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Outcome Paper for Global Consultation

Issue #1: Harmonization of MFA with the SEEA concepts[1]

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[1] This outcome paper has been prepared by the SEEA Editor. It is based on papers presented to the London Group of Experts on Environmental Accounting and discussions among those experts. Investigation and research for this outcome paper was led by Bram Edens when he was a staff member of UN Statistics Division and Alessandra Alfieri of the UN Statistics Division.

A. Introduction

1. In many countries the recording and study of physical flows of materials and resources has been a focus of environmental accounting. Some of this work is focused on individual substances while other work has considered broader ranges of materials, up to and including economy wide measures of physical flows. This work is generally grouped into a body of work known as Material Flow Analysis (MFA) and includes Economy Wide – MFA (EW-MFA). This work has been developed over a long period of time and consequently has developed a range of recording conventions. While related to the System of Environmental and Economic Accounts (SEEA), MFA and EW-MFA in particular are not completely aligned with the SEEA. As part of the revision of the SEEA the alignment between the SEEA and MFA boundaries was identified as an issue.

2. There were anumber of areas of particular interest in considering the relationship between SEEA and EW-MFA. These were differences in terminology, the use of the residence or territory principle of recording, the treatment of cultivated biological resources, the treatment of consumer durables, and the recording of emissions from controlled landfills. For the first two issues there was early, widespread agreement that terminology to be used in the revised SEEA should follow SEEA terminology rather than adopting MFA terms and that, consistent with SEEA-2003 and the 2008 System of National Accounts, the residence principle of recording should be used in the revised SEEA. These issues are not considered further in this outcome paper.

3. For the other three issues further investigation and discussion took place and the outcomes and recommendations from that work are presented in this outcome paper. The paper is structured to consider each of these three issues in turn.

4. It should be recognised that accounting for flows of materials is a subset of overall accounting for physical flows. Accounting sub-systems are also developed in the SEEA for water and energy. While water and some parts of energy flow accounting may also be considered within a material flow accounting framework there are differences in approach, particularly regarding units of measurement, that need to be considered. This paper deals exclusively with some boundary issues as they concern material flow accounting. The links to other forms of physical flow accounting are considered in detail in SEEA Revision Issue #2: Classification of physical flows.

B. The treatment of cultivated biological resources

Description of the measurement issue

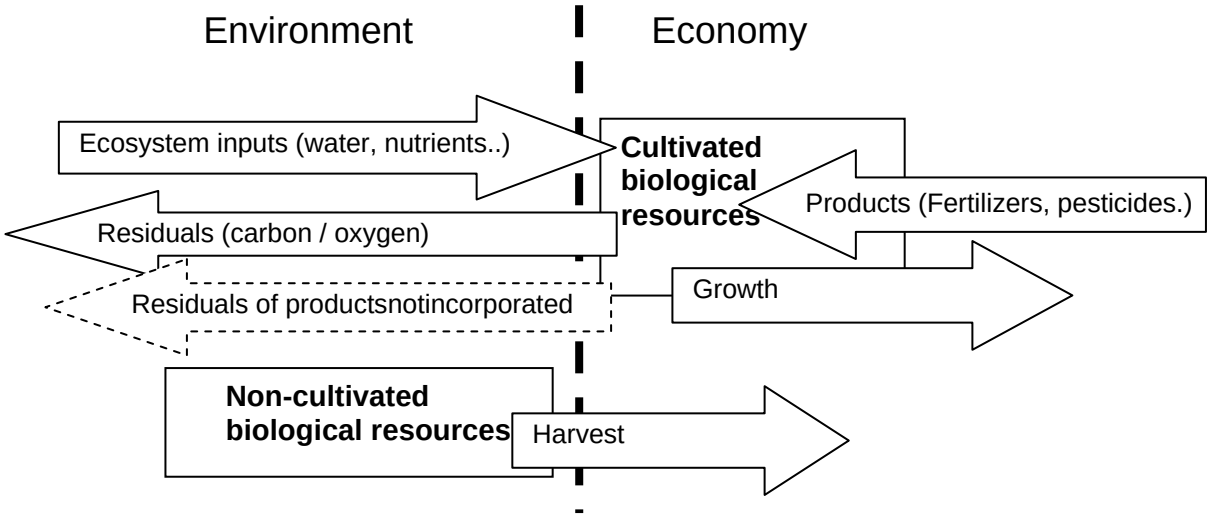
5. The 1993 and 2008 SNA distinguish between cultivated biological resources and non-cultivated biological resources. In an SNA context biological resources cover trees, crops, livestock, timber, and fish, i.e. those animals and plants that (i) have economic value via their ability to produce economic goods on an ongoing basis, for example dairy cows and vineyards; or (ii) have one-off economic value, for example trees for timber or cattle for slaughter.

