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Pre-modelling analysis of the Footprint family of indicators in EU and international policy contexts

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25 OCTOBER 2010

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Acknowledgements

We would like to thank Katy Roelich (Stockholm Environment Institute), Stefan Giljum (Sustainable Europe Research Institute), Alessandro Galli (Global Footprint Network), Gertjan Storm (University of Maastricht) and R. Andreas Kramer (Ecologic Institute) for the feedback they provided on earlier versions of this report.

These acknowledgements do not necessarily imply that the experts mentioned above endorse the analysis and conclusions presented in this report. The responsibility for the content and for any errors lies exclusively with the authors.

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Abbreviations

6EAP	6th Environmental Action Programme
BAP	Biomass Action Plan
BIOSTRAT	EU Biodiversity Research Strategy
BIP	Biodiversity Indicator Partnership
CAP	Common Agricultural Policy
CBD	Convention on Biological Diversity
CCS	Carbon Dioxide Capture and Storage
CF	Carbon Footprint
CFP	Common Fisheries Policy
COMTRADE	United Nations Commodity Trade Statistics
CSD	Commission on Sustainable Development
DG	Directorate General
DWD	Drinking Water Directive
EC	European Commission
ECCP	European Climate Change Programme
EET	Emissions Embodied in Trade
EF	Ecological Footprint
EFTA	European Free Trade Association
ETS	Emission Trading System
EU SDS	European Sustainable Development Strategy
FAO	Food and Agricultural Organisation of the United Nations
FAP	EU Forest Action Plan
GDP	Gross Domestic Product
GEI	Green Economy Initiative
GFN	Global Footprint Network
GHG	Greenhouse Gases
GPP	Green Public Procurement
GTAP	Global Trade Analysis Project
HDI	Human Development Index
ICZM	Integrated Coastal Zone Management
IEA	International Energy Agency
IEEP	Institute for European and Environmental Policy
IOA	Input-output analysis
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization :
JRC	Joint Research Centre
LCA	Life Cycle Assessment

MP	Marrakech Process
MRIO	Multi-regional input-output model
MS	EU Member State
NGO	Non-governmental organisation
OPEN:EU	One Planet Economy Network: Europe
PAS	Publicly Available Specification
PCB	Polychlorinated Biphenyl
PCF	Product Carbon Footprint
RACER	Relevant, Accepted, Credible, Easy, Robust analysis
RBMP	River Basin Management Plan
RP	Resource Panel
SCP	Sustainable Consumption and Production
SDI	Sustainable Development Indicator
SDS	Sustainable Development Strategy
SFC	Standing Forestry Committee
SWOT	Strengths, Weaknesses, Opportunities, Threats analysis
TEC	Treaty establishing the European Community
TFEU	Treaty on the Functioning of the European Union
TS	Thematic Strategy
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
WF	Water Footprint
WFD	Water Framework Directive
WFN	Water Footprint Network
WP	Work Package
WSSD	World Summit on Sustainable Development
WWF	World Wide Fund For Nature

1. Introduction

This report is part of work package 6 (WP 6) of the One Planet Economy Network: Europe (OPEN:EU) project and aims to ensure that the project findings and recommendations are relevant for policy makers. The Footprint Family of indicators will be evaluated for their sustainability within the current policy processes.

This report serves, inter alia, to:

- Evaluate the usefulness of the Footprint Family indicators for policy-makers; and
- Improve integration of the indicators into policy-making processes and government reporting (EU and international).

This report provides a pre-modelling assessment of the Footprint Indicators and their usefulness in evaluating progress towards EU and international policy objectives. Furthermore, the report will provide a basis for sound decision making and setting new policy goals and development priorities.

The analysis pursues the following objectives:

- To summarise the EU and international policy objectives in the field of sustainable development and environmental policies (with a focus on resource use, water policy and climate change policy);
- To evaluate the robustness of the Footprint Indicators (i.a. regarding their methodology) and their usefulness for assessment of progress towards the policy objectives (RACER analysis);
- To assess the benefits of using the Footprint Family of indicators in decision making for the European Commission and possibilities for their integration into policy making (SWOT analysis).

In the OPEN:EU project, the Ecological, Carbon, and Water Footprints are for the first time grouped under a signle conceptual framework, the ”Footprint Family”. As a result, alternative accounting methods will be used to calculated the Footprint Indicators, in order to align their methodologies. The differences between the pre and post OPEN:EU accounting models are pointed out in the WP8 report (Galli et al., 2010).

Furthermore, the so called EUREAPA tool is being developed. It uses a sophisticated economic input-output model to understand the environmental pressures associated with consumption activities. It will combine data on what products citizens from each of the 27 EU countries are buying (the current consumption profile) with data on where these products are made and how efficient production techniques are to calculate the direct and indirect environmental impact of goods and services consumed in the EU. The Footprint Family will be incorporated into this tool. Accordingly, this report analyses the single Footprints from this point of view.

The report begins with an overview of the EU and international policies intended to secure sustainable development and sustainable resource use. Here the general policies and their objectives are considered (Sustainable Development Strategy, Resource Strategy, etc.), as well as specific policies related to water use and greenhouse gas (GHG) emissions.

The second section of the report introduces the RACER and SWOT methodologies used for evaluations of criteria to measure policy progress (used here for environmental policy progress).

The report then applies RACER and SWOT analyses on the three indicators of the "Footprint Family" relevant to help inform European Environmental Policy:

- Ecological Footprint,
- Water Footprint,
- Carbon Footprint.[1]

This analysis will help to assess the Footprints according to general criteria, i.a. suitability to guide policy, soundness of methodology, potential ambivalence of messages, etc.

The SWOT analysis will look at opportunities for the European Commission to adopt the Footprint approach as an official method on which to base their environmental policies.

The conclusions of this report shall sum up the results from the RACER and SWOT analyses and recommend how to use the assessed indicators to further EU environmental policy.

[1] For more information on the definition of the three indicators as well as the Footprint Family, see Galli et al. (2010).

2. EU policy objectives

In the following, we will present an overview of the most important policies in the areas of resources and resource use, water and climate change both on the EU and the international level. Furthermore, overarching policies (e.g. the Sustainable Development Strategy) will be looked at. This overview aims at presenting a basis for analysing the usefulness of the different Footprint Indicators.

2.1. EU general policy objectives

2.1.1. EU SUSTAINABLE DEVELOPMENT STRATEGY

The EU Sustainable Development Strategy (SDS) was adopted by the European Commission at the Gothenburg European Council in 2001, renewed in 2006 and reviewed in 2009. The strategy defines sustainable development as a long-term goal combining economic growth, social cohesion and environmental protection.

The SDS aims at supporting economic growth which enables sustainable social development and use of natural resources, as well as the elimination of harmful environmental effects. The Strategy suggests a set of targets for EU sustainable development with a particular emphasis on the use of natural resources and environmental protection.

The 2009 Review of the SDS (Commission of the European Communities, 2009) indicates that in spite of significant progress towards sustainability, unsustainable trends persist. In particular "the demand on natural resources has been growing fast and exceeds what the Earth can sustain in the long term" (Commission of the European Communities, 2009).

The renewed SDS defines specific objectives and necessary actions for their achievement in several areas (Council of the European Union, 2006b):

- Climate change and clean energy. An overall objective in this area is to limit climate change and its costs and negative effects on society and the environment.
- Sustainable transport. An overall objective here is to ensure that transport systems meet society's economic, social and environmental needs while minimising their undesirable impacts on the economy, society and the environment.
- Sustainable consumption and production with an overall objective to promote sustainable consumption and production patterns.
- Conservation and management of natural resources. An overall objective in this area is to improve management and avoid overexploitation of natural resources, recognising the value of ecosystem services.
- Public health. An overall objective in this area is to equitably promote good public health and improve protection against health threats.
- Social inclusion, demography and migration. An overall objective here is to create a socially inclusive society by promoting solidarity between and within generations and to secure and increase the quality of life of citizens as a precondition for lasting individual well-being.
- Global poverty and sustainable development challenges. An overall objective here is to actively promote sustainable development worldwide and ensure that the European Union's internal and external policies are consistent with global sustainable development and its international commitments.

The renewed SDS also specifies that SDS implementation is to be monitored and reported every two years. The first such report was produced in 2007 (Eurostat and Commission of the European Communities, 2007). Sustainable development indicators (SDIs) are used to monitor the SDS implementation. A set of 155 such indicators was developed by an SDI Task Force involving national experts and adopted by the Commission in 2005. This set of SDIs was further developed and renewed in 2007. The SDIs cover 10 themes (Commission of the European Communities, 2005a): (1) economic development, (2) poverty and social exclusion, (3) aging society, (4) public health, (5) climate change and energy, (6) production and consumption patterns, (7) management of natural resources, (8) transport, (9) good governance, and (10) global partnership. These major themes are further divided into sub-themes and areas to be addressed.

Box 1: Criteria for Selecting a Sustainable Development Indicator (SDI)

Criteria for a Sustainable Development Indicator:

- An indicator should capture the essence of the problem and have a clear and accepted normative interpretation.
- An indicator should be robust and statistically validated.
- An indicator should be responsive to policy interventions but not subject to manipulation.
- An indicator should be measurable in a sufficiently comparable way across Member States and comparable as far as practicable with the standards applied internationally by the UN and the OECD.
- An indicator should be timely and susceptible to revision.
- The measurement of an indicator should not burden Member States, enterprises, or EU citizens disproportionately compared to the benefits of its regulation.

Criteria for a portfolio of indicators:

- The portfolio of indicators should, as far as possible, be balanced across different dimensions.
- The indicators should be mutually consistent within a theme.
- The portfolio of indicators should be as transparent and accessible as possible to the citizens of the European Union.

Source: Commission of the European Communities (2005a). Communication from Mr. Almunia to the Members of the Commission: Sustainable Development Indicators to monitor the implementation of the EU Sustainable Development Strategy.

The sustainable development indicators are to be further developed and improved. This process is to be supported by a Working Group on SDI within Eurostat.

2.1.2. EU ENVIRONMENTAL ACTION PROGRAMMES

The decision on the current 6th Environmental Action Programme (6EAP) was adopted jointly by the European Council and the European Parliament in 2002, after the 5th Environmental Action Programme "Towards Sustainability" expired in December 2000. EU Environmental Action Programmes constitute a guideline for medium-term policies and are meant to target the environmental dimension of an overarching sustainable development strategy (Commission of the European Communities, 2001).

The 6EAP covers a period of ten years from 2002 to 2012. It addresses the key environmental objectives and priorities, i.e.

- Climate change;
- Nature and biodiversity;
- Environment, health and quality of life; as well as
- Natural resources and waste.

The 6EAP was the first Environmental Action Programme to be adopted under ordinary legislative procedure according to changes in the EC Treaty, which now states "general actions programmes setting priority objectives to be attained shall be adopted by the European Parliament and the Council, acting in accordance with the ordinary legislative procedure" (article 175, paragraph 3 TEC, now article 192 TFEU). Environmental Action Programmes constitute a mixture between political programmes and political strategy. They are themselves not legally binding but can be considered a politically binding guide for subsequent legal acts, whose content they cannot anticipate from general priority objectives.

The 6EAP is meant to promote the integration of environmental concerns into all Community policies and contribute to the achievement of sustainable development throughout the EU. The initiatives in these policy areas are supposed to contain a wide range of measures including legislation and a number of "cross-cutting" strategic approaches. These contain *inter alia* the development of relevant legislation, the improvement of existing legislations' implementation, better integration of environmental concerns into other policies as well as the promotion of sustainable production and consumption patterns. The 6EAP also stimulates a stronger EU role as a leading partner in the protection of the global environment and in the pursuit of sustainable development as well as the integration of environmental concerns and objectives into all aspects of the Community's external relations. The programme provides for environment policy making and monitoring as well as evaluation of results.

The 6EAP aims to set a strategic framework and broad priorities for Community actions, whereas the development of specific quantitative and qualitative targets is postponed to the adoption of the so called "Thematic Strategies". These strategies – focused on air pollution, waste recycling, marine environment, soil protection, sustainable use of pesticides, sustainable use of resources and urban environment – are the main tools to implement the programme. Due to their focus on cross-cutting environmental issues and vertical and horizontal policy integration rather than a sectoral approach, they represent a new approach to policy development. The strategies have been developed through a network of working groups involving a range of Commission Directorates-General, stakeholders and Member State experts (IEEP, 2010). They are supposed to "include an identification of the proposals that are required to achieve the objectives set out in the Programme and the procedures foreseen for their adoption" and be presented to the European Parliament within 3 years of the adoption of the Programme. Although no strategy has met this requirement, seven Thematic Strategies have been adopted to date, i.e.:

- Thematic Strategy on soil protection COM (2006)231;
- Thematic Strategy on the Protections of the Marine Environment COM(2005)504;
- Thematic Strategy on Pesticides COM (2006)372;
- Thematic Strategy on Air Quality (CAFE), COM (2005)446;
- Thematic Strategy on Urban environment COM(2005)718;
- Thematic Strategy on sustainable use of Natural Resources COM(2005)670;
- Prevention and Recycling of Waste, COM (2005)666.

In addition, the 6EAP aims to implement two existing strategies, i.e. the European Climate Change Programme and the EU Biodiversity Research Strategy (BIOSTRAT).

2.1.3. EU THEMATIC STRATEGY ON THE SUSTAINABLE USE OF NATURAL RESOURCES

The Thematic Strategy (TS) on the Sustainable Use of Natural Resources (Resource Strategy) (Commission of the European Communities, 2005b) was launched by the European Commission on 21 December 2005.

The TS is considered by the EU Commission to be the main policy output based on the "natural resources" chapter of the 6EAP. This Strategy does not include quantitative targets for the diminution of resource use and resource efficiency as envisaged by the 6EAP. No concrete legal targets have been formulated at the European level to decouple economic growth from resource use. Even so, the Strategy empowers the Commission to develop a database and criteria to measure and assess resource use. The Strategy furthermore suggests setting up an International Panel on the sustainable use of natural resources in cooperation with the United Nations Environment Programme (UNEP) and possibly other international partners and initiatives, e.g. United Nations Industrial Development Organization (UNIDO) and the International Energy Agency (IEA).

The TS does not commit to reducing resource consumption by a specific amount, except to state that for renewable resources this means staying below the threshold of overexploitation. While the 6EAP called for the strategy to include the development and implementation of a broad range of instruments including research, technology transfer, market-based and economic instruments, programs of best practice and indicators of resource efficiency, the TS clearly fails to meet these objectives. It merely provides a framework for further attempts to meet it in the future.

As a result, there is no clear indication as to how to measure and prevent resource consumption exceeding the capacity of the environment.

2.1.4. LISBON STRATEGY AND EUROPE 2020

EUROPE 2020 replaces the expired Lisbon Strategy on Growth and Jobs in 2010. In comparison to the previous agenda, it includes and treats environmental objectives more explicitly but without outlining concrete policies and measures or "timelines" towards the objectives.

The aforementioned EU SDS was developed to complement the 2000 Lisbon Strategy by highlighting the fundamental global issues of climate change and biodiversity loss and the need to address them by taking the environmental, social and economic dimensions as well as the global context, including equity (the so-called "external dimension" of the EU-SDS) into account.

A review of the current EU-SDS is foreseen in the near future. The adoption of an emission reduction target of 30% by 2020 would have an important impact on the currently adopted "post-Lisbon"-economic growth-strategy. To date, the EU has committed to reduce greenhouse gas emissions of at least 20% below 1990 levels by 2020. The adoption of a higer reduction target depends on the agreement of corresponding commitments from other major emmitters under an international climate agreement (see below 2.2.3).

The Lisbon Strategy was launched in 2000, focusing primarily on social and economic aspects. The European Council agreed that the EU should by 2010 be "*the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion*" (Lisbon European Council, 2000). The Lisbon Strategy was implemented through the "open method of coordination" and the adoption of national action plans as opposed to the ordinary legislative procedure, since most of the policies concerned fell within Member States' competences. After a mid-term review a renewed strategy was initiated in 2005, prioritizing growth and employment (European Commission, 2005a). It introduced new instruments to improve governance concerning the EU and the Member State level. After the initiation of the renewed strategy, ecological objectives found their way into the agenda. For instance, the 2006 Spring European Council endorsed actions regarding environmental sustainable growth (Council of the European Union, 2006a).

In 2010, the Lisbon Strategy will expire and be replaced by the "Europe 2020" strategy, which will have to put particular emphasis on meeting the challenges of the recent economic crisis (European Commission, 2010). The new strategy, proposed by the European Commission on 3 March 2010, aims to enhance the coordination of economic policies and focuses on smart, sustainable and inclusive growth. The Commission's approach is twofold: a thematic approach on the one hand, and a focus on country reporting on the other. In May and July 2010, the European Council endorsed the overall aim and headline targets of the Commission's proposal and adopted it formally (European Council, 2010). The strategy will focus on key areas where action is needed, i.e. knowledge and innovation, a more sustainable economy, high employment and social inclusion. Moreover, there are five headline targets which are supposed to guide both Member States and EU institutions. One of them is an environmental target, i.e. tackling climate change: reaffirming the 20-20-20 targets that were introduced at the 2007 Spring European Council. To meet the targets, there will be flagship initiatives with specific themes, including "Resource efficient Europe" aiming "*to support the shift towards a resource efficient and low-carbon economy that is efficient in the way it uses all resources. The aim is to decouple our economic growth from resource and energy use, reduce CO_2 emissions, enhance* *competitiveness and promote greater energy security*" (European Commission, 2010). Their implementation is a shared responsibility between the EU and Member States. Moreover, integrated guidelines as well as country specific recommendations will be adopted to support Member States.

