The role of Ecosystem Services Demand in assessing the Ecosystem Services Actual Flow: three possible combinations

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Introduction

Scaling down ecosystem complexity (with the purpose to fit accounting mechanisms and formats) may require a sort of simplification but should not imply oversimplification. Measurements for services provided by ecosystems cannot be collected by censuses or officially conducted surveys as it usually happens for conventional economic accounts. Ecosystem services (ES) are generated by ecosystems through ecological processes. Scientific knowledge can help and support in estimating such measurements. Technology is mature enough to provide tools for non-scientists to use such a knowledge practically and pragmatically. However, knowledge without an underpinning consistent and comprehensive framework risks to remain a missed opportunity.

The INCA (Integrated system for Natural Capital Accounts) project was funded by the European Commission to test and implements the System of integrated Environmental and Economic Accounts – Ecosystem Accounting (SEEA EA) in Europe (UN et al, 2021). The INCA partnership was coordinated by ESTAT and included the Joint Research Centre (JRC) DG Environment, DG Research and Innovation and the European Environment Agency. During phase 2 of INCA (2016-2020), in-depth applications and analyses have been carried out on nine ecosystem services (Vysna et al, 2021). Thanks to these applications a few lessons learned are now available (La Notte et al. 2022a). Among them, the aim of this paper is to focus on the conceptual framework, specifically on the role of ES demand and its interaction with ecosystems' ecological processes.

The two pillars of the INCA approach

When approaching ES assessment, it becomes very clear that each ES has its own peculiarities, and that what is assessed for ecological purposes may not equal what matters from a socio-economic perspective. The INCA approach was developed with the purpose of building a consistent conceptual scheme that keeps a meaning in ecological terms and meets the need to integrate economic accounts. **The INCA approach is based on two pillars**:

1. ES play different roles according to the way ecosystems deliver them;
2. there is an interaction between what ecosystem provide and what is needed by economy and society.

About the first pillar, the way ecosystems deliver services is framed in five types, according to the fate of the energy, biomass or information that is produced, absorbed or mediated by ecosystems (La Notte et al., 2019). Specifically, as visually simplified by Figure 1:

- for source-provision services ecosystems act as sources of matter and energy in the form of biomass (e.g. wood provision);
- for source-suitability services ecosystems act as sources of matter and energy by providing suitable habitats (e.g. pollination);
- for sink services ecosystems act as sinks to store, immobilise or absorb matter (e.g. water purification);
- for buffer services ecosystems act as transformers, changing the magnitude of flows of matter or energy (e.g. flood control);
- for information services the information delivered by ecosystem does not modify the original state of the ecosystem (e.g. nature based recreation).

In the case of "source-provision" services (e.g. timber provision), the extraction of the biological resource can exceed the regeneration rate that guarantees the long-term sustainability of ecosystems and their capacity to generate service flows in the future. The same applies to "sink" services (e.g. water purification): pollutants' emissions can exceed the absorption rate that guarantees the long-term sustainability of ecosystems and their capacity to clean undesired and unhealthy externalities of human activities. **For**

“source-provision” and “sink” services, management practices matter: the quantity of natural resources extracted, the use of chemicals, hazardous emissions drive the change in ES delivery now and in the future. The way management practices take place can be sustainable or not (with respect to the sustainability thresholds that is set) and affect the yearly flow of the ES.

For all the other types of ES, there cannot be any exceedance in the use of services, because the presence of ecosystems able to provide those services is key for delivery. Where there is a need for “source-suitability”, “buffer” and “information” services but there are no ecosystems able to provide them, this need will remain unsatisfied. The **driver of change is land use**. Examples are: presence of pollinator-depended vegetation and absence of habitat suitable for pollinators; upstream absence of natural defence to reduce the risk of flood, landslides and avalanches for downstream human settlements; absence of parks to preserve physical and mental health pf local residents. Land use transformations may imply a remarkable time lag.

