GENERATION AND FATE OF CROP RESIDUES – METHODOLOGICAL TREATMENT IN SEEA AND ESTIMATES FOR ITALY

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ABSTRACT

The growing economic and environmental relevance of biological residues from cultivation (non-edible parts of vegetables, stalks, pruning residues, end-of-life trees…) calls for greater attention to their measurement. Biological residues from cultivation are often gathered and composted, or used as fodder, or for energy production. The remaining quantities are left on the soil or burnt in the open, or eventually landfilled. Different consequences in terms of environmental pressures and economic results arise from different management ways of these residues. It is therefore of great interest for research and policy use, to gain better knowledge on the amounts of biomass involved, as well as of their current distribution between the various possible destinations.

We first introduce the notion of "biological *residues* from cultivation" and clarify its relation to the definitions of "products" and "residuals" in the general SEEA Central Framework physical flow accounts context (SEEA Central Framework 2012, ch. 3), as well as to that of "unused materials" in Economy-wide material flow accounts (Eurostat, 2001; SEEA-CF, 3.6.6). "Residues" covers a broader set of materials than "residuals", which in turn is broader than "unused" (as for biological residues of cultivation).

Very little official statistics is available on biological residues from cultivation. In Italy, estimates were made in the past by using agronomic information. Istat's structural surveys on agricultural holdings, carried out in 2013 (focussing on permanent crops) and 2014, introduced questions for the first time on these flows. In the paper we show the results of these data collection exercises and conclude that, in order to fill this information gap, official statistics needs not embark on regularly surveys but only provide some benchmark as for the supply of residues, while for the management and uses, the phenomenon should be considered in structural surveys and in exploiting administrative sources. SEEA AFF could also play a role in this respect, though maintaining its focus on main crops, by including the connected ancillary biomass flows.

Keywords: SEEA-CF, SEEA AFF, crop residues, biological residuals, unused biomass.

1. Introduction

Unused residues stemming from crop, timber, fish and other primary biomass production processes make up for a significant part of the total biomass produced in Agriculture, Forestry and Fisheries activities: 20% of it, i.e. 5.5 billion tons, according to data responding to the Economy-wide material flow accounting (Eurostat 2001) definition of "unused" available on

www.materialflows.net. The wise management of these residues, though probably not the key to solving any specific problem, may help reach some sustainable development (SD) goals, many of which rely on an environmentally sound agricultural sector. Indeed, crop residues may be left on the soil; burnt; collected and used - in the same holding or in other establishments – as inputs in the production of other goods (e.g. straw used as fodder; non-edible parts of plants fed into a digester or a composter); collected and put into a landfill. The way they are dealt with has consequences in terms of soils health, greenhouse gas emissions, fertilisers consumption, waste management, energy production, agricultural income. Depending on the way these residues are managed, the nutrients contained in them may be squandered or returned to the soil (directly, or as manure, or after composting). From a policy concepts and programs point of view, this issue is relevant for the *circular economy* (EU, http://ec.europa.eu/environment/circular-economy/index_en.htm), for *sustainable production and consumption* (UNEP - http://www.unep.org/rio20/About/SustainableConsumptionandProduction/tabid/102187/Default.aspx; EU, http://ec.europa.eu/environment/eussd/escp_en.htm) and for the *green economy* and green *growth* concepts (OECD, http://www.oecd.org/greengrowth/; ESCAP, http://www.unescap.org/our-work/environment-development/green-growth-green-economy; World Bank, https://issuu.com/world.bank.publications/docs/9780821395516).

Information on biological resource residues exists but is not gathered in a systematic way. Whilst it is relatively easy to calculate their quantities supplied by agriculture and forestry, on the basis of agronomic knowledge (much less so for fisheries), on the use side no systematic gathering of basic data is available. Some information is provided by waste statistics. This information is, however, neither complete as for its coverage of the phenomenon – residues not entering a waste collection scheme do not feature in them - nor always clearly referable to harvest or felling residues.

The System of Economic and Environmental Accounts for Agriculture, Forestry and Fisheries (SEEA-Agriculture), promoted by FAO and UNSD, is a powerful tool for organising SD-relevant information on these primary activities, covering among others the data domains of crops, forest products, fisheries, energy, greenhouse gas emissions, fertilisers consumption, water use, soil and agricultural income – to which the supply and/or the use of biological resource residues are related. It does not explicitly include, for instance, crop residues. Only the used part of these may in principle feature in the physical account for crops. In an implementation exercise, should one want to include them, however, there would be the need to come up with a figure for the share of used quantities over total quantities, in order to estimate the quantity that belong to that account and keep it distinct from the part being managed differently.

