more prolonged and destructive forest fire seasons, have challenged this assumption. Similarly, it is important to monitor whether harvesting practices continue in a sustainable manner.

Figure 5-5 Canada's Timber Net Present Value in the National Balance Sheet Accounts



Preliminary testing found that, even without factoring in regeneration or unexpected events or additional investment, it would take approximately 70 to 100 years to exhaust Canada's timber assets at the current rate of extraction. In this calculation, the portion of the forest that is valued is that which is accessible for harvesting, where commercially valuable species grow to a marketable size within a reasonable length of time, and where harvesting is allowed. Additional investment in infrastructure, such as service roads, would expand the timber assets accessible for harvesting. These projections would point to a much longer reserve life when factoring in future tree growth, which also serves as justification for assuming an infinite reserve life. At the same time, major losses of trees resulting from a catastrophic environmental event could also force a reevaluation of this assumption.

The treatment of an infinite reserve life also has implications for the estimation of depletion. When reconciling between two successive periods, Canada assumes that the net increment is equal to net fellings and, thus, a situation of sustainable extraction without depletion prevails. Statistics Canada is planning to revisit the timber physical account and test this assumption regularly as years with depletion or negative depletion may occur.

Illegal logging

486. In case of illegal logging, different situations may need to be distinguished, depending on whether the asset was already recognized or not and whether the logging occurs on an incidental (one-off) or structural (ongoing) basis.

487. In case the illegal logging occurs structurally (2025 SNA 13.22, 13.56, 27.36) where no asset was previously recognized (for instance in a protected forest / forest not available for wood supply) this may

[122] Canada's Quarterly Natural Resource Wealth (statcan.gc.ca)
[123] National Balance Sheet Accounts (statcan.gc.ca)

draw the composite asset into the asset boundary (assuming the logging serves a commercial purpose). This should be recorded first as K1 economic appearance of assets followed by K4 uncompensated seizure. Here it should be understood that the uncompensated seizure is not a seizure of the land itself (e.g. as in a situation of war), but of the work-in-progress and underlying asset i.e. the provisioning of timber. The logging itself leads to production and depletion and depletion of the forest land. In case the illegal logging occurs structurally where assets are already recognized, the same logic applies however there would be no need to first recognize the asset through a K1.

488. In case of irregular (incidental) illegal extraction at small scale: if the asset exists, K1 and K4 would only apply for the work-in-progress, not the forest land. In case the asset does not exist, illegal extraction would simply be ignored (as it does not concern a transaction (because it is illegal and there is no inventory to record a loss against), but if it is informal extraction (e.g. household gathering of firewood), it would be recorded as own account production.

5.2.4. Modifications to the standard approach

489. The approach described in Section 5.2.2 is to be understood as the default. As countries differ in their data availability and resources for conducing valuation of natural resource, this section describes also a Tier 1 or basic approach that would typically be followed in case of limited data availability and/or resources, as well as a possible advanced or Tier 3 methods requiring high data availability and resources.

Basic methods

490. In the 2015 FRA, 209 of 263 countries reported information on timber growing stock (FAO 2016). Countries that do not report this data are being imputed by the FAO. The 2020 FRA (FAO 2021) received information on growing stock from 183 countries and territories representing 95 percent of the world's forests. This does illustrate however that there are quite a number of countries that do not collect information on growing stocks. The 2020 FRA has omitted the mean annual increment variable from the survey, so it is difficult to assess data availability for this aspect.

491. In the absence of information about growing stock and/or annual increment, a short-cut may consist in looking at the value of harvests as proxy for the accrual recording of output. This may be reasonable if the following two conditions are met: land cover data should indicate that no deforestation is taking place[124]; there are a significant number of forest companies in the country. From the perspective of the inventories, this entails estimating the additions to inventories by the withdrawals (i.e. the harvest).

492. The composite asset value could then be estimated based on the NPV of resource rents where the value of output consists of the observed harvests, together with the default asset life (see country example Canada). This method would be the same as followed in the *Workbook: fish resources,* but instead of sales of gross catch/harvest, use the sales of removals. As no information about the growing stock would be available, it would be difficult to partition the composite asset into timber resources and the underlying asset would be possible. In those circumstances, the total asset value should be recorded under the asset category where the majority of value is expected to be.

493. In case deforestation takes place (as observed through changes in land cover), the same method could be used as above, however instead of using the default asset life of 100 years, the asset life should be estimated based on the average deforestation rate compared with the total forest stock. As deforestation is usually lagging the actual depletion, this estimate should be understood as a lower bound and clearly

[124] Looking at deforestation / afforestation provides however only a rough indication of the sustainability of timber harvesting practices, as a lot of timber harvesting occurs in forest land that will not immediately transition to a different land cover.

indicated in the meta-data. Depletion could be estimated in Tier 1 approach (see Section 3.5.4) by dividing the asset value by the expected asset life.

494. In case afforestation takes place, it is recommended to include a value of regeneration (recorded as negative depletion).

Advanced methods

495. There are a number of more advanced methods that can be applied depending on data availability.

496. The preferred approach for valuing timber resources and forest land would be to apply a hedonic pricing analysis using observed land transactions. Hereto, we would need to collect information about the characteristics of each transacted piece of land such as size, stocks of standing timber, location (e.g. proximity to roads or urban areas / surface water such as lakes / streams), which would allow to do a regression analysis to estimate the relative value of these elements. Such a hedonic analysis would allow to directly differentiate between the value of the timber resources and the land itself.

497. Applying the consumption value method rather than the stumpage value method is also considered an advanced method. The consumption value method in concept is more accurate than the stumpage value method in its valuation of work-in-progress. However, it requires more detailed information about the composition of the harvest (in terms of different ages) as well as different stumpage prices for each age bracket.

498. Finally, applying the RVM by focusing on ISIC 21: Silviculture and other forestry activities, instead of silviculture (instead of ISIC 2: Forestry and logging) is also considered an advanced method. The reason being twofold: choosing this sharper delineation clearly follows the distinction between the two different products that are produced in forestry and logging, namely standing trees by silviculture and logs (roundwood) by logging. The output of standing trees provides the direct link to the timber resources (and the value of the land in its capacity to continue generating timber), that we are trying to value. Second, for the estimation of resource rent, there should in principle exist a link to the economic ownership of the resource used in production. Silviculture typically is the economic owner of the timber resources, reaping the risks and rewards (e.g. in case of a forest fires the loss is for the silviculturist), which is typically not the case for logging companies. This of course requires that the national accounts are compiled at that level of detail.

5.3. Aquatic resources

5.3.1. What to include in the national accounts

499. The treatment of aquatic resources is complex as these resources are quite different in nature (e.g. aquaculture versus wild fish). They sometimes move across economic territories as defined for national accounts purposes; national resources can be accessed and impacted by non-resident units (and vice vera); and the resources (e.g. fish stocks) themselves are usually not directly observable: it is only possible to estimate them through what fishermen catch. In this section we will start by distinguishing between different types of fishing activities. We will then discuss how the SEEA describes aquatic resources. This will be followed by a clarification of SNA production and asset boundaries.

Fishing and aquaculture

500. The term aquatic resources is not used as such in the 2025 SNA asset classification, however it is useful to define this term for purposes of this guide. Aquatic resources are much broader than marine fish resources, and also includes crustaceans, molluscs and other marine organisms and products (e.g.

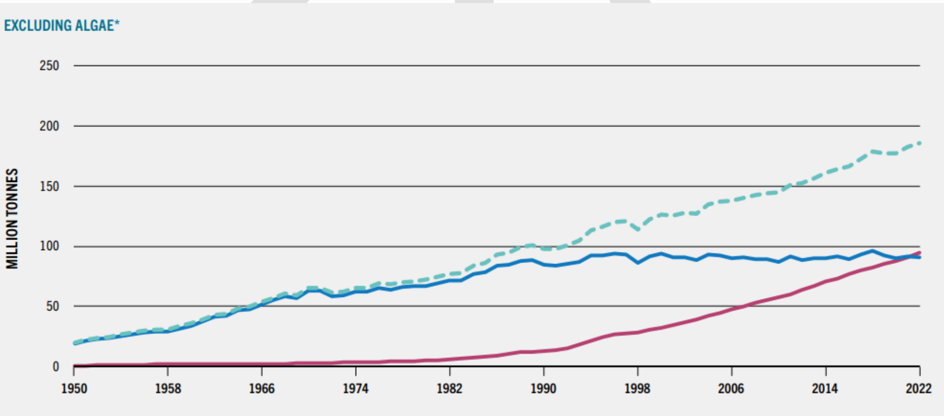
aquatic plants, pearls, sponges etc). ISIC Revisions 4 and 5 (Table 5-13) distinguish at the division level between Fishing and Aquaculture, with further disaggregation at the class level between marine and freshwater fishing. The importance of aquaculture is increasing (Figure 5-6) with aquaculture overtaking fishing globally in 2022 in terms of aggregate production (in physical tons). Aquaculture resources (cultivated aquatic resources) are in principle recorded as work-in-progress, however in exceptional circumstances may also be under animal resources yielding repeat products (2025 SNA 11.215). Nevertheless, the focus of this guide is on non-cultivated fish resources (classified under AN3322), i.e. fishing (sometimes called capture fishery) because the 2025 SNA follows the same treatment for aquaculture (cultivated resources) as in the 2008 SNA. Aquaculture is briefly discussed in the Section 5.4.3.

Table 5-13 ISIC classification of fishing and aquaculture

ISIC Rev 5 Division/Group/Class	Description
03	Fishing and aquaculture
031	Fishing
0311	Marine fishing
0312	Freshwater fishing
032	Aquaculture
0321	Marine aquaculture
0322	Freshwater aquaculture

Source: ISIC Rev 5.

Figure 5-6 World fisheries and aquaculture production



Source: FAO 2024. Notes: red is aquaculture production; blue is capture fisheries production; green: total

501. Another breakdown that is sometimes used (Lam and Sumaila 2021) is between industrial, artisanal, subsistence, and recreational fisheries. The difference between artisanal and industrial fishing is primarily one of scale, with both types of activities included in the SNA production boundary. Subsistence fishing is included in the SNA production boundary and may be part of the non-observed economy. Recreational fisheries can be neglected for purpose of national accounts measurement, because in most cases the caught fish are being released.

Delineating fish resources

502. In this section we will clarify the scope of fish resources (included under AN3322 Non-cultivated biological resources yielding once-only products) to be measured in national accounts. It is helpful to recall the SNA asset boundary: "Assets as defined in the SNA are entities that must be owned by some unit, or units, and from which economic benefits are derived by their owner(s) by holding or using them over a period of time." (2025 SNA 1.68) In case of fish resources, the SNA stipulates: "Assets over which ownership rights have not, or cannot, be enforced, such as open seas or air, are excluded, unless exclusive right on the resources are established, for example in the form of quota regimes for capturing fish." (2025 SNA 11.22) Furthermore, "In cases where there is no effective management of the fish stock or an associated water body, then there is no legal owner and consequently no asset is recorded on the balance sheet notwithstanding the resource rent that may be earned by fisherman. This treatment is consistent with economic theory where the resource rent in open access fishery contexts will tend to zero and hence there will be no balance sheet value of the stock to record in an SNA context." (2025 SNA 27.38). Therefore, fish stocks that are not exploited or are not subject to a quota regime would not constitute assets in the SNA (although they would likely be included in the SEEA which has a broader asset boundary).

503. There are a few specific cases to consider. Fish resources would generally be restricted to resources within water bodies under the administration or management of economic units (usually government) corresponding with the exclusive economic zone (EEZ) of a country (2025 SNA 27.37). However, the 2025 SNA is clear that also "fish stocks in the high seas which are subject to international agreement on how much may be caught by individual countries may be counted as falling within the asset boundary." (11.206) Secondly, illegal fishing in a country's national waters for commercial purposes (either by resident or non-resident operators) would lead to the recognition of an asset, as discussed further in Section 5.3.3.

504. The 2025 SNA[125] also specifies that capture fisheries should be treated as non-cultivated assets. This implies that we should record their catch as output of the fisheries sector (ISIC group 031), by contrast with timber resources where it is the growth of the stocks that is recorded as output. Furthermore, similar to the treatment of timber, the 2025 SNA (13.21) makes a conceptual distinction between the current resource and the underlying asset: "The value of these biological resources may consist of two elements: the natural growth of fish itself, and the value of the underlying asset (i.e., the geographical area through which the fish migrates). In the latter case, the value is often encapsulated in the value of the quota put in place." The area through which the fish migrates can be understood here as the fishery or fishing ground. However, for practical purposes, due to the lack of data on physical stocks, it may be difficult to value both components separately. Moreover, the two elements would not obtain a different accounting treatment as the composite asset as a whole is considered a non-produced asset (there is no work-in-progress as in the case of timber resources). We will use the term fish resources to describe the composite asset in these guidelines.

505. According to the SEEA CF (5.398) "The aquatic resources for a given country comprise those resources that are considered to live within the Exclusive Economic Zone (EEZ) of a country throughout their life cycles, in both coastal and inland fisheries. Migrating and straddling fish stocks are considered to belong to a country during the period when those stocks inhabit its EEZ." It is important to further clarify what this entails.

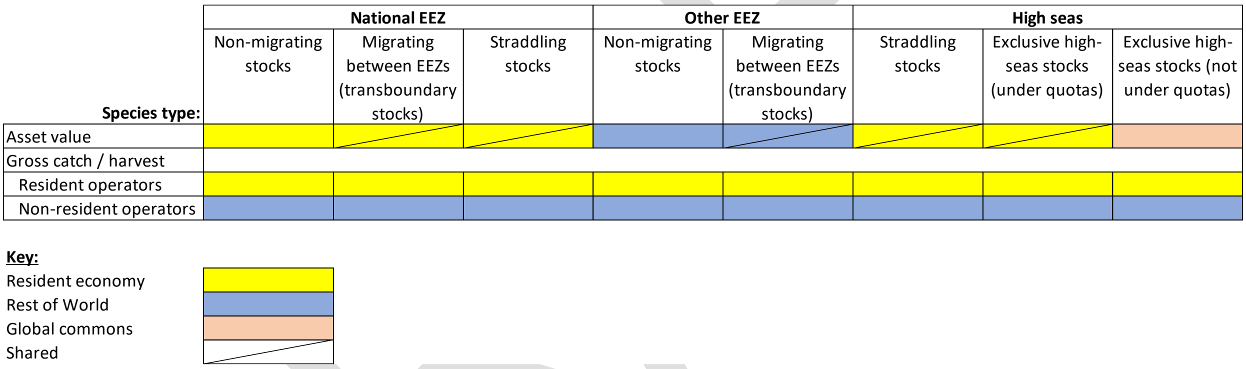
[125] 2025 SNA (11.222): "Non-cultivated biological resources consist of animals, birds, fish and plants that yield both once-only and repeat products over which ownership rights, often collectively by government, are enforced but for which natural growth or regeneration is not under the direct control, responsibility and management of institutional units. In practice, these resources are restricted to migrating biological resources, such as fish in open seas, which are subject to some form of quota regime."

506. The SEEAF (UN 2006; para 2.48) includes a very helpful classification: “Shared fish stocks are understood (see, in particular, the FAO Code of Conduct of Responsible Fisheries, article 7.1.3) to include the following:

- Fish resources crossing the EEZ boundary of one coastal State into the EEZ(s) of one or more other coastal States (transboundary stocks);
- Highly migratory species, as set forth in annex 1 of the United Nations Convention on the Law of the Sea (United Nations, 1982), consisting primarily of the major tuna species. Being highly migratory in nature, the resources are to be found both within the coastal State EEZs, and the adjacent high seas;
- All other fish stocks (with the exception of anadromous and catadromous stocks[126]) that are to be found, both within the coastal State EEZ and the adjacent high seas (straddling stocks);
- Fish stocks to be found exclusively in the high seas (discrete high seas fish stocks).”

507. Figure 5-7 summarizes the main possibilities regarding the inclusion of different types of fish stocks for compiling national accounts. The columns describe various types of situations that can occur.

Figure 5-7 Different types of fish stocks in relation to asset value and gross catch



Source: authors.

