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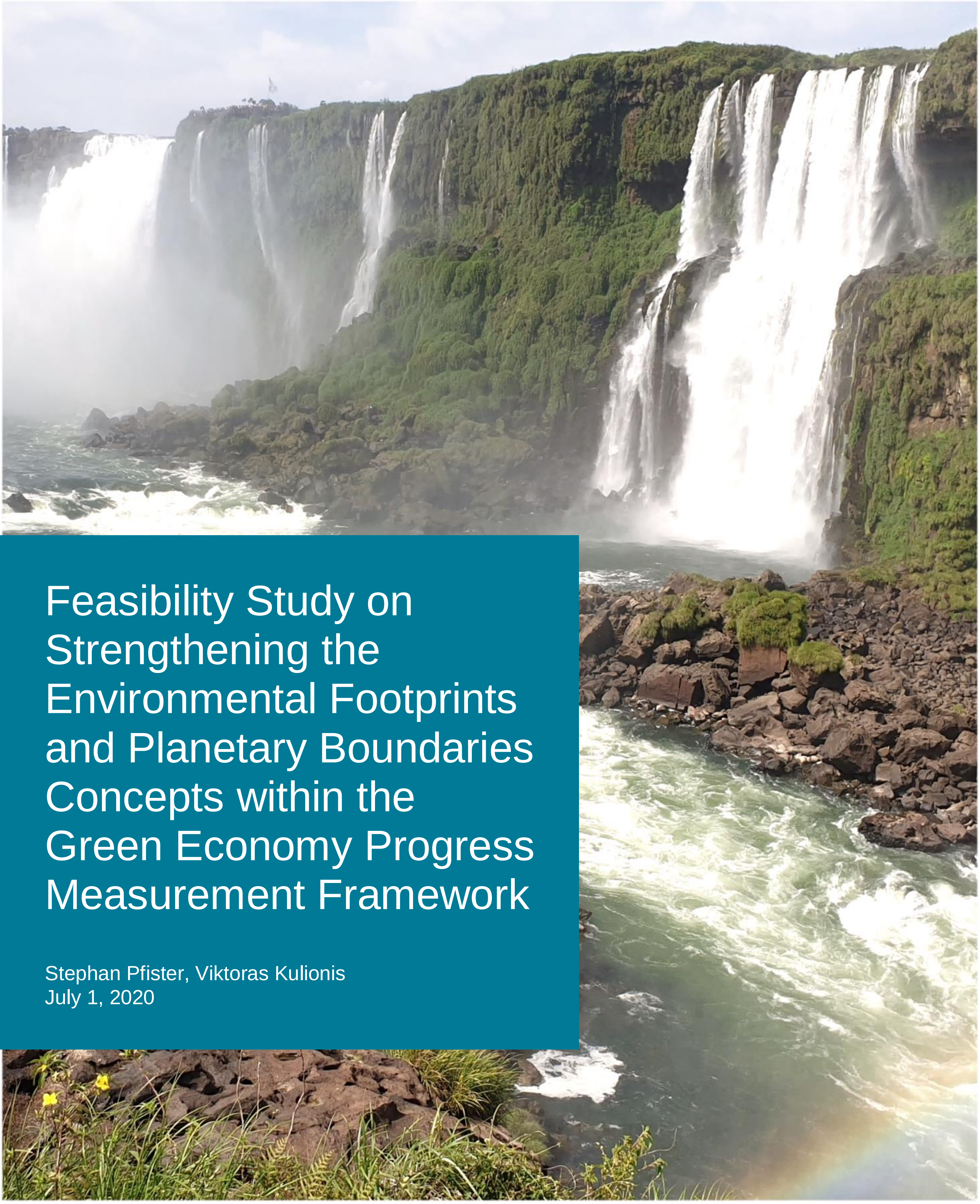

Feasibility Study on Strengthening the Environmental Footprints and Planetary Boundaries Concepts within the Green Economy Progress Measurement Framework

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July 1, 2020

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Imprint

Commissioned by

United Nations Environment Programme P.O. Box 30552-00100, Nairobi, Kenya
Represented by its Economy Division

Contractor

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Acknowledgements

This study is based on the input document by Jamal Srouji (UNEP) as well as data shared by Pablo Pinero (Vienna University) for the SCP-HAT tool and Livia Cabernard (ETH Zurich) for the GRO tool and the preliminary results from the MRIO merge of EXIOBASE and EORA. Stephan Lutter (Vienna University) provided input on the implementation section. The revised versions included detailed comments by Llorenc Mila I Canals and Jamal Srouji from UNEP and Niklas Nierhoff from Swiss Federal Office of the Environment. The final version includes improvements due to review comments by Arnold Tukker, Andreas Hauser, Jose Pineda, Stefanie Hellweg and Adebiyi Odegbile, as well as minor changes from editing and proofreading by Bushra Elmoussati and formatting by Lu Meng.

Suggested form of citation

United Nations Environment Programme (2020). *Feasibility Study on Strengthening the Environmental Footprints and Planetary Boundaries Concepts within the Green Economy Progress Measurement Framework.*

Note: This information leaflet was prepared under contract to the United Nations Environment Programme. The contractor bears sole responsibility for the content.

Content

1. Introduction

The footprint indicators and the relating planetary boundary framework provide crucial information regarding progress towards a green economy. Many international mitigation targets are set referring to the pressures generated from production activities within the territory of the country (known as the territorial perspective). However, due to increasing globalization and offshoring, value chains of most goods now span over various countries. As a result, traditional territorial accounting has become insufficient to understand how the consumption of products in a country drives environmental impacts on a global scale. The consumption-based accounting approach (known as a footprint) complements the territorial perspective by accounting for environmental pressures due to the consumption of goods and services within a country, irrespective of the geographic location of the production of goods and services (EEA, 2013). Although the consumption-based perspective is not addressed within international conventions, it has become an invaluable tool for the international community to better understand the effect of consumption patterns on various environmental pressures.

GHG emissions and the use of resources, such as land, water and materials, were amongst the first indicators that were assessed from a consumption perspective (Wiedmann and Lenzen, 2018). The results have sparked political debates regarding the responsibility for impacts resulting from the consumption of goods and services. Many studies have attempted to quantify the magnitude and severity of these impacts to improve decision making and design an appropriate policy response. Currently, many national statistical institutes, as well as supranational institutes such as OECD, EEA and Eurostat, are looking into methods to compile consumption-based indicators robustly and consistently (Tukker et al., 2018).

Consumption-based indicators have also been used to assess national environmental performance on Planetary Boundaries. Nykvist et al. (2013) provide the first attempt to downscale global limits to national limits and to perform a comparison with territorial (or production-based) estimates.

Similar efforts followed within other countries. Dao et al. (2015) and Dao et al. (2018) computed national environmental limits based on the Planetary Boundary framework for Switzerland. In that sense, the Swiss Green Economy Indicator Set includes, amongst other indicators, the Swiss footprints for i) biodiversity loss, ii) greenhouse gas (GHG) emissions and iii) water. Nathani et al. (2019) extended the planetary boundary framework to the industry level and calculated environmental limits and footprints for Swiss companies. Lucas and Wilting (2018) performed a similar study based on the Planetary Boundary framework to support a national implementation of environment-related sustainable development goals for the Netherlands. Others (Hoff et al. 2014; Häyhä et al. 2018; EEA 2019; EEA 2020) have operationalized a safe operating space concept at the EU level.

However, there is no scientifically agreed approach to properly address footprints in the context of planetary boundaries yet. A main issue is the assessment of absolute targets for a boundary vs. the political practicability for reaching a target. This is especially difficult for biodiversity loss, which is exceeding estimated boundaries by far (Steffen et al. 2015).

2. Goal of the project

The aim of this feasibility study is to combine the efforts on the measurement of environmental footprint indicators within the Green Economy Progress (GEP) Measurement Framework developed by UN Environment. More specifically, the study will focus on establishing the availability of data and the most appropriate database. This will be achieved by assessing the feasibility of a country's specific footprints and recommending a methodology (as well as creating a link to the GEP Measurement Framework). **In particular to its dashboard of environmental sustainability indicators**, for the following footprints indicators (see appendix for more details):

- greenhouse gas footprint
- biodiversity footprint (based on LC Initiative recommendations for land use)
- water footprint based on LC Initiative recommendations (AWARE)

Additionally, the feasibility study will explore the linkages to the SCP-HAT tool, also developed by UN Environment aimed at supporting the design of national action plans for sustainable consumption and production.

3. Data sources for calculating country environmental footprints

Below, the main data source to assess footprints are described and Table 1 summarizes the main features, incl. the sectoral and regional resolution as well as the extensions available for assessing carbon, water and land footprints.

3.1 Databases

3.1.1 Eora

This database has one major advantage in comparison to other available MRIO databases. It covers 188 countries/regions (of which about 113 are estimated) and thus, allows performing nation-specific analysis for a larger number of countries/regions than any other MRIO database. Two Eora versions are available; the Full Eora and the Eora26. The difference between them resides in the sectoral classification. The former has a higher resolution, which varies depending on the country from 26 to ~500, whereas the latter includes 26 sectors for all countries (which is the resolution adopted in the SCP-HAT). Even though Full Eora can be considered more accurate, using Eora26 avoids possible computational problems, since memory needs and server space would be significantly lower. However, this is not a major issue with current IT infrastructure. EORA 26 also provides more consistent results, since many countries have only 26 sectors also in full EORA.

3.1.2 EXIOBASE 3

EXIOBASE 3 has a different focus: It distinguishes 163 sectors, but only 44 individual countries (plus 5 Rest of the World regions). It covers the EU plus the largest economies world-wide as individual countries. This means the EXIOBASE study does not allow for the assessment of most countries. On the other hand, the environmental assessment improves greatly since exchanges are distinguished in more sectors (e.g. knowing what type of electricity is used, or what type of crop). Time series is available from 1995 to 2011 and for the newest version (3.7) time series is available for the period 1995–2016. However, it should be noted that the original EXIOBASE 3 data series ends in 2011. The new time series are estimates based on trade and macro-economic data up to 2016. A lot of care must be taken when utilising this data as it is only partially suitable for analyzing trends over time.

3.1.3 GTAP

The Global Trade Analysis Project (GTAP) database version 10 (released in 2019), covers 121 countries (plus aggregate 20 regions) and 65 industries for four benchmark years; 2004, 2007, 2011 and 2014 (no time series). GTAP consists of individual country input-output tables and in its original format is not suitable for an MRIO analysis. Peters et al. (2011) demonstrated how the GTAP database can be converted into an MRIO table. The GTAP database will be updated for the newest release including the energy and environmental extension and the land use and cover extension (no publication date available). However, neither water nor all greenhouse gas extensions are available. Furthermore, a license needs to be purchased.

3.1.4 WIOD

World input-output database (WIOD) contains two releases: WIOD 2013 release and WIOD 2016 release. The earlier WIOD 2013 release covers 35 industries and 41 countries/regions. This includes 27 EU countries, 13 other major economies alongside the rest of the world (ROW) region for the period 1995–2011. It comes with environmental accounts containing data for CO_2, other greenhouse gas emissions, energy, land, material and water use for the period 1995–2009. WIOD 2013 does not cover smaller countries (such as Switzerland) as a separate entity in the MRIO table. Instead, it is included in the ROW region.

A more recent WIOD 2016 release provides monetary MRIO tables covering 56 industries and 44 countries (including e.g. Switzerland) for the period 2000–2014. Initially, the WIOD 2016 release did not contain any environmental extensions, but recently (July 2019), the Joined Research Center (JRC) launched the WIOD-based environmental extensions. However, land and water use are not covered by the JRC environmental extensions. It contains data only for CO_2 emissions and energy use.

3.1.5 OECD IO

The most recent version of the OECD Inter-Country Input-Output (OECD ICIO) database covers 65 countries/regions and 34 industries for the period 2005–2015. The OECD ICIO is built by this internationally recognized organization and consequently can be seen as part of “official statistics”. All other databases have been built by academic researchers and face questions regarding credibility (see e.g. Tukker et al., 2018). However, it is highly aggregated (34 sectors) and provides environmental extensions only for CO_2.

Table 1 Database overview

Database	Coverage			Extensions				
	Country	Sector	Time	CO2	GHG	Energy	Land	Water
Eora	189	26 to ~500	1990–2013	+	+	+	+	+
EXIOBASE v3.4	44 + 5	163	1995–2011	+	+	+	+	+
EXIOBASE v3.7	44 + 5	163	1995–2016	+	+	+	+	+
WIOD 2013	40 + 1	35	1995–2009	+	+	+	+	+
WIOD 2016	43 + 1	56	2000–2014	+		+		
GTAP	121 +20	65	2004,2007, 2011, 2014	+	(+/-)	+	+	
OECD ICIO	64+1	34	2005-2015	+				

3.1.6 Empirically observed differences in footprint indicators across databases

Footprint indicators calculated with different MRIOs might vary considerably (see Tukker et al. 2020 for an overview). For instance, Moran and Wood (2014) show that carbon footprint results disagree up to 10-20% for major economies. Owen et al. (2014) found deviations of 30% or more for eight countries, out of a 40 country sample harmonized across the databases. There is no clear pattern in which countries are more vulnerable to large deviations, but relatively small economies tend to feature higher differences. That being said, some large economics like Russia, Spain, Brazil and Japan also show high deviations (Tukker et al. 2020). It should also be noted that production-based accounts based on standard inventories of territorial emissions also contain uncertainties.

A variety of factors contribute to the observed differences in carbon footprint indicators. Usually these include i) differences in levels of sectoral and spatial aggregation, ii) use of territorial vs. residential allocation principle when compiling environmental accounts, iii) MRIO construction process, iv) adjustment for transit trade, and v) underlying emission data. The most significant being the underlying emission data which accounts for about 50% of variation in carbon footprint estimates (Moran and Wood, 2014). Harmonizing the underlying data is the single most important factor that can help reduce uncertainty in carbon footprint estimates (Tukker, et al. 2020).

Whilst there may be significant differences between MRIOs for the levels of carbon emissions, the relative changes (from year to year) in carbon footprints are robust. Wood et al. (2019) demonstrate that variation in consumption-based emissions of large country blocks (such as the EU) is reduced to very low levels (less than 2%) if results are normalized to a common value for a common base year.

Furthermore, it should be noted that a carbon footprint usually accounts for all greenhouse gases (GHG) and summarizes the effects in CO_2-equivalents (see also the details in the Appendix 8.1 and 8.2). However, not all databases have the same coverage of GHGs: some focus on CO_2, CH_4 and N_2O, as the main GHGs of human activities. Many of the studies mentioned above focus mainly on CO_2 emissions.It is very likely that other GHG emissions have higher uncertainties, since methane and N_2O emissions are more difficult to estimate and include additional assumptions in terms of their global warming potential. For other environmental indicators, such as water use and biodiversity, the uncertainties and differences among databases and methods are even higher, as illustrated for the comparison of different water scarcity footprints of the EU27 (Pfister and Lutter 2016).

3.2 Available Tools

Several tools (apps) have been built to explore and analyze the results from production and consumption-based perspectives. Here we describe the several tools and their respective features. Additionally, there are other similar tools available online such as bluedot.world (from UNEP, Geneva and EA), https://environmentalfootprints.org/ (from NTNU). These tools focus on different aspects and serve a different purpose. It should be noted that these tools (apps) are not the underlying sources of data (see section 3.1 for data sources).

3.2.1 The SCP-HAT (Sustainable Consumption and Production Hotspot Analysis Tool)

The SCP-HAT (SCP Hotspot Analysis 2019) allows for analysing direct (as well as indirect) trade-related impacts which are brought about by national economies. The tool is therefore able to identify hotspots related to domestic pressures and impacts (production or territorial perspective). Moreover, the impacts occurring in supply chains in foreign countries or linked to domestic consumption (consumption or footprint perspective). Importantly, the SCP-HAT provides the possibility for analysing the performance of a large number of countries by identifying different product groups and economic sectors. This is executed with regard to specific environmental and social pressures and impacts they cause. Thereby, the tool allows for identifying the hotspot areas of unsustainable production (and consumption). Based on this analysis, it supports setting priorities in national SCP and climate policies for investment, regulation and planning.

To achieve this, the SCP-HAT provides a range of production and footprint-type indicators which are accessible through an intuitive and flexible online app. While the default version allows users of any level of expertise to retrieve valuable information, more advanced users have the possibility of using country data to specify the results.

