DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS
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Draft Guidance Note

B1/B5: Description of physical supply and use tables with relation to economy-wide material flow accounts

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DRAFT GUIDANCE NOTE Issue B.1/B.5 "Description of PSUTs and EW-MFA"

Content

1 Introduction

1.1 Purpose of the Guidance note

1. This guidance note integrates two issues for which separate scoping notes had been prepared in the update process of the SEEA CF:

   B1 “Description of PSUTs (physical supply and use tables)”

   B5 “Differences between PSUTs and EW-MFA (economy-wide material flow accounts)”

2. The accounting framework of physical supply and use tables (PSUTs) forms the conceptual basis for SEEA physical flow accounts. Its generic architecture is derived from monetary supply and use tables (SNA SUTs) extended by additional components necessary to present physical flows within the economy and between environment and economy.

3. Scoping note B1 (PSUT) identifies a range of motivations, proposals for changes, and research questions, which may be summarized to three clusters:

   - Enhance consistency throughout chapter III describing different physical flow accounts (energy, water, materials, waste) and their relations with other SEEA- and SNA-accounts (monetary SUTs), and new treatments introduced by the 2025 SNA (e.g., biological natural resources);
   - Focus on policy relevance (e.g., circular economy);
   - Elaborate on possible ‘new’ physical accounts that are emerging (e.g., plastics).

4. Scoping note B1 also states: “Although the issue was tagged as “textual” the revision would appear to be more substantial since the concepts of the PSUT lay the foundation for the physical flow accounts.”

5. Scoping note B5 calls for a clarification of differences between PSUTs and economy-wide material flow accounts (EW-MFA), with a focus on treatment of biomass flows.

1.2 Process for developing the Guidance Note

6. From the beginning, it was obvious that this guidance note does tackle more than one single item. In a first step, the lead author collected from the team possible issues. These were compiled to a remarkable long list with annotations and shared. The next challenge was to develop a structure (table of content) for this guidance note able to accommodate the long list of issues.

1.3 Structure

7. The structure of this Guidance note deviates from the template recommended by the chief editor for several reasons. The most important is that this guidance note does not only tackle on single issue but obviously many, which in addition needed to be ordered and structured in a

systematic way. The latter is significantly facilitated by distinguishing between the theoretical framework and applications thereof.

8. Chapter 2 presents issue related to the theoretical framework. The clearer the concepts are for the theoretical framework, the easier is it to use them as guidance for the implementation of specific physical flow accounts and thus ensuring conceptual coherence across them. Chapter 3 addresses issues related to the implementation/application of the theoretical framework, including policy relevance (circular economy). Chapter 4 briefly presents most common examples of applications of physical flow accounts.

9. Chapter 5 addresses the re-organization of SEEA-CF's chapter III, as proposed by Scoping note B1. One basic choice to be discussed is the clear distinction between descriptions of the theoretical framework and descriptions of a wide range of implementations/applications. This distinction proofed to facilitate the grouping of the many issues relevant for this guidance note, also enabling a more systematic discussion.

10. Questions for discussion by task team B are spread throughout the text.

1.4 Links to other Guidance notes

11. This guidance note B1/B5 has links to the following other Guidance notes

- A1: links to SEEA EA
- A9: Consistency with the SNA
- B2: Treatment of losses
- B3: Carbon flows
- B6: Pressure accounts
- B7: Waste accounts
- D1: Carbon stock
- D3: Physical produced assets
- D4: Water as a produced asset
- D8: Atmosphere as an asset

2 Issues for clarification related to the theoretical framework:

2.1 Introduction

12. This chapter presents issues for clarification related to the theoretical framework for physical flow accounts. The SEEA-CF has chosen physical supply and use tables (PSUT) as the appropriate accounting framework to represent the physical economy and its interrelations

with the environment. This choice goes back to earlier versions of the SEEA. It has to be noted that the accounting framework of supply and use tables induces double-counting. A piece of matter extracted from nature is counted several times along its production-consumption-chain throughout the economy.

13. The issues presented in this chapter relate to the scope and basic accounting principles of the theoretical framework and the accurate description of rows and columns. The presentation and discussion of these issues is structured and facilitated with the help of an 'image': Basic form of a physical supply and use table (Table 1), which is an up-date/refinement of Table 2.2 in the 2012 SEEA-CF section 2.3.2.
14. Evidently, the theoretical framework is 'theoretical'. It is not supposed to be entirely implementable. Therefore, classifications and balancing items are not tackled at this stage, but addressed in the next chapter presenting issues related to the various implementations/applications of the theoretical framework.
15. The theoretical framework aligns by default to SNA principles such as e.g., the residence principle and the change-of-ownership principle (transactions in products between residents and non-residents). Deviations or exceptions are thinkable for the various implementations/applications and hence presented and further discussed in the next chapter.
16. The scope of the theoretical framework is all-encompassing and as wide as thinkable. It aims at covering all theoretically thinkable physical flows related to and within the economy and its physical interrelations with the environment. This includes all economic flows (transactions in products) as recorded in SNA's supply and use tables associated to economic units' activities of production, consumption and accumulation. In addition, it encompasses intra-economy flows beyond the SNA theoretical ('general') and practical ('measurement') production boundary. Finally, it takes into account all imaginable physical interrelationships between economy and environment. This includes also e.g., respiration flows of humans, pets and farm animals; evapotranspiration of cultivated plants etc.

Question 1

Q: Do you agree to choose the widest scope thinkable for theoretical framework of physical flow accounts?

Question 2

Q: By default, stick to basic SNA principles such as e.g., the residence principle for the theoretical framework of physical flow accounts?

17. Less clear is the theoretical link between ecosystem accounts and the theoretical framework for physical flow accounts. For instance, should ecosystem services be included in physical flow accounts (aka PSUTs) or are they already included in form of natural inputs in cases they are physically measurable?

Question 3

Q: Include flows of ecosystem services (as row category) into the theoretical framework?