- The assets to be included in the national balance sheet (yellow) consist in first instance of non-migrating resources that are subject to a quota regime and part of the national EEZ. It may also include part of the transboundary stocks (shared with neighboring country(ies)) and/or straddling stocks to the extent these are subject to quota regimes. For a proper physical asset account (required for the SEEA but not for the SNA) an assumption would need to be made how much time the fish spend in each EEZ and apportion the stock accordingly. For the SNA it would

126 “Diadromous fishes describe species that spend part of their lives in freshwater and part in saltwater. There are two categories of diadromous fishes, catadromous and anadromous. Catadromous fishes hatch or are born in marine habitats, but migrate to freshwater areas where they spend the majority of their lives growing and maturing. As adults they return to the sea to spawn. .. The best-known group of catadromous fishes are the true eels. ..Anadromous fishes are the opposite of catadromous fishes in that hatching and a juvenile period occur in freshwater. This is followed by migration to and maturation in the ocean. Adult fish then migrate back up rivers .. in order to reproduce in freshwater habitats. There are approximately 100 known species of anadromous fishes. Several of these are well-known and of great commercial value, including many species of salmon along with striped bass, steelhead trout, sturgeon, smelt, shad, and herring.” Based on: https://www.encyclopedia.com/science/news-wires-white-papers-and-books/catadromous-diadromous-and-anadromous-fishes

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be sufficient to rely on information about actual harvest taking place in the national EEZ and the high seas (subject to quota regime).

- Regarding gross catch/harvest (output), this should include all fish caught by resident operators regardless of location (in national EEZ, other EEZ or the high seas). “By convention, the output associated with the harvest of these resources is allocated to the country of residence of the operator of the vessel undertaking the fishing rather than to the country in which the resources are located.” (2025 SNA 27.46) This would include for instance resident fishermen fishing in another country’s EEZ. The income generated through these activities would be included in the GDP of the economy of the fisherman, however these fish stocks would not be included on the national balance sheet as they are part of the foreign country’s natural resources. Likewise, access rights may have been provided to foreign operators to fish in national waters. These catches should be recorded as reductions in stocks in the national balance sheet.

5.3.2. Compilation stages

508. Regarding the measurement of fish resources, four compilation stages are distinguished: identifying the types of assets and valuation methods; collecting the physical data; building the monetary asset accounts; and integration of the results into the sequence of economic accounts.

Stage 1 (fish resources): Identifying types of assets and valuation methods

Identifying types of assets

509. It would be important to start with compiling a list of fish stocks occurring within the national EEZ and waters (frequently) visited by resident operators (other EEZs, high seas). In the absence of national data, international databases could be used as starting point such as: https://standardgraphs.ices.dk/stockList.aspx. Also the FAO has a database on marine fisheries by species, country and year: https://www.fao.org/fishery/en/collection/global_production?lang=en

510. The relevant international classifications pertaining to fish species should be used. As indicated by the SEEA CF: 5.404 “The Aquatic Sciences and Fisheries Information System (ASFIS) list of species contains over 11,500 species, and is commonly used as the standard reference for fisheries production. It is linked to the FAO International Standard Classification for Aquatic Animals and Plants (ISCAAP) which divides commercial species into 50 groups on the basis of their taxonomic, ecological and economic characteristics FAO classification.”

511. The SEEA-AFF (3.156) contains an aggregated list of 12 major groups based on the International Standard Statistical Classification of Fishery Commodities. (ISSCFC): Freshwater fish; Diadromous fish; Demersal fish; Tuna, bonito, billfish; Other pelagic fish; Other marine fish; Crustaceans; Cephalopods; Other molluscs; Aquatic mammals; Other aquatic animals; Aquatic plants, algae.

512. The SNA is exhaustive implying that all assets with economic value within the asset boundary should be estimated. However due to the resource-intensive nature of the valuation of fish resources, it is proposed to apply a materiality threshold and focus on the valuation of assets that contribute more than 5% of output in ISIC 031 (Fishing), and for which the long-term average contribution of Fishing to GDP is at least 0.1%.[127] When a reasonable estimate can be made of how much of the asset value is missed, it is recommended to gross up the asset value.

[127] These thresholds were suggested by the EGNC as a reasonable compromise.

513. It is recommended to use the 12 major groups as a checklist to assess which fish resources are available in the country and would be above the threshold in terms of output.[128] For the national accounts it is sufficient to report the aggregate asset value under AN3322 Non-cultivated biological resources yielding once-only products.

Valuation methods

514. Regarding valuation methods, according to SEEA CF (5.442), there are two main possibilities. "One is to value the aquatic resource using the value of long-term fishing licences and quotas where realistic market values are available. The other is to base the value on the net present value of the resource rent of the aquatic resources." We will first discuss the possibility to apply market values of quotas for valuing the resource.

515. As indicated in the SEEA-F (2.102) "An increasingly frequent approach to managing marine fisheries is by means of harvesting quotas. They are usually allocated by the Government (which is responsible for ensuring their enforcement as well) 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 fish stock. They may be allocated for free based on such criteria as historical catches by fishers or fishing firms and/or allocated to communities in locations where fishing is the main source of livelihood. They may also be auctioned or allocated in other ways (e.g. by lottery). A quota may be valid for one year only but is typically valid for a longer period, and often in perpetuity. It may be tradable to third parties or not. Even if not tradable, in certain circumstances it may still be transferable; say, from one generation to the next."

516. As discussed in Chapter 3, and discussed in 2025 SNA (27.41-43) under some circumstances the value of quota sales can be used to value the fish resource. Necessary conditions are that the right was required during an open competition and that it is transferable i.e. it may be sold to other economic agents.

517. This is further discussed in SEEA-F (2.61): "Some fisheries are managed under a system of freely tradable individual fishing rights, individual transferable quotas (ITQs). Under the right circumstances, the trading prices for ITQs can reflect the asset value of a fishery. However, only a few fisheries are managed through ITQs, and thus such quota markets do not exist. Even when ITQs are used, the market may be "thin" or subject to other constraints that distort the quota price."

518. If rights have been granted to a foreign economy, it is likely that some form of payment takes place (e.g. for allowable catch quota). There are various types of quota (transferable, tradeable), for a limited number of years or in perpetuity. In case of quotas for a limited number of years, the value of the quota will not represent the total value of (that part of) the resource. However, the compiling economy would likely have a view on the value of its fish stock, if only to be able to negotiate fish quotas with foreign operators, for instance based on the resource rents captured by resident operators (under comparable circumstances).[129] The actual payments would be recorded as rent (received from the rest of the world) in the national accounts. In case no information is available for estimating the fish asset (e.g. in case there is only fishing by non-resident operators), the rent payments can be used (through NPV) to estimate the value of the fish asset.

519. In most cases, however, the residual value method (RVM) would be applied to estimate asset values for fish resources as the NPV of future resource rent (see Chapter 3). This method is discussed in detail in the remainder of this section.

[128] The ISCAAP list can be found here: https://www.fao.org/fishery/static/ASFIS/ISSCAAP.pdf

[129] The resource rents captured (by the non-resident operator) will likely be non-observable for the compiling country.

Stage 2 (fish resources): Collecting physical data

Gross catch/harvest

520. While it would be advantageous to compile a full physical asset account for fish resources, it is recognized that this may not be possible for many countries due to data constraints, so this is considered an advanced method.

521. The most essential piece of physical data that is required for the default approach to the compilation of the monetary asset accounts and national accounts lines is gross catch/harvest (physical output). In most countries, what is statistically observable is the catch by resident operators of different species. The catch from non-resident operators will generally not be observable.

522. There are different concepts corresponding with different stages of the catch (SEEA CF: 5.428 - defined by FAO):

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

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

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

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

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

523. As indicated by SEEA (5.429): "The most common catch concept used in practice is that of "landings". Landings are directly linked to the economic value of the product. However, this measure excludes the discards of organisms incidentally caught through harvesting activity (discarded catch) as well as the amount of the catch used for own consumption." The best measure for estimating depletion is gross removals (a), so this is the preferred approach for national accounts compilation; but landings (d) is a good alternative option. It is also important to separately identify within gross removals or landings by resident operators the part associated with fishing in national waters (the national EEZ) versus the part associated with other country's EEZs and fishing in high seas because this will be important for estimating asset values (as shown in Figure 5-7).[130]

524. In case national data is not available, a possible global data source may exist in Sea Around Us (SAU)[131], a research initiative at the University of British Columbia and the University of Western Australia. SAU have developed a "catch reconstruction database which utilizes data from various sources including published literature, informal reports and expert knowledge to derive estimates for all fisheries components missing from the officially reported data. SAU provides catch time series by flag state, fishing sector, species, and catch type starting from 1950 and also links the data to other fisheries-related information for every maritime country including the ex-vessel price data developed by the Fisheries Economic Research Unit (FERU) of the University of British Columbia, cost of fishing and the government subsidies." (Lam and Sumaila 2018) The data is also spatially explicit / available per grid cells. The cost data distinguishes between different gear types (e.g. dredgers, drift and/or fixed netters), and boat size (e.g. vessels under 12m or 15 GT, over 24m and 100 GT).

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

[131] https://www.seaaroundus.org/

Assessing stocks to estimate asset life

525. In order to estimate the asset value (and how it changes over time), we need to know the asset life of the resource. This will depend on how the fish stocks are managed.

526. The preferred option would be to use stock assessments for all the species identified within the previous stage. For instance, the United Kingdom (see UK country example) uses stock assessments from the International Council for the Exploration of the Sea (ICES) to assess, for each fish species in its waters, whether fishing is sustainable (UK 2022) checking two elements: whether fishing pressure is at or below levels capable of producing Maximum Sustainable Yield (MSY) and whether spawning biomass for each stock is sufficient for MSY.

527. As an example, Figure 5-8 provides (part of) a stock assessment of anchovy in the Bay of Biscay. For non-migrating / non straddling fish stocks, it is common to talk about fisheries i.e. the location of the stocks. The advice is that total catch should be no more than 33 000 tonnes in 2024. This type of information can be contrasted with the actual catch, to assess whether depletion (or regeneration) is taking place.

Figure 5-8 Example of a stock assessment

ICES Advice on fishing opportunities, catch, and effort
Bay of Biscay and the Iberian Coast ecoregion
Published 08 December 2023

ICES CIEM

Anchovy (*Engraulis encrasicolus*) in Subarea 8 (Bay of Biscay)

ICES advice on fishing opportunities

ICES advises that when the EU management plan is applied, catches in 2024 should be no more than 33 000 tonnes.

ICES advice on conservation

ICES is not aware of any information on stock-/species-specific conservation status.

Stock development over time

Spawning-stock size is above B_{lim}; no reference points for B_{pa}, MSY $B_{trigger}$, or fishing pressure have been defined for this stock.

Figure 1 Anchovy in Subarea 8. Summary of the stock assessment. Trends in catch (the 2023 lighter blue bar is a preliminary estimation), recruitment (age 1 biomass), harvest rate (catch/SSB), and spawning-stock biomass (estimated in mid-May).

Source: International Council for the Exploration of the Sea.

528. Such stock assessments may not exist for many fisheries in the global south. A good starting point may exist in the RAM Legacy Stock Assessment Database (RLSADB)[132] which "includes most of the publicly available stock assessments conducted around the world, contains information on just over 1,300 stocks." (Ovando et al. 2021)

529. The second-best option would be to collect catch per unit effort (CPUE) data as suggested in the SEEA CF and SEEA AFF. Increasing levels of catch effort for comparable catch would provide a clear indication of depletion. An exciting recent development has been the use of satellite data to track fishing effort (Paolo et al. 2024), which can be compared with actual catch data. This would constitute an advanced method (see section 5.3.4).

530. The third option, which was used in the context of CWON (World Bank 2021) and UNEP's Inclusive Wealth report (UNEP 2023), would be to use time series information about catch (landings) to deduce sustainability following a scheme as in Table 5-14: if the landing within the accounting period is less than 10-50 % of the max landing recorded earlier it can be assumed that the stock is over exploited. This requires however the availability of a time series of sufficient length for individual species.

Table 5-14 Derivation of fishery status based on time series of landings

Sources: www.searoundus.org

Status of fishery	Criterion applied
Rebuilding (Recovering)	Year of landing > year of post-max. min.* landing AND post-max. min. landing < 10% of max. landing AND landing is 10-50% of max. landing
Developing	Year of landing < year of max. landing AND landing is < or = 50% of max. landing OR year of max. landing = final year of landing
Exploited	Landing > 50% of max. landing
Over exploited	Year of landing > year of max. landing AND landing is between 10-50% of max. landing
Collapsed	Year of landing > year of max. landing AND landing is < 10% of max. landing

Notes: *Post-maximum minimum (post-max. min.) is the minimum landing after the maximum catch.

Source: World Bank 2021b (Table 9)

531. The final option would be to rely on other indicators of condition of the fishery / fish stock such as water quality, harvest of related species (predator-prey relationships) to deduce a status and ultimately asset life of the species in question.

532. Whichever data source and method is applied, at the end of this stage, we should have an idea for each species included in national boundaries of its sustainability and asset life, which is important information for both the estimation of asset values and for estimating cost of depletion in the next stage.

533. This information can be presented by species, identifying whether each fish species is overexploited, exploited (but managed sustainably) or rebuilding. The *Workbook: fish resources* and Table

[132] Available at: www.ramle gacy.org; the name RAM derives from Ransom A. Myers who pioneered this work. (https://onlinelibrary.wiley.com/doi/full/10.1111/j.1467-2979.2011.00435.x)

5-15, present an example where fishing activity is dominated by three species responsible for 50%, 30% and 20% of fisheries output respectively, and that species A and C are overexploited.

534. If it is not possible to estimate the asset life of each fish species, but it is known that the species is in scope of the asset boundary and is sustainably managed, a default asset life can be used. In this case, rather than using an infinite asset life, it is recommended to use a finite asset life of 25 years as the default in light of the critical state of most of the world's fisheries, unless compilers have better information about the expected asset life.

Table 5-15 Fish stock assessments and asset lives

	2023			2024		
Species	Stock assessment	Output (%)	Asset life	Stock assessment	Output (%)	Asset life
A	Overexploited	50	10	Overexploited	55	9
B	Exploited (sustainably managed)	30	25	Exploited (sustainably managed)	25	25
C	Overexploited	20	5	Overexploited	20	4

Source: *Workbook: fish resources, Stage 2 Physical data worksheet.*

535. For over-exploited and rebuilding resources, preferably, we would use fishery-specific information, sourced from a fisheries management authority when available. If that type of information is not available, an expert guess could be made of the asset life, with 10 years used as the default asset life.

Stage 3 (fish resources): Building the monetary asset accounts

536. After collecting the physical data, the next stage is to compile the monetary asset accounts. These provide information on stocks and changes in stocks that are needed to populate the natural resource lines in the 2025 SNA, including estimates of the cost of depletion and various entries in the capital accounts and balance sheets.

537. Eight steps are required to compile the monetary asset accounts, as shown in the example for the year 2023 in the *Workbook: fish resources*, which is discussed below. The eight steps are:

1. Calculate resource rents (past and present).
2. Project the physical asset account and physical output until end of the asset life of the resource.
3. Calculate the unit resource rent.
4. Smooth unit resource rents to address price volatility.
5. Project future resource rents.
6. Calculate NPV for the opening stocks.
7. Calculate NPV for the closing stocks.
8. Put together the monetary asset account.

Step 1: Calculate resource rents (past and present)

538. When using the RVM to calculate resource rents (see Section 3.3), a distinction can be made between a top-down approach using information included in the national accounts or a bottom-up approach applying information from other data sources such as business statistics. For valuing fish resources, it is recommended to apply a top-down approach departing from national accounts information on gross

operating surplus (GOS) of ISIC group 031 - Fishing. In contrast to the treatment of timber where the output consist of the natural growth (i.e. not the actual harvest), here the output is based on the catch.

539. Table 5-16 presents an example for Species A, which follows the steps of the RVM top-down approach set out in Figure 3.1. The calculation is shown in the *Workbook: fish resources* in rows 6-25 of the Year 1 and Year 2 worksheets. It is assumed Species A is overexploited as seen by the diminishing resource rent over time. The same steps would need to be undertaken also for the other species.