In its basic conception, the approach adopted for the SCP-HAT is an Environmentally Extended Multi-Regional Input-Output (EE-MRIO) model coupled with Life Cycle Assessment (LCA) for environmental impact assessment. EE-MRIO is an analytical tool supported by the System of Environmental-Economic Accounting (SEEA), to attribute environmental burdens to final demand categories (United Nations et al. 2017). EE-MRIO adopts a top-down approach. Supply chain-wide environmental pressures and impacts are modelled at a macro level for broad product groups or industries. This is done by linking domestic data on pressures (e.g. material extraction) and impacts (e.g. deforestation) expressed in physical units (also called ‘satellite accounts’) with monetary data on transactions among economic sectors and final consumers of different countries (mathematical details in Annex I). Applying this approach to the SCP-HAT allows tracking the flow of goods and services by linking domestic pressures (national environment) with foreign consumption (countries A to F in Figure 1), and foreign pressures with domestic consumption. This characterization of global supply-chains and the identification of hotspots is developed at the level of economic sectors and final demand categories.

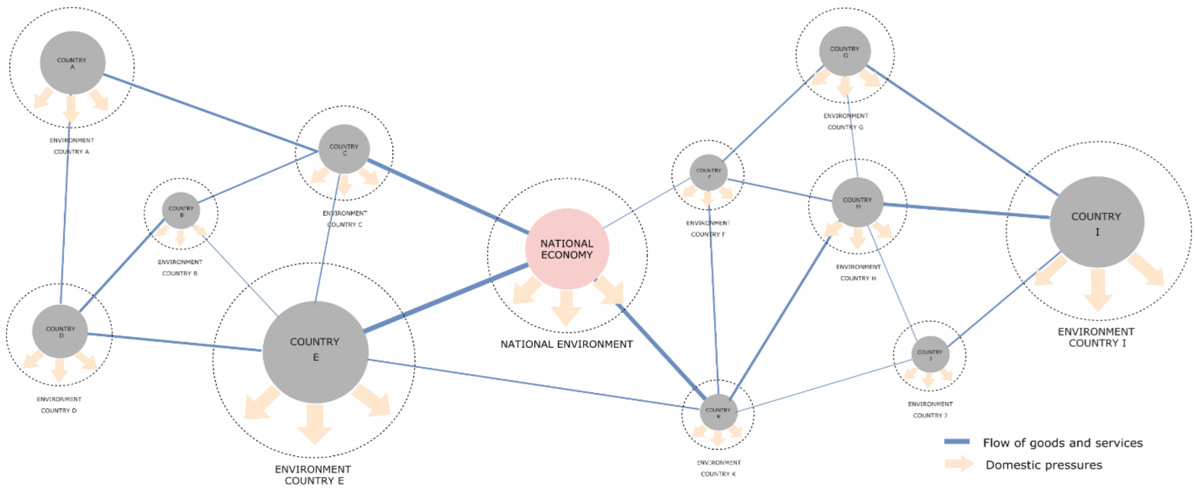

Figure 1: The basic concept of SCP-HAT

EE-MRIO is complemented by LCA for the calculation of certain environmental and social impact variables. LCA adopts a bottom-up approach and assesses environmental impacts related to certain pressures (using Life Cycle Impact Assessment (LCIA) characterization factors). For example, while environmental accounts used in EE-MRIO provide data on land use in the countries around the world, LCA “translates” the amounts of land use into biodiversity loss. This step adheres as much as possible to the Global Guidance for Life Cycle Impact Assessment Indicators set by the Life Cycle Initiative, hosted by the United Nations Environment Programme (Frischknecht et al. 2016)

Because of the structure of SCP-HAT there are important synergies with the feasibility study at hand.

3.2.2 GRO Tool (based on EXIOBASE)

EXIOBASE v3 (Stadler et al. 2018) shares similar structures and functionalities as the database used in the SCP-HAT tool. EXIOBASE has been used to develop a tool for the Global Resource Outlook (GRO) 2019 report by IRP (IRP 2019a) (Cabernard et al. 2019). The Developed tool allows not only to assess production and consumption perspectives, but also intermediate steps (e.g. impact of material production) without double-counting.

i. Greenhouse Gas Emissions

Eora presents several extensions for GHG emissions with limited documentation. The use of GHG is further described in the Appendix.

EXIOBASE is documented in detail (Stadler et al. 2018) and no further changes have been made. They have used a bottom-up model to avoid data inconsistencies arising from different databases. The main procedure for the calculation of GHG emissions is the combination of process activity data and emission factors of the TEAM model (Pulles et al. 2007).

ii. Water and land use / biodiversity

Land use impact indicators are available in the SCP HAT. For water consumption, data is missing in the SCP HAT.

EXIOBASE used water consumption data for sectors and countries to create extensions. Alongside this, the same water data can be used for extensions. Furthermore, EORA already provides some water consumption data as part of their satellite matrix (KGM & Associates 2019).

Since both, land and water impact assessment require spatial explicit assessment, no direct conversion from land use to biodiversity impacts is possible. However, the same procedure as used in EXIOBASE for water consumption and related impacts (Lutter et al. 2016) could be applied to quantify land use impacts based on the UNEP/SETAC report on recommended LCIA methods. This could be done in combination with land use maps, such as available from FAO (Food and Agriculture Organization of the United Nations).

The GRO-tool provides a spatial explicit impact assessment for land use and water consumption (IRP 2019a). It is based on the procedure explained by Lutter et al. 2016. It builds up on the extensions from EXIOBASE v3, described below (Stadler et al. 2018).

The EXIOBASE v3 water data is based on Pfister et al. (2011); Pfister and Bayer (2014) and Mekonnen and Hoekstra (2011). These studies are partially based on FAO data. For industrial water consumption, WaterGAP results (Flörke et al. 2013) are used. WaterGAP covers livestock, electricity production and manufacturing sectors. However, allocation to specific sectors is difficult and should be improved in future.

EXIOBASE v3 land-use data is mainly based on annual statistical data from FAO (FAO 2017). This data is combined with spatially explicit land-use data (Erb et al. 2007; Ramankutty et al. 2008; Schepaschenko et al. 2015; Potapov et al. 2017) to determine land use types and location.

The impact assessment requires differentiation into 6 land use types (urban, intensive forestry, extensive forestry, permanent crop, annual crop and pasture). This data has been calculated based on Pfister et al. (2011) for the individual crops (with subsequent assessment of respective biodiversity impact). For forestry, pasture and urban land use, land cover maps are used for quantifying the related impacts on a spatial explicit level.

3.3 Other valuable data sources

3.3.1 Pfister and Bayer 2014

Data on monthly and watershed levels for individual crops allowing for a water scarcity assessment is available from Pfister and Bayer (2014).[1] However, this represents the year 2000 and needs to be scaled to represent the current situation.

3.3.2 Scherer and Pfister 2017

The second most important water consumer sector is hydropower, for which detailed data is available as “National Carbon and Water Footprints of Hydropower” (Scherer and Pfister 2016).

[1] Available online https://data.mendeley.com/datasets/brn4xm47jk/2

3.3.3 USGS land use data

Detailed data from land use include sources used in EXIOBASE (e.g. Erb et al. (2007); Ramankutty et al. *(2008)) but also high resolution maps such as those form USGS (*U.S. Geological Survey) are available for more detailed assessments. However, a main limitation is the lack of a more detailed differentiation of land use in the impact assessment method compared to Chaudhary, Pfister, and Hellweg (2016).

3.3.4 Utilization of detailed data

In order to utilize more detailed data on water and land use, they need to be coupled with trade statistics. As agricultural production is of highest importance, FAOSTAT is an adequate resource. This has been shown for the combined assessment of water footprint using EXIOBASE and FAOSTAT data by Weinzettel and Pfister (2019) alongside land use by Bruckner et al. (2019) and Bjelle et al. (2020). The latter also includes additional data sources.

In summary, SCP-HAT allows us to cover 171 countries for carbon footprints, based on detailed assessments of the 26 Sectors. This is a low resolution leading to higher uncertainty. Carbon Footprint is in general less affected by the aggregation than water impacts and biodiversity loss. For water footprint, the errors can be unacceptably large according to Bouwmeester and Oosterhaven (2013). The same applies to land use impacts. Additionally, SCP-HAT does not allow us to calculate water footprints. Data is available for calculating the progress from 1990-2015.

EXIOBASE allows for the calculation of all 3 impacts for 44 countries only. Carbon, land and water scarcity footprints are calculated based on detailed input data. Data is available for calculating the progress from 2000-2015 (data form 2012-2015 are “now-casted, i.e. projected from previous data).

EORA has water consumption, land use and several GHG emissions options. However, the SCP-HAT tool impact assessment does not include water use. This may be due to the largely missing documentation of environmental extensions in EORA. Biodiversity impacts related to land use in the SCP-HAT are available in the tool. However, access to the underlying data has not been available for this study. This study uses the version 1.0, which was publicly available at the time of the analysis.

In order to calculate all indicators for as many countries as possible with a balanced global distribution, this study uses preliminary results from a merge of EXIOBASE and EORA data (Cabernard et al. in preparation[2]). The resulting MRIO data was only available for 2001 and 2011 for 189 individual countries (since the work is still in progress). Other environmental impacts covered in LCA such as toxic emissions, PM impacts and resource consumption, cannot currently be implemented in order to allow the assessment of a comprehensive set of impact categories or for assessing “total environmental impacts” provided in fully aggregating LCA methods, such as ReCiPe or Swiss Ecoscarcity.

This would require a combination of Life Cycle inventory (LCI) databases such as ecoinvent v3 (ecoinvent 2019) with MRIO databases. The Global LCA Data Access network (GLAD) of UNEP (United Nations Environment Programme 2019) should be involved in providing guidance on the general structure to include additional LCI sources. Such a combination is possible, but involves several methodological issues. These issues involve data gaps as process LCI databases cover only a fraction of all industrial activities. Available options and recommended solutions for GEP data sources are described below.

3.3.5 Available options

Option 1: Only SCP-HAT

[2] The method has been applied for resolving 2 additional countries for the IRP G20 factsheets on resource use (IRP 2019b)

As discussed above and indicated in the results, the use of the SCP-HAT tool is straight-forward, but only allows to directly account for carbon footprints.

Option 2: Only GRO tool

The GRO tool (Cabernard et al. 2019) provides the three necessary extensions to calculate the footprints, but only for 44 countries. This is insufficient coverage for the GEP framework.

Option 3: Combination SCP-HAT and GRO-Tool (i.e. of the underlying databases)

This combination can help to achieve high country resolution. Therefore, the coverage provided by EORA in the SCP-HAT tool (including the sector detail and extensions) form EXIOBASE that have been coupled with spatially explicit impact assessment for agriculture and forestry for land and water use in the GRO tool.

Option 4: Combination SCP-HAT and GRO-Tool plus linkage with LCI databases

Linking the MRIO with ecoinvent (or other LCI databases) can increase the level of detail of crop production and forestry while covering additional impacts such as toxicity for sectors of special concern. However, this requires inclusion of additional detailed trade data, (such as FAOSTAT) and is a larger project. An integrated combination would allow for a more complete impact assessment based on LCA methods. Having said that, many limitations need to be overcome in making this option a long-term vision.

Option 5: New merged MRIO database

Theoretically, the best solution would be a fully merged database using the strengths of the existing databases. This requires a MRIO project with significant funding.

It is important to note that calculations using very large databases are computationally heavy and may require supercomputers or the adjustment of a method. For instance, Bjelle (2020) recommends using an emissions embodied in bilateral trade (EEBT) approach instead of the conventional MRIO method.

3.3.6 Recommended solution: integrate data of existing tools into one

In order to achieve acceptable country and sector resolution (as well as for covering carbon, water and land use related impacts), a detailed combination of the SCP-HAT and GRO tool may be the best option. In principle, it would link EORA and EXIOBASE as a basis while updating data by using synergies with developments for the next versions of the SCP HAT tool. Resolving EXIOBASE through Eora would facilitate 189 countries with a sector resolution of 163. Obviously, data quality is limited for those countries that are estimated based on this approach. It still is a substantial improvement over the 26 sector resolution from EORA for these countries. Seeing that agricultural production in EORA26 is limited to 1 sector, it dominates the land and water use impacts. Further research is needed to assess the quality in detail, but results using this approach for Saudi-Arabia and Argentina (IRP 2019b) are considered to be meaningful.

If the goal is to cover additional environmental impacts, a combination of ecoinvent and the merged MRIO database, then additional impact categories could be covered. However, this is not recommended within the GEP framework.

Finally, synergies between updates of SCP-HAT, the GRO tool and the GEP measurement framework would allow for the use of synergies while providing consistent assessments concerning environmental assessment for footprints.

4. Incorporating environmental footprint indicators to the GEP Measurement framework

4.1 Introduction: GEP Measurement framework and environmental footprint indicators

In 2017, UNEP launched the Green Economy Progress (GEP) Measurement Framework (GEMF) consisting of two components: the **Green Economy Progress Index** (GEP Index) which includes 13 multidimensional indicators; and the **Dashboard of Sustainability** composed of six indicators (PAGE 2017a). The GEMF includes the material footprint in the GEP Index (from a consumption perspective) alongside the ecological footprint in the dashboard of sustainability indicators (consumption perspective). Freshwater withdrawal, greenhouse gas emissions, nitrogen emissions, and land use are calculated based on a territorial perspective following Nykvist et al. (2013). A challenge for considering additional footprint indicators in the GEMF is the lack of time series of data which were not available in most of the countries in 2017. Therefore, the first implementation of the methodology (PAGE 2017b) only included three of the six indicators for the **Dashboard of Sustainability** (these being GHG emissions, Nitrogen emissions and Land use).

The variables in the GEP Index contribute, in a comprehensive way, towards the measurement of the welfare or development of the present generation. Moreover, they carry some, but limited, information on its sustainability. Variables that are related to the sustainability of development are placed in the **dashboard**. Just as progress was calculated for each indicator *y* in the GEP Index, it is calculated for each indicator *K* in the dashboard as $\frac{dK_j dK_j}{dK_j^* dK_j^*}$, for all relevant indicators $j = 1, \ldots, Jj = 1, \ldots, J$.

However, for the dashboard indicators it is crucial to understand not only about progress but also how this progress relates to the sustainability thresholds. This gives specific information about the importance of this progress. For example, if two countries experienced similar progress but country A was already on a sustainable path while country B was not sustainable (above the sustainability threshold), progress for country B should be considered relatively more important for the overall progress of country A, and the planet, towards an Inclusive Green Economy (IGE).

Although the GEP Index should not be combined with the Dashboard of Sustainability in a composite measure of sustainable development, the information from both instruments can inform which countries are in a comparably more favorable position than others. This methodology allows the GEP measurement framework to rank all index-dashboard profiles but not to combine the index and dashboard information into a synthetic index. When comparing progress based on the GEP Index and the dashboard, countries are ranked according to their worst-performing type of progress based on the principle of *Priority to the Worst Achievement*. This methodology sends apolicy message of a country that is only making progress on a few aspects of an Inclusive Green Economy will not necessarily surpass one that is moving forward in all areas. Ranking countries based on the area in which they are making the least progress makes the policy an incentive for countries to implement a more balanced and integrated policy approach aimed at moving forward across the broad spectrum of an Inclusive Green Economy. This methodology serves a double purpose for countries by undertaking Inclusive Green Economy action. It allows them to learn about their relative green economy performance while also informing them on how their worst-performing areas of progress compare with the achievements of other countries.

Limitations of the current approach include the lack of data for some indicators in the GEP indicator as well as the dashboard. Moreover, mixing very different aspects in an aggregate indicator is subject to the normative choices when selecting indicators and how they are grouped. Some indicators could arguably be used in both dashboard and Index. For instance, there is one footprint indicator (material footprint) in the GEP Index and one (ecological footprint) in the dashboard. Based on the GEP report, indicators relating to sustainability are in the dashboard. Based on this definition, the carbon, land and water footprint indicators analyzed in this project should be a part of the dashboard and not the GEP Index.

4.2 Methodological changes to the GEP Measurement framework to strengthen the use of environmental footprint indicators

4.2.1 Methodology of existing framework

The GEP framework includes the GEP Index and the dashboard. These can be combined to derive the GEP+ ranking. Both include “goods” and “bads”. In other words, there are positive developments (such as generating wealth or increasing life expectancy), and negative developments such as increase of environmental pressure or impacts.

The GEP Index consists of 13 indicators (8 “goods” and 5 “bads”) as reported in Table 2. The dashboard consists of 6 indicators (1 “good” and 5 “bads”). In section 3.3 of the Page report, inclusive wealth is reported once as total wealth and once as natural capital only, which leads to 7 indicators (2 “goods” and 5 “bads”).

The key principle is similar between the dashboard and the GEP Index: a progress measure is weighted by a term relating the initial level to a threshold. The progress of indicators (per-capita) is analyzed for 5 years on average between a decade (e.g. 2000-2004 vs 2010-2014) and normalized by a target progress (see details below).

