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 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 2.0[1]. 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 three 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, "SCP Hotspots", contains a wide range of SCP indicators to analyse hotspots of unsustainable consumption and production at country and sector levels. This module supports policy advisors and researchers with expertise by means of detailed information. Finally, module 3, "National Data System", provides technical experts such as statisticians the option of inserting national data to receive more tailored results and carry out crosschecks against the default data as contained in the underlying model. 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".

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.,

[1] For changes between SCP-HAT v1.1 and 2.0 please refer to Annex XIII.

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). 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.

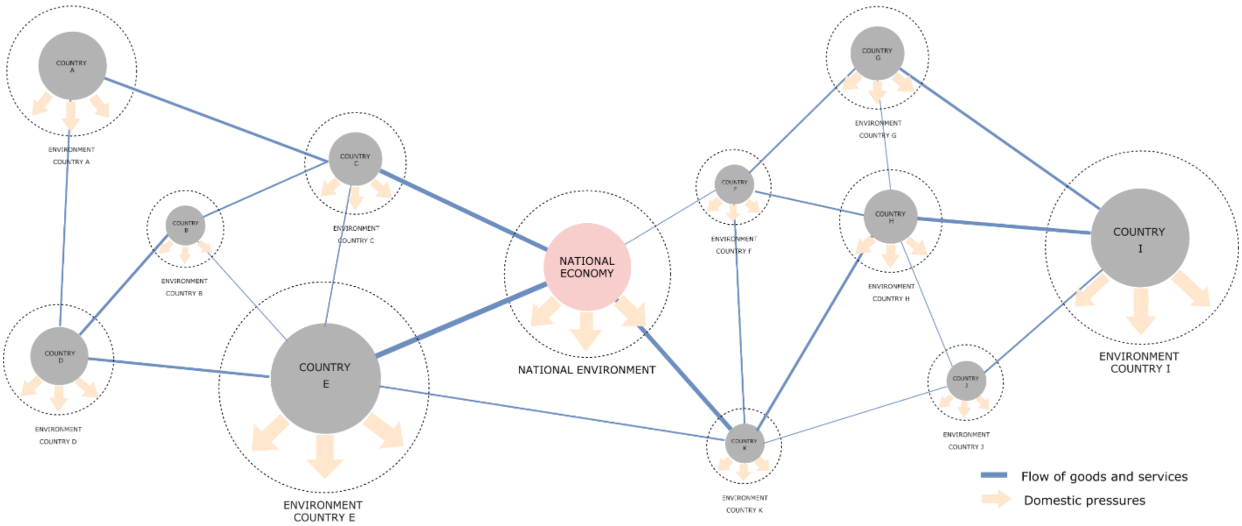

Figure 1: The basic concept of SCP-HAT

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).

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[2], 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, 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

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

- 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
- 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.

Depending on future data availability, further categories to be integrated in future version of the SCP-HAT could include, for example:

- Land transformation
- Mercury emissions
- Solid waste
- Social life-cycle impacts (hazardous or child labour, corruption, etc.)

Geographical and Industry/Product 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 and sector coverage of SCP-HAT is based on the EE-MRIO database employed and includes 160 countries and 4 “rest of the world” regions (full classification in Annex II). It covers 97 different sectors for a large number of countries, and 26 sectors for those countries with less favourable data coverage.

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[3]) database (Lenzen et al., forthcoming). The GLORIA database is a multi-regional input-output database that 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, 2021). 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 environmental categories than raw materials, to ensure environmental flows through the economy are reflected adequately. For further detail on the setup of the model please refer to the technical documentation[4].

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 UNEP are applied to GHG emissions data, including differentiation of fossil- and biogenic methane (Full list of GWP and GTP factors in Annex IV). 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 EDGAR v.6.0 database[5] (Crippa et al., 2021), which is maintained by the European Commission Joint Research Centre (JRC) and the Netherlands Environmental Assessment Agency (PBL). Emissions data in Edgar follow the IPCC 1996 and 2006 categories, and the GHG gases included are CO_2, CH_4, and N_2O. Version 2006 was used for developing the GHG emissions extension in

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[3] https://ielab.info/analyse/GLORIA
[4] https://ielab.info/analyse/GLORIA
[5] https://edgar.jrc.ec.europa.eu/index.php/dataset_ghg60

the SCP-HAT (full classification is provided in Annex V). 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 for IPCC categories 1,2,3,5;
- FAO emissions data for IPCC category 3 Agriculture. FAO data are reported for different livestock and crop types and the relative emissions reported by FAO are therefore used to distribute the emissions reported in EDGAR v6.0, over the relevant MRIO sectors. See Annex X for details.

