National hotspots analysis to support science-based national policy frameworks for sustainable consumption and production

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Technical documentation of the Sustainable Consumption and Production Hotspots Analysis Tool (SCP-HAT) Version 3.0

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Disclaimer:

Version 3.0 is an interim version of the SCP-HAT with increased coverage regarding sectors (97 → 120) and time (2018 → 2024). For the sake of updating the tool in time for the sixth session of the United Nations Environment Assembly (UNEA-6), some simplifications regarding the compilation of environmental satellites and their allocation to economic sectors were necessary. This document elaborates on the approaches taken for version 3.0 and specifies the changes made in comparison to version 2.0.

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Abbreviations

10YFP	10-year framework of programmes on sustainable consumption and production patterns
DALY	Disability-Adjusted Life Years
EDGAR	Emission Database for Global Atmospheric Research
EE-MRIO	Environmentally-Extended Multi-Regional Input-Output
FAO	UN Food and Agriculture Organisation
GDP	Gross Domestic Product
GHG	Greenhouse gas
GTP	Global Temperature change Potential
GWP	Global Warming Potential
HDI	Human Development Index
IPCC	Intergovernmental Panel on Climate Change
LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
MRIO	Multi-Regional Input-Output
OECD	Organisation of Economic Co-operation Development
RIVM	Dutch National Institute for Public Health and the Environment
SCP	Sustainable Consumption and Production
SCP-HAT	Sustainable Consumption and Production Hotspots Analysis Tool
SDG	Sustainable Development goals
UN	United Nations
UN IRP	UN International Resource Panel
UN LCI	UN Life Cycle Initiative
UNEP	UN Environmental Programme
UN-SEEA	UN System of Environmental-Economic Accounting

1. Introduction

This document provides the technical documentation for the Sustainable Consumption and Production Hotspots Analysis Tool (SCP-HAT), version 3.0. The SCP-HAT allows for analysing direct as well as indirect, i.e. trade-related impacts, brought about by production and consumption activities of national economies. It is therefore able to identify hotspots related to domestic pressures and impacts (production or territorial perspective), but also pressures and impacts occurring along the supply chains of goods and services for final consumption in a given country. The SCP-HAT provides the possibility of analysing the performance of a large number of countries. These analyses can be conducted at national as well as sectoral level. Thereby, the tool allows identifying the hotspot areas of unsustainable production and consumption and, based on this analysis, supports the setting of priorities in national SCP and climate policies for investment, regulation and planning.

The SCP-HAT is a web-based tool at the state of the art of web design. It consists of two main modules: Module 1, "Country Profile", provides the key information regarding the country's environmental performance, in the context of the most relevant SCP-related policy questions. The target users are policy makers, NGOs and the general public. Module 2, "Hotspots Identification", contains a wide range of SCP indicators to analyse hotspots of unsustainable consumption and production at country and sector levels. In addition, SCP-HAT provides the so-called "standard reports", which provide pre-compiled information and first analyses regarding three topics – "Countries at a glance", "Sector profiles", and "Climate change impact hotspots". Finally, in the section "Data download" all data used in the SCP-HAT can be accessed.

2. Method description

Technical foundations

In its basic conception, SCP-HAT is based upon an Environmentally-Extended Multi-Regional Input-Output (EE-MRIO) model coupled with Life Cycle Assessment (LCA) for environmental impact assessment. An EE-MRIO model is an analytical tool supported by the UN System of Environmental-Economic Accounting (UN-SEEA; United Nations, 2014), to attribute environmental pressures and impacts to final demand categories (European Commission et al., 2017). EE-MRIO analysis adopts a top-down approach, where supply chain-wide (so-called "indirect") environmental pressures and impacts are accounted for at the macro level for broad product groups or industries. This is done by allocating domestic data on pressures (e.g. material extraction) and impacts (e.g. material depletion) expressed in physical units (e.g. kg;

also called 'satellite accounts') to monetary data on transactions among economic sectors and final consumers of different countries. Hence, each monetary flow is associated with a physical equivalent (mathematical details in Annex I: Mathematical description MRIO methodology). By that means, double counting is avoided, as the specific supply chains, be they national or international, can be clearly identified form their start at resource extraction until the point of final demand. This approach allows tracing all the pressures and impacts occurring at the different stages of even very complex supply chains and allocating them to the country of final consumption, or sectoral production. Hence, domestic pressures (national environment) are linked to foreign consumption (countries A to F in Figure 1), and foreign pressures to domestic consumption. This allows to analyse both the domestic situation ("domestic production") with regard to prevailing pressures and impacts and the role a country plays as global consumer ("consumption footprint"), where the focus is set on pressures and impacts occurring along the supply chains of consumed products.

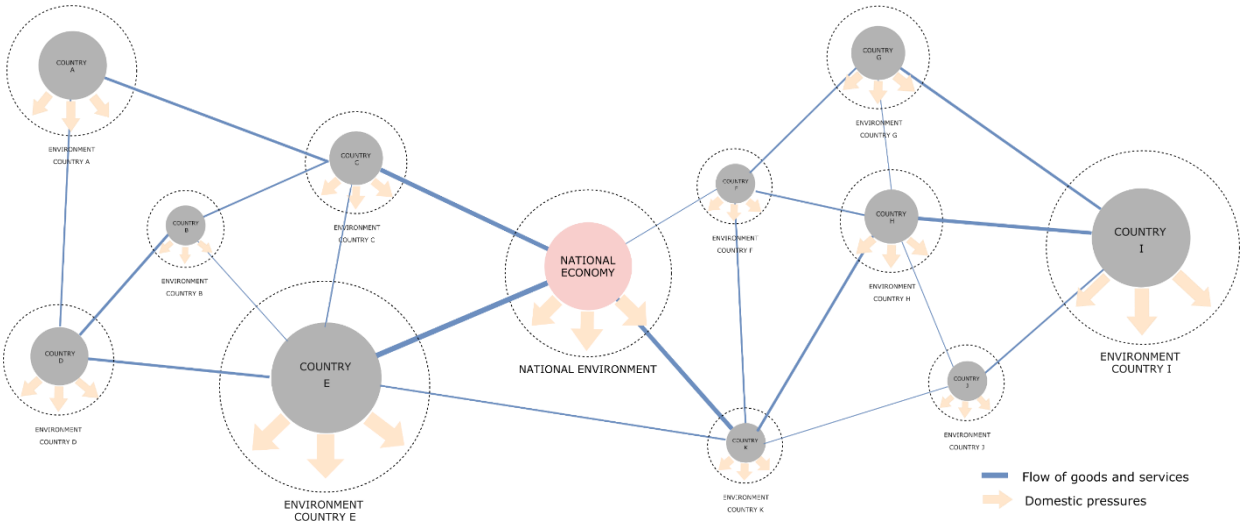

Figure 1: The basic concept of SCP-HAT

This type of analysis is used to identify hotspots of unsustainable consumption and production and opportunities for action: (1) pressure or impact categories where immediate action is needed on the national level; and (2) sectors or consumption areas where the pressures or impacts caused directly or indirectly are specifically high and action is required.

In general, the consumption footprint of a country is calculated by adding the pressures and impacts related to imports to those occurring domestically, and subtracting those related to the exports. It is important to note the differences between approaches based upon EE-MRIO and those using coefficients to estimate the indirect trade flows of pressures and impacts and the consumption footprint of a country:

- Coefficient approaches calculate the total environmental pressures or impacts associated with final consumption by accounting for physical in- and out-flows of a country and considering the environmental intensity of the traded commodities along the whole production chain. They apply intensity coefficients – or "cradle-to-product" coefficients – to the specific traded products and activities. Here, the consumption footprint of a country is calculated by adding the pressures and impacts related to all imports to those occurring domestically, and subtracting those related to all the exports.

  Coefficient approaches apply the concept of "apparent consumption", i.e. they cannot specify, whether a certain environmental pressure or impact is associated with intermediate production or consumed by the final consumer. Accordingly, trade balances are calculated in gross terms, i.e. considering both intermediate and final trade products (see above). Though conceptually feasible, in practice it is not possible to separate e.g. private consumption from government consumption. Finally, often so-called "truncation errors" are produced, as the indirect flows are not traced along the entire industrial supply chains. The most important advantage of coefficient-based approaches is the high level of detail and transparency, which can be applied in footprint-oriented indicator calculations.

- As explained above, input-output analysis allows tracing monetary flows and embodied environmental factors from its origin (e.g. raw material extraction) to the final consumption of the respective products. The so-called "Leontief inverse", a matrix generated from an input-output table (see Annex I), shows, for each commodity or industry represented in the model, all direct and indirect inputs and related environmental pressures and impacts required along the complete supply chain. Doing the calculation for all product groups, all environmental pressures and impacts needed to satisfy final demand of a country can be quantified.

  A major advantage of input-output based approaches is that input-output tables disaggregate a large number of different product groups and industries as well as final demand categories (e.g. private consumption, government consumption, investments, etc.). They allow calculating the footprints for all products and all sectors, also those with very complex supply chains and thus avoid truncation errors (see above). Finally, the countries of origin of a country's consumption footprint can be identified, as well as the countries of destination of the domestic environmental pressures and impacts.

  Consequently, in contrast to coefficient-based approaches, analyses of indirect trade flows are done from the perspective of linking source countries with final demand in the destination countries. Hence, trade analyses in Module 1 and 2 of SCP-HAT have to be

understood before this background: import flows into a country of interest will only include those pressures and impacts occurring abroad, which contribute to the country's final demand. Export flows incorporate only the pressures and impacts, which occur domestically and contribute to final demand abroad. Consequently, flows, which "pass through" the country via imports and re-exports, are not accounted for.

When comparing results for a country of interest, which stem from MRIO-based and coefficient-based approaches, conceptually the numbers for the consumption footprint can be directly compared, while those for trade flows cannot.

The EE-MRIO model is complemented by data stemming from impact assessment for the calculation of certain environmental impact variables (using Life Cycle Impact Assessment (LCIA) characterization factors). While environmental accounts used in EE-MRIO provide data on domestic resource use in the countries around the world, LCIA "translates" these amounts into environmental impacts, such as biodiversity loss from land use or resource depletion related to raw material use. This methodological step is realised in accordance with the LCIA guidelines set by the United Nations Environment Programme (UNEP, 2016).

Supply chain analysis

The module "Hotpots Identification" contains a tab "Supply Chains", where additional analytical detail on supply chain structures is provided. To do so, a methodology called "Structural Path Analysis" (SPA) is applied. This method allows analysing footprint calculations carried out with a multi-regional input-output (MRIO) database and identifying all the sectors and their related environmental pressures (or impacts) involved in a global supply chain that serve final consumption in the country of interest.

An environmental footprint of a country is usually composed of the environmental pressures (or impacts) happening at different stages (or "tiers") of all the supply chains contributing to final demand in the country. Quite often, the largest contribution to the overall environmental pressure embodied in a specific supply chain does not occur in tier zero, that is, the pressure caused by the sector that delivers a good to final demand. Instead, large parts of the pressures occur further upstream the supply chain. In addition, in a given tier, only a small number of sectors may contribute to the environmental pressure. For instance, in the case of the production of aluminium, the first tier input of electricity produced by coal might give the largest contribution to the overall environmental pressure. In contrast, the first tier input of insurance services may have a negligible impact.

An SPA identifies the linkages in the production chain that lead to the largest environmental pressures and consequently the areas for political intervention. It allows assessing (1) the

number of supply chains contributing to the footprint of a country as well as the size of their contributions; (2) the complexity of the supply chains (i.e. the number of tiers or layers); and (3) those areas where the largest contributions within a specific supply chain are located.

However, the higher the level of sector and country detail covered by an MRIO system, the larger the computational requirements for an SPA. With increasing number of sectors, also the supply chains between them become more complex, as trade between sectors, which in a system of lower level of disaggregation are aggregated in a sector group, become apparent. Hence, to ensure technical feasibility, it has to be considered if and how the number of analysed supply chains can be reduced.

For the application in SCP-HAT. The following approach was used:

- *Use of an aggregated version (20/35 sectors, see* Annex Ia: Mathematical description SPA methodology*) of the MRIO database GLORIA (see below) for the supply chain assessments.* This has positive effects for both the complexity of the computational analysis as well as the interpretability of the results. Especially regarding the latter, using the aggregated sector detail avoids that the displayed contributions of single supply chains become too small to convey a meaningful message to users, i.e. the identification of hotspot supply chains. For SCP-HAT, a GLORIA sector aggregation of 20 sectors is used. For the detailed analysis of mining supply chains (tick box "mining detail"), the sectors relevant to the mining sector are further disaggregated, resulting in an overall 35 sector aggregation (Annex IIIa: GLORIA 20/35-sector aggregation for SPA).
- *Focus on a limited number supply chains***.** Only the largest flows between domestic production and final demand are analysed and displayed.
- *Coverage of three environmental categories.* In the first version, the categories raw materials, GHG emissions, and water consumption are covered. The coverage of more environmental categories will depend on the experiences made with the first three.
- *Visualisation via Sankey Diagramme.* The advantage is that both types of flows, from one origin to different destinations and from various sources to one destination, can be illustrated.

Two perspectives are applied to support policymaking:

- (1) Production perspective as the starting point: Looking at a specific domestic environmental pressure (or impact) caused in a specific country, what are the supply chains transmitting the largest shares of domestic pressure to domestic or foreign final demand. In which other country's footprint do large shares of the domestic pressure related to exports end up?

- (2) Consumption perspective as the starting point: Looking at a country's specific environmental footprint, what are the supply chains that contribute most to this footprint? In other words, where is the largest source of the footprint geographically located and which supply chains were involved?

Pressure and impact categories

Ideally, the SCP-HAT would cover all indicators included in the 10-year framework of programmes on sustainable consumption and production patterns (10YFP) Evaluation and Monitoring Framework[1], i.e. material use, waste, water use, energy use, GHG emissions, air, soil and water pollutants, biodiversity conservation and land use and human well-being indicators related to gender, decent work and health. However, already for the development of the SCP-HAT v2.0, the following pressure and impact categories were implemented:

- Environmental pressures:
    - Raw material use
    - Land use (occupation only)
    - Emissions of greenhouse gases
    - Emissions of particulate matter and precursors
    - Blue water consumption
    - Primary energy supply
- Environmental impacts:
    - Mineral resource scarcity
    - Fossil resource scarcity
    - Short-term climate change
    - Long-term climate change
    - Potential species loss from land use
    - Damage to human health from particulate matter
    - Water stress
    - Marine eutrophication from nitrogen emissions

The selection of pressures and impacts was guided by a set of criteria:

- Relevance for SCP policy questions
- Data availability
- Interrelatedness of pressures and impacts

[1] http://www.oneplanetnetwork.org/resource/10yfp-indicators-success

- Widely accepted impact characterization factors

Moreover, the focus was set on an extensive coverage of related issues to be covered indirectly with the selected domains. For instance, material flows allow for proxies for waste, and GHG emissions also have a large overlap with energy use (more comprehensively when compared to material flows). They relate to two important policy areas of resource efficiency and climate mitigation identified as priorities by many governments, including the G7 and G20.

Geographical, Industry/Product and time coverage

The aim of SCP-HAT is to cover all countries in the world, including those with relatively short history of engaging more actively in policy making around policy areas such as SCP, the SDGs, green economy, etc. The geographical, sector and time coverage of SCP-HAT is based on the EE-MRIO database employed (see below) and includes currently 160 countries and 4 "rest of the world" regions (full classification in Annex II: Geographical coverage of the SCP-HAT). It covers 120 different sectors for a large number of countries, and 28 sectors for those countries with less favourable data coverage (v059; Annex III: Sector classification of the SCP-HAT) and encompasses the time period 1990-2024.

3. Data sources

Multi-Regional Input-Output

There are a number of global input-output models available, which allow for comprehensive (i.e. global) EE-MRIO modelling. Depending on the political or scientific question to be answered, they have their strengths and weaknesses. The input-output core applied in the SCP-HAT is the GLORIA (Global Ressource Input-Output Assessment[2]) database (Lenzen et al., 2022). The GLORIA database is a multi-regional input-output database covering 164 countries (Annex II: Geographical coverage of the SCP-HAT) and 120 sectors (v059; Annex III: Sector classification of the SCP-HAT), which was built by the University of Sydney for the UN International Resource Panel (UN IRP) in the context of the update of the material footprint accounts forming part of the UN IRP Global Material Flows Database (UN IRP, 2023). To use synergies between different UNEP initiatives, it was decided to use the GLORIA database also as underlying MRIO database for the SCP-HAT. As a consequence, additional modifications and quality assurance was needed to allow to apply the GLORIA database also to other

[2] https://ielab.info/analyse/GLORIA

environmental categories than raw materials, to ensure environmental flows through the economy are reflected adequately.

Data update to 2021, and forecast of all tables starting 2022 until 2024, are based on GDP projections by the International Monetary Fund (IMF 2023) and the World Bank (World Bank 2023a), capturing developments caused by the Ukraine war.

For further detail on the setup of the model please refer to the technical documentation[3].

Changes from v2.0 to v3.0

SCP-HAT 3.0 uses a new version of the GLORIA database (v059) with a larger sector and time coverage). Environmental data was updated from 2018 to 2024 using economic proxy data.

GHG emissions and Climate Change (Short-Term and Long-Term)

The UNEP LCI guidance for LCIA indicators makes an interim recommendation for considering two impact categories for climate change, short-term related to the rate of temperature change, and long-term related to the long-term temperature rise (UNEP, 2016). The indicators recommended for short-term and long-term respectively are Global Warming Potential 100 (GWP100) and Global Temperature change Potential (GTP100) at 100 years horizon. The corresponding characterization factors provided by IPCC are applied to GHG emissions data, including differentiation of fossil- and biogenic methane (IPCC 2021; Full list of GWP and GTP factors in Annex IV: Characterisation factors for GHG emissions). Near-term climate forcing gases are excluded, as the UNEP LCI guidance recommends those for sensitivity analysis only.