The main difference is that the indicators in the GEP Index are aggregated. Therefore the weighting is normalized within the index, while the dashboard indicators are reported individually.

Finally, this also translates to the weight in GEP+ ranking and the *Priority to the Worst Achievement* criterion; the dashboard indicators get much higher weights.

Table 2: Progress on an Inclusive Green Economy by indicator – full sample (from PAGE 2017b)

Variable	Obs	Mean	Std. Dev.	Min	Max
material footprint	104	-1.83	5.57	-52.53	1.43
air pollution	105	-0.13	0.89	-5.70	1.23
protected areas	101	0.15	0.35	-0.04	2.44
energy use	102	0.37	0.46	-1.43	2.03
green trade	93	0.10	0.30	-0.28	1.61
green technology innovation	54	0.13	0.98	-0.92	5.98
renewable energy source	101	0.04	0.36	-0.78	1.11
Palma ratio	96	0.06	0.68	-2.04	1.74
gender inequality index	98	0.39	0.30	-0.28	1.46
access to basic services	71	0.38	0.23	-0.05	1.00
mean years of schooling	103	0.39	0.25	-0.42	1.04
pension coverage	66	0.22	0.96	-4.55	2.19
life expectancy	103	0.39	0.20	-0.32	1.48

Table 3: Summary of dashboard indicators (sample of countries with GEP Index, from PAGE 2017b)

Indicator	Obs.	Mean	Std. Dev.	Min	Max
Freshwater withdrawal	79	-0.07	1.65	-10.93	1.28
Greenhouse gas emissions	104	-0.31	0.68	-3.74	0.84
Emissions of nitrogen	102	-0.35	1.11	-5.07	1.48
Land use	104	-0.31	1.03	-4.24	1.54
Ecological Footprint	92	-0.34	0.82	-4.95	1.02
Inclusive Wealth Index	100	0.31	0.52	-1.11	1.84
Inclusive Wealth Index (Natural Capital)	100	-5.84	7.48	-26.41	5.21

Table 4: Number of countries making progress/regress in dashboard indicators, from PAGE 2017b)

Indicator	Obs.	Progress	Regress
Freshwater withdrawal	79	60	19
Greenhouse gas emissions	104	40	64
Emissions of nitrogen	102	49	53
Land use	104	49	55
Ecological Footprint	92	32	60
Inclusive Wealth Index	100	73	27
Inclusive Wealth Index (Natural Capital)	100	13	87

4.2.2 General issues with existing framework

An issue with the framework is that not all of the data is available for every country (see table 2-4). Consequently, the normalization of the weights is biased by the selection of data covered for the GEP Index. For instance, if a country has the highest weight on a specific indicator, missing this indicator would change the results and thus the GEP Index significantly.

Missing data is especially an issue for calculating targets and thresholds. It is therefore necessary to have a complete list of values, or at least for 90% of the countries, to allow for a consistent assessment.

Lacking data also affects the GEP+ ranking in the same way (PAGE 2017b): The *Priority to the Worst Achievement* criterion, may miss data for the actual worst progress.

Information regarding uncertainty could help to achieve more robust results. It would allow for a sensitivity assessment and for calculating probabilities for each indicator being the worst. Uncertainty is more important for footprint indicators, since trade and impacts in the supply-chain need to be assessed on top of national impact accounting.

On a normative level, the question of which indicator is to be used as part of the dashboard or the GEP Index (or excluded) is highly important. While it is a strength of the method to determine the weights, it does not account for subjective priorities of countries. Some of the indicators (e.g. example gender equality, green trade) are much more relevant for high-income countries than for low income. Perhaps a survey among member states could be used to better understand this issue. Example data from a survey of priority issues is available online: My World (2019).

One option to mitigate the influence of this choice is to create an interactive dashboard where a user can decide which indicators are important. A solution which is similar to what is implemented in the OECD's better life index (Organisation for Economic Co-operation and Development 2019).

Another issue is the choice of the thresholds. While some indicators (e.g. the material and ecological footprint) have absolute thresholds, others are based on the percentile of initial performance. This also introduces inconsistency, since absolute thresholds are based on external assessments (e.g. by the author of the respective datasets). On the other hand, the others are based on empirical information and reflect to some extent feasibility. It has to be noted that the indicators published in the application study used absolute thresholds only (PAGE 2017b).

4.2.3 New indicators' overlap with existing indicators

From a footprint (i.e. consumer) perspective, only two existing indicators have a potential overlap: Material footprint (GEP indicator) and ecological footprint (dashboard). The material footprint of countries is correlated with the land, water and carbon footprints, but also has large deviations for specific sectors and countries (see IRP (2019). Agriculture is driving water and land use impacts, while it is less important for carbon footprints. Therefore, it is sensible to keep it within the GEP Index, if the other footprints are part of the dashboard. However, the ecological footprint has a much higher correlation to land use and carbon footprint (since it mainly consists of the two aspects) even if it also covers other issues such as nuclear power.

Therefore, it is recommended to avoid having ecological, carbon, water and land footprint together in the dashboard. In order to increase transparency, it is recommended to exclude the ecological footprint from the dashboard.

In terms of the other indicators from the dashboard, no overlap is observed for footprints but for the producer perspective; water use, land use and greenhouse gas emissions are covered already. For GHG, it is also an impact, while land and water use are reporting pressure indicators. Therefore, it is recommended to exclude these from the dashboard, since the impact assessment used for environmental footprints is more suitable. The impact assessment generates knowledge regarding the severity of land and water use, which is important when assessing sustainability (e.g. water used in Switzerland has lower impacts on water scarcity than if used in Southern California or land used in Siberia has a lower impact on global biodiversity than land use in Madagascar).

4.3 Calculation of footprint indicators

4.3.1 Starting position: The GEP Framework for calculation of indicators

The indicators considered represent “bads” and therefore the equations for these “bads” are applicable here (PAGE 2017a). However, the principle is the same for the “goods”, but with different signs in the equations and different percentiles. We describe the procedure below:

All data on water, land and carbon indicators from producer and consumer perspectives are calculated for 2001-2005 (**y^0**) and 2011-2015 (**y^1**) to use it for the GEP Index (consumer perspective) as well as the Indicator dashboard (production perspective). An overview of the indicators necessary is provided in table 5 (GEP Index) and 6 (dashboard).

Table 5: Calculation of Indicator in GEP Index (from PAGE 2017b)

Country	*Current greenness*			*Progress of greenness*					
	2000-2004 average value of material footprint = y^0	**2010-2014 average value of material footprint = y^1**	**threshold = t**	**change = y^1-y^0**	**rate of change = (y^1-y^0)/y^0**	**target = y***	**Weight**	**Weight π**	**progress on material footprint**
Albania	4.44	9.09	5	4.65	1.05	3.72	0.89	0.09	-6.43

Table 6: Calculation of Indicator in Dashboard (from PAGE 2017b)

Freshwater withdrawal (m3/capita/year)								
Country	*Current sustainability*			*Progress of sustainability*				
	2000-2004 average value of freshwater withdrawal = y^0	**2010-2014 average value of freshwater withdrawal = y^1**	**threshold = t**	**change = y^1-y^0**	**rate of change = (y^1-y^0)/y^0**	**target = y***	**Weight**	**progress on freshwater withdrawal**
Albania	602.34	472.67	585	-129.67	-0.22	433.33	1.03	0.77

The **target y*** is determined by calculating the β value and a threshold (t) for a relevant comparison group (i.e. countries with similar human development according to the Human Development Index). We used the HDI of each country for the year 2015.

The target is calculated by multiplying the country’s initial value, y0, with the value of β. β is calculated as the sum of 1 plus the relative change (**y^1- y^0**)/ **y^0)** achieved by the 10 per cent best performing countries in the relevant comparison group. This signifies that a country should have a target reduction rate as large as the one achieved by the 10 per cent best performing countries in the relevant comparison group.

In addition to the progress for the target described above, thresholds are also considered. The thresholds are determined based on the indicator results from the MRIO data. The value of the threshold is set at the value of the 75th percentile of the per-capita impact distribution in 2001-2005 of all countries within each HDI group. This means the countries should never go above the value achieved by the bottom top 75 percent of all countries (of the same HDI class) for water, land and carbon footprint indicators. This is set as the maximum target value and thus the minimum value of t and target is used to calculate the progress indicator. It has to be noted that some countries change their HDI class over time so we have used the reference year (2015) for the classification.

Therefore, the target y* is calculated as follows:

$$y^* = \min(t, \beta y^0)$$

The progress is therefore calculated as:

$$progress = (y^0 - y^1) / (y^0 - y^*)$$

The weights are required for a composite indicator or ranking to provide a normative weighting system which helps guide policy. The weighting should include local and global contexts (i.e. comparing among indicators and countries). The GEP framework uses a weight π^ for each indicator that relates the urgency of acting considering the starting point and the threshold:

$$\hat{\pi} = (y^0/t)$$

For the **GEP** Index, the weights must be normalized over the total weights (i.e. the weights sum up to 1). The normalized weights (π) are calculated as follows:

$$\pi_j = \hat{\pi}_j / \text{sum}(\hat{\pi}_j)$$

The GEP Index is calculated as the sum of all products of progress and normalized weight:

$$GEP = \text{sum}(\pi_j * (y^0_j - y^1_j) / (y^0_j - y^*_j))$$

An example is given in Table 7 for Colombia, which results in a GEP Index of -0.02.

Table 7: Example calculation of GEP Index and indicator progress and weights (importance) for Colombia, resulting a GEP Index of -0.02 (from PAGE 2017b)

Colombia	material footprint	air pollution	protected areas	energy use	green trade	environmental patents	renewable energy	Palma ratio	gender inequality	access to basic services	mean years of schooling	pension coverage	life expectancy
Weights $\hat{\pi}$	1.22	0.53	1.33	0.41	0.52	0.82	0.22	1.41	0.88	0.67	0.71	0.40	0.87
Weights π	0.12	0.05	0.13	0.04	0.05	0.08	0.02	0.14	0.09	0.07	0.07	0.04	0.09
Progress	-1.62	-0.19	0.10	0.46	-0.15	0.41	-0.12	0.23	0.30	0.20	0.29	0.16	0.36

The dashboard has no aggregation and therefore no normalization of the weights is done to obtain the importance of each indicator.

4.3.2 Data sources for an extension

The indicators for carbon, water and land footprint (as well as the production impact for each country) are calculated based on the results from SCP-HAT and the GRO tool (EXIOBASE v3) for the years 2001-2005 and 2011-2015. In order to obtain per-capita values, the population data for the respective years used for the GRO report (IRP 2019a) are applied.

In order to calculate all indicators for more than a hundred countries, this study used preliminary results from a merge of EXIOBASE and EORA data (Cabernard et al. in preparation). In principle, the Rest of the World countries in EXIOBASE v3 are distributed into individual countries based on EORA data, as well as more specific data on water and land to better distinguish biomass production (which is essential for land and water footprints).

For this, EXIOBASE sectors are attributed to EORA26 sectors and split per country based on the shares reported by EORA26. This involves additional uncertainties and should be done carefully in the future.

The resulting MRIO data was available for 2001 and 2011 and results in 189 individual countries.

4.3.3 Aggregating the indicators form the dashboard and GEP Index and creating the GEP+ Ranking

Starting point

In order to combine the information, from the GEP Index and dashboard indicators, an aggregation procedure is applied (PAGE 2017a). As for the GEP Index, dashboard indicators are reported as the weight multiplied by the progress. In this GEP+ aggregation, the GEP indicators from the GEP Index are added by weighting the GEP Index result with the average weights (importance) of all indicators of the GEP Index, following PAGE (2017a).

The application of the *Priority to the Worst Achievement* criterion takes the lowest weighted progress result of the GEP Index and the dashboard indicators to report the highest importance. It also allows to report the progress on the *protective criterion* (i.e. the worst progress result), as presented in Table 8.

Extension

We suggest analyzing both production and consumption (footprint) based indicators. These indicators highlight two areas of policy action: the production progress can be directly influenced by national policies, while the footprint progress depends partially on national progress in other countries. However, the share of the footprint abroad can be influenced through different sourcing policies (i.e. source from countries with better environmental performance), through international engagement or through the introduction of resource efficient technologies and processes in international supply chains of domestic companies. It is also suggested to indicate the main drivers of the GEP Index in the event that the Index is performing the worst within GEP+.

Table 8 Extract of Rank based on GEP+. The 4 best performing countries per HDI are shown (from PAGE 2017b). Note that this table is based on the following four categories: (a) the GEP Index, (b) greenhouse gas emissions, (c) nitrogen emissions, and (d) the share of land used as permanent crops. If the categories considered change, the ranking would vary also. The lowest value (marked as bold font) determines the "protective criterion". Therefore, the higher this criterion, the better the country performs.

Table 8: Rank GEP Index-dashboard profiles using the Protective Criterion (top 4 countries per HDI group). Adopted from PAGE 2017b.

		gas emissions	*emissions*	*Land use*	*Index*	*e criterion*	
1	Cyprus	0,5566	0,5971	**0,1800**	0,5862	0,1800	Very High
2	Portugal	0,9080	0,7315	0,1120	**0,0999**	0,0999	Very High
3	Spain	1,3180	1,7082	**0,0873**	0,2118	0,0873	Very High
4	Italy	0,9423	1,9024	**0,0664**	0,2598	0,0664	Very High
1	Jamaica	1,1022	0,4906	0,1682	**0,1256**	0,1256	High
2	Azerbaijan	**-0,1942**	0,0018	0,0010	0,2512	-0,1942	High
3	Jordan	**-0,2369**	2,1228	0,0080	0,1523	-0,2369	High
4	Venezuela, RB	**-0,3027**	0,3700	0,0227	-0,0497	-0,3027	High
1	Dominican Republic	**-0,2539**	-0,2341	0,0000	0,2801	-0,2539	Medium
2	South Africa	**-0,3429**	0,6564	-0,0059	-0,1977	-0,3429	Medium
3	Philippines	0,1430	0,3621	**-0,3572**	0,1978	-0,3572	Medium
4	Honduras	**-0,3793**	0,6753	-0,1613	0,1329	-0,3793	Medium
1	Zimbabwe	0,9104	0,2037	**0,0000**	0,0530	0,0000	Low
2	Senegal	0,2000	0,0080	**-0,0052**	0,1607	-0,0052	Low
3	Cameroon	0,8613	0,0657	**-0,1058**	0,2448	-0,1058	Low
4	Mali	**-0,1776**	1,7463	-0,0061	0,1931	-0,1776	Low

4.3.4 Alternative thresholds based on absolute limits

The thresholds used in this report are based on percentile as described above as it is difficult to establish global thresholds. It should be noted that in the first implementation of the methodology (PAGE 2017b), only absolute thresholds have been used as these have been available for the three selected indicators.

For GHG emissions, we could also set thresholds following the goals of the Paris Agreement. However, several pathways with different goals over time to achieve them are theoretically possible and depend on assumptions regarding future technology. Steffen et al. (2015) use the remaining “budget”, i.e. the difference between the current level, and the threshold of 450 ppm (parts per million), for global warming to stay below the two-degree goal.

For water and land, the difficulty is the regional variability and setting an absolute threshold has not yet been done in science. For biodiversity loss, Steffen et al. (2015) propose to use the global yearly extinction rate as an interim control variable with a boundary value of yearly ≤ 10 extinctions per million species-years (E/MSY). They indicate that the current impacts are exceeding natural extinction rates by a factor of ~100.

It should be noted that extinction rates are not exclusively linked to land use. Moreover, Steffen et al. (2015) proposed the extinction rate solely as an interim control variable, as long as global data for Phylogenetic Species Variability are not yet available. As a second control variable, Steffen et al. propose the Biodiversity Intactness Index (BII). Frischknecht et al. (2018) assessed Switzerland’s land use related to biodiversity footprint against the background of this indicator. They determined an overshoot of the planetary boundary level by 270%.

Defining a threshold value for the land use related biodiversity loss therefore needs further research and consensus. Currently, there is an ongoing project at ETH Zürich that analyses various options on how to downscale water and biodiversity planetary boundaries and derive threshold values at sub global scales.

For water scarcity, a reduction of 40-50% is suggested globally (Ridoutt and Pfister 2010), but this has not been an outcome of consensus building efforts and therefore cannot be considered as generally agreed.

The science based target initiative is currently working on suggesting procedures for target setting that could be used for absolute thresholds (t) in the GEP framework. As an example, (Newbold et al. 2016) examined the state of biosphere integrity. Land use has reduced local biodiversity intactness beyond the planetary boundary proposed by Steffen et al. (2015) across 58.1% of the world’s land surface.