Lastly, emissions from road transportation from industries and households are recorded together in EDGAR v6.0, which need to be disaggregated for a finer analysis in the SCP-HAT. This was done applying the shares of different industries and households in the overall use of the refined petroleum products, as provided in the GLORIA data.

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, 2021) are used. 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. 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 SCP-HAT. Annex VI provides an overview of how material categories were assigned to the 97 GLORIA sectors. Allocation to more than one sector was performed using total sectoral output as proxy. 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.

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 (m2*a) for six land use classes - Annual crops, Permanent crops, Pasture, Extensive forestry, Intensive forestry, and Urban.

Annex VIII 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 as well as the Technical Documentation for SCPHAT 1.0 (Piñero et al., 2019). Annex VII shows sector correspondences for the land use categories in the SCP-HAT, 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.

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 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 and IX.

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.

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.

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 database v5.0[6] (Crippa et al., 2019). This database covers all countries and years up to and including 2015, and this last observation was carried forward to 2018.

Air polluting emissions associated with agricultural activities are 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 and X 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).

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

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[6] https://edgar.jrc.ec.europa.eu/index.php/dataset_ap50

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). The details on constructing the extension for N leached are provided in Annex X.

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

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

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.

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

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

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: International Labour Organization
- 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

Employment by sector and gender/skill is compiled from the ILO (International Labour Organization, 2018). The dataset on employment by gender/skill and sector includes fewer sectors than the GLORIA database. Disaggregation is done using compensation to employees as proxy (i.e. it is assumed same retribution between sectors belonging to an ILO category).

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Annex I: Mathematical description

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 II: Geographical coverage of the SCP-HAT

Country 1-41	**42-82**	**83-123**	**124-164**
Afghanistan	DR Yemen (Aden)	South Korea	Paraguay
Angola	Denmark	Kuwait	Qatar
Albania	Dominican Republic	Laos	Romania
United Arab Emirates	Algeria	Lebanon	USSR/Russian Federation (1990/1991)
Argentina	Ecuador	Liberia	Rwanda
Armenia	Egypt	Libya	Saudi Arabia
Australia	Eritrea	Sri Lanka	South Sudan
Austria	Spain	Lithuania	Senegal
Azerbaijan	Estonia	Luxembourg	Singapore
Burundi	Ethiopia/DR Ethiopia (1992/1993)	Latvia	Sierra Leone
Belgium	Finland	Morocco	El Salvador
Benin	France	Moldova	Somalia
Burkina Faso	Gabon	Madagascar	Yugoslavia/Serbia (1991/1992)
Bangladesh	United Kingdom	Mexico	Sudan/North Sudan (2010/2011)
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 Arab Republic/Yemen (1989/1990)
Colombia	Jamaica	Panama	South Africa
Costa Rica	Jordan	Peru	Zambia
Cuba	Japan	Philippines	Zimbabwe
Cyprus	Kazakhstan	Papua New Guinea	Rest of Americas

CSSR/Czech Republic (1992/1993)	Kenya	Poland	Rest of Europe
Germany	Kyrgyzstan	North Korea	Rest of Africa
Djibouti	Cambodia	Portugal	Rest of Asia-Pacific

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

Annex III: Sector classification of the SCP-HAT

The following table provides a list of the 97 sectors of the SCP-HAT.

