NATIONAL DISTANCE EDUCATION UNIVERSITY
Faculty of Economics and Business Administration

UNIVERSITY JAUME I
Faculty of Law and Economics

METHODOLOGICAL APPROACH FOR ENVIRONMENTAL ASSESSMENT IN ECONOMY FOR THE COMMON GOOD MATRIX

Final Project

MSc SUSTAINABILITY AND SOCIAL CORPORATE RESPONSABILITY

Carlos López Monllor

September 2017

ETHICAL COMMITMENT (Spanish)

El abajo firmante:

CARLOS LÓPEZ MONLLOR, con DNI 48491902J, con respecto a la realización del Trabajo de Final del Máster en Sostenibilidad y Responsabilidad Social Corporativa impartido conjuntamente por la Universidad Nacional de Educación a Distancia y la Universidad Jaume I de Castellón que estoy cursando, declaro que:

1. Reconozco la ilegitimidad e ilegalidad del plagio, consintiendo éste en usar el trabajo de otra persona con la pretensión de considerarlo como propio.
2. Cada contribución y cita de este Trabajo Final de Máster ha sido Convenientemente citada y referenciada.
3. Este Trabajo Final de Máster es fruto de mi propio trabajo.
4. No he permitido a nadie, ni permitiré, copiar este Trabajo Final de Máster con la intención de hacerlo pasar como suyo propio.

Y para que así conste, firmo la presente declaración.

En Madrid, a 12 de septiembre de 2017

FIRMA

Acknowledgment

I would like to acknowledge Orencio Vázquez Oteo, coordinator of the Spanish Social Corporate Responsibility Observatory and supervisor of this project, his approval to the challenge of supervising this work and his guidance during these months.

Thanks to Marta de la Cuesta González, coordinator of the MSc in Sustainability and Social Corporate Responsibility, the help received during these two years.

I wish to acknowledge Pedro Olazábal Herrero, from ES Madrid of the Economy for Common Good, his support and valuable feedback to the project, as well as his guidance with Open LCA software.

I would like to express my sincere gratitude to Christian Loy, from ES Vienna of the Economy for the Common Good and also member of the Matrix Development Team, for the help and encouragement received in the very beginning with the project proposal related to the Corporate Sustainability Thresholds Approach, as well as his very useful feedback to the project.

Many thanks to Lutz Knakrügge, from ES Lörrach of the Economy for the Common Good and member of the Matrix Development Team, for answering my questions about Common Good Matrix 5.0 and also his feedback to the work.

I wish also to acknowledge to Germán Giner Santonja, from ES Seville of the Economy for the Common Good, for his feedback to the project, it certainly helped to improve the quality of the work.

And last, but not the least, thanks to Alejandro Mora Rodríguez, from ES Madrid of the Economy for the Common Good, for his support and dedication, not only in this work but also in the projects developed together in ECG scope during the last years.

CONTENTS

List of Tables

List of Figures

Glossary of terms

BAT	: Best Available Technologies
CTUe	: Comparative Toxic Units for Ecosystems
CTUh	: Comparative Toxic Units for Humans
DALY	: Disability Adjusted Life Years
ECG	: Economy for the Common Good
EF	: Environmental Footprint
EMAS	: Eco-management and Audit Scheme
EU	: European Union
GHG	: Greenhouse Gas
GRI	: Global Reporting Initiative
GWP	: Global Warming Potential
ILCD	: International Reference Life Cycle Data System
JRC	: Joint Research Centre of the European Commission
LCA	: Life Cycle Assessment
m2a	: Accounting of Land Occupation
ODP	: Ozone Depletion Potential
OEF	: Organisation Environmental Footprint
PAF	: Potentially Affected Fraction of Species
PDF	: Potentially Disappeared Fraction of Species
PEF	: Product Environmental Footprint
PM	: Particulate Matter
PPP	: Purchasing Power Parity
P/S	: Products and Services
SMEs	: Small and Medium Enterprises
WIOD	: World Input-Output Database
WP	: Weighting Point

Definitions

Corporate Sustainability Thresholds Approach: Approach consisting of the definition of a conceptual framework for both deducting corporate sustainability thresholds and deducting a safe operating space for companies, based either in the planetary boundaries definition or in the management of the required information from Input-Output databases.

Endpoint impact indicators: An endpoint indicator can be defined as a parameter that measures the impact produced over the nature. For example, in climate change category a typical endpoint indicator would be the average world temperature. They can also be defined as state-variables.

Midpoint impact indicators: A midpoint indicator can be defined as a parameter in a cause-effect chain or network (environmental mechanism) for a particular impact category that is between the inventory data and the category endpoints. For example, in climate change category a typical midpoint indicator would be the Tonnes emitted of CO_2 equivalent. They can also be defined as pressure-variables

1. INTRODUCTION

The Economy for the Common Good (ECG) is a comprehensive and coherent economic model and is being practiced in hundreds of organisations, as businesses, universities, municipalities, or local chapters, across Europe and South America. It represents an alternative to both capitalism and communism. It emerges out of a holistic worldview and is based on a democracy in which the sovereign has greater power of decision than is usual in existing democracies [1].

The model has five underlying goals [1]:

1. Reuniting the economy with the fundamental values guiding society in general. The ECG encourages business decisions that promote human rights, justice, and sustainability.
2. Transitioning to an economic system that defines serving the "common good" as its principal goal. The business community and all other economic actors should live up to the universal values set down in constitutions across the globe. These values include dignity, social justice, sustainability, and democracy. These do not include profit maximization and market domination.
3. Shifting to a business system that measures success according to the values outlined above. A business is successful and reaps the benefits of its success not when it makes more and more profits, but when it does its best to serve the public good.
4. Setting the cornerstones of the legal framework for the economy democratically, in processes which result in concrete recommendations for reforming and re-evaluating national constitutions and international treaties.
5. Closing the gaps between feeling and thinking, technology and nature, economy and ethics, science and spirituality.

Rewarding "good" behaviour, and making "poor" behaviour more visible to the public and less profitable, will lead to a general paradigm shift at all levels of the economy. More cooperation among business partners would be seen. Less uncontrolled and destructive growth would be seen, and organisations would strive towards their optimal size. Business profits will increasingly be used to improve products, infrastructure, and working conditions and less used for increasing dividends for investors, which widens the social divide [1].

In order for ECG to measure the common good, the common good balance or common good matrix is defined. Since its beginning this matrix has suffered several modifications, fruit of decisions of discussion panels. The current version, Common Good Matrix 5.0, is based in the following four values and group of values that are allocated in the columns of the matrix:

1. Human dignity
2. Solidarity and social justice
3. Environmental sustainability
4. Transparency and co-determination

In the rows of the matrix are presented the main stakeholders of the organisation that is assessed by the common good balance:

1. Suppliers
2. Owners, Equity and Financial Service Providers
3. Employees
4. Customers and Business Partners
5. Social Environment

In each cell of the matrix, coming from the cross between a stakeholder and a value, a topic is created. Each topic is assessed on the basis defined in the ECG manual [22] in terms of how the organisation respects the associated value with the named stakeholder. The following Figure show the Common Good Matrix version 5.0.

VALUE / STAKEHOLDER	HUMAN DIGNITY	SOLIDARITY AND SOCIAL JUSTICE	ENVIRONMENTAL SUSTAINABILITY	TRANSPARENCY AND CO-DETERMINATION
A: SUPPLIERS	**A1** Human dignity in the supply chain	**A2** Solidarity and social justice the supply chain	**A3** Environmental sustainability the supply chain	**A4** Transparency and participation in the supply chain
B: OWNERS, EQUITY- AND FINANCIAL SERVICE PROVIDERS	**B1** Ethical position in relation to financial resources	**B2** Social position in relation to financial resources	**B3** Use of funds in relation to the environment	**B4** Ownership and co-determination
C: EMPLOYEES	**C1** Human dignity in the workplace and working environment	**C2** Self-determined working arrangements	**C3** Environmentally friendly behaviour of staff	**C4** Co-decision making and transparency within the organisation
D: CUSTOMERS AND BUSINESS PARTNERS	**D1** Ethical customer relations	**D2** Cooperation and solidarity with business partners	**D3** Impact on the environment of the use and disposal of products and services	**D4** Customer participation and product transparency
E: SOCIAL ENVIRONMENT	**E1** Purpose of products and services and their effects on society	**E2** Contribution to the community	**E3** Reduction of environmental impact	**E4** Social co-determination and transparency

Figure 1: Common Good Matrix 5.0 [22]

For each topic a maximum score is defined. In principle this maximum score is set equal for the 20 topics, accounting for an overall maximum mark of 1.000 points (50 points per topic), but later an adjustment is performed, making this maximum score depending upon some critical factors as the industrial sector to which the organisation belongs to, the size of the organisation or the social risk associated to the country of origin of the organisation. The sum of the maximum score of all the topics is 1.000 points, even after the adjustment. The assessment of each topic takes to overall common good performance of the organisation that would vary between 0 and 1.000 points. The more points the organisation has, the more the activities of the organisation are in line with common good.

The purpose of ECG is giving visibility to organisations promoting common good and that in the future fiscal incentives are established in order to encourage organisations to foster the common good and not only the profit maximisation.

2. AIM AND OBJECTIVES

The **aim** of this project is reviewing the current methodology for measuring the environmental impact of an organisation in the framework of Economy for the Common Good (ECG) and proposing an alternative one. This methodology will not comprise other qualitative aspects related to environmental management and policies of the organisation or the risks measurement that could also be valid to assess an organisation in an environmental basis. For the elaboration of the alternative methodology the following criteria should be taken into account:

- The methodology should be easy to understand and to implement by the organisations.
- The methodology should consider at least the main environmental impacts.
- The environmental impacts considered should be quantified in such a way that they can be compared and aggregated in a total environmental impact.
- The environmental impact indicators considered should be easily comparable and compatible with the most relevant existing tools to measure the environmental impact.
- The methodology should be easily extrapolated from the organisation scope to the product/services scope.
- The methodology proposed should be focused within the conceptual framework for both deducting corporate sustainability thresholds and deducting a safe operating space for organisations. If not currently because there is not enough background information available, the methodology should be flexible enough to enable a later adaptation to approaches of this nature. This approach is defined in this project as "Corporate Sustainability Thresholds Approach"

In order to carry out the aim, the following **objectives** are established:

1. Literature review of the existing methods for quantifying or defining the environmental impact of both organisations and P/S, as well as for setting environmentally based planet boundaries
2. Evaluation of the current methodology for environmental impact assessment in the ECG framework.
3. Selection of the environmental impacts categories as well as their indicators to be considered in the methodology.
4. Definition of a procedure to aggregate all those categories in a "total environmental impact".
5. Discussion about the possible integration of the proposed methodology within the Common Good Matrix 5.0.
6. Discussion on the potential use of the proposed methodology in a "Corporate Sustainability Thresholds Approach".
7. Discussion of the limitations of the proposed methodology and of the further advances required and recommendations in the future development of the matrix with the proposed methodology.

3. METHODOLOGY OF THE PROJECT

The methodology of the work performed in this project is described by seven steps, which are linked with the objectives defined in Section 2:

- **Step 1 -** Literature review. The main sources for environmental assessment of both organisations and P/S, such as environmental impact assessment tools, environmental reporting, input-output databases and other sources, are reviewed. This can be found in the Section 4 of this report.
- **Step 2 –** Current methodology for environmental impact assessment in ECG. To this end, the current matrix (version 5.0) is analysed. First, a general description of the tools and then a more detailed analysis of how environmental issues are assessed, are exposed in Section 5 of this report. A critical assessment of this current approach is also performed in that section.
- **Step 3 -** Selection of categories and indicators. First, the selection of the adequate categories is performed. Secondly, indicators for those categories that should be both widely accepted and easily attainable by the organisations, if not by direct measures by acceptable estimations, are defined. These indicators should be easily comparable with the most well-known environmental methods and also it is desirable that these indicators considered in satellite accounts of input-output databases or other initiatives that are appropriate for a Corporate Sustainability Thresholds Approach". These are shown in Section and 6 of this report.
- **Step 4 –** Procedure for defining the total environmental impact. A widely accepted procedure for the normalisation of the chosen indicators and their weighting is selected after the literature review is performed. This is shown in Section 6 of this report.
- **Step 5 –** Integration in the Common Good Matrix. It will be defined how this methodology could be integrated in the current matrix of ECG. The requirements for the integration are defined in order to take them into account for future versions of the matrix. This is shown in Section 7 of this report.
- **Step 6 -** Corporate Sustainability Thresholds Approach. This is done by analysing the satellite accounts of the input-output databases reviewed and other bibliographic sources that could also be used for this purpose. Checking the compatibility of the proposed indicators with those defined in these sources is a key issue of this objective. This is shown in Section 7 of this report.
- **Step 7 –** Limitations. The limitations of the proposed methodology as well as the further advances required and the recommendations are discussed in Sections 7 and 8 of this report.

4. LITERATURE REVIEW

Different sources for assessing the environmental impact of either organisations, P/S or industries/countries have been considered in the literature review. These sources are classified in four categories:

1. Environmental Impact Assessment Tools
2. Environmental reporting of organisations
3. Input-output databases
4. Other sources

The information checked in this project for each category is shown below:

1. Environmental Impact Assessment tools

- International Reference Life Cycle Data System (ILCD) Handbook [2][3][4].
- Organisation environmental footprint (OEF) and Product Environmental Footprint (PEF) guides and related documents [5][6][7][8].
- Open LCA [9][10].

