Crop and timber provisioning services application and revision: a pilot assessment for Europe

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ARTICLE INFO

Keywords:

System of Environmental Economic Accounting Central Framework (SEEA CF)

SEEA Agriculture Forestry and Fisheries (AFF)

SEEA Experimental Ecosystem Accounting (SEEA EEA)

System of National Accounts (SNA)

ABSTRACT

The FAO develops the SEEA Agriculture Forestry and Fisheries (AFF), which applies the environmental economic structures and principles described in the System of Environmental Economic Accounting - Central Framework (SEEA-CF) to the activities of agriculture, forestry and fisheries. The value-added of the SEEA AFF lies in the integration of information that is considered standard from either an SNA or a SEEA perspective. The JRC, as part of the KIP-INCA project, develops the ecosystem services supply and use tables of the SEEA 2012 Experimental Ecosystem Accounting (EEA). The joint JRC-FAO analysis described in this paper allows the development of the SEEA AFF integrating provisioning ecosystem services, consistently with the SEEA EEA. After an initial screening, a simplified procedure (i.e.: tier one approach, using FAOSTAT and JRC-Eurostat database) is formulated for terrestrial provisioning services. More specifically, the tier one procedure described in this paper assess the contribution of ecosystem types Cropland (i.e.: Cropland E) and Forest (i.e.: Forest E) starting from the SNA products they generate and are reported and includes, trough the SEEA AFF, also the specific features that characterize agriculture, forestry and fisheries. By applying the SEEA AFF to the tier 1 procedure for SEEA EEA provisioning services full consistency of the provisioning ecosystem services accounts with the SEEA CF and with the SNA is guaranteed. More specifically, the paper analyses two provisioning services: crop and timber provisioning and set the basis to calculate some indicators that may be derived from the JRC FAO related accounting tables for crops and timber and how these indicators may refer to the SDGs framework. In the JRC FAO crop provisioning accounting table, a coefficient is assessed to disentangle ecosystem contribution from human input in crop production. This approach allows to separate crop provision as service from crops as product. The latter should not be used as proxy for the former as it is. For timber provision, the simplified procedure is tested by using ESTAT-FAO common dataset and some measurement from the *JRC biomass study on forests*. Preliminary results of both accounts are presented and discussed in physical terms using FAOSTAT database, and in monetary terms using ESTAT database.

Introduction

The System of Environmental-Economic Accounting Central Framework (SEEA CF) was adopted by the United Nations Statistical Commission at its 43rd Session in 2012, as the first international standard for environmental-economic accounting. The SEEA Agriculture Forestry and Fisheries (SEEA AFF) extends to these primary sectors the environmental-economic structure and principles of the SEEA CF. The SEEA AFF

is therefore a statistical framework that facilitates description and analysis of agriculture, forestry and fisheries as economic activities, and their relationship with the environment. It defines core national accounting tables, easily integrated into synthetic view tables, provided as a basis for the measurement and reporting of information on physical and monetary assets and flows accounts on natural resource use, production, trade and consumption of food and other agricultural products. It thus offers countries a robust statistical structure for the development of Agri-environmental indicators, including SDGs, which can be monitored in a transparent, coherent and internationally comparable manner. In particular the SEEA AFF includes specific accounting tables for Crop and Timber Production (respectively: "*Table 3.1, Physical flow account for crops"* and "*Table 3.4, Physical flow account for wood forestry products"*) which have been used in this analysis as starting point to measure timber and crops as SNA products (see Figure 1).

Physical supply table for crops

	Output							
	Gross production	Harvest losses	Agricultural industry		Manufacturing industry	Total Output	Imports	Total supply
			Total	of which Household production				
Selected products*								
Maize (raw)								

Physical supply table for forestry products

	Output						
	Forestry activity (ISIC 021)	Logging activity (ISIC 022)		Other industries	Total output	Imports	Total supply
		Total	of which H/hold prodn				
Product							
Net annual increment							
Gross fellings							
Felling residues (not removed)							
Removals (over bark)							
Bark							
Removals (under bark)							
Roundwood (under bark)							
of which Industrial roundwood							
-Sawlogs &veneer logs							
-Pulpwood, round & split							
-Other industrial roundwood							
wood fuel							