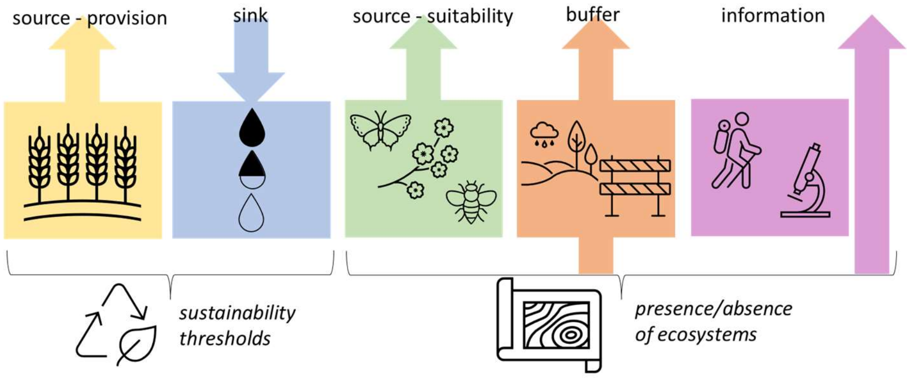

Figure 1- Conceptual scheme underpinning the measurement of Ecosystem Services actual flow

About the second pillar, ecosystem properties and conditions determine the ecological potentials to provide services. Properties are defined as the structure and processes of an ecosystem; conditions refer to the integrity and health status of an ecosystem (Burkhard and Maes, 2017). The potentials to provide services only tells the story from the ecosystem perspective. There could in fact be a demand for those services, where people or firms are located (e.g. pollination in pollinator-dependent cultivations), or there could be no demand (e.g air filtration in artic forests) and this represents the socio-economic perspective. In other words, there is a potential supply provided by ecosystems (that we may call ES potential [ES P]), independently whether it is used or not used. The ES P becomes a service (i.e. ES actual flow) when there is an interaction with the Ecosystem Service Demand (ES D). The ES actual flow is then used to fill the Supply and Use tables, which are the official accounts part of the SEEA EA (Figure 2).

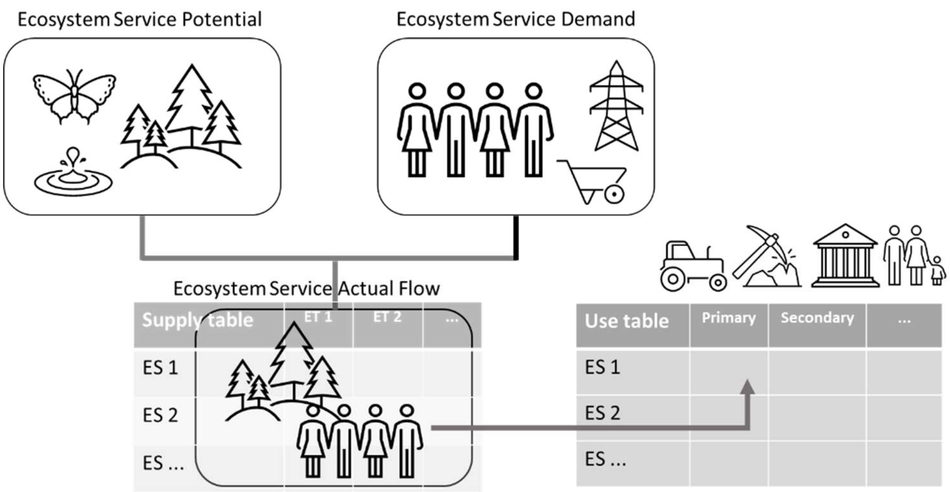

Figure 2- Conceptual scheme underpinning the measurement of Ecosystem Services actual flow

The behaviour of ES P in interacting with the ES D puts together the first and the second pillars is. Such an interaction in fact does not behave in the same way for all services. There are a few elements that matter in this respect:

- the existence of sustainable thresholds in ES regeneration and absorption rates;
- the presence of specific ecosystem types and their potential to provide ES;
- the “public good” nature of the service.

In addition, this interaction can generate a match (ecosystem service actual flow) or a mismatch. Based on INCA applications, it is possible to provide a range of examples for each of the previous cases. In the following sections, we are going to explore each case.

ES with “non-public good” nature

As already explained in the previous paragraph, there is an interaction between what ecosystems can provide in terms of potentials and what is actually needed by the society and the economy. Figure 3 visualizes the conceptual scheme that occurs by separately identifying the ES P and the ES D and what can occur as result of their interaction.