The main dataset employed for compiling the SCP-HAT's GHG emissions input data is the emission extension provided together with the GLORIA database (v059), which is based upon the EDGAR v7.0 database[4] (Crippa et al., 2021; Crippa et al., 2022) maintained by the European Commission Joint Research Centre (JRC) and the Netherlands Environmental Assessment Agency (PBL). Emissions data in Edgar follow the IPCC 1996, 2006 and 2021 categories, and the GHG gases included are CO_2, CH_4, N_2O, and other. Version 2021 of IPCC's emission intensities was used for developing the GHG emissions extension in the SCP-HAT (full classification is provided in Annex V: IPCC categories). GHG emissions were allocated to one or more sectors of the SCP-HAT. For those categories allocated to more than one sector, the emissions were disaggregated according to the relationship of the total output of the sectors.

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[3] https://ielab.info/analyse/GLORIA
[4] https://edgar.jrc.ec.europa.eu/index.php/dataset_ghg70

Emissions from road transportation from industries and households are recorded together in EDGAR v7.0, which need to be disaggregated for a finer analysis in the SCP-HAT. For the GLORIA emission extension, this was done consulting additional data sources (Pomponi et al. 2021) to split road transport emissions into private vehicles (allocated to households), and allocated the remainder to the road transport, and postal and courier services, as provided in (Annex Va: Correspondence between GLORIA sectors and IPCC categories).

Changes from v2.0 to v3.0

Within IPCC category 3 Agriculture, emissions are now allocated to the relevant subsectors by total output. In SCP-HAT 2.0, this allocation was based on physical rather than economic data, using FAO (relative) emission values to disaggregate the emissions reported in Edgar. See Annex X for details.

Raw material use and mineral and fossil resource scarcity

For physical data for raw material extraction data from UN IRP Global Material Flows Database (UN IRP, 2023) are used as extension for the GLORIA database. The publicly available online database presents direct material flows data for four main material categories and provides further disaggregation of these four main categories into 13 sub-categories. The process of collating and/or modelling of data was actually performed at a much higher level of disaggregation, using a classification system with 62 different categories, broken down into 367 individual materials. This system was designed to conform as well as be practicable with the system of categories used in (Eurostat 2013) and was used to compile the extension used for GLORIA and applied to SCP-HAT. Annex VI: Raw materials, TCCC categories and material groups of the SCP-HAT provides an overview of how induvial materials relate to the material categories and the material groups used in SCP-HAT. More details on the UN IRP Global Material Flows Database and access to the data are available at https://www.resourcepanel.org/global-material-flows-database.

Raw material extraction for abiotic materials is translated into impacts by using the mineral and fossil resource scarcity characterization factors from the Dutch National Institute for Public Health and the Environment (RIVM) (Huijbregts et al., 2016). The midpoint indicator (i.e. focussing on intermediate stage along the impact pathway) for fossil resource scarcity is defined as the ratio between the energy content of fossil resource x and the energy content of crude oil. The unit of this indicator is kg oil-equivalent and it simply reflects the energy content compared to a kilogram of oil. The characterization method for mineral resource scarcity is Surplus Ore Potential which expresses the average extra amount of ore to be produced in the future due to the extraction of 1 kg of a mineral resource x. In other words, this reflects the decrease in ore grade of remaining reserves. The indicator is expressed relative to copper in

units of kg Cu-equivalent. The "hierarchist" version of this indicator is applied, which means that future production is chosen to be the ultimate recoverable resource. For more details, see RIVM (Huijbregts et al., 2016).

Changes from v2.0 to v3.0

For SCP-HAT v2.0 materials were allocated directly to one of the 97 sectors, with allocation to more than one sector being performed using total sectoral output as proxy. The data used for SCP-HAT v3.0 stem from a new approach used for GLORIA, where sectoral output is used as proxy for allocating the 367 individual materials to one or more sectors out of 6357 sectors aligned with the HSCPC classification system. The results are then aggregated back to the 120 sectors used by the current version of GLORIA (v59).

Land use and potential species loss from land use

The UNEP LCI guidance for LCIA indicators makes an interim recommendation (see UNEP, 2016) for characterization of biodiversity impacts of land use, discerning occupation and transformation, based on the method developed by Chaudhary et al. (2015). SCP-HAT only includes land occupation, and modelling of land transformation is left for future tool developments. To allow for the application of the recommended characterization factors, inventory data is required for land occupation (m^2*a) for six land use classes - Annual crops, Permanent crops, Pasture, Extensive forestry, Intensive forestry, and Urban.

The definition of the two forestry land use classes used for the impact characterization is:

- **Intensive Forest**: forests with extractive use, with either even-aged stands and clear-cut patches or less than three naturally occurring species at planting/seeding; and
- **Extensive Forests**: forests with extractive use and associated disturbance like hunting, and selective logging, where timber extraction is followed by re-growth including at least three naturally occurring tree species.

For the latter, alternative uses to wood and paper, e.g. recreation, hunting, etc., are not considered.

Land use for other industrial activities than agriculture or forestry (e.g. mining) is not covered. Built-up land is estimated using OECD land use statistics (OECD, 2018) and allocated directly to final demand.

For SCP-HAT v3.0, the land use extension applied in SCP-HAT v2.0 was disaggregated from 97 to 120 sectors using sectoral output as proxy. Land use for extensive forestry is allocated entirely to wood production.

Following UNEP's recommendations, country-level average characterization factors for global species loss from Chaudhary et al. (2015) are used in the SCP-HAT, aggregated over five taxa (mammals, reptiles, birds, amphibians and vascular plants) for each of the six land use categories. The unit of this indicator is PDF*year which stands for the Potentially Disappeared Fraction of species for the duration of a year. Land use impact modelling assumes that once an activity (land use) stops, the system will slowly return to the natural state. The indicator therefore does not reflect full extinction of species but a temporary decline in biodiversity.

Changes from v2.0 to v3.0

The approach applied for v2.0 was more detailed than in v3.0, as it considered subsistence farming and domestic wood fuel production.

Annex VIII: Calculation of land use and allocation to sectors – SCP-HAT 2.0 gives the details on the derivation of land use for those land use classes and allocation to economic sectors. Land use for crops and pasture is also allocated partly to final demand. The allocation to final demand is made based on data on subsistence and low-input crop farming derived from the Spatial Production Allocation Model version 2010 (SPAM; You et al. 2014). For details on this allocation methodology, see Annex IX: Allocation of agricultural activities to households (SCP-HAT 2.0) as well as the Technical Documentation for SCPHAT 1.0 (Piñero et al., 2019). Annex VII: Land use and biodiversity loss categories and sector correspondence in SCP-HAT v2.0 shows sector correspondences for the land use categories formerly used, as well as detailed correspondence between FAO crop categories, SPAM crop categories and MRIO sectors for the allocation of land use for Annual crops and Permanent crops.

Land use for intensive forestry is allocated to wood production, while land use for extensive forestry is allocated partly to wood production and partly to final demand, based on domestic wood fuel production and consumption statistics. For details on calculation and allocation methodologies, see Annex VIII: Calculation of land use and allocation to sectors – SCP-HAT 2.0 and Annex IX: Allocation of agricultural activities to households (SCP-HAT 2.0).

Air pollution and health impacts

Many emissions contribute to air pollution via a variety of mechanisms. SCP-HAT focuses on air pollution via particulate matter (PM) which is caused by emissions of PM itself as well as by emissions of NH_3, NOx and SO_2, which form so-called secondary PM via chemical reactions. The UNEP LCI guidance for LCIA indicators (UNEP, 2016) recommends the use of characterization factors at end-point, reflecting damages to human health expressed in Disability-Adjusted Life Years (DALY). The recommended approach for calculating DALY impact factors is via emission source archetypes but this could not be implemented at the global,

highly aggregated scale of emissions data used in SCP-HAT. The tool therefore uses DALY impact factors from RIVM (Huijbregts et al., 2016), which reflect country-averaged DALY impacts per unit of emission for each of the four substances (PM2.5, NH_3, SO_2, NOx). No differentiation is made by emission source type at this stage. A recent set of new effect factors (Fantke et al., 2019) is still only available at country level, without additional distinction of emission source type.

The emissions data are taken from the EDGAR v6.1 database[5] (Crippa et al., 2021; Crippa et al., 2022). This database covers all countries and years up to and including 2021.

For SCP-HAT v3.0, extension on air pollution and related health impacts applied in SCP-HAT v2.0 was disaggregated from 97 to 120 sectors using sectoral output as proxy.

Changes from v2.0 to v3.0

For SCP-HAT v2.0, air polluting emissions associated with agricultural activities were allocated to the relevant subsectors and partly allocated directly to households using the same approach as applied to land use and other extensions, reflecting (semi-)subsistence farming. Please see Annex IX: Allocation of agricultural activities to households (SCP-HAT 2.0) and Annex X: Allocation of agricultural emissions (SCP-HAT 2.0) for details.

Nitrogen flows and marine eutrophication

Nitrogen (N) and Phosphorus (P) cycles are altered by human activities and can cause non-linear change in ecosystems brought about by eutrophication processes and the reduction of water quality. This oversupply of nutrients occurs mainly due to excessive fertilization in agriculture, and therefore measures for reducing nutrient losses are largely related to food security (e.g. SDG-2 Zero Hunger) and sustainable agriculture (e.g. SDG-12 Responsible Consumption and Production). The need for monitoring reactive N and P losses are also emphasized in the planetary boundaries framework (Rockström et al., 2009; Steffen et al., 2015). Data on P flows are not available in the resolution required for SCP-HAT, but data on N flows are well covered given the relevance of activity data for N use in greenhouse-gas accounts. To cover the impact category of N eutrophication, which is deemed to have effects on marine environment while P eutrophication effects are seen in freshwater environments, the following emissions need to be included: NO_x and NH_3 to air, N and nitrate to water (leaching and run off).

[5] https://edgar.jrc.ec.europa.eu/index.php/dataset_ghg60

The two emissions to air are already available from the human health extension. Lacking comprehensive information on deposition rates of NO_x and NH_3 to soil, freshwater or oceans, it is assumed that all emissions to air are deposited directly to the marine environment. This is estimated to cause a 10% overestimate of the impact of NO_x emission to air (approximately 65% deposited to soil, 12% not deposited; Roy et al. 2012) and a 25% overestimate of the impact of NH_3 emission to air (approximately 80% deposited to soil; Roy et al. 2012). The pathway of deposition to soil and subsequent transport to the marine environment has a higher characterisation factor (UNEP 2019, see also below) but those specific impact pathways have not been implemented given that the uncertainty due to use of global (non-country-specific) characterisation factors is much higher.

Nitrogen leaching occurs from agricultural use of N as well as wastewater treatment. Data for the latter is not available with sufficient quality to include in SCP-HAT at this point. However, the agriculture sector is the main anthropogenic source of these emissions (Beusen et al. 2016) although there is some variation by country depending on effectiveness of sewage treatment. Activity data are sourced from FAOSTAT for all countries. This aligns with the assumptions about nitrogen leached with those underlying the greenhouse-gas emissions from the agricultural sectors (IPCC categories 3.A.2 and 3.A5, see Annex V: IPCC categories).

Characterisation factors for NO_x, NH_3 and N leached are used as recommended in the UNEP LCIA guidelines (Volume 2, UNEP 2019) but country-level factors are not available yet. Therefore, global factors were applied, noting that this introduces uncertainty in the impact results. There is expected to be about a factor of 10 variation in characterisation factor between the lowest and highest deciles of country-specific factors (UNEP 2019). This is in addition to the uncertainty introduced by the use of a default factor for leaching (0.30) for all countries, which is the case for both FAOSTAT and Edgar emission data. The eutrophication effect is typically overestimated in lower rainfall countries.

The following characterisations were applied:

- 1.6 kg N-eq/kg NOx for agricultural emission sources and 0.8 kg N-eq/kg NOx for other emission sources
- 1.6 kg N-eq/kg NH3 for agricultural emission sources and 1.5 kg N-eq/kg NH3 for other emission sources
- 0.84 kg N-eq/kg N-leached

For SCP-HAT v3.0, the extension on nitrogen flows and marine eutrophication applied in SCP-HAT v2.0 was disaggregated from 97 to 120 sectors using sectoral output as proxy.

Changes from v2.0 to v3.0

The approach to allocate emissions to economic sectors applied for v2.0 was more detailed than in v3.0, as it considered subsistence farming. The details on constructing the extension for N leached are provided in Annex X: Allocation of agricultural emissions (SCP-HAT 2.0).

Blue water consumption and water stress

Protecting water resources and guaranteeing access to clean water is at the core of UN's priorities (e.g. SDG-6 Clean Water and Sanitation), and accordingly, in SCP-HAT 2.0 one environmental pressure (blue water consumption), and one environmental impact (water stress) were incorporated.

SCP-HAT presents data on blue water consumption per country. Blue water is defined as water stemming from surface water sources (e.g. rivers or lakes) or groundwater bodies. Water consumption is defined as the difference between overall water withdrawals and direct return flows. Blue water consumption hence encompasses water withdrawn from surface water sources or groundwater bodies that is either incorporated into products or evaporated during the growth period of a crop or the production process of a good. The data from Pfister and colleagues (2011) representing production patterns in the year 2000 were matched to country and sector resolution in the same way as described in Lutter et al. (2016). Time series are developed based on a regionalized Exiobase 3[6] version (Cabernard et al., 2019)

Water stress was introduced via the AWARE characterisation factor. AWARE is a midpoint indicator representing the relative Available WAter REmaining per area in a watershed, after the demand of humans and aquatic ecosystems has been met Boulay et al. (2018). It builds on the assumption that the less water remaining available per area, the more likely another user will be deprived. The indicator is available on watershed and monthly level, as well as on country level averaged for agricultural water use and non-agricultural water use (reflecting typical consumption patterns and locations of the sectors within a country). For crop production, the watershed indicator was applied on the high spatial resolution water consumption in SCP-HAT, while the other sectors used the country-specific coefficients.

Data available in the regionalized Exiobase 3 version (as used by Cabernard et al., 2019) covers the period 1995-2015, and was extrapolated using land use for crop products and sectoral output for industrial sectors, for 1990 to 1994 and 2016 to 2018. Estimates are offered

[6] For a description of Exiobase, see Stadler et al. 2018

at two levels in the SCP-HAT: agriculture (i.e. crops and farming) and non-agriculture blue water consumption/water stress.

For SCP-HAT v3.0, the extension on nitrogen flows and marine eutrophication applied in SCP-HAT v2.0 was disaggregated from 97 to 120 sectors using sectoral output as proxy.

Changes from v2.0 to v3.0

-

Primary energy production

SCP-HAT 2.0 for the first time includes an environmental extension that covers the production of primary energy from a wide range of energy carriers. Data for the energy extensions was extracted from the 2020 version of International Energy Agency's 'Extended World Energy Balances' (IEA, 2020). All data are represented in Terajoule (TJ). We have selected 21 different energy products that can be allocated to specific sectors in the MRIO table. The allocation table between IEA energy products and the respective sectors in the MRIO table can be found in Annex XI: Allocation table between IEA energy products and MRIO sectors.

The 21 energy products were then grouped into 6 groups, in order to allow easier communication in SCP-HAT:

- Coal and peat: Anthracite, Coking coal, Other bituminous coal, Sub-bituminous coal, Lignite, Peat
- Oil and natural gas: Oil shale and oil sands, Natural gas, Crude oil, Natural gas liquids, Other hydrocarbons
- Nuclear: Nuclear energy
- Solid biofuels: Primary solid biofuels
- Captured energy: Hydro, Geothermal, Solar photovoltaics, Solar thermal, Tide, wave and ocean, Wind, Other sources
- Heat: Heat

For SCP-HAT v3.0, the extension on nitrogen flows and marine eutrophication applied in SCP-HAT v2.0 was disaggregated from 97 to 120 sectors using sectoral output as proxy.

Changes from v2.0 to v3.0

-

Socio-economic data

The SCP-HAT includes a set of basic socioeconomic data, which mainly serves for the estimation of relative performance indicators of economies and industries, e.g. carbon per unit of economic output. In the following, the data sources used are listed:

- Population: The World Bank Group
- GDP: The World Bank Group
- Value added: GLORIA database
- Output: GLORIA database
- Employment per sector by gender and skill: GLORIA database
- Country groups: The World Bank Group
- Government and private final consumption: GLORIA database
- HDI: United Nations Development Programme
- Country groups: The World Bank Group
- Socio-economic vulnerability index: INFORM Global Risk Index

The GLORIA database (v059) is aligning "Compensation of Employees" (wages and salaries) in the value added block with the employment satellite, using data from the International Labour Organisation (ILO 2022) to produce estimates for per-worker wage, female labour participation and percentage of wages in value added over time. Classification of employment by skill is done in the same way as in previous versions of SCP-HAT (see Piñero et al., 2019).

Changes from v2.0 to v3.0

The employment data is now used directly from the GLORIA database (v059).

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Annex I: Mathematical description MRIO methodology

In this description the nomenclature introduced in the System of Environmental-Economic Accounting (SEEA) 2012 (European Commission et al., 2017) is followed, and the reader is referred to that document for further method details. Table 1 shows the main components of a two countries EE-MRIO model. Using matrix notation, Z records intermediate deliveries between industries of each country, y is the final demand of products, and v is value added in production (or payments to suppliers of primary inputs). Sub-indexes A and B denote the country of origin, or the country of origin and destination (i.e. $y_{A,B}$ records final demand of products from country A consume by country B). In the input-output system, total output must be equal to total input per sector. Total output x equals intermediate consumption plus final demand, that is, $x = Zi + y$, whereas total input x' equals all inter-industry purchases plus value added, $x' = i'Z + v$. In the EE-MRIO, the monetary framework is expanded to include exchanges between the natural and socioeconomic systems measured in physical units. This is represented by r, which accounts for physical flows by industry (inputs to the system, such as raw material extracted in tons, or outputs, e.g. CO_2 emissions in kg). Capital and minor letters denote matrix and column-vector, respectively, and i is a vector of ones. The general expression of the EE-MRIO model is presented in equation 1,

$$\Phi = \delta'(I - A)^{-1}y = \delta' Ly = \alpha' y \quad (1)$$

where Φ is the consumption-based or footprint for a given final demand y. The allocation to final demand is calculated using the Multipliers α, obtained multiplying the Leontief inverse $L = (I - A)^{-1}$, whose elements indicates total input requirements per unit of final demand of products, and the environmental pressure intensity δ', which expresses physical flows per unit of industry output and calculated following $\delta' = r'q$. I is the identity matrix and $A = Zx$ is the direct input coefficients matrix.