Figure 1 SEEA AFF PSUT for Crops and Timber

Timber and crops as SNA products constitute also the output of the provisioning services as described in the System of Environmental-Economic Accounting 2012 Experimental Ecosystem Accounting (SEEA EEA). The SEEA EEA complements the conceptual framework and accounts presented in the SEEA CF from the perspective of ecosystems and links ecosystems to economic and other human activities. The SEEA EEA reflects a synthesis of current knowledge in the measurement of ecosystems. It represents a convergence of disciplines across ecology, economics and statistics on ecosystem accounting. The European Commission aims to apply the SEEA framework in its Knowledge Innovation Project Integrated system for Natural Capital Accounts (KIP INCA) initiative. The objective of INCA is to build biophysical and monetary accounts at European Union (EU) level to respond to EU policies. As part of the KIP-INCA project, the Joint Research Centre (JRC) is assessing crop and timber provisioning services by applying a procedure that aims at disentangling the contribution of ecosystem from the natural resource that is generated. The supply and use tables generated for KIP-INCA would show the flow of the service from the ecosystem to the primary sector. The attempt to combine INCA with SEEA AFF would allow to link ecosystem contribution even further to check its relative impacts.

In accounting for the SNA products produced by the Agriculture and Forestry ISIC A industries, consistency with the SEEA CF is obtained through the linkages with the SEEA AFF accounting tables for timber and crops. The Crop and Timber provisioning services accounting tables built by JRC and FAO guarantee therefore a full consistency with the SNA while applying an ecosystem perspective. Moreover they highlight the role and the contribution of the Cropland E and Forest E[1] to the agriculture and forestry industries. Moreover these accounting tables would create the basis to compute indicators such as: (i) *ecosystem contribution to agricultural production;* (ii) ecosystem contribution to the supply chain of food (iii) *ecosystem contribution Dietary Energy Supply* that are directly linked to the SDG 2: "***End hunger, achieve food security and improved nutrition and promote sustainable agriculture***", in its Targets 2.1 and 2.1[2].

[1] Cropland and forest ecosystems (respectively: Cropland E and Forest E) are defined in this paper coherently with INCA classification, with is based on MAES Ecosystem types and CORINE Land Cover.

[2] Goal 2: "End hunger, achieve food security and improved nutrition and promote sustainable agriculture"; Target 2.1: "By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round" Target 2.2 "By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons".

Crop provision

For the biophysical assessment of the crop provisioning service, the ecosystem contribution is considered as one of production components that lead to the agro biomass accumulation. In our application it builds on data derived from previous works focusing on the quantification of energy flows in agricultural systems. The former studies quantify the energy needed, directly and indirectly, by considering the natural inputs (i.e. sun rainfall, soil nutrients) and human inputs (i.e. planting, irrigation, chemical products) in agroecosystems generating the yield production. All inputs and outputs are converted to a common unit, which in this case is solar energy (joule). The ratio used to quantify ecosystem contribution is given by the share of natural input with respect to the sum of natural input plus human input. The ecosystem contribution varies between 0, when yield is practically derived from human inputs, and 1 in situations in which the ecosystem generates the yield and, therefore, human inputs do not play a key role. Currently the crops for which this ratio is currently available are: soft wheat, durum wheat, barley, oats, maize, other cereals, rape, sunflower, fodder maize, other fodder on arable land, pulses, potatoes and sugar beet.

The JRC FAO crop provisioning accounting Table 1 JRC FAO Crop Provisioning Service

records the contribution of Cropland Ecosystem (Cropland E) to the supply and use of agricultural products (excluding livestock)[3], by crop. It measures the contribution of Cropland E in the production chain including the agricultural industry and the manufacturing industry and records the amount of food produced and available for consumption. Table 1 compiled with FAOSTAT data for all European countries is shown below. The table refers to barley production and use.