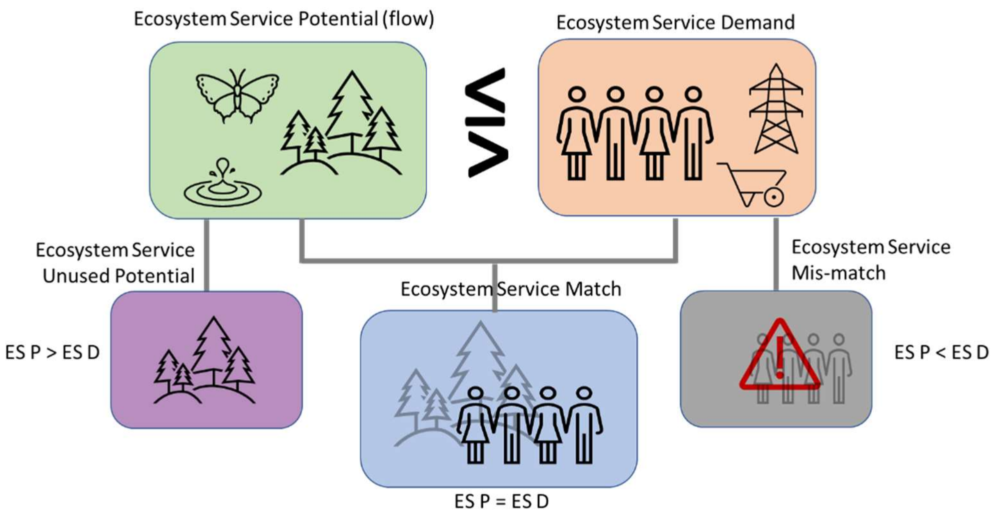

Figure 3 – Conceptual scheme underpinning ecosystem service flow

In fact, what reported in the SUT is only the quantification of the match between ES P and ES D. While there is no problem in case ES P remains unused, on the other hand there could be serious socio-economic problems when ES mis-match occurs.

Case 1: ES P and ES D interaction when there are sustainable thresholds in ES regeneration and absorption rates

For source-provision and sink services (pillar 1), the ES actual flow (recorded in the official SUT) will always meet the ES D. However, whether this kind of ES actual flow is sustainable is a different question. When looking at the interaction between ES P and ES D (pillar 2), in the case of ES D exceeding the sustainable use of service, the mis-match between the ES P and the ES D is quantified in terms of overuse. Figure 4 reports the water purification example (for further details on the assessment procedure please check chapter 5 of La Notte et al., 2021).

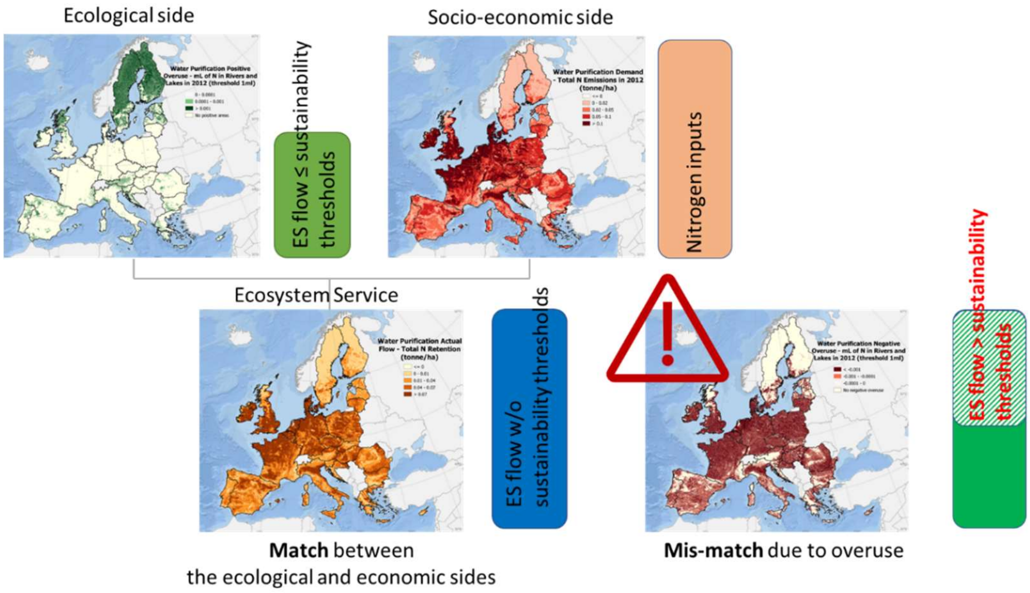

Figure 4 – Match (actual flow) and mis-match (overuse) of Water Purification

A mis-match caused by overuse eventually leads to ecosystem degradation (La Notte et al, 2017). **A degraded ecosystem may not be able to provide the same ES flow over time until it collapses. For policy making purposes it would be important to provide the policy makers with this kind of alerting information**.