Table 5-16 Calculating resource rents for fish resources (Species A)

	2020	2021	2022	2023
Output (producer prices)	100	98	96	94
Less Taxes on products	0	0	0	0
Plus Subsidies on products	1	1	1	1
Output (basic prices)	**101**	**99**	**97**	**95**
Less operating costs, specifically:	23	22	21	21
Less Intermediate consumption	10	9	8	8
Less Renumeration of employees	12	12	12	12
Less Other taxes on production	2	2	2	2
Plus Other subsidies on production	1	1	1	1
Gross operating surplus (GOS) and gross mixed income (GMI)	**78**	**77**	**76**	**74**
Less Specific subsidies on products	0	0	0	0
Plus Specific taxes on products	0	0	0	0
Less Specific other subsidies on production	1	1	1	1
Plus Specific other taxes on production	0	0	0	0
GOS and GMI for the derivation of resource rent	**77**	**76**	**75**	**73**
Less User costs of capital, specifically:	10	10	10	10
Value of fixed assets	90	90	90	95
Less Consumption of fixed capital (depreciation)	5	5	5	5
Less Return to fixed capital	5	5	5	6
Resource rent	**67**	**66**	**65**	**63**

Source: *Workbook: fish resources*, Year 2 worksheet**.**

Note: Cells in green indicate input data; blue indicates calculated estimates. Specific taxes on products / specific other taxes on production should be recorded as rent payment (D42) when government is the legal owner. Depreciation includes decommissioning costs (see Section 4.2.3).

540. The main difficulty here is the aggregated nature of the top-down information. For the valuation of the aquatic resources two distinctions are important. First, as the intention is to calculate asset values, it is important that only the part of the resource rent that is generated within the national EEZ or high seas is included (see Figure 5-4). Second, the resource rent should be split between the most important species groups. Such a split should preferably be made based on relevant data on output, costs and capital stocks for each species group. However, if that is not feasible, the split can be proxied based on output shares. As a result, one should obtain a time series of (past and present) resource rents for each of the main species that are in scope.

541. It is assumed that countries that have a significant fisheries industry already compile figures for the production and generation of income account and therefore have estimates of GOS for the relevant industries as a starting point for the top-down approach, so we do not cover compilation of these figures in this guide. However, some guidance may be helpful for estimating specific taxes/subsidies, and this is discussed in Chapter 3.

542. Gross mixed income (GMI) is recorded when it is not possible to separate compensation of employees from return to capital, for instance in case of household fishing activities. In some countries, the inclusion of GMI may therefore be relevant. As discussed in Section 5.2.1 the key criteria for recognition as economic asset would be whether the fishing activity is of commercial scale. Subsistence fishing activity would therefore need to be excluded in the estimation of resource rent. Unlike the situation of renewable energy production by households, compensation of labour would likely not be negligible and it is recommended to make a suitable estimate (for instance by using the minimum or median wage in the fisheries sector together with hours worked).

543. As explained in Section 3.3.1 the user costs consist of two elements: depreciation and a rate of return to capital (excluding natural resources), specifically fixed capital. The value of depreciation (consumption of fixed capital in the 2008 SNA) is usually derived from a perpetual inventory model (PIM) and available as part of the national accounts. The asset life of the fixed assets could differ from the asset life of the natural resource, but in principle it should not be longer than the life of the natural resource.

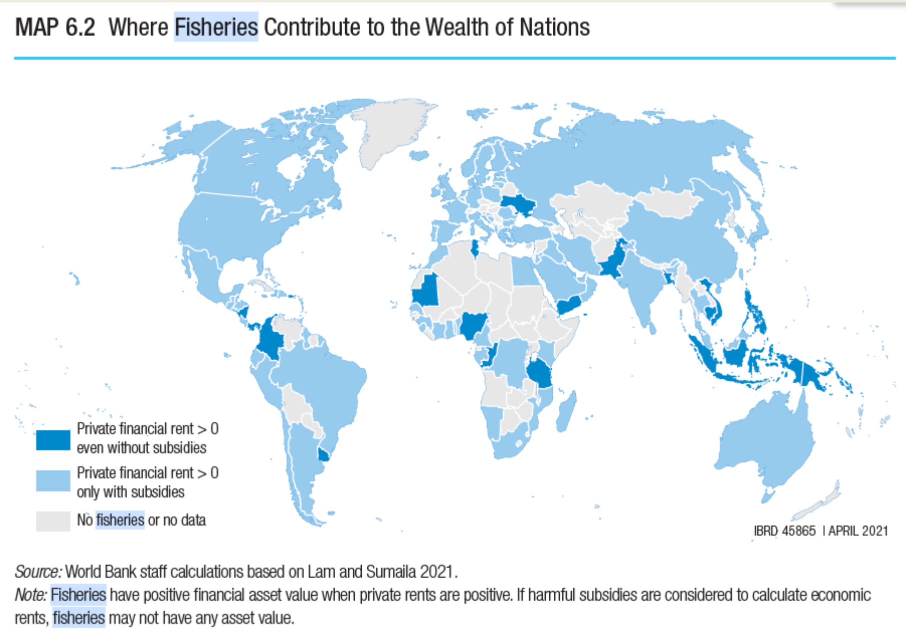
544. The return to fixed capital is estimated by multiplying the value of fixed assets (row 22) with the rate of return, which is specified in cell H24. The rate of return is assumed to be 6% real in the example, but countries should apply their own rate of return.

545. After deducting both elements – depreciation and the return to fixed capital – from GOS and GMI for the derivation of resource rent, we obtain the resource rent.

Box 5.2 Fisheries wealth

To provide some context and manage expectations, the World Bank's Changing Wealth of Nations report (World Bank 2021) includes an assessment of the value of fisheries for about 110 countries including a time series from 1995-2018. The analysis distinguishes between private rent (operating surplus) and economic rent (resource rent) where the value of subsidies have been deducted. It finds that in 2018 global economic rent of all fisheries as a whole was negative, with 89 out of 110 countries recording negative rents (see map below). To the extent that this analysis would be corroborated by national data / estimations, this would imply zero asset value and also zero depletion for most countries in the world.

Figure 5-9 Negative resource rents



Source: World Bank (2021)

Step 2: Project the physical asset account and physical output until end of the asset life of the resource

546. As indicated in Stage 2, for the standard approach it is not deemed realistic that countries compile physical asset accounts for fish as most countries only have available data on catch or landings. In the *Workbook: fish resources* (Year 1 worksheet, rows 33-44) most of the lines are therefore not compiled. We only require row 39: gross catch/harvest. In the example, we assume that in 2023 we have landings of 10 physical units (e.g. tons of herring) which is assumed to remain constant (see Chapter 3).

547. For the asset life, it is recommended to base this on the status of the individual species groups. After stage 2, we should have an indication of the asset life of the fish resource (Species A). In the example, we assume it to be 10 years in the Stage 3 Year 1 worksheet, and 9 years in the Year 2 worksheet.

Step 3: Calculate the unit resource rent

548. The unit resource rent is the resource rent (from Step 1) for a species divided by the gross catch/harvest during the same accounting period. It can be considered a price measure. The unit resource

rent needs to be calculated for several years, as this is required for the next step. This is done in row 48 of the workbook.

549. In the workbook it is assumed (as a convention) that the resource rent is generated in the middle of the accounting period and therefore reflects the average price level of the accounting period[133].

550. In order to apply smoothing of unit resource rents in Step 4, we need to first bring the unit resource rent of the previous years to the same price level as the current accounting period (in this case 2023). This is done in the Year 1 worksheet by applying a price deflator in row 49 to the unit resource rent figure (row 48), obtaining – for each past year – the unit resource rent in mid-2023 prices (row 50). We use a fixed price deflator of 2% in the example but countries should apply their own price index (which may differ from year to year).

Step 4: Smooth unit resource rents to address price volatility

551. We recommend assuming the unit resource rent will remain constant in the projection period unless specific policies have been implemented which would allow us to estimate a specific path of future unit resource rents. As discussed in Chapter 3, it is recommended to project future unit resource rents based on an average of actual unit resource rents for several years. Due to volatility in commodity prices for several natural resources, if we were to use only the unit resource rent of the last year, asset values would become highly volatile, and hard to cope with in the national accounts. The number of years used for smoothing will depend on the type of resource, but typically would range from 3 to 10 years.

552. Under certain circumstances there may be good reasons not to smooth, for instance when futures markets provide a different signal compared with the long-term price trend or if there are expected to be changes in the regulatory regime.

Step 5: Project future resource rents

553. We now multiply the smoothed unit resource rent in mid-2023 prices (cell F54) by the projected physical production for the year in question (Year 1 worksheet row 39). This results in a projection of future resource rents in mid-2023 (constant) prices in row 59.

554. We project discounted future flows of resource rents using a discount factor for each projected year (Year 1 worksheet row 61). The discount factors are calculated from a real discount rate (cell B60). The opening stock is to be calculated (in Step 6) for the start of the accounting period (1 January) and the resource rents are assumed to arise in the middle of the accounting period as these activities occur mid-year on average, so we halve the discount factor in the first period (in this case 2023).

555. As the resource rent in future periods is expressed in constant prices, the discount rate used must be 'real' (excluding inflation), as noted in Section 3.3.2 on Discounting future flows of resource rent. The *Workbook: fish resources* example uses the real discount rate of 2% that is recommended as the common, stable rate by the EGNC (see Chapter 3). The resulting discounted projections of future resource rents is shown in the Year 1 worksheet row 62.

556. Countries may prefer to use a real discount rate that is higher or lower than the common, stable rate agreed by the EGNC. As noted in Section 3.3.2, countries are free to set their own discount rates as long as they also include a valuation using the common agreed rate as part of sensitivity analysis. This is simple to do as part of Step 5: compilers need only change the figure in cell B54 from 0.02 (2%) to the desired rate.

[133] It would be possible to make a different choice (e.g. that it falls at the end of the accounting period) as this is merely a convention. However, in order to standardise the approach, a decision had to be made and this was the recommendation of the EGNC and is consistent with 2025 SNA (18.117) which mentions that for flow variables the desired valuation point is usually the mid-point of the period.

557. Countries may also prefer to project resource rents including future price increases (e.g. the average price of fish resources, Species A, will increase with X percent per year). If so, a nominal discount rate which includes price changes must be used. However, it is easier to assume that the price of the resource remains constant and apply a real discount rate, and this is the method recommended in this compilation guide.

Step 6: Calculate NPV for the opening stocks

558. Now we are able to estimate the opening stock value (in this case of the year 2023) by applying the NPV equation (see Section 3.3.2 Net present value method). In the *Workbook: fish resources* (Year 1 worksheet cell F60), we obtain an opening asset value as of 1 January 2023 of 624.

Step 7: Calculate NPV for the closing stocks

559. A year goes by, after which we redo compilation steps 1-6 using information now available (Year 2 worksheet in the *Workbook: fish resources*) in order to estimate, in Step 7, the opening stock value of the year 2024 (which gives us the closing stock value of the year 2023).

560. For the year 2024, we now also have measured data on output and user cost of fixed assets (included in column F of the Year 2 worksheet). We again estimate the resource rent, unit resource rent, but now expressed in mid-2024 prices. Again, we do smoothing, and we have an opening stock value for 2024 of 554, which is also the 2023 closing stock value. This figure can be found in cell G71 of the Year 2 worksheet. The opening stock for 2023 (cell F67) is not re-calculated in the Year 2 worksheet, but instead taken from the Year 1 worksheet. This is because of the forward-looking (or ex ante) nature of balance sheets: their main purpose is to describe how the value of assets change over time.

561. We should repeat Steps 1-7 for all major species groups that are distinguished, hence in the example we should do this for all 3 species. However, this is not shown in the *Workbook: fish resources.*

Step 8: Put together the monetary asset account

562. We now have the NPV of each species of fish resources at the start of the accounting period (624 for species A as of 1 January 2023) and end of the accounting period (554 as of 1 January 2024, or end of 2023). It is important to realize that these NPV estimates represent the value of the assets in current prices. The compilation of the monetary asset account in constant prices in discussed in Chapter 6.

563. The approach to estimate the cost of depletion differs from the method applied for the other resources as we do not have a physical asset account. The cost of depletion in 2023 (Table 5-17) can be calculated by applying the approach described in 3.5.4 Depletion and tiers by dividing the NPV for opening and closing stocks by the corresponding asset life from Table 5-15, and taking the average.

Table 5-17 Average asset life and depletion (Species A)

	2023	2024
Asset life of the resource	10	9
NPV of asset in current prices, opening balance	624	554
Depletion	62.4	61.6
Depletion during accounting period	62	

Source: *Workbook: fish resources*, Year 2 worksheet.

564. If fish resources are sustainably managed, there is no depletion (by definition). Therefore, if the example shown was for Species B instead of Species A (see Table 5-15), no depletion would be recorded in the accounts. Also, if species B remains sustainably managed while Species A and C are overexploited, in the next year that we compile the worksheets, the asset lives of Species A, B and C would be 9, 25 and

7 years respectively. The asset lives of Species A and C would then be reduced by one year each year, while that of Species B would remain at 25 years. In case eventually only Species B would be left, we would stop recording depletion.

565. It should also be noted that the cost of depletion is restricted to the effects of overharvesting. In case fisheries are directly damaged (for instance by practices such as bottom trawling), these reductions in value – if they can be estimated – are recorded as other changes in volume.

566. In the monetary asset account, rows 83-96 of the Year 2 worksheet in the *Workbook: fish resources*, shown in Table 5-18, revaluation is obtained as a residual to reconcile opening and closing stocks. To obtain the monetary asset account for all fish resources (not included in the accompanying workbook), all elements of the monetary asset accounts for the individual species need to be added (opening and closing stocks, regeneration, depletion, revaluation). Due to the absence of a physical asset account, it is not possible to measure catastrophic losses, reclassifications or reappraisals in the standard method (default approach); but they are included in Table 5-18 for completeness.

Table 5-18 Monetary asset account, Species A, 2023 (current prices)

	Monetary value, 2023	**Monetary value, 2024**
Opening stock	624	554
Additions		
Regeneration		
Upward reappraisals	0	
Reclassifications	0	
Reductions		
Depletion	62	
Catastrophic losses	0	
Downward reappraisals	0	
Reclassifications	0	
Revaluation	-8	
Closing stock	554	

Source: *Workbook: fish resources*, Year 2 worksheet.

Note: In case the fish resource is regenerating (as evidenced by a longer asset life and asset value) it should be recorded as additions to stock (regeneration) in the monetary asset account. However, in the production and capital account it would be recorded as negative depletion.

567. If the asset life remains equal (indicating sustainable management), no depletion or regeneration cost should be recorded. If the asset life is increasing, a value for regeneration should be recorded in the monetary asset account, and this is calculated in the same way as the cost of depletion. Regeneration should only be recorded in case there is a clear indication, for instance as substantiated in a fishery management plan, that the higher future yields are expected to be harvested. It should be noted that although regeneration may be recorded in the monetary asset account, in the production and generation of income account it would be recorded as negative depletion (see Stage 4: Integration).[134]

[134] For recovering resources (e.g. where the fishery is closed for a number of years), the asset value can be estimated based on NPV of resource rents, where these rents are assumed to be equal to the average rent when the fishery was exploited, discounted based on when the fishery is expected to open again (say X years from now). In case the future estimates do not change, the increase in value will be solely due to the unwinding of the discount rate (i.e. that we get

Stage 4 (fish resources): Integration

568. The information from the monetary asset account for …will be used in the sequence of economic accounts (standard SNA presentation), see Table 5-19.

569. In the 2025 SNA, depletion of fish resources is recorded as a cost of production, similar to depreciation (instead of other changes in the volume of assets and liabilities as it was in the 2008 SNA). This will be recorded in the production account, in the earned income, the transfer of income account, and the capital account. Depletion may also be caused by resident operators outside national waters and vice versa, this is discussed in Section 5.3.3.