The equation 1 shows the generic expression for EE-MRIO models, and it corresponds with the 'supply extension', that is, environmental intensities refer to the industry supplying products whose production causes environmental pressure directly (e.g. sand and gravel extraction is allocated to the mining and quarrying sector). However, when the sectoral resolution of the EE-MRIO model is low, allocating the environmental pressures to intermediate consumers (i.e. using a 'use extension') can be an acceptable solution for preventing aggregation errors (Giljum et al., 2017) (e.g. sand and gravel extracted is allocated to the construction sector). This can be performed using a supply-to-use conversion matrix M, whose elements are zeros and ones appropriately placed, so the general expression is slightly modified,

$$\Phi = \delta' MLy \quad (2)$$

In practice, it may be also convenient to combine both logics in a mixed approach. Accordingly, which perspective provides more satisfactory results need to be assessed in a case by case basis.

Further, equation 1 can be further developed for applying LCIA characterization factors β, which convert physical flows (i.e. environmental pressures) to environmental impacts, for example from km^2 land use to number of species loss. This expansion is shown in equation 3,

$$\Phi = \beta' \delta^{Ly} \quad (3)$$

Lastly, in EE-MRIO trade and international dependencies in terms of natural resources and environmental impacts can also be assessed for each country's final demand bundle y. However, since in EE-MRIO trade of intermediates is endogenized, EE-MRIO trade balances refer exclusively to indirect and direct pressures and impacts of final products (Cadarso et al., 2018, Kanemoto et al., 2015). As a consequence, EE-MRIO trade balances aren't directly comparable to conventional bilateral trade balances.

Annex Ia: Mathematical description SPA methodology

A Structural Path Analysis (SPA) identifies the linkages in the production chain that lead to the largest environmental pressures and consequently the areas for political intervention. The main formula behind the analysis is the following:

$$E = e * (I - A)^{-1} * Y = e * (I + A + A^2 + A^3 + \ldots) * Y$$

Where:

E is the environmental variable of interest (e.g., carbon emissions);

e is an environmental coefficient (e.g., the share of a country's or sector's carbon emissions in total carbon emissions).

eIY represents the impact of the 0th tier on environmental variables, that is, the environmental impact of the sector that delivers a good to final demand (see above).

eAY represents the impact of the 1st tier on the environment (e.g., the impact of the steel sector delivering steel to the car assembler that finally sells the car to a consumer).

eA²Y represents the environmental impact of the 2nd tier (e.g., the iron ore mining sector delivering iron ore to the steel sector) (Xie et al., 2020).

Hence, with increasing tier, also the number of sectors contributing to the environmental footprint of a good increases. The number of these transactions reflected in an MRIO system is literally endless, resulting in more or less complex supply chains where economic (and related environmental) flows can be very large but also very small, i.e. insignificant.

In this context, it is worth examining how paths become smaller with increasing rank (i.e. position in a ranked list) and order (i.e. production tier – see Section 2 above). Let $\mathbf{A}$ be an $N \times N$ input coefficients matrix, and $\mathbf{eA}^n$ be the n^{th}-order contribution to total environmental impact (also see Section 2 above). Then, we can define the rate of convergence of these contributions towards infinite order as $\kappa_i(n) = \frac{(\mathbf{eA}^n)_i}{(\mathbf{eA}^{n-1})_i}$ (Lenzen 2001). Let λ_j and $\boldsymbol{v}_j$ be eigenvalues and eigenvectors of $\mathbf{A}$, so that $\boldsymbol{v}_j\mathbf{A} = \lambda_j\mathbf{v}_j \forall j = 1, \ldots, N$. Using induction, we can show that $\mathbf{v}_j\mathbf{A}^n = \lambda_j^n\mathbf{v}_j \forall j = 1, \ldots, N \wedge n \in \mathbb{N}$. Further, we can find scalar coordinates ξ_j to represent $\mathbf{e}$ as a vector in the space defined by the eigenvectors $\mathbf{v}_j$ as a basis, ie a linear combination $\mathbf{e} = \sum_j \xi_j \mathbf{v}_j$. We can then express the rate of convergence as $\kappa_i(n) = \frac{(\sum_j \xi_j \mathbf{v}_j \mathbf{A}^n)_i}{(\sum_j \xi_j \mathbf{v}_j \mathbf{A}^{n-1})_i} = \frac{(\sum_j \xi_j \lambda_j^n \mathbf{v}_j)_i}{(\sum_j \xi_j \lambda_j^{n-1} \mathbf{v}_j)_i} = \frac{\sum_j \xi_j \lambda_j^n \mathbf{v}_{j,i}}{\sum_j \xi_j \lambda_j^{n-1} \mathbf{v}_{j,i}}$. For small systems with a dominant eigenvalue $\lambda_{\text{d}} = \max_j \lambda_j$ this rate converges to $\kappa_\infty = \lim_{n\to\infty} \kappa_i(n) = \frac{\xi_{\text{d}} \lambda_{\text{d}}^n \mathbf{v}_{\text{d},i}}{\xi_{\text{d}} \lambda_{\text{d}}^{n-1} \mathbf{v}_{\text{d},i}} = \lambda_{\text{d}}$. For large systems with closely spaced eigenvalues – as in this work – this rate

converges to $\kappa_\infty = \lim_{n\to\infty} \kappa_i(n) \approx \frac{\sum_j \xi_j \bar{\lambda}^n \mathbf{v}_{j,i}}{\sum_j \xi_j \bar{\lambda}^{n-1} \mathbf{v}_{j,i}} = \bar{\lambda}$, where $\bar{\lambda}$ is the mean of the $\lambda_{j,j=1,\dots,N}$. We can now proceed to establishing a relationship between path value *p* and path rank *r*. Consider the slope $\frac{\Delta \log(p)}{\Delta \log(r)} = \frac{\log(p^{(n)}) - \log(p^{(m)})}{\log(r^{(n)}) - \log(r^{(m)})}$ connecting paths across two orders $m < n$ (Lenzen and Treloar 2003). At order m, we have N^m paths with an average value $\overline{p^{(m)}}$, at order n, we have N^n paths with an average value $\overline{p^{(n)}}$. The rate-of-convergence relationship derived above connects their cumulative values as $\frac{N^n \overline{p^{(n)}}}{N^m \overline{p^{(m)}}} = \bar{\lambda} \Leftrightarrow \frac{\overline{p^{(n)}}}{\overline{p^{(m)}}} = \frac{\bar{\lambda}^{n-m}}{N^{n-m}} \Leftrightarrow \log \frac{\overline{p^{(n)}}}{\overline{p^{(m)}}} = (n-m) \log \frac{\bar{\lambda}}{N}$. The rank of a path $p^{(n)}$ originating from order n is N^n, so that $\log \frac{\overline{r^{(n)}}}{\overline{r^{(m)}}} \approx \log \frac{N^n}{N^m} = (n-m) \log N$. Inserting this into $\frac{\Delta \log(p)}{\Delta \log(r)} = \frac{\log(p^{(n)}) - \log(p^{(m)})}{\log(r^{(n)}) - \log(r^{(m)})}$ we find that $\frac{\Delta \log(p)}{\Delta \log(r)} \approx \frac{\log\left(\overline{p^{(n)}} / \overline{p^{(m)}}\right)}{\log\left(\overline{r^{(n)}} / \overline{r^{(m)}}\right)} = \frac{(n-m)\log(\bar{\lambda}/N)}{(n-m)\log N} = \frac{\log \bar{\lambda}}{\log N} - 1$.

Appling the SPA methodology to the 20-sector version of the GLORIA database extended by data on material extraction, we analysed for the example country Chile how many supply chains (i.e. "paths") which share in the overall domestic material extraction is delivered to final demand (within Chile or abroad) by a certain number of paths.

First of all, we measured the mean eigenvalue of $\mathbf{A}$ as $\bar{\lambda} = 0.006344$, and we have $N = 164 \times 20 = 3280$. Theoretically, the slope of the rank-order relationship should be $\frac{\Delta \log(p)}{\Delta \log(r)} \approx \frac{\log \bar{\lambda}}{\log N} - 1 = -1.3406$. Using our SPA results, we measured $\frac{\Delta \log(p)}{\Delta \log(r)} \approx -1.3123$, which is in very good agreement with the theory (Figure 2).

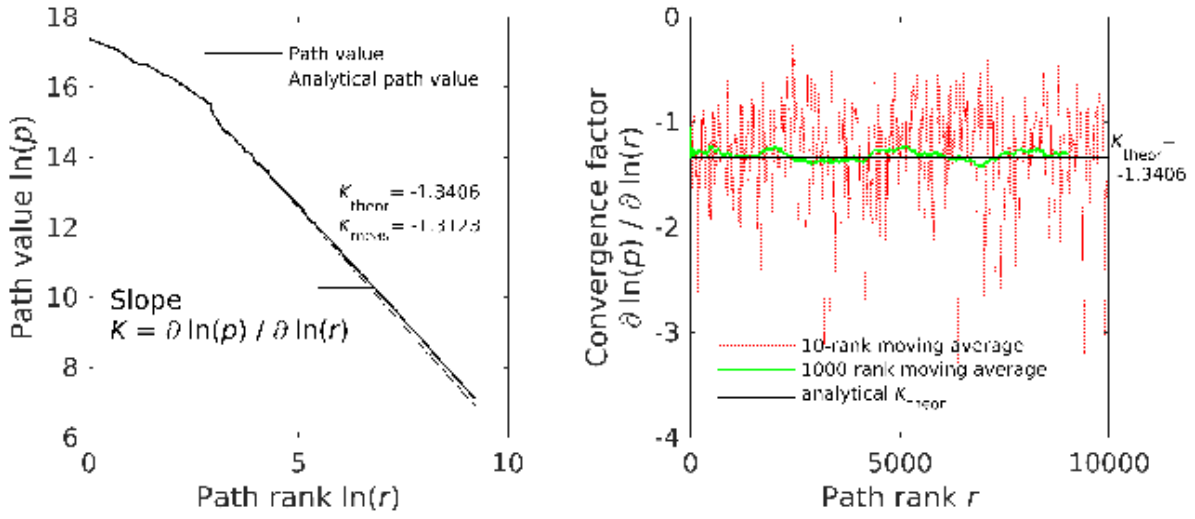

Figure 2: Comparison between theory and measurement of the path value – path rank relationship. Left: Path value as a function of path rank. Right: Convergence factor $\frac{\Delta log(p)}{\Delta log(r)}$ *as a function of path rank.*

We now explain what this relationship means for our ability to capture a certain percentage of a footprint using SPA.

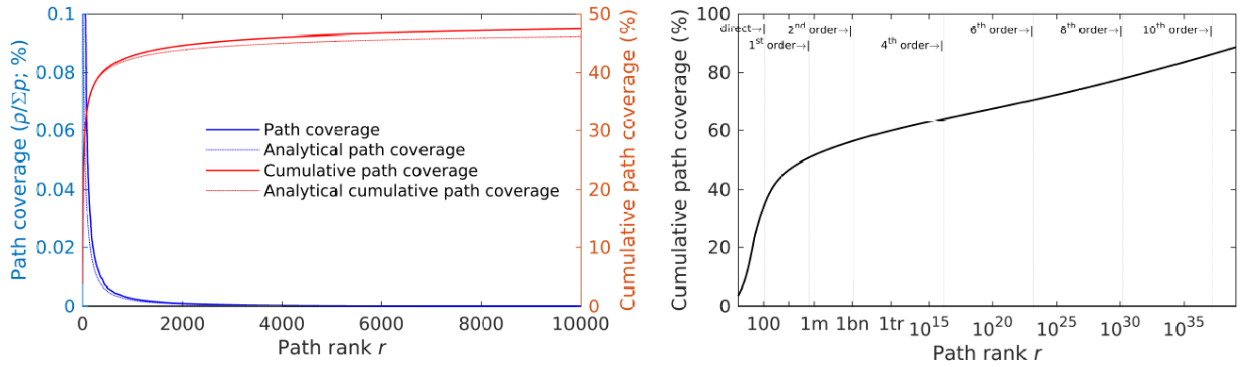

Figure 3: SPA rank-path convergence analysis for material extraction in Chile

The left diagramme in Figure 3 shows two graphs: The blue graph illustrates the percentage share of individual paths in the overall material extraction in Chile. It can be seen that the largest paths (i.e. with low ranks) deliver around 0.1% only to final demand, while the contribution of smaller paths, i.e. rank 1,000ff. is negligible. The red line shows the cumulative coverage: With around 1,000 paths around 45% of domestic extraction is represented. However, increasing the number of paths analysed to 10,000 increases the coverage only to around 48%. These results illustrate very clearly the large amount of existing supply chains with small contributions. The right diagramme shows an estimate of how many paths would have to be included to achieve a coverage of 90% of domestic extraction in Chile – an incredible number of 10^{35} paths!

The analysis shows that it's of no use aiming at analysing all supply chains delivering domestic extraction to final demand elsewhere. However, an SPA can provide two types of information relevant for the application in SCP-HAT, and for SCP policy development, respectively: (1) it can identify the supply chains delivering the largest amounts of domestic extraction to final demand. (2) By quantifying the share in total domestic extraction covered by these chains, we get an understanding of their relevance, i.e. the role of a country in the global material economy. (3) Identifying the most important paths allows to recognize a geographical pattern, i.e. which foreign final demand is most important for domestic withdrawal

Annex II: Geographical coverage of the SCP-HAT

Country 1-41	42-82	83-123	124-164
Rest of Americas	Cyprus	Kazakhstan	Papua New Guinea
Rest of Europe	Czech Republic	Kenya	Poland
Rest of Africa	Germany	Kyrgyzstan	North Korea
Rest of Asia-Pacific	Djibouti	Cambodia	Portugal
Afghanistan	DR Yemen (Aden)	South Korea	Paraguay
Angola	Denmark	Kuwait	Qatar
Albania	Dominican Republic	Laos	Romania
United Arab Emirates	Algeria	Lebanon	Russian Federation
Argentina	Ecuador	Liberia	Rwanda
Armenia	Egypt	Libya	Saudi Arabia
Australia	Eritrea	Sri Lanka	South Sudan
Austria	Spain	Lithuania	Senegal
Azerbaijan	Estonia	Luxembourg	Singapore
Burundi	DR Ethiopia	Latvia	Sierra Leone
Belgium	Finland	Morocco	El Salvador
Benin	France	Moldova	Somalia
Burkina Faso	Gabon	Madagascar	Serbia
Bangladesh	United Kingdom	Mexico	North Sudan
Bulgaria	Georgia	Macedonia	Slovakia
Bahrain	Ghana	Mali	Slovenia
Bahamas	Guinea	Malta	Sweden
Bosnia and Herzegovina	Gambia	Myanmar	Syria
Belarus	Equatorial Guinea	Mongolia	Chad
Belize	Greece	Mozambique	Togo
Bolivia	Guatemala	Mauritania	Thailand
Brazil	Honduras	Malawi	Tajikistan
Brunei Darussalam	Hong Kong	Malaysia	Turkmenistan
Bhutan	Croatia	Namibia	Tunisia
Botswana	Haiti	Niger	Turkey
Central African Republic	Hungary	Nigeria	Tanzania
Canada	Indonesia	Nicaragua	Uganda
Switzerland	India	Netherlands	Ukraine
Chile	Ireland	Norway	Uruguay
China	Iran	Nepal	United States of America
Cote d'Ivoire	Iraq	New Zealand	Uzbekistan
Cameroon	Iceland	Oman	Venezuela
DR Congo	Israel	Pakistan	Viet Nam
Rep Congo	Italy	Palestine	Yemen
Colombia	Jamaica	Panama	South Africa
Costa Rica	Jordan	Peru	Zambia
Cuba	Japan	Philippines	Zimbabwe

Source: GLORIA (https://ielab.info/analyse/GLORIA)

Annex III: Sector classification of the SCP-HAT

The following table provides a list of the 120 sectors of the SCP-HAT.

