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LInking accounts for ecosystem Services and Benefits to the Economy THrough bridging (LISBETH)

Natural Capital Accounts and economic models: interaction and applications

Alessandra La Notte, Alexandra Marques, Domenico Pisani, Silvia Cerilli, Sara Vallecillo, Chiara Polce, Ana Cristina Cardoso, Eugenio Gervasini, Joachim Maes

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Joint Research Centre

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Contact information
Name: Joachim Maes
Email: joachim.maes@ec.europa.eu

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Authors

Alessandra La Notte

Alexandra Marques

Domenico Pisani

Silvia Cerilli

Sara Vallecillo

Chiara Polce

Ana Cristina Cardoso

Eugenio Gervasini

Joachim Maes

Abstract

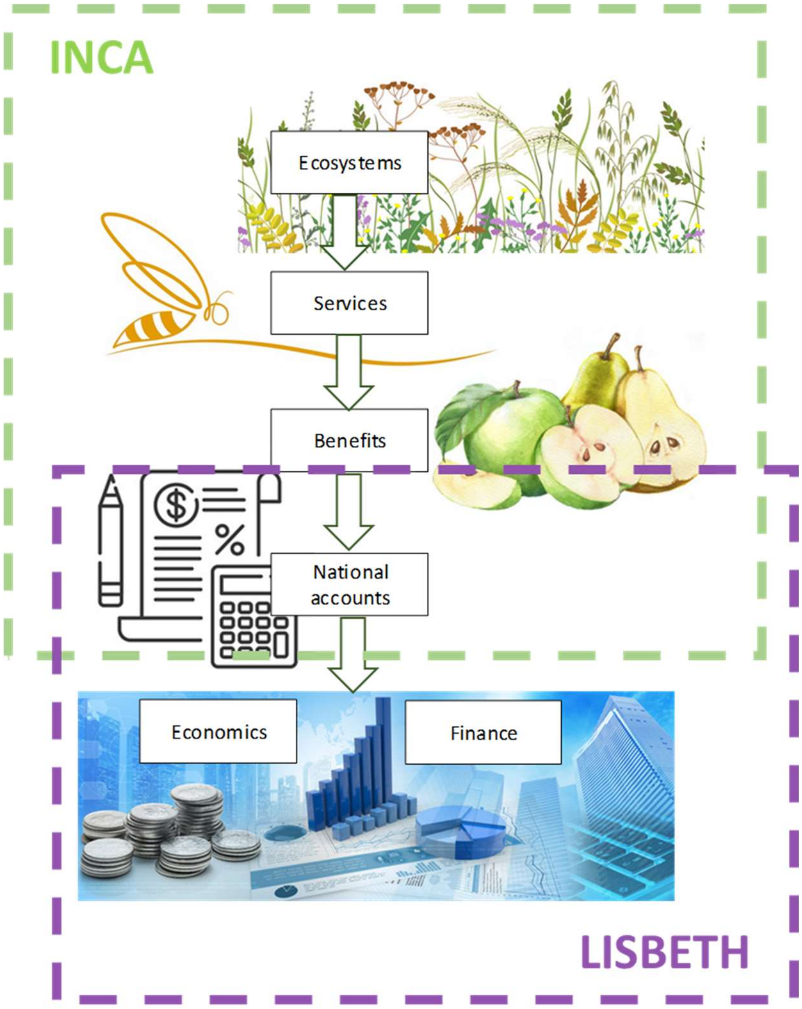
The acronym LISBETH stands for LInking accounts for ecosystem Services and Benefits to the Economy THrough bridging. LISBETH is based on INCA (Integrated system for Natural Capital Accounting) and is meant to facilitate the use of INCA accounts in traditional economic analytical tools. Three practical examples are described and commented on. The first application shows how to combine crop provision accounts with the conventional accounts related to agricultural products and their trade. Combined account presentations are useful for policymakers, not only for technical analytical purposes but also for communicating with a wider non-technical audience. The second application shows how to build consumption-based accounts using multiregional input–output tables; in our example we assess the water purification service embedded in traded crops. Consumption remains in fact the ultimate driver behind production processes. The third application shows how to link ecosystem services accounts to general equilibrium models to assess the economic impacts generated by changes in ecosystem services; in our example we address the impact of invasive alien species on pollination and in turn on pollination-dependent crops and their trade. The three applications provide several insights in terms of their usefulness at different steps of the policy cycle, their feasibility, their technical complexity (and thus the level of skill required) and also in terms of the primary users (from specialised analysts to a non-specialised audience).

Executive summary

Those making and implementing policies and actions on sustainable development need to acknowledge the bounds of the natural world and aim to achieve human well-being on a sustainable planet. This requires systems thinking: an understanding of the complex chain of cause–effect relationships. This new mindset requires operational **metrics** to enable policymakers to support holistic and sustainable planning. Natural capital accounts (NCAs) can provide such metrics because they use the same concepts, rules and framework as the System of National Accounts (SNA). The SNA describes the economic system and is the primary source of information for economic policies. Once the new NCA metrics are made available, it is necessary to specifically understand how to use them in **decision-making processes**.

The acronym LISBETH stands for LInking accounts for ecosystem Services and Benefits to the Economy THrough bridging. LISBETH is a contribution to the Knowledge Innovation Project on an Integrated system for Natural Capital and ES Accounting (KIP INCA), set up by the European Commission and the European Environment Agency in 2016 to design and implement an integrated accounting system for ecosystems and their services in the EU. LISBETH is meant to facilitate the use of INCA accounts in traditional economic analytical tools (Figure I). Several uses of NCAs in decision-making are possible, e.g. they can be directly employed by policymakers and based on relatively easy tools, or they may need to be processed by specialised analysts and integrated into complex modelling tools.

Figure I. From the accounts (INCA) to the policy uses (LISBETH)



In this report we describe three possible applications and their **key findings** in which NCAs, and specifically ecosystem services (ES) accounts, are *bridged* to economic accounts and models.

The first application shows how to combine the ES account with the **conventional accounts related to agricultural products and their trade**, specifically through the joint System of Environmental–Economic Accounting for Agriculture, Forestry and Fisheries (SEEA AFF) (by the Food and Agriculture Organization of the United Nations) and INCA (by the Joint Research Centre) accounts. Additional information on food availability and food system also allows us to further link ES and agricultural production to an indicator concerning nutrition. When these conjoined datasets are developed, there is considerable opportunity for descriptive analysis. Our example shows a scoreboard in which the three pillars of sustainability are logically and consistently combined to demonstrate that high levels of crop production could clash with sustainable management practices.

Combined account presentations (on which scoreboards are based) are useful for policymakers, especially those responsible for communicating with a wider non-technical audience. The main findings from combined presentations can in fact be easily processed to raise relevant policy issues. In our example we build a scoreboard, but there is a wide range of ways to proceed (from simple descriptive statistics to performance indicators). The statistical offices could easily establish links with the most popular initiatives targeting sustainability, e.g. the **Sustainable Development Goals** (SDGs). Some SDGs (to refer to our exercise) in a number of their targets mention agricultural resilience (e.g. target 2.4) and sustainable management practices in terrestrial ecosystems (e.g. target 5.1).

The second application shows how ES accounts can be used in combination with quantitative economic tools such as input–output tables to build **consumption-based accounts**. The purpose is to supplement production-based accounts that show the flow from ecosystems to the SNA with consumption-based accounts that address (at least some of) the real end users and that also take into account trade flows. In fact, consumption is the ultimate driver behind production processes: knowledge of the ES embedded in SNA products is an important piece of information for identifying indirect drivers of pressures on ecosystems.

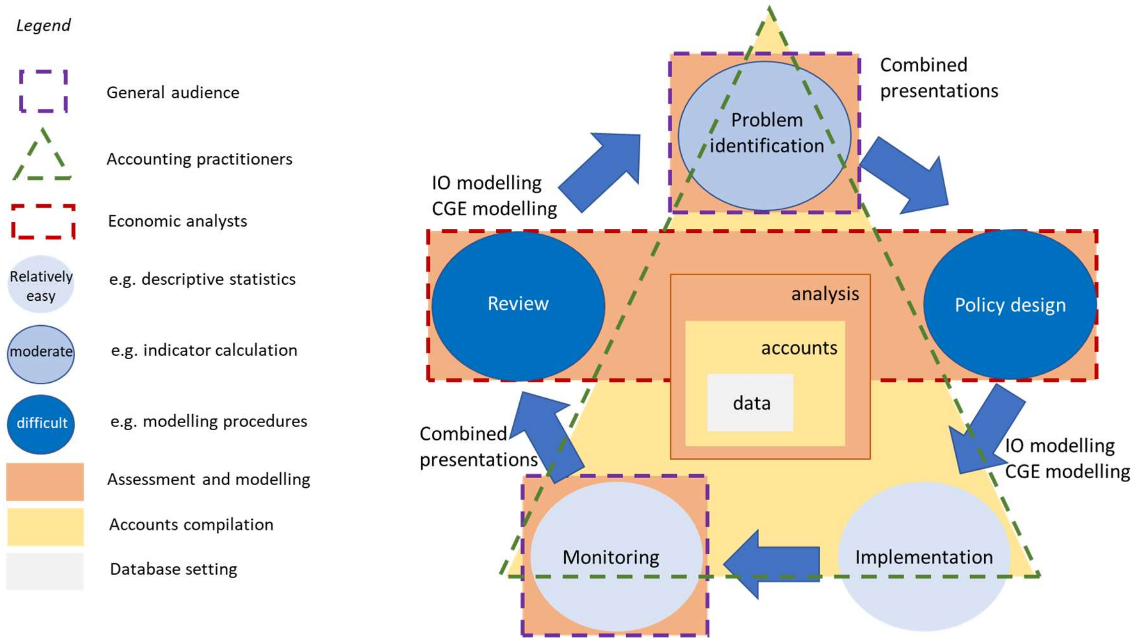
Consumption-based accounts can be useful for policymakers, because they allow us to **assess the use of ES at the very end of the supply chain** from the perspective of the final users, who remain a crucial driver of change and of sustainable use. In fact, policies can be oriented towards the producers (especially in terms of changing production processes and technologies) or trade (subsidising imports or exports), or they can be oriented towards consumers (especially in driving their purchasing behaviour). Consumption-based accounts are a precious source of information for the latter, because they specifically address consumption.

The third application shows how to link ES accounts to **general equilibrium models** to assess the **economic impacts generated by changes in ES**. ES accounts are structured to be consistent with the SNA, which is in turn the source of data for economic modelling and analysis. Thanks to the rigour of the accounting framework, when the benefit of an ecosystem service is part of an SNA product, the linkage is straightforward, as shown in the example of invasive alien species.

As in the case of consumption-based accounts, bridging ES accounts with general equilibrium models creates a nexus between the ecosystem flow and the economic behaviour (in this case, how invasive alien species affect pollinators, which in turn affect pollinator-dependent crops). The existence and assessment of this nexus is important information in the hands of analysts, helping policymakers to assess the **consequences of an action (or inaction) when exogenous changes affect ecosystems and their services**.

The three applications provide several insights in terms of (i) their usefulness at various stages of the policy cycle, (ii) their feasibility, (iii) their technical complexity (and thus the level of skill required) and also (iv) the primary users, which in some cases are specialised analysts rather than a non-specialised audience (Figure II).

Figure II. The policy cycle and applications of ecosystem services accounts



Based on the outcomes from INCA and LISBETH, NCAs offer the metrics for applications concerning complex and dynamic links between the environment, the economy and society. The purpose of LISBETH is to set up and empower the regular cross-sectoral processes that are the basis for national development planning, risk analysis and the economic mainstreaming of ecological issues.

After a general introduction to ES accounts, Chapter 3 of this report describes the SEEA AFF–INCA accounts, whose outcome is a scoreboard for the three pillars of sustainability, i.e. environment, economy and society. Another application, described in Chapter 4, is about the linkage between ES accounts and multiregional input–output tables, whose outcomes are consumption-based accounts. The last application, discussed in Chapter 5, is about bridging ES accounts with the Global Trade Analysis Project general equilibrium model, whose outcome is an assessment of the economic consequences of exogenous changes affecting ecosystems and their services.

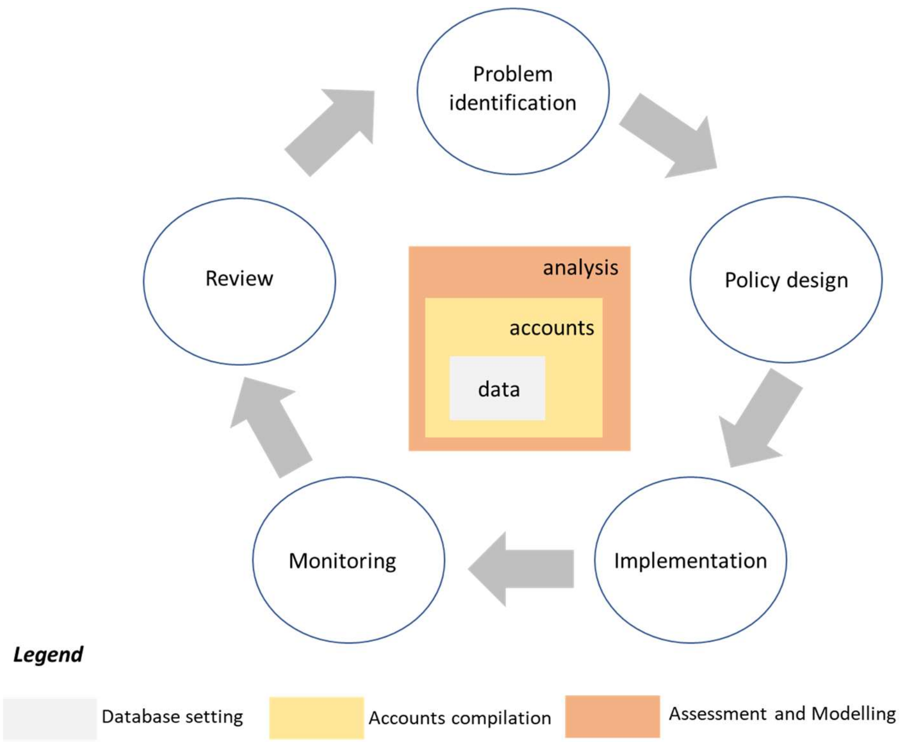
1 Introduction

Those making and implementing policies and actions that aim to reconcile human well-being with a sustainable planet need to acknowledge the bounds of the natural world. This requires a new mindset, as demonstrated, for example, in the case of whales (Chami R. et al., 2019): protection of this species would significantly benefit not only life in the oceans but also our own life on land. This new mindset implies systems thinking (Lezak and Thibodeau, 2016) and understanding complex chains of cause–effect relationships. This **new mindset needs metrics** to become operational for policymakers who need to provide evidence-based strategies and programmes.

National economic policy is underpinned by macroeconomic theory, supported by information retrieved from the System of National Accounts (SNA) (Vardon et al., 2018). The SNA represents the framework for understanding the economic system and provides the set of rules for gathering the data that describe it. As the SNA does not comprehensively account for natural capital, a system of satellite accounts was built to complement the core economic framework, specifically the System of Environmental–Economic Accounting (SEEA) (United Nations, 2019; United Nations et al., 2014b; United Nations et al., 2014d). The objective of the SEEA is to link economic information from the SNA to environmental information through common concepts, definitions, classifications and standardised tabular outputs.

Natural capital accounts (NCA) contribute to several steps of the policy cycle (Vardon et al., 2016) (Figure 1): from the identification of policy issues through the design and assessment of policy options to the monitoring of policy goals. A range of examples of this have been presented to the Policy Forum on Natural Capital Accounting for Better Decision Making [1] and in related publications (Vardon et al., 2017; Vardon et al., 2016).

Figure 1. The policy cycle with reference to the ecosystem accounting information system



Source: Adapted from (Vardon et al., 2016).

The SEEA describes stocks and changes in stocks of natural capital as well as a broad range of products and ecosystem services (ES) that flow from these stocks. The type of information and amount of products and ecosystem services coming from the natural capital can assist short- and long-term decision-making to support

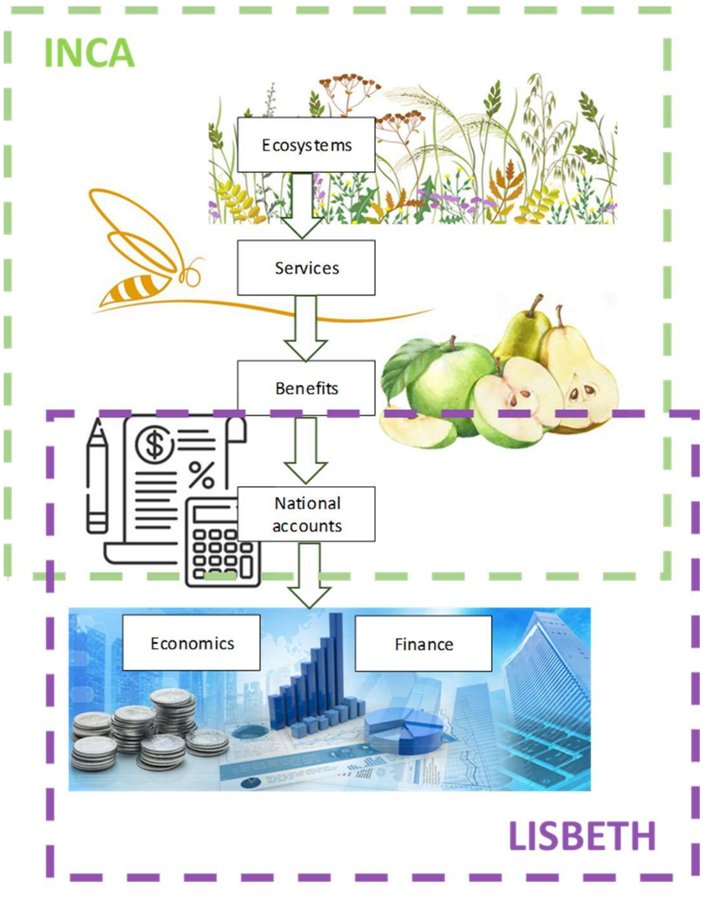
(1) See https://www.wavespartnership.org/en/policy-forum-natural-capital-accounting-better-decision-making

sustainable development. One of the several ways in which ES can be effectively aligned with decision problems (Wright et al., 2017) is in the improved modelling of biophysical and social processes and contexts.

NCA provide essential information for the new metrics needed in decision-making processes. It is necessary to understand how they do so in practice. The acronym LISBETH stands for LInking accounts for ES and Benefits to the Economy THrough bridging. This acronym explicitly contains a few key words: ES, benefits, economy and accounts. The last key word, and more specifically **national accounts**, underpins the logical flow of the system we are about to propose.

LISBETH is based on to the Knowledge Innovation Project on an Integrated system for Natural Capital and ES Accounting (KIP INCA) (Figure 2), set up by the European Commission in 2016 (European Commission and European Environment Agency, 2016). The KIP INCA partnership, which includes the Directorate-General for Environment, the Directorate-General for Research and Innovation, Eurostat, the European Environment Agency and the Joint Research Centre (JRC), aims to design and implement an integrated accounting system for ecosystems and their services in the EU. INCA has already generated a number of deliverables (European Commission and Agency, 2016; La Notte A. et al., 2017; Vallecillo S. et al., 2019; Vallecillo S. et al., 2018). LISBETH is meant to facilitate the use of INCA accounts in traditional economic analytical tools, such as partial and general equilibrium models.

Figure 2. The logical flow of INCA and LISBETH



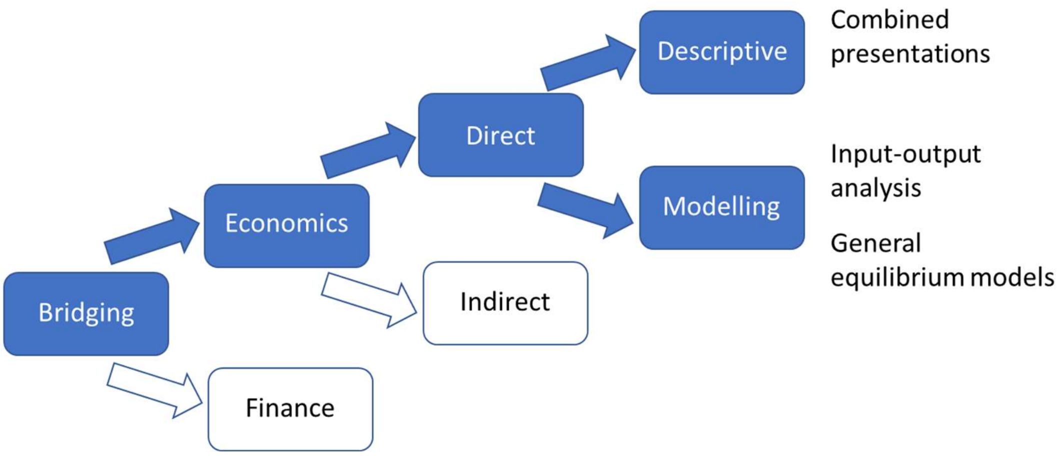
The other key word is '**bridging'**. The idea behind bridging is that ecology and economics have their own tools, models and techniques, whereby experts in each field provide the best available knowledge. The attempt to integrate the two disciplines is a huge opportunity but brings specific risks. When experts in one discipline aim to integrate another discipline, they may tend to oversimplify what is not their primary field of research. When we refer to 'bridging', the purpose is to connect one discipline to the other without re-inventing each other's tools, models and techniques. In our case, we can operationalise bridging between ecology and the economy using NCA. Through NCA, ecologists can use their best available knowledge for the assessment of services that flow from the ecosystem to the economy. They are structured as satellite accounts to national accounts; this implies their compliance with the accounting structure and accounting rules followed in building the SNA. The SNA is in turn used by economists as the basis for building tools and models. NCA, specifically ES supply and use tables, are briefly explained in Chapter 2.