570. While they would not be calculated as part of the standard approach, reclassifications (upward or downward) and catastrophic losses are recorded as other changes in volume. Likewise, reappraisals (upward and downward) are treated as other changes in volume. The direct estimate for revaluation is to be recorded in the revaluation account. Finally, opening and closing stocks are part of the national accounts balance sheets (opening and closing balance sheet). In case of legal fishing in national waters by non-resident units, rent payments may take place which will be recorded as property income from the rest of the world in the allocation of earned income account.

Table 5-19 Integration in SNA sequence of economic accounts

Items from monetary asset account	Where to put these items in the national accounts
Opening stock	Balance sheet
Additions	
Regeneration	Production, capital account (record as negative depletion), as relevant allocation of earned income *
Upward reappraisals	Other changes in volume
Reclassifications	Other changes in volume
Reductions	
Depletion	Production, capital account (record as depletion), as relevant allocation of earned income **
Catastrophic losses	Other changes in volume
Downward reappraisals	Other changes in volume
Reclassifications	Other changes in volume
Revaluation	Revaluation
Closing stock	Balance sheet

Source: *Workbook: fish resources*, Year 2 worksheet.

Notes: * if split asset: part of the regeneration (recorded as negative depletion) allocated to the legal owner; ** if split asset: part of the cost of depletion allocated to the legal owner.

5.3.3. Specific topics

Costs of fishery management

571. In some countries, government makes (significant) cost to manage the fishery. It is not recommended to include the cost of fishery management as costs in resource rent calculation. This is also not standard practice when valuing other natural resources such as subsoil assets.

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one year closer to the resource rent being generated). This value increase (in the year it happens) should be recorded as negative depletion in the production and generation of income account. In the year that the decision was taken to close the fishery, the increase in value of the resource should be recorded as negative depletion.

Vertical integration

572. In many circumstances, fishing operations are highly intertwined with the processing of fish, which is called vertical integration. For instance, fish is already processed on vessels, or by the same company on shore. While it is preferred to separately identify processing activities, and only record resource rents generated by the fish before processing, it is recognized that this will prove difficult in practice. The distortion this may cause will in many cases be negligible.

Treatment of overseas territories

573. Some countries may have overseas territories with fish resources. The recommendation here is to fully align scope of measurement with the economic territory which underpins national accounts compilation, and is defined as: 2025 SNA (5.14): “The economic territory includes the land area, airspace, territorial waters, including jurisdiction over fishing rights and rights to fuels or minerals. In a maritime territory, the economic territory includes islands that belong to the territory.” For users it may be useful to disaggregate the values of fish resources between areas for which it is recommended to align with the Standard country or area codes for statistical use (M49).[135]

Resource rent for different types of activities.

574. As mentioned, there are very different types of fishing activity (commercial vs artisanal) which may result in very different resource rents. It is therefore recommended to separately identify the resource rent inherent in these activities to the extent possible. The output of fishing activities undertaken for own final consumption (e.g. subsistence fishing) would be included in production, however would not lead to the recognition of an asset. Therefore, also no depletion would be recorded in these instances, which would be consistent with the observation that oftentimes such activities can be considered sustainable.

Depletion caused by non-resident operators

575. During the development of the guide, the issue emerged how to treat depletion caused by non-resident operators (both inward i.e. by non-resident operators (from country A) in the economic territory of the compiling economy (say country B) and outward i.e. by resident operators (from B) abroad). This is a highly complex issue which was not explicitly discussed during the SNA update process. The 2025 SNA states as follows: “While in principle depletion would be recorded against the production of the non-resident unit, there is currently no agreed treatment for the recording of these flows in the integrated framework of national accounts or balance of payments. Thus, an exception is made such that no depletion is recorded in the accounts of the non-resident extractor. Where the fishing is managed, for example under quota arrangements, then following the treatments outlined above, the manager of the resource, commonly the government, may receive payments of rent and consequently have a share of the value of the fish resources on its balance sheet. An associated entry for depletion should also be recorded as appropriate in the other changes in volume of assets and liabilities account.” (2025 SNA 27.46) Therefore, in these situations, no depletion should be recorded in the current accounts; depletion will only be recorded as in the 2008 SNA as an entry in the other changes in the volume of assets account (K21). The issue is placed on the post 2025 SNA/BPM research agenda.

576. However, countries are encouraged to further test and experiment with measurement in these types of situations. A possible solution that emerged from discussions in the EGNC would be the following:

- All production is recorded by country A. This appears to be in line with current national accounting practices to include all fishing activity regardless in which economic territory it occurs.

[135] https://unstats.un.org/unsd/methodology/m49/

- All depletion is recorded by country A in its production and generation of income account.
- All the asset value is recorded by country B which receives through the allocation of earned income account all the depletion from country A (in addition to rent payments). It is important to note that the rent payment need not be equal to the depletion.
- Country B therefore ends up with 100% of the depletion in its capital account.

577. This recording however introduces a discrepancy with the Balance of Payments due to the transfer of depletion costs from the rest of the world. There are also several practical measurement challenges, such as the estimation of depletion costs to stocks outside the national territories. An alternative recording solution would be to introduce notional units which would be resident units in country B owned by country A.

578. Regarding the treatment of illegal fishing, the 2025 SNA specifies the following: "It is not realistic to consider that permission would be given to exhaust fish stocks, but illegal and unregulated fishing may either reduce the stock below the point of sustainability or exhaust them altogether. In these cases, and providing the activity is of a sufficiently large size and has an ongoing nature, entries to recognize additional economic asset value can be recorded. Specifically, entries will be required to show the economic appearance of the additional value of fish resources (generally in the accounts of the government) and to show the uncompensated seizure of fish resources by the extractor. Any depletion of the fish resources attributable to the fishing activity should be recorded against the extractor. Where the illegal or unregulated fishing is small in scale no changes in stock are recorded" (27.45). In case fishing activity by non-resident operators occurs illegally (and on a commercial basis), the asset would first be recognized as an appearance of an asset (K1) in country B, followed by uncompensated seizure (K4) by country A, after which recording of depletion in the accounts of country A would take place.

5.3.4. Modifications to the standard approach

579. The approach described in Section 5.3 is to be understood as the Tier 2 (default) method. As countries differ in their data availability and resources for conducting valuation of natural resource, this section describes also a Tier 1 (basic) approach that would typically be followed in case of limited data availability and/or resources, as well as Tier 3 (advanced) methods requiring high data availability and resources.

Basic approach

580. For the basic method it is assumed that no physical data exists about catch or landings. Therefore, instead of averaging unit resource rents, the best thing we can do is to average resource rents (that is we skip Steps 3 and 5 of stage 3). Moreover, it may not be possible to determine separate resource rents for species groups.

581. As a result, it is recommended in the basic approach to estimate a weighted asset life based on output shares of the various species groups see Table 5-20. The development of the weighted asset life can be used to estimate the cost of depletion (or regeneration in case the weighted asset life increases), as in Table 5-17, with revaluation obtained as a residual.

Table 5-20 Weighting asset lives for fish stocks based on output shares

	2023				2024			
Species	**Stock assessment**	**Output (%)**	**Asset life**	**Weighted asset life**	**Stock assessment**	**Output (%)**	**Asset life**	**Weighted asset life**
A	Overexploited	50	10	5.0	Overexploited	55	9	5.0
B	Exploited (sustainably managed)	30	25	7.5	Exploited (sustainably managed)	25	25	6.3
C	Overexploited	20	5	1.0	Overexploited	20	4	0.8
		100		**13.5**		100		**10**

Source: *Workbook: fish resources*, Stage 2 Physical data worksheet.

582. In case individual species are not managed, it can be assumed that the asset value is 0.

Advanced methods

583. In an ideal situation, one would have detailed information about each of the main fisheries (i.e. spatially explicit) that would allow to compile a physical asset account of each species (opening and closing stocks, growth, catch, age groups etc.). Sometimes, such information is readily available from specialized research agencies or universities. One could measure depletion by comparing the natural growth with the gross catch (multiplied with the asset price in use) i.e. the default approach to measuring depletion. In case of significant by-catch, it would be generally recommended to assess the gross catch instead of landings.

584. In case more detailed information was available about different age cohorts within specific fisheries, it would be possible to set-up biophysical models as mentioned in Section 3.5.1 for the main fish species. These models have two key advantages. First, they would allow to make dynamic projections of future stocks based on current catch levels. Second, they would allow to estimate the sustainable yield (and maximum sustainable yield) of fisheries. As a result, more advanced measures of depletion could be undertaken based for instance on the reduction in sustainable yield of current fishing efforts. Hereto, also more specific information about the type of catch (e.g. by size or age of different species) would be relevant. As a result, it would also be possible to assess for instance, the effect of switching to different fishing techniques that reduce by-catch of immature fish.

Biophysical models may also be established that go beyond individual fish stocks and look at the interaction between different fish species (e.g. predator-prey relationships). (Yun et al. 2017). This would bring us in the realm of SEEA Ecosystem Accounting.

Country example: valuation of fish resources in the United Kingdom

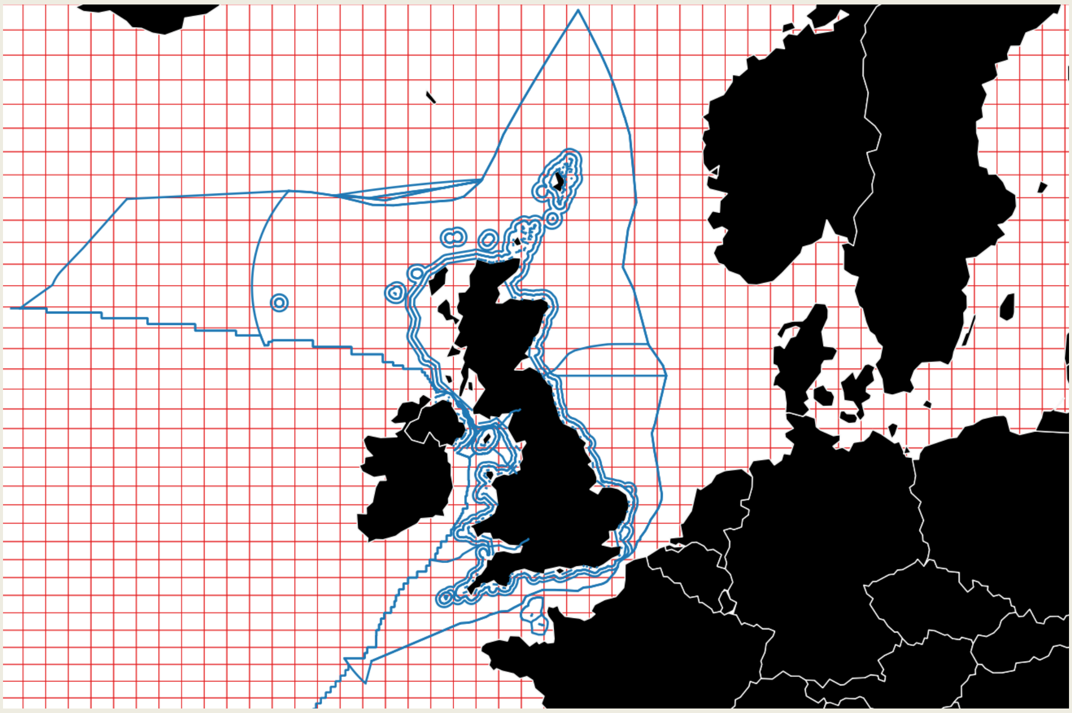
The UK's Natural Capital Accounts included estimates for fisheries value since their first publication. This was a challenge since the intent was to value fisheries in the UK Exclusive Economic Zone (EEZ) but UK vessels capture fish from outside of this area. Equally fish from the UK EEZ are captured by foreign vessels meaning that the UK fishing industry does not provide an accurate representation of UK fisheries and this is likely the case for all nations.

In response we initially developed a method linking data from: fishery capture data from vessel logbooks, EEZ mapping and an economic survey of fishing vessels. That work produced a net annual value of fish landed to the fishermen but little about the fish that remained in the sea. We then mapped species catches to estimates of sustainability and used a basic heuristic to estimate the asset value.

STEP 1: Estimate total UK EEZ fishery catch

The EU Commission's Joint Research Centre (JRC) Scientific, Technical and Economic Committee for Fisheries (STECF) as part of the Fisheries Dependent Information (FDI) data call (deep sea) publish annual data on fish captures by species aggregated from logbooks. These are spatially referenced to International Council for the Exploration of the Sea (ICES) rectangles which do not neatly align to the UK EEZ (Figure 5-10). We supplement this with data from the UK's Marine Management Organisation (MMO) who gather the initial data from the UK fleet.

Figure 5-10 Figure 1: Map of North West Europe with ICES Rectangles (red) overlayed with the UK EEZ and territorial boundaries (blue)



The MMO produced a GIS analysis weighing ICES rectangles by the percentage of them lying within the UK EEZ. We then assumed that the fish caught within a rectangle would be caught evenly across that area. Those percentages provided weightings for catch data to provide a near total estimate of catch by species in UK EEZ waters. We do not distinguish between UK and foreign vessels. This figure goes into the physical flow account.

Figure 5-11 Fish capture as an index from the UK Natural Capital Accounts 2023

STEP 2: Net income per tonne landed

Seafish is a public body that supports the UK seafood industry. They produce an annual economic survey of the UK fishing fleet. They gather data on costs by vessel type and can link that to species caught and price of landings with the use of MMO data on landings by stocks (landed value and landed weight) and landings by stocks and species (in cases where species are not managed by total allowable catches). Seafish produce, from those data, estimates of net profit per tonne of fish landed. We make the assumption that foreign vessels have the same costs and income.

STEP 3: Aggregate Fish Profit

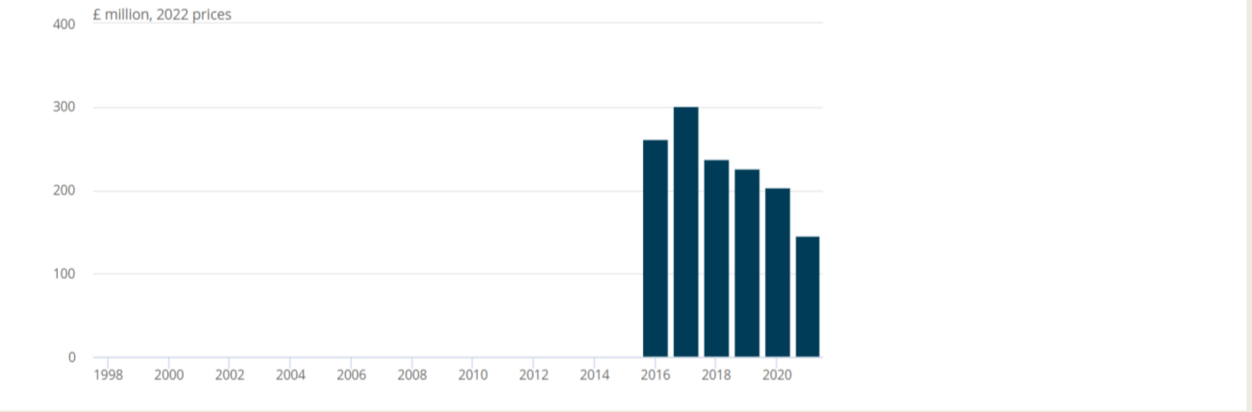
We then match the data using the species name and FAO area[136] caught in between total catch estimated in step 1 with species profits per tonne. We are able to match profit data for approximately 85% of the fish capture tonnage. Once that is done we can multiply the total catch by profit per tonne to produce an annual value. Fish capture data is in landed weight which could mean whole, or gutted but profit data are in live weight leading to a further discrepancy. Using MMO data on live and landed weights of UK vessel landings into the UK showed aggregate landed weight is around 7% less than live weight.

STEP 4: Match to Sustainability Indices

ICES stock assessments produce estimates of whether acceptable mortality range is at or below levels capable of producing maximum sustainable yield; and if each stock's spawning biomass is at or above the level capable of producing the maximum sustainable yield. We rate a stock as sustainable if it meets both requirements. We can spatially match these estimates to catch areas and species. This approach provided stock sustainability estimates for 72% of the fish capture tonnage when we first developed the approach.