6. Cultivated biological resources are those biological resources that are under the direct control, responsibility and management of institutional units. Consequently the growth of cultivated biological resources constitutes a controlled and managed process of production in the 1993 and 2008 SNA while the growth of non-cultivated biological resources is outside of the production boundary. Outputs derived from non-cultivated biological resources enter the production boundary when they are harvested or extracted rather than as they grow.

7. This distinction in the SNA is also adopted in the SEEA-2003. Since the SEEA has a focus on the flows between the environment and the economy the SEEA-2003 also records flows from the environment to the economy that contribute to the growth in the cultivated biological resources, that is, the ecosystem inputs necessary for the growth of the resources, for example carbon dioxide, nutrients and soil water. These flows are not recorded for non-cultivated biological resources since the growth of these resources is considered to occur within the environment and hence the same ecosystem inputs are considered “within environment” flows.

8. Figure 1 depicts the SEEA-2003 treatment of cultivated and non-cultivatedbiological resources in terms of their physical flows.

Figure 1: SEEA-2003 recording of flows related to biological resources



9. The drawing of the boundary between the economy and the environment not only impacts on the point at which products and inputs are recognized but also impacts on the recording of flows from the economy to the environment. For cultivated biological resources, the SEEA-2003 only records as residuals thoseamounts of the fertilizers, farm manure and pesticides that are not incorporated into cultivated plantsthemselves. The amounts that become incorporated or embedded into the cultivated plants stay within the economy.

The EW-MFA approach

10. In general the EW-MFA approach considers the growth of both cultivatedand non-cultivated biological resources as a process that takes place in the environment and not within the economy. Hence the flow from the environment to the economy is recorded at the time of the harvest of the resources.Consequently, the EW-MFA approach has been labelled the “harvest” approach.

11. Consistent with its drawing of the boundary between the economy and the environment, the EW-MFA sees the use of produced inputs such as irrigated water and fertilizers as a flow from the economy to the environment. Thus, for example, under the EW-MFA, it is not necessary to estimate the percentage of fertilizerthat is incorporated in harvested plants and trees.

12. However, there is a significant exception to this general treatment. The treatment just mentioned is applied to cultivated crops and trees, including timber, but it is not applied in the case of cultivated livestock or fish. Cultivated livestock and fish are considered as ‘secondary products’ in EW-MFA which means that they are not considered as extracted from the environment. For cultivated livestock and fish what is recorded as flows from the environment to the economy are:

- The uptake of fodder, grazed biomass and the like by cultivated livestock which in turn is accounted for as harvest/extraction of crops, and
- The oxygen required for respiration by livestock and cattle (these are called ‘balancing items’ in EW-MFA).

13. Animals that are caught in the wild are treated following the harvest approach which is the same as the way that non-cultivated biological resources are treated in the SEEA-2003.

Discussion and recommendations

14. The advantages of the SEEA-2003 treatment are that:

- It provides a consistent treatment for all types of cultivated assets both crops and trees as well as livestock and fish.
- It provides a direct link to several crucial life cycles such as the carbon cycle, the nutrient cycle, the hydrological system (evaporation etc..) that are 'missed' when looking at harvest.
- It is in line with SNA accounting practices. Especially in case of plants and trees that take several years to reach maturity and are recorded progressively as work-in-progress in the SNA the differences can be large.