2.2 SEEA-typology of physical flows

18. The SEEA-CF has established three categories of physical flows, namely natural inputs, products and residuals (referred to as 'SEEA-typology of physical flows'). The theoretical framework aims at capturing all thinkable physical flows within the economy and those between environment and economy. Hence, the three types of physical flows should capture all these thinkable physical flows in a as far as possible statistically discrete manner.

19. The current SEEA-CF 2012 definitions of residuals (e.g., chapter III section 3.2.4, §§ 3.73ff.) are somewhat unclear and may deserve improvement. Initially, residuals were defined as physical flows from economy to environment. Later, its coverage was extended to include certain flows within the economy such as e.g., waste and energy temporarily stored in plastic products. One may try to define residuals by negation; the basic idea: Residuals are physical flows other than products and natural inputs. This requires as clear as possible definitions of products and natural inputs - and related to this - of the sphere 'environment' (see paragraphs related to the PSUT-column 'environment').

Natural inputs

20. Based on the current SEEA-CF 2012, natural inputs may be defined as all physical flows that are moved or directly used from their location in the environment as part of economic activities of production, consumption and accumulation. Natural inputs include all thinkable physical artefacts flowing from the environment to the economy, including things such as solar radiation, wind, geothermal energy, ambient heat, kinetic energy etc.

21. The current SEEA-CF 2012 text related to the definition of natural inputs might deserve some refinements/improvements with regards to the following aspects:

    - The current three broad classes of natural inputs (SEEA 2012 § 3.46) should be revisited after the SNA 2025 has introduced a new classification of non-financial assets (AN codes) including a separate class for natural resource assets which explicitly include renewable energy resources.
    - SEEA-CF 2012 § 3.48 stating that the environment-economy-border is to be determined on a case-by-case basis should be revisited. Maybe it is better to develop a theoretical 'entry-point' that is valid for all natural inputs at least as far as the theoretical framework is concerned; case-by-case determination could be mentioned for the applications?
    - SEEA-CF 2012 §§ 3.49-3.51 on natural resource residuals could be revisited. The current definition seems to be limited to natural inputs that are not incorporated into products and immediately re-injected into the environment without being transformed. Maybe the scope could be widened as to include transformed natural inputs returned to the environment such as respiratory flows (O_2 transformed to CO_2 by human respiration).

Products

22. The current SEEA-CF definition of product flows (SEEA-CF 2012 § 2.19) is derived from SNA (e.g., SNA 2025 §§ 1.61 ff., §§ 7.23 ff.). Products are the output of the activity of production which is "understood to be a physical process, carried out under the responsibility, control and management of an institutional unit, in which labour and assets are used to transform inputs of goods and services into outputs of other goods and services. All goods and services produced as outputs must be such that they can be sold on markets or at least be capable of being provided by one unit to another, with or without charge." (SNA 2025 § 1.61). Goods for own use are within SNA production boundary, while services produced for own use are out (SNA 2025 § 1.61). For example, … agricultural products consumed by households that they have produced themselves and also the values of the housing services consumed by owner occupiers are within production boundary (SNA 2025 § 1.67).
23. The SNA distinguishes a 'general production boundary' (SNA 2025 §§ 7.24-7.25) and a 'measurement' production boundary applied in the integrated framework of the SNA (SNA 2025 §§ 7.26-7.56, §§ 7.93-7.98, §§ 7.104-108, §§ 7.120-7.135, §§ 7.140-146, §§ 7.147-7.160). For the theoretical framework of physical flow accounts, it is recommended to employ the wider, 'general' production boundary to demarcate flows of products in order to capture all intra-economy physical flows. With regards to a clear boundary towards intra-economy residual flows it might be worthwhile to further examine whether the SNA boundary of transactions in products (SNA 2025 Annex 2; P codes) could serve as a helpful criterion.

Residuals

24. Physical flows from the economy to the environment are per se of the residual type. The current definition (SEEA-CF2012 § 2.92) is clear with regards to this. It is less clear concerning intra-economy physical flows that might be classified under the residual type. The main challenge is to develop clear criteria for the demarcation between intra-economy flows of products and intra-economy physical flows of residuals? When does the 'SNA-life' of a product end and when is it turned into a residual?
25. One idea is to define residuals by negation: An intra-economy residual flow is any actual physical flow within the economy that does not fall under the scope of transactions in products produced within the 'general' SNA production boundary.
26. Residuals may form input to production; how can this case be distinguished from intermediate consumption of products? The residual should not have any economic value similar to that it delivered in its former product-life. For example, a motor vehicle constitutes a residual when it flows from one economic unit to another who uses it to recover secondary raw materials such as steel, plastics etc. However, if a motor vehicle flows from one unit to another who uses it for its original purpose, it is a product flow (transaction in products) even if the providing unit does not receive money for this transaction.

2.3 Basic form of a physical supply and use table

27. Table 1 presents a basic form of a physical supply and use table. The rows are organised by three generic types of physical flows, described already in the 2012 SEEA-CF and discussed in previous paragraphs.

Table 1: Basic form of a physical supply and use table

what (activity):	production	consumption	accumulation	rest of the world	environment	total
who:	resident economic units involved in production	resident economic units involved in final consumption	resident economic units involved in accumulation	non-resident economic units	global natural resources (non-produced)	
breakdown e.g. by...:	ISIC industries	sectors relevant	to be determined	aggregated	domestic vs. rest of the world; owned vs. non-owned	
Supply table	1	2	3	4	5	6
Natural inputs A.					supply to resident units	total supply of natural inputs
Products B.	output		from produced assets	imports - from non-residents to residents		total supply of products
Residuals C.	generated from production	generated from final consumption	from domestic stocks	shipments		total supply of residuals
Use table						
Natural inputs D.	input to production (extraction)	used by resident community e.g. oxygen				total use of natural inputs
Products E.	intermediate consumption	final consumption	to produced assets	exports - from residents to non-residents		total use of products
Residuals F.	input to production		to deposits of residuals	shipments	released to environment	total use of residuals
supply and use are...	*balanced*	*balanced*	*not balanced*	*not balanced*	*not balanced*	*balanced*
				balanced		

28. With regards to the PSUT columns one may consider to improve the current description with the aim to make clear what exactly PSUTs present in columns. This concerns rather the theoretical all-encompassing physical flow accounting framework and maybe less the specific physical flow accounts as those may have rows and columns tailored to the respective subject (see further below). One particular case for clarification is the PSUT-column heading 'accumulation'. It certainly encompasses the changes in produced assets as applied in the SNA SUTs (gross capital formation). But there are other forms of physical accumulation that need to be considered in physical flow accounts. For instance, private households accumulate durable consumer goods which do not have any equivalent item in SNA SUTs.