Case 2: ES P and ES D interaction where ecosystems can be present/absent

For source-suitability, buffer and information services (pillar 1), the ES actual flow (recorded in the official SUT) may not fully meet the ES D. When looking at the interaction between ES P and ES D (pillar 2), in the case there are no ecosystems able to provide the services needed, the mis-match between the ecosystem potential and the ES D is quantified in terms of ES unmet demand. Figure 5 reports the flood control example (for further details on the assessment procedure please check chapter 6 of Vallecillo et al., 2019).

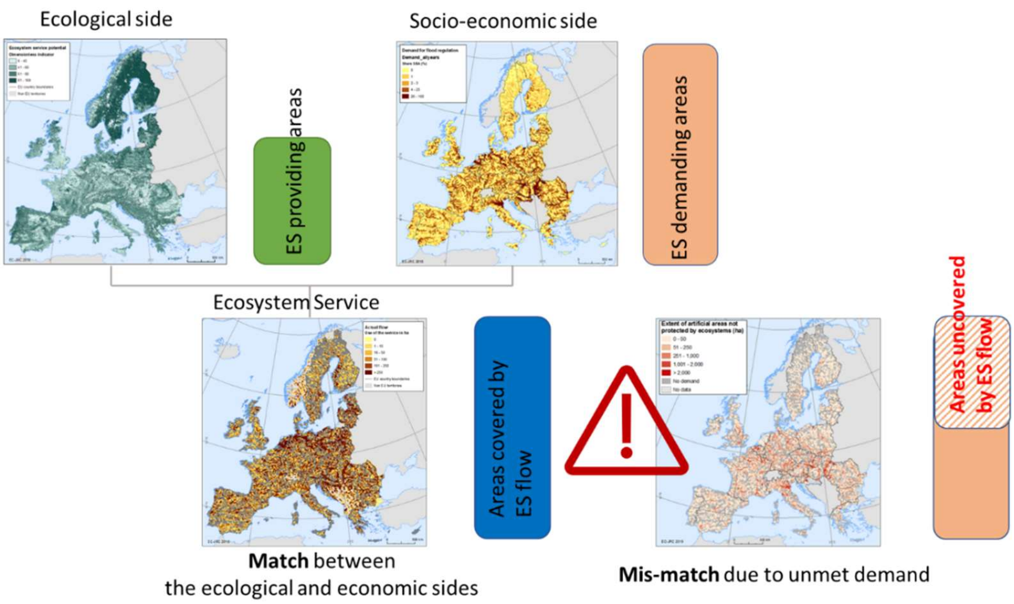

Figure 5 – Match (actual flow) and mis-match (unmet D) of Flood Control

A mis-match caused by unmet demand, imply (in this case) to increase the exposure of economic assets and human settlements natural hazards or in other cases (e.g. in the case of pollination and soil retention) reduce the ecological input for the agricultural sectors (La Notte et al., 2022b). **The vulnerability of ES is a concrete policy issues about which policy makers should be constantly updated to direct concrete actions where they are needed**.

ES with "public good" nature

There are some ES where users are not a specific sector in a specific country. Those particular ES represent a sort of public good for the global population and its survival on the planet. Specifically, the reduction in damages caused by climate change and biodiversity loss is connected to the production of public goods, and "global public goods" are acknowledged in the form of some regulating and maintenance services. The examples reported for global public goods are the world's rainforests and oceans and it is clearly stated that if we are to preserve them, the global community should be prepared to pay and their management requires transnational institutions. When ecosystem services address overarching environmental targets, such as climate change mitigation and halting biodiversity loss, the conceptual scheme becomes as visualized in Figure 6.