In the present paper we discuss the treatment of residues in SEEA physical flow accounts and describe calculations and results of two complementary data survey and elaboration exercises carried out in Italy in a context of collaboration between producers of structural statistics on crops and national accountants in charge of environmental satellite accounts. This exercise is limited to crop production systems (temporary and permanent) and relies on the data collected in two different occasions, namely the Survey on the Structure and Production of Agricultural Holdings and the Survey on Permanent Crops, carried out by the Italian National Statistical Institute, Istat. Both these surveys are regulated by binding legal acts of the European Union (regulations 1166/2008 and 1337/2011 respectively) but the questions on crop and pruning residues were added as *ad hoc* information sources for enhancing economic accounts and environmental accounts as well as other possible uses such as greenhouse gas emissions estimation.

2. Treatment of crop residues in SEEA-CF physical flow accounts

The SEEA for Agriculture, Forestry and Fisheries (SEEA AFF) is the internationally agreed methodological document in support of the SEEA-Central Framework (SEEA-CF) dealing with the

application of the latter in the agricultural field (outcome of the XI meeting of the UN Committee of Experts on Environmental-Economic Accounting – UNCEEA, June 2016). This document focuses on the main products of agricultural activities, and leaves to future developments the "important area of research" of "a more complete and consistent articulation of losses, unused biomass, residues, waste, reuse and recycling in relation to biomass" (§ 2.133, SEEA AFF, draft for consideration by the UNCEEA, June 2016). In trying and contributing to these developments, we therefore will refer directly to the SEEA-CF as for the definitions and treatment of these concepts.

The first and most general concept we use here and in the surveys described in the following chapters, however, is used in SEEA-CF (see in particular §3.99) and AFF (see above), but is not defined in there. It is that of crop *residues*. The way we use the term here, which we think is consistent with the way it is used in SEEA, it designates all the parts of plants different from their main useful product, such as e.g. non-edible parts of vegetables' plants, stalks or wood resulting from pruning, discarded fruits, crops grown but not harvested for whatever reason. These include not only things that respond to the SEEA definition *residuals* (§3.73), but also to that of *products* (§3.64), such as e.g. straw that is gathered and sold (or used on own purpose, which is common for holdings having animals) by the producing units.

In the SEEA-CF, like in the System of National Accounts (SNA), biological resources are distinguished into cultivated and non-cultivated (SEEA-CF §3.54). Non-cultivated biological resources are not covered at all by the present discussion, which only concerns biological residues from cultivation processes, i.e. stemming from *cultivated biological resources.* In particular, we do not cover here residues from extraction of *non-cultivated biological resources* (felling residues of natural forests, discarded catch of wild animals) – called *natural resource residuals* in SEEA-CF (§3.49).

Cultivated biological resources may be considered in two different ways, corresponding to two different system boundaries. Both are described in the SEEA-CF[1]:

- In the most general description of physical flows, coherently with the national accounting concept that cultivated plants are assets within the economy, they are considered as "produced within the economy and hence are not flows from the environment" (§3.47). It is important to note however that *natural inputs* comprise the "precursors" (water, inputs from soil, inputs from air) of the *cultivated biological resources*, including of the residues we are interested in (SEEA-CF §3.45, table 3.2). The present discussion is therefore relevant – although only indirectly – for these *natural inputs*. According to this approach, indeed, the physical flow account records, among *natural inputs*, the elements – such as carbon, oxygen, nitrogen, other nutrients and water – entering the cultivated plants, since the nature-economy boundary is set at the trophic level of plants' metabolism (correspondingly, the elements exiting the plant are recorded as residuals flowing to the environment). However, only part of the total plants' biomass, in which the input elements are embodied, constitutes a *product*. The rest is immediately transformed, at the time of harvest or catch, in what the SEEA calls *residuals*, and precisely into *solid waste*.
- In the section dedicated to Economy-wide material flow accounts (Ew-MFA: SEEA-CF, section 3.6.6), instead, the so called "harvest approach" is taken, according to which the treatment is the same as for non-cultivated resources (§3.282). In this approach, the plants and