[3] Livestock products are dealt in SEEA AFF *Chapter 3, Accounting for agricultural, forestry and fisheries production and associated biological resources,* paragraph 3.4 *Asset account for livestock* and are not included in this paper analysis, which extends instead accounting rules and principles contained in Chapter 3, paragraph 3.2, *Physical flow account for crop and paragraph* and 3.6, *Asset accounts for forestry and asset accounts for timber resources* and Chapter 4 *Accounting for environmental assets, primary natural inputs and residual flows*, paragraph 4.5 *Physical flow accounts for fertilizers, nutrient flows and pesticides*.

Selected products*	Ecosytem Types EC	Type of economic unit*				Flows from the rest of the world		Food Availability	
	Cropland EC	Supply		Use		Imports	Exports	Food	Food supply (Kcal/capita/day)
		Agricultural Industry (ISIC A 01)	Forestry and Logging	Energy (ISIC D 3510)	Crop processed				
Cereals									
Barley *1000 tons*									
AT	171	662			893	163	76	3	2
BG	149	662			-	1	325	8	6
BLX	61	397			1,879	1,779	356	2	8
DE	2,232	10,391			8,850	1,409	1,535	26	2
DK	1,203	4,059			608	83	1,042	0	0
EE	142	341			146	8	85	7	39
EL	38	336			406	70	2	5	3
ES	1,232	5,956			-	276	71	2	0
FI	467	1,581			403	4	93	27	33
FR	2,122	11,341			1,714	97	4,657	62	6
HU	368	996			639	69	299	1	0
IR	280	1,261			820	198	69	3	4
IT	178	940			1,279	498	6	30	3
LT	241	742			284	35	102	25	55
LV	111	249			149	111	114	49	151
NL	64	206			2,427	1,547	85	26	8
PL	1,330	4,180			3,961	197	321	251	34
PT	5	21			799	225	5	15	9
RO	282	986			1,832	138	688	22	7
SE	508	1,702			454	61	494	15	11
SI	17	85			188	16	9	4	13
SK	148	470			300	54	58	21	25
UK	1,079	5,522			4,296	162	590	49	5
EU	12,427	53,088			32,327	7,200	11,081	653	20.4

Table 1 JRC FAO Crop Provisioning Service

From Table 1, it is possible to extract some information that allow to set the basis for more in depth analysis. From Table 2 it is possible to compare the ecosystem contribution to agricultural production with the relative importance of this production across European countries, the relative importance of the process crop across European countries, the trading and the food availability.

	ecosystem contribution	*food availability (1,000 tons)*	*% of agricultural production*	*% of processed crop*	*(eXport-iMport)*
AT	0,258436815	3	1,25%	2,76%	-87,024
BG	0,224964605	8	1,25%	0,00%	324,514
BLX	0,15316663	2	0,75%	5,81%	-1423,85
DE	0,214791841	26	19,57%	27,38%	125,858
DK	0,296427511	0	7,65%	1,88%	958,489
EE	0,414889072	7	0,64%	0,45%	76,772
EL	0,113844329	5	0,63%	1,26%	-68,427
ES	0,206822656	2	11,22%	0,00%	-205,071
FI	0,295250575	27	2,98%	1,25%	89,125
FR	0,187098479	62	21,36%	5,30%	4560,928
HU	0,369718394	1	1,88%	1,98%	230,834
IR	0,222396792	3	2,37%	2,54%	-128,84
IT	0,188949256	30	1,77%	3,96%	-491,511
LT	0,325377679	25	1,40%	0,88%	67,061
LV	0,445978777	49	0,47%	0,46%	2,944
NL	0,308483527	26	0,39%	7,51%	-1461,879
PL	0,318083972	251	7,87%	12,25%	123,838
PT	0,258011843	15	0,04%	2,47%	-220,911
RO	0,285532071	22	1,86%	5,67%	550,051
SE	0,298318253	15	3,21%	1,40%	433,434
SI	0,195095135	4	0,16%	0,58%	-7,297
SK	0,315304306	21	0,89%	0,93%	3,939
UK	0,195413092	49	10,40%	13,29%	428,011

Table 2 JRC FAO Crop Provisioning Service: relevant data extraction

There are countries like Germany, UK and Poland that use an important part of barley as intermediate production to produce beer. Their ecosystem contribution ranges from 0.31 (Poland) to 0.21 (Germany) and 0.19 (UK). All the three countries have exports higher than imports. Their food availability is in the upper ranking in absolute terms (1,000 tons) but for Germany and UK it falls in the lower ranking in relative terms (Kcal/person/day).