29. The following paragraphs describe in more detail each of the five columns shown in Table 1. Emphasis is given to issue where the scope of the theoretical framework for physical flow accounts necessarily goes beyond the scope of SNA SUTs in order to cover all physical flows.

Production (column 1 in Table 1) - balanced

30. The SNA provides a clear definition of production activities (see above, section on products). Production activities are undertaken by potentially all resident economic units including households. For the theoretical framework the 'general' production boundary applies. This includes for instance intra-establishment own account production for intermediate use as well as e.g., household's production such as e.g., gardening.
31. The first PSUT-column in Table 1 records in the upper supply part all physical outputs from the production processes undertaken by resident economic units. It is composed of the output of products (quadrant B.1) and the supply of residuals that arise during the production process (quadrant C.1). The output of products in physical terms (B.1) goes beyond the output recorded in monetary terms (SNA-code P1) because of intra-establishment flows that are additionally taken into physical account and a specific way of recording the production of agriculture, forestry and fishing (see below).
32. The lower use part of the production column shows the physical inputs into the production processes by resident economic units. These are composed of natural inputs (D.1), products (E.1) and residuals (F.1).
33. By definition, the production column must be balanced in physical terms; i.e., the inputs into the production process equal the output. Any accumulation by the economic units engaged in production must be recorded in the accumulation column.

Consumption (column 2 in Table 1) - balanced

34. The second PSUT-column in Table 1 is dedicated to final consumption, which by definition is only undertakable by resident economic units grouped in households, government and NPISH. This physical consumption column is termed 'households' in 2012 SEEA-CF. The rationale behind was that final consumption expenditures by government and NPISH include only services that are non-physical. This justification is debatable because also the consumption of services can involve physical flows. On the other hand, it can be argued that final expenditures by government and NPISH eventually are for the benefit of private households. Irrespective of the heading labelling, collective consumption activities by government and NPISH are included in the theoretical framework.
35. The physical consumption column in Table 1 is confined in a narrower sense than in the respective column of the monetary SUT (SNA-code P3). The physical consumption column excludes consumer durables which are recorded separately under accumulation.
36. In the lower use part, the physical consumption column shows the consumption of products (E.2) that are consumed within the current accounting period. Next to this, it records the use of natural inputs (D.2) in association with consumption, i.e., the physical inflows related to the metabolism of humans and domestic animals.

37. The PSUT consumption column shows in the upper supply part the residuals arising from the consumption of products that takes place in the accounting period (C.2). This includes the metabolic outflows of humans and domestic animals. By definition, quadrants A.2 and B.2 are blank.

38. By definition, the consumption column must be balanced in physical terms; i.e., the inputs equal the outputs. Any accumulation by economic units engaged in consumption must be recorded in the accumulation column.

Accumulation (column 3 in Table 1) – not balanced

39. The third PSUT-column in Table 1 is dedicated to accumulation activities undertaken by resident economic units. Accumulation relates to stocks of physical artefacts built-up by and under control of economic units – referred to as produced assets in the following. More precisely, accumulation in the context of the theoretical physical flow accounts relates to changes of produced assets, i.e., the physical flows that constitute additions/entries to and withdrawals from.

40. The upper supply part of the accumulation column in Table 1 records withdrawals from produced assets. These concern products (B.3) and residuals (C.3). Withdrawals of products occur in association with inventories of finished goods and produced natural resources (see below). Withdrawals of residuals mainly in form of used-up products at the end of their lifetime concerns produced assets such as consumer durables (see below) and fixed assets (of investment goods).

41. The lower use part of the accumulation column in Table 1 records additions/entries to produced assets for products (E.3) and residuals (F.3). The latter are related to physical deposits such as controlled landfills (see below).

42. Natural inputs (A.3 and D.3) are by definition not subject to accumulation activities by resident economic units.

43. The accumulation-column in the theoretical framework for physical flow accounts (Table 1) deviates significantly from its equivalent in SNA SUTs. There are a range of additional accumulation processes that are relevant from a physical perspective.

44. The SNA SUT accumulation column is confined to the SNA concept of gross capital formation (SNA-code P51g), with its components gross fixed capital formation, changes in inventories of finished products, and changes in valuables. Notably, SNA SUTs include in gross capital formation only those changes that correspond to transactions. Other flows, non-transaction flows such as e.g., catastrophic losses, are not considered in SNA SUTs. Obviously, these need to be taken into account in the all-encompassing theoretical framework for physical flow accounts as they constitute physical exchange between economy and environment.

45. A further important point is that the SNA SUTs apply a net-recording of accumulation processes. Instead of recording additions/entries to and withdrawals from stocks separately in the use and supply table respectively, they record only net changes of stocks in the use table. I.e., the supply table remains null for accumulation. This net-recording of accumulation in

products has good reasons: the total supply of products is confined to the accounting period, i.e., domestic production of output of the accounting period plus imports of product; elsewise recording would inflate the total supply with products produced in earlier periods that are released from stocks. As for the theoretical framework for physical flow accounts (Table 1) the same net-recording for accumulation in products is recommended (see Question 4 further below). In contrast, accumulation in residual should be recorded gross in both: the physical supply and use table.

46. In addition to the afore mentioned gross capital formation the accumulation column of the theoretical framework includes physical flows related to:
    - consumer durables;
    - physical deposits of materials/energy such as e.g., landfills or batteries;
    - produced natural resources.

47. Physical transactions in products associated with final consumption expenditures are to be decomposed into those used off in the accounting period (discussed above under consumption) and those used over a longer period by the owning resident economic unit. The latter form stocks of consumer durables and the respective changes (entries and withdrawals) fall under accumulation activities recorded in in the theoretical framework for physical flow accounts.