2. Environmental reporting for organisations

- Global Reporting Initiative (GRI) [11]
- Eco-management and Audit Scheme (EMAS) [12]

3. Input-output databases

- World Input-Output Database (WIOD) [13][14]
- EORA MRIO Database [15]

4. Other sources

- Planetary boundaries [16][17]
- Ecological footprint (EF) and biocapacity [19].
- Greenhouse Gas Protocol (GHG Protocol) [20][21].

Rating agencies tools, as FTS4Good index or Dow Jones Sustainability Index, would have probably be a good source of both information and inspiration for this project but their detailed methodologies were not publicly available.

A summary of the information contained in the literature review and the main conclusions is shown in the last part of this chapter. These conclusions will be mainly the basis of the methodological proposal of this project.

4.1. SUMMARY OF THE LITERATURE REVIEW

4.1.1. ILCD HANDBOOK

The ILCD Handbook is a series of detailed technical documents, providing guidance for good practice in Life Cycle Assessment in business and government. The development of the

ILCD was coordinated by the European Commission and has been carried out in a broad international consultation process with experts, stakeholders, and the general public.
The ILCD handbook consists of a set of documents that are in line with the international standards on LCA (ISO 14040/44). For this project only three of the documents have been reviewed in detail:

- "Analysis of existing Environmental Impact Assessment methodologies for use in Life Cycle Assessment" [2]
- "Recommendation for Life Cycle Impact Assessment in the European context" [3]
- "Characterisation Factors of the ILCD Recommended Life Cycle Impact Assessment Method" [4]

4.1.1.1. ANALYSIS OF ENVIRONMENTAL IMPACT ASSESSMENT METHODS

In the document "Analysis of existing environmental Impact Assessment Methodologies for Use in Life Cycle Assessment", the main Life Cycle Impact Assessment methodologies are studied. These methodologies are:

1. CML 2002
2. Eco-indicator 99
3. EDIP97 and EDIP 2003
4. EPS 2000
5. IMPACT 2002+
6. LIME
7. LUCAS
8. MEEuP
9. ReCiPe
10. Swiss Ecoscarcity 07
11. TRACI

According to ISO 14044 (2006) Life Cycle Impact Assessment (LCIA) proceeds through two mandatory and two optional steps:

1. Selection of impact categories and classification
2. Characterisation, where the impact from each emission is modelled quantitatively according to the underlying environmental mechanism. A characterization factor or indicator is defined for each category after this step.
3. Normalisation, where the different characterised impact scores are related to a common reference
4. Weighting, where a ranking and/or weighting is performed of the different environmental impact categories reflecting the relative importance of the impacts considered in the study.

The purpose of this document is to study these four steps for the previously named methodologies. Five sections have been defined for each methodology:

1. Source of methodology documentation
2. General principles: Where selection and characterisation of impact categories are defined, also stating if the model used was midpoint or endpoint model.
3. Normalisation and weighting
4. Interesting (unique features)
5. Impact categories pre-selected for further evaluation

Figure 2 shows the conclusions of this study and states the impact categories considered significantly rigorous for each methodology and also the nature of model used (either midpoint or endpoint).

	Climate change	Ozone depletion	Respiratory inorganics	Human toxicity[11]	Ionising radiation	Ecotoxicity	Ozone formation	Acidification	Terrest. Eutrophication	Aquatic Eutrophication.	Land use	Resource Consumption	Others
CML2002	o	o		M	o[12]	o	M	M	M	M	o	M	
Eco-indicator 99	E	E	E	o	o		E	E	E		E	E	
EDIP 2003/EDIP97[13]	o	M	o	M	o	M	M	M	M	M		M	Work environ. Road noise
EPS 2000	E	E	E	E	o	E	E	o	o	o	E	E	
Impact 2002+	o	o	E	M E	o	M E	E	M E		M E	o	E	
LIME	E	E	M	E		o	M E	M E	o	E	E	E	Indoor air
LUCAS	o	o		o		o	o	o	o	o	o	o	
MEEuP	o	o	M	M		M	M	M	M	M		water	
ReCiPe	M E	E	M E	M E	o	M E	M E	M E	o	M E	M E	E	
Swiss Ecoscarcity 07	o	o	o	o	M E	M	o	o	o	o	M E	water	Endocrine disruptors
TRACI	o	o	M	M		M	M	M	o	M		o	
Specific methods to be evaluated	Ecological footprint		14	USETox		USETox		Seppälä		Payet	Ecological footprint	deWulf et al.	Noise Müller Wenk
Specific methods of potential interest (not to be evaluated)				Watson (Bachmann)	Ecotoxicity of radiation (Laplace et al.)		EcoSense (Krewitt et al.)	EcoSense (Krewitt et al.)		Kärman & Jönsson	15		Meijer indoor air UNEP Indoor air (Bruzzi et al., 2007)

o: Available in the methodology, but not further investigated

M: Midpoint model available and further analysed

E: Endpoint model available and further analysed

Figure 2: Conclusions of the study "Analysis of existing Environmental Impact Assessment methodologies for use in Life Cycle Assessment" [2]

4.1.1.2. RECOMMENDATION FOR LIFE CYCLE IMPACT ASSESSMENT

In the document "Recommendation for Life Cycle Impact Assessment in the European Context" the main impact categories identified in 4.1.1.1 are studied in detail. The impact categories considered are:

1. Climate Change
2. Ozone Depletion
3. Human Toxicity
4. Particulate Matter / Respiratory Inorganics

5. Ionizing Radiation
6. Photochemical Ozone Formation
7. Acidification
8. Eutrophication
9. Ecotoxicity
10. Land Use
11. Resource Depletion

In each impact category, the different methodologies used are compared and assessed, and finally one reference methodology and one indicator is proposed per type of indicator (midpoint and endpoint) and per agent analysed (human health or ecosystems), for each impact category.

4.1.1.3. CHARACTERISATION FACTORS

In the document "Characterisation Factors of the ILCD Recommended Life Cycle Impact Assessment Methods" the conclusions of 4.1.1.2 are exposed. For each impact category is defined the model (methodology) used and the indicator for midpoint and endpoint scope. This document also points out some limitations of the methodologies proposed.

The next table shows the reference methodology and indicator proposed for each impact category by ILCD.

Table 1: Conclusions of the study "Characterisation Factors of the ILCD Recommended Life Cycle Impact Assessment Method" [4]

Impact category	Midpoint /Endpoint	Reference methodology	Indicator
Climate Change	Midpoint	IPPC 2007	Kg CO2 eq
	Endpoint HH	ReCiPe 2008	DALY
	Endpoint Ec	ReCiPe 2008	Potentially disapperared number of species · time
Ozone Depletion	Midpoint	WMO 1999	Kg CFC 11 eq
	Endpoint HH	ReCiPe 2008	DALY
Cancer Health Effects	Midpoint	USEtox	CTUh
	Endpoint HH	USEtox	DALY
Non-cancer Health Effects	Midpoint	USEtox	CTUh
	Endpoint HH	USEtox	DALY
Respiratory Inorganics	Midpoint	Rabl and Spadaro (2004) and Greco et al (2007)	Kg PM2.5 eq
	Endpoint HH	Humbert et al (2009)	DALY
Ionizing radiation	Midpoint HH	Frischknecht et al. (2000)	Kg U_{235} eq
	Midpoint Ec	Camier-Laplace et al (2008)	CTUe / m^3· year
	Endpoint HH	Frischknecht et al. (2000)	DALY
Photochemical ozone formation	Midpoint HH	Van Zelm et al (2008)	Kg C_2H_4 eq
	Enpoint HH	Van Zelm et al (2008)	DALY
Acidification	Midpoint	Seppala et al 2006, Posch et al (2008)	Mole H+eq
	Endpoint	Van Zelm et al (2007)	Potentially not occurring number of plant species in terrestrial ecosystems / year
Eutrophication	Midpoint	Seppala et al 2006, Posch et	Mole N-eq

Impact category	Midpoint /Endpoint	Reference methodology	Indicator
terrestrial		al (2008)	
Eutrophication marine	Midpoint	ReCiPe 2008	Kg N-eq
Eutrophication freshwater	Midpoint	ReCiPe 2008	Kg P-eq
	Endpoint	ReCiPe 2008	Potentially disappeared number of freshwater species / year
Ecotoxicity freshwater	Midpoint	USEtox	CTUe / m^3· year
Land Use	Midpoint	Mila I Canals et al (2007)	Kg deficit of soil organic carbon
	Endpoint	ReCiPe 2008	Potentially disappeared number of species in terrestrial ecosystmes/ year
Water depletion	MIdpoint	Swiss Ecoscarcity 2006	M3
Mineral, fossils and renewable depletion	Midpoint	Van Oers et al (2002)	Kg Sb eq
	Endpoint	ReCiPe 2008	Marginal increase of cost ($)

HH – Human Health
Ec – Ecosystems

The contents of ILCD Handbook are useful for this project for the selection of impact categories and for the characterisation of those categories (selection of indicators).

4.1.2. OEF AND PEF GUIDES

The Product Environmental Footprint (PEF) and the Organisation Environmental Footprint (OEF) Guides are documents performed by the Institute for Environment and Sustainability of the Joint Research Centre of the European Commission, in the context of the Europe 2020 Strategy – "Roadmap to a Resource Efficient Europe". They provide a life cycle approach to quantifying environmental performance and, whereas the PEF method is specific to individual goods or services, the OEF method applies to organisational activities as a whole. These documents are the official reference in EU for LCA.

The requirements considered in both OEF and PEF have been chosen taking into consideration the recommendations of the following methodology guides:

- ISO standards, in particular: ISO 14064 (2006), ISO/WD TR 14069 (working draft, 2010), ISO 14044 (2006), Draft ISO/DIS 14067 (2012), ISO 14025 (2006) and ISO 14020 (2000).
- ILCD Handbook (2011)
- Corporate Accounting and Reporting Standard of the Green House Gas Protocol (WRI/WBCSD) (2011)
- Bilan Carbona (version 5.0)
- DEFRA – Guidance on how to measure and report our greenhouse gas emissions (2009)
- The carbon Disclosure Project for Water (2010)
- The Global Reporting Initiative (GRI) (version 3.0)
- Ecological Footprint Standards 2009 (Global Footprint Network)
- Greenhouse Gas Protocol (WRI/WBCSD)
- General principles for an environmental communication on mass market products BPX 30-323-0 (ADEME)

- Specification for the assessment of the life cycle greenhouse gas emissions of goods and services (PAS 2050, 2011)

From OEF and PEF Guides what results of special interest for this project are both impact categories and the indicators selected. The next table, retrieved from the guides, shows the Default EF Impact categories (with respective EF impact category indicators) and EF Impact assessment models suggested in these documents for both PEF and OEF studies.

EF Impact Category	EF Impact Assessment Model	EF Impact Category Indicator	Source
Climate Change	Bern model - Global Warming Potentials (GWP) over a 100 year time horizon.	Tonne CO_2 equivalent	Intergovernmental Panel on Climate Change, 2007
Ozone Depletion	EDIP model based on ODPs of the WMO over an infinite time horizon.	kg CFC-11 equivalent*	WMO, 1999
Ecotoxicity – fresh water[41]	USEtox model	CTUe (Comparative Toxic Unit for ecosystems)[42]	Rosenbaum et al., 2008
Human Toxicity - cancer effects	USEtox model	CTUh (Comparative Toxic Unit for humans)[43]	Rosenbaum et al., 2008
Human Toxicity – non-cancer effects	USEtox model	CTUh (Comparative Toxic Unit for humans)[12]	Rosenbaum et al., 2008
Particulate Matter/Respiratory Inorganics	RiskPoll model	kg $PM_{2.5}$ equivalent**	Humbert, 2009
Ionising Radiation – human health effects	Human Health effect model	kg U^{235} equivalent (to air)	Dreicer et al., 1995
Photochemical Ozone Formation	LOTOS-EUROS model	kg NMVOC equivalent***	Van Zelm et al., 2008 as applied in ReCiPe
Acidification	Accumulated Exceedance model	mol H+ equivalent	Seppälä et al., 2006; Posch et al, 2008
Eutrophication – terrestrial	Accumulated Exceedance model	mol N equivalent	Seppälä et al., 2006; Posch et al, 2008
Eutrophication – aquatic	EUTREND model	fresh water: kg P equivalent marine: kg N equivalent	Struijs et al., 2009 as implemented in ReCiPe
Resource Depletion – water	Swiss Ecoscarcity model	m^3 water use related to local scarcity of water[44]	Frischknecht et al., 2008
Resource Depletion – mineral, fossil	CML2002 model	kg Sb equivalent****	van Oers et al., 2002
Land Use	Soil Organic Matter (SOM) model	kg C (deficit)	Milà i Canals et al., 2007

* CFC-11 = Trichlorofluoromethane, also called freon-11 or R-11, is a chlorofluorocarbon.
** $PM_{2.5}$ = Particulate Matter with a diameter of 2.5 µm or less.
*** NMVOC = Non-Methane Volatile Organic Compounds
**** Sb = Antimony

Figure 3: EF Impact categories. EF Impact assessment models and EF impact category indicators [5][6]

Additional documents

Apart from these guides, two additional documents have been developed by the JRC of the European Commission in order to set a common guidelines for both normalisation and weighting of the environmental impact categories and characterisation factors defined in the guides:

- “Normalisation method and data for Environmental Footprints” [7]
- “Evaluation of Weighting Methods for Measuring the EU-27 Overall Environmental Impact” [8]

4.1.3. OPEN LCA

OpenLCA is an open source and free software for Sustainability and Life Cycle Assessment. It can be downloaded in the website http://www.openlca.org/. It has the following features:

- Fast and realizable calculation of Sustainability Assessment and Life Cycle Assessment.
- Very detailed into calculation and analysis results; identify main drivers throughout the life cycle, by process, flow or impact category, visualize results and locate them on a map.
- Life Cycle Costing and social assessment is smoothly integrated in the life cycle model

The figure below shows the LCA methods covered by OpenLCA with the impact categories covered by each method.