[1] The two approaches are reconciled within a common framework in the OECD manual on Material Flows and Resource Productivity (OECD, 2008, vol. 2). Within this framework the two different boundaries define a *semi-natural system* that extends from the trophic level of cultivated plants nutrition (outer boundary of the economy) to the point of harvest (inner boundary of the economy). An accounting scheme could be defined describing inputs and outputs of this semi-natural system. Its inputs would be exactly the ones defined by the first approach (the trophic level of the SEEA-CF); its outputs would comprise the *crop residues* we are dealing with here.

their metabolism are left out of the economic system boundary, so that the flows accounted for as crossing the Ew-MFA environment-economy boundary are directly the quantities of cultivated biomass resulting from the cultivation process. These quantities are then distinguished into *used* and *unused*, according to whether they are subsequently embodied into products or not. Eurostat's 2001 methodological guide (§3.31) gives the following definitions:

- "Used refers to an input for use in any economy, i.e. whether a material acquires the status of a product".
- "Unused flows are materials that are extracted from the environment without the intention of using them, i.e. materials moved at the system boundary of economy-wide MFA on purpose and by means of technology but not for use".

Unfortunately, these definitions do not seem to be clear enough as to easily accommodate all crop residues to either category, although the two should be jointly exhaustive with respect to crop residues. In fact, some crop residues are inputs for use in economic production processes (which would qualify them as "used") but do not acquire the status of a product (which would qualify them as not "used"). Think for instance of crop residues that are fed into digestors for biogas production, or into composting facilities for making compost, without their owners (who discard them as waste) receiving any payment or allowance in exchange (as is the general case). It is recognised that these residues are generated "without the intention of using them" (which would qualify them as "unused"), that the guidance for implementation provided by Eurostat (2013) – which provides tools for calculation of used residues – does not foresee these flows, and that the common practice of environmental accountants is to ignore them in their estimation of (used) Domestic extraction. All this notwithstanding, we will consider these flows as of materials that are used, because: *a)* these destinations are becoming more and more common for crop residues and economically important, at least for their users; *b)* if these residues are not accounted among the "used" materials, material goods would emerge at some point in the economic process (biogas, compost) and at the output side (air emissions, dissipative use of products) without any corresponding input (used domestic extraction or imports) being recorded, which would contradict the logic of Ew-MFA and the mathematical equilibrium of inputs and outputs in its Direct material flow balance account. As a corollary, only the residuals left on the soil or burnt in the open, or landfilled are *unused* in Ew-MFA sense.

Summarising, we have *unused crop residues* which are a subset of *residuals from crop residues*; these form the total of *crop residues* together with *products from crop residues* – which are of course made of *used materials* in the sense of Ew-MFA. The following scheme shows this, and in the bottom row the connection to the categories used in the presentation of data in chapter 5 of this paper.

CROP RESIDUES	
PRODUCTS FROM CROP RESIDUES	RESIDUALS (SOLID WASTE) FROM CROP RESIDUES
USED CROP RESIDUES	UNUSED CROP RESIDUES
E.g. Burning for heat, composting use in husbandry, use for biogas production	E.g. Leaving on soil possibly after shredding, open-air disposal (including burning), disposal as waste outside the holding

The peculiar nature of *crop residues* is highlighted by considering that many *crop residues* may a-priori be *products* or *used residuals* or *unused residuals*, and what they actually are only depends on circumstances, i.e. on whether there is a market for them or not. E.g. straw is always a crop *residue*, but it is not always a *residual*, as it is often sold or used in the holding producing it: in this case it is a (by-)*product* with a positive economic value of its own. Use of straw as fodder or for

animals' bedding is indeed very common and the value of this straw is accounted for in standard National accounts as included in the agricultural industry's output. But not all straw is gathered and marketed or used: if there are no animals, it is usually left on the soil or burnt, which makes it an *unused residual*. In other words, the concept of *crop residues* is a more "stable" one and this seems a good reason for using this more general concept in combination with the concepts of *residuals* and *unused* instead of either of the two alone, because it provides a more sound reference point for analysis, given that the materials contained in crop residues are always relevant from the environmental and/or economic point of view, whatever their fate.

In the general supply-use scheme of the SEEA-CF, the flows of *products from crop residues* are not distinct from those of all the other products, and only if a detailed waste supply and use account is compiled, the fate (being used or left unused) of the *residuals from crop residues* is visible. The Ew-MFA treatment helps in that it identifies the quantities of residues that are left *unused*. These have potential uses as input materials for other production processes or even as *products* of their own, and as such could provide indirect or direct sources of income for crop producers and of raw materials for the potential users.