2.2. EU Specific Policy Objectives

As economies have grown, so has the use of materials and resources. It is one major aim to de-couple economic growth from resource use while another aim is to increase the use of renewable resources.

2.2.1.RESOURCE RELATED POLICIES

There are a couple of EU policies regarding resource policy.

Among these figure:

The Directive on renewable energy

The new Directive on renewable energy (Directive 2009/28/EC) sets ambitious targets for all Member States, such as that the EU will reach a 20% share of energy from renewable sources by 2020 and a 10% share of renewable energy specifically in the transport sector (see European Parliament and Council of the European Union, 2009b). This target is accompanied by a novel policy instrument: all biofuel products counting towards the target must fulfil a set of sustainability criteria, aimed at addressing the environmental and social concerns linked to biomass production.

It also improves the legal framework for promoting renewable electricity, requires national action plans that establish pathways for the development of renewable energy sources (including bioenergy), creates cooperation mechanisms to help achieve the targets cost effectively, and establishes the sustainability criteria for biofuels. The new Directive should be implemented by Member States by December 2010.[2]

The Forestry Strategy

On 15 December 1998 the European Council adopted a Resolution on a Forestry Strategy for the EU. It set overall principles for sustainable forest management and the multifunctional role of forests, as defined in the Ministerial Conferences on the Protection of Forests in Europe of Helsinki (1993) and Lisbon (1998). The strategy is based on the commitments made by the EU and the Member States in international processes related to forests. Its substantial elements are: (a) responsibility for forest policy lies with the Member States, the EU can contribute to the implementation of sustainable forest management through EU policies (subsidiarity, shared responsibility); (b) implementation of international commitments, principles and recommendations through national or sub-national forest programmes developed by the Member States; (c) integration and support of these forest programmes developed by the Member States through specific measures and EU policies such as Common Agricultural Policy and Rural Development, Environment, Research, Energy, Internal Market, Health and Consumer Protection.[3]

2 See http://ec.europa.eu/energy/renewables/index_en.htm, retrieved 3 July 2010.
3 See http://forestportal.efi.int/view.php?id=815&c=EU, retrieved 3 July 2010.

The Forest Action Plan

The EU Forest Action Plan (FAP), adopted in 2006 for the 2007-2011 period was the result of a multi-stakeholder process involving, among other things, consultations from different committees working on forestry. The FAP works as a framework which uses existing elements in forestry policy and builds on other EU policies that are related to forest issues such as Natura 2000, the Rural Development Schemes of the Common Agricultural Policy (CAP) and the Biomass Action Plan (BAP).

The actions outlined in the FAP refer predominantly to activities in the areas of coordination (including the exchange of information and experience), communication and research. The SFC (Standing Forestry Committee, i.e. Board of representatives for Forest policies of all EU Member States (MS) plays a major role in organising and undertaking those tasks. Nonetheless, these groups represent different stakeholders and the implementation of forest policies rely primarily on MS.

The FAP lays out 4 general objectives

- Improving long-term competitiveness;
- Improving and protecting the environment;
- Contributing to the quality of life;
- Fostering coordination and communication.

The objectives are accompanied by 18 key actions concretising how the objectives should be achieved. Key actions include:

- Facilitate EU compliance with the climate change mitigation obligations of the UNFCCC and its Kyoto Protocol and encourage adaptation to the effects of climate change;
- Contribute to achieving the revised Community biodiversity objectives for 2010 and beyond;
- Work towards a European Forest Monitoring System;
- Enhance the protection of EU forests.

2.2.2. EU WATER USE POLICIES

Water is a precondition for life as well as a fundamental resource for economic activities. However, human activities create pressures on water quality and quantity. Water quality is threatened by point source urban and industrial waste water and non-point source agricultural runoff. The overexploitation and unsustainable use of water resources as well as floods are the main threats to water quantity.

The **EU Water Framework Directive** (WFD) (Directive 2000/60/EC) is the most important piece of water legislation in the Community to address water quality and quantity issues. The main aim of the WFD is achieving 'good water status'[4] in all Community waters by 2015. To achieve this far-reaching goal, the Directive established an integrated

[4] Good water status refers to a set of biological, chemical and hydrological elements.

river basin management approach in which Community waters are managed according to natural geographical and hydrological units, as opposed to administrative or political boundaries. River basin management plans (RBMPs) and associated programmes of measures must be developed for each river basin and need to be updated every six years. RBMPs must provide detailed accounts of how 'good water status' will be achieved within the timescale required. Furthermore, they must estimate whether existing legislation, as outlined in more detail below, is sufficient to meet objectives or if additional, supplementary measures are needed. These supplementary measures will address both quality and quantity issues within the context of sectoral water use.

To complement the work under the WFD, a number of other water related policies exist at EU level to address water quality and quantity:

Water quality

The **Drinking Water Directive (DWD)** (Council Directive 98/83/EC) aims to protect the health of consumers and guarantee that water is clean. In particular, it:

- Sets quality standards for drinking water at the tap (microbiological, chemical and organoleptic parameters) and the general obligation that drinking water must be wholesome and clean, and;
- Obliges Member States to regularly monitor drinking water quality and to provide consumers adequate and up-to-date information on their drinking water quality.

Member States may exempt water supplies serving less than 50 persons or providing less than 10 m^3 of drinking water per day as an average as well as water in food-processing activities where the quality of water cannot affect the safety of the foodstuff in its finished form.[5]

The **Bathing Water Directive** (76/160/EEC), which was revised in 2006 (2006/7/EC) aims at "protecting public health and the environment by keeping our coastal and inland bathing waters free from pollution" (see European Parliament and Council of the European Union, 2006a). The Bathing Water Directive in its current form continues its focus on public health and the environment but also incorporates the knowledge, experiences and technologies that have developed since 1976. For instance, it will move from "simple sampling and monitoring of bathing waters to bathing quality management" and it will furthermore be linked to the WFD.[6]

The **Urban Waste Water Directive** (Council Directive 91/271/EEC, see Council of the European Communities, 1991a) aims to protect the environment from uncontrolled discharge of untreated waste water. It regulates the collection, treatment and discharge of different water types (e.g. domestic waste water, mixture of waste water and waste water from certain industrial sectors).

Thematically related to the Urban Waste Water Directive is the **Nitrates Directive** (Council Directive 91/676/EEC, see Council of the European Communities, 1991b), which is highly relevant for the control of water pollution from diffuse agricultural sources. Its objective is to protect the water quality by eliminating nitrates from agricultural sources which pollute ground and surface waters.

[5] See http://ec.europa.eu/environment/water/water-drink/index_en.html, retrieved 6 July 2010.
[6] See http://ec.europa.eu/environment/water/water-bathing/index_en.html, retrieved 6 July 2010.

The **Groundwater Directive** (Directive 2006/118/EC) aims, inter alia, to ensure a balance between abstraction and recharge of groundwater (see European Parliament and Council of the European Union, 2006b).

Water quantity

While water quality is certainly an issue across all Member States, water quantity concerns are also prevalent. In 2007, "at least 11 % of Europe's population and 17 % of its territory had been affected by water scarcity, putting the cost of droughts in Europe over the past thirty years at EUR 100 billion".[7]

The **Communication "Addressing the challenge of water scarcity and droughts"** (COM(2007)414final) lays out "an initial set of policy options at European, national and regional levels to address and mitigate the challenge posed by water scarcity and drought within the Union" (Commission of the European Communities, 2007b) and marks a first step towards regulating water quantity. In this context, seven policy options were identified:

- Putting the right price tag on water;
- Allocating water and water-related funding more efficiently;
- Improving drought risk management;
- Considering additional water supply infrastructures;
- Fostering water efficient technologies and practices;
- Fostering the emergence of a water-saving culture in Europe;
- Improving knowledge and data collection.[8]

However, water quantity is not only about water scarcity but also about floods and flood risk management. Since 1998, particularly between 1998 and 2004, over 100 major damaging floods were recorded in Europe. Consequently, the EU **Floods Directive** (Directive 2007/60/EC) "requires Member States to assess if all water courses and coast lines are at risk from flooding, to map the flood extent and assets and humans at risk in these areas and to take adequate and coordinated measures to reduce this flood risk".[9]

In order to address a gap in EU water legislation, which largely targets freshwater, the **Marine Strategy Framework Directive** (Directive 2008/56/EC) was established to focus efforts on marine waters and aims to protect the marine environment. Closely linked to marine waters and corresponding to the river basin management approach, the EU aims towards **Integrated Coastal Zone Management (ICZM)**. So far this approach is not regulated by legislation but is nevertheless promoted by the EU.[10]

[7] See http://ec.europa.eu/environment/water/quantity/scarcity_en.htm, retrieved 1 July 2010.
[8] See http://ec.europa.eu/environment/water/quantity/eu_action.htm#2007_com, retrieved 1 July 2010.
[9] See http://ec.europa.eu/environment/water/flood_risk/index.htm, retrieved 1 July 2010.
[10] See http://ec.europa.eu/environment/iczm/home.htm, retrieved 6 July 2010.

2.2.3. EU CLIMATE CHANGE POLICIES

In the context of the OPEN:EU project Carbon Footprint measures the total emissions of GHGs caused by the consumption of goods and services including emissions associated with imported goods and services, and excluding emissions related to exported ones.

It is broadly used as an argument in the debates on climate change and on policies to combat it that the level of EU GHG emissions is unsustainably high. Therefore, the RACER and SWOT analyses for the Carbon Footprint indicator will be conducted looking first at the EU climate objectives. At the same time, GHG emissions should be considered not only as a result of industrial and agricultural production but their link to the use of natural resources in general should be recognised. Therefore, the EU objectives expressed in the Thematic Strategy (TS) on the Sustainable Use of Natural Resources (Resource Strategy) will be addressed. The EU Sustainable Development Strategy (SDS) suggests the general trajectory towards a sustainable Europe which covers economic, environmental and social issues.

The EU climate objectives

The climate change issue is on the EU political agenda since 1991 when the Community Strategy to Limit Carbon Dioxide Emissions (Commission of the European Communities 1991) was issued.

The specific measures to combat climate change were agreed upon in the **Kyoto Protocol** during the 3rd UNFCCC Conference of Parties (1997), and approved by EU Council Decision 2002/358/EC of 25 April 2002. The Kyoto Protocol legally fixed the obligation of a range of industrialised countries and countries with economies in transition to reduce their GHG emissions. The objective for (at that time) EU-10 countries was to reduce GHG emissions by 8% from the 1990 level over 2008-2012.

After ratifying the Kyoto Protocol, the EU made a number of steps towards meeting its climate change objectives. In June 2000 the **European Climate Change Programme (ECCP)** was launched. The objective of the programme was to support the achievement of the Kyoto objectives. The first ECCP included ten meetings which took place in 2000/2001. It was devoted to the development of flexible mechanisms with a particular focus on the **Emissions Trading System (ETS)** which is seen as a cost-effective tool for reducing the GHG emissions in the EU. The ETS was introduced into practice in January 2005 on the basis of the Directive 2003/87/EC (European Parliament and Council of the European Union, 2003). The EU ETS covers 27 EU members, as well as Iceland, Norway and Liechtenstein. It provides a platform for carbon trading on a market level and accounts for over 11.000 installations in power generation and manufacturing (European Commission, 2009). From 2012 onward the scheme will include emissions caused by air transport.

In 2007, EU climate policy was revisited. The 2007 Spring European Council agreed on what are known as the **20-20-20 targets**, aiming to reduce the EU´s GHG emissions by 20% by 2020 compared to 1990 levels, to increase the share of renewable energy sources in the EU energy consumption to 20% in 2020 and to save 20% of primary energy compared with projected levels. The Commission adopted corresponding proposals in January 2008. A package of measures was adopted, including a revised EU ETS Directive, a so-called Effort Sharing Decision on emissions from sectors not covered by the EU ETS, a new directive of renewable energy, a directive on the geological storage of CO_2 and a regulation on CO_2 emission performance standards for cars. The revised EU ETS

Directive provides for a single EU-wide cap instead of national caps. Moreover, the auctioning of allowances will progressively replace their free allocation.

Moreover, in the context of the international climate negotiations the EU made the conditional offer "to move to a 30% reduction by 2020 compared to 1990 levels, [...] provided that other industrialised countries commit themselves to comparable emission reductions and that developing countries contribute adequately according to their responsibilities and respective capabilities" (Council of the European Union, 2009).

In February 2010, the Commission created a new Directorate General (DG) Climate Action. Subject to the recent Treaty of Lisbon, combating climate change is explicitly stated as an objective of EU policies on the environment.

2.2.4. EU ADAPTATION POLICIES

In 2007, the European Commission **Green Paper on adaptation** (Commission of the European Communities, 2007a) stressed that early action to prevent reactive and unplanned adaptation in response to more frequent crises and natural disasters is most important. With late or no action, damages and associated economic costs could rise sharply until 2080. The Green Paper also calls for an integration of climate change adaptation into existing policies.

The European Commission's **White Paper "Adapting to climate change: Towards a European framework for action"** of April 2009 recognises that adaptation is already happening, but in a piecemeal manner, and identifies the need for a more strategic approach that will enable coherency and ensure timely and effective adaptation measures are taken.

The EU climate adaptation objectives

The EU Commission launched an Adaptation Framework (2009 – 2012) that shall lay the ground work for a comprehensive EU adaptation strategy. The European Commission plays a central role in encouraging Member States to take adaptive tactical and strategic adaptation measures. This can be achieved through Community sectoral policies (such as CAP, Common Fisheries Policy (CFP), EU Energy and Transport policies, WFD) or the EU spending programmes for research, cohesion, solidarity measures and rural development.

2.3. International general policy objectives

On the international level, there is no legislative body comparable to EU institutions to agree on general policy objectives. International law – whether hard or soft – is developed by states concluding international agreements or producing customary principles. A number of relevant multilateral environmental agreements can be identified, in which states agreed on policy objectives regarding sustainable development and resource use or - more specifically - on water use and reduction of GHG emissions as well as on instruments for varying regimes of enforcement and compliance (e.g. "Bio-safety protocol" Cartagena Protocol on Biosafety, Kyoto Protocol, etc.).

UNEP – which was founded 1972 as a result of the 1972 UN Stockholm Conference on the Human Environment (hereinafter Stockholm-Conference) – constitutes an institutional framework regarding the coordination of environmental activities in the UN-system. Environmental analysis is a major field of action for UNEP, which also proposes policy action. Depicting the global state of the environment is a major area of UNEP's attention as seen by the "Geographical Environmental Outlook-series" ("GEO-1-4" and regional ones). UNEP supports the development of international environmental law and of "international environmental governance". The relationship and the reconciliation between the global trade regime (WTO) and Multilateral Environmental Agreements is another important area of focus.

The early launch (i.e. nearly two decades ago) of the UNEP-Finance Initiative ("Innovative Financing for Sustainability") and the "Global Reporting Initiative" are other examples of successful initiatives related to the global sustainability agenda.

Important milestones in the development of international environmental law include:

- **1972 Stockholm Declaration on the Human Environment** (adopted at the Stockholm Conference): This declaration – aims to "inspire and guide the peoples of the world in the preservation and enhancement of the human environment" - constitutes a catalogue of 26 non-binding principles, of which principle 21 became especially prominent. It does recognize both state sovereignty and development concerns, but claims that transboundary environmental harm must be controlled.

- **1987 Report of the World Commission on Environment and Development** (Brundtland Report): This report called for a new approach on a sustainable use of resources and recommended that the UN transform its conclusions into a Programme of Action on Sustainable Development.

- **1992 Rio Declaration on Environment and Development** (adopted on the 1992 United Nations Conference on Environment and Development – hereinafter UNCED - in Rio de Janeiro): The Rio Declaration is an action plan including 27 non-binding principles on sustainable development. Its objective is the "goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people." It seeks to work "towards international agreements which respect the interests of all and protect the integrity of the global environmental and developmental system". The principles generally support the connection of development and environment.

- **1992 Agenda 21:** this programme of action, also adopted on the UNCED, covers a great variety of issues related to sustainable development. It is a comprehensive agenda, including 40 chapters, divided in four main sections. The agenda aims to include international, national, regional as well as local levels.

- **1992 Convention on Biological Diversity:** this convention has also been adopted by the UNCED.

- **2000 UN Millennium Development Goals:** are comprised of eight international development goals that all Member States and also a number of international organizations have agreed to achieve by the year 2015. Goal 7 aims to ensure environmental sustainability.