METHODS	Acidification	Climate change	Resource depletion	Ecotoxicity	Energy Use	Eutrophication	Human toxicity	Ionising Radiation	Land use	Odour	Ozone layer depletion	Particulate matter/ Respiratory inorganics	Photochemical oxidation
CML (baseline)	✓	✓	✓	✓	-	✓	✓	-	-	-	✓	-	✓
CML (non baseline)	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	-	✓
Cumulative Energy Demand	-	-	-	-	✓	-	-	-	-	-	-	-	-
eco-indicator 99 (E)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	-
eco-indicator 99 (H)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	-
eco-indicator 99 (I)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	-
Eco-Scarcity 2006	-	-	✓	-	-	-	-	-	-	-	-	-	-
ILCD 2011, endpoint	✓	✓	-	-	-	✓	✓	✓	✓	-	✓	✓	✓
ILCD 2011, midpoint	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	✓
ReCiPe Endpoint (E)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	✓
ReCiPe Endpoint (H)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	✓
ReCiPe Endpoint (I)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	✓
ReCiPe Midpoint (E)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	✓
ReCiPe Midpoint (H)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	✓
ReCiPe Midpoint (I)	✓	✓	✓	✓	-	✓	✓	✓	✓	-	✓	✓	✓
TRACI 2.1	✓	✓	✓	✓	-	✓	✓	-	-	-	✓	✓	✓
USEtox	-	-	-	✓	-	-	✓	-	-	-	-	-	-

“√” represent that the impact category is contained in the correspondent method and “–“ that is not contained

Figure 4: Availability of impact categories per method in OpenLCA [10].

The units (indicators) used in OpenLCA for measuring the main commonly used impact categories are shown in the table below.

Table 2: Indicators of impact categories considered in OpenLCA [10].

Impact category	Indicators (units)
Acidification	kg SO_2 equivalent
Climate change	kg CO_2 equivalent
Depletion of abiotic resources	kg antimony equivalent, kg of minerals, MJ of fossil fuels and m^3 of water consumption
Ecotoxicity	kg 1,4-DB equivalent, PDF and PAF
Eutrophication	kg PO_4^{3-} equivalent and kg N equivalent
Human toxicity	kg 1,4-DB equivalent and DALY
Ionising radiation	kg U^{235} equivalent and DALY
Land Use	PDF/m^2, m^2a
Ozone Layer Depletion	kg CFC-11 equivalent
Particulate matter	kg particulate matter
Photochemical oxidation	kg ethylene equivalent, kg NMVOC and kg of formed ozone

The Open LCA is an especially useful tool. Using databases of impacts by industrial process or by P/S itself it is possible to obtain average impacts that have an important potential for statistical purposes and for comparing performances of different organisations or different industrial sectors. Several data-bases of the unit impacts can be downloaded from: http://www.openlca.org/lca-data/

In principle this tool was created to compare P/S, but if the scope is changed to an organisation and the required inputs are included, then it can be also used to compare business and organisations performance.

The contents of Open LCA and the associated databases are useful for this project because they can be the basis for comparing the environmental impact of organisations or P/S with what can be defined as environmental standard performance or environmental optimal performance. In other words, Open LCA helps to define different baselines to which compare the environmental performance of organisations and P/S.

4.1.4. GRI

In 1997 two US non-profit organisations, the Coalition for Environmentally Responsible Economies (CERES) and the Tellus Institute, founded the Global Reporting Initiative (GRI). GRI is an international independent organisation that helps businesses, governments and other organisations understand and communicate the impact of business on critical sustainability issues such as climate change, human rights, corruption and many others.

In the past GRI published guidelines for reporting sustainability in organisations and, in October 2016, GRI launched the first global standards for sustainability reporting [11]. Developed by the Global Sustainability Standards Board (GSSB), the GRI Standards enable all organisations to report publicly on their economic, environmental and social impacts – and show how they contribute towards sustainable development. The GRI Standards are also a trusted reference for policy makers and regulators, and have a modular structure so they can be kept up-to-date and relevant.

The consolidated set of GRI sustainability reporting standards 2016 include the description of the 33 standards. Out of those standards, there are 8 related to environment which are shown below:

- Materials
- Energy

- Water
- Biodiversity
- Emissions
- Effluents and waste
- Environmental compliance
- Supplier environmental assessment

Each standard has their own indicators, defined as top specific disclosures in the document. The following table show the top specific disclosures:

Table 3: Indicators for each standard In GRI [11]

Code	Name of each top specific disclosure (indicators)
Standard: Materials	
301-1	Materials used by weight or volumen
301-2	Recycled input materials used
301-3	Reclaimed products and their packaging materials
Standard: Energy	
302-1	Energy consumption within the organisation
302-2	Energy consumption outside the organisation
302-3	Energy intensity
302-4	Reduction of energy consumption
302-5	Reductions in energy requirements of products and services
Standard: Water	
303-1	Water withdrawal by source
303-2	Water sources significantly affected by withdrawal of water
303-3	Water recycled and reused
Standard: Biodiversity	
304-1	Operational sites owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected áreas
304-2	Significant impacts of activities, products, and services on biodiversity
304-3	Habitats protected and restored
304-4	IUCN Red List species and national conservation list species with habitats in areas affected by operations
Standard: Emissions	
305-1	Direct (Scope 1) GHG emissions
305-2	Energy indirect (Scope 2) GHG emissions
305-3	Other indirect (Scope 3) GHG emissions
305-4	GHG emissions intensity
305-5	Reduction of GHG emissions
305-6	Emissions of ozone-depleting substances (ODS)
305-7	Nitrogen oxides (NOx), sulfur oxides (SOx), and other significant air emissions
Standard: Effluents and waste	
306-1	Water discharge by quality and destination
306-2	Waste by type and disposal method
306-3	Significant spills
306-4	Transport of hazardous waste
306-5	Water bodies affected by water discharges and/or runoff
Standard: Environmental Compliance	
307-1	Non-compliance with environmental laws and regulations
Standard: Supplier environmental assessment	
308-1	New suppliers that were screened using environmental criteria
308-2	Negative environmental impacts in the supply chain and actions taken

When baselines, conversion factors, estimates, standards, methodologies, and assumptions are used the documents clearly state that they must be reported. If there are different sources (like in energy-renewable/non-renewable, or in water -river/lake/aquifer-for example), they must be exposed and detailed. For water bodies or protected areas affected by the organisation activity both the location and the impact scope of the activity must be detailed.

The supplier environmental assessment is a standard that is especially significant, as in some organisations the environmental impact of the suppliers are much more important than the organisation one. The indicator 308-2 called "Negative environmental impacts in the supply chain and actions taken" is the most relevant and the associated reporting requirements are shown below:

a. Number of suppliers assessed for environmental impacts
b. Number of suppliers identified as having significant actual and potential negative environmental impacts.
c. Significant actual and potential negative environmental impacts identified in the supply chain.
d. Percentage of suppliers identified as having significant actual and potential negative environmental impacts with which improvements were agreed upon as a result of assessment.
e. Percentage of suppliers identified as having significant actual and potential negative environmental impacts with which relationships were terminated as a result of assessment, and why.

The contents of GRI sustainability reporting standards are useful for this project for the selection of indicators, as they use environmental indicators that are feasible for organisations to be obtained.

4.1.5. EMAS

Eco-management and audit scheme (EMAS) is an environmental management system defined within the European Union framework and it is published by a Regulation Act (Regulation (EC) Nº 1221/2009 of the European Parliament and of the Council of 25 November 2009). It has the objective of promoting continuous improvements in the environmental performance of organisations by the establishment and implementation of environmental management systems by organisations, the systematic, objective and periodic evaluation of the performance of such systems, the provision of information on environmental performance, an open dialogue with the public and other interested parties and the active involvement of employees in organisations and appropriate training.

If the organisation comprises one or more sites, each of the sites to which EMAS applies shall comply with all the requirements of EMAS.

In the Annex IV of the Regulation, about Environmental Reporting, there is a Chapter about Core indicators and other relevant existing environmental performance indicators, what is the main part of the Regulation of importance for this project. About the proposed indicators it is stated:

"The indicators shall:

(a) give an accurate appraisal of the organisation's environmental performance

(b) be understandable and unambiguous

(c) allow for a year on year comparison to assess the development of the environmental performance of the organisation

(d) allow for comparison with sector, national or regional benchmarks as appropriate

(e) allow for comparison with regulatory requirements as appropriate"

The key environmental areas defined are:

(i) Energy efficiency

(ii) Material efficiency

(iii) Water

(iv) Waste

(v) Biodiversity

(vi) Emissions

The core indicators for these categories are:

Energy efficiency

- Concerning the "total direct energy use", the total annual energy consumption, expressed in MWh o GJ.
- Concerning the "total renewable energy use", the percentage of total annual consumptions of energy (electricity and heat) produced by the organisation from renewable energy sources.

Material Efficiency

- Concerning the "annual mass-flow of different materials used" (excluding energy carriers and water), expressed in tonnes

Water

- Concerning the "total annual water consumption", expressed in m^3

Waste

- Concerning the "total annual generation of waste", broken downs by type, expressed in tonnes
- Concerning the "total annual generation of hazardous waste" expressed in kilograms or tonnes

Biodiversity

- Concerning the "use of land", expressed in m2 of built-up area

Emissions

- Concerning the "total annual emissions of greenhouse gases", including at least emissions of CO_2, CH_4, N_2O, HFCs, PFCs and SF_6, expressed in tonnes of CO_2 equivalent
- Concerning the "total annual air emissions", including at least emissions of SO_2, NO_x and PM, expressed in kilograms or tonnes

However, it is stated that each organisation shall also report annually on its performance relating to other more specific environmental aspects as identified in its environmental statement and, where available, take into account sectorial reference documents.

The indication of the overall annual output of the organisation, depending on their type of activity shall be reported as follows:

- For organisations working in the production sector (industry), it shall indicate the total annual gross value-added, expressed in million euro or total annual physical output expressed in tonnes, in the case of small organisations the total annual turnover or number of employees.
- For organisations in the non-production sectors (administration/services), it shall relate to the size of the organisation expressed in number of employees.

As GRI, the contents of EMAS are useful for this project for the selection of indicators, as they use environmental indicators that are feasible for organisations to obtain. Also it can be an inspiration source for the indicators normalisation in order to allow comparison between organisations.

4.1.6. WIOD

World Input-Output Database (WIOD) was constructed within the official WIOD Project, funded by the European Commission as part of the 7th Framework Programme. It was first released in 2013 with three different sources of information: input-output tables, socio-economic accounts and environmental accounts. Later, in 2016 a new version of WIOD was released but only with two sources of information for 43 countries: input-output tables and socio-economic accounts.

Although all the sources of information are very useful to typify the sustainability of a country or an industry, only the environmental accounts are taken into account for this project (environmental satellites).

The environmental accounts of WIOD provide time-series for forty countries covering the period from 1995 to 2011. The information per country is broken down in data for 35 sectors, classified according to the International Standard Industrial Classification revision 3 (ISIC Rev. 3).

The environmental satellites of WIOD were defined in order to cover the broadest range of environmental themes as reasonably achievable while maintaining a data quality that is well grounded in the empirical availability of primary data. The core of environmental database is constituted by energy and air emission accounts, but also additional accounts for material extraction, land use and water use were included. It has the limitation that it does not take into account local aspects to assess the availability of water or materials, and other significant environmental impacts as soil pollution or waste generation.

Energy accounts include gross energy use and emission relevant energy use by energy commodity.

Air emission accounts include CO_2, N_2O, CH_4, NOx, SO_x, NH_3, NMVOC and CO emissions. With those an approximation to global warming, acidification and tropospheric ozone formation impacts can be assessed.

Material extraction accounts include:

- Biomass categories: animals, feed, food, forestry and other
- Minerals categories: construction, industrial and metals.
- Fossil categories: coal, gas, oil and other

For every category, used materials (which represent the amount of extracted resources which enters the economic system for further processing or direct consumption) are distinguished from unused materials (which refer to materials that never enter the economic system and thus can be described as physical market externalities).

Land use accounts include three categories: agricultural area (subcategories: arable land, permanent corps land and permanent meadows and pastures), forest area and other land.

Water use accounts include blue, green and grey water needs.

The contents of WIOD are useful for setting the planet boundaries for a Corporate Sustainability Thresholds Approach. For the methodological proposal of this project to be compatible with a Corporate Sustainability Thresholds Approach, the indicators selected should be either the same or easily convertible. That is the reason why environmental accounts of input-output tables are important for this project.