120 Sector	28 Sector
Growing wheat	Agriculture
Growing maize	Agriculture
Growing cereals n.e.c.	Agriculture
Growing leguminous crops and oil seeds	Agriculture
Growing rice	Agriculture
Growing vegetables, roots, tubers	Agriculture
Growing sugar beet and cane	Agriculture
Growing tobacco	Agriculture
Growing fibre crops	Agriculture
Growing crops n.e.c.	Agriculture
Growing grapes	Agriculture
Growing fruits and nuts	Agriculture
Growing beverage crops (coffee, tea etc)	Agriculture
Growing spices, aromatic, drug and pharmaceutical crops	Agriculture
Seeds and plant propagation	Agriculture
Raising of cattle	Agriculture
Raising of sheep and goats	Agriculture
Raising of swine/pigs	Agriculture
Raising of poultry	Agriculture
Raising of animals n.e.c.; services to agriculture	Agriculture
Forestry and logging	Forestry and logging
Fishing	Fishing
Crustaceans and molluscs	Fishing
Hard coal	Coal, oil & gas mining
Lignite and peat	Coal, oil & gas mining
Petroleum extraction	Coal, oil & gas mining
Gas extraction	Coal, oil & gas mining
Iron ores	Ore mining
Uranium ores	Ore mining
Aluminium ore	Ore mining
Copper ores	Ore mining
Gold ores	Ore mining
Lead/zinc/silver ores	Ore mining
Nickel ores	Ore mining
Tin ores	Ore mining
Other non-ferrous ores	Ore mining
Quarrying of stone, sand and clay	Construction material quarrying

Chemical and fertilizer minerals	Construction material quarrying
Extraction of salt	Construction material quarrying
Mining and quarrying n.e.c.; services to mining	Construction material quarrying
Beef meat	Nutrition
Sheep meat	Nutrition
Pork	Nutrition
Poultry meat	Nutrition
Other meat products	Nutrition
Fish products	Nutrition
Cereal products	Nutrition
Vegetable products	Nutrition
Fruit products	Nutrition
Food products and feeds n.e.c.	Nutrition
Sugar refining; cocoa, chocolate and confectionery	Nutrition
Animal oils and fats	Nutrition
Vegetable oils and fats	Nutrition
Dairy products	Nutrition
Alcoholic and other beverages	Nutrition
Tobacco products	Nutrition
Textiles and clothing	Textiles
Leather and footwear	Textiles
Sawmill products	Wood and Paper
Pulp and paper	Wood and Paper
Printing	Wood and Paper
Coke oven products	Energy
Refined petroleum products	Energy
Nitrogenous fertilizers	Chemical products
Non-nitrogenous and mixed fertilizers	Chemical products
Basic petrochemical products	Chemical products
Basic inorganic chemicals	Chemical products
Basic organic chemicals	Chemical products
Pharmaceuticals and medicinal products	Chemical products
Dyes, paints, glues, detergents and other chemical products	Chemical products
Rubber products	Chemical products
Plastic products	Chemical products
Clay building materials	Ceramics
Glass and other ceramics n.e.c.	Ceramics
Cement, lime and plaster products	Ceramics
Other non-metallic mineral products n.e.c.	Ceramics
Basic iron and steel	Basic metals
Basic aluminium	Basic metals
Basic copper	Basic metals

Basic gold	Basic metals
Basic lead/zinc/silver	Basic metals
Basic nickel	Basic metals
Basic tin	Basic metals
Basic non-ferrous metals n.e.c.	Basic metals
Fabricated metal products	Fabricated metals
Machinery and equipment	Fabricated metals
Motor vehicles, trailers and semi-trailers	Transport equipment
Other transport equipment	Transport equipment
Repair and installation of machinery and equipment (service)	Repair and installation
Computers; electronic products; optical and precision instruments	Fabricated metals
Electrical equipment	Fabricated metals
Furniture and other manufacturing n.e.c.	Other manufacturing
Electric power generation, transmission and distribution	Electricity, gas and water
Distribution of gaseous fuels through mains	Electricity, gas and water
Water collection, treatment and supply; sewerage	Electricity, gas and water
Waste collection, treatment, and disposal	Waste and recycling
Materials recovery	Waste and recycling
Building construction	Construction
Civil engineering construction	Construction
Wholesale and retail trade; repair of motor vehicles and motorcycles	Wholesale and retail trade
Road transport	Transport
Rail transport	Transport
Transport via pipeline	Transport
Water transport	Transport
Air transport	Transport
Services to transport	Transport
Postal and courier services	Post and telecommunications
Hospitality	Hotels and restraurants
Publishing	Post and telecommunications
Telecommunications	Post and telecommunications
Information services	Post and telecommunications
Finance and insurance	Financial intermediation and business activities
Property and real estate	Financial intermediation and business activities
Professional, scientific and technical services	Financial intermediation and business activities
Administrative services	Public administration
Government; social security; defence; public order	Public administration
Education	Education, health and other social work activities
Human health and social work activities	Education, health and other social work activities
Arts, entertainment and recreation	Other services
Other services	Other services

Source: GLORIA (https://ielab.info/analyse/GLORIA)

Annex IIIa: GLORIA 20/35-sector aggregation for SPA

20 sectors	**35 sectors**
Agricultural cultivation	Agricultural cultivation
Forestry	Forestry
Livestock raising & Fishing	Livestock raising & Fishing
Coal oil & gas mining	Coal oil & gas mining
Ore mining	Iron ore mining
	Aluminium ore mining
	Copper ore mining
	Gold ore mining
	Lead/zinc/silver ore mining
	Nickel ore mining
	Tin ore mining
	Other non-ferrous ore mining
Construction material and other mineral quarrying	Construction material and other mineral quarrying
Animal food products	Animal food products
Other food products	Other food products
Wood and paper	Wood and paper
Energy	Energy
Chemical products	Chemical products
Non-metallic mineral products	Non-metallic mineral products
Basic metals	Basic iron and steel
	Basic aluminium
	Basic Copper
	Basic Gold
	Basic lead/zinc/silver
	Basic nickel
	Basic tin
	Basic non-ferrous metals n.e.c.
Fabricated metals, machinery, electronics	Fabricated metals, machinery, electronics
Transport equipment	Transport equipment
Textiles, leather, furniture and other manufacturing	Textiles, leather, furniture and other manufacturing
Electricity, gas, water, waste recycling	Electricity, gas, water, waste recycling
Construction	Construction
Transport	Transport
Public admin, edu, health	Public admin, edu, health
Other services	Other services

Annex IV: Characterisation factors for GHG emissions

Full list substances	kg CO2-eq/kg [GWP100]	kg CO2-eq/kg [GTP100]
Methane (IPCC Cat 1,2, 5)	29.8	7.5
Methane (IPCC Cat 3 and 4)	27.2	4.7
Carbon dioxide	1	1
Dinitrogen Oxide	273	233

Source: IPCC, (2021)

Annex V: IPCC categories

Main IPCC category	IPCC category	
1. ENERGY	1.A.1.a	Main Activity Electricity and Heat Production
	1.A.1.bc	Petroleum Refining - Manufacture of Solid Fuels and Other Energy Industries
	1.A.2	Manufacturing Industries and Construction
	1.A.3.a	Civil Aviation
	1.A.3.b	Road Transportation
	1.A.3.c	Railways
	1.A.3.d	Water-borne Navigation
	1.A.3.e	Other Transportation
	1.A.4	Other Sectors
	1.A.5	Non-Specified
	1.B.1	Solid Fuels
	1.B.2	Oil and Natural Gas
2. INDUSTRIAL PROCESSES AND PRODUCT USE	2.A.1	Cement production
	2.A.2	Lime production
	2.A.3	Glass Production
	2.A.4	Other Process Uses of Carbonates
	2.B	Chemical Industry
	2.C	Metal Industry
	2.D	Non-Energy Products from Fuels and Solvent Use
	2.G	Other Product Manufacture and Use
3.AGRICULTURE, FORESTRY AND OTHER LAND USE	3.A.1	Enteric Fermentation
	3.A.2	Manure Management
	3.C.1	Emissions from biomass burning
	3.C.2	Liming
	3.C.3	Urea application
	3.C.4	Direct N2O Emissions from managed soils
	3.C.5	Indirect N2O Emissions from managed soils
	3.C.6	Indirect N2O Emissions from manure management
	3.C.7	Rice cultivations
4. WASTE	4.A	Solid Waste Disposal
	4.B	Biological Treatment of Solid Waste
	4.C	Incineration and Open Burning of Waste
	4.D	Wastewater Treatment and Discharge
5. OTHER	5.A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
	5.B	Other

Source: Edgar(https://edgar.jrc.ec.europa.eu/index.php/dataset_ghg60)

Annex Va: Correspondence between GLORIA sectors and IPCC categories

GLORIA sectors	IPCC	IPCC descritpion
Growing wheat	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3B2	Cropland
	3C1b	Emissions from biomass burning - Croplands
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C8	Other
Growing maize	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3B2	Cropland
	3C1b	Emissions from biomass burning - Croplands
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C8	Other
Growing cereals n.e.c.	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3B2	Cropland
	3C1b	Emissions from biomass burning - Croplands
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C8	Other
Growing leguminous crops and oil seeds	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3B2	Cropland
	3C1b	Emissions from biomass burning - Croplands
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C8	Other
Growing rice	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3B2	Cropland
	3C1b	Emissions from biomass burning - Croplands
	3C2	Liming
	3C7	Rice cultivations
	3C8	Other
Growing vegetables, roots, tubers	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3B2	Cropland
	3C1b	Emissions from biomass burning - Croplands
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C8	Other

Growing sugar beet and cane	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3B2	Cropland
	3C1b	Emissions from biomass burning - Croplands
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C8	Other
Growing tobacco	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3B2	Cropland
	3C1b	Emissions from biomass burning - Croplands
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C8	Other
Growing fibre crops	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3B2	Cropland
	3C1b	Emissions from biomass burning - Croplands
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C8	Other
Growing crops n.e.c.	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3B2	Cropland
	3C1b	Emissions from biomass burning - Croplands
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C8	Other
Growing grapes	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3B2	Cropland
	3C1b	Emissions from biomass burning - Croplands
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C8	Other
Growing fruits and nuts	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3B2	Cropland
	3C1b	Emissions from biomass burning - Croplands
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C8	Other
Growing beverage crops (coffee, tea etc)	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery

	3B2	Cropland
	3C1b	Emissions from biomass burning - Croplands
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C8	Other
Growing of spices, aromatic, drug and pharmaceutical crops	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3B2	Cropland
	3C1b	Emissions from biomass burning - Croplands
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C8	Other
Seeds and plant propagation	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3B2	Cropland
	3C1b	Emissions from biomass burning - Croplands
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C8	Other
Raising of cattle	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3A1	Enteric Fermentation
	3A2	Manure Management
	3B3	Grassland
	3C1c	Emissions from biomass burning - Grasslands
	3C6	Indirect N2O Emissions from manure management
	3C8	Other
Raising of sheep and goats	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3A1	Enteric Fermentation
	3A2	Manure Management
	3B3	Grassland
	3C1c	Emissions from biomass burning - Grasslands
	3C6	Indirect N2O Emissions from manure management
	3C8	Other
Raising of swine/pigs	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3A1	Enteric Fermentation
	3A2	Manure Management
	3C6	Indirect N2O Emissions from manure management
	3C8	Other
Raising of poultry	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3A1	Enteric Fermentation
	3A2	Manure Management
	3C6	Indirect N2O Emissions from manure management
	3C8	Other
Raising of animals n.e.c. – services to agriculture	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3A1	Enteric Fermentation

	3A2	Manure Management
	3C6	Indirect N2O Emissions from manure management
	3C8	Other
Forestry and logging	1A4ci	Other Sectors - Stationary
	1A4cii	Other Sectors - Off-road vehicles and other Machinery
	3B1	Forest land
	3C1a	Emissions from biomass burning - Forest lands
Fishing	1A4ci	Other Sectors - Stationary
	1A4ciii	Other Sectors - Fishing
Crustaceans and molluscs	1A4ci	Other Sectors - Stationary
	1A4ciii	Other Sectors - Fishing
Hard coal	1A1cii	Other Energy Industries
	1B1	Solid Fuels
Lignite and peat	1A1cii	Other Energy Industries
	1B1	Solid Fuels
Petroleum extraction	1A1cii	Other Energy Industries
	1B2	Oil and Natural Gas
Gas extraction	1A1cii	Other Energy Industries
	1B2	Oil and Natural Gas
Iron ores	1A2i	Manufacturing Industries and Construction - Mining (excluding fuels) and Quarrying
Uranium ores	1A2i	Manufacturing Industries and Construction - Mining (excluding fuels) and Quarrying
Aluminium ore	1A2i	Manufacturing Industries and Construction - Mining (excluding fuels) and Quarrying
Copper ores	1A2i	Manufacturing Industries and Construction - Mining (excluding fuels) and Quarrying
Gold ores	1A2i	Manufacturing Industries and Construction - Mining (excluding fuels) and Quarrying
Lead/zinc/silver ores	1A2i	Manufacturing Industries and Construction - Mining (excluding fuels) and Quarrying
Nickel ores	1A2i	Manufacturing Industries and Construction - Mining (excluding fuels) and Quarrying
Tin ores	1A2i	Manufacturing Industries and Construction - Mining (excluding fuels) and Quarrying
Other non-ferrous ores	1A2i	Manufacturing Industries and Construction - Mining (excluding fuels) and Quarrying
Quarrying of stone, sand and clay	1A2i	Manufacturing Industries and Construction - Mining (excluding fuels) and Quarrying
Chemical and fertilizer minerals	1A2i	Manufacturing Industries and Construction - Mining (excluding fuels) and Quarrying
Extraction of salt	1A2i	Manufacturing Industries and Construction - Mining (excluding fuels) and Quarrying
Mining and quarrying n.e.c..; services to mining	1A2i	Manufacturing Industries and Construction - Mining (excluding fuels) and Quarrying
Beef meat	1A2e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco
	2H	Other
Sheep meat	1A2e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco
	2H	Other
Pork	1A2e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco
	2H	Other
Poultry meat	1A2e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco
	2H	Other
Other meat products	1A2e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco
	2H	Other

Fish products	1A2e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco
	2H	Other
Cereal products	1A2e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco
	2H	Other
Vegetable products	1A2e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco
	2H	Other
Fruit products	1A2e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco
	2H	Other
Food products and feeds n.e.c.	1A2e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco
	2G	Other Product Manufacture and Use
	2H	Other
Sugar refining; cocoa, chocolate and confectionery	1A2e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco
	2H	Other
Animal oils and fats	1A2e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco
	2H	Other
Vegetable oils and fats	1A2e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco
	2H	Other
Dairy products	1A2e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco
	2G	Other Product Manufacture and Use
	2H	Other
Alcoholic and other beverages	1A2e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco
	2H	Other
Tobacco products	1A2e	Manufacturing Industries and Construction - Food Processing, Beverages and Tobacco
Textiles and clothing	1A2l	Manufacturing Industries and Construction - Textile and Leather
Leather and footwear	1A2l	Manufacturing Industries and Construction - Textile and Leather
Sawmill products	1A2j	Manufacturing Industries and Construction - Wood and Wood products
Pulp and paper	1A2d	Manufacturing Industries and Construction - Pulp, Paper and Print
	2H	Other
Printing	1A2d	Manufacturing Industries and Construction - Pulp, Paper and Print
Coke oven products	1A1ci	Manufacture of Solid Fuels
Refined petroleum products	1A1b	Petroleum Refining
	1B2	Oil and Natural Gas
Nitrogenous fertilizers	1A2c	Manufacturing Industries and Construction - Chemicals
	2B	Chemical Industry
Non-nitrogenous and mixed fertilizers	1A2c	Manufacturing Industries and Construction - Chemicals
	2B	Chemical Industry
Basic petrochemical products	1A1b	Petroleum Refining
	2D	Non-Energy Products from Fuels and Solvent Use
	2F	Product Uses as Substitutes for Ozone Depleting Substances
Basic inorganic chemicals	1A2c	Manufacturing Industries and Construction - Chemicals
	2B	Chemical Industry
Basic organic chemicals	1A2c	Manufacturing Industries and Construction - Chemicals
	2B	Chemical Industry
Pharmaceuticals and medicinal products	1A2c	Manufacturing Industries and Construction - Chemicals
	2B	Chemical Industry
Dyes, paints, glues, detergents and other chemical products	1A2c	Manufacturing Industries and Construction - Chemicals
	2B	Chemical Industry

	2D	Non-Energy Products from Fuels and Solvent Use
Rubber products	1A2c	Manufacturing Industries and Construction - Chemicals
	2B	Chemical Industry
Plastic products	1A2c	Manufacturing Industries and Construction - Chemicals
	2B	Chemical Industry
Clay building materials	1A2f	Manufacturing Industries and Construction - Non-Metallic Minerals
	2A4	Other Process Uses of Carbonates
Glass and other ceramics n.e.c.	1A2f	Manufacturing Industries and Construction - Non-Metallic Minerals
	2A3	Glass Production
	2A4	Other Process Uses of Carbonates
Cement, lime and plaster products	1A2f	Manufacturing Industries and Construction - Non-Metallic Minerals
	2A1	Cement production
	2A2	Lime production
Other non-metallic mineral products n.e.c.	1A2f	Manufacturing Industries and Construction - Non-Metallic Minerals
Basic iron and steel	1A2a	Manufacturing Industries and Construction - Iron and steel
	2C	Metal Industry
Basic Aluminium	1A2b	Manufacturing Industries and Construction - Non-Ferrous metals
	2C	Metal Industry
Basic Copper	1A2b	Manufacturing Industries and Construction - Non-Ferrous metals
	2C	Metal Industry
Basic Gold	1A2b	Manufacturing Industries and Construction - Non-Ferrous metals
	2C	Metal Industry
Basic Lead/Zinc/Silver	1A2b	Manufacturing Industries and Construction - Non-Ferrous metals
	2C	Metal Industry
Basic nickel	1A2b	Manufacturing Industries and Construction - Non-Ferrous metals
	2C	Metal Industry
Basic tin	1A2b	Manufacturing Industries and Construction - Non-Ferrous metals
	2C	Metal Industry
Basic non-ferrous metals n.e.c.	1A2b	Manufacturing Industries and Construction - Non-Ferrous metals
	2C	Metal Industry
Fabricated metal products	1A2h	Manufacturing Industries and Construction - Machinery
Machinery and equipment	1A2h	Manufacturing Industries and Construction - Machinery
Manufacture of motor vehicles, trailers and semi-trailers	1A2g	Manufacturing Industries and Construction - Transport Equipment
Other transport equipment	1A2g	Manufacturing Industries and Construction - Transport Equipment
Repair and installation of machinery and equipment (service)	1A2m	Manufacturing Industries and Construction - Non-specified Industry (ISIC Divisions 25,33,36 and 37)
Computers; electronic products; optical and precision instruments	1A2h	Manufacturing Industries and Construction - Machinery
	2E	Electronics Industry
Electrical equipment	1A2h	Manufacturing Industries and Construction - Machinery
	2F	Product Uses as Substitutes for Ozone Depleting Substances
	2G	Other Product Manufacture and Use
Furniture and other manufacturing n.e.c	1A2h	Manufacturing Industries and Construction - Machinery
Electric power generation, transmission and distribution	1A1a	Main Activity Electricity and Heat Production
Distribution of gaseous fuels through mains	1A1cii	Other Energy Industries
	1B2	Oil and Natural Gas
Water collection, treatment, and supply; sewerage	4B	Biological Treatment of Solid Waste
	4D	Wastewater Treatment and Discharge
	4E	Other waste handling
Waste collection, treatment, and disposal	4A	Solid Waste Disposal