15. The advantages of the EW-MFA harvest approach is that

- It better captures the pressure that is exerted on the environment by economic activities than the ecosystem inputs; seeing biomass growth as a pressure could be seen as counter-intuitive and in the EW-MFA approach this is considered a within environment flow.
- Since there is no need to record data at the level of ecosystem inputs(e.g. carbon, nitrates, water) the information aligns better to monetary information that is available at the level of products (e.g. tomatoes) and hence the overall analytical usefulness of EW-MFA is better.
- Most of the data on harvest of crops can be obtained directly from official statistics (e.g. agricultural statistics).However, it may be difficult if not impossible to estimate many of the data on "ecosystem inputs" related to crops, plants and trees with a meaningful degree of accuracy[2]. It is also rather difficult to arrive at an estimate of what part of the fertilizers, farm manure and pesticides is incorporated into cultivated plants and what part is dissipated directly into the environment, for example, as nitrate pollution of groundwater.

16. Taking into account these different advantages and disadvantages, the proposal from the London Group is to determine the treatment based on the nature of the cultivation process. This treatment is suggested as the preferred method because it aligns the MFA approach with the SEEA-2003 and SNA concepts as well as for practical considerations (data availability).The proposed treatment is that

a) wherethe cultivation process is dominated by a natural process in which cultivation occurs under near-natural conditions and in direct interaction with the environment, the flows from the environment to the economy consist of the biomass growth that is drawn into the economy;

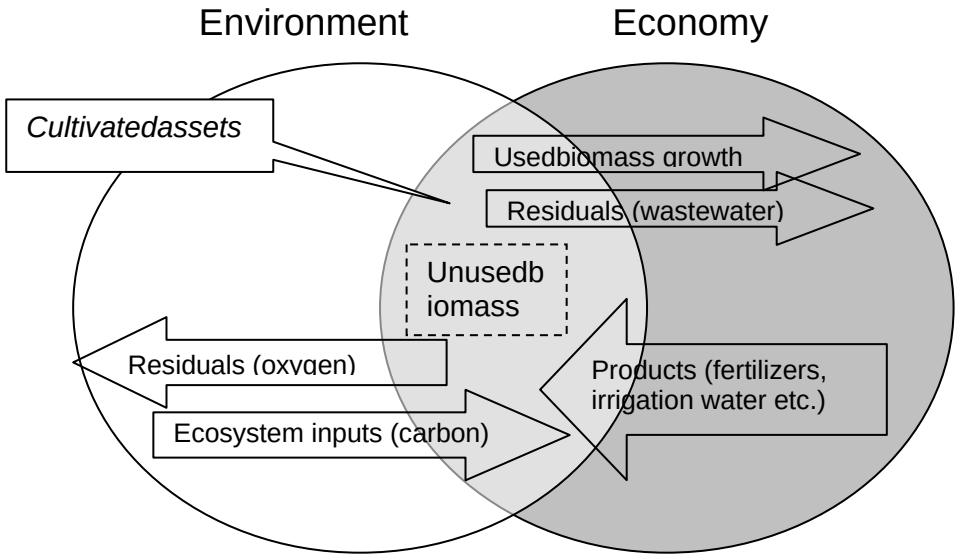
b) wherethe cultivation process is dominated by an economic process in which cultivation occurs under artificial conditions and there is little direct interaction with the environment, the flows from the environment to the economy consist of ecosystem inputs.

Note: The biomass growth that has been drawn into the economy is distinguished from the biomass growth that occurs through cultivation processes but is not drawn into the economy. The term "used" biomass growth is applied for the growth drawn into the economy and the term "unused" biomass growth is applied for the growth left behind in the environment.

17. The proposed approachis based upon two main considerations. First, cultivation is recognised as a production process that takes place simultaneously in the economy and the environment (this is illustrated in the figure below by the light grey area that is the result of the overlapping white and dark grey circle). The production process can be considered as consisting of two interrelated processes: a natural process e.g. photosynthesis in which there is a direct exchange with the environment (sun, soil, precipitation) and an economic process that comprises all other activities related to cultivation, like ploughing, harvesting as well as spreading fertilizers and pesticides, etc.