97 Sector	26 Sector
Growing Wheat	Agriculture
Growing Maize	Agriculture
Growing cereals n.e.c	Agriculture
Growing oil crops (inc soy)	Agriculture
growing rice (paddy)	Agriculture
Growing of vegetables melons, roots, tubers, non-perrenial fruits	Agriculture
Growing of sugar crops	Agriculture
Growing of tobacco	Agriculture
Growing of fibre crops	Agriculture
Growing of non-perennial crops n.e.c.	Agriculture
Growing of grapes	Agriculture
Growing of fruit and nuts	Agriculture
Growing of beverage crops	Agriculture
Growing of spices, aromatic, drug and pharmaceutical crops	Agriculture
Growing perennial crops n.e.c. and plant propagation	Agriculture
Raising of ruminant animals	Agriculture
Raising of swine/pigs	Agriculture
Raising of poultry	Agriculture
Raising of animals n.e.c. - support for animal production - mixed farming - Hunting gathering and related services	Agriculture
Post harvest and support activities for crop production	Agriculture
Wood production	Forestry
Wood production related services	Forestry
Wild fish capture	Fishing
Aquaculture	Fishing
Hard coal production	Coal oil & gas mining
Lignite and peat production	Coal oil & gas mining
Extraction of petroleum	Coal oil & gas mining
Extraction of natural gas	Coal oil & gas mining
Ferrous ores extraction	Ore mining
Mining of uranium ores	Ore mining
Mining of Aluminium ore	Ore mining
Mining of copper dominated ores	Ore mining
Mining of gold dominated ores	Ore mining
Mining of lead/zinc/silver dominated ores	Ore mining
Mining of nickel dominated ores	Ore mining
Mining of tin dominated ores	Ore mining
Mining of other non-ferrous ores n.e.c.	Ore mining

Quarrying of stone, sand and clay	Construction material quarrying
Mining of chemical and fertilizer minerals	Construction material quarrying
Extraction of salt	Construction material quarrying
Mining and quarrying n.e.c. and support for petroleum natural gas and mining	Construction material quarrying
Processing, preserving, and manufacture of meat and fish based products	Food
Processing and manufacture of cereal based products	Food
Processing, preserving, and manufacture of food crop products n.e.c - mixed food and feeds n.e.c	Food
Sugar refining and Manufacture of cocoa, chocolate and sugar confectionery	Food
Processing and manufacture of fibre based products and hide (natural or other) based products	Food
Manufacture of vegetable and animal oils and fats	Food
Manufacture of dairy products	Food
Manfacture of Alcoholic and other beverages	Food
Manufacture of tobacco products	Food
Sawmilling and planing of wood - Wood based manufacturing excl. pulp and paper	Wood and paper
Wood pulp and paper production and printing	Wood and paper
Manufacture of coke oven products	Energy
Manufacture of refined petroleum products	Energy
Manufacture of nitrogenous fertilizers	Chemical products
Manufacture of non-nitrogenous and mixed fertilizers	Chemical products
Manufacture of basic petrochemical products n.e.c.	Chemical products
Manufacture of basic inorganic chemicals n.e.c.	Chemical products
Manufacture of pharmaceuticals, medicinal chemical and botanical products	Chemical products
Manufacture of rubber and plastic products n.e.c.	Chemical products
Manufacture of clay building materials	Ceramics
Manufacture of other ceramics n.e.c.	Ceramics
Manufacture of cement, lime and plaster and articles made there-of	Ceramics
Manufacture of other non-metallic mineral products n.e.c.	Ceramics
Manufacture and casting of basic iron and steel	Basic metals
Manufacture and casting of basic Aluminium	Basic metals
Manufacture and casting of basic Copper	Basic metals
Manufacture and casting of basic Gold	Basic metals
Manufacture and casting of basic Lead/Zinc/Silver	Basic metals
Manufacture and casting of basic nickel	Basic metals
Manufacture and casting of basic tin	Basic metals
Manufacture of basic non-ferrous metals n.e.c.	Basic metals
Manufacturing of fabricated metal products, machinery and transport equipment n.e.c., and repair and installation of machinery and equipment	Fabricated metals
Manufacture of computer, electronic, and optical products	Fabricated metals
Manufacture of electrical equipment including metal wiring and cables	Fabricated metals
Manufacture of motor vehicles, trailers and semi-trailers	Transport equipment
Manufacture of furniture and other manufacturing n.e.c	Other manufacturing