- **2002 Declaration on Sustainable Development** (adopted on the 2002 World Summit on Sustainable Development WSSD in Johannesburg 2002): this declaration reaffirms and refines existing policies and principles, but did not launch new ones.

These milestones also include major environmental impact assessments and analyses that revealed, among other things, the global economic benefits of ambitious environmental policy (such as the so-called Stern-report "Stern Review on the Economics of Climate Change" released in 2006 and the global study "The economics of Ecosystems and Biodiversity" launched in 2007 by Germany and the European Commission). In 2010, the UNEP Resource Panel published an analysis entitled "Assessing the environmental impacts of consumption and production: priority products and materials", which includes an examination of how different economic activities currently influence the use of natural resources and the generation of pollution.

2.4. International specific policy objectives

2.4.1. INTERNATIONAL RESOURCE POLICIES

The Resource Panel (RP), Marrakech Process (MP) and the Green Economy Initiative (GEI) are complementary UNEP initiatives within the Resource Efficiency priority area (one of six priorities) in UNEP. Within this work area, the RP's primary role is to conduct scientific assessment. The GEI and MP on the other hand, have stronger roles in developing and implementing policies and tools (International Panel for Sustainable Resource Management, 2009).

International Panel for Sustainable Resource Management

The International Panel for Sustainable Resource Management (also known as Resource Panel) is an initiative at the international level dealing with resource policy, specifically aimed at making resource policy coherent. The Panel was officially launched in November 2007 by UNEP. It is expected to provide the scientific impetus for decoupling economic growth and resource use from environmental degradation. The overall objective of the Resource Panel is therefore to provide independent scientific assessment of the environmental impacts due to the use of resources over the full life cycle, and advise governments and organisations on ways to reduce these impacts.[11]

The Resource Panel closely observes tendencies of exploitation of renewable and non-renewable resources. It is also serves to foster international information exchange concerning resource management. In particular, the Resource Panel's strength is its holistic view of resources over the life cycle to identify possible burden shifting between resource consumption and environmental impact categories (climate change, biodiversity, resource scarcity, toxicity etc) (International Panel for Sustainable Resource Management, 2009).

Marrakech Process

The Marrakech Process (launched in 2003) is a global multi-stakeholder process to accelerate the shift towards sustainable consumption and production patterns and to support the elaboration of a 10-Year Framework of Programmes on Sustainable Consumption and Production (SCP) (10YFP). The proposal of the 10YFP will be reviewed by the Commission on Sustainable Development (CSD) during the 2010/11 two-year cycle. The Process re-

[11] See http://www.unep.fr/scp/rpanel/, retrieved 3 August 2010.

sponds to the call of the WSSD Johannesburg Plan of Implementation in support of the regional and national initiatives to accelerate the shift towards SCP patterns, thus decoupling economic growth from environmental degradation (International Panel for Sustainable Resource Management, 2009).

Specific objectives of this process are

- To assist countries in their efforts to green their economies;
- To help corporations develop greener business models;
- To encourage consumers to adopt more sustainable lifestyles.

Green Economy Initiative (GEI)

The GEI includes research, advisory services, and partnerships with UN agencies, civil society groups, researchers, and businesses at global, regional, and country levels. GEI seeks to demonstrate and convince businesses that investing in green sectors such as renewable energy, and improving resource and energy efficiency can make a significant contribution to economic growth, job creation, and poverty reduction while improving the environment. They also seek to identify and assess reforms in public policies and institutions that are required to scale up these green investments. The aim is to encourage and enable governments to increase investments in green sectors, by illustrating their commercial and economic potential (International Panel for Sustainable Resource Management, 2009).

Further initiatives

The OECD is preparing the way for further decision making on a proposal for "Green Growth", in the ministerial meeting of May 2011.

The forthcoming UN2012-Rio conference on sustainable development (www.UNCSD.org) will constitute an important milestone in sustainable development policy and will require UN Member States to formulate their visions, contributions and expectations, building on further developments in the UNFCCC-process and on same in CBD (COP Nagoya Japan, Autumn 2010).

In June 2010, after years of negotiation, governments agreed to establish an "Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services" as a science-policy platform, modelled on the Intergovernmental Panel on Climate Change. The platform should, among other things, "identify and prioritize key scientific information needed for policymakers at appropriate scales and catalyse efforts to generate new knowledge by engaging in dialogue with key scientific organizations, policymakers and funding organizations". It is expected to be formally endorsed in 2011 and established as an independent intergovernmental body administered by one or more existing United Nations organizations, agencies, funds or programmes.

2.4.2. INTERNATIONAL WATER USE POLICIES

There are a number of international conventions regulating water quantity and quality regarding regional seas or watercourses as well as the marine environment: These include on the regional level:

- **1992 OSPAR Convention** regulating the international cooperation on environmental protection in the North-East Atlantic;
- **1992 Helsinki Convention** on the Protection of the Marine Environment in the Baltic Sea Area;
- **1995 Barcelona Convention** on the Protection of Marine Environment and the Coastal Region of the Mediterranean;
- **1992 Bucharest Convention** for the Protection of the Black Sea;
- **1980 Convention on Conservation of Antarctic Marine Living Resources** (CCAMLR).

On a global level, the most important international agreements are:

- **1992 UN/ECE Water Convention** on the Protection and Use of Transboundary Watercourses and International Lakes;
- **1972 London-Dumping Convention**: Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972;
- **1973/1978 MARPOL** International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978;
- **1982 United Nations Convention on the Law of the Sea (UNCLOS).**

2.4.3. INTERNATIONAL CLIMATE CHANGE POLICIES

The negotiations between states on international climate change policies generally turn out to be rather difficult due to the variety and complexity of issues involved as well as the economic implications of climate change.

Important international policies are:

- **1992 United Nations Framework Convention on Climate Change (UNFCCC)** which was adopted in the UNCED: It does not formulate specific GHG emission reduction targets, but constitutes a framework convention establishing a process for reaching further agreement on policies and measures to tackle climate change. To date, 192 states are parties to the convention. They agreed on a "stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (article 2 UNFCCC). One guiding principles is that "parties have a right to, and should, promote sustainable development" (article 3 UNFCCC).
- **1997 Kyoto Protocol:** This protocol was adopted on the basis of the UNFCCC and established quantitative restrictions on emissions from 37 industrialized

economies, the so called Annex I-countries of the UNFCCC. These countries shall "individually or jointly, ensure that their aggregate anthropogenic CO_2 equivalent emissions of the GHGs listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012" (article 3 Kyoto Protocol). Moreover, all Annex I-countries must show demonstrable progress in meeting their Kyoto Protocol commitments by 2005. The protocol also introduced three "flexibility mechanisms" to reach the reduction targets, the Clean Development Mechanism, Joint Implementation and Emission trading. The international negotiations for a follow-up instrument regarding the post-2012 period have not been successful so far.

- **2009 G8 Declaration of the leaders the mayor economies forum in energy and climate**: Climate change has been on the agenda of G8 summits for quite a time. On the summit in 2009 L'Aquila, Italy, leaders reaffirmed that climate change is currently one of the greatest challenges. For the first time, mayor economies as the US and Russia acknowledged the two-degree-limit ("We recognize the scientific view that the increase in global average temperature above pre-industrial levels ought not to exceed 2 degrees C") and promised to improve the common work on the identification of "a global goal for substantially reducing global emissions by 2050".

3. Methodology for evaluating Footprint Indicators

Against this policy background, we will analyse the different Footprint indicators. Before doing so, we will present the methodology for these analyses, namely the RACER and the SWOT analyses.

3.1. RACER analysis

The RACER (**r**elevance, **a**cceptance, **c**redibility, **e**asiness and **r**obustness) criteria for evaluating the sustainability of indicators were set by the European Commission in the Impact Assessment Guidelines (SEC(2005)791) (see European Commission, 2005b). The RACER Analysis aims at assessing the value of an indicator for political decision making. The initial RACER criteria were further specified in the framework of the project "Potential of the Ecological Footprint for monitoring environmental impacts from natural resource use" (see Best et al., 2008) by adding specific sub-criteria to each of them. The description of the RACER criteria and sub criteria in the context of the OPEN:EU project can be found in the following table:

Criteria and sub-criteria of RACER Analysis	
Relevance	The indicator should be closely linked to the objectives to be reached.
• Policy support, identification of targets or gaps	Is the indicator/methodology related to existing EU-specific policy objectives? Does it provide guidance in monitoring, strategic policy making and/or target setting? Does it quantify gaps between the current situation and specified targets? Does it provide adequate early warning to guide policy action? Does it react to short-term changes that can (among other things) show whether policies are having an effect?
• Identification of trends	Can the methodology/indicator be used to track changes through time? • This implies that at least one input variable will require time series data (e.g. a series of annual measurements).
• Forecasting and modelling	Can the methodology/indicator be used in a predictive sense to forecast future environmental impacts from natural resource use or for more sophisticated modelling where the impact of different potential policies or of technology progress and/or change of consumption patterns can be simulated? Can the indicator function as an early warning indicator?
• Scope/levels of application	Does the indicator provide information relevant to the effective levels of application? Disaggregations – either spatial, by product, by industry or by ecosystem type – may be required for effective policy. For example, if policy decisions are made at the local level, does the indicator provide the required local information? Or, if decisions are specific to a certain industry, is industry-level data provided by the methodology/indicator?
• Function-and needs-related analysis	The indicator should allow for comparisons among material and energy resources in terms of their functions and competition in the real world (e.g. in a case where one energy carrier, foodstuff or construction material is substituted by another). Similarly, the methodology should allow the comparison of different ways of fulfilling basic hu-

	man needs (housing, mobility, food, etc.) with regard to their resource-use implications.
Acceptability	The indicator should be accepted by the stakeholders.
• Stakeholder acceptance	The underlying rationale and meaning of a methodology/indicator should be easily understood and accepted by stakeholder groups. This will be facilitated by conceptual simplicity and simplicity of calculation. For effectiveness in public communication the methodology/indicator must resonate with widely held values and concerns to motivate stakeholders to calculate or provide data and accept interpretations of the meaning of the methodology/indicator.
Credibility	The indicator should be unambiguous and easy to interpret, be credible for non-experts.
• Unambiguousness	The indicator should be suited to convey a clear, unambiguous message. This relates to the interpretation by political decision makers (i.e. does it allow for clear conclusions to guide political action?) as well as to its interpretation by the general public (does it indeed provide the information that non-experts believe it to?).
• Transparency of the method	The underlying data and calculation methods should be fully disclosed, interpretable and reproducible.
Easiness	The indicator should be easy to monitor.
• Data availability	The methodology/indicator does not require inputs of data that are overly excessive, expensive or onerous to collect, or that cannot be properly measured. Ideally the methodology/indicator should be based on data that are already collected and readily available in electronic form.
• Technical feasibility	The methodology is simple enough to be carried out using software and expertise appropriate to the scale of application and the typical capabilities of the institution doing the calculations. The input and the calculation methodology are clearly defined to avoid ambiguity and consequent error in implementation.
• Complementarity and integration	Are there potential complements between the methodology/indicator and the others being assessed? Is there the potential for further integration of the methodology/indicator with the others? This can refer to the data collection, storage, analysis and reporting, but also the way indicators work together to guide policy makers and the public in formulating and fulfilling policy objectives.
Robustness	The indicator should be robust against manipulation.
• Defensible theory	The methodology/indicator is based on sound theory; avoids double counting or omissions of resources used; is consistent in its units of measure; relies on assumptions that are clearly stated and reasonable and does not require the use of ill-defined or poorly quantified parameters. The methodology should normally avoid the use of subjective factors to weight different components. In cases where subjective weighting is used, it must at least be justified and made explicit.
• Sensitivity	The value of the indicator outputs change rapidly enough with respect to input parameters to pick up policy-significant changes and

	can detect non-linearities, discontinuities and thresholds.
• Data quality	The value of the indicator outputs change rapidly enough with respect to input parameters to pick up policy-significant changes and can detect non-linearities, discontinuities and thresholds.
• Reliability	The methodology/indicator is reliable in terms of its accuracy, repeatability, and the clear specification of protocol and formulas used in the calculations. This aspect includes that all details of calculation are openly exchanged among researchers in order to avoid different standards (i.e. there may be disputes about the right methodology but methodological differences must be accounted for).
• Completeness	Is the indicator/methodology complete in terms of the safeguard object it is assessing (e.g. natural environment, human health, future resource availability)? Is a shifting of burdens avoided among single problems/impact types (e.g. from climate change to nuclear risks), among the safeguard subjects (e.g. from human health to the natural environment) and among regions (e.g. relocation of production may shift environmental burden away from the place of consumption)?

3.2. SWOT analysis

The SWOT (**s**trengths, **w**eaknesses, **o**pportunities and **t**hreats) analysis in the context of the OPEN:EU project analyses the suitability of Footprint indicators in shaping the EU policy goals.

The interpretation of the SWOT criteria which will be used for the analysis of Footprint indicators within the OPEN:EU project is given in the following table:

SWOT Analysis	
Strengths	Positive aspects identified through RACER analysis.
Weaknesses	Negative characteristics of an indicator identified through its RACER analysis.
Opportunities	Aspects of the institutional, political, intellectual and technological environments that could help to improve the indicator.
Threats	Aspects of the institutional, political, intellectual and technological environments that could hinder successful adoption of the indicator.

For a more comprehensive representation of RACER and SWOT analyses see Best et al. (2008).

The Footprint indicators belong to the group of sustainable development indicators. Sustainable development itself is a broad concept which aims at covering a number of environmental, social, economic and institutional issues. It is important to consider whether the Footprint indicators will be analysed only from the perspective of addressing environmental impacts (climate change, resource consumption etc.), or also by addressing impacts in other fields, for example, health.

3.3. Differences between RACER and SWOT analyses

The RACER analysis is developed on the basis of the RACER criteria set in the Impact Assessment Guidelines 2005, and aims at assessing the quality of the Footprint indicators.

The discussion on strengths and weaknesses of Footprint indicators within the SWOT analysis summarises the outcomes of the RACER analysis. At the same time, the SWOT analysis is much more than a summary of the RACER outcomes. SWOT focuses not only on the quality of an indicator, but also on the opportunities for its use in policy and decision making and the threats (or obstacles) to an indicator's adoption. Furthermore, the threats summarise the methodological weaknesses, as well as external factors (i.e. factors outside the scope of the respective Footprint indicator, e.g. resources that are not included in the calculation).

The quality of an indicator does not necessarily lead to the use of an indicator. The SWOT methodology explicitly analyses the reasons why a particular indicator is used or not used. The 'opportunities' and 'threats' within the SWOT analysis will look at the Footprint indicators in the context of the EU institutional and political environment. As an outcome, recommendations will be given as to 1) how to use the advantages of the Footprint indicators, and 2) how to overcome the threats the indicators are facing.

4. RACER Analysis of the Footprint Indicators

Since the Footprint indicators will be used within the EUREAPA model in this project, we will assess the different Footprints with regard to the EUREAPA models.

4.1. Ecological Footprint (EF)[12]

The Ecological Footprint (EF) was already introduced in the early 1990s by Mathis Wackernagel and William Rees and was therefore the first of the three Footprint Indicators. It measures resource use and CO_2 emissions and is measured in global hectares. Both, direct and indirect human demands for resource production and waste assimilation are measured in a certain entity and then compared to the biocapacity of that entity in a given year (see Kitzes et al. 2009). Since the human demand on the Earth's biocapacity is measured and compared to the planet's ecological capacity to regenerate, the indicator is particularly suitable to measure overshoot. Furthermore, the EF can be analysed at different scales ranging from single products, to countries and the whole planet. However, national EF accounts are often regarded as the most complete (see Kitzes et al. 2009).

The RACER analysis of the EF has been conducted according to the methodology described in chapter 3.1 of this report. The summary of the analysis is provided in Table 1**Table 2** at the end of this section. Along with assessing the indicator according to the RACER criteria and sub-criteria, the summary provides background information on the indicator, its brief institutional and policy analysis and links to sustainable development and other indicators.

4.1.1. RELEVANT

Policy support, identification of targets and gaps

Is the indicator/methodology related to existing EU-specific policy objectives?

This study is intended to evaluate the Footprint Family for their sustainability within the current policy processes. The EF is an accounting tool that compares resources and CO_2 emissions. More specifically, the EF accounts for human demand on global biological resources and compares the level of consumption with available bioproductive land.

The EU policies relevant for the EF cover a variety of issues ranging from the SDS (e.g. sustainable transport; sustainable consumption and production; conservation management and natural resources; public health; social inclusion, demography and migration as well as global poverty), over the 6th Environmental Action Programme (6EAP) (e.g. nature and biodiversity; environment, health and quality of life; and natural resources and waste) to several Thematic Strategies (e.g. on soil protection; marine environment; pesticides; etc.) and the Europe 2020 Strategy (focusing primarily on smart, sustainable and inclusive growth).

The EF calculation basically translates one quantitative dimension of resource use (mass) into another quantitative dimension (land area). Consequently, policy goals that could be informed by the EF are:

[12] The RACER analysis of the EF is based on Best et al. 2008. For more information on the three indicators please refer to Galli et al. (2010).