48. There are physical deposits of materials/energy produced and maintained by economic units that are not considered in SNA SUTs but obviously need to be taken into account in the theoretical framework for physical flow accounts. Most prominent example are controlled landfills which are the destination for residuals that are not released to the environment. Another example is carbon capture storage.

49. Physical flows related to changes in produced biological resources is a special issue to be considered in the theoretical framework for physical flow accounts (Table 1). It closely relates to the recording of physical flows related to production activities in agriculture and forestry (see separate section below

Rest of the world (column 4 in Table 1) – not balanced

50. The fifth PSUT-column in Table 1 is dedicated to physical flows between resident economic units of the reporting country and non-resident economic. The upper supply part of the rest of the world column in Table 1 records imports of products (B.4) and inward shipments of residuals (C.4). The lower use part of the rest of the world column in Table 1 records exports of products (E.5) and outward shipments of residuals (F.4). Natural inputs (A.4 and D.4) are by definition not subject to physical exchanges between resident and non-resident units.

51. The change-of-ownership principle is the guiding SNA concept for recording transactions in products between residents and non-resident units. A priori, the theoretical framework would stick to this. However, SNA rules for 'goods sent abroad for processing' or more broadly 'processing abroad' in general might be a problem case from a physical recording point of view. This issue is addressed in the next chapter dealing with issues related to implementation/application of the theoretical framework?

52. In addition, there are physical exchanges of residuals between resident units and non-resident units, referred to as cross-border shipments of residuals. For instance, it is common that waste management companies of a given country send waste for further treatment to waste management companies in another country. These shipments of wastes may be reported in ITGS.

Environment / global natural resources non-produced (column 5 in Table 1) – not balanced

53. The fifth PSUT-column in Table 1 is dedicated to physical flows between environment and resident economic units.

54. What is environment? = Non-produced natural resources; i.e. physical stocks not managed, controlled by economic units; can be located anywhere (e.g. atmosphere)

Basic accounting rules

55. The following basic accounting rules can be formulated (also indicated in Table 1):

- row-totals in supply table must equal row-totals of use table
- supply and use of columns 1 and 2 must be balances
- supply and use of the individual columns 3,4, and 5 are not balanced; for their collective (the aggregated columns 3,4 and 5) the supply and use must be balanced.

2.4 General links between assets and physical flows

56. The theoretical framework includes numerous physical flows that at the same time may constitute items of stock accounts, namely additions to and withdrawals from certain stocks of physical artefacts. These 'stock-changing' physical flows are recorded in the PSUT-columns 'accumulation' and 'environment'. Broadly, one can state that physical flows related to intra-economy stocks are recorded under PSUT column 'accumulation', while physical flows related to natural stocks in the widest sense are recorded under PSUT-column 'environment'. In detail, things are a bit more complicated and depend on how asset accounts are defined, demarcated and classified.

Physical flows related to 'accumulation' = (net) changes of intra-economy physical stocks

57. The intra-economy physical stocks are located within the economy and can be broadly grouped into those ones defined in the SNA and others beyond SNA. Notably, the SEEA-CF has not established physical asset accounts for intra-economy stocks so far.

58. The SNA 2025 includes two intra-economy stocks which are relevant for physical flow accounts[1]:

[1] The third category *non-produced non-financial assets (excluding natural resources)* encompasses immaterial assets such as contracts, leases and licenses.

- Produced non-financial assets (excluding produced natural resources) (SNA code AN1); notably annex 2 of SNA 2025 mentions consumer durables as a supplementary item.
- Natural resources (AN3), of which the class of cultivated biological resources are considered intra-economy physical stocks.

59. Products are added to and withdrawn from these types of intra-economy assets. SNA-SUTs do record these product flows in form of net changes (acquisition less disposals) denoted as 'gross capital formation', which is further broken down by three sub-classes:

    - Gross fixed capital formation (GFCF);
    - Changes in inventories;
    - Acquisition less disposals of valuables.

    Notably, these intra-economy assets include cultivated biological resources (see separate section further below).

60. In addition, there are two intra-economy stocks not considered in SNA SUTs, which are relevant for recording in physical flow accounts:

    - Consumer durables
    - Physical deposits of materials and energy (e.g., landfills, carbon capture storages)

Question 4

Q: Do you agree that the theoretical framework for physical flow accounts should record product flows related to intra-economy stocks on a net-change basis (consistent with SNA SUTs).

Pros:

Cell B.3 of the physical supply table remains null, implying that total supply of products is composed of two components – namely, output (P1) and imports (P6) – fully consistent with SNA SUTs.

In case, cell B.3 of the supply table is filled, the total supply of products is higher than P1+P6. Transactions in used products (e.g., from fixed assets to households) or transfers of mature biological resources from inventories to gross capital formation would significantly inflate the total supply of products.

Physical flows related to 'environment' = physical exchanges with natural capital stocks

61. The bio-physical environment – also referred to as natural capital or environmental assets (terminology still needs to be clarified and settled, see issue A.9 and guidance note A9.3) – can be thought of as a huge stock of natural materials and energy surrounding the economy. Physical flow accounts (PSUT) record all thinkable physical exchanges between this widest scope of 'environment' and the economy (aka the entirety of all resident economic units' activities) under the heading of PSUT-column 'environment'. Natural inputs are physical removals from the natural stocks flowing into the economy and are recorded in the physical supply table against the heading 'environment'. The use table records residuals flowing from

the economy to the 'environment' which can be considered physical additions to or uptakes by the natural stocks.

62. Some of the physical exchanges between the 'environment' and the economy recorded in physical flow accounts may constitute accounting-items in physical asset accounts. The exact determination depends on the future definitions and classifications of physical asset accounts in SEEA-CF and SEEA-Ecosystem Accounts (see SEEA-CF up-date issues A1 and A9). So far, only parts of the all-encompassing natural capital stock are articulated in SEEA-CF asset accounts. Notably, only those environmental assets can be linked to physical flow accounts that are measurable in tonnes or Joule.