[2]An exception in terms of data availability and usefulness may be carbon-binding by growth of trees, as that information has to be included into the inventories of the international greenhouse gas reporting process. That requirement has lead or will lead to an improvement of the statistical basis for calculating those figures.

Figure 2: Proposed recording of flows related to biological resources



18. Second, cultivation processes differ considerably within countries and between countries. When the natural process is dominant the used biomass growth is recorded as the flow from the environment to the economy; when the economic process dominates the ecosystem inputs are recorded. This is reflected in the graph as follows:if we focus on the light grey area of the figure that depicts cultivation, we see that the right border records the used biomass growth as flows from the environment to the economy, while the left border records the ecosystem inputs as flows from the environment to the economy.

19. As noted in paragraph 5, one feature of the SNA recording of cultivated biological resources is that a distinction is made between biological resources that provide ongoing outputs such as diary cows and apple trees and those that provide one-off benefits such as timber and wheat. While the definition of used biomass growth is clear in the case of those biological resources providing one-off benefits, the situation with those producing ongoing outputs needs explanation.

20. In the SNA two outputs are recorded the growth in the biological resource itself – the growth in the dairy cow and the apple tree – and the output from the biological resource – the milk and the apples. Consistently then, the definition of used biomass growth should include both the growth in the biological resource and the amount of output from the biological resource. This conclusion applies irrespective of whether the nature of the cultivation is highly managed or relatively natural.

21. The proposed treatment is best considered through description of some examples in the cases of crops and trees, livestock and fish.

(a) Crops and trees

22. The cultivation of crops and trees is generally dominated by a natural process and hence the flow from the environment to the economy would be represented by the growth in used biomass over the accounting period. This physical flow is aligned to the required monetary valuations of production in the SNA. In the case of those crops and trees that are fully harvested within an accounting period, say one year, the used biomass growth will equal the harvest. For those crops and trees which take either more than one-accounting period to reach maturity or which produce an ongoing series of crops the use biomass growth will equate to the growth in the trees and crops over the accounting period.

23. Special considerations are needed in a few areas.

i. The growth in cultivated crops and trees which is not used such as branches and leaves that are left to decay are considered as unused biomass and are not accounted for as output in physical terms and therefore are not considered as flows from the environment to the economy.

ii. In forestry, a distinction is often made between fellings and removals: “the term removal differs from fellings as it excludes felled trees left in the forest; [but] includes removal from fellings in an earlier period and from trees killed or damaged by natural causes; [and] includes removal by local people or owners for their own use” (FAO FRA 2005). In this case the used biomass growth of the forest is recorded as additions to work in progress (inventories) of the forestry industry; fellings are recorded as both a reduction in work-in-progress and as intermediate or final consumption (according to whether the harvested products are used by households or industries); the timber that is felled but not directly removed from the plantation remains in inventories until removed.

iii. Where the cultivation process is predominantly natural the intermediate consumption of seeds, fertilizers etc. is treated as dissipative use of products and is considered as a flow from the economy to the environment that occurs as soon as these products are spread on land.

iv. The growth of plants and crops under greenhouse cultivation is strongly dominated by an economic process. In this case almost all inputs are products: fertilizer, seeds, irrigated water, and even light and heat are frequently used as an alternative for sunlight. Recording the used biomass growth would imply that all these product inputsare treated as dissipative use of products i.e. they leave the economy and subsequently re-enter as biomass, waste or waste water. Under such circumstances recording the ecosystem inputs seems more appropriate than recording the used biomassgrowth and means that the inputs that are products (fertilizer, seeds, etc) remain as flows within the economy.

(b) Livestock

24. Cultivation of livestock in many countries is often rather industrialized where the direct exchange with the environment plays a minor role (mainly respiration). In this case the proposed treatment to record output equal to the biomass growth considered to take place within the economy but records the specific inputs from the environment as ecosystem inputs – primarily carbon dioxide, water and oxygen.

25. However, in many other countries the cultivation of livestock takes place as near-natural cultivation in the open, like cattle ranching characterized by low densities of animals per hectare where virtually all the fodder and water is provided from natural ecosystems with comparatively few other inputs. The excreta flows from biological metabolism usually directly enter the environment.Under such circumstances recording the environmental input as equal to the used biomass growth is more appropriate.