- Ensuring that human production and consumption activities are kept within the ecological boundaries of the planet. [13]

- Achieving a de-coupling between economic growth and resource use / use of bio-capacity

- Reducing environmental impacts from resource use (except for monitoring abiotic resources and most emission sinks).

However, trade flows between the EU and other parts of the world do not necessarily need to be reduced. Using the EF accounting as a tool allows assessing resource-related implications of different trade options. This again allows for assessing both quantity and quality of trade flows with respect to their ecological sustainability.

In sum, it is unlikely that the EF as an indicator will become policy relevant for specific sectoral policies. The EF is strong when it comes to aggregating resource types rather than single-resource issues (see Best et al. 2008: 46).

Does the indicator provide guidance in monitoring, strategic policy making and/or target setting? Does it quantify gaps between the current situation and specified targets?

The EF measures human demand on ecosystems. Consequently, it could help formulating strategic goals on anthropogenic use of resources, while accounting for the biosphere's regenerative capacity. If the policy goal were, for example, to reduce the EF by a certain percentage, then the EF would allow for a quantification of the gap between the current situation and this target.

Does the indicator provide adequate early warning to guide policy action? Does it react to short-term changes that can, among other things, show whether policies are having an effect?

Within the OPEN:EU project, the calculation of the EF will be based on a complex multi-regional input-output (MRIO) model which will not be updated annually.[14] Due to being a highly aggregated indicator by nature, the EF does not allow one to trace back observed changes to specific policies. It furthermore does not contain variables that are directly policy driven.[15] Consequently, the EF is not suitable to provide adequate early warning to guide policy action and does not react to short-term changes. This is particularly true because the OPEN:EU project uses the MRIO model, which relies on updates to the economic data held within the model to update the calculation of the EF.

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[13] However, the world average EF amounted to 2.7 gha in 2007, equaling 1.5 Planet Equivalents (WWF, GFN and ZSL, 2010, p. 34).

[14] For more information on the MRIO model, please see Hawkins et al. 2010; Hertwich and Peters 2010; Galli et al. 2010.

[15] This is also true for most other indicators and indicator systems, other than "response" type indicators (e.g. "designated areas" as a biodiversity indicator).

Identification of trends

Can the methodology/indicator be used to track changes over time? This implies that at least one input variable will require time series data (e.g. a series of annual measurements).

There will be no historic time series data for the EF so it will not be possible to identify historical trends. The data that will be used for the OPEN:EU project has been produced for 2004. In principle, it is possible to track changes if future updates are made to the tool. However, this is not incorporated in the current tool.

Forecasting and modelling

Can the methodology/indicator be used in a predictive sense to forecast future environmental impacts from natural resource use or for more sophisticated modelling where the impact of different potential policies or of technology progress and/or change of consumption patterns can be simulated? Can the indicator function as an early warning indicator?

The EUREAPA tool (which calculates the EF) is an accounting tool, not a forecasting tool. It measures the current resource use and uses ex-post data. Principally, the EF can and has been used to do "what if" modelling (e.g. what would the global EF in 2050 be as based on UN projections about population growth, food and fibre consumption, agricultural productivity, etc.?).

The EUREAPA tool developed within OPEN:EU will use data on what goods and services citizens from each of the 27 EU countries are buying (the current consumption profile) combined with data on where these goods and services are made and how efficient production techniques are to calculate the direct and indirect environmental impact of goods and services consumed in the EU. By relating these two to each other, the EF could serve as a 'warning light' with regard to the long term over-use of natural resources. However, this 'warning light' stays on an abstract level due to the level of aggregation of the EF.

Scope/levels of application

Does the indicator provide information relevant to the effective levels of application? Does it allow for disaggregation – either spatial, by product, by industry or by ecosystem type?

Different methodologies exist to calculate the EF. Generally speaking, the EF is able to provide information relevant to the effective levels of application and allows for disaggregation. The impact will be reported for each EU Member State individually and for the EU as a whole. For the sub-national level, pilot studies have been calculated, in particular for the UK. In general it is difficult to calculate the Ecological Footprint below the national level (e.g. region, city, local authority) because the consumption data is difficult to obtain at this level of disaggregation.

Function and needs-related analysis

Does the indicator allow for comparisons between material and energy resources in terms of their functions and competition in the real world (e.g. in cases where one energy carrier, foodstuff or construction material is substituted by another)? Similarly, does the *methodology allow the comparison of different ways of fulfilling basic human needs (housing, mobility, food, etc.) with regard to their resource-use implications?*

The EF reflects changes in the ways human needs are fulfilled (e.g. high versus low-meat diets; different types of housing developments or transportation systems; fossil fuels versus biofuels). While other methodologies (e.g. the National Footprint Accounts) are not suitable to compare different options, the EUREAPA tool which is being developed within the OPEN:EU project is particularly designed for this purpose: comparing different options. Therefore, the EF as it will be used within OPEN:EU has a core strength in comparing the different effects of different policy options.

4.1.2. ACCEPTED

Stakeholder acceptance

Are the underlying rationale and meaning of the methodology/indicator easily understood and accepted by stakeholder groups? Does the methodology/indicator resonate with widely held values and concerns to motivate stakeholders to calculate or provide data and accept interpretations of the meaning of the methodology/indicator?

The EF is a popular tool which shows its appropriateness when addressing a broad audience.[16] This is probably due to its ability to easily communicate complex issues – a core strength of the EF. However, some stakeholder groups (e.g. representatives from statistical offices) criticise the EF for relying too much on conversion factors and imputations of missing data. A related problem is the fact that some of the conversion factors and missing data are not sufficiently transparent to be independently reviewed. This criticism was for instance raised in a Eurostat paper (Schaefer et al., 2006, p. 8).

Furthermore, the EF is not entirely comprehensive. For instance, it only measures the impacts of human resource use on the biocapacity of ecosystems, thus focusing on biotic resources, and addressing only indirectly abiotic resources. Furthermore, it does not cover all pollution categories and their impacts on the environment, in fact, the current method only includes CO_2 emissions. This is one of the reasons why stakeholders argue to use several indicators that complement one another.

Since the EF will be included in the EUREAPA tool which will present the outcomes of different policy options, we assume that this tool will be particularly helpful for strategic policy makers. How this stakeholder group will accept this tool remains to be seen.

4.1.3. CREDIBLE

Unambiguous

Is the indicator suitable to convey a clear, unambiguous message? Does it allow for clear conclusions to guide political action? Does it actually provide the information that non-experts believe it does?

As mentioned earlier, the EF is easily understood by the public. However, its limitations (e.g. no indication of ecosystem disturbance, not tracking the depletion of non-renewable resource stocks, see Ewing et al., 2009, p. 88) are less easily understood. Consequently, there may be confusion about what the EF actually measures.

[16] Moreover, there are several formal endorsements of the EF, for instance, the Convention on Biological Diversity (CBD) has adopted it as an indicator to measure progress towards the 2010 goals.

The EF is an indicator that needs to be interpreted and validated. This means that the EF needs to be contextualised so that policy decisions can be derived from the trends the indicator is showing. In any case, these interpretations are preceded by normative decisions.

Transparency of the method

Are the underlying data and calculation methods fully disclosed, interpretable and reproducible?

Generally speaking, the basic principles of EF calculation are publicly available. Moreover, they are standardised for some methodological approaches (e.g. national EF accounts). An earlier but no longer relevant critique is that not all the underlying assumptions and not all steps of the calculation process are documented to a satisfactory extent (Schaefer et al., 2006, p. 9). This was particularly true for the equivalence factors, as noted by Kitzes et al. (2009). However, since 2008 the Global Footprint Network (GFN) has worked on improving the transparency of the method. For instance, there is a Guidebook (see Kitzes et al. 2008) which explains the calculation method, use of data and methodological assumptions.[17]

Within the OPEN:EU project, the EF will be used as an environmental extension in the MRIO model. All data are collated in the model, which automatically calculates the EF based on current spending profiles and production efficiency. The methodology for calculation is clearly documented (see Hertwich and Peters, 2010) which provides transparency. However, the input data will not be accessible to users for interpretation.

4.1.4. EASY

Data availability

Does the methodology/indicator work without inputs of data that are overly excessive, expensive or onerous to collect, or that cannot be properly measured? Ideally, is it based on data that are already collected and readily available in electronic form?

Generally speaking, the calculation of the EF requires a large amount of data from different sources. However, since the EF will be incorporated in the EUREAPA tool within the OPEN:EU project, the user does not need to collect any data. The tool is fed with data and allows the user to compare the effect of different policies. For instance, if a policy will presumably lead to a change in the consumption pattern, the user will be able to change the consumption profile in the tool and, therefore, will see what effect this policy could have compared to other policies.

[17] The enhanced transparency of the method furthermore favors third party reviews of the National Footprint Accounts. Since 2006, reviews have been undertaken in, among other countries, France, Germany, Spain, Switzerland and the UK (see http://www.footprintnetwork.org/en/index.php/GFN/page/national_reviews/, retrieved 1 October 2010).

Technical feasibility

Is the methodology simple enough to be carried out using software and expertise appropriate to the scale of application and the typical capabilities of the institution doing the calculations?

Since the EUREAPA tool undertakes the calculation for the user, technical feasibility is ensured by this tool. The user does not need any technical expertise but can simply use the online tool.

Are the input and calculation methodology clearly defined to avoid ambiguity and consequent errors in implementation?

Since the EUREAPA tool undertakes the calculation for the user, the user is not undertaking the implementation by him- or herself. Consequently, no errors can occur in this regard.

Complementarity and integration

Are there potential complements between the methodology/indicator and the others being assessed?

The EF is not an overarching tool to measure sustainable development. What it does not cover is, for example, the use and/or contamination of fresh water (see Ewing et al., 2009, p. 88). Furthermore, the only GHG included in the EF is CO_2. In contrast, the Water Footprint (WF) measures the use of water while the Carbon Footprint (CF) measures the GHG emissions caused by an organization, event or product. Consequently, the individual indicators which make up the Footprint Family (EF, WF and CF) complement each other very well and together these indicators reflect an overarching picture. Although not all aspects are included when these three indicators are used (e.g. no indication of ecosystem disturbance, no tracking of the depletion of non-renewable resource stocks, see Ewing et al., 2009, p. 88), they still provide information on sustainable development to a satisfactory extent.

Is there a potential for further integrating the methodology/indicator with the others?

Since the three indicators of the Footprint Family complement each other well, there is great potential for integrating them. This is one of the main goals of the OPEN:EU project. As mentioned earlier, the EUREAPA tool which will be developed within the project will integrate information stemming from all three indicators, thus integrating them to an overarching tool that allows comparing the different effects of different policy options.

4.1.5. ROBUST

Defensible theory

Is the methodology/indicator based on sound theory? Does it avoid double counting or omissions of resources used? Is it consistent in its units of measure? Does it rely on assumptions that are clearly stated and reasonable? Does it avoid the use of ill-defined or poorly quantified parameters? In cases where subjective weighting cannot be avoided, is this justified and made explicit?

The EF is often used and furthermore supported by a number of scientists – not least by GFN founded in 2003. However, it is also criticised for relying too much on conversion factors and imputations of missing data. The EF is at present mostly calculated using process-based life cycle assessment (LCA) data and physical quantities of traded goods. Among the three Footprint indicators, the EF is the one with the longest history, having been established in the early 1990s. Since then, scholars have criticised it and others have improved the methodology. Consequently, there is a sound theory on which the indicator can build. Within the OPEN:EU project, the calculation methodology for the EF is clearly defined and robust, even though the methodology still has some shortcomings (see also Hawkins et al. 2010; Hertwich and Peters 2010; Galli et al. 2010).

Sensitivity

Do the values of the indicator outputs change rapidly enough with respect to input parameters to pick up policy-significant changes?

Generally speaking, the EF is sensitive to changes in input variables. However, the EF is more suitable as a long-term aggregate indicator than a tool to reflect short-term changes. Within the OPEN:EU project, the EF will be integrated into the EUREAPA tool for which data is available for 2004 (GTAP data): The data are not updated on a yearly basis. The EF is therefore not suitable to reflect short-term changes. Moreover, the indicator is not directly linked to certain policies. As mentioned earlier, the indicator needs to be normatively interpreted and contextualised in order to judge policies and policy changes.

Is the methodology suitable to detect non-linearities, discontinuities and thresholds?

Basically, the EF may be suitable to show non-linearities if the indicator values can be compared annually. If the EF shows that an entity is exceeding its biologically productive capacity, it may also be suitable to detect whether a threshold is reached or not. However, within the OPEN:EU project and the EUREAPA tool, data are not available for every year. Consequently, the EF is in this case not suitable to detect non-linearities, discontinuities or thresholds. However, the EF is well suitable to define at what point of consumption the world reaches an overshoot.

Data quality

Is the underlying data of a quality that is sufficient to ensure that it leads to correct results? Could inaccuracies and variations within the uncertainty margin lead to opposite findings and conclusions?

As mentioned earlier, the calculation of the EF requires a large amount of data from different sources. Not all of the data necessary for the calculation of the EF is of equal value (see Best et al., 2008, p. 57). The EF alone is already an aggregated indicator. However, combined with the other two Footprint indicators in the EUREAPA tool, the indicators reach an even higher level of aggregation. Given this high level of aggregation and the use of generalised conversion factors for the EF, data quality should be validated before data are fed in the EUREAPA tool and error margins should not only be reported but also considered when conclusions from the tool are drawn.

Concerning the data, as of October 2010 it has not been decided yet whether the data from the Global Trade Analysis Project (GTAP) or from the EXIOPOL project will be used. The GTAP is a global network of researchers (see www.gtap.agecon.purdue.edu) providing a complete model of global trade. So far, the OPEN:EU project plans to use this data.

However, the EXIOPOL data might replace the GTAP data. This complete model of the European economy will be produced by the EXIOPOL project funded by the EC (FP6) http://www.feem-project.net/exiopol/index.php.

Both data sets are of sufficient quality to ensure that the indicator will lead to correct results.

Reliability

Is the methodology/indicator reliable in terms of its accuracy, repeatability and the clear specification of protocol and formulas used in the calculations? Are all of the calculation details openly exchanged among researchers in order to avoid different standards?

The EF is at present mostly calculated using LCA data.[18] However, within the OPEN:EU project, a new methodology will be used to calculated the different Footprint indicators, using a MRIO model. The total initial quantities will be assigned to the responsible economic sectors and allocated through the MRIO model, rather than estimating the EF of production. The calculation details are so far only exchanged among the OPEN:EU researchers but will be made transparent during the course of the project.

Completeness

Is the indicator/methodology complete in terms of the safeguard object it is assessing (e.g. natural environment, human health, future resource availability)? Is a shifting of burdens avoided among single problems/impact types (e.g. from climate change to nuclear risks), among the safeguard subjects (e.g. from human health to the natural environment) and among regions (e.g. relocation of production may shift environmental burden away from the place of consumption)?

The EF is not complete in terms of the safeguard object it is assessing. With regard to environmental concerns, the EF does not capture those for which no regenerative capacities exist. Furthermore, the EF only shows pressures that could lead to degradation of natural capital but does not predict degradation. The EF is not geographically explicit.

The new calculation method used within the OPEN:EU project addresses some of these weaknesses. For instance, the EF will then provide an aggregate indicator of the biological resource requirements of economic flows and will be geographically specific on the national level, namely in connecting resource demands to consumption. However, the new calculation methodology still does not allow the indicator to be geographically specific on the sub-national level and it still does not provide direct links to land or ecosystem degradation. Furthermore, the time series estimates are no longer calculated by the same method as the detailed single year model.

In sum the new calculation method nevertheless improves the informative value and explanatory power of the Footprint indicators. This is particularly true if all three are combined and looked at together.

[18] This is also true for the WF while the CF at present already uses a MRIO model to allocate emissions to consumption.

4.1.6. SUMMARY OF RACER ASSESSMENT

Table 1 summarises the key findings of the RACER assessment of the EF.

Table 1: Summary of RACER assessment of the Ecological Footprint

I. Indicator Summary	
Name of indicator	Ecological Footprint
Indicator category (economic, social, environmental)	Measures the human demand on the Earth's biocapacity and compares it with the planet ecological capacity to regenerate (unit in global hectares, gha), (environmental indicator).
Name of person providing evaluation	Doris Knoblauch (with input from Nataliya Stupak)
Date	August 2010
II. Background information on the indicator	
a. What is the official definition of the indicator?	It measures how much bioproductive land and water in terms of area a human population requires to produce the resources it consumes and to absorb its wastes, using prevailing technology.[19]
b. Unit(s) of measurement of the indicator	global hectares, gha (sometimes local hectares)
c. What does the indicator seek to measure?	The biocapacity actually needed by the people in a country in relation to their consumption pattern.
d. Provide a brief history of the indicator. Which organization or body originally proposed the indicator (and in what year)? Which organizations currently advocate for the indicator's use?	The EF was created in 1990 by Mathis Wackernagel and William Rees at the University of British Columbia. Several institutions use and/or advocate for the EF. A prominent representative among them is the Global Footprint Network (GFN).
e. What are the known limitations of the indicator?	The EF is limited to the accounting and communication of over-consumption and does not provide information on when ecological limits might be reached related to key ecological services.
f. What is the history and status of the methodological development and adoption of the indicator (e.g. major revisions, current efforts, future plans/initiatives)?	In 2006, a first set of internationally recognized standards were released by GFN and its partners. In 2009, these standards were updated and now include standards and guidelines for product and organizational Footprint assessments.[20] Furthermore, a Guidebook was published in 2008 (see Kitzes et al. 2008). The OPEN:EU project develops a MRIO model to calculate the Footprint.[21]

[19] See http://www.Footprintnetwork.org/en/index.php/GFN/page/Footprint_basics_overview/, retrieved 3 August 2010.
[20] See http://www.Footprintstandards.org/, retrieved 3 August 2010.
[21] See also Hawkins et al., 2010; Hertwich and Peters, 2010.