	4B	Biological Treatment of Solid Waste
	4C	Incineration and Open Burning of Waste
	4E	Other waste handling
Materials recovery	4B	Biological Treatment of Solid Waste
	4E	Other waste handling
Building construction	1A2k	Manufacturing Industries and Construction - Construction
Civil engineering construction	1A2k	Manufacturing Industries and Construction - Construction
Wholesale and retail trade; repair of motor vehicles and motorcycles	1A4a	Other Sectors - Commercial/Institutional
Road transport	1A3b	Road Transportation
	1A3b_noRES	'Road Transportation no resuspension'
	1A3b_RES	'Road Transportation resuspension'
Rail transport	1A3c	Railways
Transport via pipeline	1A3e	Other Transportation
Water transport	1A3d	Water-borne Navigation
Air transport	1A3a	Civil Aviation
Services to transport	1A3e	Other Transportation
Postal and courier services	1A3e	Other Transportation
Hospitality	1A4a	Other Sectors - Commercial/Institutional
Publishing	1A4a	Other Sectors - Commercial/Institutional
Telecommunications	1A4a	Other Sectors - Commercial/Institutional
Information services	1A4a	Other Sectors - Commercial/Institutional
Finance and insurance	1A4a	Other Sectors - Commercial/Institutional
Property and real estate	1A4a	Other Sectors - Commercial/Institutional
Professional, scientific and technical services	1A4a	Other Sectors - Commercial/Institutional
Administrative services	1A4a	Other Sectors - Commercial/Institutional
Government; social security; defence; public order	1A4a	Other Sectors - Commercial/Institutional
	1A5	Non-Specified (military)
	3B4&6	Wetlands and other land
	3C1d	Emissions from biomass burning - other lands
Education	1A4a	Other Sectors - Commercial/Institutional
Human health and social work activities	1A4a	Other Sectors - Commercial/Institutional
	2G	Other Product Manufacture and Use
Arts, entertainment and recreation	1A4a	Other Sectors - Commercial/Institutional
Other services	1A4a	Other Sectors - Commercial/Institutional
Households	1A4b	Other Sectors - Residential
	3B5	Settlements
	3C1d	Emissions from biomass burning - other lands

Annex VI: Raw materials, TCCC categories and material groups of the SCP-HAT

The following table provides a list of the 367 materials and their concordance with 62 raw material categories, the four material groups and the depletion groups of the SCP-HAT:

Raw material	TCCC code	TCCC name	SCP-HAT material group	SCP-HAT depletion group
Rice	TCCC.1.1.1.1	Rice	Biomass	n/a
Rice_Residues	TCCC.1.2.1.1	Straw	Biomass	n/a
Wheat	TCCC.1.1.1.2	Wheat	Biomass	n/a
Wheat_Residues	TCCC.1.2.1.1	Straw	Biomass	n/a
Barley	TCCC.1.1.1.3	Cereals n.e.c.	Biomass	n/a
Barley_Residues	TCCC.1.2.1.1	Straw	Biomass	n/a
Buckwheat	TCCC.1.1.1.3	Cereals n.e.c.	Biomass	n/a
Buckwheat_Residues	TCCC.1.2.1.1	Straw	Biomass	n/a
Canary seed	TCCC.1.1.1.3	Cereals n.e.c.	Biomass	n/a
Canary seed_Residues	TCCC.1.2.1.1	Straw	Biomass	n/a
Cereals n.e.c.	TCCC.1.1.1.3	Cereals n.e.c.	Biomass	n/a
Cereals n.e.c._Residues	TCCC.1.2.1.1	Straw	Biomass	n/a
Fonio	TCCC.1.1.1.3	Cereals n.e.c.	Biomass	n/a
Fonio_Residues	TCCC.1.2.1.1	Straw	Biomass	n/a
Maize (corn)	TCCC.1.1.1.3	Cereals n.e.c.	Biomass	n/a
Maize (corn)_Residues	TCCC.1.2.1.1	Straw	Biomass	n/a
Millet	TCCC.1.1.1.3	Cereals n.e.c.	Biomass	n/a
Millet_Residues	TCCC.1.2.1.1	Straw	Biomass	n/a
Mixed grain	TCCC.1.1.1.3	Cereals n.e.c.	Biomass	n/a
Mixed grain_Residues	TCCC.1.2.1.1	Straw	Biomass	n/a
Oats	TCCC.1.1.1.3	Cereals n.e.c.	Biomass	n/a
Oats_Residues	TCCC.1.2.1.1	Straw	Biomass	n/a
Quinoa	TCCC.1.1.1.3	Cereals n.e.c.	Biomass	n/a
Quinoa_Residues	TCCC.1.2.1.1	Straw	Biomass	n/a
Rye	TCCC.1.1.1.3	Cereals n.e.c.	Biomass	n/a
Rye_Residues	TCCC.1.2.1.1	Straw	Biomass	n/a
Sorghum	TCCC.1.1.1.3	Cereals n.e.c.	Biomass	n/a
Sorghum_Residues	TCCC.1.2.1.1	Straw	Biomass	n/a
Triticale	TCCC.1.1.1.3	Cereals n.e.c.	Biomass	n/a
Triticale_Residues	TCCC.1.2.1.1	Straw	Biomass	n/a
Natural rubber in primary forms	TCCC.1.1.10	Other crops n.e.c	Biomass	n/a
Natural rubber in primary forms_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Anise, badian, coriander, cumin, caraway, fennel and juniper berries, raw	TCCC.1.1.11	Spice - beverage - pharmaceutical crops	Biomass	n/a
Anise, badian, coriander, cumin, caraway, fennel and juniper berries, raw_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Chillies and peppers, dry (Capsicum spp., Pimenta spp.), raw	TCCC.1.1.11	Spice - beverage - pharmaceutical crops	Biomass	n/a
Chillies and peppers, dry (Capsicum spp., Pimenta spp.), raw_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Cinnamon and cinnamon-tree flowers, raw	TCCC.1.1.11	Spice - beverage - pharmaceutical crops	Biomass	n/a
Cinnamon and cinnamon-tree flowers, raw_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Cloves (whole stems), raw	TCCC.1.1.11	Spice - beverage - pharmaceutical crops	Biomass	n/a

Cloves (whole stems), raw_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Cocoa beans	TCCC.1.1.11	Spice - beverage - pharmaceutical crops	Biomass	n/a
Cocoa beans_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Coffee, green	TCCC.1.1.11	Spice - beverage - pharmaceutical crops	Biomass	n/a
Coffee, green_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Ginger, raw	TCCC.1.1.11	Spice - beverage - pharmaceutical crops	Biomass	n/a
Ginger, raw_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Hop cones	TCCC.1.1.11	Spice - beverage - pharmaceutical crops	Biomass	n/a
Hop cones_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Maté leaves	TCCC.1.1.11	Spice - beverage - pharmaceutical crops	Biomass	n/a
Maté leaves_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Nutmeg, mace, cardamoms, raw	TCCC.1.1.11	Spice - beverage - pharmaceutical crops	Biomass	n/a
Nutmeg, mace, cardamoms, raw_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Other stimulant, spice and aromatic crops, n.e.c.	TCCC.1.1.11	Spice - beverage - pharmaceutical crops	Biomass	n/a
Other stimulant, spice and aromatic crops, n.e.c._Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Pepper (Piper spp.), raw	TCCC.1.1.11	Spice - beverage - pharmaceutical crops	Biomass	n/a
Pepper (Piper spp.), raw_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Peppermint, spearmint	TCCC.1.1.11	Spice - beverage - pharmaceutical crops	Biomass	n/a
Peppermint, spearmint_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Pyrethrum, dried flowers	TCCC.1.1.11	Spice - beverage - pharmaceutical crops	Biomass	n/a
Pyrethrum, dried flowers_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Tea leaves	TCCC.1.1.11	Spice - beverage - pharmaceutical crops	Biomass	n/a
Tea leaves_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Vanilla, raw	TCCC.1.1.11	Spice - beverage - pharmaceutical crops	Biomass	n/a
Vanilla, raw_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Unmanufactured tobacco	TCCC.1.1.12	Tobacco	Biomass	n/a
Unmanufactured tobacco_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Cassava, fresh	TCCC.1.1.2	Roots and tubers	Biomass	n/a
Cassava, fresh_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Edible roots and tubers with high starch or inulin content, n.e.c., fresh	TCCC.1.1.2	Roots and tubers	Biomass	n/a
Edible roots and tubers with high starch or inulin content, n.e.c., fresh_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Potatoes	TCCC.1.1.2	Roots and tubers	Biomass	n/a

Potatoes_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Sweet potatoes	TCCC.1.1.2	Roots and tubers	Biomass	n/a
Sweet potatoes_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Taro	TCCC.1.1.2	Roots and tubers	Biomass	n/a
Taro_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Yams	TCCC.1.1.2	Roots and tubers	Biomass	n/a
Yams_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Yautia	TCCC.1.1.2	Roots and tubers	Biomass	n/a
Yautia_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Other sugar crops n.e.c.	TCCC.1.1.3	Sugar crops	Biomass	n/a
Other sugar crops n.e.c._Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Sugar beet	TCCC.1.1.3	Sugar crops	Biomass	n/a
Sugar beet_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Sugar cane	TCCC.1.1.3	Sugar crops	Biomass	n/a
Sugar cane_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Bambara beans, dry	TCCC.1.1.4	Pulses	Biomass	n/a
Bambara beans, dry_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Beans, dry	TCCC.1.1.4	Pulses	Biomass	n/a
Beans, dry_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Broad beans and horse beans, dry	TCCC.1.1.4	Pulses	Biomass	n/a
Broad beans and horse beans, dry_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Chick peas, dry	TCCC.1.1.4	Pulses	Biomass	n/a
Chick peas, dry_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Cow peas, dry	TCCC.1.1.4	Pulses	Biomass	n/a
Cow peas, dry_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Lentils, dry	TCCC.1.1.4	Pulses	Biomass	n/a
Lentils, dry_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Lupins	TCCC.1.1.4	Pulses	Biomass	n/a
Lupins_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Other pulses n.e.c.	TCCC.1.1.4	Pulses	Biomass	n/a
Other pulses n.e.c._Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Peas, dry	TCCC.1.1.4	Pulses	Biomass	n/a
Peas, dry_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Pigeon peas, dry	TCCC.1.1.4	Pulses	Biomass	n/a
Pigeon peas, dry_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Vetches	TCCC.1.1.4	Pulses	Biomass	n/a
Vetches_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Almonds, in shell	TCCC.1.1.5	Nuts	Biomass	n/a
Almonds, in shell_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Areca nuts	TCCC.1.1.5	Nuts	Biomass	n/a
Areca nuts_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Brazil nuts, in shell	TCCC.1.1.5	Nuts	Biomass	n/a

Brazil nuts, in shell_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Cashew nuts, in shell	TCCC.1.1.5	Nuts	Biomass	n/a
Cashew nuts, in shell_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Chestnuts, in shell	TCCC.1.1.5	Nuts	Biomass	n/a
Chestnuts, in shell_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Hazelnuts, in shell	TCCC.1.1.5	Nuts	Biomass	n/a
Hazelnuts, in shell_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Kola nuts	TCCC.1.1.5	Nuts	Biomass	n/a
Kola nuts_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Other nuts (excluding wild edible nuts and groundnuts), in shell, n.e.c.	TCCC.1.1.5	Nuts	Biomass	n/a
Other nuts (excluding wild edible nuts and groundnuts), in shell, n.e.c._Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Pistachios, in shell	TCCC.1.1.5	Nuts	Biomass	n/a
Pistachios, in shell_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Walnuts, in shell	TCCC.1.1.5	Nuts	Biomass	n/a
Walnuts, in shell_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Castor oil seeds	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Castor oil seeds_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Coconuts, in shell	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Coconuts, in shell_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Groundnuts, excluding shelled	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Groundnuts, excluding shelled_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Hempseed	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Hempseed_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Jojoba seeds	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Jojoba seeds_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Kapok fruit	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Kapok fruit_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Karite nuts (sheanuts)	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Karite nuts (sheanuts)_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Linseed	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Linseed_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Melonseed	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Melonseed_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Mustard seed	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Mustard seed_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Oil palm fruit	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Oil palm fruit_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Olives	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Olives_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Other oil seeds, n.e.c.	TCCC.1.1.6	Oil bearing crops	Biomass	n/a

Other oil seeds, n.e.c._Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Poppy seed	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Poppy seed_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Rape or colza seed	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Rape or colza seed_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Safflower seed	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Safflower seed_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Sesame seed	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Sesame seed_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Soya beans	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Soya beans_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Sunflower seed	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Sunflower seed_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Tallowtree seeds	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Tallowtree seeds_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Tung nuts	TCCC.1.1.6	Oil bearing crops	Biomass	n/a
Tung nuts_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Artichokes	TCCC.1.1.7	Vegetables	Biomass	n/a
Artichokes_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Asparagus	TCCC.1.1.7	Vegetables	Biomass	n/a
Asparagus_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Broad beans and horse beans, green	TCCC.1.1.7	Vegetables	Biomass	n/a
Broad beans and horse beans, green_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Cabbages	TCCC.1.1.7	Vegetables	Biomass	n/a
Cabbages_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Carrots and turnips	TCCC.1.1.7	Vegetables	Biomass	n/a
Carrots and turnips_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Cassava leaves	TCCC.1.1.7	Vegetables	Biomass	n/a
Cassava leaves_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Cauliflowers and broccoli	TCCC.1.1.7	Vegetables	Biomass	n/a
Cauliflowers and broccoli_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Chicory roots	TCCC.1.1.7	Vegetables	Biomass	n/a
Chicory roots_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Chillies and peppers, green (Capsicum spp. and Pimenta spp.)	TCCC.1.1.7	Vegetables	Biomass	n/a
Chillies and peppers, green (Capsicum spp. and Pimenta spp.)_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Cucumbers and gherkins	TCCC.1.1.7	Vegetables	Biomass	n/a
Cucumbers and gherkins_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Eggplants (aubergines)	TCCC.1.1.7	Vegetables	Biomass	n/a
Eggplants (aubergines)_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Green corn (maize)	TCCC.1.1.7	Vegetables	Biomass	n/a

Green corn (maize)_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Green garlic	TCCC.1.1.7	Vegetables	Biomass	n/a
Green garlic_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Leeks and other alliaceous vegetables	TCCC.1.1.7	Vegetables	Biomass	n/a
Leeks and other alliaceous vegetables_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Lettuce and chicory	TCCC.1.1.7	Vegetables	Biomass	n/a
Lettuce and chicory_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Locust beans (carobs)	TCCC.1.1.7	Vegetables	Biomass	n/a
Locust beans (carobs)_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Mushrooms and truffles	TCCC.1.1.7	Vegetables	Biomass	n/a
Mushrooms and truffles_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Okra	TCCC.1.1.7	Vegetables	Biomass	n/a
Okra_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Onions and shallots, dry (excluding dehydrated)	TCCC.1.1.7	Vegetables	Biomass	n/a
Onions and shallots, dry (excluding dehydrated)_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Onions and shallots, green	TCCC.1.1.7	Vegetables	Biomass	n/a
Onions and shallots, green_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Other beans, green	TCCC.1.1.7	Vegetables	Biomass	n/a
Other beans, green_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Other vegetables, fresh n.e.c.	TCCC.1.1.7	Vegetables	Biomass	n/a
Other vegetables, fresh n.e.c._Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Peas, green	TCCC.1.1.7	Vegetables	Biomass	n/a
Peas, green_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Pumpkins, squash and gourds	TCCC.1.1.7	Vegetables	Biomass	n/a
Pumpkins, squash and gourds_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Spinach	TCCC.1.1.7	Vegetables	Biomass	n/a
Spinach_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
String beans	TCCC.1.1.7	Vegetables	Biomass	n/a
String beans_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Tomatoes	TCCC.1.1.7	Vegetables	Biomass	n/a
Tomatoes_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Apples	TCCC.1.1.8	Fruits	Biomass	n/a
Apples_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Apricots	TCCC.1.1.8	Fruits	Biomass	n/a
Apricots_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Avocados	TCCC.1.1.8	Fruits	Biomass	n/a
Avocados_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Bananas	TCCC.1.1.8	Fruits	Biomass	n/a
Bananas_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Blueberries	TCCC.1.1.8	Fruits	Biomass	n/a
Blueberries_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a