Therefore, thresholds are probably lower than the targets derived above using percentiles and consequently, the performance of many countries would be lower and the weight of the indicator would increase - especially in affluent countries.

5. Comparing overall Green Economy Progress between production and environmental footprint indicators

All presented results are available as XLS tables (for all countries available for the different indicators and data sources). The results are also visualized with maps in Appendix 8.4. The calculation of all footprint results for the different databases and times, including the threshold and target calculation are provided in the XLS files only.

5.1 Calculations for the dashboard of environmental sustainability indicators

5.1.1 Carbon footprint indicator

In this section, selected results are presented for those 43 of the 44 individual countries which are covered by EXIOBASE v3. Therefore, these results can be compared with the results of SCP-HAT v1.0. Taiwan, one of the 44 counties reported in EXIOBASE is excluded as it is considered to be part of PR China by the UN and the SCP-HAT tool.

Table 9 shows the progress and weights for the analysis with 3 different data sets (SCP-HAT, EXIOBASE-Eora and EXIOBASE). The correlation between the results for the carbon footprint weights by SCP-HAT and EXIOBASE, and between SCP-HAT and EXIOBASE-EORA ranges from 0.85 to 0.87 for both the production and consumption perspective. This signifies that it is relatively high and reflects the match of the carbon footprint at the starting period. The correlation between Eora and EXIOBASE-EORA is 0.99 for the consumption perspective, indicating a limited effect of the enhanced country resolution. The correlation of the weights between EXIOBASE and EXIOBASE-Eora is 1 for the production perspective (by definition as no changes to the data are made, except that only one year was considered in EXIOBASE-EORA instead of a five-year average).

However, there is no positive correlation observed between the progress results of the 3 datasets in the consumption perspective and also none between EXIOBASE and SCP-HAT in the production perspective. This result shows that the time series are less consistent among the databases and therefore induce high uncertainties in the GEP indicators.

From the analysis of countries with high HDI only, we observe a similar pattern for weights (figure 2 for consumption and figure 4 for production perspective) and progress (figure 3 for consumption and figure 5 for production perspective).

Table 9: Weights and progress of carbon footprint from a production and consumption perspective for 3 databases. Countries are sorted based on the rank in GEP+ among all indicators introduced in this study

	Carbon FP											
	consumption						production					
	SCPHAT		Exiobase-EORA		Exiobase		SCPHAT		Exiobase-EORA		Exiobase	
	Weight	progress	Weight	progress	Weight	progress	Weight	progress	Weight	progress	Weight	progress
Spain	1.01	1.11	0.92	0.99	0.80	1.30	0.73	0.88	0.95	0.85	0.67	1.41
Portugal	0.99	0.93	0.88	1.07	0.71	1.01	0.78	0.72	0.82	0.54	0.54	0.63
Greece	1.35	0.95	1.55	0.25	1.28	0.98	1.00	0.55	1.76	0.12	1.21	0.80
USA	2.17	0.31	1.92	0.30	1.61	0.45	2.02	0.25	2.23	0.22	1.46	0.40
Ireland	1.28	1.01	1.35	0.64	1.22	0.87	1.53	0.76	1.97	0.39	1.23	0.81
Malta	1.09	0.35	1.09	0.45	0.85	0.06	0.60	-0.26	1.11	0.93	0.71	1.10
Denmark	1.30	0.76	1.40	0.40	1.17	0.80	1.15	0.99	1.59	0.18	1.05	0.79
Hungary	0.64	0.85	0.71	0.27	0.70	1.09	0.72	0.56	0.68	0.39	0.45	0.74
Mexico	0.64	0.98	0.47	0.01	0.38	-0.11	0.74	0.54	0.59	-0.17	0.39	2.11
France	1.02	0.86	0.92	0.49	0.76	0.60	0.71	0.75	0.80	0.39	0.52	0.65
Japan	1.19	0.30	1.03	0.18	0.85	0.10	0.85	-0.03	1.12	-0.11	0.76	-0.24
Austria	1.19	0.40	1.10	-0.03	0.91	0.37	0.88	0.42	0.97	-0.05	0.68	0.47
UK	1.37	0.78	1.16	0.87	0.98	0.81	1.01	1.01	1.10	0.65	0.72	0.86
Poland	0.70	-0.31	0.83	-0.30	0.66	-0.02	0.86	0.00	1.03	-0.22	0.68	0.05
Bulgaria	0.42	-0.50	0.62	-0.35	0.49	2.66	0.58	-0.34	0.81	-0.58	0.53	0.26
Romania	0.48	4.04	0.40	-0.88	0.35	0.25	0.60	4.15	0.60	0.15	0.40	0.74
Finland	1.15	0.45	1.62	0.09	1.33	0.71	1.04	-0.03	1.53	0.19	1.06	1.01
Switzerland	1.35	0.47	1.15	-0.15	0.93	0.02	0.61	0.61	0.74	0.74	0.51	1.14
Croatia	0.43	-0.77	0.56	0.25	0.54	1.06	0.38	-1.25	0.59	0.22	0.41	0.51
Sweden	0.95	0.39	0.93	0.12	0.76	0.34	0.66	0.84	0.74	0.49	0.49	0.99
Canada	1.59	-0.03	1.57	0.04	1.37	0.46	2.29	0.19	2.31	0.15	1.55	0.33
Australia	2.00	0.29	1.94	-0.34	1.78	-0.09	2.66	0.44	3.34	0.03	2.22	0.11
Latvia	0.54	1.01	0.66	0.02	0.46	-0.05	0.40	2.78	0.48	-1.30	0.35	-0.83
Brazil	0.77	1.02	0.40	-0.47	0.32	7.64	1.00	0.78	0.53	-1.33	0.36	14.60
Turkey	0.40	-1.05	0.31	-1.11	0.31	7.65	0.38	-0.51	0.41	-2.03	0.29	15.69
Czech Republic	0.93	0.41	1.02	-0.21	0.86	0.40	1.12	0.51	1.52	0.24	1.00	0.59
Slovakia	0.77	-0.21	0.74	-1.19	0.66	0.01	0.68	0.34	0.88	0.39	0.59	0.64
Netherlands	1.32	0.64	1.32	0.45	1.11	0.70	1.15	0.56	1.39	0.13	0.92	0.35
Italy	1.01	1.05	0.91	-0.16	0.78	0.55	0.79	0.81	0.85	0.30	0.56	0.68
South Korea	0.91	-0.75	1.00	-1.03	0.85	-0.48	0.90	-0.83	1.18	-0.88	0.79	-1.05
Cyprus	1.18	0.57	1.20	0.39	0.95	0.59	0.84	0.61	1.00	-1.12	0.71	-0.72
India	0.18	0.02	0.14	3.87	0.11	1.31	0.23	0.00	0.21	-6.59	0.13	2.57
Lithuania	0.75	-0.35	0.55	-2.61	0.44	-1.78	0.63	-0.12	0.55	-0.75	0.38	-0.42
Estonia	1.24	0.25	1.31	0.02	1.04	0.13	1.53	0.06	1.39	-1.04	1.00	-0.64
Belgium	1.08	0.73	1.14	-0.30	0.99	0.10	1.15	0.90	1.38	0.36	0.87	0.61
Germany	1.17	0.70	1.08	-0.13	0.90	0.14	1.06	0.52	1.17	-0.12	0.80	-0.06
Slovenia	0.62	-0.52	0.94	0.24	0.81	0.84	0.46	-0.88	0.92	0.50	0.61	0.88
Norway	1.15	-0.15	1.36	-0.74	1.23	-0.17	0.67	0.41	2.47	0.29	1.58	0.58
Russia	0.96	-0.40	0.59	-3.25	0.53	-1.72	1.44	-0.11	1.51	-0.46	1.04	-0.39
Luxembourg	3.60	0.05	2.06	0.02	1.61	-0.22	2.20	0.31	2.02	0.00	1.51	0.49
China	0.28	-4.16	0.29	-1.52	0.28	15.90	0.41	-1.99	0.46	-5.25	0.37	32.76
Indonesia	0.37	-1.83	0.15	5.05	0.14	1.69	0.50	-1.31	0.24	-8.29	0.17	3.15
South Africa	0.60	-0.09	0.35	7.40	0.35	0.92	0.84	-0.01	0.88	-4.83	0.64	0.61

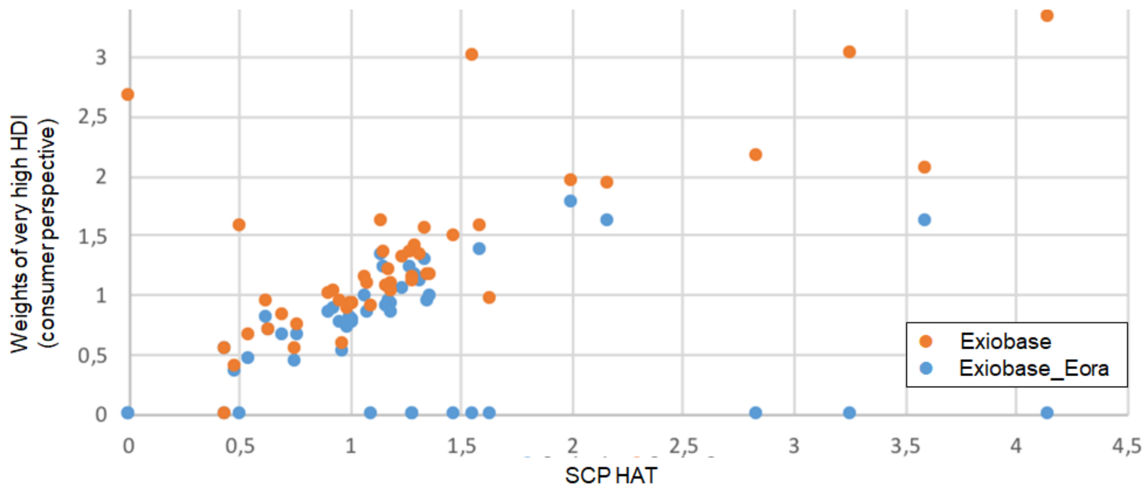

Figure 2: Scatter plot of weights for carbon footprint from a consumption perspective (only high HDI countries, due to coverage in EXIOBASE). The Y axes plots the results for Exiobase v3.4 (Exiobase) and the resolved Exiobase-Eora (Exiobase_Eora).

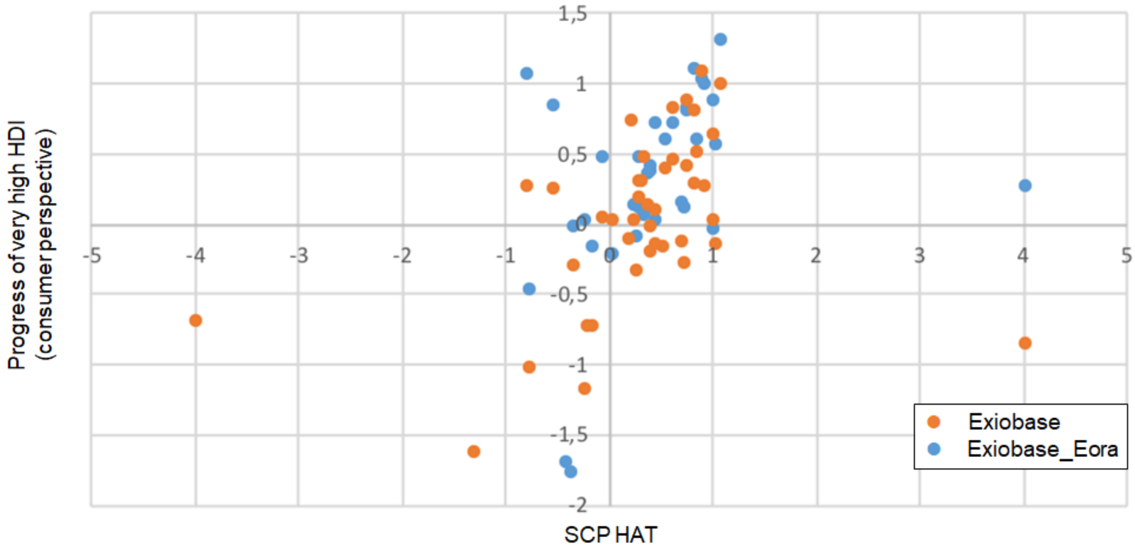

Figure 3: Scatter plot of progress for carbon footprint from a consumption perspective (only high HDI countries, due to coverage in EORA). The Y axes plots the results for Exiobase v3.4 (Exiobase) and the resolved Exiobase-Eora (Exiobase_Eora).

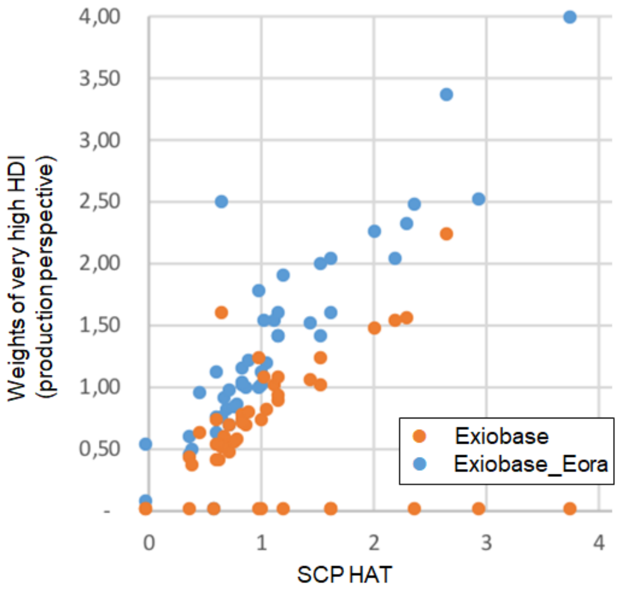

Figure 4: Scatter plot of weights for carbon footprint from a production perspective (only high HDI countries, due to coverage in EORA). The Y axes plots the results for Exiobase v3.4 (Exiobase) and the resolved Exiobase-Eora (Exiobase_Eora)

Figure 5: Scatter plot of progress for carbon footprint from a production perspective (only high HDI countries, due to coverage in EORA). The Y axes plots the results for Exiobase v3.4 (Exiobase) and the resolved Exiobase-Eora (Exiobase_Eora).

5.1.2 Water and land indicator

For water and land use related impacts, only results of EXIOBASE-Eora are presented in Table 10. This is because it is the only database to cover the indicators and countries needed for substantial coverage of UN countries and differentiation of agricultural sectors. As it can be seen, the indicators for production and consumption perspectives vary widely. The correlation between consumption and production perspectives have a correlation of 0.75 for water and 0.82 for land. Regarding the progress, the correlation is much lower, with 0.31 for water and 0.32 for land. This indicates that the choice of the perspectives are highly relevant for the outcome of the index. In many cases, the indicators of the two perspectives have a different sign, and therefore it should be carefully considered if one or both perspectives are to be included.