III. Data	
g. How is the underlying data gathered and by whom?	Usually, international data sets are used to calculate the EF (e.g. from the FAO, IEA, UN, IPCC). The EUREAPA tool uses data from the GTAP, which is a global network of researchers (see www.gtap.agecon.purdue.edu). It is a complete model of global trade so in terms of the MRIO approach it is 'complete'. Alternatively, the EXIOPOL data might be used in the future.
h. How accurate are the results (e.g. is the result an estimate, are there data gaps, imputations, assumptions, etc)?	Generally, the EF leads to "robust, aggregate estimate of human demand on the biosphere as compared to the biosphere's productive capacity".[22] However, the methodology relies on the quality of the data. The OPEN:EU project uses economic data which are complete for the multi-regional input-output analysis. Here, too, the methodology is dependent on the data quality.
i. How often is the indicator recalculated/released? Have there already been any major indicator revisions?	Each year a new edition of the National Footprint Accounts is calculated by GFN and made available for the public. In even years, results are co-published by GFN and WWF in the Living Planet Report. In odd years, results are independently published by GFN. The OPEN:EU project develops a tool to easily calculate the EF also in relation to different policy options.
IV. Link to sustainable development	
j. Is there an operational definition of sustainability 'built-in' to the methodology?	The methodology to analyse the EF takes into account the sustainability principles identified by Herman Daly (1990); it identifies the extent to which human activities exceed a) the availability of bioproductive land to produce resources and b) the availability of forests to uptake CO_2 emissions (see also Galli et al., 2010).
k. If yes, does the indicator measure 'strong' or 'weak' sustainability?	
l. Does the approach have numerical value(s) assigned to sustainability (e.g. thresholds/ irreversabilities below which a region/activity is not sustainable)?	Not directly. However, biocapacity could serve as a benchmark indirectly. If a region's biocapacity is overexploited, its development is not sustainable.
m. Please describe the key methodological links to highly related indicators (what exactly are the commonalities and differences among these indicators)?	The other members of the Footprint Family are similar in approach, information content and methodology. However, the EF and WF are mostly calculated using LCA data while the CF already uses a MRIO model to allocate emissions to consumption. Furthermore, while the EF yields information of land use and the CF yields information on GHG emissions (equivalents), the WF complements the picture by giving information on water consumption.

[22] See http://www.Footprintnetwork.org/en/index.php/GFN/page/frequently_asked_technical_questions/#dai1, retrieved 4 August 2010.

n. What are the key "bridging" links to other dimensions of sustainability (environmental, social, economic) and are there any explicit hybrid measures incorporating multiple dimensions in a single metric (e.g. GHG intensity—GHG emissions per unit of GDP).	The EF does not include aspects related to public health or well being. That is one of the reasons why it is often used in combination with the Human Development Index (HDI). Furthermore, the EF does not state who should use what or how many resources. Consequently, it does not comment on fair or equitable resource consumptions but rather needs to be (normatively) interpreted.
V. Institutional Analysis	
o. Which institutions are currently using the indicator, and for which purposes?	The European Commission regularly refers to the EF, for instance in its Action Plan on the Sustainable Consumption and Production and Sustainable Industrial Policy COM(2008)397 final. However, the EC is not using the indicator systematically, e.g. as part of a major European indicator set (such as the Sustainable Development Indicators). By contrast, the CBD has formally adopted the EF as an indicator to measure progress towards the 2010 goals.
p. What are the driving forces and characteristics that affect institutional adoption (consider this question from the perspectives of political science, sociology and political economy)?	Most likely, institutions will adopt an indicator if they perceive it as useful (i.e. measuring the right issues), practical (i.e. applicable by the institution) and trustworthy (i.e. based on solid data and transparent methodology).
q. Are there links to international or European laws, conventions or agreements (this could range from an explicit legal requirement to a general policy concern)?	No.
VI. RACER Analysis	
Criteria and Sub-criteria	**Analysis**
Relevant	
POLICY SUPPORT	+ Relevant for various EU policy objectives: • Ensuring that human production and consumption activities are kept within the ecological boundaries of the planet. • Achieving de-coupling between economic growth and resource use / use of biocapacity. • Reducing environmental impacts from resource use (except for monitoring abiotic resources and most emission sinks). + Could provide support for the definition of targets and measuring gaps in implementation towards these targets. + Compares human demand against 'carrying capacity', an oth-

	erwise overlooked aspect. – Requires interpretation and does not immediately lead to policy recommendations. – Although the facts measured by the EF are clearly relevant to sustainability, the messages that can be derived from EF accounting may not provide the full information relevant for EU policy goals (e.g. no information is provided on health issues), signifying that complementary indicators are required. – The EF alone does not reveal all important facts about environmental impacts.
IDENTIFICATION OF TRENDS	+ Basically reflecting changes over time. – However, with the new calculation method no time series will be available. – When only looking at the aggregated, total EF, opposite trends in individual variables may compensate for each other.
FORECASTING AND MODELLING	+ By relating resource use to carrying capacity, the EF provides a 'warning light' regarding the long-term degradation of natural resources. – Not a forecasting tool. It is an accounting tool that relies on ex-post data. – Does not provide for feedback loops that would link current policies to future resource use or present resource use to impacts occurring in the future.
SCOPE/LEVELS OF APPLICATION	– The EF will be reported for the EU as a whole as well as for the individual Member States since the EUREAPA tool will only be able to calculate national Footprints (not sub-national ones).
Accepted	
STAKEHOLDER ACCEPTANCE	+ The straightforward communication of a complex matter is one of the main strengths of the EF. + The existing popularity of the EF indicator shows its suitability to address a broad public. + Furthermore, it can be assumed that the EUREAPA tool will be particularly interesting for strategic policy makers. – Important stakeholder groups oppose the accounting system (e.g. statistical offices and some indicator experts have expressed reservation about applying EF accounting).
Credible	
UNAMBIGUOUS	+ Addresses a clearly defined research question. + The basic concept of relating resource use to carrying capacity can be easily understood. – The limitations of the research question are not readily understood. This may lead to confusion about what the EF really measures. – Does not lead to immediate policy conclusions. Policy implications depend on interpretation and valuation. – Undesirable conclusions (from an environmental point of view) are possible, signifying that complementary indicators are required.
TRANSPARENCY OF THE METHOD	+ The basic principles of EF calculation are publicly available and are being increasingly standardised, notably for national EF accounts. + There is a lively and open scientific discussion on various aspects of the EF methodology. + Within the OPEN:EU project, the methodology will be documented and made transparent. – Not all calculation steps and underlying assumptions are sufficiently documented (though documentation is improving).

Easy	
DATA AVAILABILITY	+ Generally, data availability has been sufficient to calculate national EF accounts for more than 150 countries since 1961. Primary data collection is already done by international statistical agencies. + Using the EUREAPA tool the user does not need to collect data by him- or herself since the data is already included in the tool. – GTAP data are so far only available for 2004. – Imputation techniques have to be used where data gaps exist (e.g. with trade flows).
TECHNICAL FEASIBILITY	+ Different methodologies exist that feature different levels of technical difficulties. The OPEN:EU project has developed the MRIO methodology which does not present any problems regarding technical feasibility. Calculations are undertaken for the user.
COMPLEMENTARITY AND INTEGRATION	+ The EF measures resource consumption while the WF measures the use of fresh water and the CF all GHG emissions used by certain entities. Therefore, they complement each other well. However, this is only one possibility of combination. In addition, the HDI could be combined with the Footprint Family since it includes social aspects. – The EF alone is not an indicator for overall sustainability. Stand-alone use is therefore not recommended.
Robust	
DEFENSIBLE THEORY	+ The EF is the indicator with the longest history within the Footprint Family. + Its methodology has been criticised but was also improved and regularly updated. + Within the OPEN:EU project, the calculation methodology for the EF is clearly defined and robust. – The methodology requires the conversion factors. The underlying assumptions for the factors applied have not been sufficiently explained in all cases to allow for independent reviews.
SENSITIVITY	+ Generally, the EF is sensitive to changes in input variables. + The EUREAPA tool is designed to help policy makers in evaluating the impacts of potential policies with regard to resource consumption. Thus, the indicator outputs change with respect to input parameters to recognise policy-significant changes (related to potential policies). – However, the EUREAPA tool is not able to detect short term changes (in the 'real' world).
DATA QUALITY	+ Generally, the EF leads to "robust, aggregate estimate of human demand on the biosphere as compared to the biosphere's productive capacity".[23] However, the methodology relies on the quality of the data. + The OPEN:EU project uses economic data which are complete for the MRIO analysis. Here, too, the methodology is dependent on the data quality. – Data quality problems and data gaps might significantly affect the results of EF calculations
RELIABILITY	+ The OPEN:EU project introduces a new methodology to calculate the Footprint indicators using a MRIO model. – So far, calculation details are only exchanged between OPEN:EU researchers but will be made transparent during the course of the project.

[23] See http://www.Footprintnetwork.org/en/index.php/GFN/page/frequently_asked_technical_questions/#dai1, retrieved 4 August 2010.

COMPLETENESS	+ The new calculation method connects resource demands to consumption patterns (i.e. geographically specified where the resources used are produced *and* where they are consumed). – Calculations on the sub-national level are difficult, due to lack of sub-national input data.
Summary appraisal	+ A core strength of the EF lies in its capacity to condense many aspects of the use of biological resources into one indicator that resonates with a wide audience. + The new calculation method used within the OPEN:EU project improves the informative value and explanatory power of the Footprint indicators. This is particularly true if all three indicators are looked at together. – It is not yet clear who will be responsible for updating the data within the tool once the project has ended.
VII. Supplemental RACER policy analysis	
Policy Target	**Does the indicator reflect this target?**
CLIMATE CHANGE AND CLEAN ENERGY	No.
SUSTAINABLE TRANSPORT	No.
SUSTAINABLE CONSUMPTION AND PRODUCTION	Yes.
CONSERVATION AND MANAGEMENT OF NATURAL RESOURCES	Partially.
PUBLIC HEALTH	No.
SOCIAL INCLUSION, DEMOGRAPHY, AND MIGRATION	No.
GLOBAL POVERTY AND SUSTAINABLE DEVELOPMENT CHALLENGES	No.
INVESTMENT IN RESEARCH AND DEVELOPMENT	No.
UNEMPLOYMENT RATE	No.
How does the indicator help measure progress toward the policy targets (marked 'Yes' and 'Partially, above)? What are the advantages of using this indicator?	The EF measures resource use and related demand for biocapacity as compared to the Earth's carrying capacity. Thus, it provides insights into how many resources were used for production and where these were used. At the same time it provides insight as to where these resources have been consumed.
What are the most important pitfalls of using this indicator as a measure of progress to the policy targets (marked 'Yes' and 'Somewhat', above)?	The EF is not a sustainability indicator although it is sometimes communicated as such. However, it does not capture important aspects of sustainability. At the same time, the EF is highly aggregated, occasionally leading to difficulties in interpretation.

VIII. Potential Links with Other Indicators	
What other indicators could be combined in a basket with the one in question to address specific policy challenges relevant to the EU policy framework?	Carbon Footprint, Water Footprint, Human Development Index.
IX. SWOT Analysis	
Strengths	• Easily understood by the public. • Condenses many aspects of resource and land use into one indicator. • Can be applied at multiple scales.
Weaknesses	• Lack of transparency (e.g. calculations are not always reproducible). • Data quality problems and some underlying assumptions are controversial. • Oversimplification could lead to lack of clarity for policy makers. • Several environmental impacts not included.
Opportunities	• Relevant for strategic policy-makers when included in the EUREAPA tool.
Threats	• Need for high-quality, unbiased data. • Needs to be used within a 'basket of indicators'. • Resources needed to improve methodology and implement it.

4.2. Water Footprint (WF)

The Water Footprint (WF) of a country is the total volume of freshwater consumed and polluted for the production of goods and services consumed by citizens in that country. It looks at both direct and indirect water use of a consumer or producer. Part of the WF lies outside of the territory of the nation given that virtual water imports (via the import of goods) is taken into account in the national WF. Consumption is defined as water permanently removed from a water body in a catchment, which happens when water evaporates, returns to another catchment area or the sea or is incorporated into a product. The pollution element of the Footprint is the water required to dilute pollution so that it can be returned to the environment. The WF is a further development of the virtual water concept and was proposed by Dutch scientist Arjen Y. Hoekstra (Sonnenberg et al., 2009, p. 8). The WF of a community or business is defined as the total volume of freshwater that is used to produce the goods and services consumed by the community or produced by business.[24]

The RACER analysis of the WF has been conducted according to the methodology described in chapter 3.1 of this report. The summary of the analysis is provided in Table 2 at the end of this section. Along with assessing the indicator according to the RACER criteria and sub-criteria, the summary provides background information on the indicator, its

[24] See Glossary of the Water Footprint Network: http://www.waterFootprint.org/?page=files/Glossary, retrieved 1 July 2010.

brief institutional and policy analysis and links to sustainable development and other indicators.

4.2.1. RELEVANT

Is the indicator/methodology related to existing EU-specific policy objectives?

The main overall objective of EU water policy is to ensure access to sufficient quantities of good quality water for all Europeans and to ensure the good status of all water bodies across Europe. Therefore, policies and actions are set up in order to prevent and mitigate water scarcity and drought situations, having the priority of moving towards a water-efficient and water-saving economy.[25] The preservation or achievement of a good ecological and chemical status of surface water is another objective of European water policy. The WF is one indicator that might inform water-related EU policies and is increasingly used to raise the awareness of consumers on water consumption. A Commission representative made the point that it should be considered whether or not the WF has a role to play in future policy on water scarcity and droughts (Gasparinetti, 2010).

At a high level, the WF is suitable for helping to analyse the water management levels of a country, especially when comparing the extent of water resources available with water use.

Does the indicator provide guidance in monitoring, strategic policy making and/or target setting? Does it quantify gaps between the current situation and specified targets?

A nation's WF provides insight into the total amount of fresh water that is used to produce the goods and services consumed by the inhabitants of the nation.

Thus, the Footprint indicates at least how water-intensive a country's production and consumption are. As such, the WF of a nation is an indicator of water use in relation to the consumption volume and pattern of the people. As an aggregated indicator, it shows the total water demand of a nation and, when combined with data on water availability, can be a measure of the impact of human consumption on the national water environment.

Given that the WF provides information on the origin of water and is based on **local productivities**, i.e. the way water is consumed locally (volumes blue water or green water, etc.),[26] water saving potentials could be identified where they are most needed. Those savings could be realized by adapting production patterns to local conditions. Policy makers should concentrate their efforts on water savings wherever high virtual water consumption has the strongest negative impact on humans and nature. For example, water-scarce countries can shift to increased imports of water intensive goods in order to save their domestic water resources; a strategy some countries in the Middle East currently follow (Hoekstra, 2009, p. 1969).

Does the indicator provide adequate early warning to guide policy action? Does it react to short-term changes that can (among other things) show whether policies are having an effect?

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[25] See http://ec.europa.eu/environment/water/quantity/scarcity_en.htm, retrieved 1 July 2010.

[26] Green Water is rain water stored in soil as soil moisture, Blue Water is surface and ground water, Grey Water is diluting water needed to offset water pollution.

The WF analysis can help in assessing the impact of EU and national policies on the Water Footprint. The EUREAPA tool which will be developed in OPEN:EU will enable policy makers to provide policy suggestions and receive an estimate of how this change of policy would affect water consumption.

It is important to note that trade data and water consumption data are not updated as regularly as would be needed to calculate the WF on the basis of current data. This means we are not able to look at historic trends in water consumption.

Identification of trends

Can the methodology/indicator be used to track changes over time? This implies that at least one input variable will require time series data (e.g. a series of annual measurements).

There will be no historic time series data for the WF so it will not be possible to identify historical trends. The data that will be used for the OPEN:EU project has been produced for 2004. It may be possible to track changes if future updates are made to the tool. However, this is not incorporated in the current tool.

Forecasting and modelling

Can the methodology/indicator be used in a predictive sense to forecast future environmental impacts from natural resource use or for more sophisticated modelling where the impact of different potential policies or of technology progress and/or change of consumption patterns can be simulated? Can the indicator function as an early warning indicator?