(c) Fish

26. As for livestock, aquaculturecan be undertaken in very controlled environments such as fish farms or ponds but in many countries it occurs in estuariesor rivers where part of the sea/river is fenced. In the first case the flows from the environment are equal to the specific ecosystem inputs, while in the latter case the used biomass growth represents the extent of input from the environment.

27. Overall, the proposed approach has a range of positive features. Itmaintains consistency in the relationship between the measures of output in the SNA in monetary terms and the SEEA recording of output in physical terms (including maintaining a distinction between cultivated and non-cultivated assets). It alsoremoves an analytical impediment in the SEEA-2003 where specific ecosystem inputs were recorded as flows to the economy for all cultivated biological resources irrespective of the nature of the cultivation process.

28. It is recognised that the proposed approach requires the measurement of detailed ecosystem inputs in the case where cultivation is dominated by economic processes rather than natural ones. Even thought this was also required in the SEEA-2003, the calculation of these ecosystem inputs is understood to be a difficult task.

29. Also on the issue of measurement it is recognized that estimating growth over more than one year is very difficult in practice but it is noted that this also needs to be estimated to suit general national accounts requirements

30. Experts in water accounts may recognise that under the proposed treatmentwhere water is used within non-natural cultivation processes the recording of water consumption will align with the standard water accounting treatment.On the other hand, for natural cultivation processes since the water is considered to be embodied in the used biomass growth there will be no explicit recording of the input of water to the growth in used biomass. However, as stated in the introduction to this paper, these recommendations are intended to apply to material flow accounting and generally water is excluded from such analysis. Water accounting itself is a separate system and thus these recommendations have no direct impact on the calculation of water accounting aggregates such as water consumption.

31. Finally, it is true that the proposed approach better aligns the SEEA with the EW-MFA. However, the alignment is not complete. There are differences in cases where crop rotation cycles are greater than one year where used biomass growth will not necessarily equal harvest and also between the treatment of livestock which EW-MFA records as secondary products as described in paragraph 11.

32. It seems likely that these differences would have a large impact on the currently defined aggregates in the EW-MFA – indicators such as Domestic Material Consumption (DMC) - which themselves are well-established. Thus the treatments proposed here and the datasets that are constructed from them will need to be bridged to the EW-MFA in order for EW-MFA indicators to be compiled from a SEEA starting point. Nonetheless, on the basis of the work undertaken and presented here the conceptual bridge will be quite straightforward to build.

33. On balance it is considered that the proposed treatment provides a firm basis for the treatment of the physical flows associated with cultivated biological resources in a way that aligns very well to the monetary flows recorded in the SNA. This objective has been a key feature in proposing the new treatment.

Recommendation 1.1: That in the revised SEEAwhere the cultivation process is dominated by a natural process the flows from the environment to the economy consist of the used biomass growththat is drawn into the economy; and where the cultivation process predominantly occurs under artificial conditions and there is little direct interaction with the environment, the flows from the environment to the economy consist of ecosystem inputs.

The treatment of consumer durables

34. For consumer durables the SEEA-2003 has followed the accounting treatment of the SNA whereby the consumer durable (televisions, cars, refrigerators, etc) is considered to be fully consumed by the household at the time of purchase. If consumer durables where to be treated as having a longer life, in the same way as assets owned by businesses, then in a complete national accounting sense there would need to be extensions to the production boundary, i.e to GDP, in order to account for the services delivered by the consumer durables and the associated activity undertaken by households on their own account (transportation, cooking, entertainment, etc).

35. While such a complete accounting treatment is not considered standard SNA practice it is suggested in the SNA that as memorandum items countries might compile estimates of the value of consumer durables in the same way as for business assets and place these estimates within national balance sheets. A number of countries undertake this compilation.

36. In the EW-MFA as there is no restriction concerning a production boundary the standard practice is to record flows of consumer durables as they occur thus production and purchase is recognised at one point in time and disposal at later date. Emissions from consumer durables as they are used are recorded as they occur.