[136] The Food and Agricultural Organisation of the UN has defined areas of the sea for statistical purposes.

Figure 5-12 Fish capture value from the UK Natural Capital Accounts 2023



STEP 5: Estimate fisheries asset value

Asset values within the UK Natural Capital accounts are usually estimated as the net present value (NPV) of the discounted stream of income into the future. The UK Natural Capital Accounts have a set of principles which underpin assumptions including that NPV is estimated over 25 years for non-renewable resources and 100 years for renewable resources when there is no alternative. In the absence of detailed fishery models, enabling us to make estimates of the period of time over which an unsustainable fishery would be lost, we consider an unsustainable stock to be a non-renewable asset. We therefore restrict its asset lifetime to 25 years while sustainable fisheries are valued over 100 years.

NEXT STEPS: Depletion

This Methodology represents the current state of the production of fish natural capital estimates for the UK. The UK does not yet produce estimates of depletion. To do so there are some options:

- Develop full bio-economic models of all fisheries and calculate the annual marginal loss from long term production of the population.
- Use the change in asset value from species becoming sustainable and unsustainable appropriately.

Option 1 is highly challenging as has been outlined in section 5.3.4. It would likely to be costly to develop initially and to involve significant ongoing costs to produce. The outcome would however very accurately reflect annual depletion or restoration of fisheries.

Option 2 is initially straightforward. Where a species shifts from sustainable to unsustainable or vice versa the asset value declines in accordance with UK Natural Capital Principles. If a fishery becomes unsustainable, we can estimate the net present value of that fishery if it had remained sustainable and subtract the value it now holds over just 25 years. That difference represents how our crude method estimates the expected loss in asset value assuming the fishery continues to be fished unsustainably.

The simplest thing to do would be to net off that full cost in a single year. However, this does not really represent the impact of a single year of fishing. Some way of apportioning the expected long-term loss across each year the fishery continues to be unsustainable would be more reflective of the impact in that year. For instance, since our approach implies that the population would be fished out over a 25-year period you could divide the total loss by 25, as recommended in the chapter.

If we took this approach to shifting to an unsustainable fishery however it is not clear how we would reflect the process in reverse. Using our current approach the fishery appears to become sustainable in a single year. In truth much of the recovery is likely to have happened while the fishery was classed as unsustainable. To overcome this, we would need to consider ways to differentiate unsustainable fisheries in recovery and unsustainable fisheries in decline. In that way we could use our apportioned values symmetrically.

5.4. Other biological resources

585. In this section we will discuss briefly the valuation of biological resources other than timber or aquatic resources. We will first discuss biological resources yielding repeat products (AN331), followed by biological resources yielding once-only products (AN332) other than fish resources, and then work-in-progress on cultivated biological resources (AN333).

5.4.1. Cultivated biological resources yielding repeat products

Tree, crop and plant resources (AN3312)

586. The 2025 SNA distinguishes between "single-use plants, trees and livestock that produce an output once only (when the plants or trees are cut down or uprooted or the livestock slaughtered) from the relevant work-in-progress related to trees (including vines and shrubs) and livestock that are used in production repeatedly or continuously for more than one year to produce outputs such as fruit, nuts, rubber, milk, wool, power, transportation and entertainment" (11.223).

587. Mature tree, crop and plant resources yielding repeat products are treated as fixed assets. They are usually valued based on a PIM. UNECE (2024), see Table 5-21 provides recommendations for a range of the service life, including an average service life of 15 years that can be used as default.

588. The using up of tree, cop and plant resources in production processes is recorded as depreciation, not as depletion. Investment is recorded as GFCF. Immature tree, crop and plant resources yielding repeat products are recorded as work-in-progress (AN3331).

Table 5-21 Recommendations for average service lives for biological resources yielding repeat products

Asset	Average service life (years)	Range (years)
Animal resources yielding repeat products	10	
Tree, crop and plant resources yielding repeat products	15	10-20

Source: Based on UNECE (2024)

Animals resources yielding repeat products (AN3311)

589. Mature animals yielding repeat products consist of a diverse group including: farm animals such as cows, sheep and goats kept for milk, eggs, or wool; animals such as bulls kept for generating power; horses used for transportation, and finally animals used for entertainment such as circus animals or animals kept in zoos.

590. They are treated as fixed assets and usually valued based on a PIM. UNECE (2024), see Table 5-21, provides recommendations for a range of the service life, including an average service life of 10 years that can be used as default. The using up of animal resources yielding repeat products in production processes is recorded as depreciation, not as depletion.[137] Immature animal resources yielding repeat products are recorded as work-in-progress (AN3331).

5.4.2. Biological resources yielding once only products (other than fish resources)

591. Biological resources yielding once-only products consist of AN3321 Cultivated biological resources yielding once-only products and AN3322 Non-cultivated biological resources yielding once-only products. AN3321 Cultivated biological resources yielding once-only products is in principle an empty category which is only included for completeness of the classification structure. The class is empty because timber resources are always recorded as AN333 work-in-progress, while forest land is always recorded under AN31 Land. The main example of non-cultivated biological resources yielding once-only products consist of fish resources (see Section 5.2 for a detailed discussion of definition and scope), and wild animals (e.g. game) hunted not for own final consumption.

Wild animals (AN 3322)

592. 2025 SNA 11.206-207 clarifies that wild animals are in principle outside the asset boundary, except when the species is controlled (e.g. through hunting rights) or owned. “The growth of animals, birds, fish, etc., living in the wild, or growth of uncultivated vegetation in forests, is not an economic process of production so that the resulting assets cannot be classed as produced assets. Nevertheless, when these uncultivated biological resources forests or the animals, birds, fish, etc. are actually owned by institutional units and are a source of benefit to their owners, they constitute economic assets. When wild animals, birds, fish, etc. live in locations such that no institutional unit is able to exercise effective ownership rights over them they fall outside the asset boundary.”

593. Wild animal resources that fall within the asset boundary can be valued based on market transactions (e.g. prices for killed animals) in combination with information about the population of different species. In the absence of market transaction, the asset value can be based on NPV of future resource rents (for instance by looking at ISIC 017 - Hunting, trapping and related service activities). Their accounting treatment is similar to that of fish resources: they are non-cultivated assets; their generation is recorded as regeneration (and hence as negative depletion) while their run-down is recorded as depletion.

Non-timber forest resources (AN 3322)

594. Gathering of non-timber forest resources such as berries and wild berries constitutes production (2025 SNA 1.68). Only in case gathering of non-timber forest resources is done on a commercial scale it would give rise to a separate asset. This is the reason why such output is not included in calculating

[137] The 2010 ESA deviated from the 2008 SNA. “According to ESA 2010 paragraph 3.140 CFC is not to be calculated for animals, so for this asset, CFC applies to tree, crop and plant resources yielding repeat products. .. For animals, ASL may nevertheless be used to calculate the gross stock with the PIM.” (UNECE 2024)

resource rent when valuing forest land based on the net present value. For the valuation of output, (equivalent) market prices may be used.

5.4.3. Work-in-progress on cultivated biological resources (other than timber)

595. This category covers both AN3331 work-in-progress on biological resources yielding repeat products such as breeding of racehorses or growing of fruit trees, as well as AN3332 work-in-progress on biological resources yielding once-only products such as trees grown for timber. We will discuss here several examples of the latter category due to their importance.

Aquaculture (AN 3332)

596. The SNA does not define or discuss aquaculture specifically. The only reference the 2025 SNA (11.85) makes to aquaculture is that “the infrastructure necessary for aquaculture such as fish farm and shellfish beds” is part of other structures. The SEEA CF follows the FAO definition: “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.”[138] The SEEA CF (5.410) is clear that all aquatic resources that are a result of aquaculture are to be considered as cultivated biological assets.

597. For the purpose of national accounts compilation, cultivated aquatic resources are treated as work-in-progress, with the exception of breeding stocks which are treated as fixed assets.[139] This implies that they are treated as inventories, and these assets are not subject to depreciation or depletion. Valuation of aquatic resources can be based on market transactions, using a PIM, but could also be undertaken based on NPV of resource rents. A recent example of the valuation of aquaculture using the residual value method is from Norway (Graeker and Lindholt (2021).

Animals for slaughter (excluding aquaculture) and agricultural crops (AN 3332)

598. Animals for slaughter consist of domestic livestock such as chickens, ducks, cows, pigs, sheep, turkeys, that are raised for food production. CPC 2.1 distinguishes in Group 21 live animals between: bovine animals; other ruminants; horses and other equines; swine / pigs; poultry; and, other. Agricultural crops are described in CPC 2,1 in Division 01 Products of agriculture, horticulture and market gardening as consisting of: cereals; vegetables; fruits and nuts; oilseeds and oleaginous fruits; edible roots and tubers; stimulant, spice and aromatic crops; pulses (dried leguminous vegetables); sugar crops; and, other.[140]

599. Their generation (growth) is recorded as additions to inventories, while their rundown is recorded as withdrawals from inventories. Valuation is usually based on market transactions in combination with agricultural (livestock) statistics: “Regarding livestock raised for slaughter and agricultural crops, the asset only consists of work-in-progress, and can usually be valued by reference to the prices of such products on markets.” (2025 SNA 14.61)

[138] https://www.fao.org/4/X6941E/x6941e04.htm https://www.fao.org/4/X6941E/x6941e04.htm

[139] However, “In all but exceptional cases, though, [aquatic resources maintained for reproduction] will be small and may be ignored unless of significant importance.” (11.214)

[140] i.e. Forage products; fibre crops; plants used in perfumery, pharmacy, or for insecticidal, fungicidal or similar purposes; beet, forage plant and flower seeds; natural rubber; living plants, cut flowers and flower buds; unmanufactured tobacco; other raw vegetable materials.

600. The 2025 SNA specifies that “the output of agriculture, forestry, and fishing is complicated by the fact that the process of production may extend over many months, or even years. For many crops the growing season will span three quarters of the year, with the harvest taking place in the third quarter, and preparation of the fields taking place in the last quarter of the preceding year.” (2025 SNA 18.212) Recording of work-in-progress for agricultural crops will therefore be especially relevant when compiling quarterly accounts.

Summary of key recommendations Chapter 5

Timber resources and forest land (section 5.2)

- It is important to distinguish between timber resources (work-in-progress) recorded under AN333 and forest land (the underlying asset) recorded under AN31 together forming a composite asset.
- For estimating the volume of timber resources, it is recommended to first compile an account for areas of forest land (expressed in hectares). The account for forest land should be disaggregated by (main) species, as different species may have different timber density, growth and mortality rates, etc.
- For valuing timber resources (work-in-progress), the default approach is to use the stumpage price in combination with stocks of standing timber (in physical units).
- When estimating a stumpage price, it is recommended to take an average price of all timber eventually sold (i.e. a weighted average across different wood types and wood uses).
- For the valuation of the underlying asset the preferred valuation method is to use market transactions. In case this is not feasible, it is recommended to apply the Net Present Value of future resource rents. In either method, the value of forest land (the underlying asset) is then calculated as a residual by deducting work-in-progress.
- Output (to be included in GDP) consists of the growth of timber minus natural losses (i.e. net annual increment) that is expected to be harvested. To estimate the percentage of the net annual increment that will be harvested in the future, it is recommended to use land-use planning information and/or information about licenses provided to forest companies. In the absence of such detailed (spatially explicit) information, a coefficient may be applied based on an analysis of historical records of net annual increment and removals.
- To calculate the resource rent for timber production, the RVM should be applied. It is recommended to apply a top-down approach starting from national accounts aggregates for ISIC Division 2: Forestry and logging. As we are valuing timber resources and forest land for the provision of timber, it is important to restrict the scope of ISIC Division 2 to commercial timber harvesting and logging activities, hence excluding ISIC 2.3 Gathering of non-wood forest products.
- It should be assumed that the projected net annual increment remains constant for the remainder of the asset life of the resource. It is recommended to apply as default an asset life of 100 years.
- It is recommended to assume that unit resource rents remain constant in the future unless specific policies have been implemented which would allow to estimate a specific path of future unit resource rents.
- It is possible to arrive at a negative asset value for the underlying asset, in case the value of work-in-progress is larger than the value of composite asset. This is an indication that the work-in-progress is overvalued. To be consistent with the valuation of other natural resources, it is recommended to limit the value of the composite asset to the net present value of resource rents (or the market value of land in case market prices are used) and reassess the value of work-in-progress.
- Overharvesting has two effects: a net withdrawal from work-in-progress and a reduction in the value of the underlying asset in case future growth of timber is reduced, which is recorded as a cost of depletion. Likewise, regeneration may occur in case of underharvesting, recorded as negative depletion. Due to natural variability, it is recommended to apply a bandwidth approach (e.g. if the

ratio of removals (harvest) to net increments is within a 95-105% range, one may just assume a sustainable use).

- The following logic is to be applied in case of illegal logging:
  - In case of regular illegal extraction at commercial scale:
    - In case the asset already exists, this is recorded as an uncompensated seizure of the asset (forest land and work-in-progress).
    - If the asset does not (yet) exist, then such illegal activity would necessitate the creation of the relevant assets in the legal owner's accounts, which would then be shown as seized by the illegal extractor (e.g. in case of logging in protected forest).
  - In case of irregular illegal extraction at small scale:
    - If the asset exists, then this would be recorded as a loss of inventory.
    - If the asset does not exist, illegal extraction would simply be ignored (as it does not concern a transaction (because it is illegal) and there is no inventory to record a loss against), but if it is informal extraction (e.g. household gathering of firewood), it would be recorded as own account production.
- A Tier 1 method consists in looking at the value of harvests as proxy for the accrual recording of output. This may be reasonable if no deforestation is taking place and there are a significant number of forest companies in the country. In case deforestation takes place, the asset life should be estimated based on the average deforestation rate compared with the total forest stock. Depletion could be estimated by dividing the asset value by the expected asset life.
- There are several Tier 3 methods such as applying a hedonic pricing method using observed land transactions or applying the consumption value method rather than the stumpage value method for valuing timber resources.

Fish resources (Section 5.3)

- The SNA is exhaustive implying that all assets with economic value within the asset boundary should be estimated. However, due to the resource-intensive nature of the valuation of aquatic resources, it is proposed to apply a materiality threshold, focusing on the valuation of assets that contribute more than 5% of output in ISIC 031 (Fishing), and for which the long-term average contribution to GDP is at least 0.1%. When a reasonable estimate can be made of how much of the asset value is missed, it is recommended to gross up the asset value. It is recommended to use 12 major groups as a checklist to assess which fish resources are available in the country and would be above the threshold in terms of output.
- The assets to be included in the national balance sheet consist of resources that are exploited and subject to a quota regime within the national Exclusive Economic Zone (EEZ); transboundary stocks (shared with neighboring country(ies)) and/or straddling stocks may also be included if they satisfy the same conditions.
- Regarding gross catch/harvest (output), this will include all fish caught by resident operators regardless of location (in national EEZ, other EEZ or the high seas).
- For valuing fish resources, under some circumstances the value of quota sales can be used to value the fish resource. Necessary conditions are that the right was required during an open competition and that it is transferable i.e. it may be sold to other economic agents. When this approach is not feasible, it is recommended to apply the Net Present Value method of future resource rents.