4.1.7. OTHER I-O DATABASES. EORA MRIO

Although WIOD has been the input-output database studied more in depth in this project, it is not the only project that constructs multiregional input-output tables. Some other prominent initiatives in the field of I-O databases are shown below:

- OECD/WTO Trade in Value Added database
- Asian Development Bank, multi-regional input-output tables (ADB-MRIO)
- IDE Jetro, Asian International Input-Output Tables (AIIOTs)
- EORA multi-region IO (EORA MRIO) database
- EXIOPOL

In this section EORA MRIO database is described briefly in order to have another reference of I-O databases apart from WIOD.

EORA MRIO is a tool created by researchers of Sydney University for 187 countries. It contains from 26 to 400 sectors per country. Some countries use different sector classifications and this heterogeneity could be a problem if the aggregation cannot easily be done. The period covered is from 1990 to 2012.

The information shown in this section was retrieved from the document “Notes on Eora indicator definitions” [15].

As with WIOD, in this database there are two main sources of information:

- country input-output tables
- satellite accounts, the various extensions of these input output tables in environmental and social areas

IO tables show flows in US Dollars. The environmental harms are defined by the environmental satellite accounts. There are 49 discrete environmental indicators:

- energy (2)
- Greenhouse gas emissions (24)
- Air quality (8)
- Ecological footprints (6)
- CO_2 from industrial processes (7)

EORA-MRIO is extending these environmental accounts, by also tracking biodiversity (threatened species) and water use.

The indicators that can result of interest for this study are shown below, together with the units used and the categories that can be found for each indicator.

CO_2 and GHG emissions: In Gg, they are classified in two top level groupings: CO_2 except those from biomass burning, and CO_2 emissions from biomass burning. From this first level there are seven categories:

- CO_2 from energy production
- CO_2 from cement / minerals
- CO_2 from solvents
- CO_2 from agricultural burning
- CO_2 from natural decay
- CO_2 from waste
- CO_2 from forest fires and other sources

Material usage: In tonnes, there are 36 material categories that are shown below:

- A.1.1.1 Cereals
- A.1.1.10 Other crops
- A.1.1.2 Roots and tubers
- A.1.1.3 Sugar crops
- A.1.1.4 Pulses
- A.1.1.5 Nuts
- A.1.1.6 Oil bearing crops
- A.1.1.7 Vegetables
- A.1.1.8 Fruits
- A.1.1.9 Fibres
- A.1.2.1 Crop residues (used)
- A.1.2.2.2 Grazed biomass
- A.1.3.1 Timber (Industrial roundwood)
- A.1.3.2 Wood fuel and other extraction
- A.2.1 Iron Ores
- A.2.2.1 Copper ores - gross ore
- A.2.2.2 Nickel ores - gross ore
- A.2.2.3 Lead ores - gross ore
- A.2.2.4 Zinc ores - gross ore
- A.2.2.5 Tin ores - gross ore
- A.2.2.6 "Gold, silver, platinum and other precious metal ores - gross ore"
- A.2.2.7 Bauxite and other aluminium ores - gross ore
- A.2.2.8 Uranium and thorium ores - gross ore
- A.2.2.9 Other metal ores - gross ore
- A.3.1.1 Ornamental or building stone
- A.3.1.2 Chalk and dolomite
- A.3.1.4 Chemical and fertilizer minerals
- A.3.1.5 Salt
- A.3.1.6 Other mining and quarrying products n.e.c
- A.3.2 Non-Metallic minerals - primarily construction
- A.4.1.1 Brown coal
- A.4.1.2 Hard coal
- A.4.1.4 Peat
- A.4.2.1 Crude oil and natural gas liquids
- A.4.2.2 Natural gas

Nitrogen and phosphorous emissions: In kg of source, they are aggregated in two categories: fertilizer and manure, in kg of source

Crop and pasture area: In hectares

Total water: In m^3, it includes:

- Water Footprint by crop demand
- Water Footprint of grazing
- Water Footprint of animal supply
- Water Footprint of industrial production
- Water Footprint of domestic water supply

As for WIOD, the contents of EORA-MRIO are useful for setting planet boundaries for a Corporate Sustainability Thresholds Approach.

4.1.8. PLANETARY BOUNDARIES

The Planetary Boundaries research is an initiative hosted at the Stockholm Resilience Centre, in which Australian National University and the University of Copenhagen have also taken part. The research group identified nine planetary life support systems essential for human survival and then aimed to determine for which of those there was a risk of irreversible and abrupt environmental change. They attempted to quantify the threshold for these systems (boundaries), usually as a percentage of the preindustrial levels, and studied how far seven of these systems have been pushed already (two of them were not quantified). The nine systems defined together with their control variable and the current, boundary and preindustrial values are shown in the table below.

Table 4: Boundary value, current value and preindustrial value for the systems defined [17]

Earth-System-process	Control variable	Boundary value	Current value	Preindustrial value
Climate change	1) Atmospheric CO_2 concentration (ppm) 2) Change in radiative forcing (W/m^2)	1) 350 2) 1,0	1) 400 2) 1,5	1) 280 2) 0
Ocean acidification	Global mean saturation state of aragonite in surface seawater	2,75	2,90	3,44
Stratospheric ozone depletion	Ozone concentration (Dobson Unit)	276	283	290
Biogeochemical nitrogen cycle and phosphorous cycle	Nitrogen: Amount of N removed from the atmosphere for human use (million tonnes per year) Phosphorous: Annual P inflow to oceans (millions of tonnes/year)	N: 35 P: 11	N: 121 P: 8,5-9,5	N: 0 P: -1
Global freshwater use	Consumption of freshwater by humans (km^3/year)	4.000	2.600	415
Land use change	Percentage of global land cover converted to cropland	15	11,7	Low
Loss of biodiversity	Extinction rate (number of species per million of species/year)	10	>100	0,1-1

Earth-System-process	Control variable	Boundary value	Current value	Preindustrial value
Chemical pollution	Overall particulate concentration in the atmosphere in a regional basis	To be determined		
Atmospheric Aerosol Loading	For example, amount emitted to, or concentration of persistent organic pollutants, plastics, endocrine disrupters, heavy metals, and nuclear waste in the global environment or the effects on the ecosystem and functioning of Earth system thereof	To be determined		

One of the main difference of the approach of the planetary boundaries compared to the LCA approaches Is that the concept of planetary boundaries is ecocentric, thus impact on humans it is not considered (human toxicity).

These planetary boundaries approach are especially useful for this study for an eventual Corporate Sustainability Thresholds Approach.

4.1.9. ECOLOGICAL FOOTPRINT AND BIOCAPACITY

Ecological Footprint (EF) and Biocapacity are indicators created by Global Footprint Network, a think tank that brings together over 70 partner organisations. They show how big humanity's demand is compared to what planet Earth can renew. Every year Global Footprint Network releases Global Footprint Network's National Footprint Accounts (NFAs) for more than 200 countries. Although in the beginning it was created to assess the sustainability for the different countries, standards for assessing organisations and product/services have also been created.

EF and Biocapacity accounting measures the demand on and supply of nature, and constitutes a potential tool to measure planetary boundaries and the extent to which humanity is exceeding them.

On the demand side, the EF measures the ecological assets that a given population requires to produce the natural resources it consumes (including plant-based food and fiber products, livestock and fish products, timber and other forest products, space for urban infrastructure) and to absorb its waste, especially carbon emissions.

The EF tracks the use of six categories of productive surface areas: cropland, grazing land, fishing grounds, built-up land, forest area, and carbon demand on land.

On the supply side, a city, state or nation's Biocapacity represents the productivity of its ecological assets (including cropland, grazing land, forest land, fishing grounds, and built-up land). These areas, especially if left unharvested, can also absorb much of the waste we generate, especially our carbon emissions.

Global hectares are the accounting unit for the EF and Biocapacity accounts and allow to report both the Biocapacity of the earth or a region and the demand on Biocapacity.

The following figure shows how from the areas of the different land types required/contributed by a country/organisations/product, both EF and Biocapacity can be calculated.

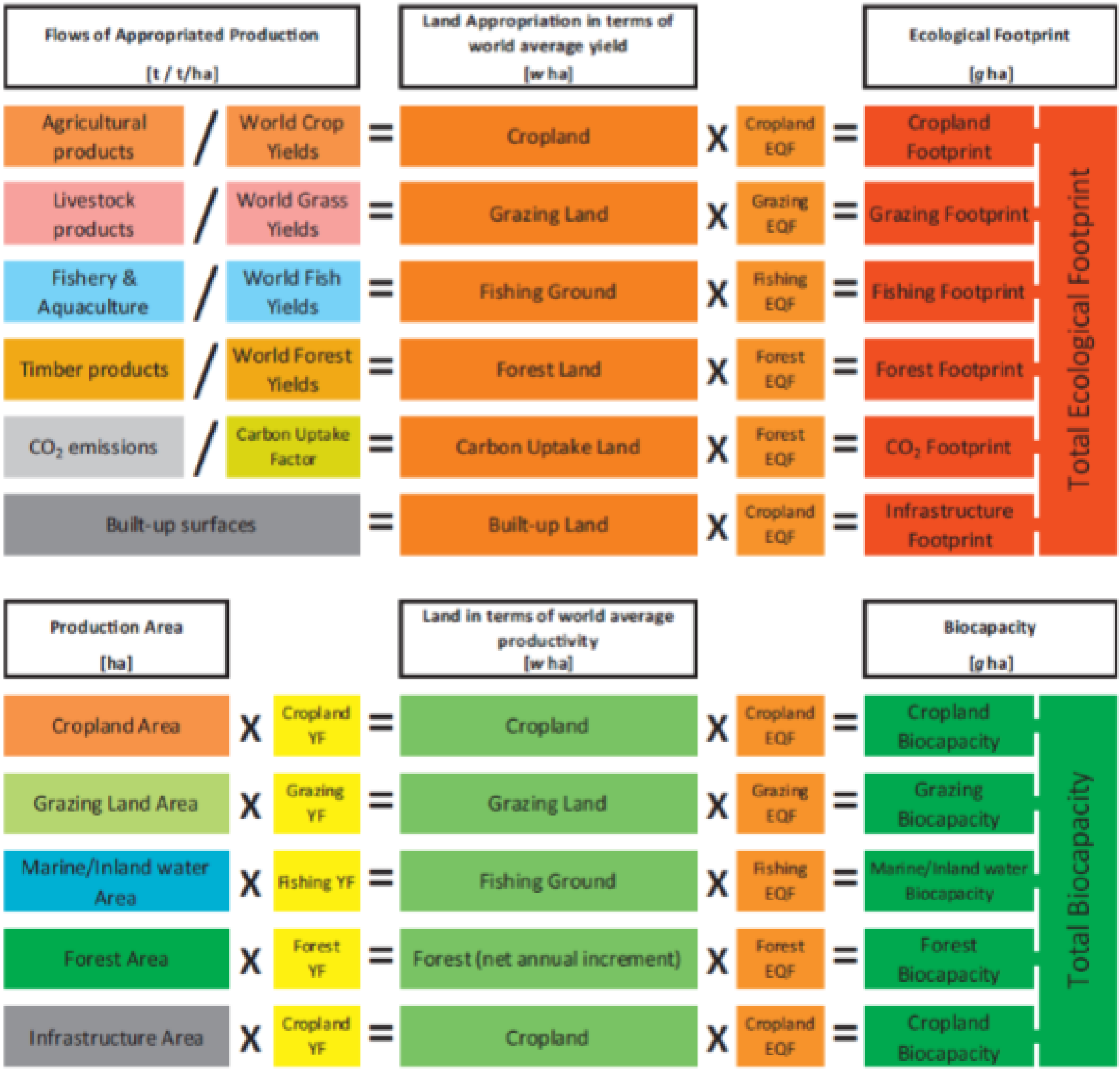

Figure 5: Methodological overview for the calculation for both EF and Biocapacity [19]

If the EF is smaller than its Biocapacity, then the Country/Organisation/Product has an ecological reserve; otherwise it is operating with an ecological deficit.

For these calculations, both equivalence and yield factors are required:

- Equivalence factors reflect the relative productivity of world average hectares of different land use types. The equivalence factor calculation assumes that the most productive land is put to its most productive use. The calculations assume that the most suitable land available will be planted to cropland, the next most suitable land will be under forest, and the least suitable land will be grazing area. The equivalence factor is calculated as the ratio of the average suitability index for a given land use type divided by the average suitability index for all land use types.

- Yield factors reflect the relative productivity of national and world average hectares of a given land use type. Each country, in each year, has a yield factor for each land use type. Yield factors are used in Biocapacity calculations when Biocapacity is reported in global hectares.

Both equivalence and yield factors are defined not only for calculation of the supply side (Biocapacity), but also for the calculation of the demand side (EF). They are average values defined by region.

The limitation of Ecological Footprint is that it only includes a limited range of environmental concerns.

The contents of Ecological Footprint and Biocapacity are useful because this is probably the first well known and quite accepted methodology that measures the environmental impact of a country/organisation/product/service (ecological footprint) compared to the planet boundary (based in Biocapacity).

4.1.10. GHG PROTOCOL

Greenhouse Gas (GHG) Protocol is a partnership between the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). It works with governments, industry associations, NGOs, businesses, and other organisations around the world to build credible, effective, and robust GHG accounting and reporting platforms that serve as a foundation to address climate change. It establishes comprehensive, global, standardized frameworks for measuring and managing emissions from private and public sector operations, value chains, products, cities, and policies.