The EUREAPA tool (which calculates the WF) is an accounting tool, not a forecasting tool. It is calculated by the water consumption data that stem from the production of certain products, services and trade data and uses ex-post data.

The EUREAPA tool developed within OPEN:EU will use data on what goods and services citizens from each of the 27 EU countries are buying (the current consumption profile) combined with data on where these goods and services are made and how efficient production techniques are to calculate the direct and indirect environmental impact of goods and services consumed in the EU. The WF can function as an early warning indicator, showing whether a country's industry or commerce manages water well and whether it already does (or in the long-term will) overexert its water capacity.

Scope / levels of application

Does the indicator provide information relevant to the effective levels of application? Does it allow for disaggregation – either spatial, by product, by industry or by ecosystem type?

The WF can be calculated for water consumption at different levels: for a product, household, firm, nation or even the world.

In the OPEN:EU project, only national WF will be of interest.

Traditionally, there is one quite elaborate approach of calculating the WF that takes the water consumption of the different items produced in a country into account by tracking down their supply chain. The approach allows for a precise disaggregation of data on the product level, provided the method of the WF calculation is made transparent; this should facilitate identifying the WF for different sectors (e.g. agriculture, industry) and even single products.

The OPEN:EU project's calculation methodology relies on the MRIO approach (see also Hawkins et al., 2010; Hertwich and Peters, 2010; Galli et al. 2010). The data used do not allow allowing the WF below the level of a nation, thus it is only possible to calculate WFs at a national or EU level.

Function and needs-related analysis

Does the indicator allow for comparisons between material and energy resources in terms of their functions and competition in the real world (e.g. in cases where one energy carrier, foodstuff or construction material is substituted by another)? Similarly, does the methodology allow the comparison of different ways of fulfilling basic human needs (housing, mobility, food, etc.) with regard to their resource-use implications?

The WF is generally suited to compare different options of producing/consuming items or crop growing with regard to water consumptions.

The EUREAPA tool which is being developed within the OPEN:EU project is particularly designed for the purpose of comparing the impacts of different policy options. Although it is possible to calculate the WF of different products of one product family, this level of detail has been aggregated into broader sectors to provide a more functional, flexible tool for policy users. The project team will develop scenarios that will be pre-loaded into the tool, which may use this level of detail, however it will not be available to tool users.

4.2.2. ACCEPTED

Stakeholder acceptance

Is the underlying rationale and meaning of the methodology/indicator easily understood and accepted by stakeholder groups? Does the methodology/indicator resonate with widely held values and concerns to motivate stakeholders to calculate or provide data and accept interpretations of the meaning of the methodology/indicator?

The main principle and rationale of the indicator can be easily understood by stakeholders and the general public. The indicator suggests the consumption-oriented approach to water use and is restricted to the medium water, generally construed as a highly important medium.

The WF approach including the definition of its scope was only introduced in 2002 in order to have a consumption-based indicator of water use that could provide useful information in addition to the traditional production-sector-based indicators of water use (Hoekstra and Hung, 2002).

The fact that the WF does not only take into account the domestic use of water in a country, but that it also includes the use of water outside the borders of the country is welcomed by stakeholders. This information shows the origin of water consumption and can help countries to develop a water saving policy with and directed at states having an important WF.

As for the methodology in general, WWF required, for example, that the methodology of the WF calculation be further developed, especially for industrial products (as opposed to agricultural products) (Sonnenberg et al., 2009, p. 8).

Some stakeholders require that the WF be integrated with other Footprint types to indicate the overall impact of resource use, implying that the WF alone will not be sufficient to give information to policy makers and consumers about the (non)sustainability of human natural resource use. Also, the volumes of water consumed alone do not provide information on whether or not this usage has considerable social or environmental impacts on a country (this will need to be identified via a concrete impact assessment).

Given the rather recent establishment of the WF, its usage has not yet been exposed to such extensive practical considerations and debates as the EF. In order to promote coherent WF accounting, the Water Footprint Network has been created, publishing papers on the methodological development and use of the WF.

The OPEN:EU project uses its own methodology to calculate the WF based on a MRIO approach. One objective of the project is also to integrate the different Footprints.

4.2.3. CREDIBLE

Unambiguous

Is the indicator suited to conveying a clear, unambiguous message? Does it allow for clear conclusions to guide political action? Does it actually provide the information that non-experts believe it does?

The concept and indicator of the WF is quite easy to understand: The WF of a nation is given in units of water consumption (m^3/capita/year).

However, the message the WF conveys is only clear and conclusive if the facts behind the calculation of the WF are revealed.

The 'Water Footprint' of a product is similar to what has been called the 'virtual-water content' of the product or the product's embedded, embodied, exogenous or shadow water in other publications (Hoekstra and Chapagain, 2008). The terms virtual-water content and embedded water, however, refer only to the water volume embodied in the product alone; the term 'Water Footprint' refers not only to the volume, but also to the sort of water (green, blue, grey) and when and where it was used. The WF of a product is a more elaborate indicator, whereas 'virtual-water content' or 'embedded water' refer to volume alone (Hoekstra et al., 2009, p. 31).

Yet, the results of WF analyses do not always reveal the volume of green water or blue water; instead, they only add up all of the water use, reducing the value of the information. In any case, the scope of the Footprint has evolved over the years. The very early Footprint assessments of nations (2002) only included blue water withdrawals (Chapagain and Orr, 2009, p. 1220). This was rectified in 2004 when green water was also included. The 'grey' dimension was only added in 2006. Thus, it depends much on the way in which the WF analysis is presented and substantiated whether it conveys unequivocal messages.

Recently, the appropriateness of the term 'Footprint' was questioned since the WF concept, as described above, includes sums of water quantities that are not put in relation to the size of a certain area. This makes it different from the EF. The value of a nation's Footprint can, however, be compared with the total annual freshwater availability, i.e. the sum of green and blue water availability, or the total precipitation above land (Hoekstra, 2009, p. 1970). There are, however, also important methodological difficulties to determine the realistic availability of blue water (Hoekstra, 2009, p. 1971).

The definition of 'grey WF' should always be given and explained when presenting the grey Water Footprint: The WFD network thus defines the term: "The grey WF of a product is an indicator of freshwater pollution that can be associated with the production of a product over its full supply chain. It is defined as the volume of freshwater that is required to assimilate the load of pollutants based on existing ambient water quality standards. It is calculated as the volume of water that is required to dilute pollutants to such an extent that the quality of the water remains above agreed water quality standards."[27]

This differs from the notion that the grey WF reflects the non-evaporative water content, i.e. the volume of polluted water, but not the volume needed to dilute the polluted water to neutralise pollutants.

Transparency of the method

Are the underlying data and calculation methods fully disclosed, interpretable and reproducible?

Traditionally, data on total renewable water resources and water withdrawals per country are taken for example from FAO data, other needed data stem e.g. from the World Bank's on-line database or the World Trade Organisation.

The EUREAPA tool uses data from the GTAP, which include data on what goods and services citizens from each of the 27 EU countries are buying (the current consumption profile) combined with data on where these products are made and efficiency of production techniques to calculate the direct and indirect environmental impact of goods and services consumed in the EU.

The efficiency of production in 87 world regions is known as well as where goods consumed in the EU are produced. The tool will therefore be able to elucidate where in the world the impact from goods and services consumed in the EU occurs.

The impact will be reported for each EU Member State individually and the EU as a whole. It cannot be reported below national level (e.g. region, city, local authority) because the consumption data is not currently available at this level of disaggregation.

4.2.4. EASY

Data availability

Does the methodology/indicator work without inputs of data that are overly excessive, expensive or onerous to collect, or that cannot be properly measured? Ideally, is it based on data that are already collected and readily available in electronic form?

Principally there are different methodological ways to calculate the WF, which differ depending on their level of complexity.

The OPEN:EU project has chosen to use the MRIO to calculate Footprints and develop a specific tool as a calculator of the WF. The users of this tool do not need to collect any data to calculate the current WF as the data is incorporated in the tool. The data set used in the EUREAPA tool is from the GTAP, which is a global network of researchers (see www.gtap.agecon.purdue.edu). It is a complete model of global trade so in terms of the MRIO approach it is 'complete'.

[27] See http://www.waterFootprint.org/?page=files/Glossary, retrieved 12 August 2010.

In order to undertake policy analysis, the tool user would have to gather data on the likely effect of policy interventions on total consumption, the basket of goods and services and the production efficiency.

Technical feasibility

Is the methodology simple enough to be carried out using software and expertise appropriate to the scale of application and the typical capabilities of the institution doing the calculations?

In general, the calculation of the WF is straightforward and feasible, provided the data are available. The calculation does not require any particular software or other specific technical equipment. However, given the fact that the WF is a more recent indicator than the EF, the debates on the methodologies of the WF calculation have not yet been as extensive. Certain methodological questions of the WF remain.

Since the EUREAPA tool undertakes the calculation for the user, technical feasibility is ensured by this tool. The user does not need any technical expertise but can simply use the online tool.

Are the input and the calculation methodology clearly defined to avoid ambiguity and consequent error in implementation?

In general, there a different methods of calculating the WF. In the OPEN:EU project the MRIO methodology is used with a specific economic data set, which is clearly described in the *Technical Report: Integrating Carbon, Ecological and Water Footprints in a Multi-Regional Input-Output Framework* (Olsen, Hawkins and Hertwich, 2010).

Complementarity and integration

Are there potential complements between the methodology/indicator and the others being assessed?

Stakeholders and scientists around the world are trying to determine how to best include different environmental impacts in the Footprints so they can be incorporated e.g. into food labels. The International Organization for Standardization now has a project underway to tackle this problem. The Water Footprint is the only indicator aiming to calculate the water consumption embodied in production.

There are concrete suggestions to integrate the WF in other Footprint indicators in the OPEN:EU project (see further below).

Is there the potential for further integration of the methodology/indicator with the others?

Building on the premise that no single indicator per se is able to comprehensively monitor (progress towards) sustainability, and that indicators need to be used and interpreted jointly, the OPEN:EU project aims to define a Footprint Family of indicators and inform its appropriate use in tracking human pressure on the biosphere. The EF focuses on the aggregate demand that resource consumption places on the planet's ecological assets, thus recognizing the existence of limits to our growth and trying to measure them. The WF focuses on the human appropriation of 'natural capital' in terms of fresh water volumes; it is primarily intended to illustrate the hidden links between consumption activities and water use and is thus suitable for pointing out major threats e.g. to a country's or a region's freshwater ecosystems. Finally, the Carbon Footprint focuses on the total amount of GHGs released due to resource-consumption activities; by complementing the production-based accounting approach taken by national GHG inventories, a better understanding of humans' contribution to climate change can be reached. The three indicators of the Footprint Family complement one another in assessing human pressure on the planet even though also their integration will not be sufficient to wholly assess sustainable development and additional or complementing assessments will have to be made.

4.2.5. ROBUST

Defensible theory

Is the methodology/indicator based on sound theory? Does it avoid double counting or omissions of resources used? Is it consistent in its units of measure? Does it rely on assumptions that are clearly stated and reasonable? Does it avoid using ill-defined or poorly quantified parameters? In cases where subjective weighting cannot be avoided, is it justified and made explicit?

The WF is an indicator that can be applied to products, processes, companies, industry sectors, individuals, governments, populations, etc. It documents all fresh water consumption resulting from the production of goods and services. The unit of measure for the national WF is m^3/capita/year. The WF and its methodology are debated in scientific literature and supported by a number of articles. However, it seems that only a limited number of scientists work with the WF in detail. A Water Footprint Network was established in October 2008 by a number of major global players from business, civil society, multilateral organizations and academia. The Water Footprint Network and its partners strive to develop and apply the WF to support the global transition to sustainable and equitable water management.[28] The Water Footprint Network (WFN) aims to achieve broadly shared global standards on WF accounting and attempts to prevent what has happened in the case of the Carbon Footprint, where a multitude of different definitions, approaches and methods have made it difficult to properly assess results. A unique set of global standards for the WF will make efforts of businesses and communities striving to reduce their WF more transparent.[29]

OPEN:EU suggests its own methodology to calculate the WF. While the WF is at present most commonly calculated using process-based LCA data and physical quantities of traded goods, OPEN:EU suggests a MRIO calculation model. This means that the total initial water quantities will be assigned to the responsible economic sectors and allocated through the MRIO model, rather than estimating WF components incurred at each production step. WF calculations currently tend to utilize a larger number of process steps in estimating total inputs to a production process, but the MRIO model may still more completely capture the total indirect water impacts of a supply chain.

The model does retain a great level of detail, allowing water use to be understood by individual products (for agricultural products only). However, the EUREAPA tool will aggregate these products into broader sectors to improve the usability of the tool. This means that some precision will be lost. However, we may be able to retain this precision in pre-loaded scenarios.

Within the OPEN:EU project the calculation methodology for the WF is clearly defined and robust, even though the methodology still has some shortcomings (see Hawkins et al., 2010; Hertwich and Peters, 2010; Galli et al., 2010.).

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[28] See http://www.waterFootprint.org/?page=files/FAQ_Question_about_the_Network, retrieved 12 July 2010.
[29] See http://www.waterFootprint.org/?page=files/FAQ_Question_about_the_Network, retrieved 12 July 2010.

Sensitivity

Do the values of the indicator outputs change rapidly enough with respect to input parameters to recognize policy-significant changes?

Within the OPEN:EU project, the WF will be integrated into the EUREAPA tool for which data is available for 2004: The data are not updated on a yearly basis. The EF is therefore not suitable to reflect short-term changes.

Is the methodology suited to detect non-linearities, discontinuities and thresholds?

There is currently no historic time series for the WF, which means that it is not possible to detect non-linearities and discontinuities. There is currently no robust threshold to compare the WF against; however, benchmarking will be investigated in more detail later in the project.

Data quality

Is the underlying data of sufficient quality so that data leads to correct results? Could inaccuracies and variations within the uncertainty margin lead to opposite findings and conclusions?

In general there is no standard database used for the WF so all data needed for the calculation must be gathered and the reliability of data has to be assessed beforehand by the person who does the calculation. The specific approach of OPEN:EU is that the EUREAPA tool provided for WF calculation will offer all the data needed so that tool users only have to insert variables.

Concerning the data, as of August 2010 it has not been decided yet whether the data from the GTAP or from the EXIOPOL project will be used. The GTAP is a global network of researchers (see www.gtap.agecon.purdue.edu) providing a complete model of global trade. So far, this data has been favored. However, the EXIOPOL data might replace the GTAP data. This complete model of the European economy will be produced by the EXIOPOL project funded by the EC (FP6) http://www.feem-project.net/exiopol/index.php.

Reliability

Is the methodology/indicator reliable in terms of its accuracy, repeatability, and the clear specification of protocol and formulas used in the calculations? Are all details of calculation openly exchanged among researchers in order to avoid different standards?

The data sources and input variables used to calculate the WF can influence the value of the indicator. OPEN:EU uses data from the GTAP, which is a global network of researchers (see www.gtap.agecon.purdue.edu). It is a complete model of global trade so in terms of the MRIO approach it is 'complete'. The Water Footprint 'environmental extensions' are provided by the Water Footprint Network, a highly respected and reliable source of Water Footprint data.

Completeness

Is the indicator/methodology complete in terms of the safeguard object it is assessing (e.g. natural environment, human health, future resource availability)? Is a shifting of burdens avoided among single problems/impact types (e.g. from climate change to nuclear risks), among the safeguard subjects (e.g. from human health to the natural environment) and among regions (e.g. relocation of production may shift environmental burden away from the place of consumption)?

The WF is designed to calculate water use for production and consumption. Therefore, the indicator and its underlying methodology can be considered complete for water accounting. It should be noted that no Water Footprint data is included for the consumption of water by industrial sectors other than agriculture, fisheries and forestry. However, these sectors account for over 85% of water consumption. The indicator aims at reallocating responsibilities between the producers and consumers of goods and services. Though the WF does not shift the burdens from producers to consumers, it can elucidate unsustainable consumption patterns and provides a basis for political decisions.

4.2.6. SUMMARY OF RACER ASSESSMENT

Table 2 summarises the key findings of the RACER assessment of the WF and provides a scoring of how well it fulfils each criteria and sub-criteria.