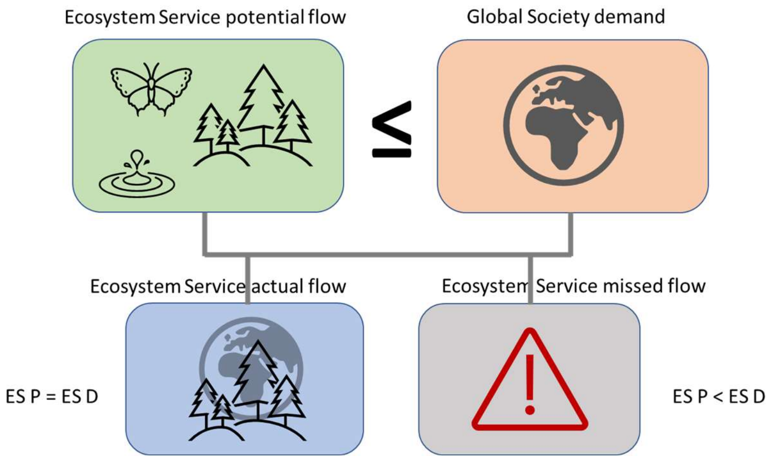

Figure 6 – Conceptual scheme of ecosystem service concerning overarching environmental targets

One important property of ES that are global public goods is that they do not require any conscious and active 'harvest efforts' to exert their benefits. Therefore, all of ES P will instantly be 'utilised' and there is no need to model, assess or map ES D, as is done for other ES. Nevertheless, it is still meaningful to compare the actual flow with an 'adjusted' version of the potential flow, which is calculated as ES P assuming a sustainable management. The difference between this (adjusted) potential flow and the actual flow is a 'missed flow' that does not reach global society. Such missed flows have an important message for global policy

Case 3: ES P and ES D interaction for "public good" services

Like it happens in the case of the ES unmet demand, for global ES there is also a part of the ES potential that does not reach global society. When services have a "public good" nature, the mis-match between the potential flow and the ES D is quantified in terms of ES missed flow. The example here shown concerns carbon sequestration (for detailed description check Chapter 6 of La Notte et al. 2021). This refers directly to climate change mitigation, which is a global issue affecting the whole planet. Among the several international initiatives that directly address climate change, the Intergovernmental Panel on Climate Change is the UN body created to provide policymakers with regular scientific assessments on the implications and potential future risks of climate change, as well as adaptation and mitigation options. In the case of carbon sequestration, the ES P flow is the net carbon removal by ecosystems, especially (but not exclusively) the net removals by 'woodland and forest'. However, ecosystems also generate net emissions. Before considering carbon removal as an ES actual flow to global society, emissions (which largely depend on how ecosystems are managed) have to be quantified and their levels will lower the net carbon removal. Figure 7 reports the carbon sequestration example.

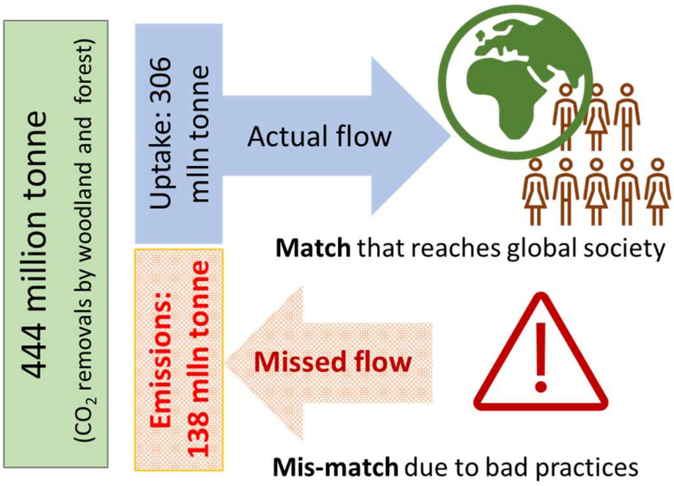

Figure 7 – Match (actual flow) and mis-match (unmet D) of Carbon Sequestration

The actual flow is therefore quantified as the net balance between removals and emissions (net carbon sequestration). Carbon emissions are the 'obstacle' to accounting all net carbon removal as ES actual flow; they can be reported as the ES missed flow. If emissions are greater than removals, then ecosystems are not contributing to the mitigation of CO_2 in the atmosphere (i.e. there is no benefit to global society). The message for policymakers is to promote policies able to reduce ecosystem emissions, and thus eliminate (as much as possible) the obstacle to full carbon removal actual flow.

Discussion

When moving from the conceptual level to the empirical level, there could be different ways to assess the actual flow. In some cases, there is the possibility to use fast track approaches, which are based on already existing datasets combined with look-up tables. In other cases, modelling is used to map and assess first the ecosystem potential flow and the ES D and then their interaction. The outcomes of applying the fast-track versus modelling approaches vary in the quantity and quality of deliverables they can generate. By applying the modelling approach, it is in fact possible to assess matches and mis-matches of ecosystem services and eventually report these information in official and complementary accounting modules.