Three scopes are considered when measuring GHG:

- Scope 1 is also referred to as Direct GHG, and is defined as 'emissions from sources that are owned or controlled by the organisation'.
- Scope 2 is also referred to as Energy Indirect GHG, and is defined as 'emissions from the consumption of purchased electricity, steam, or other sources of energy (e.g. chilled water) generated upstream from the organisation'.
- Scope 3 is also referred to as Other Indirect GHG, and is defined as 'emissions that are a consequence of the operations of an organisation, but are not directly owned or controlled by the organisation'. Scope 3 includes a number of different sources of GHG including employee commuting, business travel, third-party distribution and logistics, production of purchased goods, emissions from the use of sold products, and several more.

There are standards defined for those three scopes. These standards do not deal with emission factors of every activity.

Some helpful guidance given by GHG Protocol includes:

- Definition of the greenhouse gases (carbon dioxide, nitrous oxide, methane, hydrofluorocarbons (incl. HCFCs and HFCs), chlorofluorocarbons (CFCs), sulphur hexafluoride and nitrogen trifluoride).
- Definition of the different consolidation approaches for emissions to state the responsible of the emissions (equity share, financial control and operational control).
- Calculation of base year emissions.

The contents of GHG Protocol are especially useful for this project for setting the scope of the environmental impact measurement.

4.2. CONCLUSIONS OF LITERATURE REVIEW

Table 5 shows the utility of every bibliography source consulted for the aim of this project.

Table 5: Utility of the bibliographic sources consulted for the aim of this project. Source: Personal compilation

Activity	Useful bibliographic source
Selection of impact categories and classification	OEF & PEF guides; Planetary boundaries
Characterisation of impact categories (set indicators)	OEF & PEF guides; GRI; EMAS; Planetary boundaries
Normalisation and a weighting of the impact categories	ILCD Handbook; OEF & PEF guides; EMAS
Setting planet boundaries for a Corporate Sustainability Thresholds Approach	WIOD; EORA-MRIO; Planetary boundaries; Ecological Footprint and Biocapacity
Setting benchmarks and baselines for comparison	Open LCA
Setting scope	GHG Protocol

5. ASSESSMENT OF ENVIRONMENTAL ISSUES IN ECG

5.1. CURRENT APPROACH

As explained in Chapter 1, the Common Good Matrix is the tool used in ECG for measuring the global performance of organisations. In April 2017, it was launched the manual of the matrix 5.0, which is the latest version. This version is the one taken as reference for this project. In terms of environmental assessment, this latest version includes some major changes with respect to former versions that give a more structured and understandable approach.

The environmental sustainability is the value of ECG where this project is focused on, and specifically in the topics related to the environmental impact of the organisations and their product/services through their life cycle. The topics considered within this scope are:

- A3 - Environmental sustainability in the supply chain: this considers the environmental impact associated to all the raw materials and product-services acquired by the organisation that are required to develop its activity properly.
- D3 - Impact on the environment of the use and disposal of product and services: this considers the environmental impact associated to the organisation's P/S that will take part during their use and disposal.
- E3 - Reduction of negative environmental impact: this considers the direct environmental impact of the organisation.

Topics B3 and C3 are more oriented to analyse other environmental aspects, such as the investments performed with the objective of improving the environmental performance of the organisation and the promotion of good environmental practices of their workers, both inside and outside the facilities of the organisation.

The scope of the environmental impact of the organisation itself (E3) includes the impact of the electricity and the heat used, that are utilities, usually supplied by other organisations. It is, therefore, considered "Scope 2" as defined in GHG Protocol

The following figure show schematically how topics A3, D3 and E3 consider the environmental impact in the whole life cycle.

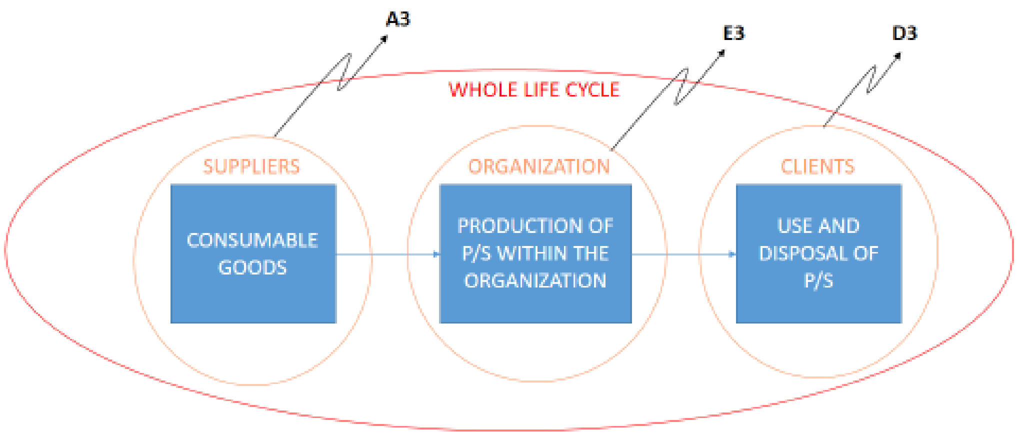

Figure 6: Scope of topics A3, D3 and E3 in the life cycle. Source: Personal compilation

In the Matrix 5.0 manual [22] only a disaggregated and detailed definition of the different environmental impact categories is developed for the topic E3. Both A3 and D3 are assessed in a more quantitative way. This project aims to define a methodology for quantifying the environmental impact, first category by category, and later aggregating them in a unique figure. Because of this, of the three topics, the E3 approach is considered the more appropriate for taking as reference for this project and will be the one studied in depth.

Topic E3 has two main aspects:

- Absolute impact (E.3.1), that aims to assess the environmental impact of the organisation in an absolute way. It could be said that by means of this aspect a comparison between organisations of different industrial sector could be performed.
- Relative impact (E.3.2). It is not fair comparing the environmental impact of an iron processing factory and of a consultant service provider. It is obvious that the first one is more energy and natural resources intense than the second one, just because of its own nature. This matter is approached by ECG by creating the relative impact, by means of what a comparison of the environmental impact of organisations of the same industrial sector can be performed.

The way of assessing the environmental impact in E3 is performed by adding weighting points to the different categories considered depending on the values of the indicators that measures the environmental impacts. The categories and methodology definitions were inspired by OEF and PEF and Planetary boundaries approaches. The structure and the main categories have been obtained from OEF and PEF approach. The concept of ecocentricity adopted is based on Planetary Boundaries approach, thus impact on humans it is not considered.

Table 6 shows the categories considered to assess the environmental impact of E3, the indicator for each category and the way of allocating the weighting points.

Table 6: Categories, indicators and allocation of weighting points in topic E3 [22]

Category	Indicator	Weighting point allocation
Climate change	T CO_2 equivalent / worker	Less than 2 T/worker: 0 WP +1 WP per T/worker above
Particulate Matter and inorganic emissions	µg/m^3 of emissions	< 2 µg/m^3: - 1 WP < 10 µg/m^3: -0,5 WP < 20 µg/m^3: -0,1 WP ≥ 20 µg/m^3: +10 WP
Ozone Depletion	Kg CFC-11 equivalent	If detectable: +1 WP
Acidification	Mol H^+ equivalent	If detectable: +1 WP
Photochemical Ozone Formation	Kg NMVOC equivalent	If detectable: +1 WP
Ionising Radiation	Kg U^{235} equivalent	If detectable: +1 WP
Toxicity	CTU	If detectable: +1 WP
Eutrophication	Land: mol N equivalent Water: kg P/N equivalent	Organic agriculture: 0 WP Non-organic agricuture: +1 WP Otherwise, only if detectable: +1 WP
Land Use	Increase in kg C with respect to previous years	If it falls more than 10%: 1 WP
Resource Depletion	Water: 1.000 m^3 / worker Mineral, fossil: Kg antimony equivalent	Water: +1 WP per 1000 m^3 consumed Mineral, fossil: If detectable: +1 WP

WP: weighting point

For evaluating the environmental performance of an organisation all the weighting points obtained in the assessment are summed up. The more points the organisation has, the worse the environmental performance will be.

Even though this methodology is defined only for the assessment of the absolute impact, it is considered that it is also very useful and required for the assessment of the relative impact.

5.2. CRITICAL ASSESSMENT OF CURRENT APPROACH

Below some inconsistencies considered from the current approach for assessing environmental issues in ECG are named:

- On the procedure for evaluating the environmental impact, although some do, not all the environmental categories considered match with those considered in LCA EU guidelines (PEF & OEF guides). It seems reasonable be in line with these regulations.
- The method for assessing the particulate matter is not clear enough: it is not clearly stated whether it is referred to a daily average, monthly average or year average and in case there are several emission points for the same organisation it is unclear how to assign the weight.
- Also on the evaluating procedure, the normalisation and weighting methods used are not the one proposed by JRC documents, that define the official position of European Commission [7] [8].
- The weighting method proposed has the advantage that is quite simple, but the drawback is that it does not correspond to any theoretical approach. Thus, the rating of the organisation and its environmental impact could deviate.
- In ECG manual [22] a quantitative assessment of the impacts is considered only for the organisation itself (topic E3), not for suppliers (topic A3) nor for clients (topic D3). From the user-point-of view, the assessment of the topic E3 is more demanding and requires more expert knowledge than D3 and A3.

  However, in organisations for which the main environmental impact comes from the supply chain and there are enough data available, the quantitative assessment (Table 6) can also be used in the topic A3, but this is a voluntary consideration. Therefore, the quantitative assessment of suppliers is a matter that would depend on both, the criterion of ECG auditor, and the availability of the required data from the supplier.

  In LCA the whole environmental impact of a P/S is quantified, from the cradle to the grave and it is not the approach of Common Good Matrix 5.0, as the scope of the environmental impact would depend on the aspects commented above.

  It is typical that there is not enough data availability about the environmental impact of the whole supply chain. In these cases, the environmental impacts could be estimated.
- About the relative impact, there is quite substantial discussion in the field in how far it is legitimate to compare organisations. All organisations differ from each other and have different “system boundaries” or differ in the kind of products they provide (e.g. it’s not so easy to compare steel producing companies, since one might produce high quality steel for specific uses and the other just plain steel).

  This relative impact comparison would be more valid if performed to P/S rather than to organisations.

6. METHODOLOGY FOR ENVIRONMENTAL IMPACT ASSESSMENT IN ECG

Two methodologies are proposed in this project:
- One to assess the absolute environmental impact of the organisations.
- Other to evaluate the relative environmental impact, that is carried out by assessing the environmental performance of the organisation compared to reference performance or benchmark of their own industrial sector.

The two methodologies are constructed based on the Life Cycle Assessment guidelines. According to ISO 14044 (2006) Life Cycle Impact Assessment (LCIA) proceeds through two mandatory and two optional steps:
1. Selection of impact categories and classification
2. Characterisation
3. Normalisation
4. Weighting

Both methodologies will follow this pattern and, as it is intended to quantify and compare the impacts of different organisations and activities, the last two optional steps will also be taken into account. The four steps are discussed in the Sections 6.1 to 6.4. In the Section 6.5 the formulas for the methodologies proposed are explained in detail.

6.1. SELECTION OF IMPACT CATEGORIES AND CLASSIFICATION

The OEF & PEF guides and the Planetary Boundaries have been reviewed for the selection of impact categories and its classification. A comparison of the categories selected for these two bibliographic sources with those categories defined in the Common Good Matrix 5.0 is shown in Table 7.

Table 7: Environmental Impact Categories defined in the bibliographic sources considered significant. Source: Personal Compilation based in [5][6][17][22].

Categories	OEF/ PEF guides	Planetary boundaries	Matrix 5.0
Climate change	X	X	X
Particulate Matter / Respiratory inorganics	X		X
Ozone Depletion	X	X	X
Acidification	X	X	X
Photochemical Ozone Formation	X		X
Ionising Radiation	X		X
Human Toxicity – Cancer effects	X		X[1]
Human Toxicity – Non-cancer effects	X		X
Ecotoxicity	X		X
Eutrophication Terrestrial	X	X	X[2]
Eutrophication Aquatic	X	X	X
Land Use	X	X	X
Water Depletion	X	X	X[3]

[1] It is considered a unique category called Toxicity

[2] It is considered a unique category called Eutrophication

[3] It is considered a unique category called Resource Depletion

Categories	OEF/ PEF guides	Planetary boundaries	Matrix 5.0
Mineral/Fossil Depletion	X		X[3]
Loss of Biodiversity		X	
Chemical Pollution		X	
Atmospheric Aerosol Loading		X	

There are three categories that are considered in Planetary Boundaries but not in the other two sources. The cause is explained below:

- Loss of biodiversity category is based on an endpoint indicator. The biodiversity loss is due to some of the other categories, as for example ecotoxicity, climate change, acidification, land use, water depletion, etc.
- Chemical pollution is defined as "emissions of toxic and long-lived substances such as synthetic organic pollutants, heavy metal compounds and radioactive materials" [16]. Therefore, it could be said that Chemical Pollution is a consequence of four of the other categories: eco-toxicity, human toxicity (cancer effects), human toxicity (non-cancer effects) and ionising radiation.
- Humans change the "Atmospheric Aerosol Loading" by emitting atmospheric pollution (many pollutants gases condense into droplets and particles), and also through land-use change that increases the release of dust and smoke into the air [16]. It could be said that "Atmospheric aerosol loading" is a consequence of two of the other categories: Particulate Matter/Respiratory inorganics and Land Use.

Furthermore, as stated in Section 4.1.8, both "Chemical Pollution" and "Atmospheric Aerosol Loading" are the two planetary boundaries that have not been quantified yet, so their equivalence with the categories of the other two sources is less important.