37. Changing the SEEA to fully account for consumer durables through changing the production boundary and recording consumer durables like SNA assets would be a very extensive process. It is therefore suggested that to better align the treatment of consumer durables in the SEEA with the EW-

MFA a memorandum item be proposed – as in the SNA – to record the stock of consumer durables and relevant inflow and outflows from that stock.

Recommendation 1.2: That in the revised SEEA the stock of consumer durables should be estimated as a memorandum item.

The treatment of emissions from controlled landfills

38. In the SEEA-2003 two treatments of controlled landfills were proposed. Under the first treatment, which is consistent with the EW-MFA, the controlled landfill is considered a being within the economy and hence disposals to the landfill are considered as flows of waste within the economy. Subsequent emissions and leakages from the controlled landfill, into soil, air or water, are regarded as flows to the environment.

39. The second treatment noted that for a range of data and measurement issues and legislative reasons it may be better to consider the controlled landfill as in the environment and hence disposals to the landfill would be considered as flows to the environment and emissions would not be recorded as they would be flows within the environment.

40. Discussion and ongoing practice in measurement have concluded that the first treatment is preferable particularly because the emissions from controlled landfills are considered to be important information to be accounted for in the SEEA.

Recommendation 1.3: That in the revised SEEA controlled landfills should be considered as part of the economy and emissions from controlled landfills should be recorded as flows from the economy to the environment.

Annex 1: Example supply and use tables for the proposed treatment of cultivated biological resources

To get a better understanding what the proposed treatment implies as compared to the SEEA-2003, we will construct the respective physical supply and use tables (SUTs). To simplify things, let us consider an economy that exists of only one economic activity (an orchard i.e. cultivated production which we assume to be dominated by a natural process) and households.[3]

Table A1.1: SEEA 2003

Inputs		Outputs	
Product flows			
Products	**14,2**	**Products**	**195,1**
Seed, fertilizers, pesticides etc.	11,2	Biomass increase (used)	195,1
Other products	3,0		
Non-product flows			
Natural inputs	**561,3**	**Outputs to the environment**	**379,4**
Carbon dioxide, natural water, oil minerals etc.to biological metabolism	552,3	Oxygen, water vapor from bilological metabolism	201,4
		Seed, fertilizers etc. from biological metabolism (not incorporated)	7,0
		Unused biomass increase from biological metabolism	159,0
Oxygen etc. to technical metabolism	9,0	Carbon dioxide, water vapor from technical metabolism	12,0
		Outputs to the economy	**1,0**
		Waste, waste water	1,0
Total	**575,5**	**Total**	**575,5**

Tables A1.2: Proposed treatment

Inputs		Outputs	
Product flows			
Products	**14,2**	**Products**	**195,1**
Seed, fertilizers, pesticides etc.	11,2	Biomass increase	195,1
Other products	3,0		
Non-product flows			
Natural inputs	**205,1**	**Outputs to the environment**	**23,2**
Biomass increase (used) from biological metabolism	195,1	Seed, fertilizers etc.(incorporated and not incorporated)	11,2
Waste, waste water from biological metabolism to waste collecting system	1,0		
Oxygen etc. to technical metabolism	9,0	Carbon dioxide, water vapor from technical metabolism	12,0
		Outputs to the economy	**1,0**
		Waste, waste water	1,0
Total	**219,3**	**Total**	**219,3**

In case of SEEA-2003the following inputs are recorded:

11.2 intermediate consumption of seeds, pesticides, fertilizers
3.0 fuel for tractors
561.3 ecosystem inputs
of which9.0 units are oxygen as balancing input (needed to combust the fuel for tractors)

As outputs:

195.1 biomass growth (used)
213.4 air emissions

[3] The numbers that we have used here are taken from the paper LG/13/2, p.7

of which12.0 units arefrom combustion of fuel

1.0 waste to controlled landfill

7.0 dissipative use of products (the part of seeds and fertilizers that are not incorporated in the products

159 unused biomass

The required products (14.2) have to be imported as by assumption there is only one economic activity in our economy. It is assumed that the 195.1 of biomass products are consumed by households (195.1) resulting in air emissions (30), flows to landfill (130), return flows (32.1) and other water losses (3) due to evaporation. This leads to the following SUT.