An additional consideration: fast track approaches are mostly suitable for provisioning services, where an SNA output already exists; for regulating, maintenance and cultural services, when there is an ES demand, it is important to be conceptually consistent on how the ES actual flow is generated from ES P and ES D.

This implies that it should not be assumed that ES P equals ES actual flow (see example in Figure 8 about crop pollination and Figure 9 about flood control). It would be wrong to insert the assessment of ES P in the SUT (Figure 10).

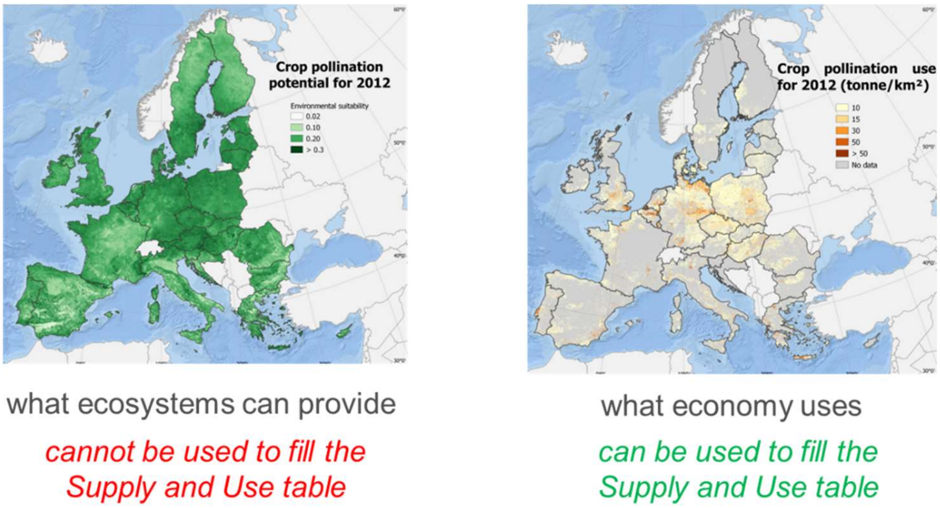

Figure 8 – Crop pollination potential and crop pollination use

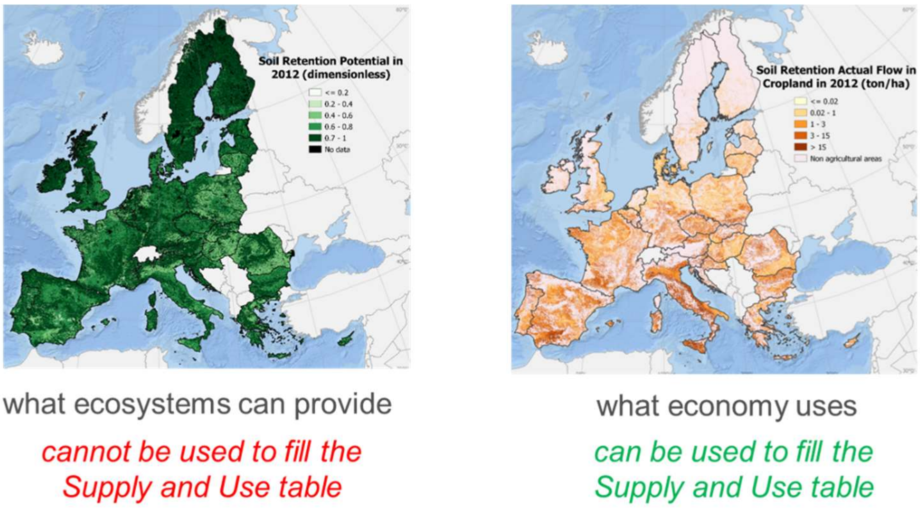

Figure 9 – Flood control potential and flood control use

It also implies that ES D does not necessarily equals what is inserted in the Use table. As shown in Figure 1 and Figure 10, it is the ES actual flow that has to be used to fill the SUT. The ES actual flow results from the interaction between the ES P and ES D. Case 2 shows that there can be cases where part of the ES D may remain unmet. To consider the ES D equal to the ES actual flow that is inserted in the Use table is a misleading message for policy makers that would not see whether there is an issue and where it occurs.