Link to land and soil resources

63. Land and soil resources are environmental assets outside the economy. Nevertheless, they are underlying assets to cultivated biological resources. The physical relation is as follows: Land is immaterial space not measured in tonnes or Joule and hence not subject to physical exchanges between environment and economy recorded in physical flow accounts. Soil is also an underlying asset to cultivated biological resources belonging to the environment (i.e. outside economy) and there are physical (widely material) exchanges between soil resources and cultivated biological resources such as flows of nutrients, water, minerals. The latter are recorded as natural inputs flows between soil resource and economy. Soil resources provide further natural inputs to the economy, i.e. beyond cultivated biological resources. E.g., construction activities excavate soil some of which is immediately returned (natural resource residuals), some of which might be transformed to products, some of which might be re-located to intra-economy deposits of residuals (e.g., landfills).

2.5 Biological resources and the representation of related flows in the theoretical framework

64. There are two generic cases of biological resources to be distinguished – that bring about two different ways representing related physical flows in the theoretical framework:

- ***cultivated*** biological resources, the growing of which falls within the SNA production boundary; and
- ***non-cultivated*** biological resources, the growing of which is natural and hence outside SNA production boundary, nevertheless, providing natural inputs to production processes.

65. The SNA represents the biomass growth of ***cultivated*** biological resources as the output of respective production activities (agriculture, forestry and fisheries). The physical inputs to that type of production process are (i) products (e.g., fertilizers, fodder, diesel) and (ii) natural inputs (e.g., transpiratory oxygen and carbon dioxide, soil nutrients, non-produced water), both recorded in the physical use table. The physical outputs, recorded in the supply table, are the respective agricultural, forestry or fishery (iii) products and (iv) residuals generated by that production process (e.g., transpiratory oxygen and carbon dioxide, water vapour, harvest and slaughter residuals). According to SNA, this biomass growth is considered an addition to product inventories (work-in-progress), while its harvest (or slaughter) and recurrent losses

(quasi natural mortality) are considered a removal from product inventories. By SNA SUT convention, additions and removals are recorded net in the use table as changes in product inventories. Net-additions (growth exceeds harvest/slaughter and recurrent losses) have a positive sign and net-removals (harvest/slaughter and recurrent losses exceed growth) have a negative sign.

66. A special case are ***cultivated*** biological resources yielding repeat products such as dairy animals or fruit trees. Their biomass growth is recorded as described above. Once they reach maturity and start to yield products, they are transferred from product inventories (work-in-progress) to gross fixed capital formation.

67. The representation of physical flows related to ***non-cultivated*** biological resources is different. Their biomass growth is considered a natural process outside the SNA production boundary and hence not represented in the recording. The production process is confined to the wild harvest or wild catch, which has slightly different portfolios of inputs and outputs. The physical inputs to that type of production process are (i) products (e.g., diesel) and (ii) natural inputs (e.g., wild fish). The physical outputs, recorded in the supply table, are the respective agricultural, forestry or fishery (iii) products and (iv) residuals (e.g., by-catch) generated by that production process.

2.6 Remarks on re-use, recovery, and recycling

68. This guidance note can only touch very broadly on re-use, recovery and recycling. More detailed elaborations will be subject to another guidance note on waste accounts (issue B7).

69. **Re-use**, in general, is the practice of using an item again for its original purpose (direct re-use) or a new purpose (indirect re-use), instead of disposing it. I.e., re-use commonly happens before an item is disposed of as waste. Usually, it is the owner of an item (product) himself who does re-use it, i.e., a kind of prolongation of the item's lifetime. If the owner sells the item (product) to another unit who intends to re-use the item, it constitutes a transaction in products (used product) and as such it is recorded in physical flow accounts.

70. **Re-use** may be the business of production activities (ISIC 4669 'Wholesale of waste and scrap and other products n.e.c.', ISIC 4774 'retail sale of second-hand goods') re-using items (or components thereof) disposed of by their holders for the same purpose for which they were conceived. In such cases, re-use commonly implies a residual flow from the former owner to the respective industry; the latter 'converts' the residual input or parts thereof into a product output.

71. **Recovery/recycling** of waste is when the holder disposes of an item (end-of-life product) as waste which the waste management industry transforms into products a or waste for further use. The difference to re-use is that a transformation takes place and the new item is functionally different from the former item disposed of.

72. **Recovery** is a production activity classified in ISIC 3830 'Materials recovery' that transforms residuals, irrespective of whether the residual is legally declared as waste or not, into products (secondary raw materials).

3 Issues related to the application/implementation of the theoretical framework

Introduction

73. This chapter addresses issues related to implementations/applications of the theoretical framework for physical flow accounts; in the following referred to as applications of physical flow accounts.

74. Applications of physical flow accounts may for good reasons deviate from principles postulated for the theoretical framework in previous chapter. The theoretical framework serves as a reference point to make these deviations explicit. Applications need detailed international guidelines to ensure cross-country-comparability.

Incomplete scope of applications – theoretical framework serves as reference

75. The theoretical framework for physical flow accounts does not claim to be implementable in its all-inclusiveness and all-encompassing scope. Data constraints, limited measurability and resources may make only 'partial' articulations of it feasible.

76. Even 'complete' PSUTs for materials – compiled by Statistics Denmark, CBS or DESTATIS – constitute such 'partial' articulations as they are not able to cope entirely with the all-encompassing scope of the theoretical framework. For instance, they may omit the one or the other physical flow related to the biological metabolism of humans, domesticated animals, cultivated plants and farm animals; or they may exclude bulk water flows. Likewise, Eurostat's physical energy flow accounts (PEFA), which at the first sight might seem a 'complete' PSUT for energy are limited in scope vis-à-vis the theoretical framework. For instance, PEFA do not take into account energy incorporated in food and beverages that energize the metabolism of humans and cultivated animals, nor do PEFA account for solar radiation energizing growth of biomass. Another example is the exclusion of water in economy-wide material flow accounts.

77. All implementations/applications of the theoretical framework seem necessarily partial and limited with regards to scope and/or coverage of flows. These can be made explicit by referring to the all-encompassing theoretical framework; serving a reference point is a benefit as such of the theoretical framework.