Poland records the highest food supply in absolute terms and a still high ranking in relative terms. Poland records a high ecosystem contribution.

There are other countries like France and Denmark that consume and/or export barley as final product. In France the ecosystem contribution is lower than other European countries. This implies higher importance of human input. The food availability in absolute terms is ranked high, while the food supply in relative terms is ranked low.

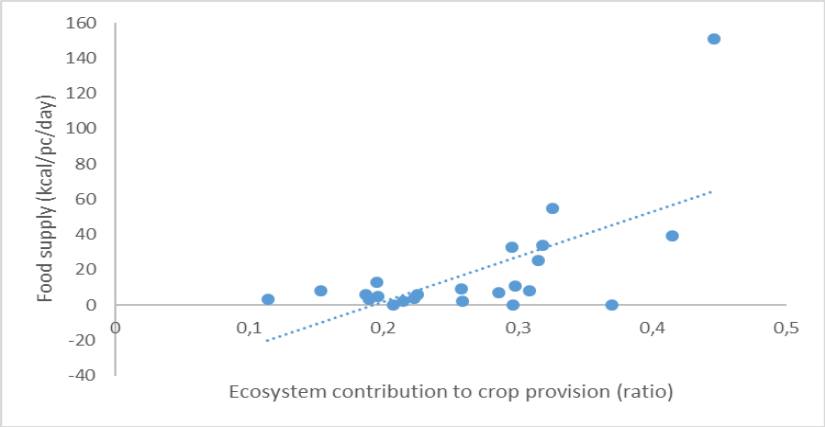


Figure 2 Correlation between ecosystem contribution and food availability

The countries with the highest ecosystem contribution (Latvia, Estonia, Hungary and Lithuania) do not record important percentage of agricultural production or beer processing; on the other hand, some these countries rank high especially in food supply (Latvia, Lithuania and Estonia).

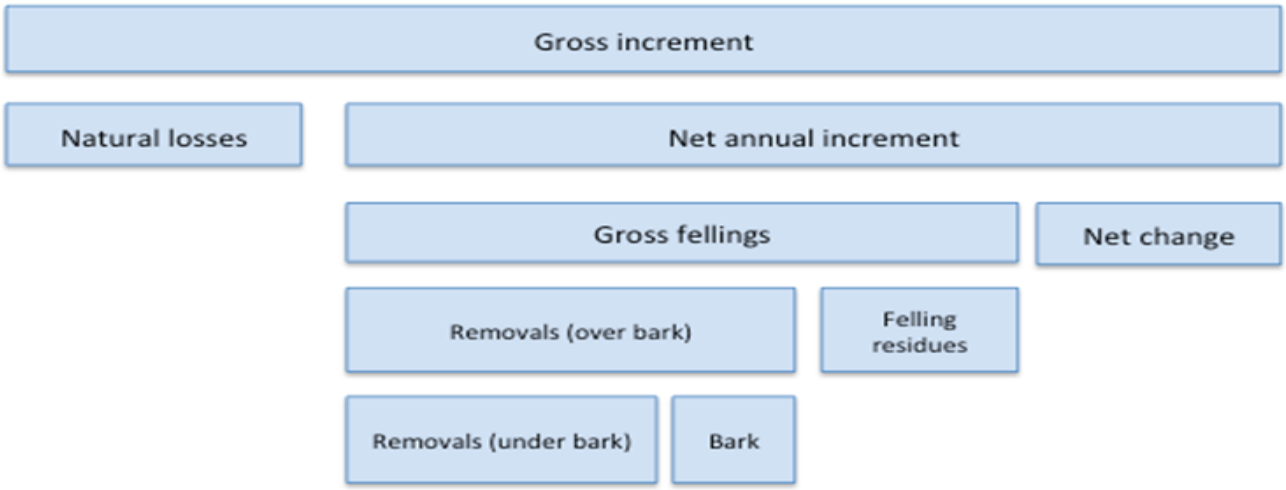
Reported data show that where agricultural production and food processing have a primary industrial productivity, ecosystem contribution is lower than in those countries where the primary sector industrial vocation is less marked. The latter seem to be more ecologically "resilient" in terms of food supply (Kcal/person/day). This is confirmed when checking the correlation between the food supply and the ecosystem contribution (ref. Figure 2), where the R^2 coefficient is 0.4164.