Table A1.3: Supply and use table for SEEA-2003 treatment

SUPPLY	**Industries**	**Final consumption**		**GFCF**		**Landfills**	**RoW**	**Environment**	**Total**
		Households	**Durables**	**FCF**	**Inventories**		**Imports**		
Inflows									
Natural resources									0
Ecosystem inputs								561.3	561.3
Products									
Products	195.1						14.2		209.3
Waste	1	130							131
Outflows									
Air emissions	213.4	30							243.4
Dissipative use	7								7
Return flows		32.1							32.1
Water losses		3							3
Unused	159								159
Total	575.5	195.1	0	0	0	0	14.2	561.3	1346.1

USE	**Industries**	**Final consumption**		**GFCF**		**Landfills**	**RoW**	**Environment**	**Total**
		Households	**Durables**	**FCF**	**Inventories**		**Exports**		
Inflows									
Natural resources									0
Balancing items	561.3								561.3
Products									
Products	11.2	195.1							206.3
	3								3
Waste						131			131
Outflows									
Air emissions								30	30
								213.4	213.4
Dissipative use								7	7
Return flows								32.1	32.1
Water losses								3	3
Unused									159
Total	575.5	195.1	0	0	0	131	0	444.5	1346.1

In case of the proposed treatment we see several differences:

- While the natural inputs consisted of ecosystem inputs in case of SEEA, they are now recorded as natural resources (with the amount of the used biomass growth). Please note as well that the total amount of natural inputs has been reduced from 561.3 to 205.1. There are two reasons for these differences:
  - The first reason being that SEEA records the 'gross ecosystem inputs' that are required in order to cultivate and grow trees. This includes the so-called water consumption i.e. the difference between use and supply of water of an establishment.[4] By contrast, the new convention records only the resulting biomass growth of these ecosystem inputs which can be seen as a 'net concept'. It therefore does not take water consumption into account as this is assumed to be a natural process that occurs in the environment.
  - The second difference is that the proposed convention only records the biomass growth that is used. The unused biomass is treated as a flow within the environment and therefore does not enter the SUT (unless it ends up in the waste collection system in our example this is 1 mass unit).
- However, the supply of products 195.1 remains the same in both SUTs.
- The second difference is due to the way dissipative use of products (e.g. seeds and fertilizers) is registered. While the SEEA records only the part of the seeds and fertilizer that is not incorporated in products (in this example 7 mass units), the new convention records the total dissipative use of products as an outflow to the environment (11.2).
- In monetary terms, it is in both cases assumed that the natural inflows (regardless whether they consist of ecosystem inputs or biomass growth classified according to CPC) are obtained at zero cost.

[4] In our example water consumption could be up to 561.3 – 205.1 = 356.2.

Table A1.4: Supply and use table for SEEA-2003 treatment

SUPPLY	Industries	Final consumption		GFCF		Landfills	RoW	Environment	Total
		Households	Durables	FCF	Inventories		Imports		
Inflows									
Natural resources								195.1	195.1
Balancing items								10	10
Products									
Products	195.1						14.2		209.3
Waste	1	130							131
Outflows									
Air emission	12	30							42
Dissipative use	11.2								11.2
Return flows		32.1							32.1
water losses		3							3
Total	*219.3*	*195.1*	*0*	*0*	*0*	*0*	*14.2*	*205.1*	*633.7*

USE	Industries	Final consumption		GFCF		Landfills	RoW	Environment	Total
		Households	Durables	FCF	Inventories		Exports		
Inflows									
Natural resources	195.1								195.1
Balancing items	10								10
Products									
Products	11.2	195.1							206.3
	3								3
Waste						131			131
Outflows									
Air emissions								30	30
								12	12
Dissipative use								11.2	11.2
Return flows								32.1	32.1
water losses								3	3
Total	*219.3*	*195.1*	*0*	*0*	*0*	*131*	*0*	*88.3*	*633.7*