Considering all this, the Environmental Impact Categories taken into account for the proposed methodology are:

1. Climate Change
2. Ozone Depletion
3. Ecotoxicity – fresh water
4. Human toxicity – cancer effects
5. Human toxicity – non-cancer effects
6. Particulate Matter /respiratory inorganics
7. Ionising Radiation
8. Photochemical Ozone Formation
9. Acidification
10. Eutrophication terrestrial
11. Eutrophication aquatic
12. Resource Depletion - water
13. Resource Depletion – mineral, fossils
14. Land Use

6.2. CHARACTERISATION

Characterisation means setting the indicators for the environmental impact categories selected. The following bibliographic sources are considered to this end:

- OEF & PEF guides, for the definition of the proper indicators.
- GRI and EMAS, to check if those indicators are easily obtainable by the organisations

- Planetary boundaries and WIOD, to check if those indicators match with the indicators used in an eventual Corporate Sustainability Thresholds Approach.
- Open LCA, to check if those indicators are comparable with the main LCA standards, as Open LCA could be the tool form setting baselines for comparison environmental performances with other organisations/product/services.
- Common Good Matrix 5.0, to check the current indicators used in ECG.

Table 8 shows a comparison of the indicators specified in the methods named before.

Table 8: Indicators used in the different methods. Personal compilation based in [5][6][11][12][17][10][22]

Impact category	OEF/ PEF guides	GRI	EMAS	WIOD	Planetary Boundaries[4]	Open LCA	Matrix 5.0
Climate change	kg CO_2 eq	Tonn CO_2 eq[5]	Tonn CO_2 eq	Tonn CO_2 eq	Atmospheric CO_2 concentration (ppm) Change in radiative forcing (W/m^2)	kg CO_2 equivalent	Tonn CO_2 eq/worker
Particulate matter	PM 2,5[6] eq	Kg of PM [7]	Tonn PM	---	---	kg PM	$\mu g/m^3$ (size dependent)
Ozone Depletion	kg CFC-11 eq	Tonn CFC-11 eq [8]	---	---	Dobson Units	kg CFC-11 eq	kg CFC-11 eq
Acidification	mol H^+ eq	Kg of NO_x and kg of SO_x	Kg of NO_x and kg of SO_2	kg SO_2 eq	Global mean saturation state of aragonite in surface seawater	kg SO_2 eq	mol H^+ eq
Photochemical ozone formation	kg NMVOC eq	Kg VOC and kg NO_x	kg NO_x	kg NMVOC eq	---	kg ethylene equivalent, kg NMVOC eq and kg of formed ozone	kg NMVOC equivalent (organic compounds other than CH_4)
Ionising radiation	kg U^{235} eq	Quality of water discharged [9]	---	---	---	kg U^{235} eq and DALY	kg U^{235} eq
Toxicity	CTU	Quality of the water discharged / Air emissions [10] / Waste by type and disposal method [11]	---	---	---	kg 1,4-DB equivalent, PDF and PAF	CTU

[4] Only defined the indicators that are directly related to each category. Biodiversity lost or chemical pollution that could form part of several categories are not stated.

[5] Indicators 305-1, 305-2 and 305-3

[6] Particulate Matter with a diameter of 2,5 μm or less

[7] Indicator 305-7

[8] Indicator 305-6

[9] Indicator 306-1

[10] Indicators 305-7 and 306-1

[11] Indicator 306-2

Impact category	OEF/ PEF guides	GRI	EMAS	WIOD	Planetary Boundaries[4]	Open LCA	Matrix 5.0
Eutrophication	Terrestrial: mol N eq Aquatic: P eq (marine) N eq (fresh water)	Materials used by weight or volume [12] / Quality of the water discharged [9]	Annual mass flow of different materials used	---	Nitrogen: N removed from atmosphere for human use (Mtonnes/year) Phosphorous: P inflow to oceans (Mtonns/yr)	kg PO_4^{3-} equivalent and kg N equivalent	land: mol N equivalent water: kg P/N equivalent
Land Use	Kg (deficit)	Geographic location [13]	m^2 of built-up area	1.000 ha [14]	% of global land cover converted to cropland	PDF/m^2, m^2a	Increase over the previous years in kg C
Water depletion	m^3 water eq	Total water withdrawal by source [15]	Total water consumed (m^3/year)	1.000 m^3	Consumption of freshwater by humans (km^3/year)	m^3 of water consumption	1000 m^3/worker
Mineral/fossil depletion	kg Sb eq	Materials used by weight or volume	Annual mass flow of used materials	Kg [16]	---	Kg antimony eq / kg of minerals / MJ of fossil fuels	kg antimony eq

[12] Indicator 301-1

[13] Indicator 304-1

[14] Only in Agriculture, Hunting, Forestry and Fishing sector. Categories: arable, permanent crops, pastures, forest

[15] Indicator 303-1

[16] Categories: Biomass (forestry, others), Fossils (coal, gas, oil, others), Minerals (construction, industrial, others)

Although, in some of the categories, other indicators could have been more appropriate, in order to use the normalisation and weighting factors defined by JRC documents [7][8], the indicators defined for each category of the proposed methodology are the ones for OEF and PEF guides:

1.	Climate Change		: kg CO_2 eq
2.	Ozone Depletion		: kg CFC-11 eq
3.	Ecotoxicity – fresh water		: CTUe
4.	Human toxicity – cancer effects		: CTUh
5.	Human toxicity – non-cancer effects		: CTUh
6.	Particulate Matter /respiratory inorganics		: PM 2,5 eq
7.	Ionising Radiation		: kg U^{235} eq
8.	Photochemical Ozone Formation		: kg NMVOC eq
9.	Acidification		: mol H^+ eq
10.	Eutrophication terrestrial		: mol N eq
11.	Eutrophication aquatic	marine	: kg P eq
		freshwater	: kg N eq
12.	Resource Depletion - water		: m^3 water eq
13.	Resource Depletion – mineral, fossils		: kg Sb eq
14.	Land Use		: kg C deficit

6.3. NORMALISATION

The normalisation is the step where the different characterised impact scores are related to a common reference, in order to allow the later comparison.

ILCD Handbook [1] reviews the normalisation approaches for eleven methodologies of Life Cycle Assessment and shows an important variability. However, there is a typical approach for normalisation of midpoint indicators based on the total environmental impact existing in the region/market where it is applied the study. This method is shown in the “Normalisation Method and Data for Environmental Footprint”, a paper of the JRC of European Commission [7]. In order to perform the normalisation, for each category, the value of the indicator for the organisation analysed is divided by the value of the indicator for the whole region where it is being applied. Previously the value of the indicator for the whole region should be adjusted, summing up the value of that indicator related to exported goods in the region, and deducting the value of that indicator related to imported goods in the region. For example, if for an organisation the value of the indicator of the category climate change is 2 Tonn of CO_2 eq and the adjusted value of that indicator for the whole region where it is being applied is 1.000 Tonns of CO_2 eq, then the normalisation factor would be 1/1.000 and the value of the category climate change normalised would be 2 x 1/1.000 =0,002. Per capita values can also be used, instead of the value for the whole region.

Table below shows the normalisation factor proposed in the JRC document “Normalisation Method and Data for Environmental Footprint”[17] with the described method.

[17] Values used were domestic, so both imports and exports has not been considered, because in that document currently available methodologies and data are not considered sufficiently mature for the results of impacts associated with trade.

Table 9: Normalisation factor per impact category [7]

Impact category	Unit	Indicator value in EU	Indicator value in EU per person
1. Climate change	kg CO_2 eq	4,60E+12	9,22E+03
2. Ozone depletion	kg CFC-11 eq	1,08E+07	2,16E-02
3. Ecotoxicity - fresh water	CTUe	4,36E+12	8,74E+03
4. Human toxicity - cancer effects	CTUh	1,84E+04	3,69E-05
5. Human toxicity - non-cancer effects	CTUh	2,66E+05	5,33E-04
6. Particulate matter	kg PM2,5 eq	1,90E+09	3,80E+00
7. Ionizing radiation - human health effects	kBq U235 eq	5,64E+11	1,13E+03
8. Photochemical ozone formation	kg NMVOC eq	1,58E+10	3,17E+01
9. Acidification	mol H+ eq	2,36E+10	4,73E+01
10. Eutrophication - terrestrial	mol N eq	8,76E+10	1,76E+02
11. Eutrophication - aquatic freshwater	kg P eq	7,41E+08	1,48E+00
Eutrophication - aquatic marine	kg N eq	8,44E+09	1,69E+01
12. Resource depletion water	m3 water eq	4,06E+10	8,14E+01
13. Resource depletion - fossils	kg Sb eq	5,03E+07	1,01E-01
14. Land use	kg C deficit	3,74E+13	7,48E+04

For the assessment of the ABSOLUTE ENVIRONMENTAL IMPACT of organisations this method seems appropriate and the “indicator value in EU per person” is chosen as reference for the definition of the normalisation factor to use in this methodological proposal.

However, for RELATIVE ENVIRONMENTAL IMPACT assessment a more suitable normalisation method can be adopted, based in the EMAS approach for normalisation. The basis for normalisation in this case would be the impact produced by the organisation with reference to the annual gross value-added of that organisation and with respect with both the impact and the gross value-added of the industrial sector that the organisation belongs to in the region where it is being applied.

6.4. WEIGHTING

Weighting is the step where a ranking and/or weighting of the different environmental impact categories, reflecting the relative importance of the impacts considered in the LCA, is set in order to enable the aggregation of all the categories in a unique number that could serve as a source for comparison of different organisations.

For ECG purposes this step would enable the definition of both, the absolute environmental impact (aspect E3.1) and the relative environmental impact (aspect E3.2).

“Evaluation of Weighting Methods for Measuring the EU-27 Overall Environmental Impact” [8], a document of the JRC of the European Commission, studies seven weighting methods, four from Europe, two from US and one from Japan. Three of those seven methods were based on midpoint impact categories (BEES, EPA and NOGEPA). As already commented, this methodological proposal will be midpoint based, so only these three approaches are taken into account. For these methods the weighting sets were all defined from a panel procedure. The following table shows the adapted weighting factors to the EOF/PEF guides impact categories, as well as the average of the three methods:

Table 10: Adapted weighting factors of three panel weighting sets and average weighting [8]

	EPA Science Advisory Board	**BEES Stakeholder Panel**	**NOGEPA additional factors (add up to 100)**	**Average**
	%	**%**	**%**	**%**
1. Climate change	16	29	25	23
2. Ozone depletion	5	2	4	4
3. Ecotoxicity – fresh water	11	7	14	11
4. Human toxicity – cancer effects	7	8	5	7
5. Human toxicity – non-cancer effects	4	5	3	4
6. Particulate matter	6	9	5	7
7. Ionizing radiation	11	3	5	6
8. Photochemical ozone formation	6	4	6	5
9. Acidification	5	3	5	4
10. Eutrophication – terrestrial	5/3	6/3	10/3	7/3
11.Eutrophication – aquatic freshwater	5/3	6/3	10/3	7/3
Eutrophication – aquatic marine	5/3	6/3	10/3	7/3
12. Resource depletion - water	3	8	4	5
13. Resource depletion - fossils	5	10	6	7
14. Land use	16	6	8	10
TOTAL	**100**	**100**	**100**	**100**

The weighting factors considered for this project are the average of the three methodologies. These are shown in the table below:

Table 11: Adopted weighting factors for this methodology. Source: Personal Compilation based in [8]

1. Climate change	23%
2. Ozone depletion	4%
3. Ecotoxicity – fresh water	11%
4. Human toxicity – cancer effects	7%
5. Human toxicity – non-cancer effects	4%
6. Particulate matter	7%
7. Ionizing radiation	6%
8. Photochemical ozone formation	5%
9. Acidification	4%
10. Eutrophication – terrestrial	2,33%
11.Eutrophication – aquatic freshwater	2,33%
Eutrophication – aquatic marine	2,33%
12. Resource depletion - water	5%

13. Resource depletion - fossils	7%
14. Land use	10%
TOTAL	**100%**

6.5. METHODOLOGIES PROPOSED

Two methodologies are defined in this section: the absolute environmental impact and the relative environmental impact. In order to be compatible with the current ECG matrix and cover the whole cycle analysis from the cradle to the grave of all the P/S produced by the organisation, the two methodologies (absolute and relative impact) have to be performed not in a single topic, but in three topics. These three topics and their scope are:

- Topic A3: In this topic, all the impacts of the suppliers of the organisation should be covered.
- Topic D3: In this topic, all the impacts of P/S produced by the organisation, associated to their use and disposal should be covered.
- Topic E3: In this topic, all the impacts of the organisation should be covered.

The methodologies propose 14 different categories of environmental impacts (Section 6.1) and the later definition of a midpoint characterisation factor, or indicator, for each category (Section 6.2). A normalisation factor has been applied in order to enable the comparison (Section 6.3), and a weighting factor for aggregating all the impacts in a unique environmental ratio (Section 6.4).