The latter potential, which appears to be exploited more and more, is not necessarily a blessing for agricultural holdings, as short-term gains in income may from selling the residues could be offset by longer-run effects of taking the residues away from the soils where they were grown. if the crop residues are taken away, indeed, the nutritive substances embodied in them will not return to the soil where they were taken from. In the long run soil quality and eventually fertility may decline, resulting in lower productivity and/or higher costs for other inputs such as synthetic or organic fertilisers.

3. Data gathered through Istat's structural surveys on agricultural holdings

For the reasons above, we introduced in two Istat's surveys (Permanent Crops Survey – PCS – 2012 and Farm Structure Survey – FSS – 2013) some simple questions, aimed at knowing more on the management of biological resources residues by agricultural holdings. These questions concern residues from permanent crops (PCS) and cultivations on arable land (FSS), i.e. from all cultivated biological resources, but from felling of cultivated forests, which are out of scope of the two surveys. The questions were kept as simple as possible, reducing to a minimum the information requested, in order to ensure its reliability and to increase the response rate, in view of the secondary importance of the topic with respect to the general aims of the surveys and of the respondents' ability to provide data on non-core activities.

In particular, for permanent crops, two questions were introduced, one concerning the quantity of pruning residues produced, the other concerning the management of all residues produced, deriving from permanent crops. As for the first question, the quantity was requested by species, for the 12 most important species, but notably excluding wine grapes, nut trees and some other minor species. The second question was referred to all residues including – besides the pruning residues covered by the first question – leaves, removed trees, non-saleable fruits etc. With this question we asked for percentages on total residues' weight, by kind of management. For the major possible uses, the residues dealt with inside the holding were distinguished from those given to others in the first place. The former were detailed into: composted; ground and released on soil; used as fuel for heating purposes; disposed of in the open (including – as specified in the instructions – possibly illegal practices such as on-field burning – which is prohibited in Italy); used in husbandry. For the residues given to others, an attempt was made to ascertain from the producer whether to his knowledge they were destined to be composted, used for energy (heat) or landfilled. Finally "other" was included as a possible answer, for special cases such as e.g. the use

of the timber as a raw material for artwork, industrial or construction uses, within or outside the holding.

As for cultivations on arable land, we concentrated on the management and only asked for the percentage distribution of the residues of two broad groups of crops – i.e. cereals and crops on other arable land – among four possible management ways: leaving the residues on the soil (whether burying them or not); reusing them within the holding for forage or bedding for animals or for any other use; selling; managing the residuals as waste (including possibly illegally burning them), whether within the holding or outside it. The first and last management ways correspond to the *unused* case, and the other two to the *used* case, with the "selling" surely points at *products* while "reuse inside the holding" includes the case of *residues* that are *products* – namely for cereals' production residues, which are given a value in Italian economic accounts for Agriculture – and that of *residuals* that are *used* but are not *products*, having no market value of their own – the case of residues from crops on other arable land.

In the PCS, 27,234 holdings were sampled. In the FSS, 44,550 of which only 28,141 having arable land (excluding land set aside, or with flowers and ornamental plants). The questions were quite successful, with response rates as high as 87% for the production of pruning residues, 86% for the management of residues from permanent crops, 95% as for residues from cereals, 78% as for residues from other arable land. In the PCS, 98.3% of the holdings who provided data on the production of pruning residues also answered to the question on the management of residues from permanent crops.

It is recognised that the overall accuracy of the permanent crop survey's results is negatively affected by the non-participation in this survey of a whole region (Tuscany). This region however is relevant, among the surveyed species, only for olives, and its contribution to pruning residues production was estimated only for this species, by expanding proportionally the results obtained on the respondents (Italy totals for other species may therefore be slightly underestimated). The same was done in order to estimate non-respondents' contributions also for the other questions. We will not dwell further on the process of going from survey data to final, complete estimates, as we followed standard control and correction procedures. An encouraging circumstance, however, is that corrections turned out to be necessary only in a quite low number of cases, e.g. concerning the order of magnitude of the reported pruning residues where it was evident that the respondents had used tons or kilograms instead of hundred kilograms as requested.

4. Estimates of the supply of agricultural residues in Italy

Estimates of agricultural residues have been made for Italy by Istat (2010 and 2011), Ispra (2010), and Paolantoni (2015).