Table 10: Weights and progress for the water and land footprint from consumption and production perspective. Countries are sorted based on the rank in GEP+ among all indicators introduced in this study

	Water FP				LAND FP			
	consumption		Production		consumption		Production	
	Exiobase-EORA		Exiobase-EORA		Exiobase-EORA		Exiobase-EORA	
	Weight	progress	Weight	progress	Weight	progress	Weight	progress
Spain	3.43	0.27	9.25	0.18	1.00	0.58	1.11	0.31
Portugal	1.86	0.33	3.16	0.29	1.02	0.70	0.74	0.26
Greece	3.24	0.11	8.34	0.34	0.96	0.64	1.02	0.13
USA	1.28	0.28	2.40	0.04	0.89	0.56	0.54	0.17
Ireland	0.95	0.78	0.03	0.61	0.55	0.69	0.08	0.20
Malta	0.80	0.26	0.12	0.20	0.55	1.01	0.05	0.07
Denmark	0.75	0.23	0.07	0.12	0.54	0.58	0.09	0.03
Hungary	0.22	-0.42	0.02	0.64	0.22	0.33	0.16	0.12
Mexico	0.64	0.28	1.47	0.11	1.74	0.39	2.62	0.20
France	0.90	-0.12	0.14	0.37	0.78	0.45	0.29	0.10
Japan	0.44	0.26	0.01	0.35	1.04	0.76	0.28	0.02
Austria	0.72	-0.45	0.02	0.19	0.76	0.49	0.57	0.18
UK	0.84	-0.42	0.03	0.68	0.75	1.00	0.02	0.13
Poland	0.19	-2.03	0.04	-0.74	0.21	0.20	0.16	0.22
Bulgaria	0.19	-1.34	0.29	-0.54	0.23	-0.03	0.38	-0.06
Romania	0.15	-3.25	0.07	-0.36	0.26	-0.40	0.42	-0.13
Finland	0.53	-0.93	0.06	0.80	0.58	0.27	0.20	0.09
Taiwan	0.34	-0.39	0.03	0.36	1.38	0.60	0.67	0.21
Switzerlanc	1.08	-0.53	0.01	0.31	0.76	0.25	0.24	0.16
Croatia	0.26	-2.25	0.12	0.34	0.52	-0.41	0.70	-0.31
Sweden	0.65	-0.99	0.06	0.44	0.45	0.21	0.18	0.14
Canada	0.61	-1.06	0.12	0.45	0.48	-0.04	0.33	0.24
Australia	1.54	0.31	4.19	0.45	3.91	0.44	8.46	0.25
Latvia	0.19	-3.68	0.01	0.07	0.17	-0.60	0.20	-0.58
Brazil	0.06	-1.02	0.05	-0.60	1.91	0.15	3.21	0.14
Turkey	0.99	-0.57	2.62	-0.04	0.54	-0.02	0.83	0.23
Czech Repu	0.28	-3.04	0.01	0.22	0.22	-0.15	0.11	0.06
Slovakia	0.21	-3.97	0.03	-0.16	0.32	0.14	0.39	0.10
Netherlanc	1.84	-0.55	0.03	-0.02	1.27	0.96	0.03	0.08
Italy	1.26	-0.83	0.94	0.35	0.77	0.38	0.55	0.23
South Kore	0.54	-0.51	0.01	-0.35	0.62	0.56	0.07	0.16
Cyprus	2.14	-0.11	6.80	0.50	0.48	0.80	0.19	0.54
India	0.83	-0.66	2.11	-0.15	0.20	0.61	0.28	0.63
Lithuania	0.21	-4.39	0.01	-0.26	0.18	-0.13	0.16	-0.03
Estonia	0.21	-6.52	0.01	-0.04	0.26	-0.41	0.20	-0.50
Belgium	0.97	-1.53	0.05	0.58	1.09	0.28	0.06	0.39
Germany	0.94	-1.65	0.01	0.24	0.55	0.30	0.08	-0.23
Slovenia	0.38	-4.48	0.01	0.39	0.50	0.04	0.44	0.10
Norway	1.42	-1.31	0.02	0.44	0.92	0.10	0.06	0.18
Russia	0.31	-3.80	0.17	-0.52	0.16	-0.98	0.22	-0.03
Luxembour	2.92	-0.81	0.00	0.96	2.18	0.29	0.11	0.30
China	0.47	-0.49	1.35	-0.92	0.18	-0.14	0.19	0.05
Indonesia	0.21	-1.84	0.44	-0.29	0.82	-2.95	2.61	0.21
South Afric	0.28	0.33	0.74	0.56	2.11	0.35	3.36	0.18

5.1.3 Priority to the Worst Achievement criterion

The input data used for the *Priority to the Worst Achievement criterion* are provided in table 11. These result from multiplying the results from table 9 and 10. Due to the low correlations in the previous steps of the assessment for weights and progress, correlation is also low. For many cases, the results have different signs for the options to calculate carbon footprints as well as between the production and consumption perspectives for all indicators.

Table 11: Results from progress times weight, which is needed to calculate ranks, based on the GEP+ method. Countries are sorted based on the rank in GEP+ among all indicators introduced in this study

	progress * weight									
	Carbon FP						Water FP		LAND FP	
	consumption			production			consumpti	Production	consumpti	Production
Country	SCPHAT	Exiobase-E	Exiobase	SCPHAT	Exiobase-E	Exiobase	Exiobase-E	Exiobase-E	Exiobase-E	Exiobase-E
Spain	1.11	0.91	1.05	0.64	0.81	0.94	0.94	1.67	0.58	0.35
Portugal	0.92	0.95	0.72	0.56	0.45	0.34	0.61	0.91	0.71	0.19
Greece	1.29	0.38	1.26	0.56	0.22	0.97	0.34	2.81	0.61	0.14
United Sta	0.67	0.58	0.73	0.50	0.48	0.58	0.35	0.10	0.50	0.09
Ireland	1.29	0.86	1.06	1.17	0.77	0.99	0.75	0.02	0.38	0.02
Malta	0.39	0.50	0.05	-0.16	1.03	0.78	0.21	0.02	0.55	0.00
Denmark	0.99	0.56	0.94	1.14	0.28	0.83	0.17	0.01	0.31	0.00
Hungary	0.54	0.19	0.76	0.40	0.26	0.33	-0.09	0.01	0.07	0.02
Mexico	0.63	0.01	-0.04	0.40	-0.10	0.83	0.18	0.17	0.69	0.53
France	0.88	0.45	0.46	0.53	0.31	0.34	-0.10	0.05	0.35	0.03
Japan	0.36	0.19	0.09	-0.02	-0.13	-0.18	0.11	0.00	0.79	0.01
Austria	0.48	-0.03	0.33	0.37	-0.05	0.32	-0.32	0.00	0.37	0.10
United Kin	1.06	1.01	0.80	1.03	0.72	0.62	-0.35	0.02	0.75	0.00
Poland	-0.22	-0.25	-0.01	0.00	-0.22	0.04	-0.39	-0.03	0.04	0.04
Bulgaria	-0.21	-0.22	1.32	-0.20	-0.47	0.14	-0.26	-0.15	-0.01	-0.02
Romania	1.95	-0.35	0.09	2.51	0.09	0.30	-0.49	-0.02	-0.10	-0.05
Finland	0.52	0.15	0.95	-0.03	0.29	1.07	-0.49	0.05	0.15	0.02
Taiwan	0.00	-0.08	0.81	0.00	-0.52	0.84	-0.13	0.01	0.83	0.14
Switzerlan	0.63	-0.18	0.02	0.37	0.55	0.59	-0.57	0.00	0.19	0.04
Croatia	-0.34	0.14	0.57	-0.48	0.13	0.21	-0.59	0.04	-0.21	-0.22
Sweden	0.37	0.11	0.26	0.55	0.36	0.49	-0.64	0.03	0.10	0.02
Canada	-0.05	0.06	0.63	0.44	0.34	0.51	-0.65	0.05	-0.02	0.08
Australia	0.58	-0.66	-0.16	1.16	0.11	0.25	0.47	1.89	1.73	2.11
Latvia	0.55	0.01	-0.02	1.11	-0.63	-0.29	-0.68	0.00	-0.10	-0.11
Brazil	0.79	-0.19	2.41	0.78	-0.70	5.26	-0.06	-0.03	0.28	0.46
Turkey	-0.42	-0.34	2.34	-0.20	-0.84	4.56	-0.56	-0.09	-0.01	0.19
Czech Rep	0.38	-0.21	0.34	0.57	0.37	0.59	-0.84	0.00	-0.03	0.01
Slovakia	-0.16	-0.88	0.01	0.23	0.35	0.38	-0.82	0.00	0.05	0.04
Netherlan	0.84	0.60	0.77	0.64	0.19	0.32	-1.00	0.00	1.21	0.00
Italy	1.07	-0.14	0.43	0.64	0.25	0.38	-1.04	0.33	0.29	0.12
Korea (Rep	-0.68	-1.03	-0.41	-0.74	-1.05	-0.83	-0.27	0.00	0.35	0.01
Cyprus	0.67	0.47	0.56	0.52	-1.13	-0.51	-0.23	3.39	0.39	0.11
India	0.00	0.52	0.15	0.00	-1.36	0.35	-0.55	-0.32	0.12	0.17
Lithuania	-0.26	-1.43	-0.78	-0.08	-0.41	-0.16	-0.91	0.00	-0.02	-0.01
Estonia	0.31	0.02	0.14	0.09	-1.45	-0.64	-1.34	0.00	-0.11	-0.10
Belgium	0.79	-0.34	0.10	1.04	0.49	0.53	-1.48	0.03	0.31	0.02
Germany	0.82	-0.14	0.13	0.55	-0.15	-0.04	-1.54	0.00	0.16	-0.02
Slovenia	-0.32	0.23	0.68	-0.40	0.46	0.54	-1.68	0.00	0.02	0.04
Norway	-0.17	-1.01	-0.20	0.27	0.71	0.91	-1.86	0.01	0.09	0.01
Russian Fe	-0.38	-1.91	-0.92	-0.15	-0.69	-0.41	-1.17	-0.09	-0.16	-0.01
Luxembou	0.19	0.04	-0.36	0.69	0.01	0.75	-2.37	0.00	0.64	0.03
China	-1.14	-0.45	4.45	-0.82	-2.40	12.10	-0.23	-1.24	-0.03	0.01
Indonesia	-0.67	0.77	0.24	-0.66	-2.00	0.53	-0.39	-0.13	-2.41	0.56
South Afri	-0.06	2.60	0.32	0.00	-4.26	0.39	0.09	0.42	0.74	0.60

Table 12 presents the results applying the *Priority to the Worst Achievement criterion* to the results provided in table 11 for comparison of carbon, water and land footprint. It is analysed for the consumption or the production perspectives individually, or for assessing it over both. It is also done for different databases for the carbon footprint. In general there is some consistency among the different options. Australia and South Africa have shown the largest differences between the use of SCP-Hat vs EXIOBASE-Eora.

Table 12: Priority to the Worst Achievement criterion for the different databases and perspective based on GEP+. "Both" means that the criterion is assessed based on consumption and production indicators. Countries are sorted based on the rank in GEP+ among all indicators introduced in this study

	Worst progress value (Priority to the Worst Achievement criterion								
	consumption	consumptio	consumptio	**Production**	Production	Production	Both	Both	Both
	Exiobase_EORA	SCP-HAT	Exiobase	**Exiobase_EORA**	SCP-HAT	Exiobase	Exiobase_EOF	SCP-HAT	Exiobase
Country									
Spain	**0.58**	0.58	0.58	**0.35**	0.35	0.35	0.35	0.35	0.35
Portugal	**0.61**	0.61	0.61	**0.19**	0.19	0.19	0.19	0.19	0.19
Greece	**0.34**	0.34	0.34	**0.14**	0.14	0.14	0.14	0.14	0.14
United Sta	**0.35**	0.35	0.35	**0.09**	0.09	0.09	0.09	0.09	0.09
Ireland	**0.38**	0.38	0.38	**0.02**	0.02	0.02	0.02	0.02	0.02
Malta	**0.21**	0.21	0.05	**0.00**	-0.16	0.00	0.00	-0.16	0.00
Denmark	**0.17**	0.17	0.17	**0.00**	0.00	0.00	0.00	0.00	0.00
Hungary	**-0.09**	-0.09	-0.09	**0.01**	0.01	0.01	-0.09	-0.09	-0.09
Mexico	**0.01**	0.18	-0.04	**-0.10**	0.17	0.17	-0.10	0.17	-0.04
France	**-0.10**	-0.10	-0.10	**0.03**	0.03	0.03	-0.10	-0.10	-0.10
Japan	**0.11**	0.11	0.09	**-0.13**	-0.02	-0.18	-0.13	-0.02	-0.18
Austria	**-0.32**	-0.32	-0.32	**-0.05**	0.00	0.00	-0.32	-0.32	-0.32
United Kin	**-0.35**	-0.35	-0.35	**0.00**	0.00	0.00	-0.35	-0.35	-0.35
Poland	**-0.39**	-0.39	-0.39	**-0.22**	-0.03	-0.03	-0.39	-0.39	-0.39
Bulgaria	**-0.26**	-0.26	-0.26	**-0.47**	-0.20	-0.15	-0.47	-0.26	-0.26
Romania	**-0.49**	-0.49	-0.49	**-0.05**	-0.05	-0.05	-0.49	-0.49	-0.49
Finland	**-0.49**	-0.49	-0.49	**0.02**	-0.03	0.02	-0.49	-0.49	-0.49
Taiwan	**-0.13**	-0.13	-0.13	**-0.52**	0.00	0.01	-0.52	-0.13	-0.13
Switzerlan	**-0.57**	-0.57	-0.57	**0.00**	0.00	0.00	-0.57	-0.57	-0.57
Croatia	**-0.59**	-0.59	-0.59	**-0.22**	-0.48	-0.22	-0.59	-0.59	-0.59
Sweden	**-0.64**	-0.64	-0.64	**0.02**	0.02	0.02	-0.64	-0.64	-0.64
Canada	**-0.65**	-0.65	-0.65	**0.05**	0.05	0.05	-0.65	-0.65	-0.65
Australia	**-0.66**	0.47	-0.16	**0.11**	1.16	0.25	-0.66	0.47	-0.16
Latvia	**-0.68**	-0.68	-0.68	**-0.63**	-0.11	-0.29	-0.68	-0.68	-0.68
Brazil	**-0.19**	-0.06	-0.06	**-0.70**	-0.03	-0.03	-0.70	-0.06	-0.06
Turkey	**-0.56**	-0.56	-0.56	**-0.84**	-0.20	-0.09	-0.84	-0.56	-0.56
Czech Rep	**-0.84**	-0.84	-0.84	**0.00**	0.00	0.00	-0.84	-0.84	-0.84
Slovakia	**-0.88**	-0.82	-0.82	**0.00**	0.00	0.00	-0.88	-0.82	-0.82
Netherlan	**-1.00**	-1.00	-1.00	**0.00**	0.00	0.00	-1.00	-1.00	-1.00
Italy	**-1.04**	-1.04	-1.04	**0.12**	0.12	0.12	-1.04	-1.04	-1.04
Korea (Rep	**-1.03**	-0.68	-0.41	**-1.05**	-0.74	-0.83	-1.05	-0.74	-0.83
Cyprus	**-0.23**	-0.23	-0.23	**-1.13**	0.11	-0.51	-1.13	-0.23	-0.51
India	**-0.55**	-0.55	-0.55	**-1.36**	-0.32	-0.32	-1.36	-0.55	-0.55
Lithuania	**-1.43**	-0.91	-0.91	**-0.41**	-0.08	-0.16	-1.43	-0.91	-0.91
Estonia	**-1.34**	-1.34	-1.34	**-1.45**	-0.10	-0.64	-1.45	-1.34	-1.34
Belgium	**-1.48**	-1.48	-1.48	**0.02**	0.02	0.02	-1.48	-1.48	-1.48
Germany	**-1.54**	-1.54	-1.54	**-0.15**	-0.02	-0.04	-1.54	-1.54	-1.54
Slovenia	**-1.68**	-1.68	-1.68	**0.00**	-0.40	0.00	-1.68	-1.68	-1.68
Norway	**-1.86**	-1.86	-1.86	**0.01**	0.01	0.01	-1.86	-1.86	-1.86
Russian Fe	**-1.91**	-1.17	-1.17	**-0.69**	-0.15	-0.41	-1.91	-1.17	-1.17
Luxembou	**-2.37**	-2.37	-2.37	**0.00**	0.00	0.00	-2.37	-2.37	-2.37
China	**-0.45**	-1.14	-0.23	**-2.40**	-1.24	-1.24	-2.40	-1.24	-1.24
Indonesia	**-2.41**	-2.41	-2.41	**-2.00**	-0.66	-0.13	-2.41	-2.41	-2.41
South Afri	**0.09**	-0.06	0.09	**-4.26**	0.00	0.39	-4.26	-0.06	0.09

Table 13 shows which indicator is the worst for different perspectives (production, consumption or both) and selection of SCP-HAT or EXIOBASE-EORA. On average, water, carbon and land have been the worst for 23, 11 and 10 countries of the 44 in EXIOBASE. It is interesting to see that water has the highest share of the worst indicator. As mentioned above, using absolute thresholds for water and land use may change the "worst indicator". Particularly for water consumption, the percentile approach is questionable as it is not problematic on a global average level, but on a regional level.