It is thus important to have a comprehensive conceptual scheme that is able to fit consistently all the components, with an underpinning coherence between the ecological meaning of the numbers and their economic contextualization.

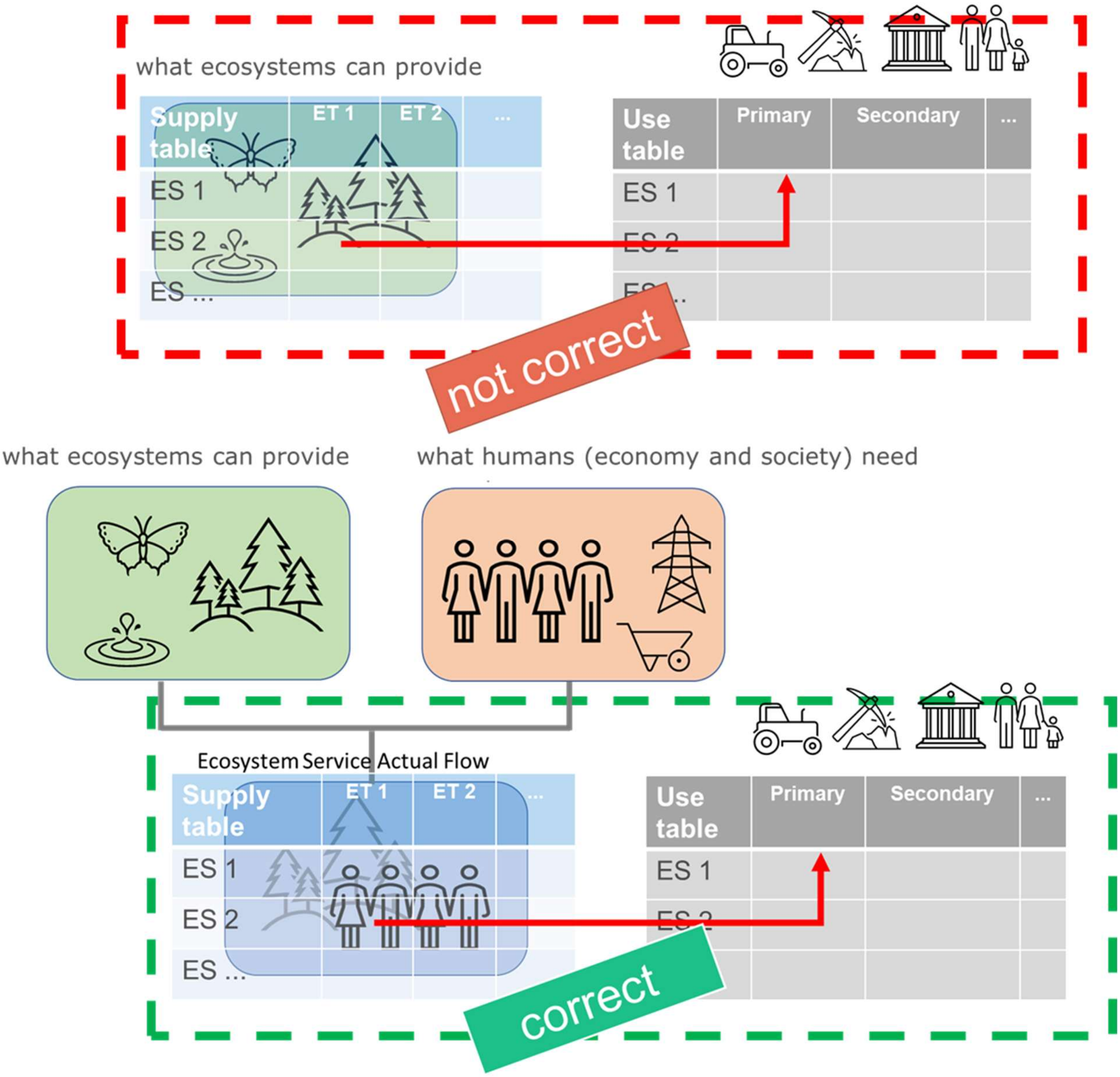

Figure 10 – Visual simplification of what should be used to fill Supply and Use Tables

It is also important to correctly frame those ES that have a “public good” nature, because they behave differently from all the other services and thus require a special attention.

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