- While it would be advantageous to compile a full physical asset account for fish resources, it is recognized that this may not be possible for many countries due to data constraints, so this is considered an advanced method. For valuing the natural resource and its depletion or regeneration a more basic method is recommended which estimates depletion as the asset value divided by the asset life.
- The asset life of the resource will depend on how the fish stocks are managed.
    - The preferred option for estimating the asset life would be to use stock assessments for all the species identified within the previous stage. The second-best option would be to collect catch-per-unit effort data. The third option would be to use time series information about catch (landings) to deduce sustainability. The final option would be to rely on other indicators of the condition of the fishery or fish stock.
    - If it is not possible to estimate the asset life of each fish species, but if it is known that the species is in scope of the asset boundary and is sustainably managed, a default asset life of 25 years is recommended.
- For measuring resource rent, it is recommended to apply a top-down approach starting from national accounts aggregates of ISIC group 031 - Fishing.
- It is recommended to assume that the unit resource rent will remain constant in the projection period unless specific policies have been implemented which would allow us to estimate a specific path of future unit resource rents.
- The number of years used for smoothing will depend on the type of resource, but typically would range from 3 to 10 years.
- It is not recommended to include these costs of fishery management as costs in the resource rent calculation.
- Some countries may have overseas territories with fish resources. The recommendation here is to fully align the scope of measurement with the economic territory which underpins the national accounts compilation.
- There are very different types of fishing activity (commercial vs. artisanal) which may result in very different resource rents. It is therefore recommended to separately identify the resource rent inherent in these activities to the extent possible.
- The output of fishing activities undertaken for own final consumption (e.g. subsistence fishing) would be included in production, however, would not lead to the recognition of an asset. Therefore, also no depletion would be recorded in these instances.
- A Tier method is required when no physical data exists about catch, in which case a weighted asset life based on output shares of the various species groups can be used.
- In case more detailed information was available about different age cohorts within specific fisheries, it would be possible to set-up biophysical models which would be considered a Tier 3 approach. Biophysical models may also be established that go beyond individual fish stocks and look at the interaction between different fish species (e.g. predator-prey relationships).

6 Volume measures, time series, quarterly estimates and recording natural resources

6.1. Introduction

601. The main purpose of this chapter is to detail how the estimates of natural resources that have been discussed in previous chapters can be recorded in a full sequence of economic accounts.

602. A key distinction in national accounts is between recording estimates in current prices and in constant prices (volume terms). In future, under the 2025 SNA, it is expected that growth estimates published by national statistical offices will include Net Domestic Product (NDP) growth as well as Gross Domestic Product (GDP) growth, and NDP will include depletion of natural resource as well as consumption of fixed capital (depreciation). As figures of economic growth are usually presented in volume terms, it is important to discuss how to obtain estimates of depletion in volume terms. Furthermore, the headline economic growth figures that are followed closely by policy makers and economic analysts are the quarterly growth estimates, so the estimation of depletion on a quarterly basis is also an important topic.

603. The outline of this chapter is as follows. The chapter starts in Section 6.2 with discussing the compilation of stocks and flows of natural resource in volume terms. Section 6.3 looks at the compilation of a time series of natural resources especially how to backcast asset values. This is followed by a discussion in Section 6.4 of quarterly estimates of depletion required to compile NDP at a quarterly basis. Section 6.5 presents split-asset calculations (how to calculate the government's share of natural resource assets). Finally, Section 6.6 contains full sequences of accounts (T-accounts) for the four types of resources discussed in Chapters 4 and 5 – subsoil assets, renewable energy resources, timber resources and forest land, fish resources – with the 2008 SNA and 2025 SNA recordings to illustrate the differences. A text box with a summary of key recommendations concludes the chapter.

6.2. Volume estimates

604. Capital has a dual nature in economics: assets are a store of wealth and they are also used in production, contributing to economic growth. These different perspectives translate into different ways of removing the effect of changes in prices (as also expressed in SEEA Energy[141]).

[141] SEEA Energy para 6.57. "*Volume measures of mineral and energy resources may be compiled to assist in the analysis of the changes in mineral and energy resources over time. Removal of the effect of a price change may be carried out for either of two main purposes: (a) to provide an indicator of the purchasing power of mineral and energy*

605. When considering assets as a store of wealth, making comparisons over time is best served by deflating current asset values by a common price deflator such as a GDP deflator or the Consumer Prices Index (CPI). For instance, if oil prices go up, the current value of subsoil assets will increase. An oil rich country will become relatively richer as the same amount of oil allows them to purchase more products. This increase in wealth is best expressed by deflating with the general change in the level of prices, which captures changes in a wide range of products and services purchased by consumers.

606. The other perspective that can be taken is the production perspective. The main intuition here is that sustaining welfare requires sustaining production possibilities (economic growth). In this perspective, it does not matter whether oil prices increase relative to prices of other products, as we would still be able to produce the same amount of products. Therefore, a comparison over time of the value of natural resources is best served by removing the effect of the price change of the resource, so we are left with the changes in the volume of the resource (e.g. the physical amount of subsoil assets).

607. The 2025 SNA (Chapter 18) contains a detailed discussion of measuring prices and volumes, although it does not specifically discuss balance sheets. Volume in national accounts includes not only changes in quantity, but also changes in quality of products or resources. While acknowledging the usefulness of real aggregates such as "real income" which are deflated by general price deflators (especially as many income flows such as cash transfers cannot be decomposed into a quantity and price dimension), the 2025 SNA generally prefers measurement in volume terms using a suitable (specific) price or volume index. For longer time series, the SNA recommends the use of chain indices. The SNA also prefers to speak about estimates in volume terms (or chain volume index) rather than estimates in constant prices, as the latter assumes the use of prices of a single base year.

608. Few countries have experience compiling natural resource estimates in constant prices or volume terms. However, the World Bank's Changing Wealth of Nations (CWON) programme has included such estimates since the beginning. In the past, a general price deflator has been used; but the 2024 release of the CWON World Bank 2024) will apply a volume index (specifically a Tornquist index).

6.2.1. Calculating monetary asset accounts in volume terms

609. As part of the work for this compilation guide, a worksheet showing how to calculate the monetary asset accounts including depletion in volume terms (constant prices) has been developed for the accompanying workbooks for subsoil assets, renewable energy, and timber resources and forest land[142]. For fish resources, an alternative (Tier 1) method is proposed that allows calculating depletion in volume terms (Section 6.2.2).

610. After exploring three possible methods to remove the effect of price changes on the monetary asset accounts, the following approach is recommended:

- When calculating the 2024 opening stock value (i.e. the 2023 closing stock value), we apply the evolution of the physical measure of the stock between 2023 and 2024. This is equal to applying a constant price-in-situ (as in 2023). To see this, if we assume that there are no changes in the price of the resource, by definition the revaluation element is zero and changes in value are solely due to changes in physical units.

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resources, that is, an estimate of the capacity of a set of resources to be used to acquire a given set of goods and services; or (b) to assess whether there has been a change in the underlying aggregate physical stock of several mineral and energy resources. It may be important for both purposes to be considered when an aggregate analysis of the wealth of a country is being undertaken, or when the relative importance of mineral and energy resources compared with other economic and social assets is being assessed."

[142] There is no depletion for timber resources, which is counted as work-in-progress.

- This is illustrated in the workbooks. For example, for subsoil assets in the worksheet "Volume terms estimates", the recommended method:
  - Calculates the opening stock for 2024 (i.e. the 2023 closing stock value) in cell D10 by multiplying the opening stock for 2023 by the ratio of physical assets at the start of 2024 to physical assets at the start of 2023.
  - Calculates the flows during 2023 by multiplying the 2023 physical asset account flows (Stage 3_Year 2 worksheet rows 28-35) by the average "in situ" price of opening and closing stocks. These in situ prices (for both opening and closing of the accounting period) are calculated as: NPV of asset in current prices *divided by* Physical assets. Revaluations is set to zero.

The results for the case of subsoil assets are shown in Table 6-1. They include a figure of 20.9 for depletion.

Table 6-1 Monetary asset account in current prices and volume terms – an example

	2023	
Subsoil assets	**Current prices**	**Constant prices**
Opening stock	204	204
Additions		
Discoveries / growth	4.2	4.1
Upward reappraisals	2.1	2.0
Reclassifications	0.0	0.0
Reductions		
Depletion	21.5	20.9
Catastrophic losses	0.0	0.0
Downward reappraisals	0.4	0.4
Reclassifications	0.0	0.0
Revaluation	11.3	0.0
Closing stock	200	189

Source: *Workbook: subsoil assets, Volume terms estimates worksheet.*

611. This recommendation is based on the SEEA CF (A5.40) "With the price, quantity and value of the natural resource in situ in hand, it is fairly straightforward to compute a volume measure of the stock of natural resources. In the case of a single homogeneous asset, the volume measure simply equals the evolution of the physical quantity in the ground. In the case of different types of natural resources, an aggregation procedure must be identified to construct a volume index across different types of natural assets." In fact, Schreyer and Obst (2015) propose a natural resource index that can be applied when aggregating across multiple natural resources.

612. The index $I_{\square}^{t}$ proposed by Schreyer and Obst (2015, p.12) is described as an example of a Marshall-Edgeworth type volume index:

$$I_{\square}^{t} = \sum_i \frac{\overline{p_i^t}\, X_i^t}{\sum_i \overline{p_i^t}\, X_i^{t-1}}$$

with $\overline{p_i^t}$ the average price of resource in situ; X_i^t the stock of resource i at time t.

In case of a single resource, this index reduces to the development in physical stocks of the resource.

613. It should be noted that two alternative options for calculating the monetary asset account in constant prices were explored as part of the work on this compilation guide:

- *Alternative option 1*: when calculating the 2024 opening stock value (i.e. the 2023 closing stock value), we apply the smoothed unit resource rent as in mid-2023 (i.e. of the previous year); this procedure can be applied in subsequent years leading to chained volume measures (by multiplication).
- *Alternative option 2*: when calculating the 2024 opening stock value (i.e. the 2023 closing stock value), we express the smoothed unit resource rent of mid-2024 in 2023 prices.

These alternative options were not chosen for the default approach because the costing of depletion is aligned with taking a production perspective, where depletion costs are deducted to signal a future decline in income. , But they are also shown (for reference) in the Volume terms estimates worksheets of the subsoil workbook.

6.2.1. Calculating depletion in volume terms using a Tier 1 method

614. If no physical asset account is available (for example for fish resources), compilers should apply a variation of the recommended approach where depletion is calculated both for opening and closing stocks by dividing these values (now in constant prices) by their respective asset lives at the beginning and end of the accounting period, followed by averaging.

615. This Tier 1 method is illustrated in the workbook for fish resources. First the asset value of the closing stock is expressed in constant prices by applying Alternative 1.[143] The depletion cost in volume terms is deducted from the opening stocks, with the remaining balance recorded as revaluation.

6.3. Backcasting

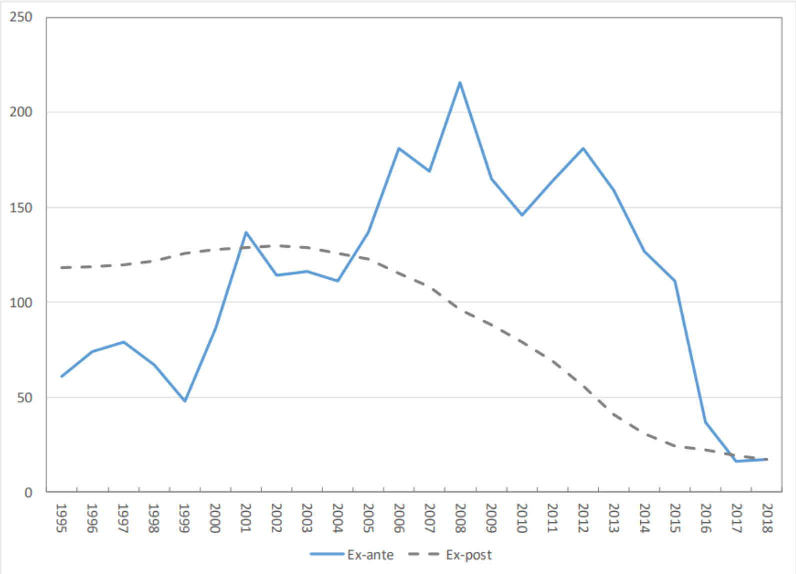
616. It is one thing to start compiling asset values of natural resource, but it is another to also construct a historical time series going back several years. When backcasting, it is useful to distinguish clearly between the principle being applied and the data sources being used.

617. Balance sheets are in principle always forward-looking (commonly referred to as *ex ante*) meaning that when compiling an estimate say for opening stocks of 2024, only information available at or around that time (recognizing that compilation usually occurs several months later) is to be used. When compiling a historical time series, the same *ex ante* principle should be applied also for earlier years (say the period 2010 – 2024) to ensure a consistent time series and thereby facilitate correct interpretation by users. This means that even though we may have information available in retrospect (commonly referred to as *ex post*), for instance that a large discovery of subsoil assets was made in 2020, we should not use this type of information that was not known at the earlier point in time when compiling a historical series.

618. The difference between *ex ante* and *ex post* estimates can be very significant for natural resources. This is well illustrated by the example from de Haan and Haynes (2019) reproduced in Figure 6-1. For resources such as natural gas, the *ex ante* estimates (solid blue line) are much more volatile than the *ex post* estimates (striped grey line) as they reflect discoveries, reclassifications etc., when they occur.

[143] Alternative 1 (as can be seen from the Workbook (Subsoil assets): volume terms, generally provides estimates that are closer to the preferred approach of using the development of physical volumes.

Figure 6-1 Ex ante and ex post values of Dutch natural gas (in billion €)



Source: De Haan and Haynes (2019, Figure 1, p.9).

619. Therefore, to compile a historical time series, it is recommended to first construct a time series of physical asset accounts for the resource, following the same *ex ante* principle. This should contain – to follow the subsoil assets example – information about discoveries, reclassifications etc, when they occurred. As a second step, the asset value at each point in time should be estimated based on the physical data that was known at that point in time (without knowledge, say, of discoveries that occurred at a later date). Unit resource rents should be estimated by applying the same principles that are used when forecasting i.e. using the observed resource rents (say of the past 3 years) and assuming that extraction[144] remains constant. This would guarantee that the resulting time series is compiled consistently.

620. Time series of national accounts data that are used for estimating resource rents are regularly updated, for instance during benchmark revisions. When estimating resource rents, it is recommended to always use the most up-to-date national accounts data for the whole time series (including previous years). This does not violate the *ex ante* principle, as resource rents measure what actually occurred during each year. In other words, there is no problem using better *ex post* data sources for compiling a historical time series based on the *ex ante* principle.

6.4. Quarterly NDP

621. With the increased focus that is expected under the 2025 SNA on net figures such as NDP, as discussed in Section 6.1, it is important to measure the cost of depletion quarterly (and ideally also compile quarterly balance sheets).

622. Ideally, quarterly estimates of depletion should be compiled in the same way as annual estimates. However, the main challenges are that physical asset accounts are not available at that frequency and physical extraction/production figures are likely also to be unavailable. In addition, we may also have

[144] This discussion refers to "extraction" and "discoveries" because the example is for subsoil assets. As shown in Chapters 3, 4 and 5 the lines of the physical asset account vary according to the type of natural resource. For example, the equivalent of extraction for timber resources is "removals" and for fish is "landings" (see Table 3-1).

insufficient information for a resource rent calculation (revenues will be available, but not (detailed) costs). Therefore, this is considered an advanced (Tier 3) method.

623. Compiling estimates for fixed capital stocks and their depreciation faces similar challenges. As explained by the OECD Measuring Capital handbook (OECD 2009) "With the rising importance of quarterly information it would, in principle, be desirable to have a complete set of measures of stocks and flows of capital at quarterly frequency. Given quarterly measures, the annual figures could be consistently built up from the sub-annual data. This is, however, a highly unrealistic scenario. Most of the data sources required to build measures of capital stocks and flows are available at annual frequency or less and the relation between annual and sub-annual measures is not one of consistent construction of yearly data from quarterly observations. Most countries do not construct quarterly capital stock measures or balance sheets. Where quarterly flow variables are required such as for the estimation of consumption of fixed capital), they would typically be based on interpolations of annual data." Although some countries, such as the United States apply a quarterly perpetual inventory model (PIM),[145] most countries still apply some form of interpolation to produce quarterly estimates, using varying methods[146].

624. For the estimation of depletion, it is recommended in the standard approach to apply to the extent possible a similar interpolation (or temporal disaggregation) method as used for estimating depreciation. This has also the advantage that it ensures consistency between depreciation and depletion estimates. Another possibility would be to apply the average ratio of depletion to output of previous periods (preferably using the same number of years as used for smoothing).

6.5. Split-asset calculations

625. In the 2025 SNA assets must be split between extractors (producers) usually in non-financial corporations) and the legal owner (usually general government) based on how much of the resource rent is captured by each party (see Chapter 3).