Table 13: Indication, of which indicator matches the Priority to the Worst Achievement criterion for the different databases and perspective (as shown in Table 12). Countries are sorted based on the rank in GEP+ among all indicators introduced in this study

	worst indicator Exiobase EORA			worst indicator SCP-HAT		
Eora clas	consum	Product	*both*	consum	Product	*both*
Spain	land	land	*land*	land	land	*land*
Portugal	water	land	*land*	water	land	*land*
Greece	water	land	*land*	water	land	*land*
USA	water	land	*land*	water	land	*land*
Ireland	land	water	*water*	land	water	*water*
Malta	water	land	*land*	water	carbon	*carbon*
Denmark	water	land	*land*	water	land	*land*
Hungary	water	water	*water*	water	water	*water*
Mexico	carbon	carbon	*carbon*	land	water	*water*
France	water	land	*water*	water	land	*water*
Japan	water	carbon	*carbon*	water	carbon	*carbon*
Austria	water	carbon	*water*	water	water	*water*
UK	water	land	*water*	water	land	*water*
Poland	water	carbon	*water*	water	water	*water*
Bulgaria	water	carbon	*carbon*	water	carbon	*water*
Romania	water	land	*water*	water	land	*water*
Finland	water	land	*water*	water	carbon	*water*
Taiwan	water	carbon	*carbon*	water	carbon	*water*
Switzerlanc	water	water	*water*	water	water	*water*
Croatia	water	land	*water*	water	carbon	*water*
Sweden	water	land	*water*	water	land	*water*
Canada	water	water	*water*	water	water	*water*
Australia	carbon	carbon	*carbon*	land	carbon	*land*
Latvia	water	carbon	*water*	water	land	*water*
Brazil	carbon	carbon	*carbon*	land	water	*land*
Turkey	water	carbon	*carbon*	water	carbon	*water*
Czech Repu	water	water	*water*	water	water	*water*
Slovakia	carbon	water	*carbon*	land	water	*land*
Netherlanc	water	water	*water*	water	water	*water*
Italy	water	land	*water*	water	land	*water*
South Kore	carbon	carbon	*carbon*	carbon	carbon	*carbon*
Cyprus	water	carbon	*carbon*	water	land	*water*
India	water	carbon	*carbon*	water	water	*water*
Lithuania	carbon	carbon	*carbon*	land	carbon	*land*
Estonia	water	carbon	*carbon*	water	land	*water*
Belgium	water	land	*water*	water	land	*water*
Germany	water	carbon	*water*	water	land	*water*
Slovenia	water	water	*water*	water	carbon	*water*
Norway	water	water	*water*	water	water	*water*
Russia	carbon	carbon	*carbon*	land	carbon	*land*
Luxembour	water	water	*water*	water	water	*water*
China	carbon	carbon	*carbon*	carbon	water	*water*
Indonesia	land	carbon	*land*	land	carbon	*land*
South Afric	water	carbon	*carbon*	carbon	carbon	*carbon*

5.2 Discussion of dashboard indicators

As presented above, values derived from different databases for the carbon footprint lead to differing results. These results ultimately transfer to uncertainties of the indicators and the overall ranking due to the choice of the database. The inconsistency among data and the production or consumption perspectives are higher for the progress report, since time series data is more uncertain. This is an intrinsic problem of the indicator definition through progress over time, and while adding an interesting dimension compared to other indicators, it is not very robust. A main reason for the uncertainty of time series is that the underlying data varies on the estimation of emissions. As explained in Appendix 8.1, GHG emissions are disaggregated from one database using a second one, which are both biased through model assumptions and data restrictions over the full time series. Additionally, the impacts are estimated based on specific emission and land/water use data from a specific year. For land and water, these have been extrapolated from the spatially explicit assessment using year 2000 data, based on land use and water consumption (IRP 2019). A description of the impact assessment is presented in Appendix 8.2.

As presented above, the sign of the carbon footprint progress value varies for different databases for many countries. As a consequence, the Priority to the Worst Achievement criterion changes also. While the ranking of countries is rather consistent when using different databases, the comparison of the ranks of individual countries alter in many cases. This is crucial for this kind of indicator as it is used to compare the progress among countries and even more importantly for individual countries. The results are less trustworthy if the ranking fluctuates as a function of the input data. Another issue is the detection of the worst criterion to prioritize the efforts: this changes as a function of the database used for some countries, e.g. Mexico (table 13). This indicates that input data uncertainty affects the ranking and the worst indicator when applying the *Priority to the Worst Achievement criterion.*

5.3 Calculations for the overall ranking (the GEP+)

Using the results from the previous sub-section, different rankings are calculated using the indicators reported in PAGE (2017b): GHG emissions, Nitrogen emissions, Land use and GEP Index. Three options have been tested: (1) Combining consumption indicators from this analysis with the original ranking from PAGE (2017b), (2) combining production indicators form this work with the original ranking, and (3) combining the new consumption indicators only with the GEP Index from PAGE (2017b).

The rank correlation of the 3 different options is very low, as visible in Figure 6,the options with new footprints and GEP Index are not well aligned with the original ranking. The rank correlation is only 0.31. An explanation for this lies in the omission of the land use and nitrogen emissions progress indicators from the original ranking. These reflect the production perspectives and have been the worst criterion in many cases. The rankings that include the full original ranking have a much better fit with the original one. The production perspective has a rank correlation of 0.92, which makes sense due to the partially overlapping indicators for land use and GHG emissions. Additionally, the consumption perspective on top of the original GEP+ assessment has a relatively high rank correlation (0.83), even if the consumption perspective is added. Overall, the ranking results reflect that in many cases, different indicators are selected by the Priority to the Worst Achievement criterion in the different approaches. It should be noted that the rankings should be assessed within the income group (PAGE 2017b) and it is combined here to have an improved statistical analysis.

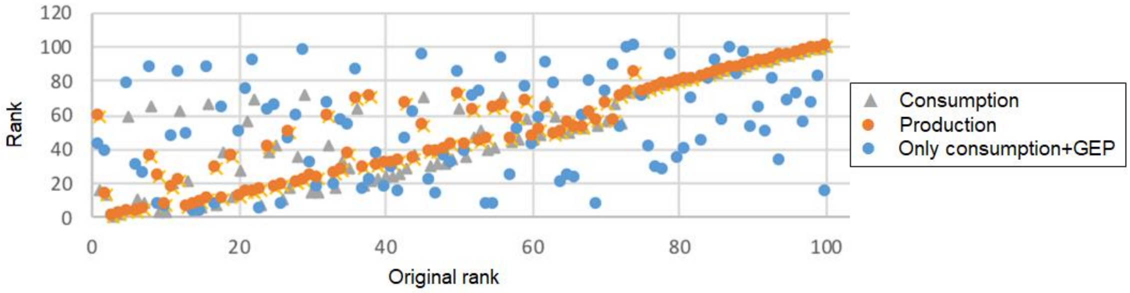

Figure 6: Scatter plot of all ranks (GEP+) (all 104 countries), based on the results as presented in Table 14.

5.4 Discussion of the GEP+ ranking

The GEP+ ranking depends heavily on the selection of indicators for the dashboard, the GEP Index and it's underlying calculation. While indicator calculation sensitivities are discussed above (section 5.2), the aggregation into one factor adds additional sensitivity due to normative choices regarding the selection of indicator. The selection of the three specific indicators for the ranking in the PAGE (2017b) report was based on threshold and data availability. This may be reconsidered as additional research has been published since then.

In general, the high sensitivity of the input data for the weight, progress calculation of the individual indicators, and the additional relevance of selecting the aggregation procedure for the ranking (section 5.3), we suggest to check the options of using weights to aggregate the individual indicators instead of priority to the worst criteria. This suggestion is made as focusing rankings on the worst criterion may be less robust. Alternatively, it may be more robust to report the individual results as spider diagrams or alike (i.e. multidimensional visual results).

Table 14: Ranks and protective criterion for the top 45 countries based on GEP+ ranking (from PAGE 2017b). New ranks are provided after including water, land and carbon footprint on top of the orignial ranking by the consumption and produciton perspective. Also, the pure consumption perspective (i.e. without other dahboard indicators) is caclulated as “only consumption+GEP”

From GEP report (PAGE 2017)								New protective criterion			Overall RANKS			
Rank within HDI	*Country*	*Progress Greenhouse gas emissions*	*Progress Nitrogen emissions*	*Progress Land use*	*GEP Index*	*Protective criterion*	*HDI group*	*consumption*	*only consumption +GEP*	*Production*	*ORIGINAL*	*consumption*	*only consumption +GEP*	*Production*
1	Cyprus	0.5566	0.5971	**0.18**	0.5862	0.18	Very High	-0.235	-0.235	-1.127	1	16	43	60
1	Jamaica	11,022	0.4906	0.1682	**0.1256**	0.1256	High	-0.144	-0.144	-0.013	2	13	38	13
2	Portugal	0.908	0.7315	0.112	**0.0999**	0.0999	Very High	0.100	0.613	0.100	3	1	1	1
3	Spain	13,180	17,082	**0.0873**	0.2118	0.0873	Very High	0.087	0.582	0.087	4	2	2	2
4	Italy	0.9423	19,024	**0.0664**	0.2598	0.0664	Very High	-1.039	-1.039	0.066	5	59	77	3
5	France	0.8247	14,731	**0.0338**	0.1664	0.0338	Very High	-0.105	-0.105	0.029	6	11	30	4
6	Hungary	0.6927	0.2506	**0.0279**	0.3902	0.0279	Very High	-0.092	-0.092	0.011	7	9	26	5
7	Slovenia	0.2241	0.8939	**0.0238**	0.4997	0.0238	Very High	-1.681	-1.681	-0.404	8	65	87	35
8	Japan	0.1101	0.2728	**0.0167**	0.112	0.0167	Very High	0.017	0.087	-0.184	9	3	7	24
9	Denmark	15,100	0.3706	**0.0125**	0.064	0.0125	Very High	0.013	0.168	0.003	10	4	6	7
10	Austria	0.392	33,070	**0.0093**	0.1031	0.0093	Very High	-0.322	-0.322	-0.049	11	20	47	17
11	Germany	0.5734	0.2181	**0.0039**	0.1664	0.0039	Very High	-1.544	-1.544	-0.146	12	62	84	22
12	UK	13,344	0.7411	**0.0033**	0.1655	0.0033	Very High	-0.349	-0.349	0.003	13	22	48	6
13	USA	16,188	0.3984	**0.002**	0.0823	0.002	Very High	0.002	0.354	0.002	14	5	4	8
14	Ireland	23,998	78,447	**0.0012**	0.6197	0.0012	Very High	0.001	0.380	0.001	15	6	3	9
15	Norway	0.5814	10,264	**0.0006**	0.1789	0.0006	Very High	-1.856	-1.856	0.001	16	66	88	10
1	Zimbabwe	0.9104	0.2037	**0**	0.053	0	Low	0.000	0.000	-0.308	17	7	8	28
16	Sweden	10,784	0.589	**-0.0023**	0.0443	-0.0023	Very High	-0.643	-0.643	-0.002	18	39	63	11
2	Senegal	0.2	0.008	**-0.0052**	0.1607	-0.0052	Low	-0.137	-0.137	-0.412	19	12	36	36
17	New Zealand	11,858	47,342	**-0.0096**	0.1482	-0.0096	Very High	-0.370	-0.370	-0.010	20	27	50	12
18	Netherlands	0.609	14,448	**-0.0194**	0.1519	-0.0194	Very High	-1.003	-1.003	-0.019	21	57	75	14
19	Luxembourg	0.6066	15,436	**-0.0331**	0.2536	-0.0331	Very High	-2.369	-2.369	-0.033	22	69	92	15
20	Greece	0.8965	20,803	**-0.041**	0.2209	-0.041	Very High	-0.041	0.343	-0.041	23	8	5	16
21	Croatia	0.1319	37,294	**-0.0412**	0.1999	-0.0412	Very High	-0.588	-0.588	-0.478	24	38	62	41
22	Australia	10,147	0.6382	-0.0017	**-0.0601**	-0.0601	Very High	-0.664	-0.664	-0.060	25	42	65	18
23	Israel	**-0.0968**	10,527	0.004	0.0676	-0.0968	Very High	-0.097	0.000	-0.097	26	10	8	19
3	Cameroon	0.8613	0.0657	**-0.1058**	0.2448	-0.1058	Low	-0.313	-0.313	-0.824	27	18	46	50
24	Switzerland	0.5174	**-0.1158**	-0.0002	0.183	-0.1158	Very High	-0.573	-0.573	-0.116	28	36	59	20
25	Singapore	0.6208	0.4228	0.0211	**-0.1218**	-0.1218	Very High	-2.760	-2.760	-0.122	29	72	97	21
4	Mali	**-0.1776**	17,463	-0.0061	0.1931	-0.1776	Low	-0.178	-0.110	-0.189	30	14	32	25
5	Malawi	**-0.1796**	-0.1059	-0.0265	0.2784	-0.1796	Low	-0.180	-0.018	-0.180	31	15	17	23
2	Azerbaijan	**-0.1942**	0.0018	0.001	0.2512	-0.1942	High	-0.668	-0.668	-1.071	32	43	66	59
3	Jordan	**-0.2369**	21,228	0.008	0.1523	-0.2369	High	-0.237	-0.031	-0.237	33	17	19	26
26	Finland	13,523	**-0.2502**	0.0018	0.1193	-0.2502	Very High	-0.494	-0.494	-0.250	34	33	56	27
1	Dominican Republic	**-0.2539**	-0.2341	0	0.2801	-0.2539	Medium	-0.425	-0.425	-0.432	35	29	54	37
4	Venezuela	**-0.3027**	0.37	0.0227	-0.0497	-0.3027	High	-1.602	-1.602	-3.493	36	64	86	69
6	Mozambique	0.0602	**-0.3168**	0.0159	0.3059	-0.3168	Low	-0.317	-0.016	-0.317	37	19	16	29
2	South Africa	**-0.3429**	0.6564	-0.0059	-0.1977	-0.3429	Medium	-0.343	-0.056	-4.258	38	21	22	70
7	Nepal	-0.2321	**-0.351**	-0.0045	0.2931	-0.351	Low	-0.351	-0.140	-0.351	39	23	37	30
3	Philippines	0.143	0.3621	**-0.3572**	0.1978	-0.3572	Medium	-0.357	-0.023	-0.357	40	24	18	31
8	Benin	**-0.359**	0.2255	-0.0758	-0.1081	-0.359	Low	-0.359	-0.101	-0.359	41	25	28	32
9	Togo	-0.2172	0.2122	**-0.3677**	0.2128	-0.3677	Low	-0.368	-0.015	-0.368	42	26	15	33
4	Honduras	**-0.3793**	0.6753	-0.1613	0.1329	-0.3793	Medium	-0.379	-0.309	-2.539	43	28	45	66
5	Moldova	-0.3642	**-0.3964**	0.0698	0.2619	-0.3964	Medium	-0.587	-0.587	-0.396	44	37	61	34
5	Tunisia	-0.2578	**-0.4145**	-0.2814	0.3572	-0.4145	High	-2.634	-2.634	-0.941	45	71	95	54

6. Concluding remarks and recommendations

6.1 Remarks

In conclusion, the study shows that it is possible to calculate footprints indicators (Greenhouse gas footprint, biodiversity footprint, water footprint) for most countries or at least >150 countries, based on existing data. Therefore, it is possible to include these indicators in the Green Economy Measurement Framework (GEMF), in particular, to its dashboard of environmental sustainability. The link to the Sustainable Consumption and Production Hotspot Analysis Tool (SCP-HAT), as well as to the Global Resources Outlook (GRO) tool of the International Resources Panel (IRP) assessment, has been explored. The data sources used by the two tools have different strengths and weaknesses. This indicates that beyond the 44 specific countries available in EXIOBASE, a combination of existing data sources is necessary. We displayed a first implementation of dissolving the EXIOBASE (database used by the GRO tool) detailed sector, and environmental data using EORA (database used by the SCP-HAT). In principle, there is an option to dissolve the EORA sectors by EXIOBASE. However, EXIOBASE was chosen as a starting point since sector resolution is of key importance, especially for reliable results regarding land and water use. Furthermore, the EORA estimates for the other countries are mainly based on estimated Input-Output tables. Considering this, EORA does not provide land use and water consumption impact results (SCP-HAT covers land use impacts).

In conclusion, existing methods and data allow enhancing the GEP+ methodology with land and water use impact assessment methods. These methods are recommended by UNEP for Life cycle impact assessment, which is the basis for these footprints.

6.2 Recommendations and next steps

6.2.1 Recommendations for the extension of the GEP Measurement Framework with environmental footprint indicators

6.2.1.1 Indicators and framework

An extension of the GEP Measurement Framework with additional environmental footprint indicators is important for two main reasons. Firstly, this allows us to assess consumption-based impacts against planetary boundaries at a higher level of detail than currently possible with the ecological footprint. Secondly, it aligns with the indicators used for LCA and IRP reports by the UN, as well as with indicators currently discussed in the science based target initiatives.

Therefore, we recommend enhancing the GEP Measurement Framework with the carbon footprint (first priority) and water and land footprint (second priority, requiring additional data sources). As environmental footprint indicators only cover the consumption perspective, a production-based impact assessment of the three indicators should be considered also. The effects on the ranking results from the interplay of indicator selection. High sensitivities to input data and the worst achievement criterion have to be taken into account, and possibly adjusted.