Bridging ES accounts and economic tools can be **direct** and relatively easy: this is the case when ES contribute to generating benefits that become direct products of the SNA, e.g. biomass growth is partly an ecological input to crops and, when biomass growth changes, the amount of crop produced is directly affected. No further processing is needed to bridge NCAs to economic tools and models. This may be the case for most provisioning services. Bridging can become more complex when the linkage has to be modelled, because it is indirect with respect to SNA products and operating sectors, e.g. croplands are protected from floods by ecosystems, but this protection is not directly contributing to an SNA product. In this case we need to build functions and further processing is needed, and it mostly applies to regulating, maintenance and cultural services. We can in this case refer to a '**functional**' bridging to differentiate it from direct bridging. In the case of direct bridging, NCA provide all the information needed and the linkages with economic tools is straightforward. In the case of functional bridging, further processing is needed to build functions that connect ES with the variables of economic models and tools.

Another important aspect is to clarify the purpose of bridging. Essentially, it is about **policy use**. Policies concerned with building a sustainable future would need to consider changes in ecosystems and their flows and focus on their economic drivers and economic impacts. Tools used for policymaking have several degrees of complexity; analysis can be based on a wide range of techniques, e.g. from descriptive statistics to complex modelling.

Two major components can be bridged by NCA: economics and finance. In this report (Figure 3), we start by focusing on the component 'economics' and specifically address 'direct' bridging. For direct bridging we consider the 'descriptive' side through the use of combined presentations (Chapter 3) and the 'modelling' side through multiregional input–output analysis (Chapter 4) and general equilibrium models (Chapter 5).

Figure 3. Objectives of LISBETH's initial applications



Specifically, some of the outcomes of INCA (specifically ES accounts) are used to illustrate three different examples of direct bridging. Combined presentations are built using the crop provision ecosystem service (Vallecillo S. et al., 2019); multiregional input–output analysis is based on the pilot account on water purification ((La Notte et al., 2017a) and (La Notte and Dalmazzone, 2018)); and the economic impact of invasive alien species is assessed through the pollination ecosystem service (Vallecillo S. et al., 2019)) and the general equilibrium model.

Future outputs of LISBETH will:

- introduce a first application for finance;
- address functional bridging by building ad hoc functions for each ecosystem service; and
- advance applications for and further develop those for both economics and finance.

2 Ecosystem services accounts

The SNA is an international standard for the systematic compilation and presentation of economic data. It presents the economy in a structured, integrated and consistent way. Natural capital does not have a role in the SNA. The way to integrate the natural capital domain into the SNA is through satellite accounts. With satellite accounts, the core SNA remains the same, while its accounting framework is applied to adapted outputs. The SEEA first proposed and supported by the UN since 1993 provides methodological guidelines for setting up satellite accounts for natural capital (United Nations, 1993; United Nations et al., 2003; United Nations et al., 2014a). Specifically, UN SEEA experimental ecosystem accounting (EEA) targets accounts reflecting the role of ecosystems and their services (United Nations, 2017; United Nations et al., 2014c). KIP INCA further develops the technical recommendations provided by the UN SEEA EEA (European Commission and European Environment Agency, 2016; La Notte et al., 2017b) and applies them in the EU. The different components of the UN SEEA EEA include accounts of ecosystem extent, ecosystem condition, ES and thematic accounts. Ecosystem accounts can be produced in both physical and monetary terms; the monetary accounts help to integrate the results of ecosystem accounting with other economic indicators derived from the SNA.

The accounting module that specifically targets ES accounts is the supply and use tables that can be compiled in both physical and monetary terms. This chapter briefly summarises the conceptual framework of supply and use tables for ES to clarify why and how they represent the entry point to the SNA.

2.1 The framework of supply and use tables

In the SNA, supply and use tables are compiled only in monetary terms and record all flows of products exchanged/produced by economic units in different countries to describe the structure of the economy and the economic activity. Products are supplied within the economy when they are produced by industries in the national economy or imported from the rest of the world. All products that are supplied are either used by other industries as intermediate consumption to produce other goods or services, or directly consumed by households and government, or exported to the rest of the world, or used as fixed capital or held as inventories. The total supply of each product should equal the total use of each product: this identity is a fundamental feature in national accounts.

The production of goods and services requires inputs from, and has effects on, the natural environment. These effects can be negative, such as the depletion of resources and degradation of ecosystems' condition, or positive, such as ecosystem restoration and organic farming. Accounting for the role of ecosystems in providing resources, absorbing waste and generally maintaining a habitable world is of crucial importance. Thanks to satellite accounts, it is possible to supplement the core accounts of the SNA with information about the effects of the economy on ecosystems without modifying the SNA's core accounts.

In the SEEA EEA, supply and use tables are used to describe the flow of ES. These tables relate to a given accounting area and are structured by the type of ecosystem. The satellite accounts report on ecosystems as an additional sector providing a set of ES (Figure 3).

The amount of services that ecosystems can supply does not always match the actual demand for them. For this reason, we distinguish between the ES potential and the actual flow, as presented graphically in Figure 4 and described in detail elsewhere (La Notte et al., 2019) (2).

SEEA EEA only records actual flows of ES supplied by ecosystem types and used by economic units during an accounting period: ES are considered to reflect transactions or exchanges that take place between ecosystem types on the one hand and economic units, including businesses and households, on the other hand. In accounting terms, supply must equal use, and the unit of measurement used for each ecosystem service must be the same in both the supply and the use table to obtain a balance.

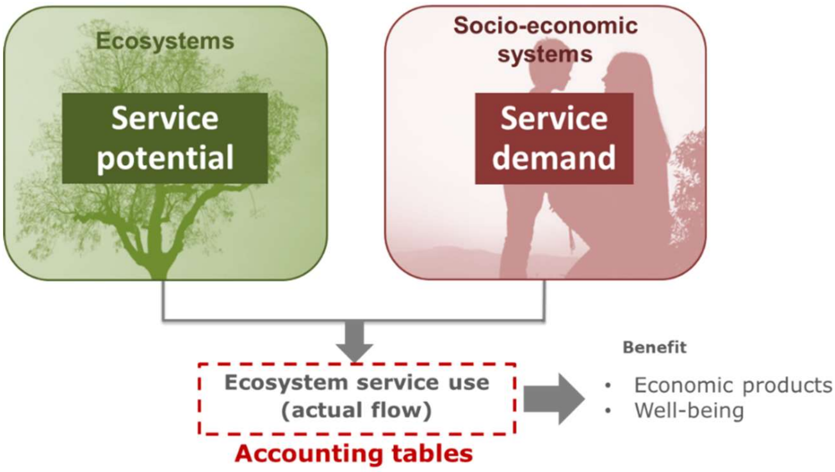
It is important to properly structure economic units and ecosystem types to allow all relevant information to be included. In this report, we used the Mapping and Assessment of Ecosystems and their Services (MAES) classification (Maes et al., 2012) at the higher hierarchical level, combined with the Corine classification (3) to classify ecosystem types and NACE rev. 2 (4) to classify economic activities.

(2) See section 4 'Ecosystem services as a flow in accounting terms'.

(3) Insert reference for Corine.

(4) See https://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=NACE_REV2&StrLanguageCode=EN&IntPcKey=&StrLayoutCode=HIERARCHIC&IntCurrentPage=1

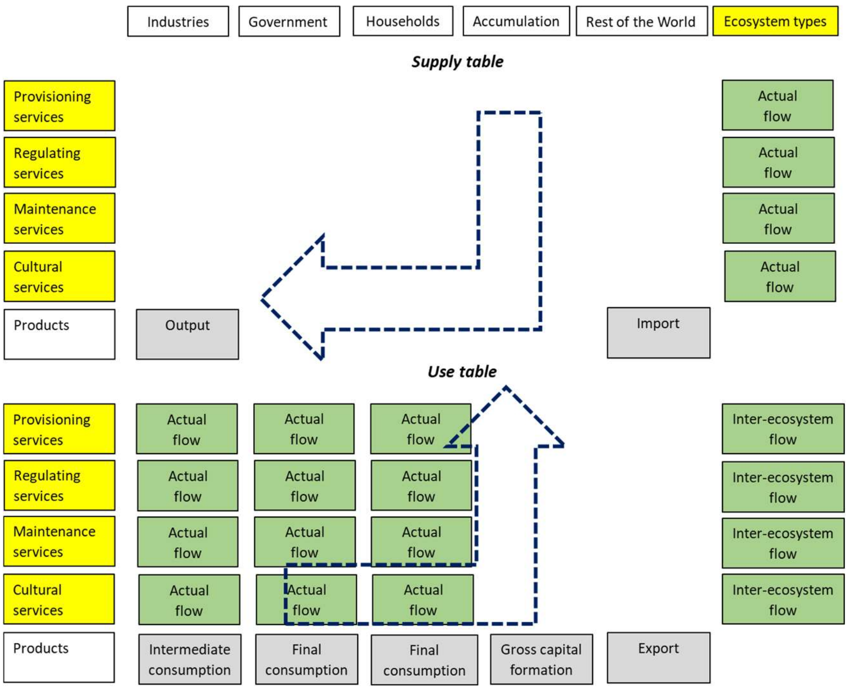
Figure 4. Graphical representation of the potential of and demand for ecosystem services



Source: (Vallecillo et al., 2019a).

ES are here generally reported in accordance with the Common International Classification of Ecosystem Services (CICES) categories ([5]). It is possible to identify division, group, class and class type within each category.

Figure 5. Graphical simplification of supply and use tables for ecosystem services



Grey cells: SNA core accounts
Green cells: SEEA EEA satellite accounts
Yellow cells: additional information arising from SEEA EEA

Source: Adapted from (La Notte and Dalmazzone, 2018).

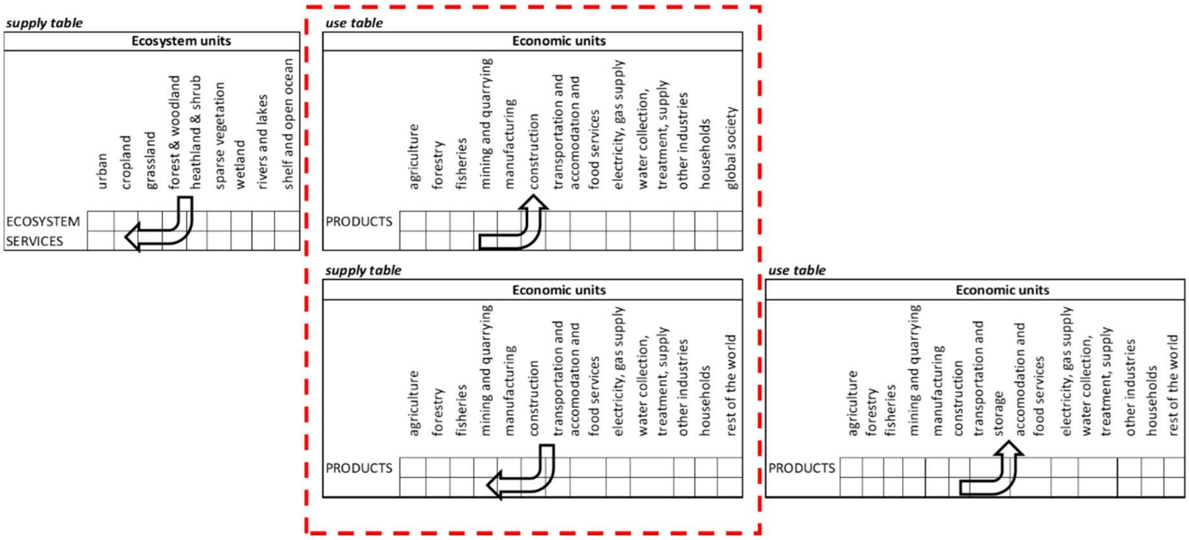
As satellite accounts, ES accounts provide an input for production and transformation to economic sectors (when allocated to 'Industries' in Figure 5) and the final consumption of services (when allocated to 'Households' in Figure 5). Inter-ecosystem flows represent flows within ecosystems: they do not enter the economy. Inter-

([5]) See https://cices.eu/

ecosystem flows act as intermediate consumption among ecosystem types; although these flows occur, they do not directly affect economic sectors or households and thus do not enter the SNA.

The use table in ES accounts is structured in exactly the same way as supply and use tables in the SNA: while the ES providers are ecosystem types, the ES users are economic sectors and households that represent the institutional units in the SNA. Those economic sectors that receive flows of ES from ecosystems (for production, protection, etc.) will in turn be enabled to produce, transform and supply flows of SNA products (or services) in core SNA supply and use tables (Figure 6).

Figure 6. The integration between ecosystem and economic accounts



An entry point for ES accounts into economic accounts is guaranteed by (i) aligning the structures of accounting tables and (ii) following the rigorous rules of the SNA when assessing and valuing ES.

Having an entry point into the SNA allows the undertaking of conjoint analysis of ES and economic accounts (La Notte and Dalmazzone, 2018) and the practical use of ES accounts in existing economic tools (which is the purpose of LISBETH), enabling more sophisticated analysis.

Integration between ES accounts and the SNA requires that the SNA's rigour and rules mechanisms are respected and that the data are harmonised with SNA data. A lack of rigour and consistency in ES accounting (in both physical and monetary terms) would nullify the whole exercise, because it would make the two systems (the satellite and core accounts in Figure 6) incompatible.

3 Combined presentations: the crop provisioning case

The UN Statistical Commission adopted the SEEA Central Framework (SEEA CF) as the first international statistical standard for environmental–economic accounting. The SEEA for Agriculture, Forestry and Fisheries (SEEA AFF) extends the SEEA CF accounting framework by detailing the structure of the accounting records for all economic activities covering agriculture, forestry and fisheries (classified as International Standard Industrial Classification, ISIC, A) and their relationship with the environment. However, the contribution of ecosystems to the growth of biomass is not currently included within the scope of the SNA, the SEEA CF or the SEEA AFF.

As part of the INCA project, the JRC assessed, among other services, crop provisioning by using a procedure that aims to disentangle the ecosystems' contribution to generating biomass in agriculture (crop production) (Vallecillo et al., 2019b).

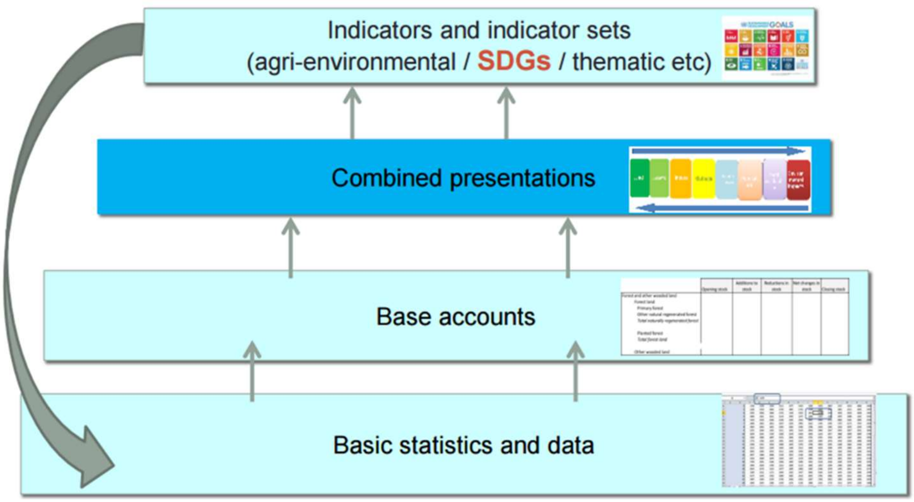
This chapter provides a combined presentation of the Food and Agriculture Organization of the United Nations (FAO) physical supply and use tables for crops and the JRC crop provisioning table. The crop provisioning accounting table records, in the cell for ISIC economic activities, the outputs of agriculture (ISIC A 01) and manufacturing industries (ISIC C 10). The resulting FAO–JRC combined accounting table allows us to conduct an analysis that goes beyond the production of raw crops: by including processed crops and crop trading, it is possible to relate the ecosystem's contribution to the supply system of crop production.

The chapter briefly describes the structure of and the steps involved in developing the combined presentation. After initial screening, a simplified procedure is formulated to quantify the flow of the crop provisioning service and the recording and analysis of its biomass production. More specifically, this chapter assesses the contribution of the ecosystem type cropland to the SNA benefits received by the consumers of agricultural products. The combined presentation is in turn used to build a scoreboard for the three pillars of sustainability: ecosystem, economy and society.

3.1 Definition of combined presentations

Combined presentations include selected information from the core accounts, relevant to a specific thematic analysis of interest. Figure 7 shows how the main components (from primary data to indicators) are linked. The nature of the connections between the components of a combined presentation is in principle not subject to strict rules.

Figure 7. General structure of combined presentations



Combined presentations may also incorporate additional information that is not in the base accounts. The structure of combined presentations (as shown in Figure 7) remains relatively stable; the content may change over time to reflect changing analytical and policy priorities, i.e. the choice of which accounts to combine and how.

3.1.1 The structure of combined presentations

The SEEA AFF expands the international statistical standard for environmental–economic accounting, the SEEA CF, to ISIC A economic activities (namely, ISIC A 01 Crop and Livestock, A 02 Forestry, A 03 Fishing). Developed by FAO in collaboration with the UN Statistics Division and other international and national partners, the SEEA AFF is an internationally agreed methodological document (UNCEEA/11/1, June 2016) in support of the SEEA CF, and therefore it is compliant with the SNA. SEEA AFF accounting tables can be easily compiled with data from the FAO Statistics Division (FAOSTAT) as a default approach, when relevant national data are not available.

A combined accounting table merging data from the SEEA AFF and INCA is therefore consistent with the SEEA EEA, the SEEA CF and the SNA. Crop provision accounts from INCA estimate the ecosystem's contribution as natural energy sources (including solar radiation, water and soil mineral resources), provided separately from anthropogenic resources (such as fertilisers, irrigation, machinery) (for more details, see Chapter 3 in (Vallecillo et al., 2019b)).

The approach follows the three major themes represented by the three pillars of sustainability: the ecosystem, the economy and society. Figure Figure **8** shows the three components in an accounting table format, highlighting the measurements upon which they are built:

- ecological component, based on INCA:
  - actual flow of crop provision as the yield derived from the ecosystem's contribution;
- market component, based on a composite indicator including:
  - raw crop production;
  - processed crop;
  - raw crop export;
  - raw crop import;
- social component, based on FAO food balance sheets:
  - food availability (used as a proxy for social component).

Figure 8. Structure of the FAO–JRC combined accounting table

Selected products*	Ecosystem Types EC	Other	Type of economic unit*		Flows from the rest of the world		Food Availability	
	Cropland E (t)		Supply: Agricultural Industry (ISIC A 01)	Use: Crop processed (t)	Imports (t)	Exports (t)	Food (t)	Food supply (Kcal/capita/day)
Wheat								
Barley								
Oats								
Maize (corn)								
Potatoes								
Sugar beet								
Rapeseed or colza seed								
Sunflower seed								

Natural Capital Input component — **ECOSYSTEM**

Market component — **ECONOMY**

Nutrition component — **SOCIETY**

The ecological and social components are available from INCA ES accounts and FAO food balance sheets, respectively. The primary source of data on crops and the market component is FAOSTAT. Crops are selected based on the availability of INCA accounts on ecosystem contribution. Further selection is applied to establish correspondence between Eurostat's crop statistics classification and FAO's classification of crops. Please be aware that the ES accounts we consider here are for crop provision only; animal husbandry is excluded. We start this exercise with a few crops for which all the necessary data are available, namely:

- barley
- wheat
- rapeseed
- maize.

Our approach considers processed crops, because is important to understand how much of the raw crop is used in intermediate production to generate goods with higher added value. Although some crops may be used for energy purposes, we do not consider that use in the current application.

3.2 Methodology

This exercise involves three steps:

- to frame the combined presentations;
- to process the composite indicator for the market component;
- to build the scoreboard.

In this section, we briefly describe each step.

3.2.1 The combined accounting tables

Bridging the ES accounts developed for INCA with SEEA AFF accounts requires applying the ecosystem contribution coefficient to the raw crop production reported by FAOSTAT. Thanks to the **emergy approach** (6) (Perez-Soba M. et al., 2019), it is possible to separate ecosystem input from human input and thus to account for the ecosystem input as ES flow. A high ecosystem contribution shows that sustainable practices are in place, in contrast with intensive agriculture for which the ecosystem's contribution is very low (Vallecillo S. et al., 2019).

The combined accounting tables (see Table 2 to Table 5) that follow report (in physical terms, tonnes) in the column headed 'Supply from ecosystem to agriculture' the ecosystem's contribution as the product of the emergy coefficient multiplied by total raw crop production. The column headed 'From ecosystem and human input to agriculture" records (in physical terms, tonnes) the total production of raw crop. Part of this production will used as final consumption in the domestic market or exported; another part of this production will be further processed. The column headed 'From agriculture to manufacturing' reports the latter situation. It should be noted that countries may need to import further raw material for processing crops.

The definition and correspondence between raw and processed crops, according to FAO's definition and coding, is shown in Table 1.