Cantaloupes and other melons	TCCC.1.1.8	Fruits	Biomass	n/a
Cantaloupes and other melons_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Cashewapple	TCCC.1.1.8	Fruits	Biomass	n/a
Cashewapple_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Cherries	TCCC.1.1.8	Fruits	Biomass	n/a
Cherries_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Cranberries	TCCC.1.1.8	Fruits	Biomass	n/a
Cranberries_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Currants	TCCC.1.1.8	Fruits	Biomass	n/a
Currants_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Dates	TCCC.1.1.8	Fruits	Biomass	n/a
Dates_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Figs	TCCC.1.1.8	Fruits	Biomass	n/a
Figs_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Gooseberries	TCCC.1.1.8	Fruits	Biomass	n/a
Gooseberries_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Grapes	TCCC.1.1.8	Fruits	Biomass	n/a
Grapes_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Kiwi fruit	TCCC.1.1.8	Fruits	Biomass	n/a
Kiwi fruit_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Lemons and limes	TCCC.1.1.8	Fruits	Biomass	n/a
Lemons and limes_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Mangoes, guavas and mangosteens	TCCC.1.1.8	Fruits	Biomass	n/a
Mangoes, guavas and mangosteens_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Oranges	TCCC.1.1.8	Fruits	Biomass	n/a
Oranges_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Other berries and fruits of the genus vaccinium n.e.c.	TCCC.1.1.8	Fruits	Biomass	n/a
Other berries and fruits of the genus vaccinium n.e.c._Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Other citrus fruit, n.e.c.	TCCC.1.1.8	Fruits	Biomass	n/a
Other citrus fruit, n.e.c._Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Other fruits, n.e.c.	TCCC.1.1.8	Fruits	Biomass	n/a
Other fruits, n.e.c._Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Other pome fruits	TCCC.1.1.8	Fruits	Biomass	n/a
Other pome fruits_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Other stone fruits	TCCC.1.1.8	Fruits	Biomass	n/a
Other stone fruits_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Other tropical fruits, n.e.c.	TCCC.1.1.8	Fruits	Biomass	n/a
Other tropical fruits, n.e.c._Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Papayas	TCCC.1.1.8	Fruits	Biomass	n/a
Papayas_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Peaches and nectarines	TCCC.1.1.8	Fruits	Biomass	n/a

Peaches and nectarines_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Pears	TCCC.1.1.8	Fruits	Biomass	n/a
Pears_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Persimmons	TCCC.1.1.8	Fruits	Biomass	n/a
Persimmons_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Pineapples	TCCC.1.1.8	Fruits	Biomass	n/a
Pineapples_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Plantains and cooking bananas	TCCC.1.1.8	Fruits	Biomass	n/a
Plantains and cooking bananas_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Plums and sloes	TCCC.1.1.8	Fruits	Biomass	n/a
Plums and sloes_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Pomelos and grapefruits	TCCC.1.1.8	Fruits	Biomass	n/a
Pomelos and grapefruits_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Quinces	TCCC.1.1.8	Fruits	Biomass	n/a
Quinces_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Raspberries	TCCC.1.1.8	Fruits	Biomass	n/a
Raspberries_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Sour cherries	TCCC.1.1.8	Fruits	Biomass	n/a
Sour cherries_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Strawberries	TCCC.1.1.8	Fruits	Biomass	n/a
Strawberries_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Tangerines, mandarins, clementines	TCCC.1.1.8	Fruits	Biomass	n/a
Tangerines, mandarins, clementines_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Watermelons	TCCC.1.1.8	Fruits	Biomass	n/a
Watermelons_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Abaca, manila hemp, raw	TCCC.1.1.9	Fibres	Biomass	n/a
Abaca, manila hemp, raw_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Agave fibres, raw, n.e.c.	TCCC.1.1.9	Fibres	Biomass	n/a
Agave fibres, raw, n.e.c._Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Coir, raw	TCCC.1.1.9	Fibres	Biomass	n/a
Coir, raw_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Flax, processed but not spun	TCCC.1.1.9	Fibres	Biomass	n/a
Flax, processed but not spun_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Jute, raw or retted	TCCC.1.1.9	Fibres	Biomass	n/a
Jute, raw or retted_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Kenaf, and other textile bast fibres, raw or retted	TCCC.1.1.9	Fibres	Biomass	n/a
Kenaf, and other textile bast fibres, raw or retted_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Other fibre crops, raw, n.e.c.	TCCC.1.1.9	Fibres	Biomass	n/a
Other fibre crops, raw, n.e.c._Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Ramie, raw or retted	TCCC.1.1.9	Fibres	Biomass	n/a
Ramie, raw or retted_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a

Seed cotton, unginned	TCCC.1.1.9	Fibres	Biomass	n/a
Seed cotton, unginned_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Sisal, raw	TCCC.1.1.9	Fibres	Biomass	n/a
Sisal, raw_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
True hemp, raw or retted	TCCC.1.1.9	Fibres	Biomass	n/a
True hemp, raw or retted_Residues	TCCC.1.2.1.2	Other crop residues (sugar and fodder beet leaves etc)	Biomass	n/a
Grazed biomass	TCCC.1.2.2.2	Grazed biomass	Biomass	n/a
Timber (Industrial roundwood)	TCCC.1.3.1	Timber (Industrial roundwood)	Biomass	n/a
Wood fuel and other extraction	TCCC.1.3.2	Wood fuel and other extraction	Biomass	n/a
Wild fish catch	TCCC.1.4.1	Wild fish catch	Biomass	n/a
All other aquatic animals	TCCC.1.4.2	All other aquatic animals	Biomass	n/a
Aquatic plants	TCCC.1.4.3	Aquatic plants	Biomass	n/a
Iron ores concentrates and compounds	TCCC.2.1.Fe	Iron ores concentrates and compounds	Metal ores	Ferrous ores
Silver ores concentrates and compounds	TCCC.2.2.Ag	Silver ores concentrates and compounds	Metal ores	Non-ferrous ores
Bauxite and other aluminium ores concentrates and compounds	TCCC.2.2.Al	Bauxite and other aluminium ores concentrates and compounds	Metal ores	Non-ferrous ores
Gold ores concentrates and compounds	TCCC.2.2.Au	Gold ores concentrates and compounds	Metal ores	Non-ferrous ores
Chromium ores concentrates and compounds	TCCC.2.2.Cr	Chromium ores concentrates and compounds	Metal ores	Non-ferrous ores
Copper ores concentrates and compounds	TCCC.2.2.Cu	Copper ores concentrates and compounds	Metal ores	Non-ferrous ores
Manganese ores concentrates and compounds	TCCC.2.2.Mn	Manganese ores concentrates and compounds	Metal ores	Non-ferrous ores
Other metal ores concentrates and compounds nec. including mixed	TCCC.2.2.nec	Other metal ores concentrates and compounds nec. including mixed	Metal ores	Non-ferrous ores
Nickel ores concentrates and compounds	TCCC.2.2.Ni	Nickel ores concentrates and compounds	Metal ores	Non-ferrous ores
Lead ores concentrates and compounds	TCCC.2.2.Pb	Lead ores concentrates and compounds	Metal ores	Non-ferrous ores
Platinum group metal ores concentrates and compounds	TCCC.2.2.Pt	Platinum group metal ores concentrates and compounds	Metal ores	Non-ferrous ores
Tin ores concentrates and compounds	TCCC.2.2.Sn	Tin ores concentrates and compounds	Metal ores	Non-ferrous ores
Titanium ores concentrates and compounds	TCCC.2.2.Ti	Titanium ores concentrates and compounds	Metal ores	Non-ferrous ores
Uranium ores concentrates and compounds	TCCC.2.2.U	Uranium ores concentrates and compounds	Metal ores	Non-ferrous ores
Zinc ores concentrates and compounds	TCCC.2.2.Zn	Zinc ores concentrates and compounds	Metal ores	Non-ferrous ores
Ornamental or building stone	TCCC.3.1	Ornamental or building stone	Non-metallic minerals	Construction minerals
Chalk	TCCC.3.2.1	Chalk	Non-metallic minerals	Construction minerals
Dolomite	TCCC.3.2.2	Dolomite	Non-metallic minerals	Construction minerals
Limestone	TCCC.3.2.3	Limestone	Non-metallic minerals	Construction minerals
Fertilizer minerals n.e.c.	TCCC.3.4.1	Fertilizer minerals n.e.c.	Non-metallic minerals	Industrial minerals
Chemical minerals n.e.c.	TCCC.3.4.2	Chemical minerals n.e.c.	Non-metallic minerals	Industrial minerals
Industrial minerals n.e.c	TCCC.3.4.3	Industrial minerals n.e.c	Non-metallic minerals	Industrial minerals
Salt	TCCC.3.5	Salt	Non-metallic minerals	Industrial minerals

Gypsum	TCCC.3.6	Gypsum	Non-metallic minerals	Construction minerals
Structural clays	TCCC.3.7.1	Structural clays	Non-metallic minerals	Construction minerals
Specialty clays	TCCC.3.7.2	Specialty clays	Non-metallic minerals	Industrial minerals
Industrial sand and gravel	TCCC.3.8.1	Industrial sand and gravel	Non-metallic minerals	Industrial minerals
Sand gravel and crushed rock for construction	TCCC.3.8.2	Sand gravel and crushed rock for construction	Non-metallic minerals	Construction minerals
Other non-metallic minerals n.e.c.	TCCC.3.9	Other non-metallic minerals n.e.c.	Non-metallic minerals	Industrial minerals
Lignite (brown coal)	TCCC.4.1.1.1	Lignite (brown coal)	Fossil fuels	Coal
Other Sub-Bituminous Coal	TCCC.4.1.1.2	Other Sub-Bituminous Coal	Fossil fuels	Coal
Anthracite	TCCC.4.1.2.1	Anthracite	Fossil fuels	Coal
Coking Coal	TCCC.4.1.2.2	Coking Coal	Fossil fuels	Coal
Other Bituminous Coal	TCCC.4.1.2.3	Other Bituminous Coal	Fossil fuels	Coal
Peat	TCCC.4.1.3	Peat	Fossil fuels	Coal
Crude oil	TCCC.4.2.1	Crude oil	Fossil fuels	Petroleum
Natural gas	TCCC.4.2.2	Natural gas	Fossil fuels	Natural gas
Natural gas liquids	TCCC.4.2.3	Natural gas liquids	Fossil fuels	Petroleum
Oil shale and tar sands	TCCC.4.3	Oil shale and tar sands	Fossil fuels	Oil shale and tar sands

Annex VII: Land use and biodiversity loss categories and sector correspondence in SCP-HAT v2.0

The following table provides a list of the six land use/biodiversity loss categories of the SCP-HAT.

Category	**Sector (Production-based)**	**Sector (Use extension – SCP-HAT)**
Annual crops	Various crops & livestock/households	Various crops & livestock/households
Permanent (perennial) crops	Various crops/households	Various crops/households
Pasture	Various livestock/households	Various livestock/households
Extensive forestry	Agriculture/households	Wood production and households
Intensive forestry	Agriculture	Wood production
Urban	Households	Households

Source: UNEP LCI guidance for LCIA indicators (UNEP, 2016)

The following table provides the concordance between FAO, SPAM 2010 (Spatial Production Allocation Model version 2010; You et al. 2014) and the IRP MRIO crop sector classifications. Crop-level land use data are sourced from FAOSTAT. SPAM 2010 data are used to determine the allocation directly to households for subsistence and informal farming (see Annex IX) and 15 MRIO sectors are distinguished for crop production (see Annex III). In order to attribute a land use category (see above) to each of the crops, they are classified as annual or perennial.

FAO Crop Name	**Annual / Perennial**	**SPAM 2010**	**MRIO sector**
Agave fibres nes	P	other fibre crops	Growing of fibre crops
Almonds, with shell	P	rest of crops	Growing of fruit and nuts
Anise, badian, fennel, coriander	A	rest of crops	Growing of spices, aromatic, drug and pharmaceutical crops
Apples	P	temperate fruit	Growing of fruit and nuts
Apricots	P	temperate fruit	Growing of fruit and nuts
Areca nuts	P	rest of crops	Growing of fruit and nuts
Artichokes	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Asparagus	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Avocados	P	tropical fruit	Growing of fruit and nuts
Bambara beans	A	other pulses	Growing of vegetables melons, roots, tubers, non-perennial fruits
Bananas	P	banana	Growing of fruit and nuts
Barley	A	barley	Growing cereals n.e.c
Bastfibres, other	P	other fibre crops	Growing of fibre crops
Beans, dry	A	bean	Growing of vegetables melons, roots, tubers, non-perennial fruits
Beans, green	A	bean	Growing of vegetables melons, roots, tubers, non-perennial fruits
Berries nes	P	temperate fruit	Growing of fruit and nuts
Blueberries	P	temperate fruit	Growing of fruit and nuts
Brazil nuts, with shell	P	rest of crops	Growing of fruit and nuts

Broad beans, horse beans, dry	A	other pulses	Growing of vegetables melons, roots, tubers, non-perennial fruits
Buckwheat	A	other cereals	Growing cereals n.e.c
Cabbages and other brassicas	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Canary seed	A	other cereals	Growing cereals n.e.c
Carobs	A	temperate fruit	Growing of fruit and nuts
Carrots and turnips	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Cashew nuts, with shell	P	rest of crops	Growing of fruit and nuts
Cashewapple	P	temperate fruit	Growing of fruit and nuts
Cassava	A	cassava	Growing of vegetables melons, roots, tubers, non-perennial fruits
Cassava leaves	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Castor oil seed	A	other oil crops	Growing oil crops (inc soy)
Cauliflowers and broccoli	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Cereals nes	A	other cereals	Growing cereals n.e.c
Cherries	P	temperate fruit	Growing of fruit and nuts
Cherries, sour	P	temperate fruit	Growing of fruit and nuts
Chestnut	P	rest of crops	Growing of fruit and nuts
Chick peas	A	chickpea	Growing of vegetables melons, roots, tubers, non-perennial fruits
Chicory roots	A	rest of crops	Growing of vegetables melons, roots, tubers, non-perennial fruits
Chillies and peppers, dry	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Chillies and peppers, green	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Cinnamon (cannella)	P	rest of crops	Growing of spices, aromatic, drug and pharmaceutical crops
Cloves	P	rest of crops	Growing of spices, aromatic, drug and pharmaceutical crops
Cocoa, beans	P	cocoa	Growing of beverage crops
Coconuts	P	coconut	Growing oil crops (inc soy)
Coffee, green	P	coffee (arabica/robusta)	Growing of beverage crops
Coir	*NA*	coconut	Growing of fibre crops
Cotton lint	*NA*	cotton	Growing of fibre crops
Cottonseed	*NA*	cotton	Growing oil crops (inc soy)
Cow peas, dry	A	cowpea	Growing of vegetables melons, roots, tubers, non-perennial fruits
Cranberries	P	temperate fruit	Growing of fruit and nuts
Cucumbers and gherkins	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Currants	P	temperate fruit	Growing of fruit and nuts
Dates	P	temperate fruit	Growing of fruit and nuts
Eggplants (aubergines)	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Fibre crops nes	A	other fibre crops	Growing of fibre crops
Figs	P	temperate fruit	Growing of fruit and nuts
Flax fibre and tow	A	other fibre crops	Growing of fibre crops
Fonio	A	other cereals	Growing cereals n.e.c
Fruit, citrus nes	P	temperate fruit	Growing of fruit and nuts
Fruit, fresh nes	P	temperate fruit	Growing of fruit and nuts
Fruit, pome nes	P	temperate fruit	Growing of fruit and nuts
Fruit, stone nes	P	temperate fruit	Growing of fruit and nuts
Fruit, tropical fresh nes	P	tropical fruit	Growing of fruit and nuts

Garlic	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Ginger	A	rest of crops	Growing of spices, aromatic, drug and pharmaceutical crops
Gooseberries	P	temperate fruit	Growing of fruit and nuts
Grain, mixed	A	other cereals	Growing cereals n.e.c
Grapefruit (inc. pomelos)	P	temperate fruit	Growing of fruit and nuts
Grapes	P	temperate fruit	Growing of grapes
Groundnuts, with shell	A	groundnut	Growing oil crops (inc soy)
Hazelnuts, with shell	P	rest of crops	Growing of fruit and nuts
Hemp tow waste	A	other fibre crops	Growing of fibre crops
Hempseed	A	other fibre crops	Growing oil crops (inc soy)
Hops	A	rest of crops	Growing of beverage crops
Jojoba seed	P	other oil crops	Growing oil crops (inc soy)
Jute	A	other fibre crops	Growing of fibre crops
Kapok fibre	*NA*	other fibre crops	Growing of fibre crops
Kapok fruit	P	other fibre crops	Growing of fibre crops
Kapokseed in shell	*NA*	other fibre crops	Growing oil crops (inc soy)
Karite nuts (sheanuts)	P	other oil crops	Growing oil crops (inc soy)
Kiwi fruit	P	temperate fruit	Growing of fruit and nuts
Kola nuts	P	rest of crops	Growing of fruit and nuts
Leeks, other alliaceous vegetables	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Lemons and limes	P	temperate fruit	Growing of fruit and nuts
Lentils	A	lentil	Growing of vegetables melons, roots, tubers, non-perennial fruits
Lettuce and chicory	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Linseed	A	other oil crops	Growing oil crops (inc soy)
Lupins	A	other pulses	Growing of vegetables melons, roots, tubers, non-perennial fruits
Maize	A	maize	Growing Maize
Maize, green	A	maize	Growing Maize
Mangoes, mangosteens, guavas	P	tropical fruit	Growing of fruit and nuts
Manila fibre (abaca)	A	other fibre crops	Growing of fibre crops
Mate	P	rest of crops	Growing of beverage crops
Melons, other (inc.cantaloupes)	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Melonseed	A	other oil crops	Growing oil crops (inc soy)
Millet	A	millet (pearl/small)	Growing cereals n.e.c
Mushrooms and truffles	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Mustard seed	A	other oil crops	Growing oil crops (inc soy)
Nutmeg, mace and cardamoms	P	rest of crops	Growing of spices, aromatic, drug and pharmaceutical crops
Nuts nes	P	rest of crops	Growing of fruit and nuts
Oats	A	other cereals	Growing cereals n.e.c
Oil palm fruit	P	oilpalm	Growing oil crops (inc soy)
Oil, palm	*NA*	oilpalm	Growing oil crops (inc soy)
Oilseeds nes	A	other oil crops	Growing oil crops (inc soy)
Okra	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Olives	P	other oil crops	Growing oil crops (inc soy)