Table 1 provides a summary of our results, showing the source for each of the figures provided. In order to ensure completeness, for those residues from permanent crops that are not covered by the question on residues generation in the PCS – namely residues from pruning of some tree species, from pruning of vineyards and from removal of whole plants – we complemented the estimates with the quantities calculated by Paolantoni (2015). These are in turn based on updating the information contained in Ispra (2010). Our estimates for temporary crops and main permanent crops are substantially in line with the figures provided by the other sources quoted above.

The residues supplied by the cultivation of temporary crops were calculated by applying agronomic coefficients to the produced quantities. These were in turn estimated in the case of *dry pulses* and *other vegetables* by the application of agronomic coefficients to the production data supplied by another Istat survey the "crop estimates survey" (CES). In all other cases, where the FSS survey provides accurate area data we calculated the production of residues by each holding by

applying the same coefficients to that holding's production estimate, resulting from multiplying the average yield-per-area-unit provided by the CES with the area declared in the FSS by that holding for that specific crop (area data for *pulses* in the FSS may be overestimated from wrong allocation to it by respondents of fresh peas, beans etc, with a corresponding under estimation of the area devoted to *other vegetables*).

It is recognised that these supply estimates do not include residues from cultivation of ornamental plants and flowers, as well as from elements of the rural landscape, such as e.g. hedges, which may also be considered as "cultivated" in SNA's sense but do not yield products and are therefore not considered in agricultural statistics. These have so far not been considered in any material flows accounting exercise, not even for the products' part of them.

Table 1: *Supply of residues from the cultivation of crops and source of information, by crop, Italy 2012 or 2013(000 tons)*

	Total Supply	Source of the estimate
TOTAL CROPS	**43,573**	
Temporary crops	**35,611**	
Cereals	*29,040*	*Istat's 2014 survey on the structure and production of agricultural holdings, with yields and some area data from crop estimates survey (2013 data)*
Wheat and barley	11,922	
Rye, corn	13,211	
Other	3,907	
Other temporary crops	*6,571*	
Dry pulses	189	
Tubers	1,211	
Industrial crops	1,829	
Other vegetables	3,342	
Permanent crops	**7,961**	
Pruning of main permanent crop species, excluding vineyards	*3,715*	*Istat's 2013 survey on main permanent crops (2012 data)*
Pruning of vineyards, almond, hazelnuts, plum trees	*2,417*	*Paolantoni (2015) (estimates based on agronomic coefficients)*
Removed plants	*1,829*	
main permanent crop species, excluding vineyards	999	
vineyards, almond, hazelnuts, plum trees	830	

5. The "use" side

Tables 2 provides a summary of results from the two surveys, having the same sources as shown in table 1. As for permanent crops other than pruning residues of main species, again we complemented the survey results by using the estimates made by Paolantoni (2015), who exploited information provided by ISPRA in order to separate the used from the unused part of the residues. As said in section 3, *used* corresponds to either "reused within the holding" or to "sold" (in the latter case we have a product for sure), while *unused* corresponds to "left on soil" or "wasted".

It can be observed that use is dominant for residues from removal of fruit-bearing trees and significant for straws and similar residues from cereals cultivation and for pruning residues of main permanent species (excluding vineyards), whilst residues from all other cultivations are mostly left on the soil.

Table 2: *Use of residues from crops production, Italy 2012 or 2013, by crop and kind of use (000 tons and %)*

	"USED"		"UNUSED"		TOTAL USE (=TOTAL SUPPLY)
	within the holding	outside the holding	Left on soil	Wasted	
TOTAL CROPS	12,233 (28%)		31,34 (72%)		43,573
Temporary crops	***10,116* (28%)**		***25,496* (72%)**		**35,612**
	4,554 (13%)	**5,562 (16%)**	**24,970 (70%)**	**526 (1%)**	
Cereals	*4,356 (15%)*	*5,195 (18%)*	*19,123 (66%)*	*366 (1%)*	*29,041*
Wheat and barley	1,842	3,101	6,704	275	11,922
Rye, corn	1,994	1,675	9,492	51	13,212
Other	520	419	2,927	40	3,907
Other temporary crops	*198 (3%)*	*366 (6%)*	*5,847 (89%)*	*160 (2%)*	*6,571*
Dry pulses	22	21	145	2	189
Potatoes	55	41	1,093	22	1,211
Industrial crops	47	72	1,699	11	1,829
Other fresh vegetables	75	232	2,910	125	3,342
Permanent crops	**2,117 (27%)**		**5,844 (73%)**		**7,961**
Pruning of main permanent species, excl, vineyards	*905*		*2,810*		*3,715*
Pruning of vineyards, almond, hazelnuts, plum trees	*121*		*2,296*		*2,417*
Removed plants	*1091*		*738*		*1,829*
Main permanent species, excl, vineyards	344		655		*999*
Pruning of vineyards, almond, hazelnuts, plum trees	747		83		*830*