Table 1. Raw and processed crops according to FAOSTAT's classification and codes

Raw crops		Processed crops		Product list
15	Wheat	2511	Wheat and products	Default composition: 15 Wheat, 16 Flour, wheat, 17 Bran, wheat, 18 Macaroni, 19 Germ, wheat, 20 Bread, 21 Bulgur, 22 Pastry, 23 Starch, wheat, 24 Gluten, wheat, 41 Cereals, breakfast, 110 Wafers, 114 Mixes and doughs, 115 Food preparations, flour, malt extract
44	Barley	2513	Barley and products	Default composition: 44 Barley, 45 Barley, pot, 46 Barley, pearled, 47 Bran, barley, 48 Flour, barley and grits, 49 Malt, 50 Malt extract
75	Oats	2516	Oats	75 Oats, 76 Oats, rolled, 77 Bran, oats
56	Maize	2514	Maize and products	Default composition: 56 Maize, 57 Germ, maize, 58 Flour, maize, 59 Bran, maize, 63 Gluten, maize, 64 Starch, maize, 846 Feed and meal, gluten
116	Potatoes	2531	Potatoes and products	Default composition: 116 Potatoes, 117 Flour, potatoes, 118 Potatoes, frozen, 119 Starch, potatoes, 121 Tapioca, potatoes
157	Sugar beet	2537	Sugar beet	Default composition: 157 Sugar beet
270	Rapeseed	2558	Rape and mustard seed	Default composition: 270 Rapeseed, 292 Mustard seed, 295 Flour, mustard
267	Sunflower seed	557	Sunflower seed	Default composition: 267 Sunflower seed

(6) The 'embodied energy' of a product is defined as the total energy needed to obtain (in this case) the agricultural production, including natural and anthropic inputs. The percentage of the natural input is extracted as the ecosystem contribution (i.e. the crop provision service).

Table 2. Combined accounting table for barley in physical terms (2012)

Member State		Ecosystem type: cropland	Agriculture industry use		Flows from and to the rest of the world		Food availability	
		Supply from ecosystem to agriculture (t)	From ecosystem and human input to agriculture (t)	From agriculture to manufacturing (t)	Imports (t)	Exports (t)	Food (t)	Food supply (kcal/capita/day)
AT	Austria	170 916	662 466	120 000	162 746	75 722	2 897	2
BE	Belgium	54 942	359 100	341 000	1 774 768	342 001	1 148	1
BG	Bulgaria	148 935	661 932	133 000	614	325 128	7 761	6
CZ	Czechia	436 446	1 616 467	381 000	28 912	362 154	2 000	1
DE	Germany	2 234 130	10 391 300	1 825 000	1 408 889	1 534 747	25 720	2
DK	Denmark	1 201 375	4 058 700	127 000	83 210	1 041 699	114	0
EE	Estonia	141 640	341 300	49 000	8 137	84 909	7 393	39
EL	Greece	38 357	336 461	108 000	70 448	2 021	4 909	3
ES	Spain	1 232 954	5 956 300	700 000	276 184	71 113	2 351	0
FI	Finland	466 395	1 581 000	130 000	4 081	93 206	26 963	33
FR	France	11 341 189	11 341 189	26 000	96 518	4 657 446	61 998	6
HU	Hungary	368 561	996 110	101 000	68 642	299 476	653	1
IE	Ireland	279 875	1 260 700	179 000	198 305	69 465	3 288	4
IT	Italy	177 704	940 234	251 000	497 731	6 220	30 408	3
LT	Lithuania	241 118	741 900	55 000	34 548	101 609	24 931	55
LU	Luxembourg	5 799	37 900	8 000	4 675	13 592	989	15
LV	Latvia	110 876	248 600	30 000	110 983	113 927	49 235	151
NL	Netherlands	63 421	205 912	405 000	1 546 509	84 630	25 965	8
PL	Poland	1 329 304	4 180 200	780 000	197 035	320 873	251 104	34
PT	Portugal	5 457	21 151	150 000	225 471	4 560	15 000	9
RO	Romania	282 099	986 361	378 000	138 024	688 075	22 115	7
SE	Sweden	507 107	1 701 700	77 000	61 023	494 457	15 049	11

SI	Slovenia	16 522	84 727	35 000	15 897	8 600	3 967	13
SK	Slovakia	148 202	470 482	70 000	53 782	57 721	20 556	25
UK	United Kingdom	1 076 790	5 522 000	1 517 000	161 727	589 738	48 829	5
Total	Sum of the Member States	22 080 111	54 704 192	7 976 000	7 228 859	11 443 089	655 343	

Table 3. Combined accounting table for wheat in physical terms (2012)

Member State		Ecosystem type: cropland	Agricultural industry use		Flows from and to the rest of the world		Food availability	
		Supply from ecosystem to agriculture (t)	From ecosystem and human input to agriculture (t)	From agriculture to manufacturing (t)	Imports (t)	Exports (t)	Food (t)	Food supply (kcal/capita/day)
AT	Austria	238 518	1 275 498	18 000	512 434	587 833	689 031	646
BE	Belgium	234 832	1 834 624	1 311 000	3 995 298	648 583	1 256 639	804
BG	Bulgaria	592 529	4 455 104	111 000	21 644	2 452 535	883 795	872
CZ	Czechia	753 044	3 518 896	37 000	62 919	1 521 103	1 014 000	720
DE	Germany	3 798 376	22 409 300	89 000	3 534 904	6 993 096	6 712 498	635
DK	Denmark	905 020	4 525 100	850 000	370 639	653 005	538 001	602
EE	Estonia	199 212	484 700	18 000	12 707	251 253	117 595	755
EL	Greece	91 795	1 835 901	4 000	888 870	337 504	1 361 569	846
ES	Spain	698 032	5 189 828	34 000	5 467 687	283 463	4 410 629	688
FI	Finland	359 276	887 100	0	10 094	214 182	453 052	681
FR	France	5 365 568	37 885 742	1 575 000	284 858	16 469 022	6 984 092	817
HU	Hungary	1 159 176	4 010 990	135 000	65 090	1 324 686	1 053 271	774
IE	Ireland	133 793	707 900	14 000	304 772	50 881	494 000	937
IT	Italy	884 066	7 654 248	74 000	6 108 562	256 616	8 905 714	1 040
LT	Lithuania	806 704	2 998 900	37 000	160 446	1 680 302	356 691	920

LU	Luxembourg	10 137	79 198		113 474	32 000	55 184	796
LV	Latvia	558 947	1 539 800	21 000	251 370	1 489 974	130 921	521
NL	Netherlands	220 038	1 302 002	43 000	3 689 624	528 889	1 197 047	563
PL	Poland	1 781 773	8 607 600	22 000	735 149	1 060 554	4 146 663	875
PT	Portugal	10 036	58 990	95 000	1 389 895	44 759	993 624	690
RO	Romania	1 155 571	5 297 748	2 000	531 876	2 314 889	2 915 131	984
SE	Sweden	558 589	2 289 300	267 000	288 061	343 039	730 283	578
SI	Slovenia	30 843	188 065	0	111 993	76 937	209 291	806
SK	Slovakia	198 775	1 275 302	213 000	84 381	296 793	646 783	892
UK	United Kingdom	1 858 198	13 261 000	194 000	1 784 946	1 503 413	6 144 918	754
Total	Sum of the Member States	22 602 848	133 572 836	5 164 000	30 781 693	41 415 311	52 400 421	

Table 4. Combined accounting table for rapeseed in physical terms (2012)

Member State		Ecosystem type: cropland	Agriculture industry use		Flows from and to the rest of the world		Food availability	
		Supply from ecosystem to agriculture (t)	From ecosystem and human input to agriculture (t)	From agriculture to manufacturing (t)	Imports (t)	Exports (t)	Food (t)	Food supply (kcal/capita/day)
AT	Austria	33 227	149 000	314 000	217 418	68 286	796	1
BE	Belgium	6 864	48 000	1 390 000	2 327 684	527 156	5 000	4
BG	Bulgaria	2 992	272 000	47 000	1 708	213 682	1 000	2
CZ	Czechia	419 254	1 109 137	930 000	179 618	366 077	3 000	3
DE	Germany	985 728	4 832 000	7 522 000	4 158 694	149 616	27 000	4
DK	Denmark	115 915	485 000	492 000	221 890	97 439	1 000	1
EE	Estonia	89 586	158 000	25 000	4 698	79 102	354	4
EL	Greece	3 770	14 000	15 000	8 336	45	2 000	2

ES	Spain	11 872	53 000	95 000	45 434	9 164	3 000	1
FI	Finland	20 878	73 000	234 000	160 270	1	2 000	3
FR	France	5 477 000	5 477 000	4 622 000	474 403	1 503 774	4 000	1
HU	Hungary	166 343	419 000	15 000	93 005	579 021	1 000	1
IE	Ireland	6 325	25 000	37 000	8 557	30 118	73	0
IT	Italy	3 801	25 337	76 000	56 411	3 049	4 000	1
LT	Lithuania	283 566	640 103	155 000	4 354	420 003	1 400	6
LU	Luxembourg	2 145	15 000	2 000	1 795	13 313	36	3
LV	Latvia	139 232	304 000	136 000	80 299	321 252	835	5
NL	Netherlands	1 708	7 000	866 000	1 734 683	593 647	6 000	4
PL	Poland	475 830	1 866 000	2 080 000	485 294	256 426	5 109	2
RO	Romania	19 481	161 000	144 000	59 499	68 246	3 000	2
SE	Sweden	105 576	318 000	280 000	50 245	21 694	4 000	4
SI	Slovenia	2 958	17 000	4 000	3 169	14 970	1 000	3
SK	Slovakia	78 538	214 000	93 000	124 929	579 774	4 000	7
UK	United Kingdom	761 986	2 557 000	1 722 000	20 426	1 056 733	15 000	2
Total	Sum of the Member States	9 214 574	19 238 578	21 296 000	10 522 819	6 972 588	94 603	

Table 5. Combined accounting table for maize in physical terms (2012)

Member State		Ecosystem type: cropland	Agriculture industry use		Flows from and to the rest of the world		Food Availability	
		Supply from ecosystem to agriculture (t)	From ecosystem and human input to agriculture (t)	From agriculture to manufacturing (t)	Imports (t)	Exports (t)	Food (t)	Food supply (kcal/capita/day)
AT	Austria	185 758	2 351 370	578 000	621 494	536 644	106 279	99
BE	Belgium	52 628	701 700		1 765 928	537 022	24 615	14
BG	Bulgaria	346 993	1 717 785	237 000	92 001	825 392	193 997	197

CZ	Czechia	105 809	928 147	41 000	138 789	533 502	46 517	43
DE	Germany	584 558	5 514 700	673 000	2 215 374	1 072 395	1 045 269	89
DK	Denmark	0	75 100	0	121 228	11 829	26 471	32
EL	Greece	91 273	2 226 176	24 000	238 363	88 748	21 333	14
ES	Spain	639 317	4 262 116	91 000	6 094 528	163 135	93 333	15
FR	France	1 323 841	15 393 497	1 505 000	429 312	6 294 289	714 527	78
HU	Hungary	638 203	4 762 710	483 000	146 683	4 362 074	2 532	2
IT	Italy	951 075	7 860 123	533 000	2 653 855	68 240	231 014	28
LT	Lithuania	1 891	78 800	26 000	84 815	16 645	1 800	5
LU	Luxembourg	121	1 618		9 198	1 914	2 716	34
NL	Netherlands	22 389	191 363	232 000	4 030 812	386 814	41 406	16
PL	Poland	519 467	3 995 900	131 000	495 405	1 047 764	195 817	50
PT	Portugal	162 095	848 666	39 000	1 682 169	31 489	169 583	119
RO	Romania	1 786 006	5 953 352	32 000	698 580	2 273 741	871 795	311
SE	Sweden	1 960	14 747		22 783	208	10 091	9
SI	Slovenia	42 436	277 358	18 000	201 770	140 239	69 145	266
SK	Slovakia	138 102	1 170 354	213 000	117 634	411 726	166	0
UK	United Kingdom	23 342	70 948	826 000	1 282 377	40 010	183 908	25
Total	Sum of the Member States	7 617 264	58 396 531	5 682 000	23 143 098	18 843 820	4 052 313	

The flows related to import and export (in physical terms, tonnes) are meant to account for trade in raw crops, which from a market perspective is as important as domestic consumption. Finally, the columns headed ‘Food availability’ refer to the calculation of the food balance sheet, undertaken using the methodology adopted by FAO[7]. The purpose of this indicator is to comprehensively measure the pattern of a country’s food supply during a specified reference period. In detail, the supply available during a reference period is the total quantity of foodstuffs produced in a country added to the total quantity imported and adjusted for any change in stocks that may have occurred since the beginning of the reference period.

Please note that to include a more comprehensive supply chain among intermediate and final consumers, more information would be needed. The tables we show are focused only on a few crops and a few transformation streams, which does impose limits.

Table 2, Table 3, Table 4 and Table 4 report the data in physical terms. To compute the composite indicator, the data are multiplied by a unit price value. FAOSTAT provides ‘Output price at farm gate (USD/tonne)’ for each crop in each country. However, when this estimate is not available, the EU average is used (8). Once physical amounts produced (in tonnes) have been multiplied by the unit price, the outcome is divided by the country’s gross domestic product (GDP, USD thousands (9)). To solve the problem of the country size effect, and to introduce the issue of the relative importance of the agricultural sector (for the country’s overall economy), using GDP as the denominator has a double impact: it addresses the size effect and it weights the importance of the country’s agricultural sector.

3.2.2 The composite indicator for the market component of the scoreboard

A composite indicator was developed for the market component to account for raw and processed crops and raw crop trading. The rules followed in building the composite indicator were (i) choose sub-indicators with similar trends in terms of direction (i.e. higher trends imply an improvement in all chosen variables), (ii) use a common unit meaningful in terms of market figures (i.e. everything is reported in monetary terms), and (iii) avoid the size effect (i.e. big countries have higher values) and thus always use relative values. As already mentioned, the sub-indicators are raw crops, processed crops, export and import.

The first step is to process the datasets by making sure that countries are taken account of for the crops they produce. By comparing two datasets (e.g. FAOSTAT and Eurostat) it is possible to validate the fact that missing data mean that a specific country does not produce a specific crop, and it is not the result of gaps in the data. By comparing individual numbers, it is possible to validate similar orders of magnitude or highlight where there are inconsistencies and, where gaps in the data are recorded, the Eurostat dataset (10) can be used to complete missing data in the FAOSTAT data, as appropriate.

The variables that are used to build the composite market indicator are (i) output-raw (USD)/GDP in USD thousands = relative value of raw crops in monetary terms; (ii) output-processed (USD)/GDP in USD thousands = relative value of processed crops in monetary terms. This sub-indicator is not calculated because of gaps in the data: (iii) (Export (USD) – Import (USD))/GDP in USD thousands = relative value of net traded crops in monetary terms.

The disentangling procedure followed for the INCA accounts implicitly guarantees that there is no double counting in the processing chain. No additional valuation is undertaken, but the ecosystem contribution is kept separate. This separation concerns only raw crops. All the other values (which imply transformation) are simply reported and jointly analysed but not processed.

Following the methodology suggested by the EU Competence Centre on Composite Indicators and Scoreboards (11), the following steps are taken to process the composite indicator for the market component for all crops for each country:

(7) see http://www.fao.org/3/X9892E/X9892E00.htm

(8) This is the case for Italy for barley, sunflower, sugar beet and rapeseed; for the Netherlands for maize and oats; for Ireland for potatoes and rapeseed; for Poland for sunflower; for Portugal for sugar beet; for Greece for rapeseed; and for the United Kingdom for maize.

(9) The data were originally given in millions. They have been transformed into thousands for operational purposes.

(10) See ‘Crop production in EU standard humidity (from 2000 onwards)’ (apro_cpsh), https://ec.europa.eu/eurostat/data/database

(11) See https://ec.europa.eu/jrc/en/coin/10-step-guide/overview

1. data processing, by imputing missing data (through integration with the Eurostat dataset and the use of averages) and treating outliers;
2. assessment of the statistical and conceptual coherence, by performing correlation analysis;
3. normalisation, by applying the following equation:

$$Normalization = \frac{(x - \min\ )}{(\max x - \min x)} \qquad \text{Equation 1}$$

4. aggregation – by aggregating normalised variables through an equal weight, assuming that there is no dominance of one element over others; the equal weight is 0.333, as there are three scoreboard components:

$$Mkt = \prod \pi^{w} \qquad \text{Equation 2}$$

where *Mkt* = market component, $\pi = \text{variable}$, and $w = \text{weight}$;

5. final ranking of all countries, based on the outcomes.

3.2.3 A scoreboard for the three sustainability pillars

Once the composite indicator for the market component has been built, we have all the elements we need to create a scoreboard. Before proceeding with the comparison, we have to normalise the ecosystem contribution and the food supply element using the same formula used for the market component (see Equation 1) to be consistent. The scoreboard is composed of:

- the market element (*Mkt*), which reports on the economic side and specifically on the role of the crop in intermediate and final consumption and its importance in trade;
- the ecosystem service element (ES) which reports on the ecological side and specifically on the ecosystem contribution (as a percentage) to generating the raw crop;
- the food supply element (FS) which reports on the societal side and specifically on the availability of food for domestic consumption in kilocalories per capita per day ([12]).

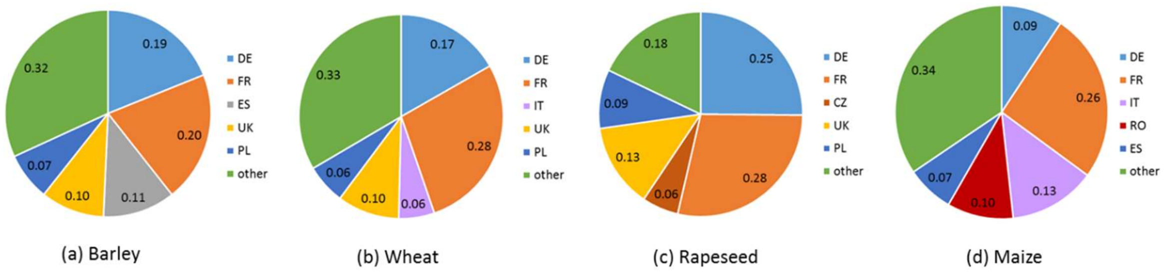
The scoreboard for each crop is reported in detail in the following section. The scoreboard is shown as a heat map based on the ranking of the indicators (left-hand side and a horizontal bar graph (right-hand side).

3.3 Results

Each crop behaves differently in the scoreboard and needs to be analysed separately. For each crop, the starting point is Eurostat's agricultural statistics for the year 2012. The agricultural statistics and the scoreboard components represent different pieces of the same narrative:

- on the one hand, agricultural statistics consider the total production in tonnes (Figure 9);
- on the other hand, the scoreboard reports rankings based on relative estimates in monetary terms (for the market element and ES).

Figure 9. Proportion of production of selected raw crops in EU Member States, 2012



Source: Eurostat.

([12]) More information on this indicator is available at http://www.fao.org/3/X9892E/X9892E00.htm

When these different pieces of information are analysed jointly, the overall picture becomes complex and multi-faceted. Figure 9 reports the relative production of selected raw crops in EU Member States in 2012. Germany, France and Poland are among the top producers: for some crops, the shares are high (e.g. France accounts for almost one third of the total production of wheat, rapeseed and maize); for other crops, the shares are in line with those of other countries. When interpreting these numbers, which refer to the total production of each crop, the reader needs to keep in mind that the percentages are calculated on absolute values, which are inevitably affected by the size of the country: production in Germany and France will always dominate over countries with small territories (even if production is extremely efficient). The reader also needs to keep in mind that we are dealing purely with 'quantity', and no inference can be made about crop quality or management practices.

A different analysis can be undertaken looking at the scoreboards. Here for the market indicator the production is considered in relative values, so the effect of country area is void. Moreover, by using GDP, the weight of the agricultural sector is reduced in those countries where the secondary and tertiary sectors are highly developed.

Considering all the data gaps, all of the crops cannot be analysed together for all countries. Figure 10 shows the scoreboards for those crops for which the three components of the market element indicator were considered and the three indicators (Mkt, FS, ES) are assessed for barley, wheat, rapeseed and maize.

For barley, wheat, rapeseed and maize, France and Germany are top producers in absolute terms (Figure 9) but their rankings are low for the Mkt indicator (Figure 10). This can be explained by the fact that agriculture does not play a dominant role in the overall national economies of these two countries.

In Figure 10, Member States in eastern Europe have higher values than the rest of the EU for most of the three indicators. For the Mkt indicator, Lithuania ranks highly for rapeseed (Figure 10c) and wheat (Figure 10b); Bulgaria and Estonia rank highly for barley (Figure 10a) and Hungary ranks highly for maize (Figure 10d).

The ES indicator also ranks highly in eastern European countries (high in Latvia for barley, high in Estonia for wheat, high in Romania for maize), but we also have to note that it ranks highly in Germany for rapeseed (Figure 10c). A high value for the ES indicator may depend on several factors: the use of extensive practices (e.g. less fertiliser and machinery), climatic conditions, larger fields, etc. Germany produces 11 % of the EU's total rapeseed output (Figure 9) and, although its Mkt indicator does not rank highly (which might imply that the role of rapeseed production is not very important for the total national economy), its high ES indicator might imply that its management practices are more sustainable than in other countries.

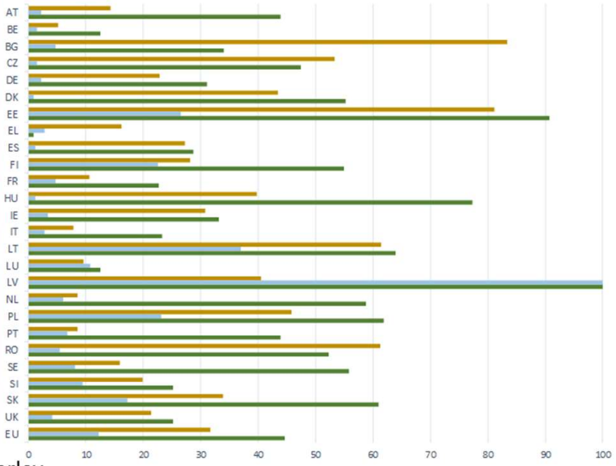
For the FS indicator, eastern European countries rank highly: Latvia ranks top for barley and rapeseed (Figure 11a and c), and Romania ranks top for maize (Figure 10d). However, Italy ranks top for wheat (with 6 % of EU production (Figure 9)) while recording low scores for the Mkt and ES indicators (Figure 10b).