Electric power generation, transmission and distribution	Electricity, gas and water
Manufacture of gas, distribution of gaseous fuels through mains	Electricity, gas and water
Water collection, treatment and supply, Sewerage, and Steam and air conditioning supply	Electricity, gas and water
Waste collection, treatment, and disposal	Waste and recycling
Materials recovery	Waste and recycling
Construction of all buildings	Construction
Construction of roads and railways, utilities and other civ. eng. inc. demolition and site preparation	Construction
All Wholesale and retail trade, plus repair of motor vehicles and motorcycles	Wholesale and Retail Trade
Land transport and transport except via pipelines	Transport
Transport via pipeline and n.e.c, Warehousing and support activities for transportation	Transport
Water transport	Transport
Air transport	Transport
Accommodation and food service activities	Hotels and Restraurants
Publishing activities, Telecommunications, Information and communication n.e.c.	Post and Telecommunications
Financial, Insurance, and Real estate activities	Financial Intermediation and Business Activities
Professional, scientific and technical activities	Financial Intermediation and Business Activities
Public administration, Social security, Defence and public order, and Administrative and support service activities n.e.c.	Public Administration
Education	Education, Health and Other Services
Human health and social work activities	Education, Health and Other Services
Arts, entertainment and recreation, Repair of computers, personal and household goods, and Other service activities n.e.c.	Other services

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

Annex IV: Characterisation factors for GHG emissions

Full list substances	kg CO2-eq/kg [GWP100]	kg CO2-eq/kg [GTP100]
Methane (IPCC Cat 1,2,3,5)	36	13
Methane (IPCC Cat 4 and 6)	34	11
Carbon dioxide	1	1
Dinitrogen Oxide	298	297

Source: UNEP, (2016)

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 VI: Correspondence between GLORIA sectors and IPCC categories

IRP-MRIO	IPCC	GLORIA sectors
Growing Wheat	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
Growing Maize	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
Growing cereals n.e.c	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
Growing oil crops (inc soy)	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
Growing rice (paddy)	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C7	Rice cultivations
Growing of vegetables melons, roots, tubers, non-perrenial fruits	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
Growing of sugar cane	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
Growing of fibre crops	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application

	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
Growing of non-perennial crops n.e.c.	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
Growing of grapes	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
Growing of fruit and nuts	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
Growing of beverage crops	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
Growing of spices, aromatic, drug and pharmaceutical crops	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
Growing perennial crops n.e.c. and plant propagation	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
Raising of ruminant animals	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	3A1	Enteric Fermentation
	3A2	Manure Management
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C6	Indirect N2O Emissions from manure management
Raising of swine/pigs	3A1	Enteric Fermentation
	3A2	Manure Management
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils

	3C6	Indirect N2O Emissions from manure management
Raising of poultry	3A1	Enteric Fermentation
	3A2	Manure Management
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C6	Indirect N2O Emissions from manure management
Raising of animals n.e.c. - support for animal production - mixed farming - Hunting gathering and related services	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	3A1	Enteric Fermentation
	3A2	Manure Management
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C6	Indirect N2O Emissions from manure management
Wood production	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Wood production related services	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Aquaculture	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
Hard coal production	1A1bc	Petroleum Refining - Manufacture of Solid Fuels and Other Energy Industries
	1A5	Other Energy Industries
	1B1	Solid Fuels
	5B	Other
Lignite and peat production	1A1bc	Petroleum Refining - Manufacture of Solid Fuels and Other Energy Industries
	1A5	Other Energy Industries
	1B1	Solid Fuels
	5B	Other
Extraction of petroleum	1A1bc	Petroleum Refining - Manufacture of Solid Fuels and Other Energy Industries
	1A5	Other Energy Industries
Extraction of natural gas	1A1bc	Petroleum Refining - Manufacture of Solid Fuels and Other Energy Industries
	1A5	Other Energy Industries
	1B2	Oil and Natural Gas
	5B	Other
Quarrying of stone, sand and clay	2A3	Glass Production

Mining of chemical and fertilizer minerals	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Mining and quarrying n.e.c. and support for petroleum natural gas and mining	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	2A3	Glass Production
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Processing and manufacture of cereal based products	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C6	Indirect N2O Emissions from manure management
	3C7	Rice cultivations
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Processing, preserving, and manufacture of food crop products n.e.c - mixed food and feeds n.e.c	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C6	Indirect N2O Emissions from manure management
Processing and manufacture of fibre based products and hide (natural or other) based products	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture of vegetable and animal oils and fats	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C6	Indirect N2O Emissions from manure management
Manfacture of Alcoholic and other beverages	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C6	Indirect N2O Emissions from manure management
Sawmilling and planing of wood - Wood based manufacturing excl. pulp and paper	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries

	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Sawmilling and planing of wood - Wood based manufacturing excl. pulp and paper	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture of coke oven products	1A1bc	Petroleum Refining - Manufacture of Solid Fuels and Other Energy Industries
	1A5	Other Energy Industries
	1B1	Solid Fuels
	5B	Other
Manufacture of refined petroleum products	1A1bc	Petroleum Refining - Manufacture of Solid Fuels and Other Energy Industries
	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	1B2	Oil and Natural Gas
	2D	Non-Energy Products from Fuels and Solvent Use
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture of nitrogenous fertilizers	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture of non-nitrogenous and mixed fertilizers	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	2C	Metal Industry
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture of basic petrochemical products n.e.c.	1A1bc	Petroleum Refining - Manufacture of Solid Fuels and Other Energy Industries
	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	2B	Chemical Industry
	2D	Non-Energy Products from Fuels and Solvent Use
	2G	Solvent and other product use: other
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture of basic inorganic chemicals n.e.c.	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	2A4	Other Process Uses of Carbonates
	2B	Chemical Industry
	2C	Metal Industry
	2G	Solvent and other product use: other
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
	1A2	Manufacturing Industries and Construction

Manufacture of pharmaceuticals, medicinal chemical and botanical products	1A5	Other Energy Industries
	2B	Chemical Industry
	2G	Solvent and other product use: other
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture of rubber and plastic products n.e.c.	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture of clay building materials	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture of other ceramics n.e.c.	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture of cement, lime and plaster and articles made there-of	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	2A1	Cement production
	2A2	Lime production
	2A3	Glass Production
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture of other non-metallic mineral products n.e.c.	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	2C	Metal Industry
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture and casting of basic iron and steel	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture and casting of basic Aluminium	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	2C	Metal Industry
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture and casting of basic Copper	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture and casting of basic Gold	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3

Manufacture and casting of basic Lead/Zinc/Silver	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture and casting of basic nickel	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture and casting of basic tin	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture of basic non-ferrous metals n.e.c.	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	2C	Metal Industry
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacturing of fabricated metal products, machinery and transport equipment n.e.c., and repair and installation of machinery and equipment	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture of computer, electronic, and optical products	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture of electrical equipment including metal wiring and cables	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture of motor vehicles, trailers and semi-trailers	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Manufacture of furniture and other manufacturing n.e.c	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	2D	Non-Energy Products from Fuels and Solvent Use
	2G	Solvent and other product use: other
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Electric power generation, transmission and distribution	1A1a	Main Activity Electricity and Heat Production
	1A5	Other Energy Industries
Waste collection, treatment, and disposal	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3

Manufacture of gas; distribution of gaseous fuels through mains	1A1bc	Petroleum Refining - Manufacture of Solid Fuels and Other Energy Industries
	1A5	Other Energy Industries
	1B1	Solid Fuels
	5B	Other
Waste collection, treatment, and disposal	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Materials recovery	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	2H	Other
	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C6	Indirect N2O Emissions from manure management
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Financial, Insurance, and Real estate activities	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C6	Indirect N2O Emissions from manure management
Professional, scientific and technical activities	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	3C1	Emissions from biomass burning
	3C2	Liming
	3C3	Urea application
	3C4	Direct N2O Emissions from managed soils
	3C5	Indirect N2O Emissions from managed soils
	3C6	Indirect N2O Emissions from manure management
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3
Arts, entertainment and recreation, Repair of computers, personal and household goods, and Other service activities n.e.c.	1A2	Manufacturing Industries and Construction
	1A5	Other Energy Industries
	5A	Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3

Annex VI: Raw material categories of the SCP-HAT and sector correspondence

The following table provides a list of the 62 raw material categories of the SCP-HAT:

Raw material use categories	**GLORIA Sectors**
Rice	Growing rice (paddy)
Wheat	Growing Wheat
Cereals n.e.c.	Growing Wheat
	Growing Maize
	Growing cereals n.e.c
	Manfacture of Alcoholic and other beverages
Other crops n.e.c	Growing of beverage crops
	Growing of spices, aromatic, drug and pharmaceutical crops
	Processing, preserving, and manufacture of food crop products n.e.c - mixed food and feeds n.e.c
Spice - beverage - pharmaceutical crops	Growing of tobacco
	Growing of fruit and nuts
	Growing of beverage crops
	Growing of spices, aromatic, drug and pharmaceutical crops
	Raising of animals n.e.c. - support for animal production - mixed farming - Hunting gathering and related services
Tobacco	Growing of tobacco
	Materials recovery
Roots and tubers	Growing of vegetables melons, roots, tubers, non-perrenial fruits
	Growing of non-perennial crops n.e.c.
	Growing of spices, aromatic, drug and pharmaceutical crops
Sugar crops	Growing of sugar crops
	Growing perennial crops n.e.c. and plant propagation
Pulses	Growing of vegetables melons, roots, tubers, non-perrenial fruits
Nuts	Growing of fruit and nuts
Oil bearing crops	Growing oil crops (inc soy)
	Growing of fibre crops
	Raising of animals n.e.c. - support for animal production - mixed farming - Hunting gathering and related services
	Processing, preserving, and manufacture of food crop products n.e.c - mixed food and feeds n.e.c
	Manufacture of vegetable and animal oils and fats
Vegetables	Growing Maize
	Growing of vegetables melons, roots, tubers, non-perrenial fruits
	Growing perennial crops n.e.c. and plant propagation
	Processing, preserving, and manufacture of food crop products n.e.c - mixed food and feeds n.e.c
Fruits	Growing of vegetables melons, roots, tubers, non-perrenial fruits
	Growing of grapes

	Growing of fruit and nuts
Fibres	Growing of fibre crops
Fibres	Processing and manufacture of fibre based products and hide (natural or other) based products
Straw	Growing cereals n.e.c
Other crop residues (sugar and fodder beet leaves etc)	Raising of ruminant animals
	Raising of swine/pigs
	Raising of poultry
	Raising of animals n.e.c. - support for animal production - mixed farming - Hunting gathering and related services
Grazed biomass	Raising of ruminant animals
	Raising of swine/pigs
	Raising of poultry
	Raising of animals n.e.c. - support for animal production - mixed farming - Hunting gathering and related services
Timber (Industrial roundwood)	Wood production
	Sawmilling and planing of wood - Wood based manufacturing excl. pulp and paper
Wood fuel and other extraction	Wood production related services
	Sawmilling and planing of wood - Wood based manufacturing excl. pulp and paper
Wood fuel and other extraction	Materials recovery
Wild fish catch	Wild fish capture
All other aquatic animals	Aquaculture
	Processing, preserving, and manufacture of meat and fish based products
Aquatic plants	Aquaculture
Iron ores	Ferrous ores extraction
Silver ores	Mining of lead/zinc/silver dominated ores
Bauxite and other aluminium ores - gross ore	Mining of Aluminium ore
Gold ores	Mining of gold dominated ores
Chromium ores	Mining of other non-ferrous ores n.e.c.
Copper ores	Mining of copper dominated ores
Manganese ores	Mining of other non-ferrous ores n.e.c.
Other metal ores	Mining of uranium ores
	Mining of other non-ferrous ores n.e.c.
Nickel ores	Mining of nickel dominated ores
Lead ores	Mining of lead/zinc/silver dominated ores
Platinum group metal ores	Mining of other non-ferrous ores n.e.c.
Tin ores	Mining of tin dominated ores
Titanium ores	Mining of other non-ferrous ores n.e.c.
Uranium ores	Mining of uranium ores
Zinc ores	Mining of lead/zinc/silver dominated ores
Ornamental or building stone	Quarrying of stone, sand and clay
Chalk	Quarrying of stone, sand and clay