Balancing items – theoretical framework serves as reference, integrate into flexible classifications

78. The limited scopes or partialities of applications of physical flow accounts make it necessary introducing sort of balancing items – e.g., to meet accounting rules of mass-balancing or energy-balancing. For instance, economy-wide material flow accounts have introduced well-defined balancing items in order to derive net additions to stock. Balancing items become in particular necessary when it comes to special physical flow accounts focussing on selected materials such as e.g., for plastic or other specific materials.

79. Referring to the theoretical framework may help to identify and clearly define balancing items for the various applications of physical flow accounts.

80. These balancing items can be introduced for rows as well as for columns:

- Balancing column-wise (input-output): Balancing item can consist of several physical flows (rows): oxygen used for incineration, water loss/gain, or dissipative flows.
- Balancing row-wise (supply-use): Applications of physical flow accounts may not include all five columns of the theoretical framework; e.g. include only environment and rest of the world. Then it is necessary to introduce balancing columns, which in this example is equivalent to accumulation (buildings, durable consumption goods). The EW-MFA indicator net additions to stock is an example.

81. Balancing items should be integrated part of classifications for rows and/or columns. As addressed elsewhere in this chapter, classifications for applications of physical flow accounts could be developed in a flexible way. This enables to integrate necessary balancing items.

82. There could be a terminological issue with 'balancing items'. The term may be used to denote two slightly different things:

(1) an 'not observable' item that can only be derived through arithmetic balancing of other 'observable' items;

(2) a class encompassing a range of items that are grouped together, like a category 'others'.

EW-MFA provide a good example for these two notions: net addition to stocks (NAS) is an item of the first meaning. In order to enable its arithmetical derivation, EW-MFA introduced to its classification of rows (aka material) two items:
- MF8.1 'balancing items: input side' and
- MF8.2 'balancing items: output side'.
The SNA employs the term 'balancing item' in the first meaning.

83. Statistical differences could be regarded as a specific balancing item that may as well occur in both, rows and columns. It accommodates imbalances due to different data sources. E.g., the amount of generated electricity might be reported by powerplants while the use of electricity is reported by retailers; it is likely that the two reported numbers do not match. Like for balancing items in general, statistical differences might be integrated into classifications for rows and columns.

Bridging items

84. Applications of physical flow accounts may for good reasons (e.g., policy relevance, data sources or constraints) deviate from SNA principles or accounting rules valid for the theoretical framework. These possible conceptual deviations concern e.g.:
- residence principle;
- change-of-ownership principle for trade;
- recording of goods sent abroad for processing or more generally processing abroad.

85. In such cases, scalars, vectors or matrices of bridging items can be used to present and make explicit conceptual differences. This might not be always feasible due to data constraints, though. SNA SUT margin/transport matrices ‘bridging’ between different price concepts are an example.

86. Bridging items may also be useful to link/connect applications of physical flow accounts to relevant other statistical frameworks. E.g., Eurostat ‘s air emissions accounts encompass bridging tables linking to policy relevant indicators of UNFCCC greenhouse gas inventories.

Flexible organisation and classification of rows and columns

87. The SEEA-CF seems partly incoherent with regards to classification of rows and columns. This incoherence across the chapters and across the sections in chapter 3 needs to be reviewed. There is an obvious need for clarification and – if appropriate – coherence across the entire text body of the SEEA-CF.

88. The previous chapter on the theoretical framework presents a basic form for physical supply and use tables with 3 rows and 5 columns (Table 1); by purpose, it did not tackle deeper classifications thereof. The basic form with 3 rows and 5 columns could be regarded as a principle or ‘minimum requirement’ to be met by applications. At least, it could serve as a reference point to make explicit deviations from it.

89. Evidently, applications of physical flow accounts require guidelines for more detailed classifications (deeper granulating the basic form’s 3 rows and 5 columns). The further detailing of rows and columns of specific applications of physical accounts depends on factors such as policy relevance (purpose of the application) and data availability. Both may change over time. Hence, one may consider to keep a certain flexibility with regards to the ‘prescription’ of classifications? This flexibility gives freedom to the applications to better serve policy demands and to adjust to data constraints.

Material layers

90. It is thinkable to apply the theoretical framework through developing layers for specific materials or substances. Imagine a complete physical supply and use table for materials. This could be decomposed into layers of selected specific materials and a layer of the remaining materials. For instance, the German physical supply and use table for 1990 (Stahmer, Kuhn, Braun 1998) was composed of three layers of supply and use tables: water, energy materials, and other materials. The three layers sum up to the ‘complete’ physical supply table for all materials.

91. This technique, which might be referred to as three-dimensional physical supply and use table or cube, increases the analytical potential. The material layers can be selected according to policy needs. Possible examples are physical flow accounts for plastic.

International trade

92. The theoretical framework for physical flow accounts complies to SNA with regards trade in products, for which the change-of-ownership principle is central. Applications of physical flow accounts may deviate from this for two main reasons: data sources and policy needs.

93. Applications of physical flow accounts employ a wide range of data on physical flows. In the case of international trade, the most common are international trade in goods statistics (ITGS) and energy statistics. Both data sources follow specific trade concepts differing from the SNA trade concept. ITGS follow a trade concept that might be referred to as 'physically-crossing-the-border' principle. The trade concept followed in energy statistics is somewhat ambiguous. IRES recommends to stick to the ITGS trade concept. The internationally harmonized annual questionnaires on natural gas by IEA and others introduce the concept of ultimate origin and destination (IEA et al. 2023). Thirdly, energy statistics include the concept of international marine and aviation bunkers (see IRES §§ 5.14-5.15, 8.54, 11.10), which may make things complicated for compilers of physical flow accounts.

94. For certain policy questions it might be favourable that applications of physical flows accounts follow other concepts of international trade than that of the SNA. In such cases, it is advisable to introduce bridging items that make explicit the respective differences.