The FS indicator reports how domestic demand is covered by production. There may be many factors affecting the interpretation of this indicator within the scoreboard, e.g. from the traditional national diet to the use of the raw crop as final consumption or as intermediate consumption (i.e. processed crop). This analysis can be undertaken for each crop in each country, but here we comment on only a few cases.

In summary, the scoreboard provides information that is complementary to commonly used agricultural production statistics, such as the importance of the ecosystem contribution in crop yield and the linkage with food availability in each Member State. By considering relative values rather than total production in absolute terms, it is possible to estimate the importance of the crop (raw and processed) with respect to the national economies. Relating this market-driven component to ecological and nutritional issues allows us to present an overall perspective.

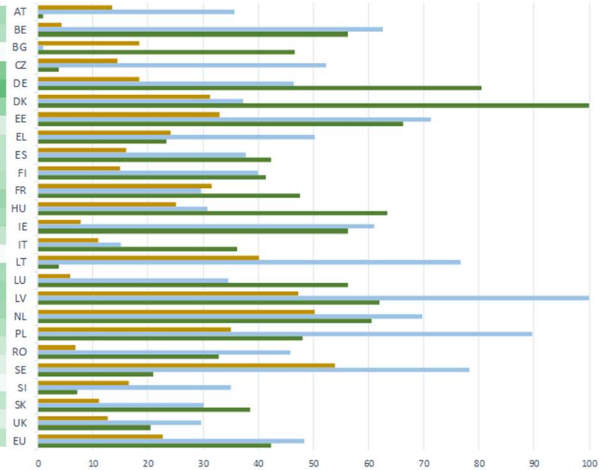
Figure 10. Scoreboard reporting the ranking of barley, wheat, rapeseed and maize with respect to the three pillars of sustainability, year 2012.

	Mkt	FS	ES
Austria	14.37	2.20	43.94
Belgium	5.20	1.54	12.63
Bulgaria	83.35	4.82	34.10
Czechia	53.33	1.54	47.52
Germany	22.94	2.20	31.12
Denmark	43.53	1.00	55.27
Estonia	81.18	26.48	90.76
Greece	16.29	2.85	1.00
Spain	27.29	1.17	28.73
Finland	28.20	22.54	54.97
France	10.70	4.82	22.77
Hungary	39.78	1.26	77.34
Ireland	30.78	3.51	33.20
Italy	7.92	2.85	23.36
Lithuania	61.38	36.99	63.92
Luxembourg	9.64	10.73	12.63
Latvia	40.56	100.00	100.00
Netherlands	8.52	6.13	58.85
Poland	45.77	23.20	61.83
Portugal	8.60	6.79	43.94
Romania	61.24	5.48	52.29
Sweden	15.94	8.10	55.87
Slovenia	19.97	9.42	25.15
Slovakia	33.89	17.29	60.94
United Kingdom	21.45	4.17	25.15
EU	31.67	12.28	44.69



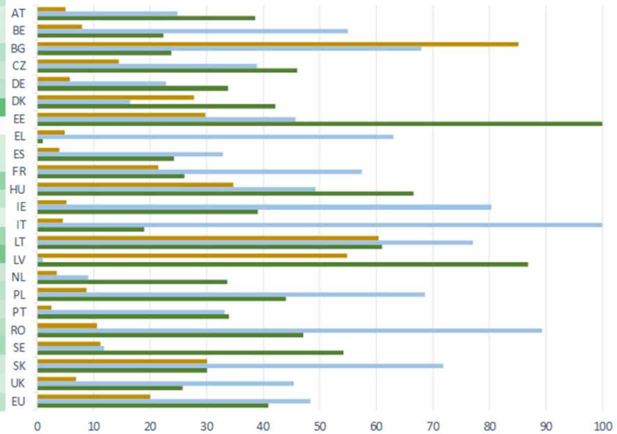
(a) Barley

	Mkt	FS	ES
Austria	13.48	35.62	1.00
Belgium	4.29	62.67	56.21
Bulgaria	18.42	1.00	46.69
Czechia	14.51	52.39	3.86
Germany	18.43	46.44	80.49
Denmark	31.21	37.25	100.00
Estonia	32.93	71.33	66.21
Greece	24.20	50.23	23.37
Spain	16.04	37.79	42.41
Finland	14.95	39.95	41.48
France	31.66	29.67	47.64
Hungary	25.02	30.75	63.35
Ireland	7.78	61.05	56.21
Italy	10.96	15.07	36.22
Lithuania	40.09	76.74	3.86
Luxembourg	5.96	34.54	56.21
Latvia	47.24	100.00	61.92
Netherlands	50.34	69.70	60.50
Poland	35.11	89.72	48.12
Romania	6.90	45.90	32.89
Sweden	53.90	78.36	20.99
Slovenia	16.57	35.08	7.19
Slovakia	11.19	30.21	38.60
United Kingdom	12.70	29.67	20.51
EU	22.66	48.38	42.33



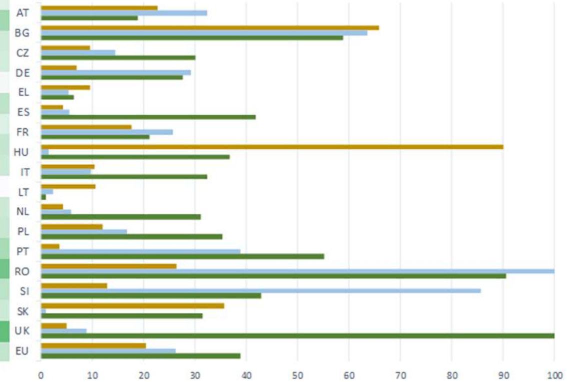
(c) Rapeseed

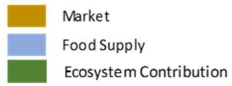
	Mkt	FS	ES
Austria	5.09	24.84	38.57
Belgium	8.02	54.98	22.39
Bulgaria	85.18	67.95	23.76
Czechia	14.43	38.96	45.98
Germany	5.81	22.75	33.77
Denmark	27.80	16.45	42.14
Estonia	29.80	45.64	100.00
Greece	4.88	62.99	1.00
Spain	3.92	32.86	24.17
France	21.45	57.46	26.13
Hungary	34.74	49.26	66.54
Ireland	5.25	80.35	39.12
Italy	4.57	100.00	18.96
Lithuania	60.31	77.11	61.06
Latvia	54.89	1.00	86.84
Netherlands	3.51	9.01	33.63
Poland	8.82	68.53	44.06
Portugal	2.61	33.24	33.94
Romania	10.56	89.32	47.11
Sweden	11.29	11.87	54.20
Slovakia	30.05	71.77	30.03
United Kingdom	6.88	45.45	25.72
EU	19.99	48.26	40.87



(b) Wheat

	Mkt	FS	ES
Austria	22.84	32.45	18.85
Bulgaria	65.87	63.68	58.78
Czechia	9.57	14.47	30.21
Germany	7.03	29.26	27.62
Greece	9.66	5.37	6.52
Spain	4.37	5.68	41.90
France	17.70	25.76	21.12
Hungary	90.07	1.54	36.70
Italy	10.57	9.83	32.49
Lithuania	10.74	2.50	1.00
Netherlands	4.38	6.00	31.19
Poland	12.03	16.83	35.41
Portugal	3.74	38.82	55.21
Romania	26.47	100.00	90.59
Slovenia	12.97	85.66	42.87
Slovakia	35.80	1.00	31.51
United Kingdom	5.04	8.87	100.00
EU	20.52	26.34	38.94





(d) Maize

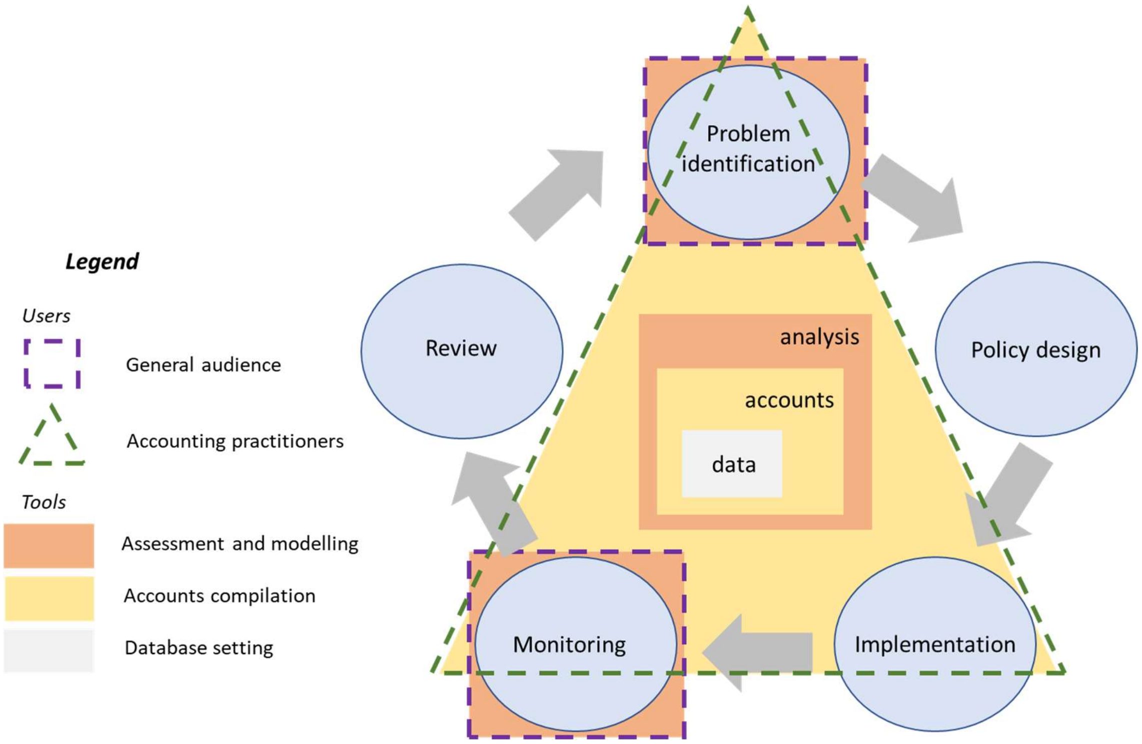
3.4 Discussion

The joint SEEA AFF–INCA accounts show how to combine the flow of ES with the conventional accounts related to agricultural products and their trade. Additional information on food availability and balance also allows us to further link ES and agricultural production to an indicator concerning nutrition. When these conjoined datasets are developed, there is considerable opportunity for descriptive analysis. Our example shows a scoreboard in which the three pillars of sustainability are logically and consistently combined to demonstrate that higher levels of crop production cannot be consistent with sustainable management practices.

With reference to (Vardon et al., 2016), this kind of application can be useful in:

- identifying criticalities, by combining the different components of the supply chain through their different accounts and building appropriate indicators and/or scoreboards;
- monitoring over time whether and how the criticalities identified evolve through the accounting tables, the indicators and the scoreboard.

Figure 11. Scheme for the policy cycle with reference to the combined presentations and scoreboard



Building combined presentations is feasible. Once the ES accounts have been prepared, the linkage with conventional accounts is straightforward. No specific expertise is needed in terms of modelling: any statistical office at any administrative level could easily set up and process the datasets. Practitioners of this kind of applications may be statistical offices or any institution enabled to set up (or simply access) the database and compile the accounts.

Combined presentations are useful for policymakers, especially those responsible for communicating with a wider non-technical audience: the main findings from combined presentations can be easily processed to raise relevant policy issues. In our example we build a scoreboards, but there is a vast range of ways to proceed (from simple descriptive statistics to performance indicators). Statistical offices could easily establish linkages with the most popular initiatives targeting sustainability, e.g. the SDGs, which (to refer to our exercise) in a number of their targets mention agricultural resilience (e.g. target 2.4) and sustainability of management practices in terrestrial ecosystems (e.g. target 5.1).

4 Multiregional input-output analysis: the case of water purification

Sustainability assessments can have a double perspective: on the one hand, the ‘production side’ uses ES flows to generate SNA and non-SNA benefits and this represent direct pressure on the ecosystem. Although production-based accounting is currently the accounting principle adopted, ES remains (directly and indirectly) embedded in goods that are traded. On the other hand, there is a demand side that drives that pressure: the consumption-based accounting approach would consider use of ES at the point of consumption. The application of the consumption-based approach implies ‘ceding’ the responsibility of using ES to export production and ‘accepting’ the responsibility of using ES use in imported production.

In this chapter, we present the methodology of and results from the case study focused on linking the ES accounts (here, water purification accounts) to input–output models to calculate consumption-based accounts. The chapter starts with a brief introduction to input–output analysis; next we explain the methodology followed in the water purification case study. Finally, we present the results and some initial discussion of this kind of work.

4.1 Input–output analysis

Input–output (IO) analysis was developed by Wassily Leontief in the 1930s. It was developed to provide an understanding of how changes in an economy’s final demand (final consumption, investments and exports) would affect the output of the economy, taking into account its intersectoral relationships (Leontief, 1936). An IO model consists of a system of linear equations describing all monetary flows between all sectors of the economy in a given year. These models require information on how the outputs of each sector are allocated among all other sectors and final demand and on how each sector needs inputs from other sectors and from primary inputs (workers, owners of land and natural resources, investors and governments as providers of subsidies and collectors of taxes). Primary input suppliers provide what are also known as primary factors of production, which are associated with primary factor costs, which are also referred to as value added. This information is organised in what is the core of an IO model, an IO table (Table 6) (Eurostat, 2008).

Table 6. Schematic representation of an IO table, for one country, in an economy with three sectors.

	Sector 1	Sector 2	Sector 3	Final demand	Total output
Sector 1					
Sector 2		***Z***		***y***	***x***
Sector 3					
Value added		***v***			
Total input		***x***			

Z is the matrix of intersectoral transactions; ***y*** is the final demand vector; ***x*** is the vector of total output (which is equal to the total input) and *v* is the value added vector. In matrix terms we can write:

$\boldsymbol{Zi} + \boldsymbol{y} = \boldsymbol{x}$ Equation 3

Where ***i*** is a vector of ones.

At the core of IO analysis is the technical coefficients matrix (***A***). Each entry of this matrix is given by dividing matrix ***Z***, by the total output ***x*** (Leontief, 1936; Miller and Blair, 2009). The technical coefficient measures how much of input of sector *i* is needed to produce one unit of output of sector *j*. Using a matrix notation, the technical coefficient matrix can be defined as follows:

$\boldsymbol{A} = \boldsymbol{Z}.\mathrm{diag}(\boldsymbol{x})^{-1}$ Equation 4

It is possible to rewrite $\boldsymbol{A} = Z.\mathrm{diag}(\boldsymbol{x})^{-1}$ Equation 4 as follows:

$Ax + y = x$

$x.Ax = y$

$(I - A)x = y$ Equation 5

The solution to this system of linear equations is given by:

$\boldsymbol{x} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{y}$ Equation 6

where $\boldsymbol{I}$ is the identity matrix and $(\boldsymbol{I} - \boldsymbol{A})^{-1}$ is called the Leontief inverse matrix (Leontief, 1936; Miller and Blair, 2009). This matrix captures all the direct and indirect requirements needed to produce a unit of output of a given sector and therefore enables us to understand how a change in final demand affects the rest of the economy.

4.1.1 Environmentally extended input–output analysis

The use of the IO framework to study environmental issues dates back to the 1970s when Leontief provided a methodology to include environmental extensions in an IO table (Leontief, 1970). Environmentally extended IO analysis has been used to identify the economic drivers of environmental impacts, as well as the environmental impacts associated with consumption activities and international trade (Kitzes et al., 2017). In an IO framework, the computation of the impacts associated with consumption activities follows a life cycle perspective, as it considers the direct and indirect impacts throughout all of the supply chain; as a result these are also referred to as embodied impacts.

To build an environmental extension for an IO model, it is necessary to add information on the environmental impact of each production activity in a certain year. It is then possible to compute the vector of intensities (or, in other words, the environmental impacts generated by producing a unit of a certain sector's output):

$\boldsymbol{d} = \boldsymbol{e}.\mathrm{diag}(\boldsymbol{x})^{-1}$ Equation 7

where $\boldsymbol{d}$ is the direct intensity vector, $\boldsymbol{e}$ the vector of the direct environmental impacts and $\boldsymbol{x}$ the total output vector. Given that $\boldsymbol{d}$ captures the impact generated per unit of an economic activity's output, and the matrix $(\boldsymbol{I} - \boldsymbol{A})^{-1}$ captures the output needed directly and indirectly to produce one unit of output, the multiplication of these two captures the total environmental impact per unit of (final) output, or in other words the total intensity vector ($\boldsymbol{t}$):

$\boldsymbol{t} = \boldsymbol{d}(\boldsymbol{I} - \boldsymbol{A})^{-1}$ Equation 8

This vector provides information on the direct environmental impacts plus the indirect impacts associated with the inter-industry activities required to produce one unit of total output of a certain sector.

4.2 Methodology

4.2.1 Water purification accounts

In this study, we used one of the first pilot applications of the SEEA EEA developed as satellite accounts of the SNA: physical and monetary accounts for the water purification ecosystem service in European countries (La Notte et al., 2017a). For the water purification service in inland water bodies in Europe, in-stream nitrogen retention is used as a proxy for the actual flow. As excessive nitrogen loading is a leading cause of water pollution in Europe and globally, nitrogen concentration is a useful indicator of water quality. We define nitrogen retention as the process of temporary or permanent removal of nitrogen taking place in the river. This includes the processes of denitrification, burial in sediments, immobilisation and transformation or simply transport (Grizzetti et al., 2015). The estimate of the actual flow is based on the Geospatial Regression Equation for European Nutrient Losses (GREEN), which is a statistical model developed to estimate nitrogen and phosphorus fluxes in surface water in large river basins (Grizzetti et al., 2012). Thanks to GREEN, it is possible to estimate the amount of nitrogen retained, which will vary according to the structure of the river network and the input of nutrient sources. Specifically, when nitrogen input increases, the nitrogen loading to rivers and in turn the total nitrogen retention in rivers increase accordingly.

The water purification accounts show that the main driver of changes in water purification is the agricultural sector – the more nitrogen is emitted through crop production and livestock, the higher the need for water purification (La Notte et al., 2017a). The actual flow of an ecosystem service should be allocated to the sectors and households that create the need for the ES and therefore have the power to modify the amount and availability of the service, i.e. the enabling actors (La Notte and Dalmazzone, 2018; La Notte and Marques, 2017). Table 7 presents the amount of water purification service (in tonnes of nitrogen removed) demanded by agricultural activities for each Member State or non-EU country for 2005 (La Notte et al., 2017a). The sources of nitrogen pressure could be agriculture, atmospheric deposition, scattered dwellings (i.e. not connected to a sewerage treatment system), waste water treatment plants and other minor sources. In this work, we account for only the service required by agricultural activities. We refer to the actual flow accounts as water purification accounts.

Table 7. Actual flow of water purification service for 2005 by Member State/non-EU country (tonne of nitrogen removed). Actual flow concerns the amount of ES used by society in a given year

Member State/non-EU country	**Total N removed (tonnes)**	**Member States/non-EU country**	**Total N removed (tonnes)**
Austria	792.22	Italy	15 407.37
Belgium	1 176.17	Lithuania	1 251.09
Bulgaria	1 679.31	Luxembourg	131.31
Cyprus	20.34	Latvia	694.74
Czechia	1 927.66	Netherlands	1 639.12
Germany	5 921.23	Poland	7 997.15
Denmark	1 624.35	Portugal	450.69
Spain	4 238.35	Romania	2 053.37
Estonia	184.43	Russia (European part)	2 174.02
Finland	1 425.26	Slovakia	305.14
France	14 001.52	Slovenia	549.44
United Kingdom	7 661.60	Sweden	2 864.46
Greece	2 039.62	Turkey	3 642.78
Hungary	456.51	Total	84 805.63
Ireland	2 496.38		

Source: (La Notte et al., 2017a).

The reader should keep in mind that in interpreting the data on water purification (**Table 7**) there are three important steps: (i) the service of nitrogen retention should not be confused with the amount of nitrogen input (caused in this case by agriculture); in fact, when the freshwater ecosystem is degraded, most of the nitrogen is not retained but flows into another catchment; (ii) in turn, the assessment of this service must be spatially explicit otherwise there would be no explanation for the remarkable difference in the loads of nitrogen between upstream and downstream catchments; and (iii) the issue of degradation depends on accumulation over time: little ability to remove nitrogen is the result of overusing water purification in the past (La Notte et al., 2019).

4.2.2 Multiregional input–output model

Multiregional IO analysis has been widely used to quantify the environmental impacts associated with consumption activities and international trade by tracing all the impacts occurring throughout the supply chain (Davis and Caldeira, 2010; Marques et al., 2017; Peters, 2008; Weinzettel et al., 2013; Wiedmann, 2009). The main features of a multiregional IO model are its coverage of the world economy and the interrelationships between the different sectors from different countries. To date, several multiregional IO databases exist, each with different characteristics (Aguiar et al., 2016; Dietzenbacher et al., 2013; Lenzen et al., 2012; Stadler et al., 2018). In this study we used the 2013 release of the World Input–Output database (WIOD), which has a disaggregation level of 40 countries and one rest of the world region, includes 35 industries and covers the period between 1995 and 2011 (Timmer et al., 2015). We have extended the database with the water purification accounts described in the previous section, linked to the agricultural sector. The water purification accounts do not cover all the countries available in WIOD. Although this does not present a methodological problem, it limits the scope of our analysis, as the water purification service transferred through international trade from the regions not covered in the water purification accounts to Europe cannot be analysed. Therefore, we focused our work on European countries, Russia and Turkey.