Timber provision

The JRC FAO timber provisioning accounting table aims to record the contribution of Forest Ecosystem (Forest E) to the supply and use of forestry products (excluding the Non-Wood Forest Products)[4]. It applies the concept of Net Annual Increment (NAI) and Forestry industries as defined in the SEEA AFF, and therefore coherently with the accounting rules described in SNA and in the SEEA CF.

[4] While this paper recognizes the importance of Non Wood Forestry Products (NWFP) accounts as essential to contribute to a proper management of the world's forests, to conserve their biodiversity, and to improve income generation and food security, it also suggests a specific monetary accounts for NWFP, which are therefore not included in this analysis.

In particular, the NAI is defined as gross increment less natural losses, where gross increment is the average annual volume of increment over the reference period of all trees, with no minimum diameter, and natural losses the average annual losses to the growing stock during the reference period due to mortality from other causes than cutting by man; for example, natural mortality, disease, insect attack, fire, wind-throw or other physical damages. By definitions, gross increment equals natural grow. The relationships between NAI, natural losses and gross increment are shown in Figure below.



Forestry Concepts (adapted from Päivinen et al., 1999)

Figure 3 NAI, Natural losses and gross increment

Timber provision as ecosystem service follows the same approach used for crop, i.e. we assess the contribution of the ecosystem as one of the production input that generates biomass accumulation. However, the case of timber is much easier than the case of crop, because the human input mostly relates to the management regime actions (e.g. measurement, control, selection cutting, plantations). In this case, the ecosystem contribution is estimated through cost, and specifically the relationship between the Gross Fixed Capital Formation and the Total Output is used as proxy for the human input.

Thanks to work undertaken by the Bio-economy team at the JRC, it is possible to track the flow of timber removals throughout the first stage of transformation. Table 2 shows the results aggregated for 28 European countries.

	Ecosytem Types EC		Type of economic unit*		
			Supply		
	Forest and Other Wooded EC	Other	Agricultural Industry (ISIC A 01)	Forestry	Logging
Net annual increment	688,67	55,53		744,2	
Residues					
Removals					
Roundwood					216,12
Sawlogs					132,62
Pulpwood					54,03
Other					
Wood fuel					88,41

	Use					Flows from the rest of the world
	Logging	Panel industry	Sawmill industry	Pulp industry	Energy use of wood	Net Imports
Net annual increment						
Residues	253,028					
Removals	491,172					
Roundwood		216,11568				13,65
Sawlogs			132,61644			
Pulpwood				54,02892		
Other						
Wood fuel					88,41096	

Table 3 JRC FAO Timber provisioning service

As expected, the importance of the ecosystem contribution is directly linked with the importance of forestry sectors in European countries (Table 3). It is interesting to note that where semi-natural management regimes (e.g. in Germany the ratio GFCF/Output is about 0.03 and in France is about 0.06) the ecosystem contribution and the importance of the forestry sector is higher or equal than in countries where practices like plantation (which is part of the GFCF) record entries (e.g. in Sweden with a ratio of 0.15 and Finland with a ratio of 0.11).

	Ecosystem contribution	Forestry sector relative importance
AT	23.23	3.38%
BE	4.33	0.62%
BG	13.94	1.93%
CY	0.03	0.01%
CZ	19.67	2.75%
DE	115.02	15.94%
DK	5.64	0.84%
EE	10.82	1.55%
EL	3.29	0.61%
ES	35.12	4.77%
FI	83.24	12.55%
FR	80.02	10.66%
HR	7.66	1.09%
HU	8.90	1.31%
IE	5.94	0.90%
IT	27.93	4.37%
LT	9.47	1.48%
LU	0.63	0.09%
LV	18.30	2.64%
NL	2.66	0.37%
PL	58.56	8.37%
PT	17.37	2.56%
RO	27.87	3.93%
SE	65.30	10.66%
SI	8.75	1.23%
SK	12.83	1.81%
UK	22.16	3.11%

Table 4 Ecosystem contribution and relative importance of forestry sectors in 28 European countries

From physical to monetary accounts: preliminary results

Crop and timber are SNA products. The provisioning services are assessed as the contribution from the ecosystem to generate these products. In monetary terms this implies to disentangle the ecosystem service (as one of the production input) from the final output.