Residence principle and goods sent abroad for processing

This issue is still under examination

95. This is a less well described point in the current 2012 SEEA-CF. On the one hand it states that the residence principle should be followed in order to ensure coherence with the national accounts. It is also stated that flows across the border for processing should be treated as physical exports and imports (as in ITGS). However, this introduces an inconsistency. If, for instance raw oil is sent abroad and being refined to petrol as a processing service, on one hand, it should be treated as intermediate consumption in the SUTs according to the residence principle and the national accounts. But then it cannot at the same time be recorded as exports. And the petrol should be recorded as output by the resident, but then it cannot at the same time be imports. The situation becomes even more complicated when also goods related to processing are bought or sold abroad, since in this case it may also affect whether the flows enter the estimation of e.g., DMC in EW-MFA in an appropriate way. Obviously, one cannot apply both principles, residence and territory, at the same time.

96. For good reasons (e.g., to increase policy relevance, see related paragraphs in this chapter), applications of physical flow accounts may deviate from SNA principles and accounting rules such as the residence principle and goods sent for processing abroad. While these concepts remain valid for the theoretical framework.

97. In cases where the applications of physical flow accounts deviate from the residence principle and the SNA recording of goods sent for processing, it is recommended to make it explicit and if

feasible develop <u>bridging items</u> in appropriate format (scalar, vector, matrices) to make these conceptual differences explicit. See paragraphs on ‘bridging items’ elsewhere in this chapter.

Waste

98. The SEEA-CF employs the term waste quite often to denote a grouping of physical flows. It is not clear, whether it is a residual or a product, or it might be both? Obviously, the up-dated SEEA-CF need to give clarification on this.
99. Waste accounts is the subject to another guidance note (B.8) which is maybe the better place to clarify what waste is? The related scoping note states that waste is legal concept, implying that its definition varies across countries.
100. Compilers of physical flow accounts use many data sources, amongst which waste statistics, ITGS etc. Different data source reporting the same physical flow need to be reconciled.

Concordance with monetary supply and use tables (SNA SUTs)

101. As shown in previous chapter 2, the theoretical framework for physical flow accounts by purpose goes beyond what is presented in monetary supply and use tables (SNA SUTs). On the other hand, one of the most useful features of the SEEA-CF is integrating monetary (SNA) data with physical data.
102. One option to overcome this trade-off is to make explicit those elements in applications of physical flow accounts that are concordant and have equivalent monetary flows recorded in SNA SUTs. And to show separately those elements beyond the recording boundary of SNA SUTs.
103. A way could be by introducing respective classes in the classifications of columns and rows (products). For column 1 ‘Production’ in Table 1, this concerns intra-establishment flows and maybe flows related to growth of biomass in agriculture and forestry, which could be shown separately. For column 2 ‘Consumption’ this concerns physical flows associated with the biological metabolism of humans and peds. For column 3 ‘Accumulation’ only physical flows related to gross capital formation are concordant with their monetary counterpart; other physical flows under accumulation are beyond.

Policy relevance

104. The updated SEEA CF should better explain how physical flow accounts can be used for policy (e.g. circular economy policies). This seems less oriented towards the theoretical framework with its multi-purpose nature at rather abstract level, namely describing the physical exchanges between economy and environment in a comprehensive and coherent manner. On the other hand, applications of physical flow accounts seem much more suited to serve policy demand because they may be tailored to it in a flexible manner.

105. Increasing policy relevance is cross-cutting to aforementioned issues. E.g. one element in the use of SEEA for policy and analysis is whether it is more appropriate to use the residence or the territory principle. In many cases policies and policy goals focus first of all on what is going in the territory. Therefore, users' interest is mainly in territory based physical data. In cases where data for extra-territorial flows are of interest, users normally wants to be able to distinguish between data for the territory and data for what goes on outside. This is especially the case for air emissions since the residence principle is not in line with the IPPC guidelines, which is where most of the policy interest is centred. However, it is probably also the case for data related to circular economy, waste etc.

106. The means to increase policy relevance of applications seems cross-cutting to the aforementioned issues. Applications of physical flow accounts may deviate from the theoretical framework and be tailored to policy demands. The above paragraphs provide guidelines and kind of 'tools' how to implement this flexibility. For instance, by tailoring classifications of rows and columns or introducing layers according to policy needs.

4 Examples of applications of physical flow accounts

107. This chapter presents examples of applications of physical flow accounts. It starts off with a fundamental question.

How far can/should SEEA-CF go in describing and providing guidelines for applications of physical flow accounts?

108. The question arises in how far the SEEA-CF should go with prescribing detailed guidelines for applications of physical flow accounts? The latter might be better treated as subjects for other guideline publications?

109. Instead providing guidelines for applications of physical flow accounts, the SEEA-CF could present examples to illustrate the various issues tackled in the previous chapter.

110. The following presentation of examples is only a preliminary selection and need to be discussed further. One general question is whether to confine the selection only to applications of physical flow accounts that have already been put into practise?

'Complete PSUTs for materials'

111. 'Complete PSUTs for materials' is a working term and denotes examples of PSUTs for materials (in tonnes) that are as complete as possible with regards to the scope of material flows and processes covered. There are a number of once-of examples for such 'complete' PSUTs for materials (Denmark, Germany, Italy, Netherlands).

112. The German PSUT – a pilot study funded by Eurostat (Stahmer, Kuhn, Braun 1998) – is maybe the application closest to the theoretical framework presented in chapter 2. The scope of the German physical supply and use table is fairly complete and articulates all components (sub-matrices) of Table 1. It includes material flows for the biological metabolism of humans and cultivated animals and plants. It implements the 'correct' recording of material flows associated with agriculture and forestry via stocks of produced natural resources. It includes water, which is a material too.

113. The German PSUT sticks to the SNA residence principle and the 'change-of-ownership' principle for trade. One exception might be for 'goods sent abroad for processing'; the study does not mention the treatment of this issue.

114. Further, the German pilot study is an example for applying material layers of supply and use tables. Because water flows dominate in quantity the tables for total materials, the latter has been separated into three sub-layer tables: water, energy materials, and remaining materials.