The computation of the consumption-based water purification indicators followed the standard environmentally extended IO model (Miller and Blair, 2009), as follows:

$$\boldsymbol{E} = \boldsymbol{d}(\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{Y} \qquad \text{Equation 9}$$

Let m denote the number of countries, k the number of industries and j the number of environmental resources or impacts under analysis. $\boldsymbol{E}$ is the (j x $m.k$) matrix of total (direct and indirect) environmental impacts associated with the consumption activities of each country. $\boldsymbol{d}$ is a (j x $m.k$) matrix of the direct environmental resources required to supply one unit of industry output. $(\boldsymbol{I} - \boldsymbol{A})^{-1}$ is the ($m.k$ x $m.k$) Leontief inverse matrix, which indicates the total (direct and indirect) environmental resources required to supply one unit of industry output. $\boldsymbol{Y}$ is ($m.k$ x m), the final demand (or consumption activities) matrix.

4.3 Results

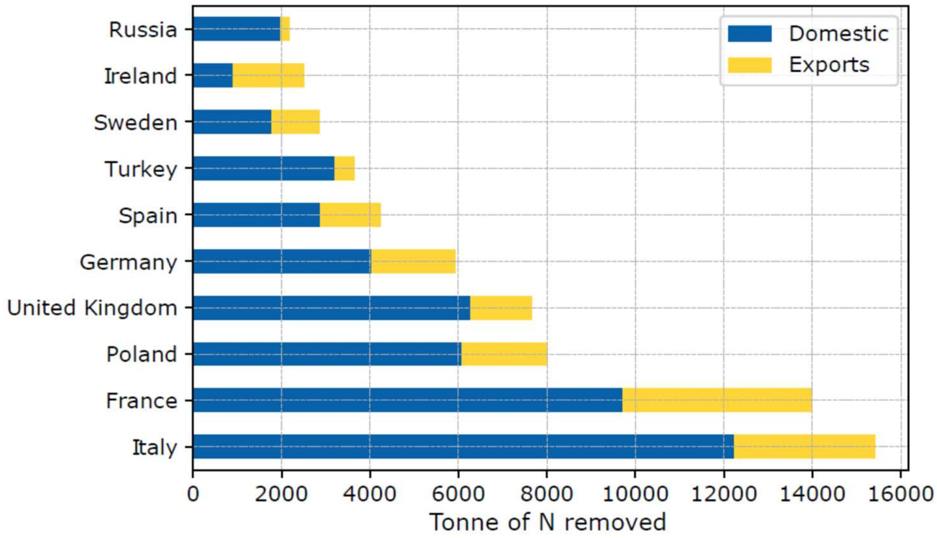
The actual flows of water purification service mainly depend on the amount of nitrogen released from agricultural activities to produce agricultural goods for domestic consumption and exports. The consumption-based indicators depend on the consumption of agricultural goods and the amount of nitrogen released from agricultural activities in the country of origin, hence domestic consumption and imports. The difference between the actual flow and the consumption-based flow occurs because of exchanges via international trade and indicates how a country's consumption is linked to water purification services in other countries. The use of multiregional IO analysis also allows us to study the interregional flows of water purification services embedded in agricultural goods between European countries.

In 2005, approximately 85 000 tonnes of nitrogen from agricultural activities were removed by rivers and lakes in EU Member States, Russia (European part) and Turkey. This does not represent the full amount of nitrogen reaching water bodies in Europe, but rather the amount that these water bodies were able to remove in a given year (hence, water purification service) (Table 8).

Approximately 65 % of the 85 000 tonnes of nitrogen was removed in rivers and lakes in Italy, France, Poland, the United Kingdom, Germany and Spain. The Member States and non-EU countries reporting the greatest flows of water purification ES in their production-based accounts are shown in Figure 13.

The water purification ES that takes place in a country may be driven by another country's imports of agricultural products if the agricultural activity that activated the ES produces goods for export. In European countries, we see that the amount of service embodied in exported agricultural goods varies greatly, for example 84 % of the need for water purification in the Netherlands arises from exporting agricultural activities, while in Russia this accounts for only 9 % of the need for water purification (see Table 8). Of the Member States and non-EU countries with higher absolute values of water purification service, Ireland is the only one with more than half of its water purification service (63 %) associated with export activities (Figure 12).

Figure 12. The 10 Member States and non-EU countries with the greatest flows of water purification ES embodied in agricultural goods in 2005, broken down into the domestic and export components



From a consumption perspective, in 2005, we see that the consumption of agricultural goods in Italy, France, the United Kingdom, Germany, Poland and Spain accounted for 61 % of the total need for the water purification service (Figure 12). Of these Member States and non-EU countries, Germany's consumption accounted for more water purification services elsewhere, with 46 % of the total consumption-based indicator from imported agricultural goods (Figure 13).

Figure 13. The 10 Member States and non-EU countries whose agricultural activities accounted for the highest amount of water purification service in 2005, broken down into the domestic and import components

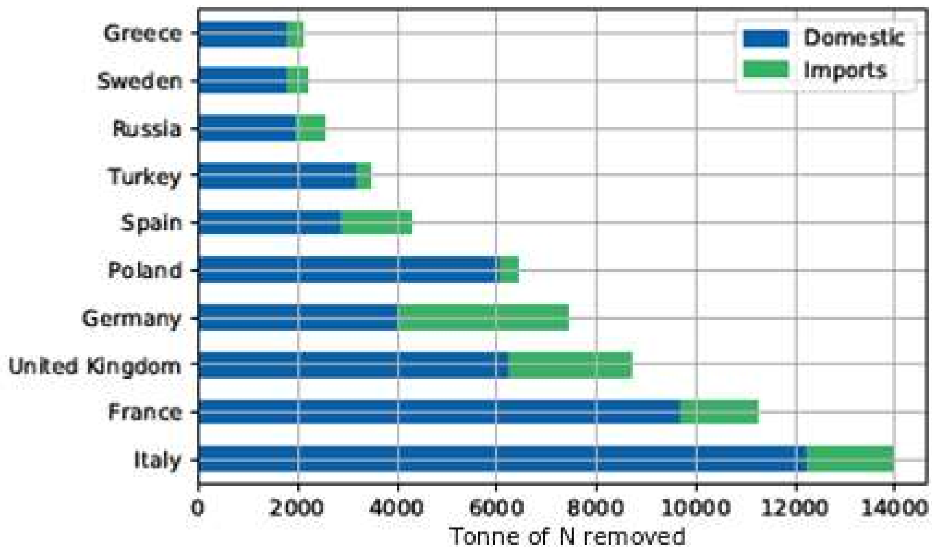


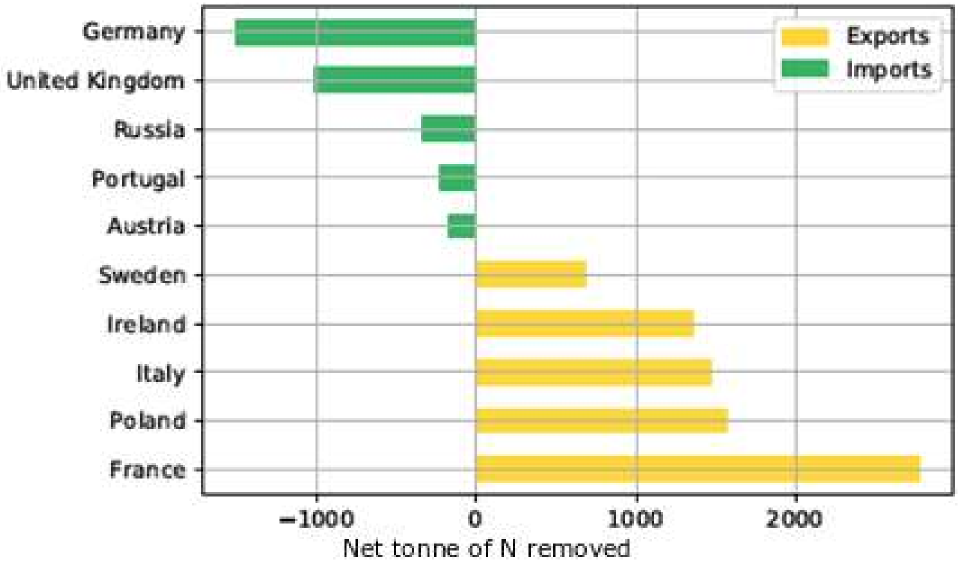
Table 8. Water purification service accounted for by agricultural activities from production and consumption activities, and water purification service embodied in exports and imports, for 2005. The grey-shaded cells indicate the non-EU countries for which we consider only imports of water purification services embodied in agricultural goods from European countries

Member State/non-EU country	**Production**	**Consumption**	**Exports**	**Imports**	Member States/non-EU country	**Production**	**Consumption**	**Exports**	**Imports**
Austria	792	970	277	454	Romania	2 053	1 969	207	122
Belgium	1 176	1 007	891	721	Russia	2 174	2 521	189	536
Bulgaria	1 679	1 225	490	36	Slovakia	305	352	101	148
Cyprus	20	52	7	39	Slovenia	549	500	131	81
Czechia	1 928	1 378	795	246	Sweden	2 864	2 181	1 093	410
Germany	5 921	7 424	1 884	3 386	Turkey	3 643	3 437	433	228
Denmark	1 624	1 019	979	374	Australia	0	160	0	160
Spain	4 238	4 267	1 352	1 381	Brazil	0	74	0	74
Estonia	184	82	149	46	Canada	0	254	0	254
Finland	1 425	1 124	539	237	China	0	389	0	389
France	14 002	11 233	4 296	1 527	Indonesia	0	49	0	49
United Kingdom	7 662	8 683	1 390	2 412	India	0	82	0	82
Greece	2 040	2 092	269	321	Japan	0	608	0	608
Hungary	457	513	141	198	Korea	0	135	0	135

Ireland	2 496	1 141	1 585	229	Mexico	0	103	0	103
Italy	15 407	13 938	3 173	1 703	Malta	0	26	0	26
Lithuania	1 251	1 006	344	99	Taiwan	0	73	0	73
Luxembourg	131	118	96	83	United States	0	1 606	0	1 606
Latvia	695	577	205	88	Rest of the world	0	4 260	0	4 260
Netherlands	1 639	1 079	1 375	8 15	Total	84 806	84 806	24 406	24 406
Poland	7 997	6 423	1 910	336					
Portugal	451	677	104	331					

The difference between the production-based and the consumption-based water purification accounts (Table 8) clarifies whether a country is a net exporter or net importer of water purification services. If the production-based indicator is higher than the consumption-based indicator, the country is a net exporter of water purification services; if production-based accounts are lower than consumption-based accounts, then the country is a net importer of water purification services. This difference captures the effects of a country's consumption on other countries' ES. This is important because consumption is the ultimate driver behind production processes; assessing the sustainable use of ES requires knowledge of who in the end uses them or benefits from them. Of the Member States and non-EU countries assessed, in 2005, the major net exporters of water purification services embedded in agricultural products were France, Poland, Italy, Ireland and Sweden and the major net importers were Germany, the United Kingdom, Russia, Portugal and Austria (Figure 15).

Figure 14. Top net exporters and net importers of water purification services in Europe in 2005



The flow of ES embedded in traded goods is a good example of the spatial disconnection between the area supplying the service and the area that ultimately drives it or enjoys it. It is important to consider this mismatch when managing ES, as it might have consequences for their sustainability (Pascual et al., 2017). However, this topic is still overlooked in ES assessments (Schröter et al., 2018).

In 2005, around 29 % (24 406 tonnes of nitrogen removed) of the total water purification service in Europe was transferred in agricultural products via international trade (see Table 8). Of the total amount of water purification services transferred via international trade, 32 % was transferred to countries outside Europe. This work considers only the water purification services accounted for by European countries; therefore, it is not possible to calculate how much was transferred from countries outside Europe to European countries.

The biggest interregional flow of water purification services between EU Member States is from Italy to Germany (Table 9): 673 tonnes of nitrogen removed in water bodies in Italy was accounted for by the consumption of agricultural goods in Germany. Exports from Ireland to the United Kingdom account for 579 tonnes of nitrogen removed, and exports from France to Italy, Germany, the United Kingdom and Spain account for 538, 498, 447 and 432 tonnes of nitrogen removed, respectively.

Table 9. Top 15 interregional flows of water purification services between EU Member States in 2005

Exporting Member State	Importing Member State	N removed (tonnes)
Italy	Germany	673
Ireland	United Kingdom	579
France	Italy	538
France	Germany	498
France	United Kingdom	447
France	Spain	432
Poland	Germany	393
Netherlands	Germany	353
Italy	France	297
France	Belgium	293
Italy	United Kingdom	248
Spain	France	239
Spain	Germany	237
Netherlands	United Kingdom	198
Czechia	Germany	186

4.4 Discussion

In this exercise, we have given an example of how ES accounts can be used in combination with quantitative economic tools such as IO tables. Specifically, the purpose is to supplement production-based accounts that show the flow from ecosystems to the SNA (without entering the economic supply chain) with consumption-based accounts that address (at least some of) the real end users by tacking specifically trading flows recorded in the SNA. In fact, consumption is the ultimate driver behind production processes: the amount of ES embedded in SNA products is an important piece of information for identifying indirect drivers of pressures on ecosystems.

With reference to Vardon et al. (2016), this kind of application can be useful in (Figure 15):

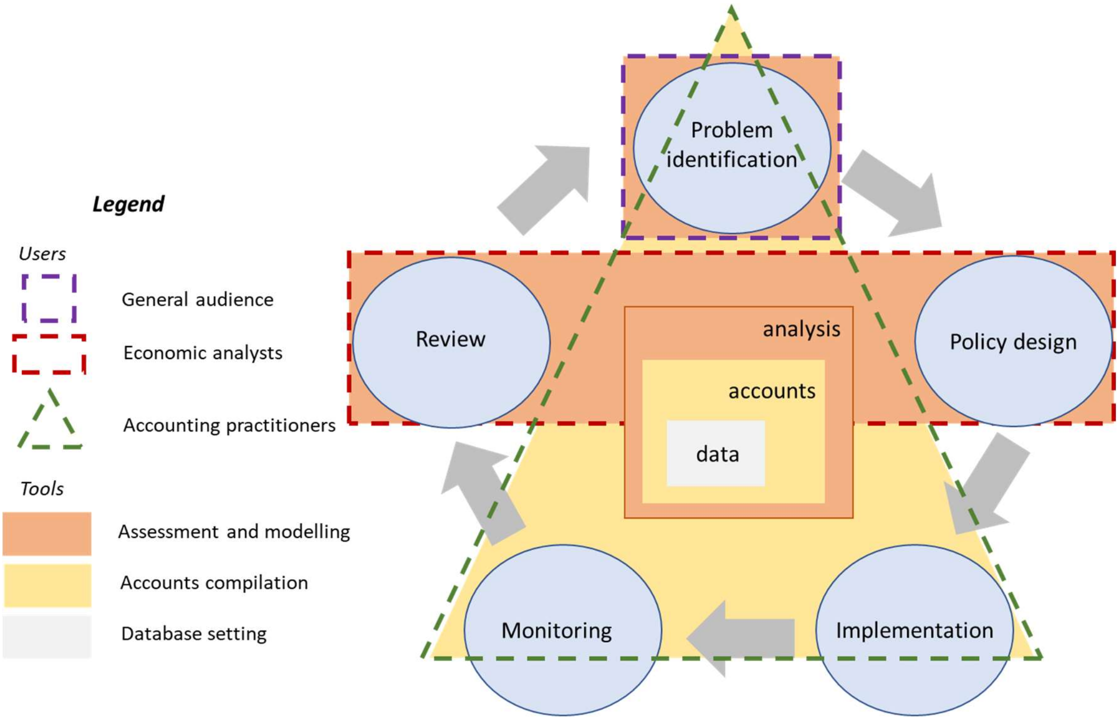
- [*ex ante*] developing policy proposals to resolve issues by defining, discussing and accepting or rejecting proposed alternative solutions;
- [*ex post*] evaluating what the policy actually produces, the impact on target (and non-target) communities and the degree to which this impact solves the problem.

Consumption-based accounts can also be useful in identifying criticalities: by considering the ES embedded in the traded products it is possible to identify the driving pressure that leads to the use (and misuse) of ES.

The main difference from the combined presentation example reported in Chapter 3 is that linking ES accounts to IO tables creates a nexus between the ecosystem flow and the economic behaviour (in this case it is about the trading of agricultural products). The nexus, and its quantitative assessment, can indeed be an important tool in the hands of analysts helping policymakers to plan future actions and to assess their outcomes.

Compiling consumption-based accounts is feasible: IO tables are already part of conventional accounting datasets. The only limit is the geographical coverage: as long as the ES accounts are compiled only for the EU, a truly global trading assessment is not possible. However, valuable (albeit limited) information can still be made available. IO modelling requires some skill to apply the knowledge and tools that are available and to analyse the outcomes appropriately.

Figure 15. Scheme for the policy cycle with reference to consumption-based accounts



Consumption-based accounts can be useful for policymakers because they allow the sustainable use of ES to be assessed at the very end of the supply chain from the perspective of the final users, who remain a crucial driver of change. In fact, some policies are oriented towards producers (especially in terms of changing production processes and technologies), while other policies are oriented towards consumers (especially in driving their purchasing behaviour). Consumption-based accounts are a precious source of information for the latter policies.

5 General equilibrium models: the case of wild pollinators

When something changes in ecosystems and the services they provide, there are impacts in the economic sectors that depend on them. Creating a direct linkage between an ecological system and an economic system would be facilitated if the structure of data and the principles of compiling data and tools on both sides were coherent and compatible. Thanks to the SEEA, environmental information is reported as satellite accounts to the core economic accounts. ES accounts can thus facilitate the assessment of economic impacts generated by changes in ecosystems and their services.

This chapter proposes an illustrative example of how ES accounts can be 'bridged' to economic modelling, specifically general equilibrium models. This exercise was inspired by earlier work that modelled six damage functions to predict the effects of an increase in temperature (driven by climate change) on sea level rise, crop yields, labour productivity, human health, tourism and household energy demand (Roson and Sartori, 2016).

The illustration we propose concerns invasive alien species (IAS), which affect the ecosystem service crop pollination, which in turn has an economic impact on pollinator-dependent crops. The following exercise is structured as follows: first, we explain the presence of IAS as an exogenous shock; second, we estimate the impact of the exogenous shock on the crop pollination; third, we assess how changes in pollination generate impacts on crops that are recorded as SNA products; finally, we use variations in the SNA product to assess changes in trading and, to some extent, welfare.

Every step of this illustrative example is subject to assumptions and limitations: Section 5.2.4 is dedicated to exploring them together with the desirable future developments envisaged. Nevertheless, the main point we want to make is that ES accounts offer the potential to bridge to economic modelling tools and bridging could be a successful option to mainstream ES into decision-making.

5.1 Materials and method

Two major components underpin the whole exercise:

- the ecosystem accounting framework that this chapter uses as the source of data is the accounting tables generated by the INCA project;
- the general equilibrium model, which in this chapter is represented by the Global Trade Analysis Project social accounting matrix.

Before specifically discussing INCA and GTAP processing, we will briefly introduce the alien species we consider in this exercise and its geographical spread throughout Europe.

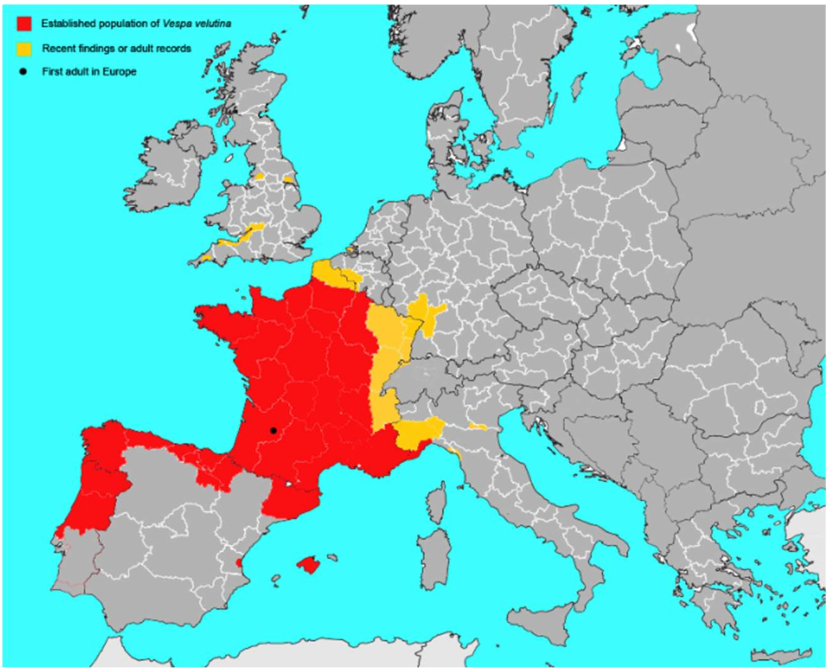
5.1.1 The context: the invasion of *Vespa velutina nigrithorax* (Asian hornet)

Pollinators provide a wide range of benefits to society (Potts et al., 2016): from providing food security to maintaining biodiversity. However, international focus on pollination services has been mostly driven by their benefits in terms of food products. In this context, understanding the relationships between pollination services and crop yield is crucial to quantifying how changing pollinator populations will affect food provision. Considering global crop markets, pollinated crops often achieve higher prices than other crops 'with the greatest benefits in southern and eastern Asia and Mediterranean Europe, owing to greater production of highly pollinator-dependent crops and higher market prices' (Potts et al., 2016).