6.2.1.2 Changes required to include new indicators

Changes to the framework to include the new environmental footprint indicators have been described above. While it is straightforward, the methodological choice of how to integrate them is to be discussed. We tested three options and believe that adding the footprint indicators to the dashboard is the most straightforward calculation, since land use is covered from a production perspective.

6.2.2 Recommendations for the data base to be used

Currently, two major MRIO databases seem suitable for straightforward calculation of the indicators. As it is necessary to enhance the framework operationally with the three indicators, this study proposes a combination of the two databases EORA and EXIOBASE, as a short-term solution, which allows it to cover > 150 individual countries. Specific options are discussed below. In general, we suggest creating a working group with various MRIO and environmental footprint experts to derive more specific suggestions.

6.2.2.1 Option 1: Combining EORA and EXIOBASE data

6.2.2.1.1 Evaluation

A combination of EORA and EXIOBASE is the most efficient way forward. As shown by the preliminary results used in this study, such a combination can help to get the country and indicator coverage required. This option can be a mathematical combination of the MRIO tables without additional data sources On the other hand, it can be coupled, e.g. with FAOSTAT data to get a higher level of detail for agriculture, which is of special interest for land and water use related impacts.

A drawback is that it does not create a consistent and new MRIO database, but a hybrid version of the two (or more sources). In general, additional MRIO could be used to create more robust results, as discussed in option 3.

It is recommended to ensure a closer alignment of the two databases, and tools respectively, in an independent project. This would avoid differing results and lead users from one tool to the other tool for additional information/analyses. It is further recommended to avoid double work in the two different approaches. Finally, this requires an integration of efforts by the different UN sections. A creation of a more sophisticated **combination of the two databases** that are used in IRP's GRO assessments, and the SCP-HAT seems to be the most promising starting point.

6.2.2.1.2 Institutions for enhancing footprint methods

It is recommended that the UNEP section that fosters the SCP-HAT tool (Life Cycle Initiative) is ensuring the data provision and monitoring of these indicators.This is based on a harmonized database as mentioned above.

The following institutions seem to be most suited to enhance the method and provide regular updates on the data:

- **Vienna University of Economics and Business (WU) / Commonwealth Scientific and Industrial Research Organisation (CSIRO):** Lutter et al.: Group providing the SCP-HAT tool and working on advanced MRIO (incl. EORA and EXIOBASE), as well as on linking MRIO and LCIA.
    - Generally open-source and open-access committed

- **ETH Zurich:** Hellweg et al.: Group that created IRP MRIO tool and provided preliminary results for combined EXIOBASE/EORA MRIO. Experts in environmental impacts of the UNEP Life Cycle Initiative's recommended footprint methods.
    - Generally open-source and open-access committed

- **University of Sydney**: Lenzen et al.: Group that created EORA (incl. Full EORA). KGM & Associates Pty Ltd, hold the rights of EORA, but little information is publicly available. There are plans to apply full EORA for SCP-HAT, as it is more detailed than EORA26 for many countries (more sectors). However, environmental extensions and documentation are not at the same level as for EXIOBASE.
    - Partially open-access committed (not for Full EORA)
    - Data of full EORA owned by spin-off company

- **Charles University, Prague, Environment Centre:** Research group of Jan Weinzettel has done several projects for disaggregating water and land use extensions of EXIOBASE to higher level of details.

- **NTNU / CML**: Research groups from NTNU (Richard Wood, Edgar Hertwich, Konstantin Stadler) and CML (Arnold Tukker) have led EXIOBASE projects. Broad range of experience in building, extending and adjusting global multi-regional input-output databases.
    - Partially open-access committed

- **OECD, Eurostat**: OECD provides inter country input-output tables (ICIO) that have been applied extensively to study trade in value added. Eurostat and JRC (in close collaboration with OECD) are working on full international and global accounts for research in an input-output analysis (FIGARO) project. It is an experimental project which aims to provide an official inter-country supply, us and input-output data at EU levels. So far there is little information regarding environmental extensions. However, it is important to note that these are non-academic institutions that are likely to play an important role in complication of global multi-region input-output tables.

Expected costs of a merge are ~100kUSD for a refined version with the use of additional data sources such as FAOSTAT, and ~50kUSD for a simpler version by only integrating the two MRIO databases.

6.2.2.2 Option 2: Extending assessment to include more life cycle impact assessment methods

6.2.2.2.1 Evaluation

In order to assess additional impacts such as toxicity in a consistent way, as well as from a production and a consumption perspective, a combination of process LCI data and MRIO could be achieved. Several databases exist, with ecoinvent being a main provider of data as a not-for–profit organization.

Such a combination would be challenging due to the highly different resolution of sectors and processes. A merge requires a lot of additional data to utilize the real potential of process data. It is therefore considered to be a longer term goal due to lack of existing preliminary results. A Swiss National Research project "OASES", is currently working on merging ecoinvent and EXIOBASE data (National Research Programme 2019).

Another issue is that LCI data is in general, not publicly available.

We recommend to re-consider this option once the indicators assessed in this study have been consolidated. However, many open issues for such a merge are to be tackled and it might rather be a long-term project.

6.2.2.2.2 Institutions to collaborate

This would involve a collaboration with a major software provider. Due to the market dominance, data coverage and transparency, collaboration with the ecoinvent association is recommended. As ecoinvent v3 is a commercial database, data access limitations need to be negotiated, such as e.g. done by the European Commission for the product environmental footprint (PEF). In the past, Swiss Federal Offices have also agreed on ecoinvent data for at least partial public access in other tools (e.g. Mobitool (2019)).

Alternatively, other data source providers, such as GABI or international efforts under the UNEP GLAD initiative (United Nations Environment Programme 2019) could also be evaluated. The costs of a first version of such a combined database merging MRIO with detailed LCI from ecoinvent may be ~100k USD (without potential data costs from ecoinvent or another supplier). This depends on the level of quality requested once the OASES results are available.

6.2.2.3 Option 3: Combination of multiple MRIO databases and additional data sources

6.2.2.3.1 Evaluation

As discussed in chapter 3 and presented in Table 1, various MRIO databases with different strengths and weaknesses exist. A combination of various databases can lead to more robust results, since different sector and country resolutions can be combined.

This would be the most promising solution, providing a new MRIO that utilises inputs from existing work. However, this also requires much more funding and is only recommended if UNEP has a commitment to maintain such a database over the years.

6.2.2.3.2 Institutions to collaborate

As different organizations have been involved in the development of the various MRIO data, a larger consortium would be required. EXIOBASE as an example as a research project with roughly 10 research groups involved. Such an option would be a longer term project and requires a clear vision and budget to achieve. It would be an option to have a UNEP database managing the inputs and updates. However, this may also cause issues of scientific independence and the need to be assessed with potential institutions.

The costs of such a project are estimated in the range of 3-5 million USD, this is similar to the estimated costs of the development of the individual EXIOBASE versions. It is suggested to create a task force with interested research groups in the field that should work for 1-2 years to create a strategy. Furthermore, they should define specific tasks to arrive at a consolidated MRIO table for environmental footprints, including the related costs.

6.3 Periodicity for updating these environment footprint indicators

It is recommended to update the indicator every 2 years (maximum 4 years). Every two years may be too short an interval to observe significant changes and add costs, so 3 years may be a viable compromise. Costs vary considerably, depending on the MRIO developments in other research projects. Without completely new MRIO data, updates can include improvements of environmental extensions (satellite matrix) over the years, based on national statistics. Adjustments of trade flows based on other trade and production data, such as FAOSTAT, COMTRADE, BGS, USGS, can help to enhance the quality.

We recommend that updates are done based on other data (scaled), and estimate these costs to be ~30k USD per update. However, this may imply that some automated update mechanisms have to be established in a project with costs of ~50k USD – i.e. the first update incl. procedure for automated update might cost ~80k USD.

We recommend creating new MRIO data at least after two rounds of updates (i.e. 9 years). Costs would be in the order of 200-300k USD, depending on the level of detail required and parallel research outcomes.

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8. Appendix

8.1 GHG emissions on the SCP-HAT tool (v1.0)

Two sources are employed for compiling the SCP-HAT's GHG emissions input data. The main dataset is the PRIMAP-hist (PRIMAP – Potsdam Real-time Integrated Model for Probabilistic Assessment of Emissions Paths), developed by the Potsdam Institute for Climate Impact Research (Gütschow et al. 2017, 2016). PRIMAP-hist is selected because of its coverage over a long time series, and because it integrates other popular global GHG datasets (e.g. British Petroleum Review of World Energy, Carbon Dioxide Information Analysis Center fossil fuel and industrial CO_2 emissions dataset, the EDGAR dataset). It includes emissions for the main Kyoto greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6), from the period of 1850 to 2014. NF_3 is not included. The country detail is 196 UNFCCC state members and other territories, including almost all countries considered in the SCP-HAT.

The PRIMAP-hist sector categorization is based on the main IPCC 1996 categories, although for CO_2 a finer resolution including some subcategories is available (from the main seven categories to fourteen). However, a weak sector resolution in the environmental extension of EE-MRIO models can cause aggregation errors (Su et al. 2010; Steen-Olsen et al. 2014), and inclusion of external data for further disaggregation is recommended (Lenzen 2011). To prevent aggregation bias, the PRIMAP-hist data is further disaggregated using GHG emissions shares from the EDGAR database, which is maintained by the European Commission Joint Research Centre (JRC) and the Netherlands Environmental Assessment Agency (PBL) (Olivier and Greet 2011). That is, the shares among sub-categories in EDGAR will be assumed, but the total emissions per category are those provided by the PRIMAP-hist. Two specific EDGAR datasets will be utilized; the EDGAR version 4.2 for the years 1990 and 1999, and the EDGAR version 4.2 Fast Tack (FT) 2010 for the period 2000 to 2010. Once the PRIMAP-hist data is disaggregated, the IPCC 1996 categories are allocated to one or more sectors of the SCP-HAT (i.e. Eora 26 sectors). The IPCC 1996 sector classification in the SCP-HAT and the correspondence to the SCP-HAT sectors is provided in Annex IV. For those categories allocated to more than one sector, the emissions will be downscaled using total output per sector.

Furthermore, GHG national inventories (and databases based on them as PRIMAP-hist) follow the territory principle, that is assuming all emissions occurring within the boundaries of a country are accounted for. In contrast, input-output databases follow the residence principle, i.e. output by the residence units, irrespective from the country where they occur, are accounted for. Although in most cases where a resident unit operates on the domestic territory, there are some exceptions, such as air and maritime transportation. Combining both approaches with any prior adjustment can lead to some inconsistencies (Usubiaga and Acosta-Fernández 2015). However, reducing this gap would require extra data and assumptions, which due to time limitations, are out of scope of the present project.

8.2 Environmental Indicators

8.2.1 GHG Footprint

The greenhouse gas footprint quantifies environmental pressures occurring anywhere in the World due to the consumption of goods and services in a particular country. This indicator includes the following substances: CO_2, CH_4, N_2O, PFC, HFC, SF_6, NF_3 expressed in $kgCO_2$ equivalent units.

8.2.2 Biodiversity Footprint

Land use is one of the primary drivers of biodiversity and species loss. According to the recommendation by the Life Cycle Initiative, the biodiversity footprint is calculated as the potential loss of species due to land use. This indicator quantifies the potential loss of species due to specific land use (use of arable land, permanent crops, pasture, intensively and extensively used forest and urban areas), in comparison to an untouched natural reference state. It takes the vulnerability of species into consideration and aggregates the regional loss of commonly occurring species and the global loss of endemic species into "globally lost species". Therefore, it aggregates a varying impact intensity under one indicator (similar to the unit kg of CO_2-equivalent used to aggregate GHG emissions). The biodiversity footprint indicator is expressed in equivalent of potentially globally lost species per millions species (micro PDF*a).

8.2.3 Water Footprint

The water footprint measures the use of global freshwater resources. It takes into account the prevailing water scarcity in the production region and usually it is quantified using a water scarcity indicator (AWARE). This indicator represents Available WAter REmaining per area in a watershed following the demands for humans and aquatic ecosystems have been met. It aims to assess the potential of water deprivation, to either humans or ecosystems by building on the assumption that decreasing water availability in the area increases the likelihood that other water users in the same area will be deprived. The AWARE characterization factors quantify the available water quantity per catchment area by subtracting the water demand of humans and aquatic ecosystems from the amount of naturally available water.

8.3 List of acronyms

EEA European Environmental Agency

EU European Union

EE-MRIO Environmentally Extended Multi-Regional Input-Output SDG

FAO Food and Agriculture Organization of the United Nations

GEP Green Economy Progress

GEMF Green Economy Progress Measurement Framework

GHG Greenhouse Gas Emissions

GRO Global Resource Outlook

GTAP Global Trade Analysis Project

HDI Human Development Index

ICIO Inter-Country Input-Output

IGE Inclusive Green Economy

IRP International Resource Panel

LCA Life Cycle Assessment

LCIA Life Cycle Impact Assessment

LCI Life Cycle inventory

MRIO Multi-Regional Input-Output

PAGE Partnership for Action on Green Economy

SCP-HAT Sustainable Consumption and Production Hotspot Analysis Tool

UNEP United Nations Environment Programme

OECD Organisation for Economic Co-operation and Development

WIOD World Input-Output Database

8.4 Results (visualized with maps)

Figure A.1-A.8 show key results of the report as maps. The results are calculated based on preliminary results of the Eora-EXIOBASE combined MRIO and should be considered with caution.

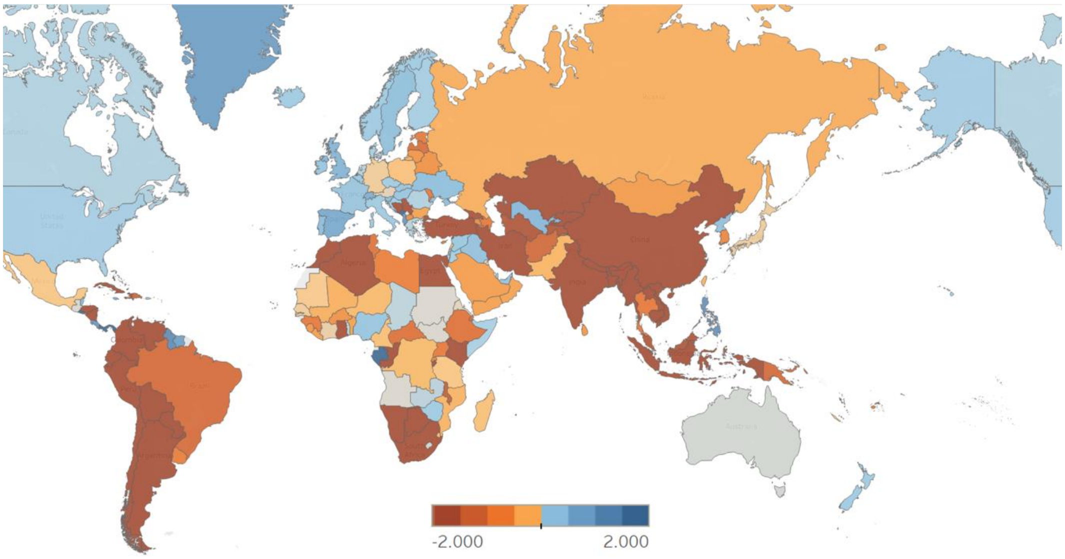

Figure A.1 Progress: GHG emissions (Production perspective)

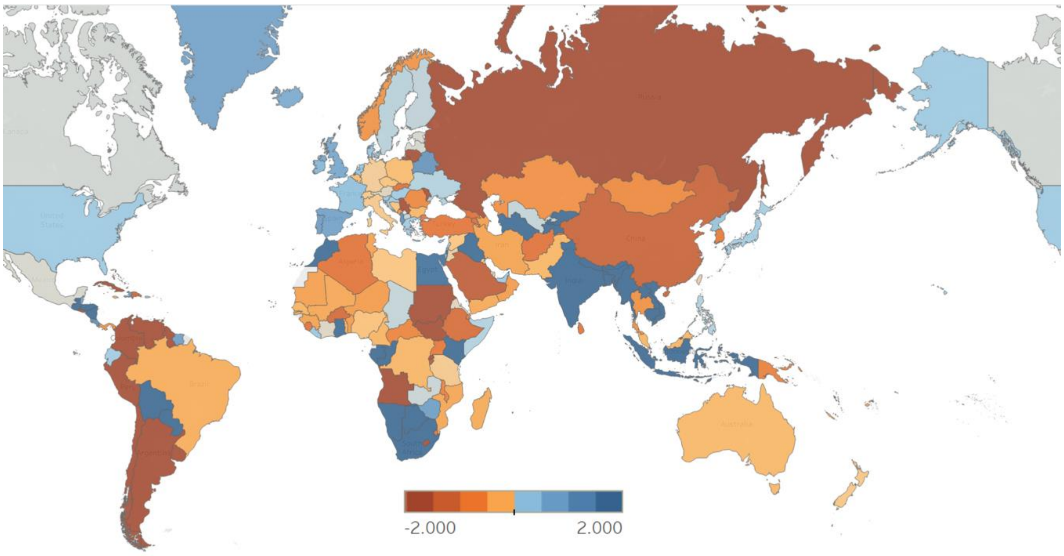

Figure A.2 Progress: GHG emissions (Consumption perspective)