The general formula for defining the environmental impact for the two methodologies is:

$$Environmental\ Impact = \sum_{i=1}^{14} OV_i \cdot NF_i \cdot WF_i$$

Where:

- OV_i: Organisation value of the indicator for each category
- NF_i: Normalisation factor for each category
- WF_i: Weighting factor for each category
- i: Categories
    1. Climate Change
    2. Ozone Depletion
    3. Ecotoxicity – fresh water
    4. Human toxicity – cancer effects
    5. Human toxicity – non-cancer effects
    6. Particulate Matter /respiratory inorganics
    7. Ionising Radiation
    8. Photochemical Ozone Formation
    9. Acidification
    10. Eutrophication terrestrial
    11.1. Eutrophication aquatic freshwater
    11.2. Eutrophication aquatic marine
    12. Resource Depletion - water
    13. Resource Depletion – mineral, fossils
    14. Land Use

6.5.1. ABSOLUTE ENVIRONMENTAL IMPACT

Table 12 shows the methodology for the quantification of the absolute environmental impact of an organisation. This absolute environmental impact is the basis for comparing the environmental performance of organisations of different industrial sector. As the normalisation factor is performed with EU figures, this methodology could only be used within EU scope.

Table 12: Methodology for absolute impact calculation. Source: Personal Compilation.

Category	Indicator	OV	NF	WF	Absolute impact by category
1	kg CO_2 eq	A	1/9,22E+03	23%	A / 9,22E+03 x 23%
2	kg CFC-11 eq	B	1/2,16E-02	4%	B / 2,16E-02 x 4%
3	CTUe	C	1/8,74E+03	11%	C / 8,74E+03 x 11%
4	CTUh	D	1/3,69E-05	7%	D / 3,69E-05 x 7%
5	CTUh	E	1/5,33E-04	4%	E / 5,33E-04 x 4%
6	kg PM2,5 eq	F	1/3,80E+00	7%	F / 3,80E+00 x 7%
7	kBq U^{235} eq	G	1/1,13E+03	6%	G / 1,13E+03 x 6%
8	kg NMVOC eq	H	1/3,17E+01	5%	H / 3,17E+01 x 5%
9	mol H^+ eq	I	1/4,73E+01	4%	I / 4,73E+01 x 4%
10	mol N eq	J	1/1,76E+02	2,33%	J / 1,76E+02 x 2,33%
11.1	kg P eq	K	1/1,48E+00	2,33%	K / 1,48E+00 x 2,33%
11.2	kg N eq	L	1/1,69E+01	2,33%	L / 1,69E+01 x 2,33%
12	m^3 water eq	M	1/8,14E+01	5%	M / 8,14E+01 x 5%
13	kg Sb eq	N	1/1,01E-01	7%	N / 1,01E-01 x 7%
14	kg C deficit	O	1/7,48E+04	10%	O / 7,48E+04 x 10%
			Total absolute impact		Σ

A, B, C, …, O: Organisation value of the indicator for each category

6.5.2. RELATIVE ENVIRONMENTAL IMPACT

Table 13 shows the procedure for the calculation of the relative environmental impact of an organisation. This absolute environmental impact is the basis for comparing the environmental performance of an organisation with either other organisations of the same industrial sector or with standards performances of that industrial sector. This methodology can be used worldwide.

Table 13: Methodology for relative impact comparison of ECG organisations of the same industrial sector. Source: Personal Compilation.

Category	Indicator	OV	NF	WF	Relative impact by category
1	kg CO_2 eq	A	AV_{ind} / (AV_{org} x A_{ind})	23%	A x AV_{ind} / AV_{org} x 23%
2	kg CFC-11 eq	B	AV_{ind} / (AV_{org} x B_{ind})	4%	B x AV_{ind} / AV_{org} x 4%
3	CTUe	C	AV_{ind} / (AV_{org} x C_{ind})	11%	C x AV_{ind} / AV_{org} x 11%
4	CTUh	D	AV_{ind} / (AV_{org} x D_{ind})	7%	D x AV_{ind} / AV_{org} x 7%
5	CTUh	E	AV_{ind} / (AV_{org} x E_{ind})	4%	E x AV_{ind} / AV_{org} x 4%
6	kg PM2,5 eq	F	AV_{ind} / (AV_{org} x F_{ind})	7%	F x AV_{ind} / AV_{org} x 7%
7	kBq U^{235} eq	G	AV_{ind} / (AV_{org} x G_{ind})	6%	G x AV_{ind} / AV_{org} x 6%
8	kg NMVOC eq	H	AV_{ind} / (AV_{org} x H_{ind})	5%	H x AV_{ind} / AV_{org} x 5%
9	mol H^+ eq	I	AV_{ind} / (AV_{org} x I_{ind})	4%	I x AV_{ind} / AV_{org} x 4%
10	mol N eq	J	AV_{ind} / (AV_{org} x J_{ind})	2,33%	J x AV_{ind} / AV_{org} x 2,33%
11.1	kg P eq	K	AV_{ind} / (AV_{org} x K_{ind})	2,33%	K x AV_{ind} / AV_{org} x 2,33%
11.2	kg N eq	L	AV_{ind} / (AV_{org} x L_{ind})	2,33%	L x AV_{ind} / AV_{org} x 2,33%
12	m^3 water eq	M	AV_{ind} / (AV_{org} x M_{ind})	5%	M x AV_{ind} / AV_{org} x 5%
13	kg Sb eq	N	AV_{ind} / (AV_{org} x N_{ind})	7%	N x AV_{ind} / AV_{org} x 7%
14	kg C deficit	O	AV_{ind} / (AV_{org} x O_{ind})	10%	O x AV_{ind} / AV_{org} x 10%
			Total relative impact		Σ

AV_{org}: Annual gross value-added of the organisation (PPP adjusted)
AV_{ind}: Annual gross value-added of the industry (PPP adjusted)
A, B, C, …, O: Organisation value of the indicator for each category
A_{ind}, B_{ind}, C_{ind}, …, O_{ind}: Industry value of the indicator for each category

7. DISCUSSION

There are some key issues about the methodological proposal itself or about the later development of it that are discussed in the following sections.

7.1. INTEGRATION OF THE METHODOLOGY WITHIN THE CURRENT ECG MATRIX

The current logic and structure of the matrix makes the environmental impact is assessed in three different topics, so the integration of the proposed methodology in the current ECG matrix would have to be performed three times:

- A3: Environmental impact of suppliers
- D3: Environmental impact of clients (use and disposal of P/S)
- E3: environmental impact of the organisation itself

The scope of what is impact of the organisation (to be reported in topic E3), what is impact of the suppliers (to be reported in topic A3) and what is impact of the use and disposal of the P/S produced (to be reported in topic D3) it is an important issue to consider in the eventual implementation of the proposed methodology. This issue is schematically shown in Figure 6.

In the ECG Manual [22] the scope considered in E3 was not only the environmental impact of the organisation itself, but also the impact of the indirect energy supply (heat and electricity). This approach matches with the Scope 2 of GHG protocol and it is considered to be adequate, however the most important issue to take into account is that the scope considered is the same. In this way, the comparison of the environmental performance of different organisations could be carried out not only as absolute or relative environmental impact but also topic by topic.

For A3 there would be some organisations where the environmental impact of the suppliers is not possible to be obtained because of lack of transparency. To this end, tools like Open LCA could help to estimate it, considering the standard environmental performance of their industrial sector in the country of origin of the supplier.

Both the absolute and the relative impact should be assessed in each one of the three topics, independently of other aspects that could be also considered in the evaluation of the topics, like environmental policies or risk measurement.

As commented in Section 5.1 the reference for setting the indicators in the Common Good Matrix 5.0 approach were PEF & OEF guides. This is the reason for the indicators of PEF and OEF guides and Common Good Matrix 5.0 to match for all the categories.

Because of all the issues commented in this section the integration of the proposed methodology in the current ECG Matrix is considered feasible.

7.2. COMPLEXITY

As commented in Section 2, the methodology proposed should be both easily understandable and easy to implement for the organisations.

The methodological proposal it is more structured and more in line with the most widely accepted methodology for LCA (ISO 14040/44). However, it seems to be quite complex as

14 multivariable indicators should be reported by the organisations. This exceeds the current regulation requirements of reporting, that for some of the environmental categories is not so stringent. Therefore, it involves an extra effort in economic terms for the organisation to implement this methodology, as new information, apart from the one required by the regulation, would be needed to be gathered.

To compensate this fact, a simpler approach could be derived from the one presented in this project. To this end, it would be needed to study both the complexity and the cost of obtaining these 14 indicators in order to determine which of the suggested indicators involve an excessive cost, mainly to SMEs, that is the current focus group in ECG. Apart from the cost, the "expert barrier" would also be reduced.

However, it is important to state that the monitoring and reporting in the proposed methodology is only required for the environmental categories where it is foreseen a minimum impact, either from the organisation itself or their suppliers. For the rest of categories, the impact would be considered zero. For example, an organisation that provides consultant services would not have to measure the ionising radiation derived from their activity as it is obvious that such impact does not take place.

Also, due to this complexity, guidelines should be edited in order for organisations to enable the procedure of gathering and reporting the indicators of the defined impact categories.

7.3. INDUSTRIAL SECTOR CLASSIFICATION

The methodological proposal for the relative environmental impact is industry specific, so an industrial sector classification would be required. Figures as the gross value-added or the value of the indicator of each category will be required by industrial sector. These figures can be easily obtained by means of Input Output Databases and their satellite accounts.

Due to this, the chosen classification should be widely accepted and used in the existing input-output databases. Theoretically the number of industrial sectors should be as big as possible for a better disaggregation of data but also, in terms of simplicity and statistical availability, this number cannot be so numerous.

Two options are proposed here, but it should be studied more in depth which is the best classification:

- International Standard Industrial Classification revision 3 (ISIC Rev. 3). This classification is used in WIOD.
- Global Industry Classification Standard. This is used by the Dow Jones Sustainability Index.

However it is important mentioning that in the same industrial sector there would be different activities and it is not so easy to compare them (e.g. in steel producing industry, one organisation might produce high quality steel for specific uses and the other just plain steel). Due to this, there is a quite substantial discussion in the field in how far it is legitimate to compare organisations.

7.4. REFERRING PHYSICAL AND MONETARY VALUES

Weisz H. and Duchim F. [23] report some problems arising when referring physical and monetary values, as is the case of the normalisation proposed for Relative Environmental

Impact Assessment as it mixes monetary values (gross value-added) and physical values (environmental impact defined by physical magnitude).These problems can derive from both, the false assumption that unitary prices are the same everywhere, and a high level of aggregation of the monetary values, due to the consideration of different items in the accountability of the organisations. The first issue could be addressed by adjusting to purchasing power parity the monetary values, when comparing organisations of countries with different levels of development. The second issue is more difficult to address, as the level of aggregation is somehow defined by the accountability of the organisation, usually depending on legislative requirements, and by the existing Input-Output Databases that aggregate data for different industries, usually depending on the data availability and the criteria of the database creators. A deeper work could be developed in the future to try to match the requirements of this normalisation by means of changing both, organisations accountability, and Input-Output Database aggregation, but it is obvious that there are difficulties that are not easy to tackle.

7.5. FROM ORGANISATION REPORTING TO P/S REPORTING

As stated in Section 2, the methodological proposal of this project should be easily extrapolated from the organisation scope to the P/S scope.

ECG matrix is designed to assess the common good performance of organisations. Just one organisation can produce several P/S, each one with a different environmental performance. From the customer point of view it is not fair that the assessment of these P/S are reflected with the same score, as some of the P/S can be produced in a sustainable way and have sustainable raw materials while others not, even though they are produced by the same organisation. For a customer to have the possibility of comparing P/S instead of organisations a common good matrix for each P/S produced would be needed. To this end, it would be desirable that in the future the organisation matrix could be the basis for obtaining the single matrices of every P/S type that the organisation produces, so that the consumer can take the decisions based on the P/S common good performance, rather than on the organisation common good performance. Furthermore, based in the discussion of how far it is legitimate to compare organisations, explained in Section 5.2, it seems that a relative impact comparison would be more adequate if performed to P/S rather than to organisations.

From the perspective of the proposed methodology, as the organisations are assessed on the basis of LCA approach, the extrapolation from organisation’s impacts to P/S’s impacts would be feasible, and the disaggregation of the total impact in the individual impact of the P/S would be just a matter of raw data arrangement.

For this approach (P/S matrix) to be implemented it would be required to perform the traceability of every link of the supply chain, so that for each consumable good had information of the environmental impact accumulated until that point of the life cycle. Either fully transparency with suppliers or a new accountability system, not only economical, but also in terms of resources and impacts, would be required to make this possible. This nowadays seems to be quite far from reality. However and in cases where the environmental impact of the suppliers is not possible to be obtained, tools like Open LCA could help to estimate it, considering the standard environmental performance of their industrial sector.

7.6. CORPORATE SUSTAINABILITY THRESHOLDS APPROACH

The recent years have been characterized by a strongly increased attention on corporate responsibility for the transition to sustainable patterns of production and consumption. A certain emphasis of governance instruments has been laid on increasing corporate sustainability reporting. This development has been accompanied by a tendency to put transparency partly on a level with sustainability impact. The latter yet remains difficult to be compared among different corporate actors. While at the level of an individual the concept of biophysical limits has been successfully applied (e.g. Ecological Footprint), a related concept for organisations is still missing.

The main objective of a Corporate Sustainability Thresholds Approach consists on developing a conceptual framework to deduct corporate sustainability thresholds and deduct a safe operating space for organisations, applying existing sectorial and product-based input-output analysis.

In this approach, an ethical debate arises about who is the responsible for the environmental impacts produced: the producer, the consumer, governments? Corporate Sustainability Thresholds Approach advocates for the producer responsibility, therefore the approach would end up assigning impact budgets to all the organisations worldwide.