Dolomite	Quarrying of stone, sand and clay
Limestone	Quarrying of stone, sand and clay
Fertilizer minerals n.e.c.	Manufacture of non-nitrogenous and mixed fertilizers
Chemical minerals n.e.c.	Mining of chemical and fertilizer minerals
	Manufacture of nitrogenous fertilizers
	Manufacture of non-nitrogenous and mixed fertilizers
Industrial minerals n.e.c	Quarrying of stone, sand and clay
	Mining of chemical and fertilizer minerals
	Mining and quarrying n.e.c. and support for petroleum natural gas and mining
	Manufacture of non-nitrogenous and mixed fertilizers
Salt	Extraction of salt
Gypsum	Quarrying of stone, sand and clay
Structural clays	Quarrying of stone, sand and clay
Specialty clays	Quarrying of stone, sand and clay
Industrial sand and gravel	Quarrying of stone, sand and clay
Sand gravel and crushed rock for construction	Quarrying of stone, sand and clay
Other non-metallic minerals n.e.c.	Quarrying of stone, sand and clay
	Mining of chemical and fertilizer minerals
	Mining and quarrying n.e.c. and support for petroleum natural gas and mining
	Manufacture of cement, lime and plaster and articles made there-of
Lignite (brown coal)	Lignite and peat production
Other Sub-Bituminous Coal	Hard coal production
Anthracite	Hard coal production
Coking Coal	Manufacture of coke oven products
Other Bituminous Coal	Hard coal production
Peat	Lignite and peat production
Crude oil	Extraction of petroleum
Natural gas	Extraction of natural gas
Natural gas liquids	Extraction of natural gas Oil shale and tar sands Extraction of petroleum
Oil shale and tar sands	Extraction of petroleum

Annex VII: Land use and biodiversity loss categories of the SCP-HAT and sector correspondence

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

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.

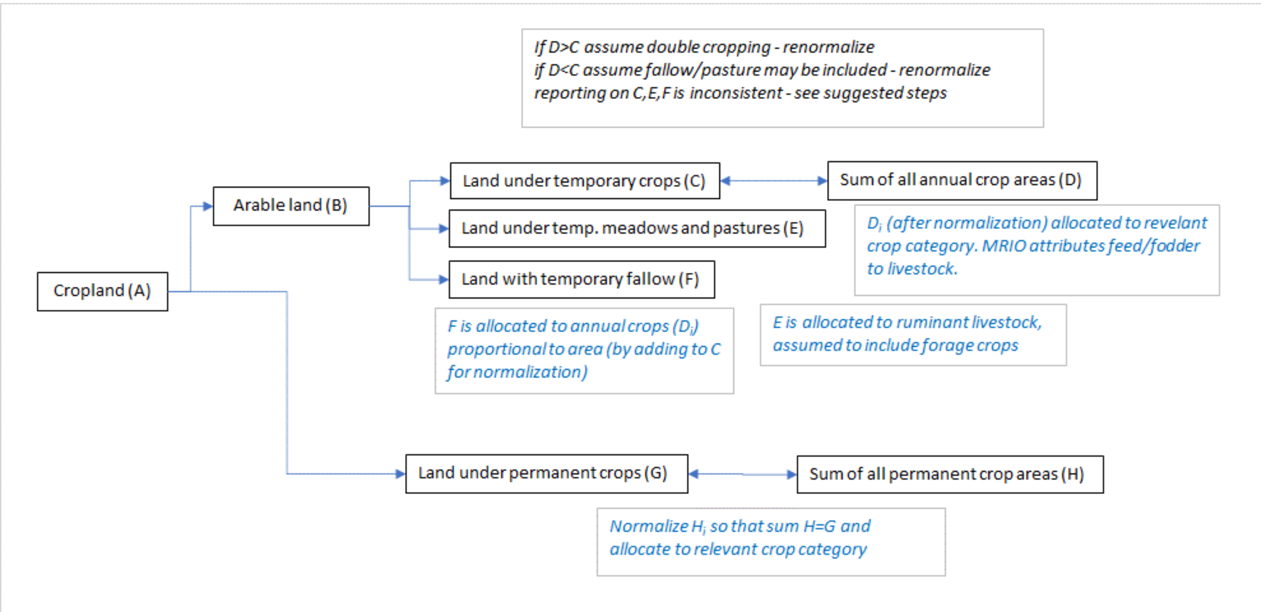

Figure 2 Schedule for calculating annual and permanent crop land use

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.