Source: our elaborations on FFS, PCS, CES and Paolantoni (2015)

Table 3 provides some additional detail from the permanent crop survey, showing how the 4.7 million tons of residues from main permanent species (pruning and removal plants) are distributed among the 9 different possible uses proposed in the question.

Table 3: *Management of residues from cultivation of main permanent crops, Italy 2012 (000 tons and %)*

	Within the holding					Outside the holding			None of the others – used within the holding	Total
	Unused, left on soil	Unused, wasted	Used			Used		Unused, wasted		
	Shredding and leaving on soil	Open-air disposal, including burning	Burning for heat	Com-posting	Use in husbandry	For energy use	For composti ng	For disposal as waste		
Quantity in thousand tons	2.832	612,4	948,2	77,5	21,9	151,5	6,4	20,4	44	4.714,2
%	60,1%	13,0%	20,1%	1,6%	0,5%	3,2%	0,1%	0,4%	0,9%	100,0%

The allocation to the categories used in table 2 is quite straightforward. *Burning for heat, composting* and *use in husbandry* within the holding correspond to the first column in Table 2, *energy use* and *composting* outside the holding to the second, *left on soil* to the third and *open air disposal* within the holding and *disposal as waste* outside the holding to the fourth. The only uncertain category is *none of the others*, which however only weights 0.9% of the total in this residues category, and has been allocated to "used" in Table 2.

6. Conclusions

Gaining sound and detailed knowledge of the amounts of used and unused biomass residuals from agricultural production is of interest for research and policy use, especially for what concern the current distribution of these precious biomass flows between the various possible destinations. However, very little official statistics is available.

In order to overcome this information gap, as far as the supply side is concerned, official statistics need not embark on regularly surveying the quantities involved, since reliable estimates can be constructed by using agronomic information (ratios of ancillary biomass to crops). However, official statistics should provide some benchmark, allowing to validate existing estimates and add detail (geographical, and by kind of plant) to them.

As for the management and uses side, the Italian experience shows that the investigation of the phenomenon greatly benefits from being considered in structural surveys.

As for the way forward, the data thus collected may then be connected to those on the destination of some agricultural residuals, present in administrative sources, e.g. on compost, biogas and biomass-based electrical energy production plants. The analysis can thus be extended to downstream steps in the use of this biomass, and possibly also transformed in terms of nutrient and pollutant elements cycles.

SEEA-Agriculture (FAO, forthcoming) could play a role in promoting this knowledge, though maintaining its focus on main crops, by including the connected ancillary biomass flows.

REFERENCES

FAO, UNSD (2016) *System of Environmental-Economic Accounting for Agriculture, Forestry and Fisheries*, draft for consideration by the UNCEEA at its eleventh meeting.

Eurostat (2001) *Economy-wide Material Flow Accounts – a methodological guide*

Eurostat (2013) *Economy-wide Material Flow Accounts – compilation guide 2013*

ISPRA (2010) Studio sull'utilizzo di biomasse combustibili e biomasse rifiuti per la produzione di energia, *Rapporti*, 111/2010.

Istat (2009) *Contabilità ambientale e pressioni sull'ambiente naturale: dagli schemi alle realizzazioni*

Istat (2013) Manual of the Permanent Crops Survey (In Italian)

Istat (2014) Manual of the Farm Structure Survey (In Italian)

OECD (2008). Measuring material flows and resource productivity: OECD guidance manual. Vol.II: A theoretical framework for material flow accounts and their applications at national level

Paolantoni, C. (2015) *Metabolismo socioeconomico delle biomasse e pressioni ambientali: descrizione e analisi attraverso il modello delle matrici Input-Output, applicato al caso italiano*, BA thesis, Università di Roma Tor Vergata.

UNSD *et al.* (2012) *System of Environmental-Economic Accounting (SEEA) – Central Framework*