A technical issue should also be addressed: how is double counting prevented? For this issue, the scope definition is a key issue. See Section 7.1.

There is a useful initiative for setting sectorial budgets in the field of climate change and it could be considered as a reference in an eventual development of the Corporate Sustainability Threshold Approach [24].

As stated in Section 2, the methodology proposed should be flexible enough to enable the later adaptation to a Corporate Sustainability Thresholds Approach. In the next paragraphs this compatibility is discussed by comparing the indicators shown in Table 8 for PEF & OEF guides with the indicators of both, Planetary Boundaries and WIOD, which are the two sources of information that would be used in the eventual development of a Corporate Sustainability Thresholds Approach.

From the comparison between PEF & OEF guides and Planetary Boundaries indicators, shown in Table 8, it can be easily deducted that they do not match for any categories. The reason is that Planetary Boundaries are based in endpoint indicators, while PEF & OEF guides are based in midpoint indicators; however midpoint and endpoint indicators of the same category could be correlated by means of a model. Also, the categories considered are not exactly the same for PEF & OEF guides and Planetary Boundaries, as already discussed in Section 6.1. Further reading and research should be conducted in order to determine the feasibility of relate in an accurate way the midpoints indicators of OEF & PEF guides with the endpoint indicators set in the Planetary Boundaries and also to correlate the different categories.

Table 8 shows that in WIOD there are not indicators available for the categories PM, Ozone Depletion, Ionising Radiation, Toxicity and Eutrophication. Also, the indicators for the categories Land Use and Mineral/Fossils Depletion are not compatible to the indicators established for PEF & OEF guides. These make impossible the correlation of both sources. However, input-output databases are relative new initiatives, in fact WIOD was first released in 2013, and it is expected that in the next years they will be completed and improved. A more complete environmental satellite accounts would be required in order to be feasible a Corporate Sustainability Threshold Approach for all the categories selected in the proposed methodology. When talking about feasibility it does not mean that the indicators are exactly the same for both information sources, but that it is possible to relate them in an accurate way by means of either approximations or aggregation.

From the paragraphs above it can be stated that further research and better information sources should be available in order to face a Corporate Sustainability Thresholds Approach with enough guarantee.

7.7. REFERENCES FOR COMPARISON

It would be appropriate to have figures of average and optimum environmental performances (benchmarks) for industrial processes and for certain P/S. From these figures, other figures for industrial sectors can be deducted and they would be a very interesting tool to assess the relative environmental impact.

This can be done quite easily with Open LCA tool, already described in section 4.1.3, where by defining both the scope of the consultation and the LCA method to use, and with the help of databases of environmental impacts, the reference numbers for comparison can be obtained. As commented in Section 7.5, Open LCA is also a very useful tool for doing estimations of environmental impacts of suppliers when these are unknown. To carry out an approach like this a common understanding of system boundaries would be required and the content of Section 7.1 can be useful with this aim.

From the comparison between PEF & OEF guides and Open LCA indicators, shown in Table 8, it can be concluded that there is a high correlation. The only categories that, in this first review, do not seem to match are Toxicity and Land Use. Further reading and research is needed to conduct in order to determine the way of correlating these different indicators for both categories in the two sources of information.

The Best Available Techniques (BAT) reference documents defined by the JRC of European Commission could be taken as reference for optimum environmental performances of different industrial processes.

8. FURTHER ADVANCES REQUIRED AND RECOMMENDATIONS

As commented in Section 2, the limitations of the proposed methodology, as well as further advances and recommendations for the eventual development of the Common Good Matrix with the proposed methodology should be explained. Although some of the advances required as well as recommendations have already been addressed in Section 7, in this section they will be already exposed in a synthetic way.

Further advances and recommendations for the proposed methodology:

- It would be required to study both the complexity and the cost of obtaining the 14 multivariable indicators of the proposed methodology in order to determine for which of them its determination involve an excessive cost. From this **cost analysis**, a simpler methodology, based in the one proposed in this project, could be elaborated.
- For the ECG and its current focus group (SMEs), the development of tools, as **guidelines**, to enable the application of the proposed methodology would be needed to reduce the "expert barrier".
- The **scope of the proposed methodology** is limited to the EU, because the absolute impact normalisation is performed with EU figures. In the future, this normalisation should be performed with world figures, so methodological approaches for ECG are easily extrapolated to organisations from other markets rather than EU.
- **Weighting factors** to apply to the different categories of the methodological proposal have been defined as the average of three panel procedures (See Section 6.4). These panel procedures have similar conditions, like being formed by experts with broad knowledge of environmental modelling or that the different social stakeholders (business community, consumers, politicians, civil society at large…) feel represented with them. However, the opinion of this expert was mainly subjective based in what they thought that were the main environmental priorities. Both Input-Output Databases management and Planetary Boundaries can be used as references to define these weighing factors based in current data and objective figures. Also, this weight would change from time to time, depending on the numbers of the figures. This should be explored more in depth for the definitions of weighting factors in the future.

Further advances and recommendations for useful tools required for a Corporate Sustainability Thresholds Approach and for setting benchmarks for industrial sectors and P/S:

- **WIOD** is considered the reference input-output database for this project. Currently available fields and data in WIOD are not enough in order to consider them as the reference source for a Corporate Sustainability Thresholds Approach that covers all the categories of the proposed methodology. Therefore, a required advance would be the improvement of WIOD, enlarging the fields of the environmental satellite accounts, in the way that they are compatible with the indicators set in the OEF & PEF guides.
- Also, in order to perform a Corporate Sustainability Thresholds Approach further reading and research should be conducted in order to determine the feasibility of correlating in an accurate way the midpoints indicators of OEF & PEF guides with the

endpoint indicators set in the **Planetary Boundaries** and also to connect the different categories of both methods.

- It is also required the development and widespread the use of tools as **Open LCA** with such a powerful potential for setting benchmarks for comparing organisations and P/S, as well as to estimate the impact of suppliers when this is unknown.

9. CONCLUSIONS

The aim of this project is reviewing the current methodology for measuring the environmental impact of an organisation in the framework of Economy for the Common Good (ECG) and proposing an alternative one. This methodology does not comprise other qualitative aspects related to environmental management and policies of the organisation or the risks measurement, which could also be valid to assess an organisation in an environmental basis.

A literature review has been performed to the main environmental impact assessment tools (ILCD Handbook, OEF and PEF guides and Open LCA), the main environmental corporate reporting tools (GRI and EMAS), the main input-output databases (WIOD and EORA MRIO) and other interesting sources (Planetary Boundaries, Ecological Footprint and GHG Protocol).

It has also been reviewed the environmental issues assessing approach in the current version of the Common Good Matrix (version 5.0). Two main limitations have been found:

- The selection of impact categories and their indicators as well as the normalisation and weighting methods used are not the ones proposed by the JRC, which define the official position of European Commission. It is expected that all technical improvements of LCA in the future, at least in EU scope, will be within this framework, so it is considered important to follow the EU criterion.
- A quantitative assessment is performed only for the impact of the organisation itself, but not for suppliers and clients. A life cycle approach considers the impact of an organisation and their P/S from the cradle to the grave.

Two methodological proposals have been made in this project, one for the absolute environmental impact and another for the relative environmental impact. The methodological proposal for the absolute environmental impact follows the approach of the JRC of European Commission for selection of impact categories, characterisation, normalisation and weighting. For the relative environmental impact, the procedure is the same but with an alternative normalisation method, based in EMAS approach. The whole organisation and their P/S life cycle impact is divided in the topics A3 (suppliers), D3 (clients) and E3 (organisation itself) resulting in a quantification for each topic.

Interesting features of the proposed methodology as well as some key issues arising through the performance of this project are named below:

- The proposed methodology can be easily integrated in the current version of Common Good Matrix.
- The proposed methodology could be too complex and a simplification would probably be required; even more taking into account that SMEs is the current focus group in ECG and their capacity, both technical and in economic terms, are limited.
- Due to its complexity, guidelines for gathering and reporting the indicators of the defined impact categories should be edited in order to enable the application of the proposed methodology to the organisations.
- As it is a LCA based methodology, the methodological proposal could be easily extrapolated to P/S reporting.

- Further development of WIOD should be performed in order to face a Corporate Sustainability Thresholds Approach with enough guarantee for the proposed methodology.
- Further reading and research should be conducted in order to determine the feasibility of correlating in an accurate way the midpoints indicators of the proposed methodology with the endpoint indicators set in the Planetary Boundaries for a Corporate Sustainability Thresholds Approach.
- Tools like Open LCA are very useful for obtaining benchmarks for comparing the environmental performance of organisations and P/S. Also for estimating the environmental impact of the supply chain.

BIBLIOGRAPHY

FELBER, Christian. *Economía del Bien Común.* 8ª Edición. Barcelona: Deusto. 2010

Gemeinwhol Ökonomie. *Arbeitsbuch zur Gemeinwhol- Bilanz 5.0 Vollbilanz.* 2017

JRC European Commission*. Analysis of existing Environmental Impact Assessment methodologies for use in Life Cycle Assessment*. Ispra: 2012

JRC European Commission. *Evaluation of Weighting Methods for Measuring the EU-27 Overall Environmental Impact*. Ispra: 2011

JRC European Commission*. Characterisation factors of the ILCD Recommended Life Cycle Impact Assessment methods*. Ispra: 2012

JRC European Commission. *Normalisation Method and Data for Environmental Footprints.* Ispra: 2014

JRC European Commission. *Organisation Environmental Footprint (OEF) Guide.* Ispra: 2012

JRC European Commission. *Product Environmental Footprint (PEF) Guide.* Ispra: 2012

JRC European Commission. *Recommendation for Life Cycle Impact Assessment in the European context.* Ispra: 2012

Rockström J et al. Planetary Boundaries: Exploring the Safe Operating Space for Humanity. *Ecology and Society*. 2009. Vol 14, No 2, Art 32

REFERENCES

[1] Economy Collaborative. *The Economy for the Common Good*. https://thenextsystem.org/the-economy-for-the-common-good. Consulted in August 2017

[2] JRC European Commission*. Analysis of existing Environmental Impact Assessment methodologies for use in Life Cycle Assessment*. Ispra: 2012

[3] JRC European Commission. *Recommendation for Life Cycle Impact Assessment in the European context.* Ispra: 2012

[4] JRC European Commission*. Characterisation factors of the ILCD Recommended Life Cycle Impact Assessment methods*. Ispra: 2012

[5] JRC European Commission. *Product Environmental Footprint (PEF) Guide.* Ispra: 2012

[6] JRC European Commission. *Organisation Environmental Footprint (OEF) Guide.* Ispra: 2012

[7] JRC European Commission. *Normalisation Method and Data for Environmental Footprints.* Ispra: 2014

[8] JRC European Commission. *Evaluation of Weighting Methods for Measuring the EU-27 Overall Environmental Impact*. Ispra: 2011

[9] Open LCA. *The Open Source Life Cycle and Sustainability Assessment Software* http://www.openlca.org/. Consulted in August 2017

[10] Aitor P. Acero, Cristina Rodríguez, Andreas Ciroth. *LCIA methods. Impact assessment methods in Life Cycle Assessment and their impact categories. Version 1.5.6.* Berlin: 2017

[11] GRI. Consolidated Set of GRI Sustainability Reporting Standards 2016. Amsterdam: 2016

[12] Regulation (EC) Nº 1221/2009 of the European Parliament and of the Council of 25 November 2009

[13] WIOD. *Environmental Accounts*. http://www.wiod.org/database/eas13. Consulted in August 2017

[14] Aurélien Genty, Iñaki Arto, and Frederik Neuwahl. *WIOD Deliverable 4.6. Final database of environmental satellite accounts: technical report on their compilation.* 2012

[15] EORAMRIO. *Notes on Eora indicator definitions.* Retrieved from http://worldmrio.com/IndicatorNotes.doc. Consulted in June 2017

[16] Stockholm Resilience Centre. *The nine planetary boundaries*. http://www.stockholmresilience.org/research/planetary-boundaries/planetary-boundaries/about-the-research/the-nine-planetary-boundaries.html. Consulted in August 2017

[17] Stockholm Resilience Centre. *Table of the nine planetary boundaries*. http://www.stockholmresilience.org/research/planetary-boundaries/planetary-boundaries/about-the-research/quantitative-evolution-of-boundaries.html. Consulted in August 2017

[18] Rockström J et al. Planetary Boundaries: Exploring the Safe Operating Space for Humanity. *Ecology and Society*. 2009. Vol 14, No 2, Art 32

https://www.ecologyandsociety.org/vol14/iss2/art32/

[19] Global Footprint Network. *Ecological Footprint Standards 2009.* Oakland: 2009

[20] The Greenhouse Gas Protocol. *A Corporate Accounting and Reporting Standard. Revised Edition*. Conches. Geneva. 2004

[21] Greenhouse Gas Protocol. *Corporate Value Chain (Scope 3) Accounting an Reporting Standard*. 2011

[22] Gemeinwhol Ökonomie. *Arbeitsbuch zur Gemeinwhol- Bilanz 5.0 Vollbilanz.* 2017

[23] Weisz H. and Duchim F. Physical and Monetary Input-Output Analysis: What Makes the Difference? *Rensselaer Working Papers in Economics*. 2014. Number 0422.

[24] Science Based Targets. *Sectorial Decarbonization Approach: A method for setting corporate emission reduction targets in line with climate science.* 2015