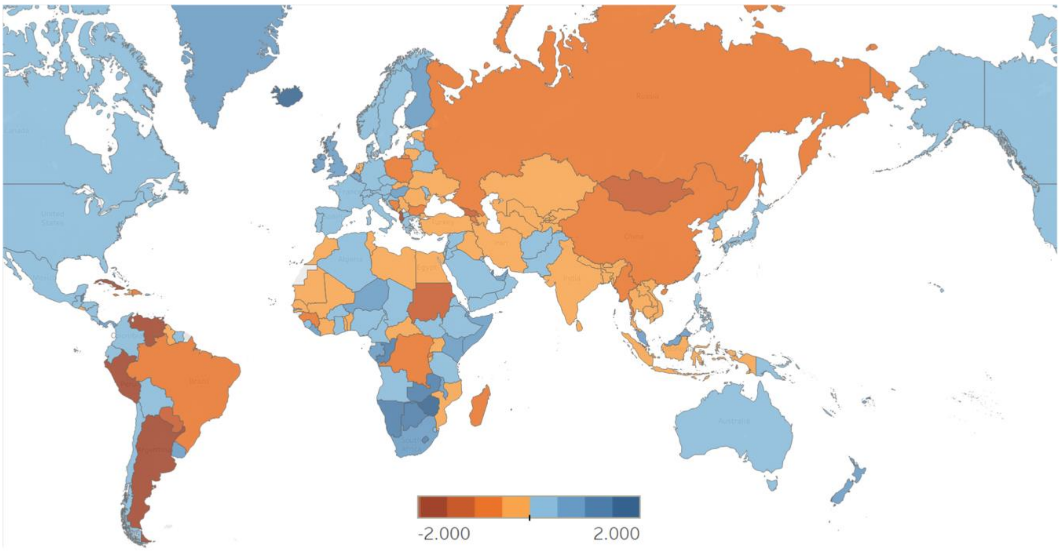

Figure A.3 Progress: Water scarcity impact (Production perspective)

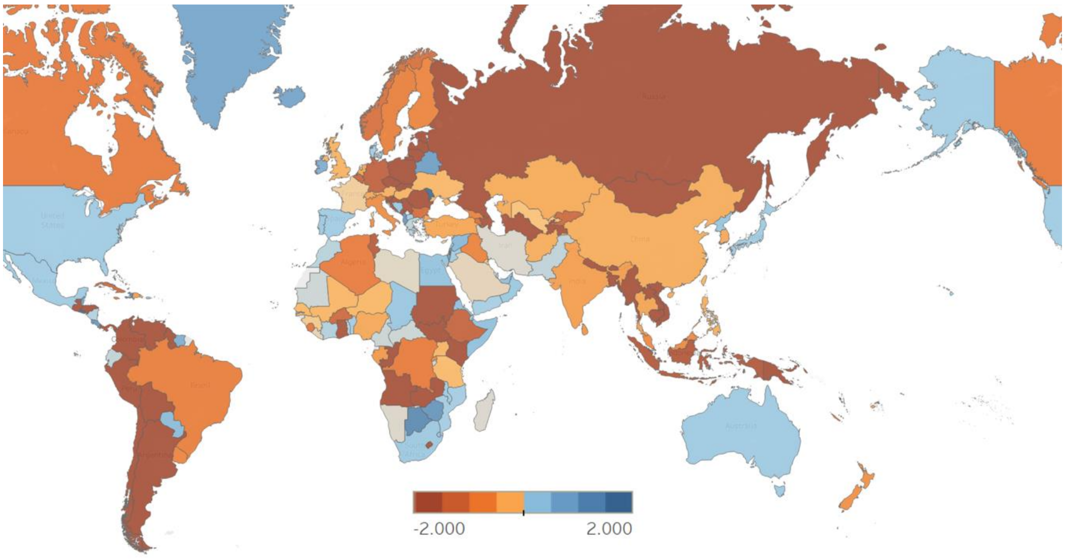

Figure A.4 Progress: Water scarcity impact (Consumption perspective)

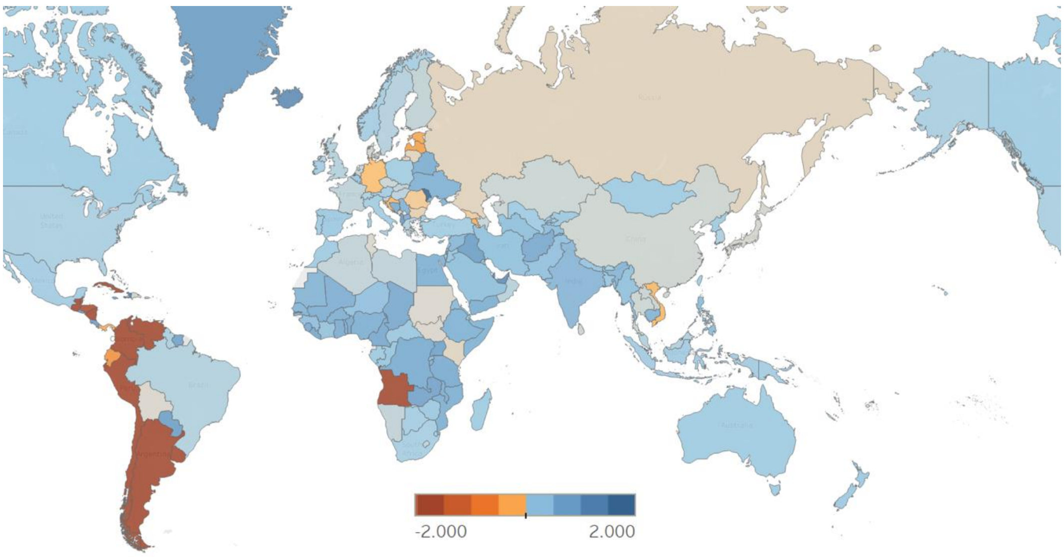

Figure A.5 Land use related biodiversity loss (Production perspective)

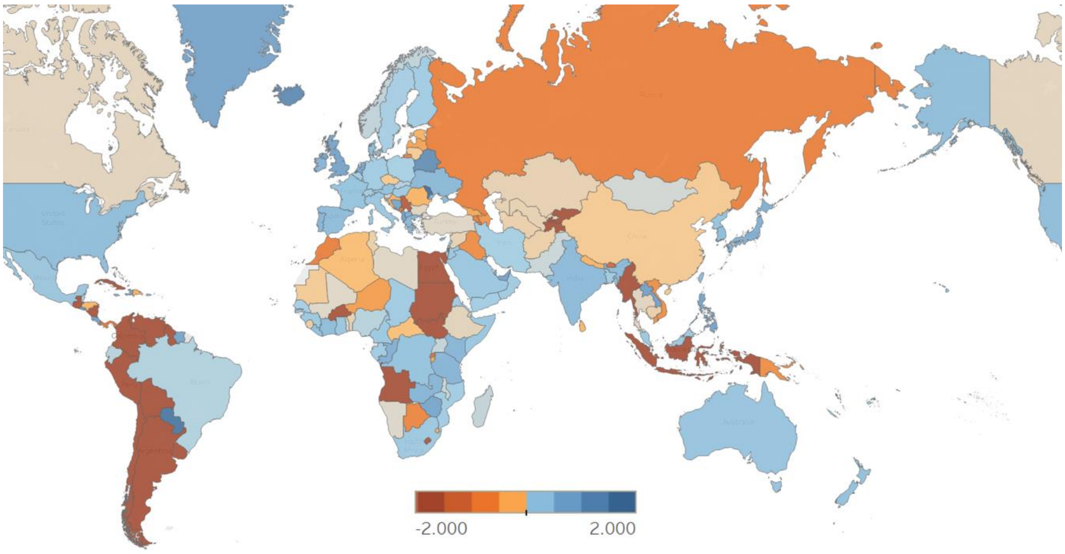

Figure A.6 Land use related biodiversity loss (Consumption perspective)

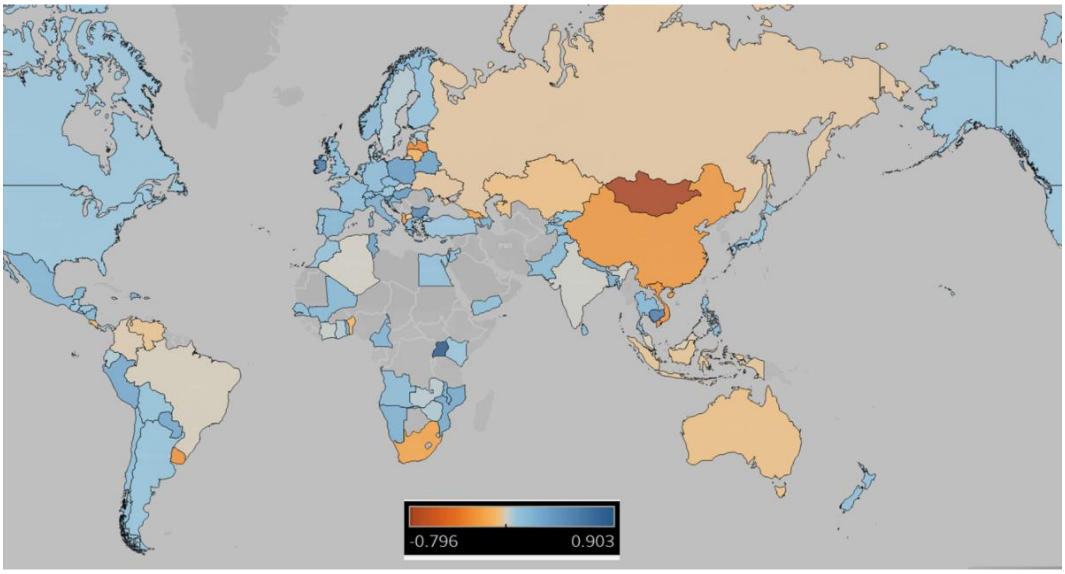

Figure A.7 Results of original GEP index (100 countries)

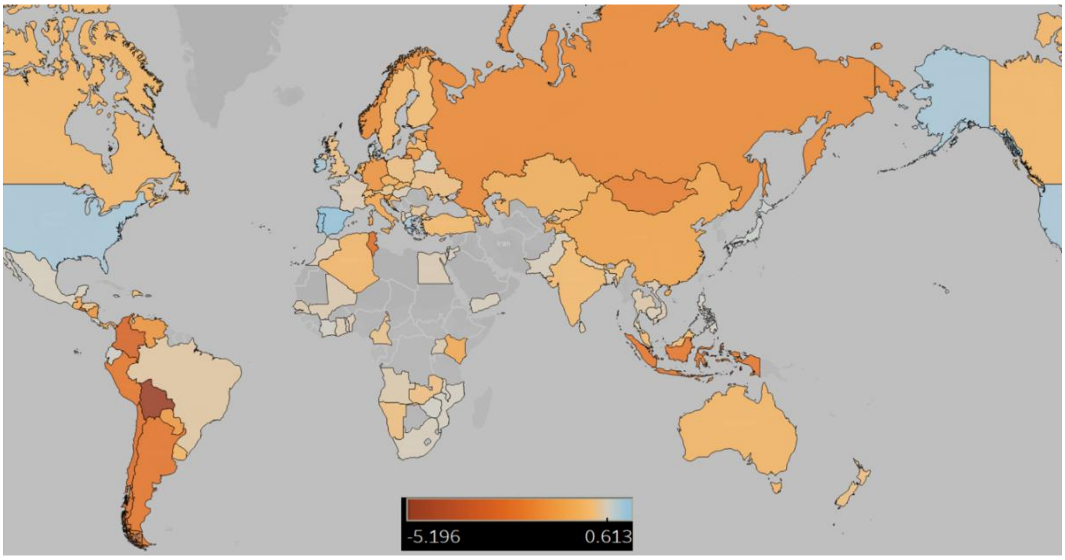

Figure A.8 Protective criteria result: GEP index plus water, land and carbon footprint

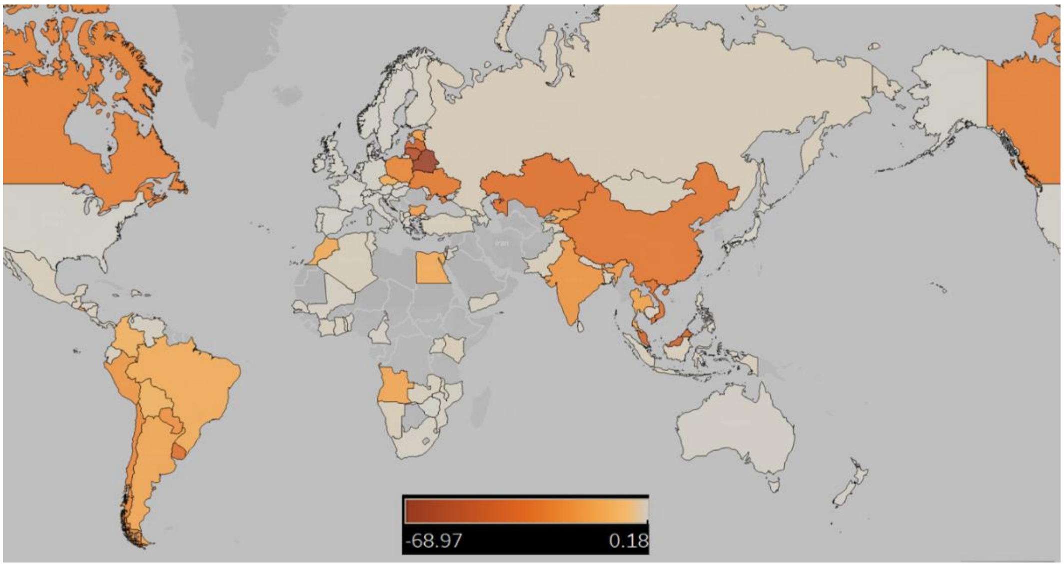

Figure A.9 Protective criteria result: original application (PAGE 2017)

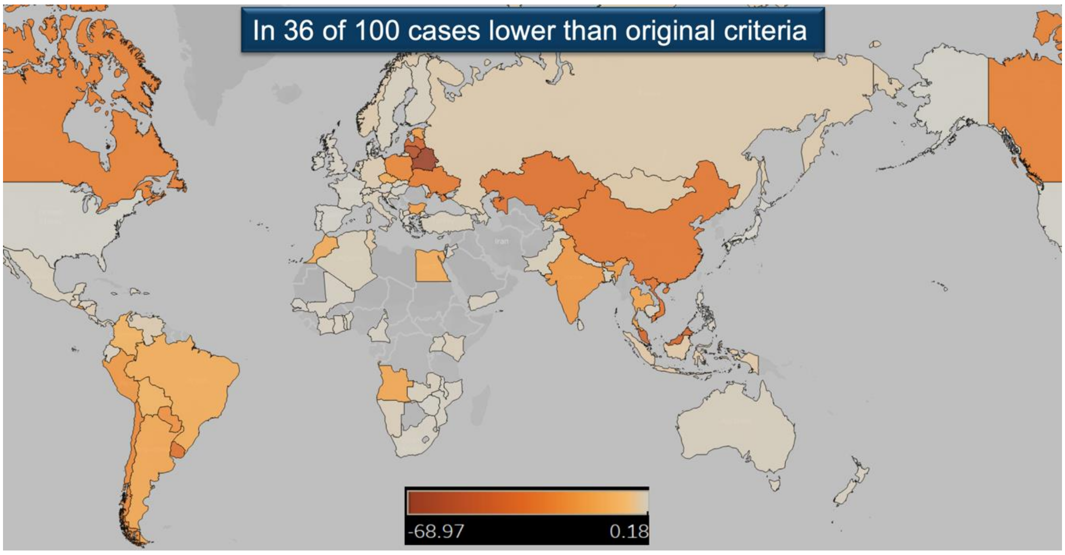

Figure A.10 Protective criteria result: original application plus water, land and carbon footprint