Alien species are organisms introduced outside their natural range as a result of direct or indirect human action (e.g. related to worldwide trade and human mobility). In their new environment, some species can be become established, spread rapidly and have a significant negative impact on the ecology of their new location, as well as having serious economic and social consequences – such species are called 'invasive alien species' (IAS) (Jeschke et al., 2014; Ricciardi et al., 2013). *Vespa velutina nigrithorax* (Buysson, 1905), known as the yellow-legged hornet or Asian hornet (Hymenoptera: Vespidae) is the first Vespidae predator accidentally introduced into Europe from Asia. It was first observed in south-western France (Villemant et al., 2006) in 2004 and has spread rapidly in Spain (Castro L. and S., 2010; Lopez Z S. et al., 2011) and other EU Member States such as Belgium, Germany, Italy, the Netherlands, Portugal and the United Kingdom (Franklin et al., 2017; Rome Q. et al., 2013). The Asian hornet is listed as an IAS of EU concern in the frame of EU Regulation 1143/2014 (IAS Regulation) because of the risk it presents to European biodiversity and ES. The IAS Regulation fosters cooperation and coordination across EU Member States and requires the establishment of national surveillance systems. Among the many initiatives supported to study and contrast the invasion of the Asian hornet, we refer to an EU LIFE project called 'Stop Vespa Asiatica' that specifically targets and monitors this IAS and its impact on pollinators ([13]).

Figure 16 shows the distribution of Asian hornet in the EU and can be used to identify the affected Member States and relevant regions. Knowledge of its geographic distribution is precondition for assessing the impact of Asian hornet. Another important piece of information is the predation rate: because of a lack of studies on the impact of Asian hornet on wild bees and bumblebees (the two groups of species modelled for crop pollination in the INCA project), we have to assume that the predation rate for wild bees and bumblebees is the same as that estimated for honey bees. Specifically, we refer to the rate estimated in rural areas (Villemant et al., 2011).

Figure 16. Asian hornet distribution in the EU



Source: http://www.stopvelutina.it/wp-content/uploads/2018/09/VV_EU.png

Based on the assessment undertaken within the Stop Vespa Asiática project, the regions or areas affected by Asian hornet (based on monitoring from 2014) are the following:

- France: Île-de-France, Champagne-Ardenne, Haute-Normandie, Centre-Val de Loire, Nord-Pas de Calais, Lorraine, Alsace, Franche-Comté, Pays de la Loire, Bretagne, Poitou-Charentes, Aquitaine, Midi-Pyrénées, Limousin, Rhône-Alpes, Auvergne, Languedoc-Roussillon, Provence-Alpes-Côte d'Azur ;
- Spain: Galicia, Asturias, Cantabria, País Vasco, Comunidad Foral de Navarra, La Rioja, Castilla y León, Cataluña, Comunitat Valenciana, Illes Balears;
- Portugal: Norte, Centro;
- Italy: Piemonte, Liguria, Veneto, Lombardia, Toscana;

([13]) Additional and complementary information can be retrieved from the European Alien Species Information Network (EASIN): https://easin.jrc.ec.europa.eu/easin/

- United Kingdom: Yorkshire and the Humber, South West;
- Netherlands: Zeeland;
- Germany: Karlsruhe, Rheinhessen-Pfalz;
- Belgium: Hainaut.

5.1.2 The crop pollination supply and use tables

KIP INCA has developed supply and use tables for a number of ES, including crop pollination (Vallecillo et al., 2019a). Crop pollination potential is based on an indicator of habitats' suitability for supporting wild insect pollinators. This indicator integrates two different models: (i) an expert-based model for solitary bees (computed with the ESTIMAP toolbox (Zulian et al., 2013)); and (ii) a species distribution model for bumblebees, predicted with observed species records (Polce et al., 2013). Both models are based on land cover, climate data and the distance to semi-natural areas. Environmental suitability is used to delineate service-providing areas (for further details, see Appendix III in Vallecillo et al.(2018)). Demand for crop pollination is based on the extent of pollinator-dependent crops, following the methodology described in Zulian et al. (2013). For the modelling, spatial data derived from the CAPRI model (Britz and Witzke, 2012; Leip et al., 2008) quantified the demand for pollination as the number of hectares of crop per square kilometre. The overlap between crop pollination potential and demand defines the area generating the actual flow of this ES. Within the areas where the pollinators are present, the service flow is calculated by multiplying the production of each pollinator-dependent crop by the level of pollination dependency (Klein et al., 2007).

Although based on the application of the pollination dependency ratio, the ES accounts clearly show that part of the demand is not met because the ES potential does not cover all the crops in need of pollination (Table 10). The exercise undertaken for the EU (Vallecillo S. et al., 2018) shows that the actual flow covers only 66 % of production rather than 100 %. Other approaches (including the FAO tool. (Gallai and Vaissière, 2009)) using the pollination dependency ratio assume that all crops were covered by the full potential of pollinators.

Table 10. Pollinator-dependent crops that were not considered in the regions affected by Asian hornet

Country	Region	Pollinator-dependent crops
France	Nord-Pas de Calais Rhône-Alpes	Soya Flax and hemp
Spain	Galicia Asturias Cantabria País Vasco La Rioja Comunitat Valenciana Illes Balears	Rapeseed, soya, sunflower, flax and hemp Other oilseeds, rapeseed, soya, sunflower, flax and hemp Other oilseeds, soya, flax and hemp Soya, flax and hemp Soya Rapeseed Rapeseed, soya, flax and hemp
Italy	Liguria	Other oilseeds, rapeseed, soya, sunflower, flax and hemp
Germany	Karlsruhe Rheinhessen-Pfalz	Sunflower, flax and hemp Sunflower

For this exercise, we considered production data extracted from the CAPRI model (Britz and Witzke, 2012; Leip et al., 2008), which reports at NUTS 2 level and considered only those pollinator-dependent crops present in the provinces affected by Asian hornet. The affected regions shown in Figure 16 and Table 10 should be checked further: based on the spatial assessment of the actual flow, it is possible to check whether pollinator-dependent crops are really affected. Some regions need not be considered because they do not grow pollinator-dependent crops. Table 10 lists the crops not considered in the regions affected by Asian hornet. This confirms how important it is to use datasets that are geographically and statistically detailed to avoid over- and underestimation.

To calculate the actual flow (*Actual* $Flow_{CP}$) of crop pollination, we apply the ES ratio (*ESratio*) (Vallecillo S. et al., 2018), which represents the pollinator dependency, and multiply it by the production data extracted from the CAPRI model, as follows:

$$Actual\ Flow_{CP} = ESratio * Production \qquad \text{Equation 10}$$

A predation rate for Asian hornet of 0.35 (Villemant et al., 2011) is applied to *Actual* $Flow_{CP}$, as follows:

$$Predation = 0.35 * Actual\ Flow_{CP} \qquad \text{Equation 11}$$

The affected service flow (predation) could be used to address two different questions. The first is: how much income was lost because of the presence of Asian hornet? To respond, we need to consider the total production of pollinator-dependent crops in the country and the predation rate in affected countries.

The following formula expresses the missed gain caused by the Asian hornet as a percentage:

$$Missed\ gain\ = \frac{\sum Predation_{affected\ regions}}{\sum Production_{tot}} \qquad \text{Equation 12}$$

The second question is: what happens if Asian hornet extends its range to other regions within each country? In this case, we need to calculate the value of predation in all the other regions that are not currently affected, and then relate it to the total production. The following formula expresses the percentage of hypothetical loss caused if the Asian hornet continues to extend its range:

$$Hypothetical\ loss\ = \frac{\sum Predation_{not\ affected\ regions}}{\sum Production_{tot}} \qquad \text{Equation 13}$$

5.1.3 The linkage with economic modelling

General equilibrium (GE) models are an important tool for analysing economic issues, as they can represent the economy throughout the linkages between agents, sectors and other economies. To do this GE models need to include a large number of variables, parameters and equations. The Global Trade Analysis Project (GTAP) was established in 1992 to facilitate quantitative analyses of economic issues in an economy-wide framework by providing (i) a standard modelling framework, (ii) a global data base, and (iii) software for implementing the model and working with the data (Hertel, 1996). The standard GTAP model is a multi-region, multi-sector computable GE model with perfect competition and constant returns to scale. The underlying equation system of the GTAP model includes two different sets of equations: (i) one set covers the accounting relationships which ensure that receipts and expenditures of every agent in the economy are balanced (i.e. a SNA macro-perspective); and (ii) the other set specifies the behaviour of optimising agents in the economy (e.g. demand functions) and is based upon microeconomic theory (Brockmeier, 2001). The GTAP consortium produces a periodically consistent global economic database, widely used in research. For this application, we used the GTAP 9 Data Base (Aguiar et al., 2016), which captures world economic activity in 57 sectors of 140 regions.

The following exercise demonstrates how to bridge ES accounts with GTAP variables to assess economic impacts driven by changes in ES flows. In the case of pollination, an external shock affects the use of ES, which in turn affects the SNA benefit entering in the production system. This is possible thank to ES accounts, which enable spatial quantification of ES flows for crops and regions (Table 11) and the changes in these flows (Table 12).

These changes will be used to 'shock' (i.e. to apply a change in percentage terms to specific sectors in specific countries) the production for the sectors supplying those crops in the GTAP system.

Before using the GTAP model and database, it is necessary to harmonise classifications and aggregations. First, we need to aggregate (i) the database in GTAP according to the specifications of this exercise, and (ii) the pollination accounts according to the GTAP classification. In the first step, we aggregate sectors and countries. For the aggregation of sectors (GTAP codes are given in brackets):

- we keep disaggregated the following sectors, which have a direct linkage with the pollinator-dependent crops we are considering: vegetables [4], oil seeds [5], plant-based fibres [7], vegetable oils and fats [21], textile [27] and wearing apparel [28];
- we partially disaggregate the following sectors, which are indirectly linked to the previous sectors because they could be substitute or intermediate consumers: 'other agri' [1–3, 6, 8–20] and 'other food & beverage' [22–26];
- we aggregate all the remaining sectors that do not have any evident linkage with the sectors above and establish a category 'other sectors' [29–57].

For the aggregation of countries, we used the UN geoscheme [14] as a reference and aggregated the Member States and regions according to their proximity to the areas affected by Asian hornet:

1. Belgium [BE]
2. France [FR]
3. Germany [DE]
4. Italy [IT]
5. Netherlands [NL]
6. Portugal [PT]
7. Spain [ES]
8. United Kingdom [UK]
9. Eastern Europe [EE]
10. Northern Europe [NE]
11. Southern Europe [SE]
12. Western Europe [WE]
13. Africa
14. Northern America [NA]
15. Latin America [LA]
16. Central America [CA]
17. Asia
18. Rest of the world [ROW]

Among the sectors identified, one is particularly sensitive to the impact of Asian hornet: 'Vegetables, fruits, nuts' (v_f [4]). For this exercise, the drawback of the GTAP database lies in the high degree of aggregation of sectors that in our case require more processing to avoid overestimation. In fact, not all products reported in 'Vegetables, fruits, nuts' are affected by the Asian hornet, only those reported in Table 12. We thus need to shock not the whole sector but only part of it. To obtain an estimate of the extent of 'Vegetables, fruits, nuts' under consideration, we used the Eurostat dataset (specifically [apro_cpsh1] [15]) and calculated for each country affected by Asian hornet the proportion of pollinator-dependent crops with respect to all crops classified in 'Vegetables, fruits, nuts' (v_f [4]). These estimates should be made for each of the GTAP sectors, but unfortunately data with a sufficient level of detail are currently not available. This is a major limitation that needs to be addressed.

Once we have calculated the percentage of 'missed gains' and 'hypothetical losses' (Table 11) and set up the database as described above, we have to identify the variable in the GTAP model to be shocked by those percentages. We need to consider changes in output (yield) everything else being equal. 'AO' represents the output augmenting technical change in sector *j* of region *r*. Within GTAP, 'AO' is a component of technical change variables.

(14) See https://en.wikipedia.org/wiki/United_Nations_geoscheme
(15) Available at https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=apro_cpsh1&lang=en

The GTAP sector 'Vegetables, fruits, nuts' (v_f [4]) also includes pulses, which is a relevant crop in the pollination account. For the sake of transparency between INCA accounts and GTAP codes we adapted the sector classification to 'Vegetables, fruits and pulses'.

Table 11. Pollination accounts aggregated according to GTAP codes

GTAP aggregation	GTAP code	Correspondence with ES accounts
Vegetables, fruits and pulses	v_f [4]	Apples, pears, peaches citrus fruits, other fruits, tomatoes, pulses
Plant-based fibres	pfb [5]	Flax and hemp
Oilseeds	osd [7]	Oilseeds
Other agricultural products	other agri [1–3, 6, 8–20]	[linked sectors]
Vegetable oils and fats	vol [21]	Soya, sunflower, rapeseed
Food and beverage	other food & beverage [22–26]	[linked sectors]
Textile	tex [27]	[linked sectors]
Wearing apparel	wap [28]	[linked sectors]
Rest of sectors	other sectors [29–57]	[not linked sectors]

5.2 Results

After reporting the pollination accounts concerning only the regions affected by the Asian hornet, this exercise addresses two questions:

- how much would be produced if the Asian hornet was not present? (missed gain)
- how much would be lost if the Asian hornet expanded its range to other regions? (hypothetical loss)

Two assessments are performed for each question based on different dataset settings:

1. without disaggregation within GTAP sector and assuming that the shock caused by Asian hornet affects all of the crops included in the GTAP sector classification;
2. with a focus only on those pollinator-dependent crops within the GTAP sector 'v_f'; the percentage of those crops over the total of the GTAP sectors is based on official estimates from Eurostat ([16]).

The purpose of the two assessments is to show how the outcomes can change as a result of different ways of aggregating the data.

The GTAP model provides a considerable number of variables. Once the applications had been computed we looked at the following variables, which we thought were instrumental in quantifying the impact of Asian hornet invasion on production and trade:

- production (q_0)

([16]) Specifically 'Crop production in EU standard humidity (apro_cpsh1)', https://ec.europa.eu/eurostat/data/database

- import prices (pms)
- export quantity (qxs)
- balance of payments ($DTBAL_i$).

5.2.1 ES accounting outcomes

Table 12 shows pollination accounts in the affected regions, aggregated by country. The service flow is quantified as the amount of annual production of pollinator-dependent crops.

Table 12. Crop pollination actual flow in physical terms (tonnes) in affected regions, 2012

	France	Italy	Spain	Portugal	Germany	Belgium	Netherlands
Apples, pears and peaches	502.86	562.79	486.59	185.97	681.01	298.35	324.54
Citrus fruits	1.34	52.46	114.45	8.26	–	–	–
Other fruits	155.21	349.93	612.64	42.26	153.42	121.87	117.88
Other oilseeds	2.56	0.01	1.11	0.15	0.71	0.35	0.07
Pulses	12.71	1.27	1.63	0.25	11.77	0.23	0.25
Rapeseed	209.13	2.02	1.74	–	1 037.68	14.59	2.05
Soya	3.12	4.87	0.10	–	0.40	–	–
Sunflower	57.41	13.49	12.47	0.39	12.39	–	0.63
Flax and hemp	13.24	0.04	0.37		0.60	2.38	0.68
Tomatoes	18.93	98.10	63.78	35.99	2.99	10.65	37.49

By applying $Missed\ gain\ = \frac{\sum Predation_{affected\ regions}}{\sum Production_{tot}}$ Equation 12

and $Hypothetical\ loss\ = \frac{\sum Predation_{not\ affected\ regions}}{\sum Production_{tot}}$ Equation 13

to the actual flows in Table 12, we can calculate missed income/gains and hypothetical losses (Table 13).

Table 13. Missed gain (MG) and hypothetical loss (HL) as a percentage of production (in tonnes) estimated by the CAPRI model for selected crops in selected Member States in the year 2012

	Belgium		France		Germany		Italy		Nether.		Portugal		Spain		United Kingdom	
	MG	HL	MG	HL	MG	HL	MG	HL	MG	HL	MG	HL	MG	HL	MG	HL
Apples, pears and peaches	15.7	22.1	8.45	0.08	0.02	18.39	1.10	3.30	5.42	14.55	12.2	2.00	4.49	4.22	2.22	16.8
Citrus fruits	–	–	0.86	0.04	–	–	0.17	0.37	–	–	0.90	0.14	0.33	0.32	–	–
Other fruits	0.10	13.6	5.06	0.07	1.17	11.28	0.85	1.83	3.26	9.05	7.50	1.23	2.78	2.64	1.41	10.2
Other oilseeds	0.37	5.13	1.42	0.00	0.07	5.19	0.56	0.90	4.23	1.11	0.01	0.74	0.18	0.27	0.81	3.35
Pulses	0.17	1.27	0.51	0.00	0.03	1.44	0.07	0.23	0.74	0.69	0.27	0.70	0.04	0.09	0.20	1.03
Rapeseed	0.78	6.78	1.44	0.00	0.10	7.40	0.94	0.86	0.25	8.09	–	–	0.62	0.18	1.17	4.39
Soya	–	–	0.96	0.00	0.27	8.37	0.21	0.11	–	–	–	–	0.72	1.74	–	–
Sunflower	–	–	1.21	0.00	0.00	7.98	0.48	1.37	0.63	7.94	0.01	1.11	0.15	0.32	1.19	5.05
Flax and hemp	0.05	1.51	0.98	0.00	0.03	1.37	0.16	0.60	1.26	0.22	–	–	0.00	0.08	0.33	1.02
Tomatoes	0.25	1.35	0.83	0.00	0.07	1.45	0.13	0.50	0.31	1.29	0.15	0.82	0.15	0.42	0.28	1.06

5.2.2 Missed gain exercise

The dataset used reflects a situation in which the Asian hornet is present. This exercise aimed to show the changes in production and trade in the absence of Asian hornet. The countries most affected by Asian hornet are expected to have higher missed production and in turn trade.

Missed production aggregated according to GTAP sector classification is reported in Table 14. The most relevant cases are shown in red.

Table 14. Missed gains caused by Asian hornet invasion (%) in 2012

	Belgium	France	Germany	Italy	Netherlands	Portugal	Spain	United Kingdom
Vegetables, fruits and pulses	0.17	3.14	0.79	0.46	2.43	4.21	1.56	1.03
Oilseeds	0.37	1.42	0.07	0.56	4.23	0.01	0.18	0.81
Vegetable oils and fats	0.78	1.20	0.12	0.54	0.44	0.01	0.49	1.18
Plant-based fibres	0.05	0.98	0.03	0.16	1.26	0.00	0.001	0.33

As expected from Table 13, the major changes in the quantity of production occur in France, the Netherlands and Portugal (Figure 17a). Without Asian hornet France would have had increases of 4.7 % for 'vegetables, fruits and pulses', 3.7 % for 'oilseeds' and 4.7 % for 'vegetable oil and fats'. The Netherlands would have had increases of 4.9 % for 'vegetables, fruits and pulses' and 10.4 % for 'oilseeds'. Portugal would have had an increase of 4.9 % for 'vegetables, fruits and pulses' and the United Kingdom an increase of 4.6 % and Belgium an increase of 3.4 % for 'vegetable oil and fats'.

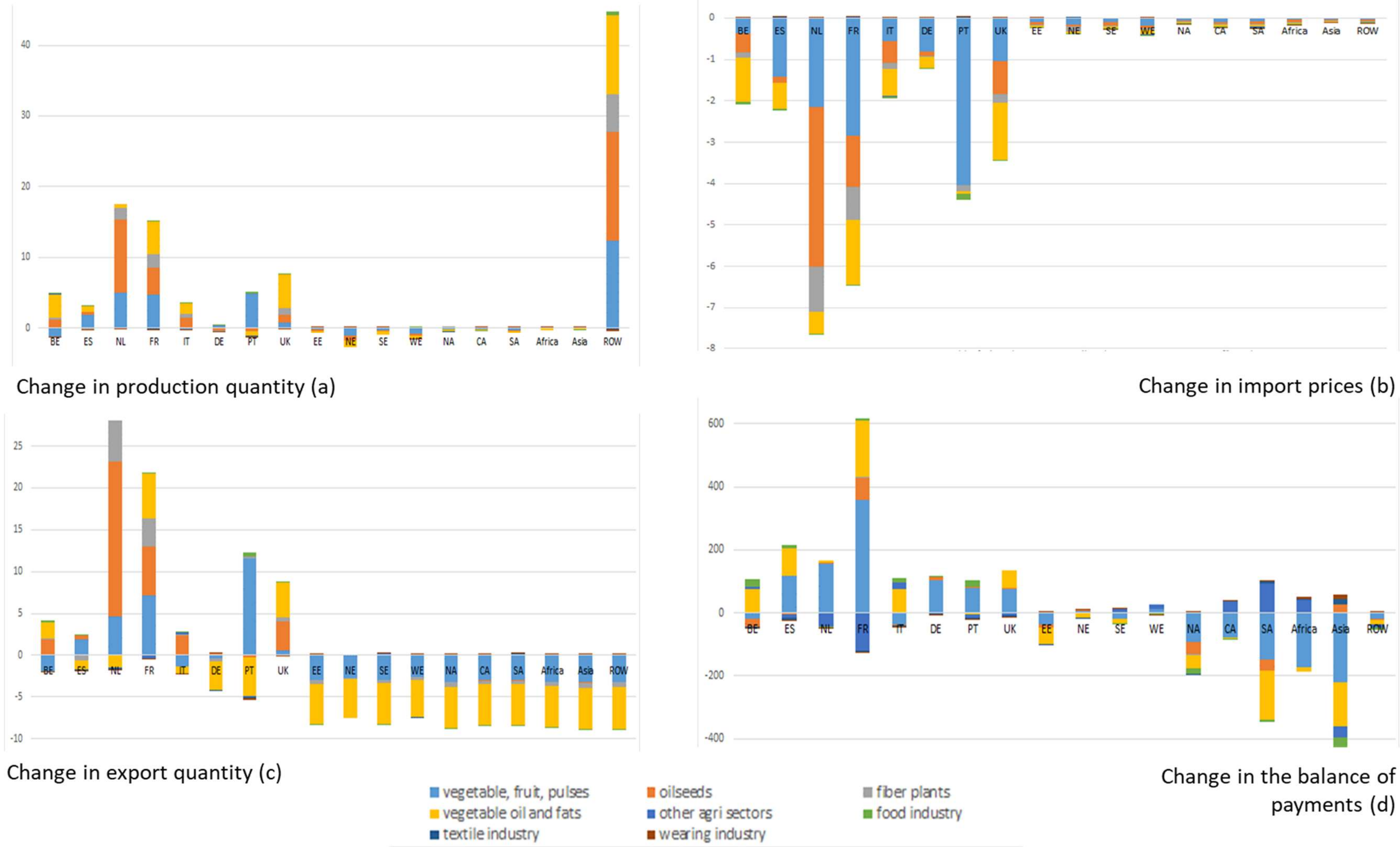
If Asian hornet were not present, there would be an increase in crop production; because of this increase, the price of imports would decrease (Figure 17b). We note a remarkable decrease in import prices of 4.03 % in Portugal, 2.85 % in France and 2.15 % in the Netherlands for 'vegetables, fruits and pulses'. For 'oilseeds', the Netherlands would record a decrease of 3.85 %.