Table 2: Summary of RACER assessment of the Water Footprint

I. Indicator Summary	
Name of indicator	Water Footprint
Indicator category (economic, social, environmental)	Use of freshwater resources (for national Footprint: unit is in m^3/capita/yr), (environmental indicator).
Name of person providing the evaluation	Alexander Neubauer
Date	August 2010
II. Background information on the indicator	
a. What is the official definition of the indicator?	Consumption-based indicator of water use. The total volume of freshwater used to produce the goods and services consumed by the individual or community or produced by the business.
b. Unit(s) of measurement of the indicator	m^3/cap/yr (for national Footprint) The components of a WF are specified geographically and temporally.
c. What does the indicator seek to measure?	The water actually needed by the people in a country in relation to their consumption pattern.
d. Provide a brief history of the indicator. Which organization or body originally proposed the indicator (and in what year)? Which organizations currently advocate for the indicator's use?	The WF was introduced in 2002 by Dutch scientists Hoekstra and Hung; "Virtual water trade". The WFN is charged with the task of elaborating on the WF's methodology.
e. What are the known limitations of the indicator?	A basic question in WF accounting is where to truncate the analysis when going back along the supply chains (which are lengthy and widely diverging) and which processes within a production system 'significantly' contribute to the overall WF (usually there are only a few process steps that contribute significantly). Furthermore, what percentage value constitutes 'significant'? (Hoekstra and Chapagain, 2008, p. 12)
f. What is the history and status of the methodological devel-	The basic approaches of the WF are bottom-up (item-by-item) or top-down (global) calculation. Some stakeholders have requested a more uniform methodology to calculate the

opment and adoption of the indicator (e.g. major revisions, current efforts, future plans/initiatives)?	WF of industrial products which are composed of other products requiring water consumption. The OPEN:EU project develops a multi-regional, input-output approach (MRIO) to calculate the Footprint.[30]
III. Data	
g. How is the underlying data gathered and by whom?	Trade data is used for calculating the global Footprint (the data stems from databases, such as FAO's). The EUREAPA uses data from the GTAP, which is a global network of researchers (see www.gtap.agecon.purdue.edu). Since it is a complete model of global trade, it is 'complete' in terms of the MRIO approach. Alternatively, the EXIOPOL data might be used in the future.
h. How accurate are the results (e.g. is the result an estimate, are there data gaps, imputations, assumptions, etc)?	In general, the WF is dependent upon the solidity of the data collected, which poses a risk to the accuracy of the results. The OPEN:EU project uses economic data which are complete for the MRIO analysis. However, Water Footprint data currently only includes agricultural sectors.
i. How often is the indicator recalculated/released? Have there already been any major indicator revisions?	There are different studies available that have calculated the national Footprint of different nations (i.e. Germany and UK). Due to the relatively recent introduction of the WF, there have not been any major indicator revisions. The OPEN:EU project develops a tool to easily calculate the WF also in relation to different policy options.
IV. Link to sustainable development	
j. Is there an operational definition of sustainability 'built-in' to the methodology?	No.
k. If yes, does the indicator measure 'strong' or 'weak' sustainability?	
l. Does the approach have numerical value(s) assigned to sustainability (e.g. thresholds/ irreversabilities below which a region/activity is not sustainable)?	No.
m. Please describe the key methodological links to highly related indicators (what exactly are the commonalities and differences among these indicators)?	The other members of the Footprint Family are similar in approach, information content and methodology. While the EF yields information of land appropriation and the CF yields information on CO_2-emissions (equivalents), the WF complements the picture with information on water consumption. However, the social/environmental impacts of water consumption are not the same everywhere, whereas CO_2-emissions do have the same effect everywhere—the WF is thus not as conclusive as the CF.
n. What are the key "bridging" links to	An example of a related social issue is the right to access water. In extreme cases, water is deviated from territories of

[30] For more information on the MRIO model, please see Hawkins et al., 2010; Hertwich and Peters, 2010; Galli et al., 2010.

other dimensions of sustainability (environmental, social, economic) and are there any explicit hybrid measures incorporating multiple dimensions in a single metric (e.g. GHG intensity—GHG emissions per unit of GDP).	indigenous people to allow extracting and processing metal ores by foreign multinational enterprises. If the Water Footprint was calculated for such an activity and put into relation with the available water in the region, some social conclusions on a fair access to the available resources could be drawn. There is an economic particularly a link to countries exporting agricultural products; in some cases, the link exists despite severe limitations in water availability (such as Israel).
V. Institutional Analysis	
o. Which institutions are currently using the indicator, and for which purposes?	The European Commission is considering using the WF more often when developing its water-related policies.
p. What are the driving forces and characteristics that affect institutional adoption (consider this question from the perspectives of political science, sociology and political economy)?	Institutional adoption of the WF is likely affected by suspicion about whether it has been calculated on the basis of solid data. Thus, WF stands a higher chance of being used when the calculation methodology and the calculation itself is transparent.
q. Are there links to international or European laws, conventions or agreements (this could range from an explicit legal requirement to a general policy concern)?	No.
VI. RACER Analysis	
Criteria and Sub-criteria	**Analysis**
Relevant	
POLICY SUPPORT	+ Conveys a broad picture of a country's level of water consumption (i.e. it is not constrained only to blue water); provides policy with the "hot spots". – The WF alone does not reveal all the important facts about water use and its impacts.
IDENTIFICATION OF TRENDS	+ Broad trends can be identified by comparing WFs from different years. – One should be extremely cautious when making claims about a WF trend; since water availability fluctuates within a year as well as across years, the particular time period when the data was chosen will affect the outcome. Varying water supply influences the fluctuation of water demand (Hoekstra and Chapagain, 2009, 14).
FORECASTING AND MODELLING	+ The WF reflects either the status quo or the status of a few years before (depending on data); it can be used for forecasting, but only to a limited extent. – Given major changes in consumption patterns (like a shift towards more meat or bio-energy), global-average WF data (spa-

	tiotemporal level A) can be useful for developing rough projections of future global water consumption. Spatiotemporal level B can provide a basis for understanding where hotspots in local watersheds can be expected. (Hoekstra and Chapagain, 2008, p. 13).
SCOPE/LEVELS OF APPLICATION	+ The WF can be calculated for different levels, ranging from single products (e.g. Spanish tomatoes) to single households or companies to a region/province/state up to the global level. Thus there is a broad range of scale: one stock-keeping unit of a particular brand, one particular sort of product, a whole product category, product(s) from one field or factory, one or more companies, or one or more production regions, one individual consumer, consumers within a municipality, province or state, boundaries, catchment, river basin, municipality, province, state or nation (Hoekstra and Chapagain, 2009, p. 11). The EUREAPA tool will, however, only be able to calculate national Footprints. + The degree of spatial and temporal detail (and concentration on a particular phase of the assessment) can be adjusted depending on the goals of the WF assessment – e.g. awareness raising, hotspot identification, policy formulation, quantitative target setting.
Accepted	
STAKEHOLDER ACCEPTANCE	+ The indicator (water consumption) is quite clear. – There are some methodological uncertainties for the calculation of the WF of industrial goods (composed of different input goods that also require water consumption). – The WF should be integrated with other Footprint indicators.
Credible	
UNAMBIGUOUS	+ The unit (m^3 water/capita/year for national Footprint) is clear. – The message of the WF will only be clear and conclusive if the WF is calculated in a transparent manner. – Some WF calculations only provide the added value of all water use (blue, green, grey) without splitting them up, which dilutes the informative value of the Footprint.
TRANSPARENCY OF THE METHOD	+ OPEN:EU develops its own methodology (multi-regional input-output). – There are different principal methods to calculate a nation's WF and the results are often conveyed without revealing the single steps of the calculation; this makes the result less transparent and dilutes its value.
Easy	
DATA AVAILABILITY	+ Different kinds of data are readily available; others are difficult to obtain. The EUREAPA tool to be developed in OPEN:EU will be based on data from GTAP, which is a global network of researchers (see www.gtap.agecon.purdue.edu). It is a complete model of global trade so in terms of the MRIO approach it is 'complete'. – General issue regarding the calculation of the WF of industrial products: "there are numerous categories of industrial products with a diverse range of production methods and detailed standardised national statistics related to the production and consumption of industrial products are hard to find" (Hoekstra and Chapagain, 2009, p. 48).
TECHNICAL FEASIBILITY	+ Different methodologies exist that feature different levels of technical difficulties. The OPEN:EU project has developed the MRIO methodology, which does not present any problems regarding technical feasibility.

COMPLEMENTARITY AND INTEGRATION	+	Stakeholders and scientists are trying to figure out how to best include different environmental impacts into the Footprint indicators so they can be incorporated (e.g. into food labels). The International Organization for Standardization has a project underway to tackle this problem. Water Footprint is the only indicator which aims to calculate the water consumption embodied in production. The OPEN:EU project is aimed at integrating the WF with the other Footprints.
Robust		
DEFENSIBLE THEORY	+	The WF is an indicator that can be applied to products, processes, companies, industry sectors, individuals, governments, populations, etc. It documents all fresh water consumption related to the production of goods and services. The unit of measure is m^3/capita/year (e.g. for national Footprint). The WF and its methodology are widely debated in scientific literature and are supported by a number of articles.
	–	However, it seems that only a small number of scientists, particularly from the Netherlands, deal with the WF in detail.
SENSITIVITY	–	In general, the water consumption data traditionally used for the calculation of the WF item-by-item relies on values from scientific literature or best-practice handbooks for different sectors. There is no routine updating of water consumption data aimed at producing a certain item like there is for CO_2-emissions. Thus, the Footprint calculation does not reflect changes regarding input data quickly.
	+	The EUREAPA tool is designed to help policy makers in evaluating policy changes with regard to water consumption. The tool allows for calculating the WF linked to policy changes. Thus, the indicator outputs change with respect to input parameters to recognise policy changes.
DATA QUALITY	+	There are some standard data sources, especially for food production (e.g. the FAO database) that can contribute to a coherent method of Footprint calculations.
	–	In general, the data needed for the WF calculation must be gathered by the administrator. There is no standard database to be used and it is up to the person calculating the WF to judge the reliability of the data used. This can be a problem. Inaccuracies and variations can lead to significant inconsistencies in the results. The EUREAPA tool developed by OPEN:EU will address this problem and provide all the data to calculate the WF of a nation.
RELIABILITY	+	The use of data sources and input variables while calculating the WF influences the value of the indicator. The calculation methods are documented in several scientific articles published in peer-reviewed journals. This indicates there is an open exchange among information between the researchers on the methodology, input data, etc. of the WF. The problem is the reliability of the data.
	+	The EUREAPA tool will use economic data from the GTAP, which is a global network of researchers (see www.gtap.agecon.purdue.edu). It is a complete model of global trade so in terms of the MRIO approach it is 'complete'. Environmental data is provided by the WFN.
COMPLETENESS	+	The WF is designed to calculate water use for production. Therefore, the indicator and its underlying methodology can be considered complete for water accounting. The indicator aims to reallocate responsibilities between the producers and the consumers of goods and services. Though the WF does not shift the burdens from the producers to the consumers, it sends comments on water consumption patterns, provides a basis for

	political decisions, shifts the responsibility for them to the national and international level. – The indicator is not suited to draw complete conclusions about the concrete environmental or social impact of the water consumption.
Summary appraisal	+ The new calculation method used within the OPEN:EU project improves the informative value and explanatory power of the Footprint indicators. This is particularly true if all three indicators are looked at together. – It is not yet clear who will be responsible for updating the data within the tool once the project has ended.
VII. Supplemental RACER policy analysis	
Policy Target	**Does the indicator reflect this target?**
CLIMATE CHANGE AND CLEAN ENERGY	No.
SUSTAINABLE TRANSPORT	No.
SUSTAINABLE CONSUMPTION AND PRODUCTION	Yes (water use).
CONSERVATION AND MANAGEMENT OF NATURAL RESOURCES	Yes (water).
PUBLIC HEALTH	No.
SOCIAL INCLUSION, DEMOGRAPHY, AND MIGRATION	No.
GLOBAL POVERTY AND SUSTAINABLE DEVELOPMENT CHALLENGES	Yes (water scarcity induces poverty).
INVESTMENT IN RESEARCH AND DEVELOPMENT	No.
UNEMPLOYMENT RATE	No.
How does the indicator help measure progress toward the policy targets (marked 'Yes' and 'Partially' above)? What are the advantages of using this indicator?	The WF evaluates total water consumption and provides insight into what kind of water has been consumed, where it was consumed and for what purpose. The information presented by the WF has to be further processed by concrete impact assessments and the sustainability of production in regard to water consumption has to be assessed politically. The integration of the Ecological, Carbon, and Water Footprint would certainly show improvements towards assessing the current state of sustainable development. However, this integration cannot provide a full sustainability assessment either.
What are the most important pitfalls of using this indicator as a measure of progress to the policy targets (marked	This depends on the policy target: for example, in the Water Framework Directive, policy targets were mostly directed towards water quality issues such as pollution. If this is the main policy objective, then the WF is not of much help.

'Yes' and 'Somewhat' above)?	If the policy target is to increase water efficiency of production and consumption or reduce water consumption in a certain region or country, then the WF can be a good indicator to monitor this policy.
VIII. Potential Links with Other Indicators	
What other indicators could be combined in a basket with the one in question to address specific policy challenges relevant to the EU policy framework?	Carbon Footprint, Ecological Footprint.
IX. SWOT Analysis	
Strengths	• Easy to understand (one parameter). • Conclusive by including green and grey water. • Conclusive by including direct and indirect water use. • Only Footprint indicator that addresses the issue of water consumption. • Applicable at various levels. • Related to policy objectives. • Can be compared with other indicators and uses a similar methodology and mode to present information as other indicators
Weaknesses	• Often lack of transparency. • Often based on subjective assumptions. • Oversimplification could lead to lack of clarity for policy makers. • In some studies, the distinction between Green and Blue Water Consumption is missing. • Further development of commonly accepted methodology is still needed. • Lack of distinction between sustainable and unsustainable water use.
Opportunities	• Relevance to EU water policy. • Improvements to data quality. • Independent review.
Threats	• Lack of specialised personnel and resources for large-scale take-up. • Use as a stand-alone indicator would be inadequate.

4.3. Carbon Footprint (CF)

The Carbon Footprint (CF) has been introduced by multiple authors since the year 2000, though a clear definition of it can be found for the first time in Wiedmann and Minx (2008): "The carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product" (Wiedmann and Minx, 2008, p. 4).

The CF measures the total amount of GHG emissions, both directly and indirectly caused by an activity or accumulated over the life stages of a product (goods and services).

Consequently, the CF can be calculated for activities of individuals, governments, populations, companies, etc. Furthermore, all direct and indirect emissions are included in the CF (see also Galli et al., 2010).

The RACER analysis of the Carbon Footprint (CF) has been conducted according to the methodology described in chapter 3.1 of this report. The summary of the analysis is provided in Table 3 at the end of this section. Next to assessing the indicator according to RACER criteria and sub criteria, the summary provides background information on the indicator, its brief institutional and policy analysis, as well as links to sustainable development and other indicators.

4.3.1. RELEVANT

Policy support, identification of targets and gaps

Is the indicator/methodology related to existing EU-specific policy objectives?

The CF indicator is directly related to the EU and international policies in the field of climate change and sustainable production and consumption.

In the field of sustainable production and consumption, the indicator relates to the goals expressed in the "Oslo Declaration on Sustainable Consumption" and the ten-year framework of programmes on sustainable consumption and production adopted during the World Summit on Sustainable Development in Johannesburg in 2002. The specific objective of the Declaration is "increased understanding of the consumption-environment connection", including "the environmental impacts of consumption in industrialised countries upon trading partners in developing nations" (Wiedmann et al., 2007, p. 16). Accounting of emissions embodied in trade is exactly the aim of the Footprint Family of indicators, including the CF.

The indicator relates to all national and international policies that aim at reducing GHG emissions from stationary and mobile sources. On the international level, it is the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol which bind all participating parties to reduce their emissions by 2012 compared to their level in 1990. The emissions accounting approach suggested in the Kyoto Protocol refers to territories. The shift of production to developing nations in the last decades reduced the GHG emissions of industrialised countries and increased GHG emissions in developing countries. A new approach to GHG emissions accounting based on CF would give more incentives to developing countries to join the UNCCC and Kyoto protocol, which would result in enhanced efforts to combat climate change.

A number of documents define the European Union's climate change and GHG emissions policy. The "Community Strategy to Limit Carbon Dioxide Emissions and to Improve Energy Efficiency" (Commission of the European Communities, 1991) was adopted in 1991 and was the first step towards an elaborated climate change policy. The Kyoto Protocol was ratified in 2002 by the EU Council Decision 2002/358/EC of 25 April 2002. The objective at that time was for EU-10 countries to reduce their GHG emissions by 8% by 2012 compared to their level in 1990. To support the goals of the Kyoto Protocol, the European Climate Change Programme (ECCP) was launched in June 2000 and introduced the Emission Trading System (ETS) as a mechanism to reduce GHG emissions from stationary sources. Emissions from transport, agriculture, housing and waste are regulated by the Effort Sharing Decision (European Parliament and Council of the European Union, 2009a).

Does the indicator provide guidance in monitoring, strategic policy making and/or target setting? Does it quantify gaps between the current situation and specified targets?