Economy-wide material flow accounts (EW-MFA)

115. Economy-wide material flow accounts (EW-MFA) describe (in tonnes) the physical interaction of the economy with the natural environment and the rest of the world economy in terms of flows of materials. EW-MFA is maybe the most often implemented application of physical flow accounts. Many national statistical institutes produce EW-MFA on a regular basis. There are two international guidelines (Eurostat, UNEP); the same institutions undertake regular data collections and the data is made available in a global database for EW-MFA. It has to be noted that the consumption indicators in EW-MFA (e.g., DMC) are based on the concept of 'apparent consumption' which differs fundamentally from the SNA concept of consumption.

116. The scope of EW-MFA is significantly limited vis-à-vis the theoretical framework. Water and flows related to the biological metabolism of humans, animals and plants are excluded. The basic idea of EW-MFA is to articulate column 4 'Rest of the world' and column 5 'Environment' of Table 1 and to arithmetically derive from those the total of column 3 'Accumulation' (net additions to stock). Columns 1 and 2 are neglected.

117. Due to data constraints, a number of pragmatic simplifications are introduced that deviate from SNA and SEEA principles and concepts. E.g., the ITGS data used to compile column 4 are only partly adjusted for the residence principle. Natural inputs into agriculture and forestry are only approximated (so-called harvest approach).

118. EW-MFA might be good example for balancing items due to limited range of materials considered (water, air).

Physical energy flow accounts (PEFA)

119. Physical energy flow accounts (PEFA) are an application of physical flow accounts for energy, established by the European Statistical System under the lead of Eurostat. PEFA record the flows of energy (in terajoules) from the environment to the economy (natural inputs), within

the economy (products), and from the economy back to the environment (residuals). PEFA record energy data in relation to the economic activities of resident units of national economies in a breakdown by economic activity. They present the supply and use of natural energy inputs, energy products and energy residuals. Economic activities comprise production, consumption, and accumulation.

120. PEFA in principle populate all columns and rows of Table 1, but there are a couple of limitations in scope though. The range of energy flows taken into account is limited because it is very closely linked to those energy flows recorded in international energy statistics. For instance, energy incorporated in food is excluded as is solar radiation energizing the growth of biomass.

121. One particular issue relates to what is defined as 'non-energy use' in energy statistics. That are fossil-based refined products used as feedstock to produce chemical products such as e.g., plastics. PEFA treat those 'non-energy-use' energy flows as residuals, which are send to accumulation.

122. As mentioned, PEFA are compiled from internationally harmonized energy statistics. The latter do not comply with the SNA residence principle. Also, the trade concept of energy statistics deviates significantly from the SNA trade concept ('change-of-ownership') and the SNA-rules related to 'goods sent for processing'.

Examples of applications: Air emissions accounts (AEA)

123. Air emissions accounts (AEA) is an application of physical flow accounts for materials developed and established by the European Statistical System under the lead of Eurostat. AEA record the flows (in tonnes) of gaseous and particulate materials from the national economy into the atmosphere (=air emissions). AEA present air emissions in a breakdown by emitting economic activity; the latter comprise production and consumption activities as defined and delineated in national accounts.

124. AEA constitute only a very partial articulation of the theoretical framework. Basically, AEA cover the supply of gaseous residuals by resident economic units that are released to the atmosphere, which is one component of the environment. In Table 1, AEA are placed in cells C.1 and C.2.

125. AEA's range of emissions (aka physical flows) to the atmosphere is limited as well. For instance, heavy metals are excluded as are oxygen (from cultivated plants) or water vapour.

126. AEA aim to comply with SNA and SEEA principles and concepts; including the residence principle. The main data source of AEA are internationally harmonized UNFCCC greenhouse gas inventories and UNECE/EMEP emission inventories for air pollutants which need to be adjusted for the residence principle.

127. AEA serve as a good example for bridging items/tables.

Examples of applications: Waste accounts

128. So far, not much waste accounts have been implemented. Eurostat did some research study on waste accounts. There is high policy interest in waste accounts in the context of circular economy.

129. Reference is made to another guidance note on waste accounts.

5 Re-organizing chapter III

130. The 2012 SEEA-CF dedicates chapter III to physical flow accounts. In addition, section 2.3.2 of chapter II describes in broader terms the accounting framework of monetary and physical supply and use tables. Scoping note B.1 'Description of PSUTs' proposes to re-organize the structure of chapter III to improve the order of content.

131. The current structure of Chapter III is

3.1 Introduction
3.2 The physical flow accounting framework
3.3 Principles of physical flow accounting
3.4 Physical flow accounts for energy
3.5 Physical flow accounts for water
3.6 Physical flow accounts for materials

132. On a first sight, this structure seems to a certain extend differentiate between theoretical framework (3.2 and 3.3) and applications (3.4 – 3.6). However, this is not really the case.

133. The current structure misses 'complete' PSUTs for materials (see above), which is an application that comes quite 'close' to the theoretical framework. In the current structure of chapter III, 'complete' PSUTs seem somehow interwoven into the rather theoretical sections 3.2-3.3, which is confusing. A new structure could improve the readability by disentangling theoretical framework and applications thereof.

134. Air emissions and EW-MFA are described as sub-sections to 3.6, both in a quite rudimentary way. Given that these are the types of accounts, which are among the most widespread SEEA accounts they may deserve to be given a more prominent place.

Question 5

Q: Do you agree to make a clear distinction between theoretical framework and implementations/applications thereof?

135. A new structure could briefly look like the structure of this guidance note:

- Theoretical framework for physical flow accounts
- General issues related to applications of physical flow accounts
- Examples of applications of physical flow accounts

136. The question arises whether selected applications deserve stand-alone sections? For instance, those which have been implemented into practise (e.g., 'complete' PSUTs, EW-MFA, AEA). Or even beyond, also applications that are less mature? Here the fundamental question arises how far the SEEA-CF should/could go in prescribing detailed compilation guidelines, or whether this should be rather subject to separate publications? Instead, the job of the SEEA-CF could be to describe the conceptual features of applications in relation to the theoretical framework in order to point out communalities and differences.

Question 6

Q: How far should/could SEEA-CF go in prescribing guidelines for applications of physical flow accounts?

6 References

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