Onions, dry	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Onions, shallots, green	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Oranges	P	temperate fruit	Growing of fruit and nuts
Palm kernels	*NA*	oilpalm	Growing oil crops (inc soy)
Papayas	P	tropical fruit	Growing of fruit and nuts
Peaches and nectarines	P	temperate fruit	Growing of fruit and nuts
Pears	P	temperate fruit	Growing of fruit and nuts
Peas, dry	A	other pulses	Growing of vegetables melons, roots, tubers, non-perennial fruits
Peas, green	A	other pulses	Growing of vegetables melons, roots, tubers, non-perennial fruits
Pepper (piper spp.)	P	rest of crops	Growing of spices, aromatic, drug and pharmaceutical crops
Peppermint	A	rest of crops	Growing of spices, aromatic, drug and pharmaceutical crops
Persimmons	P	temperate fruit	Growing of fruit and nuts
Pigeon peas	A	pigeonpea	Growing of vegetables melons, roots, tubers, non-perennial fruits
Pineapples	P	tropical fruit	Growing of fruit and nuts
Pistachios	P	rest of crops	Growing of fruit and nuts
Plantains and others	P	plantain	Growing of fruit and nuts
Plums and sloes	P	temperate fruit	Growing of fruit and nuts
Poppy seed	A	other oil crops	Growing oil crops (inc soy)
Potatoes	A	potato	Growing of vegetables melons, roots, tubers, non-perennial fruits
Pulses nes	A	other pulses	Growing of vegetables melons, roots, tubers, non-perennial fruits
Pumpkins, squash and gourds	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Pyrethrum, dried	A	rest of crops	Growing of spices, aromatic, drug and pharmaceutical crops
Quinces	P	temperate fruit	Growing of fruit and nuts
Quinoa	A	other cereals	Growing cereals n.e.c
Ramie	A	other fibre crops	Growing of fibre crops
Rapeseed	A	rapeseed	Growing oil crops (inc soy)
Raspberries	P	temperate fruit	Growing of fruit and nuts
Rice, paddy	A	rice	Growing rice (paddy)
Roots and tubers nes	A	other roots	Growing of vegetables melons, roots, tubers, non-perennial fruits
Rubber, natural	P	rest of crops	Growing perennial crops n.e.c. and plant propagation
Rye	A	other cereals	Growing cereals n.e.c
Safflower seed	A	other oil crops	Growing oil crops (inc soy)
Seed cotton	A	cotton	Growing of fibre crops
Sesame seed	A	sesameseed	Growing oil crops (inc soy)
Sisal	A	other fibre crops	Growing of fibre crops
Sorghum	A	sorghum	Growing cereals n.e.c
Soybeans	A	soybean	Growing oil crops (inc soy)
Spices nes	P	rest of crops	Growing of spices, aromatic, drug and pharmaceutical crops
Spinach	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Strawberries	A	temperate fruit	Growing of fruit and nuts
String beans	A	other pulses	Growing of vegetables melons, roots, tubers, non-perennial fruits
Sugar beet	A	sugarbeet	Growing of sugar crops
Sugar cane	A	sugarcane	Growing of sugar crops
Sugar crops nes	A	rest of crops	Growing of sugar crops

Sunflower seed	A	sunflower	Growing oil crops (inc soy)
Sweet potatoes	A	sweet potato	Growing of vegetables melons, roots, tubers, non-perennial fruits
Tallowtree seed	P	other oil crops	Growing oil crops (inc soy)
Tangerines, mandarins, clementines, satsumas	P	temperate fruit	Growing of fruit and nuts
Taro (cocoyam)	A	other roots	Growing of vegetables melons, roots, tubers, non-perennial fruits
Tea	P	tea	Growing of beverage crops
Tobacco, unmanufactured	A	tobacco	Growing of tobacco
Tomatoes	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Triticale	A	other cereals	Growing cereals n.e.c
Tung nuts	P	other oil crops	Growing of fruit and nuts
Vanilla	P	rest of crops	Growing of spices, aromatic, drug and pharmaceutical crops
Vegetables, fresh nes	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Vegetables, leguminous nes	A	other pulses	Growing of vegetables melons, roots, tubers, non-perennial fruits
Vetches	A	other pulses	Growing of vegetables melons, roots, tubers, non-perennial fruits
Walnuts, with shell	P	rest of crops	Growing of fruit and nuts
Watermelons	A	vegetables	Growing of vegetables melons, roots, tubers, non-perennial fruits
Wheat	A	wheat	Growing Wheat
Yams	A	yams	Growing of vegetables melons, roots, tubers, non-perennial fruits
Yautia (cocoyam)	A	other roots	Growing of vegetables melons, roots, tubers, non-perennial fruits

Annex VIII: Calculation of land use and allocation to sectors – SCP-HAT 2.0

Annual and permanent crop land use

To determine land use by sector in the categories of Annual crops and Permanent crops (see Annex VII), data from the FAOSTAT land use database are used to normalize and allocation land use to sectors. In Figure 2, land use data by crop (see Annex VII) are added for each country to yield the sum D. D does not reflect all annual land use accurately, because fallow periods and annual pastures are not captured, and because double counting of land may occur when more than one crop is grown in a particular year. In other words, D will not be the same as B which does give the realistic total annual crop land use for a country. When C is reported, D is not necessarily the same as C. Therefore, a conditional approach was set up to deal with a range of reporting scenarios (varying between countries and years) that allows the allocation to the detailed sectors while maintaining the integrity of the total area and therefore total biodiversity impact at country level. Note that E counts as Annual crop land but is allocated to livestock production. Also note that subsequent allocation to households of land use is discussed in Annex IX.

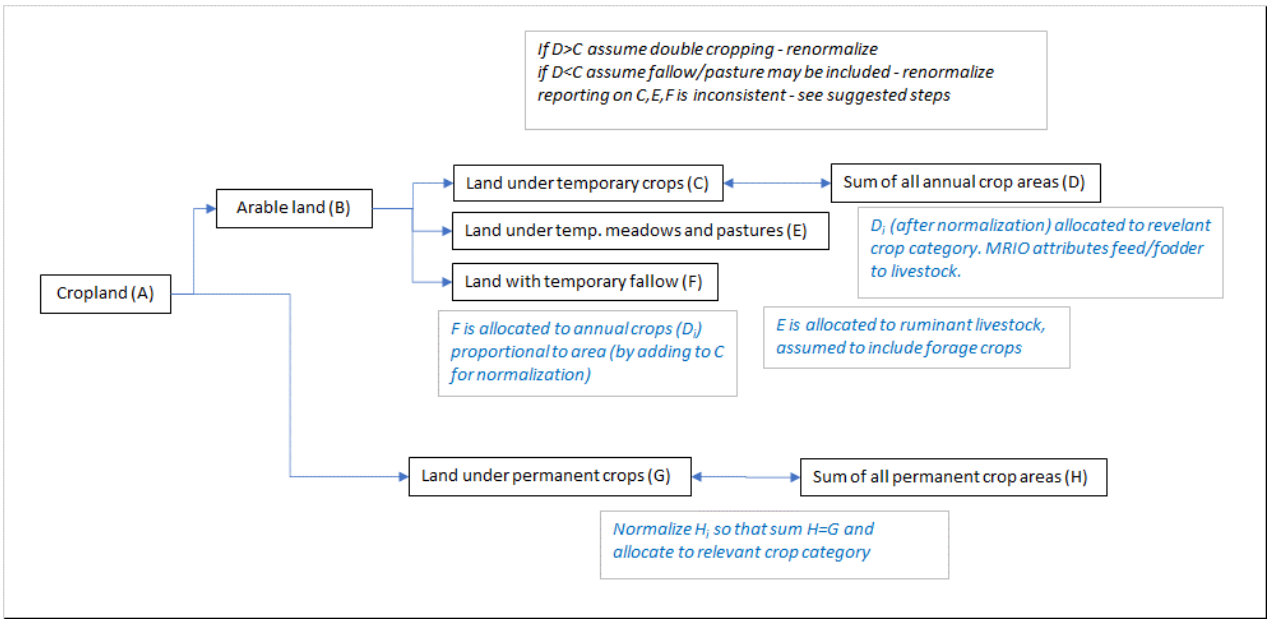

Figure 2 Schedule for calculating annual and permanent crop land use

The first step is to test whether C,E,F are reported for the country and year. If not, they are set to zero. Then the following hierarchy is followed:

- If SUM(C,E,F)=B use C+F to normalize D (and consequently all land use values for individual annual crops); allocate E to livestock;
- If C=B assume that E=B-D; do not normalize D and allocate E to livestock (this situation is unusual, but occurs in some countries with significant mixed farming such as Australia, where reporting in C is known to include E. The approach will slightly overestimate E because F is not known);
- If SUM(C,E,F)=0 assume that C=D and E=B-D (assume F=0); allocate E to livestock;
- If 0<SUM(C,E,F)<B then :
  - if C=0 and E=0 assume C=D and E=B-F-D; normalize D to D+F;
  - if the previous step results in E<0 then assume E=0 and C=B-F; normalize D to B
  - if E=0 and F=0 assume E=F=(B-C)/2; normalize D to C+F;

For permanent crops, the approach is simply to renormalize the sum of individual areas H to match the reported total land use G (see Figure 2).

Forestry land use

Forestry land use (intensive, extensive) is calculated in a very similar way to SCPHAT 1.0 but using the data from the online reporting by the Global Forest Resources Assessment (GFRA; https://fra-data.fao.org/WO/fra2020/home/).

A number of forest land use categories reported can be used to reconstruct the area of Intensive and Extensive forestry (see Annex VII) in each country. GFRA data are collected for 1990, 2000, 2010, 2015 and 2020. For SCP-HAT, data for intermediate years are derived via interpolation between nearest years. Data quality as well as coverage is very variable between countries. However, certain criteria are met in all cases (within margin of error).

The following variables were extracted from the GFRA database:

- A = 1a_forestArea
- B = 1b_naturallyRegeneratingForest
- C = 1b_plantedForest
- D= 3a_prim_prod
- E = 3a_prim_prot
- F = 3a_prim_biodiv
- G = 3a_prim_socserv
- H = 3a_prim_multi
- J = 3a_prim_other

- K = 3a_prim_no_unknown
- M = 1c_primary

For all countries, the following is valid:

- A = B + C (whenever all reported)
- Sum(D:K) = A (whenever reported)

This indicates that B includes primary forest (M). Separate reporting of M is not consistent, so therefore (E+F) is used to establish total area of forest that is not used toward productive ends. The following calculations steps are applied to derive the land use areas required for the SCPHAT modules:

1. Total productive forest Q = A – E – F
2. Intensive forestry Q_i = MIN(C,Q)
3. Extensive forestry Q_e = Q – Q_i

Using this approach, it is clear that some smaller countries have not used a consistent reporting approach over the full period which results in sudden changes in the time series but the results are largely internally consistent. For 176 countries, the total global productive forest area for 2010 thus reconstructed is 21.3 Mkm2 compared to 22.9 Mkm2 in SCPHAT 1.0 and derived from FAO land use data.

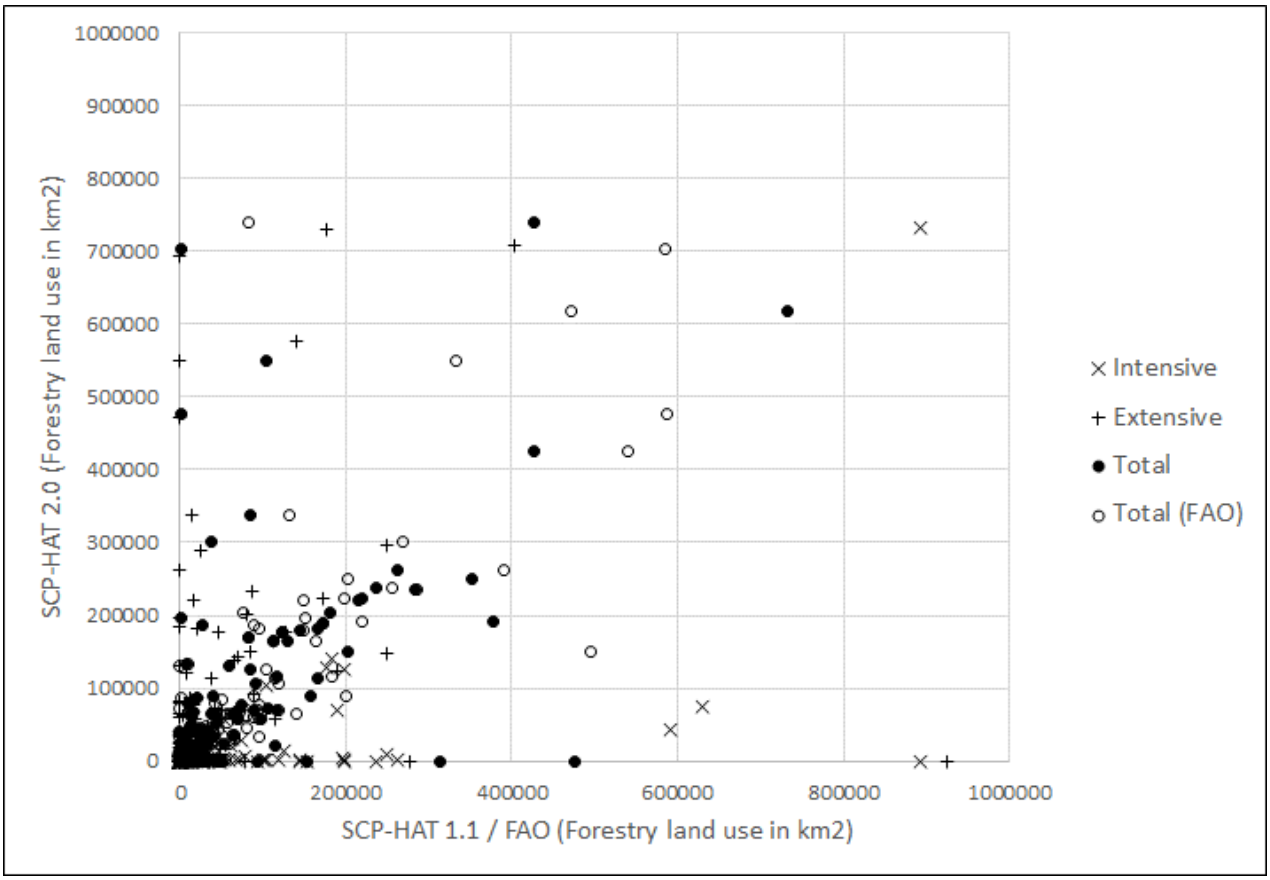

Figure 3 Comparison of forest areas in SCPHAT 2.0 against SCP-HAT 1.1 as well as FAO data for productive forest area by country for year 2010

While total forest area is similar between SCP-HAT 1.0 and 2.0, the global average split between intensive and extensive forestry is 10:90 compared to 54:46 in SCP-HAT 1.0. This may reflect a better alignment with e.g. the recent Climate Change and Land report (IPCC 2019) that reports a total area of ~29 Mkm2 with a 9:91 split between plantation and managed forests.

Definitions of forest use types are inconsistent and various data sources will give different results, but the new GFRA data and calculation approach probably gives more realistic proportions of intensive and extensive forestry than before. It is likely that intensive forestry is underestimated to some extent, resulting in some underestimation of the biodiversity footprint because extensive forestry has a lower characterization factor.

Other land use

Areas reported in FAOSTAT land use database for Land under perm. meadows and pastures are categorized as Pastures (see Annex VII) and allocated to ruminant livestock (and subsequently partly to households, see Annex IX). Areas of urban land use are allocated entirely to households.

Annex IX: Allocation of agricultural activities to households (SCP-HAT 2.0)

Subsistence farming

As in SCP-HAT 1.0 (see Technical Documentation REF@@), the fraction of agricultural activities allocated to households is derived using SPAM. Because the larger number of agricultural sectors in the MRIO, an allocation to household needs to be derived for each of them (15 crop sectors and 4 livestock sectors). The correspondences between FAO, SPAM and MRIO classifications are given in Annex VII.

The approach is otherwise identical to the approach used in SCP-HAT 1.0 using subsistence as well as low input farming reported by SPAM and determining percentages of agricultural production likely to be for subsistence or for informal trading (i.e. outside the economic IO framework) depending on the economic and geographic situation of the country.

After allocating land use, GHG emissions, air polluting emissions, nitrogen flows for marine eutrophication and biomass production to each of the MRIO economic sectors, allocation to households is applied for each of the relevant sectors.

The household allocation factors are determined separately for area and for production. This is new to SCP-HAT 2.0 because the allocation is now applied across all extensions instead of only land use. The area allocation is applied to e.g. land use and emissions from livestock, and the production allocation is applied to e.g. biomass and emissions from fertiliser and crop residue management given that those are more likely to correlate with production than area. As expected, the allocation factors based on area are higher than those based on production, because productivity will be lower for subsistence and low input farming.

For full allocation procedures for emissions (GHG, air pollution, nitrogen) see the equations in Annex X.

Subsistence wood fuel collection

The approach to allocate part of extensive forest land use to households to account for firewood collection is the same as for SCP-HAT 1.0 but adjusted for the new ratios of intensive to extensive forest land use (see Annex IX). Some allocation factors are considerably different such as e.g. for Chile, where allocation to households is now 38% instead of 83% but this reflects the fact that the total area of extensive forestry has increased. The area allocated to households has doubled for Chile.

For SCP-HAT 2.0, the allocation to households has also been calculated for productivity instead of land use area, and this is applied to the biomass production in the materials extension.

Annex X: Allocation of agricultural emissions (SCP-HAT 2.0)

For emissions of CO_2, CH_4, N_2O, PM2.5, NH_3, SO_2, NOx, Edgar v5.0 data were used. These are disaggregated by IPCC 2006 sector classifications. To disaggregate those emissions for the agricultural sectors (IPCC 3.*.*), emission data from FAO were used. To determine emissions of nitrogen to water (leaching), the FAO emissions and nitrogen load data were used and augmented by emission factors derived from UNFCCC reporting by Annex I countries where necessary.

The table below shows which FAO emission categories have been used to disaggregate the relevant IPCC/Edgar emission categories to livestock and cropping sectors.