626. To calculate this, each workbook contains a separate worksheet entitled *Split-asset calculations* which calculates the legal owner's share of resource rent (see Table 6-2), In case the government is not the legal owner, as explained in Section 3.6, the calculation of resource rent should not be corrected for specific taxes less subsidies, but that does not impact the split asset calculation as such. The resource rent is sourced from the worksheet that contains the resource rent calculation required for Step 1 of

[145] Annual Revision of the National Income and Product Accounts: Annual Estimates for 2005–2007 and Quarterly Estimates for 2005:I–2008:I (bea.gov) (p.18)

[146] Examples of methods used are:

Australia applies "Linear interpolation and extrapolation are used to estimate quarterly consumption of fixed capital." (Sources and methods - Quarterly | Australian Bureau of Statistics (abs.gov.au));

Belgium: "There is no quarterly estimate of the fixed capital stock. Quarterly consumption of fixed capital is therefore merely derived from the annual figure by a simple smoothing method, which is perfectly suited to this type of aggregate that moves in very regular patterns." Comptes nationaux trimestriels de la Belgique (nbb.be);

Germany: "The distribution to quarters is done by using an empirical formula." Quarterly national accounts inventory based on ESA 2010 methodology - FS 18, Series S.31 (destatis.de);

Portugal: applies an "econometric method" (https://ec.europa.eu/eurostat/documents/24987/4253464/PT-QNA-Inventory-ESA95.pdf/43888445-a08a-44e1-be1a-e04c98ef81a6);

Compilation stage 3 (within the workbook). Assuming that Stage 3 Step 1 has already been compiled, this process is automatic.

627. However, there is one additional item to be provided: Rent payments to general government for a number of years (D42) (green cells)

628. The legal owner's share is obtained simply by dividing the rent by the total resource rent. This is averaged over the last three years (consistent with the approach for smoothing resource rents in Step 4 of Compilation Stage 3). In the example for subsoil assets, 89% of the resource rent is captured by the legal owner. This proportion is used to split the natural resource asset (stocks) as well as the flows in the sequence of accounts such as depletion, revaluation and other changes in volume.

Table 6-2 Calculating the proportion of assets attributable to general government – an example

	2021	2022	2023
Resource rent	21	22	25
Rent payments to general government (GG) (D42)	19	20	21
GG appropriated (% of total resource rent)	91%	91%	85%
Average (last 3 years)			**89%**

Source: *Workbook: subsoil assets, Split-asset calculations worksheet.*

6.6. Sequence of economic accounts

629. This section contains the SNA sequences of economic accounts (current accounts, accumulation accounts, and balance sheets), based on the examples from the four accompanying workbooks. To illustrate the impacts of the changes, both the 2008 SNA and 2025 SNA sequences are presented. Breakdowns are shown for the two relevant national accounts sectors: S13 general government and S11 non-financial corporations (the sector of the natural resource extractors (producers)[147].

[147] In the case of household production of renewable energy or household extraction of timber or fish resources, compilers may wish to produce a separate worksheet for the 2025 SNA sequence of economic accounts replacing the column for S11 with a column for S14 household sector. In this case, GOS (code B2g) would be replaced with GMI (code B3g), NOS (B2n) with NMI (B3n) and depreciation on GOS (P51d1) with depreciation on GMI (P51d2).

Country example: The Experience of Mexico in Measuring Environmentally Adjusted GDP

The decision made more than 30 years ago by Mexican authorities to address the economic quantification of environmental damage associated with economic activity was basically due to three institutional factors: the progress in the development of systematically ordered economic information (Mexican System of National Accounts. SCNM, by its Spanish acronym); the international collaboration mechanisms (World Bank, United Nations); and the recognition and concern for environmental pressures. The commitment of the United Nations Statistics Division and the World Bank to complete jointly with the National Institute of Statistics and Geography (INEGI, by its Spanish acronym) the first environmental accounting scheme in 1991 is highlighted, which included both the main macroeconomic variables derived from the SCNM and data on the impact of productive activities on the environmental context.

The publication in 1988 of the General Law of Ecological Balance and Environmental Protection (LGEEPA, by its Spanish acronym) is also noteworthy, which demands the quantification of the cost of environmental pollution and the depletion of natural resources caused by economic activities to calculate the Environmentally Adjusted Net Domestic Product (PINE by its Spanish acronym) and its integration into the SCNM.

To integrate environmental aspects into the accounting framework, it is necessary to consider macroeconomic variables such as Gross Domestic Product (GDP) and Consumption of Fixed Capital (CFC), to obtain a measure of Net Domestic Product (NDP). In addition to being an important macroeconomic indicator that considers the wear and tear of fixed assets, is the variable on which adjustments derived from quantitative changes in natural resources and the environment are made, to obtain the PINE.

Moreover, to construct the PINE, environmental accounting in Mexico includes the following elements covering both the depletion of natural resources and environmental degradation: depletion of hydrocarbons (oil and gas); loss of timber forest resources; depletion of groundwater; soil degradation; water pollution; urban solid waste; and air emissions. The first three topics refer to the depletion of natural resources and the remaining four are related to environmental degradation.

Calculations are carried out in two phases. First, depletion and degradation are estimated in physical units such as cubic meters of water, barrels of oil, etc. Second, the economic costs associated with depletion and degradation are estimated through different valuation techniques. Once the economic values are consolidated, the PINE is obtained as follows:

$$PINE = GDP - CFC - Dep - Deg$$

Where:

PINE: Environmentally Adjusted Net Domestic Product

GDP: Gross Domestic Product.

CFC: Consumption of Fixed Capital (associated with the economic assets produced)

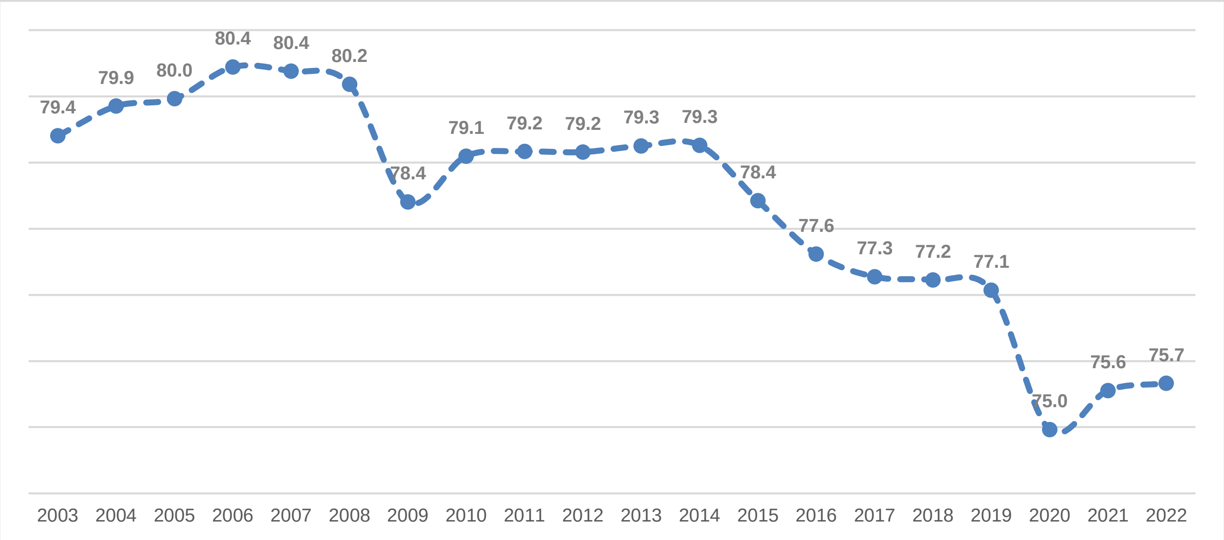
Dep: Depletion cost

Deg: Degradation cost

Particularly, the costs for depletion are the monetary estimates that express the wear or loss of natural resources (equivalent to depreciation), due to their use in the production process. In 2022, the Dep was equivalent to 0.48% of the national GDP of Mexico.

Concerning the depletion of groundwater, the aquifers of the country that are subject to water stress are identified; that is, those in which the amount of water extracted for economic activities is greater than their recharge volume. The cost of their depletion is derived from a shadow pricing technique (as mentioned in SEEA Water), using information from the SCNM and the economic censuses related to the production account of the water operating agencies.

Figure 6-2 PINE as a proportion of GDP

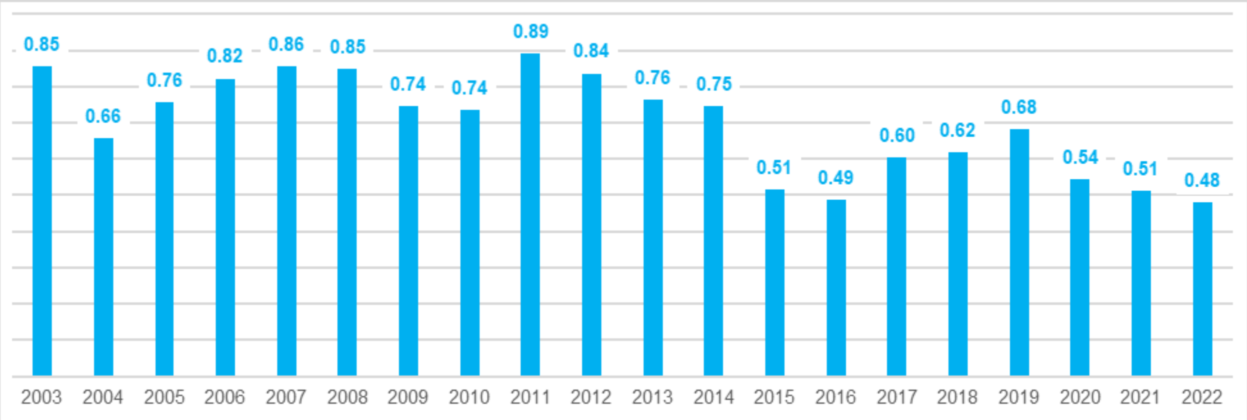


Source: INEGI. Environmental accounts of Mexico

Regarding the depletion of hydrocarbons, the costs for depletion are estimated through the net rent method, which refers to the net income derived from the economic use of the resource, for which the production costs associated with the extractive activity (intermediate consumption, fixed capital consumption, wages to employees, production taxes, and extraction rights) are deducted from the gross income. All variables come from the SCNM.

For timber forest resources, the replacement cost technique is used, which considers the costs of reforestation considering all its stages until reaching the size at which the resources can be economically utilized (minimum 15 years).

Figure 6-3 Economic cost of natural resource depletion, as a proportion of GDP



Source: INEGI. Environmental Accounts of Mexico.

Finally, the costs associated with environmental degradation are based on the minimum costs of restoring or preventing further damage to the environment caused by economic activities. For example, the cost associated with air emissions refers to the minimum amount required to avoid and/or reduce emissions through the implementation of technological solutions such as installing filters. The costs of soil degradation, water pollution, and the generation of urban solid waste are based on similar techniques.

For the implementation of the 2025 SNA, Mexico is planning to review its methods for estimating depletion and degradation.

6.6.1. Subsoil assets

630. shows the 2025 sequence of economic accounts for our workbook example of subsoil assets. Table 6-4 shows the 2008 sequence of economic accounts for our workbook example of subsoil assets. The key differences are:

- *Production and generation of earned income (formerly generation of income) accounts*: GDP is the same, but in the 2025 SNA the NDP value is lower (-21 in our example) due to the inclusion of depletion as a cost of production.
- *Allocation of earned income (formerly allocation of primary income) account*: the depletion borne by the legal owner (S13), which represents a transfer to the producer (S11), is visible for the first time in the 2025 SNA sequence of economic accounts (recorded as a negative revenue of -19 for government and a negative expenditure of -19 for the producer in our example[148]). Also, Net National Income (NNI) is lower (-21).
- *Use of income (formerly use of disposable income) account*: net saving is lower in the 2025 SNA (-21 in our example), with both sectors affected but general government more so than non-financial corporations (-19 compared with -2).

[148] The recording of depletion in the allocation of earned income account as a negative expenditure of the extractor and a negative revenue for the legal owner differs from the SEEA CF Table 5.10 which records it as a positive resource (=revenue) for the extractor and a positive use (=revenue) for the legal owner. The logic of the 2025 SNA is that this recording better shows depletion as offsetting the payment (and receipt) of rent.

- *Accumulation accounts*: there is no impact on net lending/borrowing or transactions in financial assets, but in the 2025 SNA the recording, other changes in volume does not include depletion (as it does in the 2008 SNA) and does include transfers from government to producers of the producer's share of the split assets at the start of the period; in the 2008 SNA, the asset value stays with government.
- *Balance sheet*: total net worth (opening and closing) is the same, but the sectoral allocation of the closing stocks differs, with S11 having larger net worth in the 2025 sequence.

Renewable energy resources

631. *Workbook: renewable energy resources, 2025 SNA Sequence of Accounts* shows the 2025 sequence of economic accounts for our workbook example of renewable energy resources. *Workbook: renewable energy resources, 2008 SNA Sequence of Accounts* shows the 2008 sequence of economic accounts for our workbook example of renewable energy resources. The key differences are:

- *Production and generation of earned income (formerly generation of income) accounts*: GDP and NDP are the same as no depletion (or regeneration) is possible for renewable energy resources. (In the 2025 presentation of the sequence of economic accounts in the workbook, the depletion lines are set to zero).
- *Accumulation accounts*: in the 2025 SNA other changes in volume includes transfers from government to producers of the producer's share of the split assets at the start of the period whereas in the 2008 SNA the asset value stays with government.
- *Balance sheet*: total net worth (opening and closing) is the same, but the sectoral allocation of the closing stocks differs, with S11 having larger net worth in the 2025 sequence.

6.6.2. Timber resources and forest land

632. *Workbook: timber resources and forest land, 2025 SNA Sequence of Accounts* contains the full 2025 sequence of economic accounts recording of the timber resources and forest land example. *Workbook: timber resources and forest land, 2008 SNA Sequence of Accounts* contains the full 2008 sequence of economic accounts recording of the timber resources and forest land example, where it is assumed that species A was considered cultivated according to the 2008 SNA and species B non-cultivated.

633. Compilers should note that for the accumulation accounts and balance sheet, the *Sequence of accounts 2008 SNA* worksheet in the *Workbook: timber resources and forest land* links to an auxiliary worksheet showing the monetary asset accounts compiled according to the methods for estimating cultivated and non-cultivated forest land in the 2008 SNA. The cells linking from the *Sequence of accounts 2008 SNA* worksheet to this auxiliary worksheet are highlighted in orange.

634. Key differences between the 2008 and 2025 SNAs are the following:

- *Production and generation of earned income (formerly generation of income) accounts*: the output recorded is different because in 2008 SNA the output consists of natural growth of Species A and harvest (removals) for Species B, while in the 2025 SNA the output for Species B also consists of the natural growth. In our example, GDP according to the 2025 SNA is lower

(-19).[149] NDP according to 2025 SNA presentation is lower (-22) partly due to the lower GDP and partly due to the inclusion of costs of depletion.

- *Allocation of earned income (formerly allocation of primary income) account*: the depletion borne by government (S13), which represents a transfer to the producer (S11), is visible for the first time in the 2025 SNA sequence of economic accounts (a transfer of 2 in our example). Also, Net National Income (NNI) is lower (-22).
- *Use of income (formerly use of disposable income) account*: net saving is lower in the 2025 SNA (-22 in our example), with both sectors affected but non-financial corporations more so than general government (-20 compared with -2).
- *Accumulation accounts*:
  - In the *capital account*, work-in-progress for timber resources is included in the sequence of accounts (by contrast with the other natural resources in this compilation guide). The numbers are different in the 2008 and 2025 SNA presentations, reflecting the differences in scope of cultivated assets: in the 2008 SNA, work-in-progress is only included for Species A, whereas in the 2025 SNA work-in-progress is recorded for both species.
  - In the *other changes in volume of assets account*, the 2025 SNA presentation includes transfers from government to producers of the producer's share of the split assets at the start of the period, whereas in the 2008 SNA the asset value (work-in-progress for timber resources and underlying asset) stays with government.
- *Balance sheet*: both total net worth and the sectoral allocation of the opening and closing stock values differs between the 2008 SNA and the 2025 SNA. To obtain 2008 SNA-consistent asset values, values for Species A and B are calculated in the auxiliary worksheet. Species B is valued based on sales of harvested timber as output (instead of the net increment) in the resource rent calculation. Species A is valued as in the 2025 SNA approach. In the case of our example we find that the 2025 net worth is higher than the 2008 net worth and around half of the closing stock value is attributed to the economic owner (S11).