This process can take place in two ways:

1. by multiplying an average price to the quantity in physical terms
2. by applying the ecosystem contribution ratio directly to the monetary accounts.

In principle the two approaches should lead to the same result. In practice this does not happen as shown by the case of crop provision (Table 4).

	2000	2006	2012		2000	2006	2012
	[euro(ratio*tonne)]*				*(ratio*euro)*		
AT	170	129	184		210	159	230
BE	166	197	508		120	157	465
BG	1,167	1,240	1,361		124	93	121
CZ	235	311	537		240	293	536
DE	2,245	1,961	3,368		2,662	2,107	2,948
DK	515	420	499		572	451	637
EE	34	67	109		45	81	152
EL	65	59	67		102	90	98
ES	1,015	891	1,083		1,006	961	1,564
FI	234	217	236		293	269	299
FR	3,358	2,887	3,351		3,306	3,293	4,391
HU	335	605	891		345	506	832
IE	85	83	105		247	254	362
IT	929	673	794		1,167	943	982
LT	21	42	140		23	61	136
LV	431	747	442		112	193	477
NL	478	380	446		359	331	468
PL	737	1,009	1,438		657	906	1,432
PT	96	76	104		82	55	62
RO	674	789	1,571		625	677	1,402
SE	286	227	329		477	388	611
SI	25	24	26		21	27	28
SK	80	158	231		78	125	207
UK	1,024	798	1,286		1,001	800	1,087
EU	14,406	13,993	19,105		13,877	13,220	19,527

Table 5 Valuation of crop provision: two approaches

There are obviously advantages and drawbacks in both approaches. The main drawback in the first approach concerns the availability of data. In many cases, approximation take place to cover the data gaps of original datasets. The main advantage is its full consistency with the accounts in physical terms.

The main drawback of the second approach is linked to the fact that we are not really applying the ecosystem contribution ratio to the resource rent but to the full figure reported in the economic aggregates. These numbers combined with the physical data will not generate the same estimates reported as average prices. The main advantage is a larger coverage in terms of data availability and its direct link with economic accounts (as the starting point are the same economic aggregates).

Questions for the London Group

The followings are questions for the London group:

1) How can we translate the physical analysis described in this paper for crops in monetary terms: how our preliminary results can we improve them?
2) Wow can we translate the physical analysis described in this paper for timber s in monetary terms: how our preliminary results can we improve them?
3) Which suggestions may the London group supply us for the concrete implementation of this analysis in European and non-European countries?

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ANNEXES

Crop Mapping:

INCA		FAO		CPC		by Groups
Code	**Name**	**Code**	**Name**	**Code**	**Name**	
SWHE DWHE	Soft wheat Durum wheat	0015	Wheat	0111	Wheat	*Cereals*
BARL	Barley	0044	Barley	0115	Barley	*Cereals*
OATS	Oats	0075	Oats	0117	Oats	*Cereals*
MAIZ	Maize	0056	Maize	0112	Maize (corn)	*Cereals*
OCER	Other cereals			0119	Other cereals	*Cereals*
RAPE	Rape	0270	Rapeseed	01443	Rapeseed or colza seed	*Crops Bearing Oil*
SUNF	Sunflower	0267	Sunflower seed	01445	Sunflower seed	*Crops Bearing Oil*
MAIF	Fodder maize	636	Maize for forage	01911	Maize for forage	*Fodder Crops*
OFAR	Other fodder on arable land			01919.90	Other forage products	*Fodder Crops*
PULS	Pulses			0170	Pulses (dried leguminous vegetables)	*Pulses*
POTA	Potatoes	0116	Potatoes	01510	Potatoes	*Roots and Tubers*
SUBG	Sugar beet	0157	Sugar beet	01801	Sugar beet	*Sugar Crops*