Production in the absence of Asian hornet would increase and this is in line with increased exports (Figure 17c). In this case, France would record an increase of 7.2 % for 'vegetables, fruits and pulses', 5.7 % for 'oilseeds', 3.4 % for 'fibre plants' and 5.3 % for 'vegetable oil and fats'. The Netherlands would record an increase of 4.6 % for 'vegetables, fruits and pulses', +18.6 % for 'oilseeds' and +4.9 % for 'fibre plants'. Portugal would record an increase of 11.6 % for 'vegetables, fruits and pulses' and the United Kingdom an increase of 4.1 % for 'vegetable oil and fats'.

Looking at the balance of payments (all figures in million US dollars), a few interesting features can be noted (Figure 17d). France would record the highest positive value (358) for 'vegetables, fruits and pulses' and remarkable positive values also for 'oilseeds' (70.9) and 'vegetable oil and fats' (180). 'Vegetables, fruits and pulses' would record positive gains for the Netherlands (157), Spain (117), Germany (104), Portugal (80) and the United Kingdom (74). Italy (–37) and Belgium (–19) would both record negative changes. A possible explanation might be as follows: France, for example, has higher production with lower prices, which favours its foreign trade in these crops over that of Italy. For this indicator, the food industry (a linked sector) shows interesting results: positive values would be recorded for those countries that process raw crops, such as Belgium (23), Portugal (20), Italy (16), Spain (10) and France (6).

All the results from the GTAP model run with the shock described in Table 14 are reported in Annex I.

Figure 17. Missed gains: change (%) in the quantity of production (a), price of imports (b), quantity of exports (c), and change (million USD) in the balance of payments (d) as missed gains caused by Asian hornet compared with a 2011 baseline



5.2.3 The hypothetical loss exercise

This exercise aimed to show the changes in production and trade if the Asian hornet invaded not only currently affected regions but also expanded to all remaining regions (within selected countries). The countries currently only slightly affected by Asian hornet are expected to have higher hypothetical losses in production and trade after the species' expansion to the whole territory. The first records of the presence of Asian hornet in a country should trigger an early warning and rapid response based on by the risk of its expansion and potential impact on sensitive crops and related sectors.

Relative hypothetical loss aggregated according to the GTAP sector classification is reported in Table 15. The most relevant cases are shown in red.

Table 15. Loss of production (%) if Asian hornet invaded the rest of the Member State, 2012

	Belgium	France	Germany	Italy	Netherlands	Portugal	Spain	United Kingdom
Vegetables, fruits and pulses	9.59	0.04	8.14	1.25	6.39	0.98	1.54	7.28
Oilseeds	1.51	0.00	1.37	0.88	1.11	0.74	0.27	3.35
Vegetable oils and fats	5.13	0.00	5.19	0.78	8.01	1.11	0.74	4.71
Plant-based fibres	6.77	-	7.91	0.60	0.22	-	0.08	1.02

Table 15 presents the situation opposite to that in Table 14: countries such as France and Portugal that were mostly affected by the Asian hornet for 'vegetables, fruits and pulses' would not record significant changes. On the other hand, Member States such as Germany, Belgium and the United Kingdom would be highly exposed to losses. The Netherlands seems to remain sensitive in the areas not yet touched by the Asian hornet but by different amounts for different crops.

There would be important hypothetical losses in some Member States (Figure 18a). For the 'vegetables, fruits and pulses' sector, Belgium would record a loss of 20 %, Germany 14 %, the Netherlands 13 %, and the United Kingdom 9.8 %. On the other hand, France would record an increase of 2.4 %: even if affected by the Asian hornet, production in France would gain a competitive advantage compared with the significant losses recorded in other Member States. For 'oilseeds', Belgium would record a loss of 10 %, the Netherlands 7.2 % and the United Kingdom 6.3 %. For 'fibre plants', Belgium would record a loss of 19 % and Germany 24 %. For 'vegetable oil and fats', the Netherlands would record a loss of 24 , Belgium 21 %, the United Kingdom 17 % and Germany 16 %. For the same sector France would record an increase of 6 %; even when affected by Asian hornet, its production would remain significant.

The changes in import prices follow almost consistently the changes in production: the highest increases in prices would be recorded in areas showing the greatest losses in production (Figure 18b). For 'vegetables, fruits and pulses', the highest loss of production in Belgium (20 %) would also record the highest increase in price of 8.1 %. For 'fibre plants', the highest loss of production in Germany (24 %) would record the highest increase in price of 5.4 %. For 'vegetable oil and fats', the sector with the highest loss of production in the Netherlands (24 %) would record the highest increase in price of 8.2 %. For 'oilseeds', prices would increase more in the United Kingdom (3 %) than in Belgium (1.5 %), where the highest loss would be recorded in terms of production.

Figure 18. Hypothetical losses: changes (%) in the quantity of production (a), price of imports (b), quantity of exports (c), and change (million USD) in the balance of payments (d) as hypothetical loss caused by Asian hornet compared with a 2011 baseline

A few comments need to be made about the changes that would occur in exports (Figure 18c). Firstly, Germany and Belgium would record important losses in all affected sectors (from 18 % to 26 % in Belgium and from 16 % to the 26 % in Germany): this is in line with results for the changes in production, showing that the negative effects on production are confirmed and the effect increased for exports. Secondly, the Netherlands would record the highest loss of exports for 'vegetable oil and fats' (37 %), whereas other Member States such as France (16 %), Italy (11 %), Spain (11 %) and Portugal (9 %), even if affected by Asian hornet, would increase their exports, taking advantage of the Netherlands and other Member States' losses (Belgium 19 %, Germany and the United Kingdom 18 %). Thirdly, in the case of 'oilseeds', all exports in all Member States would be negative: it seems that the losses in that sector would not be compensated. Another sector might take advantage of the situation.

Regarding the balance of payments (expressed in million US dollars), the changes in the case of hypothetical loss are higher than in the case of missed gain (Figure 18d). The four hypothetically most affected Member States would record significant losses for (in particular) 'vegetable oil and fats' and 'vegetables, fruits and pulses', respectively: Germany −965 and −743, Belgium −442 and −477, the Netherlands −442 and −422, and the United Kingdom −413 and −205. For other sectors, the changes would be much lower or in some cases positive (e.g. for 'oilseeds'). The food industry would also record some interesting results: −110 for Germany, −44 for the Netherlands, −38 for Belgium and +48 for France.

All the results from the GTAP model run with the shock described in Table 15 are reported in Annex I.

From the GTAP exercise, we consider another indicator: the equivalent variation, which represents changes in utility driven by changes in consumption, government spending and savings; equivalent variation expresses a variation in income and could be used as a proxy monetary measure of welfare (Table 16).

In the missed gain exercise, the numbers/figures change by an average of 63 % in affected Member States and regions and by 54 % in those unaffected. In the hypothetical loss exercise, the numbers/figures changes by an average of 73 % in affected Member States and regions and by 64 % in those unaffected.

Table 16. Equivalent Member State and region variation in the missed gain and hypothetical loss exercises

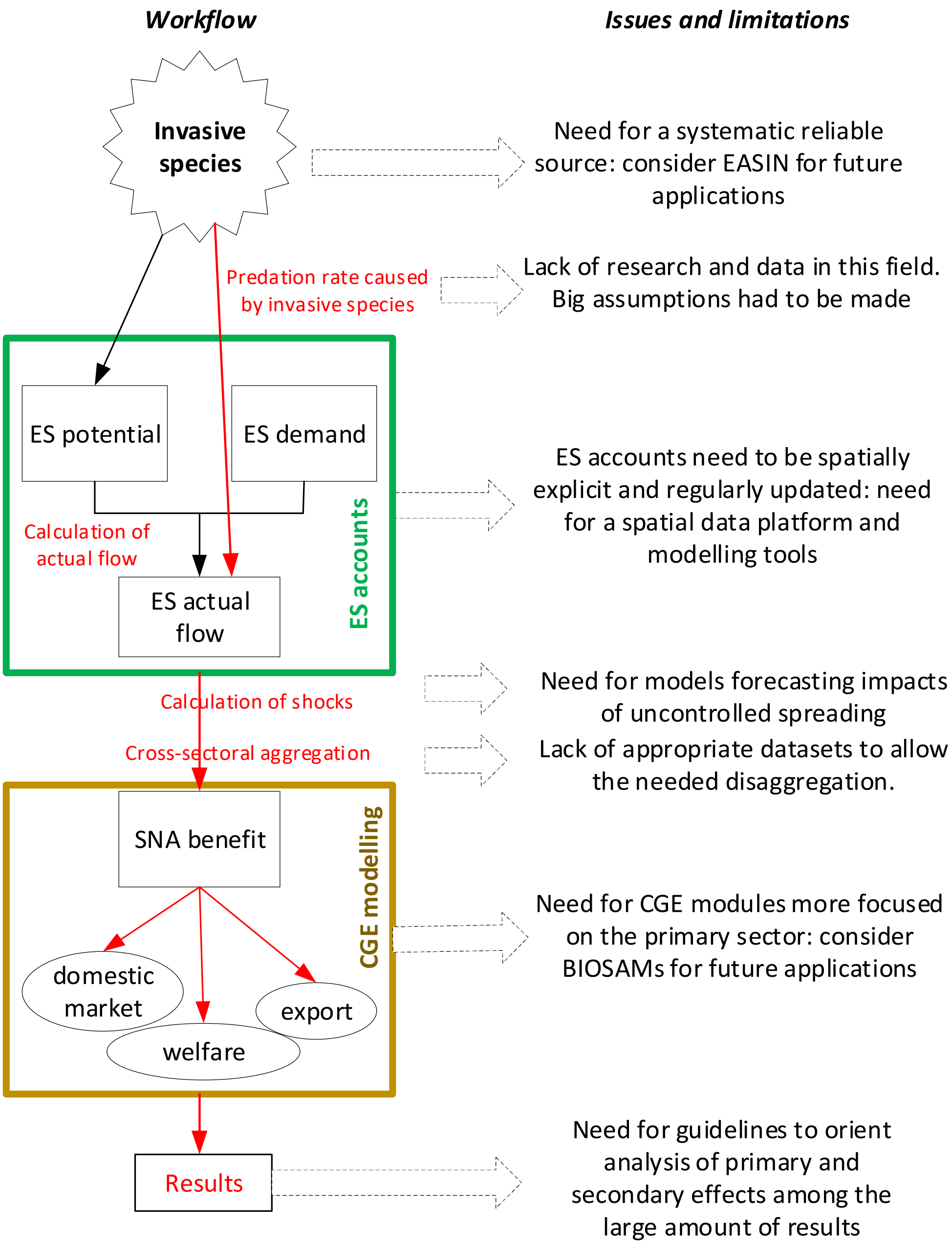
Member State/region	Missed gain	Hypothetical loss
Belgium	55.8	-303
Spain	176	-185
Netherlands	50.9	-245
France	419	-190
Italy	163	-317
Germany	204	-981
Portugal	100	-63.2
United Kingdom	168	-593
Africa	-23.8	38.4
Asia	83	-163
Eastern Europe	56.4	-224
Northern Europe	73.5	-226
Southern Europe	12.1	-29.2
Western Europe	39	-101
Northern America	11.7	-38.4
Central America	-12.4	24.9
South America	-107	255
Rest of the world	-24.7	48.3
Total	1 444	-3 290

5.2.4 Limitations

The whole exercise raises many questions for discussion and further investigation. However, several assumptions had to be made to complete this exercise. Figure 19 summarises the issues faced and limitations encountered during the assessment.

First, spatial data on species distribution need to be reliable and up to date. For this exercise we chose a dataset collected in the context of a project specifically targeting Asian hornet, i.e. the LIFE project Stop Vespa Asiatica. The date of the extracted data does not exactly match the dates of the ES accounts data (2012) and the GTAP data (2011). However, the Asian hornet data were considered suitable for testing the procedure described here. Once the procedure itself becomes a monitoring and early warning tool, then an information platform is needed to systematically monitor the species occurrence and its spread. In the EU, the European Alien Species Information Network (EASIN) constitutes the official information system of the EU IAS Regulation, facilitating access to updated information on alien species, and IAS, from a network of data partners, among which is the LIFE project Stop Vespa Asiática and relevant national authorities.

Figure 19. Issues and limitations concerning each step of the workflow



Note: BioSAMs, bio-based social accounting matrices; CGE, computable general equilibrium (model).

Second, there is a lack of knowledge on the species' impact, specifically its predation rate. Studies of predation on honey bees have been undertaken, but almost no information is available for wild bees and bumblebees. We assumed that the predation rate for honey bees in rural and forest areas is the same as for wild bees and bumblebees. This assumption has a high degree of uncertainty and more investigation of predation rates is needed to make reliable estimates.

Third, the 'hypothetical loss' exercise was based on the simple assumption that Asian hornet would invade all NUTS 2 regions. There are biological models capable of forecasting species' spread in space and time. More rigorous applications should employ these models in setting future scenarios.

Fourth, when moving to GTAP classification of sectors, we face data aggregation issues. From the available official statistics we do not have enough information to disaggregate each crop-related sector as needed. In this exercise the major sector affected by Asian hornet is 'vegetables, fruits and pulses' ('v_f' according to the GTAP classification). We made an effort to fill the information gaps for this particular sector; however, all of the sectors should also be appropriately disaggregated, but we could not proceed because of a lack of data. Considering that the results can differ if the affected sectors are disaggregated, this procedure cannot be considered fully reliable until a proper disaggregation can be performed in GTAP.

Fifth, most ES have a direct impact on the primary sector, 'agriculture'. A disaggregation of 'agriculture' would greatly enhance any assessment. The social accounting matrices built for the bio-based and agriculture sectors (Mainar Causapé A. et al., 2018) could help to overcome the aggregation issue and allow estimates that are more reliable. As social accounting matrices represent the reference database for computable general equilibrium (CGE) models, bio-based social accounting matrices, known as BioSAMs, could be an interesting option to link economic models to all those ES accounts that primarily depend on and/or affect the agricultural sector.

Finally, GTAP provides a large range of outcomes. In this exercise, we consider only changes in production, trade and in a limited way welfare. Thanks to GTAP, it is possible to assess not only primary but also secondary effects, such as impacts on labour. However, it will be necessary to have (and thus provide) a guideline targeting the chain of impacts from ecosystems to the economy to be sure that important messages will not be lost.

5.3 Discussion

The purpose of this exercise was to bridge ES accounts to economic modelling. ES accounts are structured to be consistent with the SNA, which is in turn the source of data for economic modelling and analysis. Thanks to the rigour of the accounting framework, when the benefit of an ES is an SNA product, the linkage is straightforward, as shown in the example of IAS.

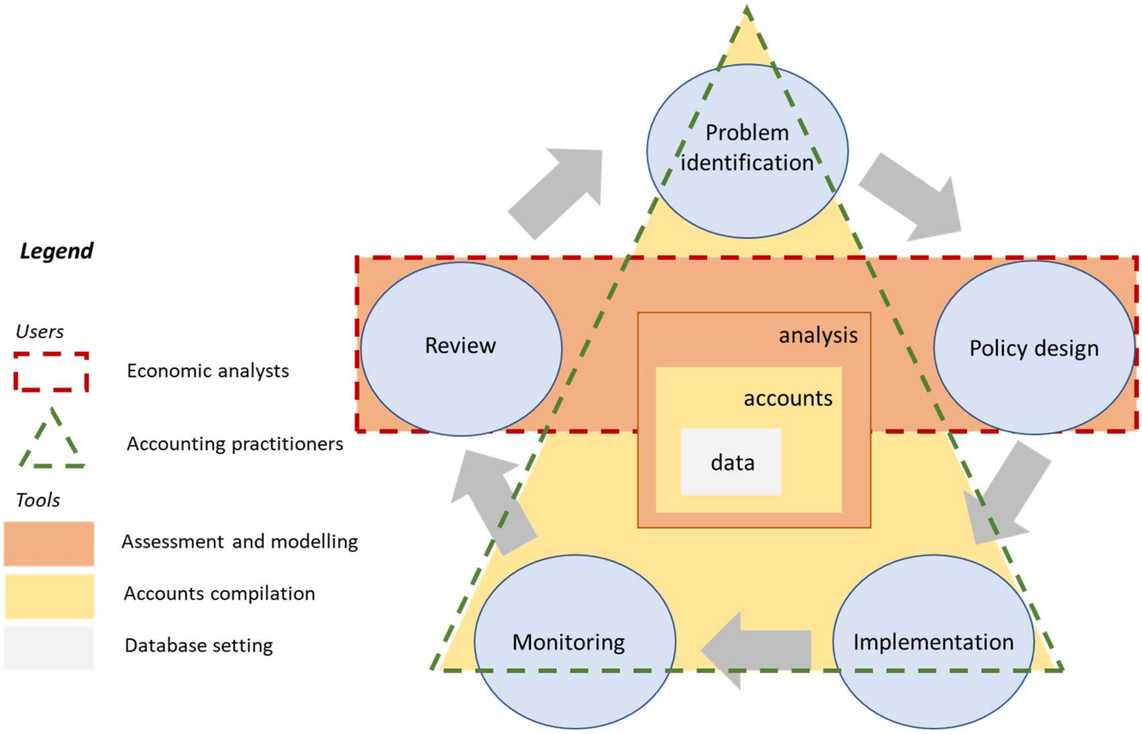
With reference to Vardon et al. (2016), this kind of application can be useful in (Figure 20):

- [*ex ante*] developing policy proposals to resolve issues by defining, discussing, accepting or rejecting alternative solutions;
- [*ex post*] evaluating what the policy actually produces, the impact on target (and non-target) communities and the degree to which this impact solves the problem.

As already described in the case of consumption-based accounts, bridging ES accounts to CGE models creates a nexus between the ecosystem flow and economic behaviour (in this case it is about how an IAS affects pollinators, which in turn affect pollinator-dependent crops). The existence of this nexus brings new knowledge that becomes an tool in the hand of analysts helping policymakers to assess the consequences of action (and inaction) when exogenous changes affect ecosystems and their services.

Bridging ES accounts to economic modelling is feasible, although initial applications (as in this case) may require many assumptions and embed a series of limitations. However, identifying gaps in the first round of applications highlights the problems that need to be addressed, so that solutions can be found and implemented in the second round of applications. The bridging is possible and opens the door to a vast range of opportunities both methodologically and analytically. The use of partial and general equilibrium models requires some expertise: specific branches of macroeconomics are dedicated to this area.

Figure 20. Scheme for the policy cycle with reference to ES accounts bridged to CGE models



Bridging ES accounts to economic modelling is useful for policymakers because it allows them to assess the economic impacts of changes in ecosystems and ES flows. Partial or general equilibrium models are tools created and used by economists to propose economic policies, explain and influence economic strategies, forecast economic activities, etc. Introducing ES into the set of relevant variables (in our example through a 'shock') can operationally mainstream the role of ecosystems in economic analysis.

6 Conclusions

The effective use of ES accounts requires referring to and bridging to economic accounts and tools, as their common framework and compilation rules guarantee inner consistency and reliability. Once the ES accounts have been compiled, it is possible to perform a series of analyses that can range from simple descriptive statistics (La Notte and Dalmazzone, 2018) to trend analysis (Vallecillo et al., 2019a). ES accounts in these cases can be used directly without any further processing. In this report we provide three additional examples in which some processing was done to merge ecosystem and economic accounts and models.

The first example (Chapter 3) is about joint SEEA AFF–INCA accounts and it shows how to combine the flow of ES with conventional accounts related to agricultural products and their trade. The outcome is a scoreboard in which the three pillars of sustainability are logically and consistently combined to determine whether (or nor) higher crop production could (be in line with sustainable management practices.

The second example (Chapter 4) is about the linkage between ES accounts and multiregional input–output tables. Production-based accounts, which show the flow from ecosystems to the SNA, are supplemented by consumption-based accounts that address (some of) the real end users. As consumption is the ultimate driver behind production processes, quantifying the ES embedded in traded products is important to identify indirect drivers of pressures on ecosystems.

The third example (Chapter 5) is about bridging ES accounts to economic modelling, where the source of data is the SNA. Thanks to the rigour of the integrated INCA (based on SEEA) accounting framework, when the benefit of an ES is an SNA product, the linkage is straightforward, as shown in the example of invasive alien species.

Applications need to be capable of the following functions.

- Building combined presentations. Once ES accounts are ready, the linkage with conventional accounts is straightforward. No specific expertise is needed in terms of modelling; any statistical office at any administrative level could easily set up and process datasets.
- Compiling consumption-based accounts. Input–output tables are already part of economic accounting datasets. Input–output modelling requires some skill to apply the knowledge and tools that are available and to analyse the outcomes appropriately.
- Bridging ES accounts to economic modelling and creating a nexus that explains how exogenous (and/or endogenous) changes impact ecosystems and their services, which in turns affect socioeconomic systems. The use of partial and general equilibrium models requires some expertise in specific branches of macroeconomy.