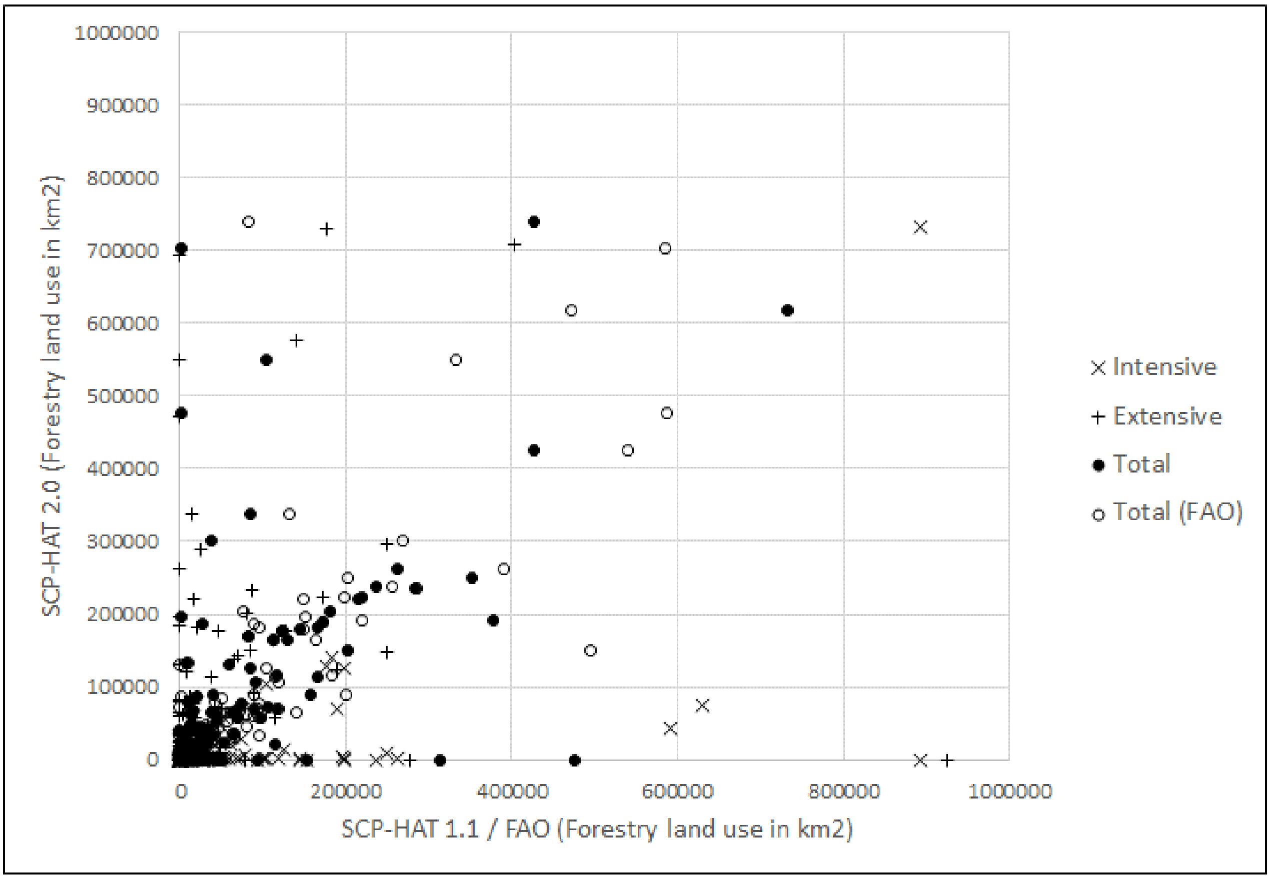

Figure 3 Comparison of forest areas in SCPHAT 2.0 against SCP-HAT 1.1 as well as FAO data for productive forest area by country for year 2010

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

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

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)

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

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

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

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

$$(FAOreportsn = 11cropsectorsthatmatch6IRPsectors)$$

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

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

$$(FAOreportsn = 16livestocksectorsthatmatch3IRPsectors)$$

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

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

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

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

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

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.

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

$$FAO_{BCR} = Emissions(CH4)(Burningcropresidues) \vee Emissions(N2O)(Burningcropresidues)$$

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)

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

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

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

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

$$= Nleach_{UNFCCC}\,(j,k) \Big/ \sum_{n=1}^{16} FAO_{MMS}(n,j,k) for Annex I countries; weighted average for non Annex I$$

$$FAO_{MMS} = nitrogen content manure management$$

Agricultural soils (3C5)

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

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

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

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

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.

Annex XIII: Changes between SCP-HAT v1.1 (release 2019) and SCP-HAT v.2.0 (release 2021)

To be updated.