6.6.3. Fish resources

635. *Workbook: fish resources, 2025 SNA Sequence of Accounts* shows the 2025 sequence of economic accounts for our workbook example of fish resources. *Workbook: fish resources, 2008 SNA Sequence of Accounts* shows the 2008 sequence of economic accounts for our workbook example of fish resources. The key differences are:

- *Production and generation of earned income (formerly generation of income) accounts*: GDP is the same, but the 2025 SNA NDP value is lower (-62) due to the recording of depletion as a cost of production.
- *Allocation of earned income (formerly allocation of primary income) account*: the depletion borne by government (S13), which represents a transfer to the producer (S11), is visible for the first time in the 2025 SNA sequence of economic accounts (a transfer of 25 in our example). Also, Net National Income (NNI) is lower (-62), with non-financial corporations affected more than general government.

[149] This is a result in our specific example. GDP could also be higher if different numbers were chosen.

- *Use of income (formerly use of disposable income) account*: net saving is lower in the 2025 SNA (-62 in our example), with both sectors affected but non-financial corporations more so than general government (-37 compared with -25).
- *Accumulation accounts*: in the 2025 SNA other changes in volume includes transfers from government to producers of the producer's share of the split assets at the start of the period, whereas in the 2008 SNA the asset value stays with government.
- *Balance sheet*: total net worth (opening and closing) is the same, but the sectoral allocation of the closing stocks differs, with S11 having much larger net worth in the 2025 sequence.

Table 6-3 Sequence of economic accounts - subsoil assets 2025 SNA

	Current accounts								
	Expenditures		S13	S11		Revenues		S13	S11
Code		**Total**	**GOVERNMENT**	**PRODUCER**	**Code**		**Total**	**GOVERNMENT**	**PRODUCER**
	Production account								
P2	Intermediate consumption	11		11	P1	Output (basic prices)	109		109
B1g	Value added (gross)/Gross Domestic Product	98		98					
P51d	Depreciation	29		29					
P8	Depletion	21		21					
B1n	Value added (net)/Net Domestic Product	*47*		*47*					
	Generation of earned income account								
D1	Renumeration of employees	27		27	B1n	Value added (gross)/Gross Domestic Product	98		98
D29	Other taxes on production	2		2					
D39	Other subsidies on production	-3		-3					
B2g	Operating surplus, gross	73		73					
P51d1	Depreciation on gross operating surplus	29		29					
P81	Depletion on gross operating surplus	21		21					
B2n	Operating surplus, net	22		22					
	Allocation of earned income account								
					B2n	Operating surplus, net	22		22
D21	Taxes on products				D21	Taxes on products	4	4	
D31	Subsidies on products				D31	Subsidies on products	-2	-2	
D29	Other taxes on production				D29	Other taxes on production	2	2	
D39	Other subsidies on production				D39	Other subsidies on production	-3	-3	
D42	Rent	21		21	D42	Rent	21	21	
D42dep	Depletion borne by legal owner	-19		-19	D42dep	Depletion borne by legal owner	-19	-19	
B5n	Balance of earned income, net/Net National Income	23	3	19					
	Transfer income account								
D51	Current taxes on income	18		18	D51	Current taxes on income	18	18	
	Use of income account								
B8n	Saving, net	23	21	1					
	Accumulation accounts								
	Changes in assets		S13	S11		Changes in liabilities and net worth		S13	S11
Code		**Total**	**GOVERNMENT**	**PRODUCER**	**Code**		**Total**	**GOVERNMENT**	**PRODUCER**
	Capital account								
					B8n	Net saving	23	21	1
NF1	Acquisition less disposals of assets	0	0	0	D9	Net capital transfers received	0	0	0
NF11 (=P411g)	Gross Fixed Capital Formation	0		0					
P51d	Depreciation	-29		-29					
NF35 (= P8)	Depletion of natural resources	-21	0	-21					
B9	Net lending/borrowing	74	21	52	B101	Changes in net worth due to saving and capital tr	23	21	1
	Financial account								
F2-F8	Transactions in financial instruments	72.5	39	34	B9	Net lending/borrowing	74	21	52
	Other changes in the volume of assets account								
K1-K6	Other changes in volume due to due to (dis)appearance of assets (discoveries), catastrophic losses, reclassifications, uncompensated seizures	5.9	5	1					
K1-K6	Other changes in volume due to transfer from government to producer of share of split asset at start of production period*	0.0	-26	26					
					B102	Changes in net worth due to other changes in vol	6	-20	26
	Revaluation account								
K7	Revaluations	11.3	10	1					
					B103	Changes in net worth due to revaluations	11	10	1
	Balance sheet								
	Assets		S13	S11		Liabilities and net worth		S13	S11
		Total	**GOVERNMENT**	**PRODUCER**				**GOVERNMENT**	**PRODUCER**
	Opening balance								
	Financial instruments	0	0	0					
	Fixed capital	264		264					
	Natural resources	204	204	0					
					B90	Net Worth	468	204	264
	Changes in assets								
	Financial instruments	73	39.0	33.5					
	Fixed capital	-29	0	-29					
	Natural resources	-4	-10	6					
	Closing balance								
	Financial instruments	73	39	34					
	Fixed capital	235	0	235					
	Natural resources	200	194	6					
					B90	Net worth	507	233	274

Source: *Workbook: subsoil resources, 2025 SNA Sequence of Accounts*.

Table 6-4 Sequence of economic accounts - subsoil assets 2008 SNA

Code	Uses	Total	S13 GOVERNMENT	S11 PRODUCER	Code	Resources	Total	S13 GOVERNMENT	S11 PRODUCER
	Current accounts								
	Production account								
P2	Intermediate consumption	11		11	P1	Output (basic prices)	109		109
B1g	Value added (gross - basic prices)/Gross Domestic Product	98		98					
P51c	Consumption of fixed capital	29		*29*					
Not app	*Depletion*								
B1n	Value added (net)/Net Domestic Product	*69*		*69*					
	Generation of income account								
D1	Compensation of employees	27		27	B1n	Value added (gross - basic prices)/Gross Domes	98		98
D29	Other taxes on production	2		2					
D39	Other subsidies on production (-)	-3		-3					
B2g	GOS	73		73					
P51c1	Consumption of fixed capital on GOS	29		29					
Not app	*Depletion of natural resources*								
B2n	NOS	43		43					
	Allocation of primary income account								
					B2n	NOS	43		43
D21	Taxes on products				D21	Taxes on products	4	4	
D31	Subsidies on products				D31	Subsidies on products	-2	-2	
D29	Other taxes on production				D29	Other taxes on production	2	2	
D39	Other subsidies on production				D39	Other subsidies on production	-3	-3	
D45	Rent	21		21	D45	Rent	21	21	
Not app	*Depletion borne by government*				*Not app*	*Depletion borne by government*			
B5n	Balance of primary incomes, net/Net National Income	44	22	22					
	Secondary distribution of income account								
D51	Current taxes on income	18		18	D51	Current taxes on income	18	18	
	Use of disposable income account								
B8n	Net saving	44	40	4					

Code	Changes in assets	Total	S13 GOVERNMENT	S11 PRODUCER	Code	Changes in liabilities and net worth	Total	S13 GOVERNMENT	S11 PRODUCER
	Accumulation accounts								
	Capital account								
					B8n	Net saving	44	40	4
AN212	Acquisitions less disposals of assets	0	0	0	D9	Net capital transfers received	0	0	0
P51g	GFCF	0		0					
P51c	Consumption of fixed capital	-29		-29					
Not app	*Depletion of natural resources*								
B9	Net lending/borrowing	74	40	34	B101	Changes in net worth due to saving and capital tr	44	40	4
	Financial account								
F2-F8	Transactions in financial instruments	73	39	34	B9	Net lending/borrowing	74	40	34
	Other changes in the volume of assets account								
K1-K6	Other changes in volume due to due to (dis)appearance of assets (discoveries, depletion), catastrophic losses, reclassifications, uncompensated seizures	-16	-16						
					B102	Changes in net worth due to other changes in vol	-16	-16	0
	Revaluation account								
K7	Revaluations	11	11						
					B103	Changes in net worth due to revaluations	11	11	0

Code	Assets	Total	S13 GOVERNMENT	S11 PRODUCER	Code	Liabilities and net worth		S13 GOVERNMENT	S11 PRODUCER
	Balance sheet								
	Opening balance								
	Financial instruments	0	0	0					
	Fixed capital	264		264					
	Natural resources	204	204	0					
					B90	Net Worth	468	204	264
	Changes in assets								
	Financial instruments	73	39	34					
	Fixed capital	-29	0	-29					
	Natural resources	-4	-4	0					
	Closing balance								
	Financial instruments	73	39	34					
	Fixed capital	235	0	235					
	Natural resources	200	200	0					
					B90	Net worth	507	239	268

Source: *Workbook: subsoil resources, 2008 SNA Sequence of Accounts*.

Summary of key recommendations Chapter 6

Calculating monetary asset accounts (and depletion cost) in volume terms (section 6.2)

- In case of a single homogeneous asset, the volume measure simply equals the evolution of the physical quantity in the ground.
- In the case of different types of natural resources, an aggregation procedure must be identified to construct a volume index across different types of natural assets, such as the index proposed by Schreyer and Obst (2015).
- If no physical asset account is available (for example for fish resources), compilers should first estimate opening and closing stocks (in constant prices), which after dividing (and averaging) by their respective asset lives at the beginning and end of the accounting period, provide a constant price estimate of depletion.

Backcasting (section 6.3)

- The NPV estimate is to be considered a best estimate at the time it is made and is always forward looking.
- Monetary values should not be revised in retrospect as a result of changes in physical estimates, but it is recommended to always use the most up-to-date national accounts data when calculating resource rent and asset values.

Quarterly estimates of depletion (section 6.4)

- Ideally, quarterly estimates of depletion should be compiled in the same way as annual estimates, however this may not be feasible due to lack of data.
- For the quarterly estimation of depletion, it is recommended in the standard approach to apply to the extent possible a similar interpolation (or temporal disaggregation) method as used for estimating depreciation.
- Another possibility would be to apply the average ratio of depletion to output of previous periods (preferably using the same number of years as used for smoothing).

Annex: The Levelized Cost of Electricity method

Least cost alternative (LCA) methods have not been applied so far within an SNA context, but they have been applied in several cases of macro-economic research for the valuation of hydro resources. The most common LCA approach involves modelling two energy systems: one system where the renewable energy asset of interest provides a certain amount of electricity and another system where that resource is not present and other technologies increase their output to meet the amount of electricity produced by the resource of interest. The cost differential between the two systems is attributed as the renewable resource value. The modelling requirements are high and lie more in the field of energy modelling (Zuker & Jenkins, 1984). This approach is therefore deemed infeasible for the purposes of valuing renewable energy resources in national accounts. Consequently, a more universally applicable cost-based method is required.

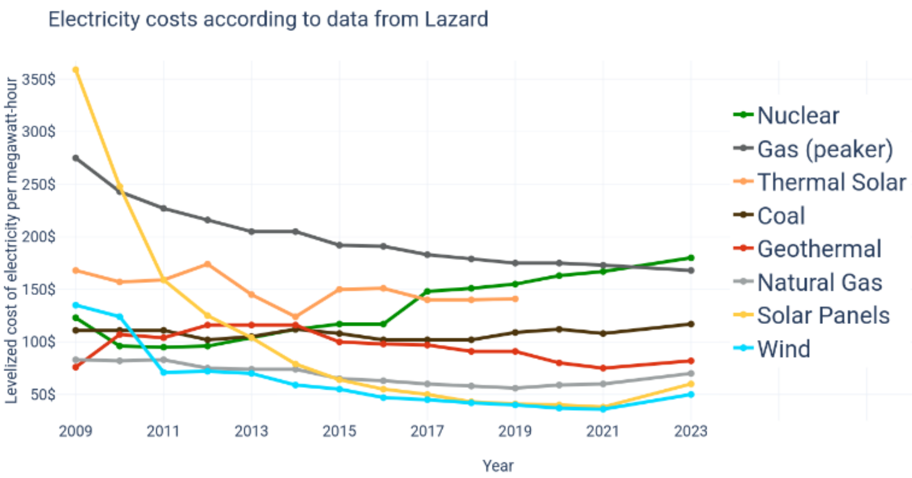
One possibility lies in applying an LCA method using the levelized cost of electricity (LCOE), a cost indicator that is widely used to compare the cost-competitiveness of energy technologies in the energy sector (IRENA, 2023). The LCOE represents the sum of discounted costs per unit electricity generated over the project's lifetime. The LCOE can also be defined as the electricity tariff at which an investor would precisely break even after paying the required rates of return on capital, given the costs incurred over the lifetime of a technology.

In its most basic and common form, LCOE can be calculated using Equation B1, which is the method used by IRENA.

$$LCOE = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

Where: I_t = investment expenditures in the year t; M_t = operations and maintenance expenditures in the year t; F_t = fuel expenditures in the year t; E_t = electricity generation in the year t; r = discount rate; n = asset life.

Several organisations produce LCOE data (with varying degrees of technology, geographical and temporal coverage) (Bloomberg, 2015; IEA, 2020; IRENA, 2023; Lazard, 2023). For instance, the LCOE data from Lazard show that the LCOE of solar panels became lower than that of coal around 2010 and that of natural gas around 2015.



Source: Lazard (2023)

The resource rent can be estimated based on the difference in LCOEs between the focus resource (e.g. solar) and the least cost alternative (e.g. gas) multiplied with the electricity generated by the resource:

$$R_{A,t} = \left(LCOE_{A,t} - LCOE_{x,t}\right) \times \left(P_{A,t}\right)$$

Where $R_{A,t}$ is the rent generated by resource A in year t in USD, $LCOE_{A,t}$ the LCOE of resource A in year t in USD/MWh, $P_{A,t}$ is the amount of electricity generated by resource A in year t in MWh. A is the resource of interest, X the least cost alternative.

The results will depend on which resource is used as least cost alternative: all possible resources, only the 'green' resources or only the 'grey' resources. It seems most logical to select the LCA from the 'grey' resources, for several reasons. First, using a comparison with all resources or with green resources would imply that some renewable energy resources would obtain a positive value and some a negative value, as only 1 resource can be the LCA. Second, it will be the case in many countries that not all renewable energy resources technologies are feasible (legally, technically).

In a final step, the estimated rent can be used to estimate an asset value by using the NPV method.

An advantage of the LCOE based LCA method is that the results are easy to interpret. Rents become positive at the moment the resource in question has the lowest cost per unit electricity.

There are however a number of challenges with the method. First, LCOE data is not publicly available for all countries. Organizations such as the IEA and IRENA compile LCOE values, but not in the year-on-year time series that is required for this method. However, it should not be very difficult to calculate LCOE values directly. The main data requirements are investment and current expenditures on fuel and maintenance which should be available from business surveys. Information about generation should be available from energy statistics; expected lifetimes of the equipment can be taken as the same as used in the capital stock model.

The second issue is that LCOE calculation methods are not standardized and different sources take different factors into account. In some cases, additional cost components are considered. BloombergNEF and the IEA, also include carbon costs and the IEA also includes decommissioning costs. Further standardisation would be required.

The third and decisive issue is that the group of resources against which you value the resource drives the outcome. The method is based on applying a counterfactual approach ('what if'') which goes beyond the valuation principles commonly applied in national accounts which describe what actually happened in the economy, not what could have happened.

Therefore, the LCA is not considered a suitable method for application in a national accounts context. However, the approach may prove valuable for application in other analytical contexts.

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