As shown in Figure 21, there can be various users and policy uses for each of the applications.

For combined presentations and scoreboards:

- practitioners of this kind of application can be national statistical offices, research institutes and international organisations as well as any other institution enabled to set up (or simply access) a database and compile the accounts;
- ministries, stakeholders and policymakers can communicate with a large (and even non-technical) audience and address the main findings consistently in the policy decision-making process.

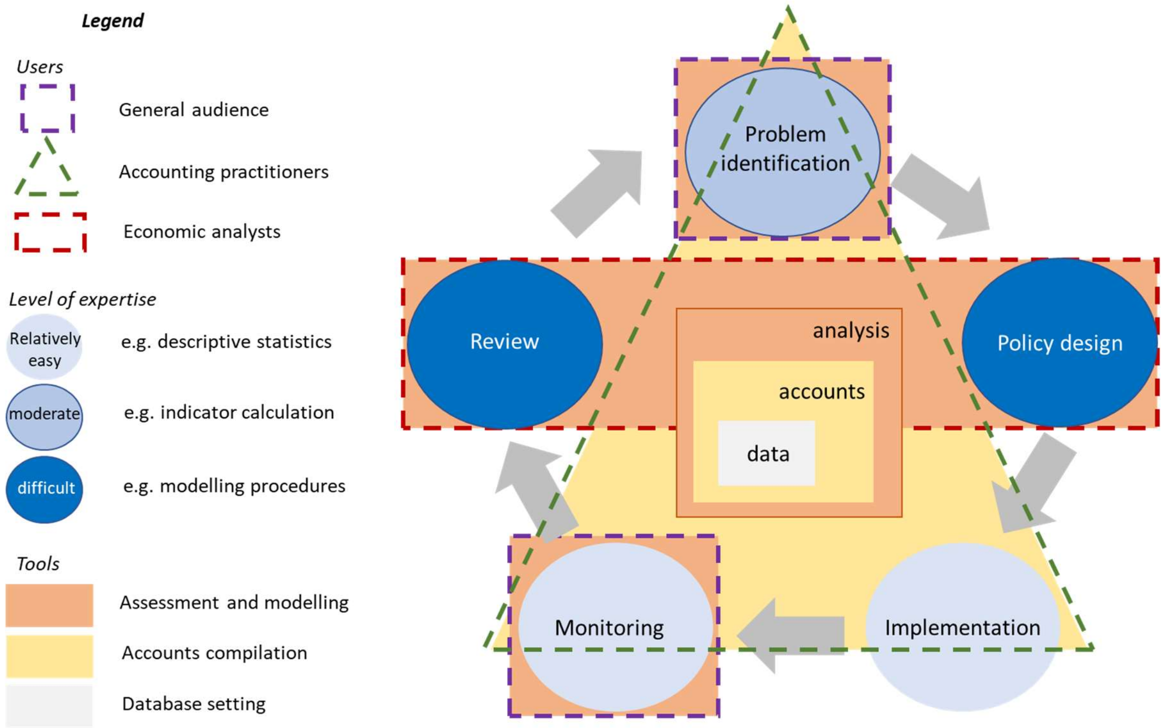
For consumption-based accounts:

- practitioners of this kind of application can be analysts who are familiar with ES accounts and input–output tables;
- policymakers can use consumption-based accounts to assess the sustainable use of ES at the very end of the supply chain from the perspective of the final users, who remain a crucial driver of change.

For bridging ES accounts to economic modelling:

- practitioners of this kind of application can be analysts who are familiar with ES accounts and partial and general equilibrium models;
- policymakers can use these bridged tools to assess the economic impacts caused by changes in ecosystems and ES flows.

Figure 21. Summary of the scheme for the policy cycle applied to ES account applications



The INCA experimental accounts on which LISBETH is based are pilot applications. Within KIP INCA, ES accounts for Europe are available on a dedicated website where maps and tables can be downloaded ([17]). To enable systematic and continuous compilation, geographical information system (GIS) tools should be developed and made available to practitioners, and a data platform should be developed and made available for downloading and extracting data. The JRC is exploring the possibility of building an ad hoc GIS plug-in for each ES proposed within INCA (Vallecillo S. et al., 2019; Vallecillo S. et al., 2018). Sensitivity and uncertainty assessments will also need to be developed and integrated with the GIS plug-in tools.

In line with the guidance developed through the World Bank policy fora (Ruijs et al., 2019), there is a structural challenge to be addressed to allow ES accounts to be used beyond the issue or problem identification stage of the policy cycle. The three applications reported here are just the start of developing applications to the stage where ES accounts can help to find synergies for the sustainable use of natural capital and where ES accounts are fully integrated into public policymaking.

Based on the experience developed in INCA and LISBETH, we can confirm that one crucial policy area that offers real potential for NCA concerns the complex and dynamic links between the environment and the economy and involves major policy and investment decisions (Ruijs et al., 2019). The purpose of LISBETH is to set up and empower the regular cross-sectoral processes that are the basis for national development planning, risk analysis and the economic mainstreaming of ecological issues.

([17]) https://data.jrc.ec.europa.eu/dataset?q=INCA&sort=score+desc&ext_bbox=&ext_prev_extent=-57.65624999999999%2C-21.289374355860424%2C97.03125%2C75.67219739055291&page=1

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Abbreviations

BioSAMs	bio-based social accounting matrices
CGE model	computable general equilibrium model
EASIN	European Alien Species Information Network
ES	ecosystem services
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FS	food supply
GE model	general equilibrium model
GTAP	Global Trade Analysis Project
IAS	invasive alien species
INCA	Integrated system for Natural Capital Accounting
IO	input–output
Mkt	market
NCA	natural capital accounts
LISBETH	LInking ecosystem Services and Benefits to the Economy THrough bridging
SEEA AFF	System of Environmental–Economic Accounting for Agriculture Forestry and Fisheries
SEEA CF	System of Environmental and Economic Accounting Central Framework
SEEA EEA	System of Environmental and Economic Accounting experimental ecosystem accounts
SNA	System of National Accounts
UN	United Nations

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Annex 1. GTAP computation results

Legend

	Directly affected Member States/regions
	Closest Member States/regions
	Other Member States/regions
	Affected sectors
	Linked sectors

Code	Member State/region
BE	Belgium
ES	Spain
NL	Netherlands
FR	France
IT	Italy
DE	Germany
PT	Portugal
UK	United Kingdom
EE	Eastern Europe
NE	Northern Europe
SE	Southern Europe
WE	Western Europe
NA	Northern America
CA	Central America
SA	South America
Africa	Africa
Asia	Asia
ROW	Rest of the world

S1

Missed gain

S1.1. Change (%) in quantity of production (q_0)

	BE	ES	NL	FR	IT	DE	PT	UK	EE	NE	SE	WE	NA	CA	SA	Africa	Asia	ROW
Vegetables, fruits and pulses	-1.25	1.88	4.91	4.69	-0.263	0.333	4.89	0.681	-0.17	-1.15	-0.343	-0.9	-0.147	-0.234	-0.346	-0.122	-0.042	12.3
Oilseeds	1.12	0.323	10.4	3.76	1.48	-0.393	-0.456	1.21	-0.254	-0.728	-0.123	-0.317	-0.11	-0.015	-0.16	-0.018	-0.059	15.5
Fibre plants	0.244	-0.175	1.69	1.91	0.526	-0.062	-0.03	0.957	0.011	0.065	0.006	0.06	0.008	0.026	0.023	0.012	-0.002	5.23
Vegetable oil and fats	3.4	0.853	0.561	4.67	1.45	-0.04	-0.676	4.65	-0.355	-0.971	-0.53	-0.322	-0.163	-0.069	-0.265	-0.2	-0.078	11.2
Other agricultural sectors	0.07	-0.01	-0.094	-0.118	0.049	0.007	-0.018	-0.006	0.004	0.004	0.036	0.057	-0.001	0.024	0.018	0.012	0	0.033
Food industry	0.121	0.039	-0.008	0.023	0.048	0.023	0.235	0.011	0.004	0.009	0.003	0.006	-0.001	-0.001	0.001	0	-0.001	0.501
Textile industry	-0.015	-0.053	-0.036	-0.043	-0.012	-0.011	-0.126	-0.013	0.002	0.001	0.016	-0.014	-0.003	0.01	0.012	0.023	0.005	-0.248
Wearing industry	-0.01	-0.038	-0.039	-0.033	-0.007	-0.004	-0.114	-0.014	0.003	0.012	0.017	-0.006	0	0.003	0.004	0.015	0.004	-0.201

S1.2. Change (%) in price of import (pms)

	BE	ES	NL	FR	IT	DE	PT	UK	EE	NE	SE	WE	NA	CA	SA	Africa	Asia	ROW
Vegetables, fruits and pulses	-0.379	-1.41	-2.15	-2.85	-0.55	-0.811	-4.03	-1.05	-0.09	-0.163	-0.105	-0.181	-0.045	-0.087	-0.086	-0.044	-0.024	-0.03
Oilseeds	-0.444	-0.16	-3.85	-1.24	-0.54	-0.104	-0.012	-0.785	-0.07	-0.047	-0.078	-0.059	-0.038	-0.053	-0.05	-0.044	-0.032	-0.048
Fibre plants	-0.133	0.012	-1.09	-0.79	-0.149	-0.028	-0.145	-0.205	-0.022	-0.109	-0.029	-0.052	-0.017	-0.03	-0.031	-0.03	-0.015	-0.009
Vegetable oil and fats	-1.06	-0.616	-0.546	-1.57	-0.637	-0.256	-0.069	-1.39	-0.04	-0.052	-0.023	-0.093	-0.019	-0.025	-0.033	-0.019	-0.02	-0.012
Other agricultural sectors	-0.013	0.002	0.008	0.028	-0.017	-0.005	0.012	-0.003	-0.007	-0.006	-0.016	-0.018	-0.008	-0.014	-0.013	-0.009	-0.007	-0.008
Food industry	-0.061	-0.041	-0.018	-0.026	-0.04	-0.025	-0.137	-0.019	-0.016	-0.019	-0.015	-0.017	-0.005	-0.006	-0.012	-0.013	-0.005	-0.006
Textile industry	0.003	0.011	0.008	0.009	0.003	0.003	0.022	0.005	0.001	0.001	-0.002	0.003	-0.001	-0.003	-0.009	-0.007	-0.002	-0.004
Wearing industry	0.003	0.01	0.009	0.009	0.003	0.003	0.026	0.005	0.001	0	-0.002	0.003	-0.001	-0.002	-0.009	-0.006	-0.001	-0.004

S1.3. Change (%) in quantity of exports (qxs)

	BE	ES	NL	FR	IT	DE	PT	UK	EE	NE	SE	WE	NA	CA	SA	Africa	Asia	ROW
Vegetables, fruits and pulses	-1.95	1.87	4.6	7.19	-1.32	-0.352	11.6	0.544	-3.02	-2.75	-2.96	-2.68	-3.19	-3.03	-3.03	-3.19	-3.26	-3.24
Oilseeds	1.88	0.492	18.6	5.79	2.36	0.217	-0.233	3.55	0.053	-0.062	0.09	-0.002	-0.105	-0.033	-0.048	-0.076	-0.135	-0.055
Fibre plants	0.09	-0.635	4.89	3.38	0.174	-0.435	0.153	0.454	-0.465	-0.03	-0.429	-0.313	-0.49	-0.422	-0.417	-0.424	-0.5	-0.528
Vegetable oil and fats	1.9	-1.01	-1.46	5.32	-0.865	-3.38	-4.62	4.1	-4.8	-4.72	-4.92	-4.45	-4.94	-4.9	-4.85	-4.94	-4.94	-4.99
Other agricultural sectors	0.098	-0.061	-0.121	-0.332	0.14	0.018	-0.166	-0.003	0.035	0.024	0.138	0.154	0.049	0.11	0.098	0.055	0.034	0.045
Food industry	0.174	0.095	-0.001	0.034	0.09	0.028	0.483	0.005	-0.006	0.006	-0.011	-0.004	-0.052	-0.049	-0.023	-0.019	-0.053	-0.048
Textile industry	-0.013	-0.073	-0.048	-0.058	-0.013	-0.011	-0.15	-0.024	0.007	0.004	0.025	-0.008	0.016	0.037	0.081	0.066	0.028	0.041
Wearing industry	-0.003	-0.051	-0.042	-0.043	-0.004	0.001	-0.173	-0.013	0.014	0.023	0.035	0.001	0.026	0.036	0.085	0.065	0.026	0.047

S1.4. Change (million USD) in the balance of payments ($DTBAL_i$)

	BE	ES	NL	FR	IT	DE	PT	UK	EE	NE	SE	WE	NA	CA	SA	Africa	Asia	ROW
Vegetables, fruits and pulses	-19.7	117	157	358	-37.4	104	80.4	74.3	-36.5	7.4	-19.8	12.5	-93.2	-78.9	-149	-171	-220	-17.5
Oilseeds	-24.4	-3.95	3.97	70.9	-2.23	9.24	2.73	5.51	-10.5	0.437	1.62	-0.481	-39	3.38	-33.4	0.048	27.2	-4.58
Fibre plants	0.036	-0.218	0.033	1.56	0.08	-0.037	0.005	0.233	0.078	0.042	0.097	0.076	-1.19	0.302	0.801	0.112	-0.769	-1.49
Vegetable oil and fats	75.4	88.5	5.31	180	75.9	-0.879	-6.01	55.8	-50.6	-13.7	-13.1	-0.923	-42.4	-3.33	-158	-14.1	-141	-13.5
Other agricultural sectors	7.04	-12.5	-42.8	-119	18.8	1.14	-8.4	-8.91	1.01	0.652	9.39	12.7	3.39	32	93.6	39.3	-34.7	-11.1
Food industry	23.5	10.3	-4.02	6.03	16.5	2.02	20.3	-0.655	-1.18	-1.43	-1.26	-3.76	-18	-3.82	-5.86	0.735	-38.2	-4.43
Textile industry	-1.38	-4.95	-1.49	-4.4	-4.15	-3.77	-4.73	-2.81	-0.314	-0.521	0.247	-0.902	-1.49	0.895	5.06	5.51	17.5	0.587
Wearing industry	-0.968	-4.4	-0.761	-5.16	-2.93	-2.75	-4.51	-2.89	0.133	0.088	0.648	-0.67	0.36	0.665	2.95	6.1	12.6	0.426

S2

S2.1. Change (%) in quantity of production (q_0)

	BE	ES	NL	FR	IT	DE	PT	UK	EE	NE	SE	WE	NA	CA	SA	Africa	Asia	ROW
Vegetables, fruits and pulses	-20.5	-0.214	-13.6	2.36	0.179	-14.3	0.104	-9.79	0.487	3.19	0.837	2.31	0.299	0.471	0.678	0.224	0.093	0.314
Oilseeds	-10.7	-0.324	-7.21	-0.694	-1.8	-6.24	-2.3	-6.27	0.279	0.741	0.637	-0.265	0.121	0.006	0.323	0.074	0.173	-1.46
Fibre plants	-19.5	-0.339	0.21	0.302	-1.68	-24.4	0.098	-2.44	0.144	-0.098	0.023	0.165	0.014	-0.049	-0.043	0.018	0.008	0.115
Vegetable oil and fats	-21.5	-0.595	-23.8	6.07	-0.667	-16.6	-3.11	-17.6	2.43	5.95	1.95	2.57	0.491	0.245	1.06	0.856	0.3	2.37
Other agricultural sectors	0.709	-0.16	0.23	-0.09	-0.095	0.212	-0.06	0.062	-0.018	-0.064	-0.002	-0.02	0.006	0.005	0.001	-0.021	0	0.011
Food industry	-0.153	-0.078	-0.135	0.005	-0.071	-0.175	-0.1	-0.029	-0.011	-0.007	-0.048	0.033	0.007	-0.018	-0.029	0.002	0.004	0.034
Textile industry	0.177	0.008	0.147	0.001	0.014	0.058	0.064	0.046	-0.012	-0.036	-0.049	0.015	0.001	-0.005	-0.009	-0.046	-0.01	-0.016
Wearing industry	0.169	-0.008	0.156	-0.013	0.006	0.046	0.051	0.06	-0.009	-0.006	-0.015	-0.001	-0.001	-0.005	-0.007	-0.029	-0.007	-0.013

S2.2. Change (%) in price of import (pms)

	BE	ES	NL	FR	IT	DE	PT	UK	EE	NE	SE	WE	NA	CA	SA	Africa	Asia	ROW
Vegetables, fruits and pulses	8.1	1.66	5.62	0.344	1.41	6.94	1.11	6.72	0.238	0.444	0.267	0.448	0.083	0.176	0.171	0.084	0.055	33.9
Oilseeds	1.45	0.339	0.716	0.034	0.927	0.891	0.765	3.09	0.133	0.087	0.242	0.047	0.058	0.103	0.102	0.089	0.082	9.01
Fibre plants	5.39	0.124	-0.14	0.085	0.515	5.41	0.117	0.519	0.084	0.299	0.078	0.16	0.031	0.061	0.066	0.061	0.034	12.9
Vegetable oil and fats	5.5	0.912	8.24	0.104	0.95	5.32	1.31	5.39	0.118	0.198	0.059	0.472	0.03	0.043	0.068	0.042	0.047	28.8
Other agricultural sectors	-0.074	0.054	-0.026	0.035	0.036	-0.049	0.025	-0.007	0.015	0.01	0.043	0.04	0.016	0.028	0.027	0.019	0.014	0.221
Food industry	0.113	0.083	0.104	0.035	0.078	0.124	0.091	0.051	0.056	0.075	0.04	0.055	0.008	0.011	0.028	0.028	0.01	1
Textile industry	-0.029	-0.003	-0.032	-0.001	-0.005	-0.015	-0.013	-0.017	-0.001	-0.002	0.006	-0.007	0	0.006	0.023	0.015	0.004	-0.062
Wearing industry	-0.029	-0.002	-0.032	-0.001	-0.005	-0.015	-0.013	-0.017	-0.002	0.001	0.006	-0.008	0.001	0.004	0.022	0.012	0.001	-0.069

S2.3. Change (%) in quantity of exports (qxs)

	BE	ES	NL	FR	IT	DE	PT	UK	EE	NE	SE	WE	NA	CA	SA	Africa	Asia	ROW
Vegetables, fruits and pulses	-24.7	-0.888	-15.6	3.97	0.032	-20.4	1.14	-19.6	4.37	3.6	4.26	3.59	4.94	4.6	4.62	4.94	5.05	5.1
Oilseeds	-18.3	-12.8	-14.7	-11.3	-15.7	-15.5	-14.9	-26.3	-11.8	-11.6	-12.3	-11.4	-11.4	-11.7	-11.7	-11.6	-11.6	-10.4
Fibre plants	-26.2	0.198	1.52	0.393	-1.76	-26.3	0.233	-1.78	0.395	-0.676	0.425	0.014	0.661	0.511	0.487	0.51	0.645	0.752
Vegetable oil and fats	-19.1	11.2	-37.1	16.5	11	-17.9	8.58	-18.3	16.4	15.9	16.8	14.1	17	16.9	16.8	16.9	16.9	17.1
Other agricultural sectors	0.895	-0.456	0.393	-0.258	-0.27	0.631	-0.146	0.184	-0.04	0.003	-0.339	-0.314	-0.055	-0.186	-0.177	-0.083	-0.036	-0.04
Food industry	-0.221	-0.101	-0.185	0.091	-0.081	-0.266	-0.135	0.028	0.008	-0.068	0.073	0.011	0.2	0.189	0.121	0.12	0.192	0.19
Textile industry	0.245	0.051	0.268	0.036	0.063	0.137	0.122	0.152	0.034	0.043	-0.018	0.078	0.025	-0.018	-0.142	-0.085	-0.005	-0.033
Wearing industry	0.143	-0.057	0.17	-0.062	-0.031	0.044	0.031	0.059	-0.056	-0.078	-0.115	-0.012	-0.072	-0.094	-0.229	-0.159	-0.077	-0.123

S2.4. Change (million USD) in the balance of payments ($DTBAL_i$)

	BE	ES	NL	FR	IT	DE	PT	UK	EE	NE	SE	WE	NA	CA	SA	Africa	Asia	ROW
Vegetables, fruits and pulses	-442	152	-442	129	56.7	-743	-2.81	-413	90.2	-15.7	49.5	-23.1	188	159	293	321	476	-132
Oilseeds	189	-12.8	200	-151	-12.3	200	5.2	-51.2	-79.7	-33.6	-4.04	-9.75	6.75	-10.5	-64.1	-3.33	-114	24.8
Fibre plants	-1.39	-0.285	0.012	0.303	-0.409	-7.5	-0.036	-0.593	-0.368	-0.093	-0.252	-0.505	5.17	-0.562	-1.45	3.39	3.09	2.53
Vegetable oil and fats	-477	-44	-422	214	-25.8	-965	-34.7	-205	319	101	48.1	7.16	132	13.1	616	58.8	539	-77.6
Other agricultural sectors	162	-72.6	128	-82	-44.1	249	-2.67	68.3	-42.6	-10.1	-26	-31.3	17.8	-61.9	-215	-65.3	43.3	54.9
Food industry	-33.7	-16.5	-44.3	48	-15.3	-110	-5.79	3.32	-7.82	-24.3	4.6	4.88	54.4	10.8	16.9	1.31	108	7.84
Textile industry	9.04	2.39	6.56	1.48	5.78	18.8	2.71	9.64	0.207	1.21	-0.877	2.25	5.3	-1.57	-12.6	-11.2	-35.1	2.73
Wearing industry	8.74	1.36	3.23	0.277	4.16	18.1	2.19	11.1	-0.936	-0.393	-2.01	1.71	1.02	-1.04	-7.41	-11.7	-24.9	2.63

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