FAO Emission category	3A1	3A2	3C1b	3C4	3C5	3C6
Emissions (CH4) (Enteric)	CH4					
Emissions (CH4) (Manure management)		CH4				
Direct emissions (N2O) (Manure management)		N2O				
Emissions (N2O) (Burning crop residues)			N2O			
Emissions (CH4) (Burning crop residues)			CH4			
Indirect emissions (N2O) (Manure management)						N2O
Indirect emissions (N2O) (Synthetic fertilizers)					N2O	
Indirect emissions (N2O) (Manure applied)					N2O	
Indirect emissions (N2O) (Manure on pasture)					N2O	
Indirect emissions (N2O) (Crop residues)					N2O	
Direct emissions (N2O) (Synthetic fertilizers)				N2O		
Direct emissions (N2O) (Manure applied)				N2O		
Direct emissions (N2O) (Manure on pasture)				N2O		
Direct emissions (N2O) (Crop residues)				N2O		
Emissions (N2O) (Cultivation of organic soils)*				N2O		

* Note this category has allocation=0, see details below

Below the procedures are described in semi-mathematical form. The key to all integer indices is as follows:

- MRIO Sector = i (1-98) (sector 98 = Households direct)(crop sectors i=1,15 and livestock sectors i=16,19)
- Country = j (1-164)
- Year = k (1990-2018)
- FAO dataset=m (1-5) (agricultural soils only)

- FAO sector = n (number varies between emission categories)

The allocation to households for subsistence farming by area is indicated by AFhha and the allocation to households for subsistence farming by production by AFhhp (see Annex IX). Note that sector definitions for AFhh (SPAM) are different from MRIO sectors, but index i is used for simplicity. The concordance between MRIO and SPAM is given in Annex VII.

Enteric fermentation and manure

3A1 – enteric fermentation – allocated to Raising of ruminant animals and Raising of swine/pigs using FAO emission data by animal (12 animal categories). *Note: horses/donkeys grouped under ruminants for all livestock related calculations to match GLORIA concordance.*

$$AF_{EF}(i,j,k) = \frac{\left[\sum_{n\to i} \quad FAO_{EF}(n,j,k)\right] * \left(1 - AFhha(i,j)\right)}{\sum_{n=1}^{12} \quad FAO_{EF}(n,j,k)} (i = 1{,}97), AF_{EF}(98,j,k)$$

$$= \sum_{i=1}^{97} \quad \left[\frac{\left[\sum_{n\to i} \quad FAO_{EF}(n,j,k)\right] * \left(AFhha(i,j)\right)}{\sum_{n=1}^{12} \quad FAO_{EF}(n,j,k)}\right]$$

$$FAO_{EF} = Emissions(CH4)(Enteric)$$

3A2 – manure management - allocated to Raising of ruminant animals, Raising of swine/pigs and Raising of poultry using FAO emission data by animal (16 animal categories). The AF_{MMS} developed for N2O is also applied to NH3 and NOx and the AF_{MMS} developed for CH4 to PM2.5.

$$AF_{MMS}(i,j,k) = \frac{\left[\sum_{n\to i} \quad FAO_{MMS}(n,j,k)\right] * \left(1 - AFhha(i,j)\right)}{\sum_{n=1}^{16} \quad FAO_{MMS}(n,j,k)} (i = 1{,}97), AF_{MMS}(98,j,k)$$

$$= \sum_{i=1}^{97} \quad \left[\frac{\left[\sum_{n\to i} \quad FAO_{MMS}(n,j,k)\right] * \left(AFhha(i,j)\right)}{\sum_{n=1}^{16} \quad FAO_{MMS}(n,j,k)}\right]$$

$$FAO_{MMS} = Emissions(CH4)(Manuremanagement) \vee$$

$$Directemissions(N2O)(Manuremanagement)(separately)$$

This allocation is also applied to NH3, NOx (identical to N2O) and to PM2.5 (identical to CH4).

3C6 – indirect emissions of manure management - allocated to Raising of ruminant animals, Raising of swine/pigs and Raising of poultry using FAO emission data by animal (16 animal categories).

$$AF_{MMS}(i,j,k) = \frac{\left[\sum_{n\to i} \quad FAO_{MMS}(n,j,k)\right] * \left(1 - AFhha(i,j)\right)}{\sum_{n=1}^{16} \quad FAO_{MMS}(n,j,k)} (i = 1{,}97), AF_{MMS}(98,j,k)$$

$$= \sum_{i=1}^{97} \quad \left[\frac{\left[\sum_{n\to i} \quad FAO_{MMS}(n,j,k)\right] * \left(AFhha(i,j)\right)}{\sum_{n=1}^{16} \quad FAO_{MMS}(n,j,k)}\right]$$

$$FAO_{MMS} = Indirectemissions(N2O)(Manuremanagement)$$

Agricultural soils

3C4 – agricultural soils – allocated to all 15 crop sectors (i=1-15) and 4 livestock sectors (i=16-19) using approach detailed below. Please note that emissions of PM2.5, NH_3 and NOx reported under 3C4 are allocated using the allocation of N_2O developed for 3C5. Rationale is that NH_3 and NOx are associated with the same processes as indirect N_2O emissions, especially for manure left in pasture. For consistency the same is applied to PM2.5.

FAO1 Direct emissions (N_2O) (Synthetic fertilizers)

FAO2 Direct emissions (N_2O) (Manure applied)

FAO3 Direct emissions (N_2O) (Crop residues)

FAO4 Direct emissions (N_2O) (Manure on pasture)

FAO5 Emissions (N_2O) (Cultivation of organic soils)

$$AF_{3C4}(i,j,k) = \frac{FAO1(j,k) * AFx(i,j,k)}{\sum_m \quad FAOm(j,k)} + \frac{FAO2(j,k) * AFx(i,j,k)}{\sum_m \quad FAOm(j,k)} + \frac{FAO3(j,k) * AF3(i,j,k)}{\sum_m \quad FAOm(j,k)}$$
$$+ \frac{FAO4(j,k) * AF4(i,j,k)}{\sum_m \quad FAOm(j,k)} + \frac{FAO5(j,k) * 0}{\sum_m \quad FAOm(j,k)}$$

$$AFx(i,j,k) = \frac{Landuse(i,j,k) * Nrate(i) * \left(1 - AFhhp(i,j)\right)}{\sum_{i=1}^{15} \quad \left(Landuse(i,j,k) * Nrate(i)\right)} (i = 1 - 15),$$

$$AFx(98,j,k) = \frac{\sum_{i=1}^{15} \quad \left(Landuse(i,j,k) * Nrate(i) * AFhhp(i,j)\right)}{\sum_{i=1}^{15} \quad \left(Landuse(i,j,k) * Nrate(i)\right)}$$

$$AF3(i,j,k) = \frac{\left[\sum_{n\to i} \quad FAO3(n,j,k)\right] * \left(1 - AFhhp(i,j)\right)}{\sum_{n=1}^{11} \quad FAO3(n,j,k)} (i = 1 - 15), AF3(98,j,k)$$
$$= \frac{\sum_{i=1}^{15} \quad \left[\sum_{n\to i} \quad FAO3(n,j,k) * AFhhp(i,j)\right]}{\sum_{n=1}^{11} \quad FAO3(n,j,k)}$$

$$(FAOreportsn = 11 cropsectorsthatmatch6IRPsectors)$$

$$AF4(i,j,k) = \frac{\left[\sum_{n\to i} \quad FAO4(n,j,k)\right] * \left(1 - AFhha(i,j)\right)}{\sum_{n=1}^{16} \quad FAO4(n,j,k)} (i = 16 - 19),$$

$$AF4(98,j,k) = \frac{\sum_{i=16}^{19} \quad \left[\sum_{n\to i} \quad FAO4(n,j,k) * AFhha(i,j)\right]}{\sum_{n=1}^{16} \quad FAO4(n,j,k)}$$

$$(FAOreportsn = 16 livestocksectorsthatmatch3IRPsectors)$$

The fraction of 3C4 emissions that is attributed to FAO5 (Cultivation of organic soils) in the above methodology is excluded from the actual data by setting all allocation values to zero. Agricultural activities on such soils are highly variable between the relevant countries and as such allocation can only be established by in-depth study of each country. Emissions of cultivation of organic soils are more than 30% of total emissions in 3.C.4 for 25 out of the 164 countries/regions, using the FAO emissions data. Notably this includes countries like Malaysia and Indonesia, where this is associated with the cultivation of oil palm, but also countries like Iceland, Sweden, Norway and Finland.

3C5 – indirect emissions from agricultural soils – allocated to all 15 crop sectors approach detailed below

FAO1 Indirect emissions (N_2O) (Synthetic fertilizers)

FAO2 Indirect emissions (N_2O) (Manure applied)

FAO3 Indirect emissions (N_2O) (Crop residues)

FAO4 Indirect emissions (N_2O) (Manure on pasture)

AFx(i,j,k) as for 3C4

$$AF_{3C5}(i,j,k) = \frac{FAO1(j,k) * AFx(i,j,k)}{\sum_m \quad FAOm(j,k)} + \frac{FAO2(j,k) * AFx(i,j,k)}{\sum_m \quad FAOm(j,k)} + \frac{FAO3(j,k) * AF5(i,j,k)}{\sum_m \quad FAOm(j,k)} + \frac{FAO4(j,k) * AF6(i,j,k)}{\sum_m \quad FAOm(j,k)}$$

$$AF5(i,j,k) = \frac{\left[\sum_{n\to i} \quad FAO3(n,j,k)\right] * \left(1 - AFhhp(i,j)\right)}{\sum_{n=1}^{11} \quad FAO3(n,j,k)} (i = 1-15), AF5(98,j,k)$$

$$= \frac{\sum_{i=1}^{15} \quad \left[\sum_{n\to i} \quad FAO3(n,j,k) * AFhhp(i,j)\right]}{\sum_{n=1}^{11} \quad FAO3(n,j,k)}$$

$$AF6(i,j,k) = \frac{\left[\sum_{n\to i} \quad FAO4(n,j,k)\right] * \left(1 - AFhha(i,j)\right)}{\sum_{n=1}^{16} \quad FAO4(n,j,k)} (i = 16-19),$$

$$AF6(98,j,k) = \frac{\sum_{i=16}^{19} \quad \left[\sum_{n\to i} \quad FAO4(n,j,k) * AFhha(i,j)\right]}{\sum_{n=1}^{16} \quad FAO4(n,j,k)}$$

As mentioned, this allocation is also applied to emissions of PM2.5, NH_3 and NOx reported under 3C4.

Other air emission sources

3C1b – burning agricultural residues – allocated to Maize, Rice - paddy, Sugar cane and Wheat using FAO emission data by crop (n=4 with one on one mapping to GLORIA sectors i). The AF_{BCR} developed for N_2O is also applied to NH3 and NOx, and the one for CH_4 is applied to PM2.5 and SO_2.

$$AF_{BCR}(i,j,k) = \frac{\left[\sum_{n\to i} \quad FAO_{BCR}(n,j,k)\right] * \left(1 - AFhhp(i,j)\right)}{\sum_{n=1}^{4} \quad FAO_{BCR}(n,j,k)} (i = 1{,}97), AF_{BCR}(98,j,k)$$

$$= \sum_{i=1}^{97} \quad \left[\frac{\left[\sum_{n\to i} \quad FAO_{BCR}(n,j,k)\right] * \left(AFhhp(i,j)\right)}{\sum_{n=1}^{4} \quad FAO_{BCR}(n,j,k)}\right]$$

$$FAO_{BCR} = Emissions(CH4)(Burningcropresidues) \vee$$

$$Emissions(N2O)(Burningcropresidues)$$

3C2 – Emissions of lime application. Applied CO_2 and PM2.5. AF_{lime} = AFx as defined for 3C4.

3C3 – Emissions of urea application (excl N_2O). Applied to CO_2, NH_3 and PM2.5. AF_{urea} = AFx as defined for 3C4.

3C7 – rice cultivation – all allocated to Rice, paddy and subsequently partly to households using AFhhp(i,j) with i=Rice, paddy. This is applied to CH_4 and to PM2.5.

Nitrate leaching

Nitrate leaching is categorized under 3A2 (manure management) and 3C5 (indirect emissions of agricultural soils). The equations below include derivation of both data for leaching by

country and year, and allocation to sectors. The results are in kg N leached, not allocation factors between 0 and 1.

FAO1 Nitrogen leached (Synthetic fertilizers)

FAO2 Nitrogen leached (Manure applied)

FAO3 Nitrogen content (Crop residues)

FAO4 Nitrogen leached (Manure on pasture)

Manure management (3A2)

$$N_{water,3A2}(i,j,k) = \left[\sum_{n \to i} FAO_{MMS}(n,j,k)\right] * EF_{UNFCCC}(j,k) * \left(1 - AFhha(i,j)\right), N_{water,3A2}(98,j,k)$$

$$= \sum_{i=1}^{97} [FAO_{MMS}(i,j,k) * EF_{UNFCCC}(j,k) * AFhha(i,j)]$$

$$\left(FAOreports16sectors(n)whichmap\middle|\ \middle|4IRPsectors(i)\right)$$

$$EF_{UNFCCC}(j,k)$$

$$= Nleach_{UNFCCC}(j,k) \Big/ \sum_{n=1}^{16} FAO_{MMS}(n,j,k) for AnnexIcountries; weightedaverage fornonAnnexI$$

$$FAO_{MMS} = nitrogencontentmanuremanagement$$

Agricultural soils (3C5)

$$N_{water,3C5}(i,j,k) = Nleach_{FAO1}(j,k) * AFx\ \ (i,j,k) + Nleach_{FAO2}(j,k) * AFx\ \ (i,j,k) +$$

$$\sum_{n \to i} N_{FAO3}(n,j,k) * EF_3 * \left(1 - AFhhp(i,j)\right) + \sum_{n \to i} Nleach_{FAO4}(n,j,k) * \left(1 - AFhha(i,j)\right)$$

$$N_{water,3C5}(98,j,k) = Nleach_{FAO1}(j,k) * AFx\ \ (98,j,k) + Nleach_{FAO2}(j,k) * AFx\ \ (98,j,k) +$$

$$\sum_{i=1}^{97} [N|\ \ |FAO3(i,j,k) * EF_3 * AFhhp(i,j)] + \sum_{i=1}^{97} [Nleach|\ \ |FAO4(i,j,k) * AFhha(i,j)]$$

EF_3 = 0.3 as the default value for FracLEACH (IPCC 2006) This is applied to all nitrogen sources potentially subject to leaching in FAO emissions data. There is no accounting for FracWET (fraction of nitrogen applied actually subject to leaching, i.e. in higher rainfall areas or under irrigation) which means leaching is overestimated. AFx is as defined for 3C4. AFhh as defined at the start of this Annex.

Annex XI: Allocation table between IEA energy products and MRIO sectors

	Mining of uranium ores	Hard coal production	Lignite and peat production	Extraction of petroleum	Extraction of natural gas	Electric power generation, transmission and distribution	Wood production related services	Water collection, treatment and supply, Sewerage, and Steam and air conditioning supply
MRIO Sector number / Energy product	30	25	26	27	28	78	21	80
Anthracite		1						
Coking coal		1						
Other bituminous coal		1						
Sub-bituminous coal			1					
Lignite			1					
Peat			1					
Oil shale and oil sands				1				
Natural gas					1			
Crude oil				1				
Natural gas liquids					1			
Other hydrocarbons				1				
Solid biofuels from non-cultivated biomass							1	
Uranium, plutonium, thorium etc.	1							
Hydro						1		
Geothermal						0.98		0.02
Solar photovoltaics						1		
Solar thermal						0.99		0.01
Tide, wave and ocean						1		
Wind						1		
Other sources						0.5		0.5
Heat								1

Note that the allocation shares of 'Geothermal', 'Solar thermal' and 'Other sources' between electricity production on the one hand and heat production on the other hand are estimated based on the respective global shares between electricity and heat production for the three energy products according to data in the IEA extended world energy balances.

Annex XII: Glossary of SCP-HAT

Indicator: this term refers to the environmental and socioeconomic variables, which are included in the SCP-HAT. Indicators available in the SCP-HAT are:

- Environmental indicators:
    - Raw material use
    - Land use (occupation only)
    - Mineral resource scarcity
    - Fossil resource scarcity
    - Short-term climate change
    - Long-term climate change
    - Potential species loss from land use
    - Damage to human health from particulate matter
    - Marine eutrophication potential
    - Primary energy supply
    - Blue water consumption
    - Water stress

- Socio-economic indicators:
    - Final demand
    - Government final consumption
    - Private final consumption
    - Employment (total)
    - Employment (women)
    - Employment (men)
    - Employment (high skilled)
    - Employment (medium skilled)
    - Employment (low skilled)
    - Output
    - Value added

Perspective: This term refers to the accounting principles guiding allocation of environmental pressures and impacts. SCP-HAT comprises two perspectives:

- *Domestic production*: This perspective, equivalent to the so-called "territorial" approach, allocates environmental pressures and impacts to the nation where those pressure and impacts physically occur, irrespectively where goods and services are finally consumed. Therefore, in the frame of SCP this perspective could be employed for sustainability assessment of certain production technologies. In this approach no allocation to trade products take place.
- *Consumption footprint*: This perspective, applying EE-IO technique, allocates environmental pressures and impacts to the nation where final consumers reside, irrespectively to where those pressure and impacts physically occur. Therefore, in the frame of SCP this perspective could be utilized for sustainability assessment of consumer lifestyles. This approach allows for defining a *Trade balance* between importers and exporters of environmental pressures and impacts.

Unit: analyses can be performed using different measurement units, which depend on the perspective on focus:

- Consumption footprint: in absolute terms, per consumer (i.e., per capita), per unit of GDP (Productivity), per unit of area (km^2), or per unit of final demand.
- Domestic production: in absolute terms, per capita, per unit of GDP (Productivity), per unit of area (km^2), per sectoral worker, or per unit of sectoral output.