The CF could assist in formulating policy goals and targets for CO_2 and other GHG emissions on the European as well as the international level. The indicator complements the production-based accounting of GHG emissions used by GHG inventories which mostly look at the GHG emissions of a nation from a territorial perspective. Using CF as an indicator for GHG emissions would give a clearer picture of the real emissions caused directly and indirectly by a country's consumption. As a result, industrialised countries would potentially face the gap between the total GHG emissions produced by their consumption and the production-oriented emissions targets which they are obliged to meet under the Kyoto Protocol. Within the OPEN:EU project, the new methodology used to calculate the indicators is not only a measure of where the products are made but also of where they are consumed, thus considering the whole supply chain. Consequently, it can now be detected where GHG intensive products are consumed. For developing countries, where industries are increasingly moving to, the CF would indicate lower emissions since the consumption related emissions will mostly be allocated to industrialised countries. These potential outcomes would result in stronger GHG reduction measures and support developing countries' ratification of the Kyoto Protocol.

Does the indicator provide adequate early warning to guide policy action? Does it react to short-term changes that can (among other things) show whether policies are having an effect?

Most of the data needed for calculation of the CF, such as the National Environmental Accounts, is updated yearly. This means that the indicator is able to track changes in GHG emissions on a yearly basis, subject to corresponding updates in economic models used in calculation. As they are strongly related to climate change policies, changes in the CF over a period of time can also be linked to changes in related policies and measures. Moreover, the indicator would also reflect changes in the production and consumption patterns of developed and developing countries.

Identification of trends

Can the methodology/indicator be used to track changes through time? This implies that at least one input variable will require time series data (e.g. a series of annual measurements).

Basically, for the calculation of the CF three types of data are used: 1) national input-output tables, representing financial transactions between economic sectors within a country, 2) trade flow tables which track the export and import of goods between countries, and 3) sectoral data on GHG emissions. All three types of data are available for recent years. The data are yearly updated and can therefore be used to track changes through time.

However, the data that will be used for the OPEN:EU project is from 2004. Consequently, the EF as it will be used within the OPEN:EU project is not suitable to track changes over time.

Forecasting and modelling

Can the methodology/indicator be used in a predictive sense to forecast future environmental impacts from natural resource use or for more sophisticated modelling where the *impact of different potential policies or of technology progress and/or change of consumption patterns can be simulated? Can the indicator function as an early warning indicator?*

The EUREAPA tool (which calculates the CF) is an accounting tool, not a forecasting tool. It measures all GHG emissions produced throughout the supply chain of a product or service.

The EUREAPA tool developed within OPEN:EU will calculate the direct and indirect environmental impact of goods and services consumed in the EU by using data on what goods and services citizens from each of the 27 EU countries are buying (the current consumption profile) combined with data on where these goods and services are made and how efficient their respective production techniques are. In this regard, the CF can be used as an early warning indicator because it tracks changes in GHG emissions over a recent time period and provides a basis to analyse current unsustainable patterns and the potential need for additional measures.

Scope / levels of application

Does the indicator provide information relevant to the effective levels of application? Does it allow for disaggregation – either spatial, by product, by industry or by ecosystem type?

Provided the required data is available, the CF can be calculated for GHG emissions caused on different levels: from a household or a firm to a nation. Moreover, the indicator covers the emissions embodied in trade; it includes emissions caused by the production of imported goods and services and excludes those related to exports. This allows each producer and consumer to calculate their own CF.

4.3.2. ACCEPTED

Stakeholder acceptance

Is the underlying rationale and meaning of the methodology/indicator easily understood and accepted by stakeholder groups? Does the methodology/indicator resonate with widely held values and concerns to motivate stakeholders to calculate or provide data and accept interpretations of the meaning of the methodology/indicator?

The public can easily understand the main principle and meaning of the indicator. The indicator uses a consumption-oriented approach to GHG emission calculation. This could both promote and hinder the stakeholder acceptance of the indicator. Transferring the responsibility of GHG emissions to consumers would be accepted by developing countries where production has been shifted to in recent years. This positive aspect of the CF acceptance corresponds to the international goals of combating climate change. At the same time, the production-based approach currently used for GHG emissions accounting is favourable for industrialised countries in regard to the goals of the Kyoto Protocol. Industrialised countries, therefore, might not be willing to accept a new indicator that would make them responsible for the emissions related to the production of exported goods from developing countries.

4.3.3. CREDIBLE

Unambiguous

Is the indicator suited to conveying a clear, unambiguous message? Does it allow for clear conclusions to guide political action? Does it actually provide the information that non-experts believe it does?

The concept of the CF indicator is easy to understand. It simplifies, for example, to what degree one country's consumption is responsible for GHG emissions in other countries. The indicator does not imply any policy-related message or recommendation. Rather, it suggests an alternative accounting approach to GHG emissions. CF, however, does provide important information to aid GHG emission-related political decisions on both the national and international level. By identifying hot spots and unsustainable consumption patterns and trends, consumption-based GHG accounting can help design strategies for sustainable consumption and production, as well as climate change mitigation and adaptation policies at the national, regional and local level.

Transparency of the method

Are the underlying data and calculation methods fully disclosed, interpretable and reproducible?

Two approaches to CF calculation (i.e. to calculate the emissions embodied in trade, EET) are currently available in the literature: 1) generalisation of environmental input-output analysis (IOA), and 2) multiregional input-output (MRIO) models (see Peters and Hertwich 2008). The IOA evaluates the domestic CO_2 emissions that are necessary in one country in order to bilaterally trade with another country, a simple and transparent method. The more complex MRIO model evaluates how many global emissions are necessary anywhere throughout the supply chain for a final consumption in one country (Peters and Hertwich 2008.). For the OPEN:EU project the more complex approach of MRIO model will be used (for more information on the MRIO model, please see Hawkins et al., 2010; Hertwich and Peters, 2010; Galli et al., 2010). The steps of CF calculation are clearly identified and documented (Peters and Hertwich 2008, Peters 2008).

Within the OPEN:EU project, the CF will be fed into the EUREAPA tool, which will automatically run calculations for the user. On the one hand, this allows the tool to be easily used. On the other hand, the calculations are not transparent because the tool does them itself.

4.3.4. EASY

Data availability

Does the methodology/indicator work without inputs of data that are overly excessive, expensive or onerous to collect, or that cannot be properly measured? Ideally, is it based on data that are already collected and readily available in electronic form?

Generally, a range of data already collected by national and international organisations can be used for calculating the CF. In particular:

- National economic accounts indentifying financial transactions between producing and consuming entities (supply, use, input-output tables) can be obtained from national statistics offices.

- International trade statistics showing bilateral trade in goods and services in monetary (and possibly physical) units.
- Environmental accounts data by economic sector and country for different types of GHG emissions. On the supranational level, these environmental accounts are available from the IEA and the GTAP. National environmental accounts provide more sectoral data.

However, since the CF will be incorporated in the EUREAPA tool within the OPEN:EU project, the user does not need to collect any data. The tool is fed with data and allows the user to compare the effect of different policies.

Technical feasibility

Is the methodology simple enough to be carried out using software and expertise appropriate to the scale of application and the typical capabilities of the institution doing the calculations?

Since the EUREAPA tool undertakes the calculation for the user, it ensures technical feasibility. The user does not need any technical expertise; he or she can simply use the online tool.

Are the input and the calculation methodology clearly defined to avoid ambiguity and consequent error in implementation?

Basically, calculation of the CF involves numerous steps which are sufficiently documented (also within the OPEN:EU project) and, therefore, reproducible (see Peters 2008, Peters and Hertwich 2008, also 4.3.3.2 "Transparency of the method" and 4.3.5.4 "Reliability").

Since the EUREAPA tool undertakes the calculation for the user, the user is not undertaking the implementation by him- or herself. Consequently, no errors can occur in this regard.

Complementarity and integration

Are there potential complements between the methodology/indicator and the others being assessed?

CF is the only indicator within the Footprint Family which aims at calculating all the GHG emissions embodied in trade (the EF only calculates CO_2 emissions and then translates them into area equivalents). A similar conceptual approach is used in the WF Indicator. In regard to EF, there is a similarity in name, but the conceptual and methodological background of the indicator is completely different from the one used within OPEN:EU. While the CF includes all GHG emissions, the EF translates the amount of CO_2 emitted into the amount of productive land and sea area required to sequester these CO_2 emissions.

Is there the potential for further integration of the methodology/indicator with the others?

The CF indicator can be further integrated with the other Footprint indicators, the EF and the WF. The three indicators of the Footprint Family complement one another in assessing different aspects of human impact on the planet. The EF focuses on the aggregate demand that resource-consumption places on the planet's ecological assets, thus recognizing the existence of limits to growth and trying to measure them. The WF focuses on the human appropriation of 'natural capital' in terms of the water volumes required for human consumption; it is primarily intended to illustrate the hidden links between consumption activities and water use. Finally, the CF focuses on the total amount of GHG emissions released due to resource-consumption activities by complementing the production-based accounting approach taken by national GHG inventories; the CF provides a better understanding of human contribution to climate change. It is one of the objectives of OPEN:EU to integrate the three indicators and facilitate the use of the Footprint Family.

4.3.5. ROBUST

Defensible theory

Is the methodology/indicator based on sound theory? Does it avoid double counting or omissions of resources used? Is it consistent in its units of measure? Does it rely on assumptions that are clearly stated and reasonable? Does it avoid the use of ill-defined or poorly quantified parameters? In cases where subjective weighting cannot be avoided, is it justified and made explicit?

The research question to be answered by the indicator is "Which is the total amount of GHG emissions (CO_2, CH_4, N_2O, HFC, PFC, and SF_6) that are directly and indirectly caused by human activities or accumulated over the life stages of products?" The CF indicator answers this question by calculating the GHG emissions caused by both production and consumption, thus tracking the entire supply chain throughout the economy. CF is a multi-dimensional indicator that can be applied to products, processes, companies, industry sectors, individuals, governments, populations, etc. It documents all direct and indirect GHG emissions due to the use of resources and products (including goods and services). The unit of measure is kg or t of CO_2 or CO_2-equivalent (when other GHGs are included in the accounting). The CF indicator and its methodology are widely debated in the literature and supported by a number of articles (Lenzen et al. 2007, Wiedmann et al. 2007, Peters 2008, Peters and Hertwich 2008, Hertwich and Peters 2009). There are several approaches to the calculation of CF: a more simple national environmental input-output analysis (IOA) and a more complex multi-regional input-output (MRIO) model. The use of different approaches results in different indicator values. Within the OPEN:EU project, the calculation methodology for the CF is robust and clearly defined, even though the methodology still has some shortcomings.[31]

Sensitivity

Do the values of the indicator outputs change rapidly enough with respect to input parameters to pick up policy-significant changes?

The CF values are sensitive to changes in input variables. The input variables are updated on a yearly basis. However, setting up and updating a system of MRIO tables and related environmental extensions is a complicated and time-consuming task. Therefore, CF should be used as a long-term indicator, rather than an indicator to track short-term changes. Although the indicator is not directly linked to policy changes, these might have significant impact on the input variables for CF calculation and on the value of the CF. Therefore, it might be possible to analyse the effects of policy changes on the CF.

[31] See Hawkins et al., 2010; Hertwich and Peters, 2010; Galli et al., 2010.

Is the methodology suited to detect non-linearities, discontinuities and thresholds?

One of the most acknowledged environmental thresholds is the 2 degree limit for global warming. Global GHG emissions can be evaluated from the perspective of this environmental target. The CF can help operationalize and monitorthis global objective if "CF budgets" are allocated to different countries and world regions. The CF allows assessing whether countries are exceeding their "carbon budget" or still have room to increase GHG emissions.

Data quality

Is the underlying data of sufficient quality so that data lead to correct results? Could inaccuracies and variations within the uncertainty margin lead to opposite findings and conclusions?

The data needed for a CF calculation is collected in most industrialised countries and in many developing countries (see Peters and Hertwich 2008, p. 1403.). It is, however, a difficult task to make all the data compatible and comparable. At present (August 2010), the GTAP database is used. It contains the data necessary for the CF calculation. The databases provide data for 87 countries and 57 industry sectors. In spite of extensive coverage, the GTAP data might not be of the highest quality and should, therefore, be carefully treated:

> "The data are often from reputable sources, such as national statistical offices. Unfortunately, due to the voluntary nature of data submissions, the data are not always the most recently available. Further, once the original data has been received "[GTAP] make[s] further *significant* adjustments to ensure that I[nput]-O[utput] table matches the external macroeconomic, trade, protection, and energy data". These adjustments (or calibrations) are made for internal consistency and are of unknown magnitude" (Peters and Hertwich 2007, p. 1403).

Due to these constraints, the data used for the OPEN:EU project may also stem from the EU project EXIOPOL. However, the final decision is to be taken during the course of the project.

Reliability

Is the methodology/indicator reliable in terms of its accuracy, repeatability, and the clear specification of protocol and formulas used in the calculations? Are all details of calculation openly exchanged among researchers in order to avoid different standards?

The data sources and input variables used to calculate the CF can influence the value of the indicator. The calculation methods are documented in several scientific articles published in peer-reviewed journals. This indicates an open exchange between researchers about the CF methodology, input data etc.

Completeness

Is the indicator/methodology complete in terms of the safeguard object it is assessing (e.g. natural environment, human health, future resource availability)? Is a shifting of burdens avoided among single problems/impact types (e.g. from climate change to nuclear risks), among the safeguard subjects (e.g. from human health to the natural environment) and among regions (e.g. relocation of production may shift environmental burden away from the place of consumption)?

The CF is designed to calculate all direct and indirect GHG emissions from all types of sources. Therefore, the indicator and its underlying methodology can be considered complete for GHG accounting. The indicator aims at reallocating responsibilities between the producers and consumers of goods and services. Although CF does not shift the burdens from producers to consumers, it informs about them about (un)sustainable consumption patterns and provides a basis for political decisions. It furthermore shifts the onus of responsibility from the individual or sub-national level to the national and international level.

4.3.6. SUMMARY OF RACER ASSESSMENT

Table 3 summarises the key findings of the CF's RACER assessment and provides a scoring of how well it fulfils each criteria and sub-criteria.

Table 3: Summary of RACER assessment of the Carbon Footprint

I. Indicator Summary	
Name of indicator	Carbon Footprint (CF)
Indicator category (economic, social, environmental)	Environmental
Name of person providing evaluation	Nataliya Stupak (with input from Doris Knoblauch)
Date	April and August 2010
II. Background information on the indicator	
a. What is the official definition of the indicator?	CF is a measure of the total amount of GHG emissions that are directly and indirectly caused by an activity or are accumulated over the life stages of a product.
b. Unit(s) of measurement of the indicator	Kg CO_2. Other GHGs (CH_4, N_2O, HFC, PFC, and SF_6) are measured in kg CO_2-e(quivalent).
c. What does the indicator seek to measure?	The indicator measures the emissions of six GHGs identified by the Kyoto Protocol (i.e. CO_2, CH_4, N_2O, HFC, PFC, and SF_6). The GHG emissions include those taking place within the geographical borders of the EU, as well as those in third countries caused by the EU consumption.
d. Provide a brief history of the indicator. Which organization or body originally proposed the indicator (and in what year)? Which organizations currently advocate for the indicator's use?	CF was originally calculated as a component of EF but eventually began to be used independently. Literature differentiates between primary and secondary CF. Primary CF calculates CO_2 emissions from burning fuel. Secondary CF calculates GHG emitted during the whole product life-cycle.
e. What are the known limitations of the indicator?	The CF looks only at one dimension of human impact on the environment (GHG emissions). The current CF calculation tools only allow for ex-post analyses.
f. What is the history and status of the methodological development and adoption of the indicator (e.g.	Two approaches for calculating the CF are currently available: generalisation of environmental input-output analysis (IOA) and life-cycle assessment (LCA) and multi-regional input-output analysis (MRIO). The project's objective is to allow ex-ante analysis of GHG

major revisions, current efforts, future plans/initiatives)?	emissions, as well as a more complete accounting of human impact on the environment by integrating the CF with other Footprint indicators (Ecological and Water) to be used as a basket of indicators.
III. Data	
g. How is the underlying data gathered and by whom?	CF calculation requires: • National economic accounts available from Eurostat, OECD and GTAP. • International trade data available from UN, OECD and GTAP. • National environmental accounts providing GHG emissions data on the level of economic sectors.
h. How accurate are the results (e.g. is the result an estimate, are there data gaps, imputations, assumptions, etc)?	The accuracy of the results depends to a large degree on the quality of the input data. At the same time, data quality is one of the main concerns regarding the CF methodology. Therefore, the input data and the CF values should be carefully treated.
i. How often is the indicator recalculated/released? Have there already been any major indicator revisions?	Up to now there were several attempts to calculate CF (Peters and Hertwich 2008, Hertwich and Peters 2009). So far, no researcher or institution provides the calculation or update of the CF on a regular basis.
IV. *Link to sustainable development*	
j. Is there an operational definition of sustainability 'built-in' to the methodology?	No.
k. If yes, does the indicator measure 'strong' or 'weak' sustainability?	-
l. Does the approach have numerical value(s) assigned to sustainability (e.g. a thresholds/ irreversabilities below which a region/activity is not sustainable)?	No.
m. Please describe the key methodological links to highly related indicators (what exactly are the commonalities and differences among these indicators)?	The WF indicator is similar to the CF in principle and methodological approach but it is established for water resources. EF has a similar name, but it looks at the human demand on nature expressed in global hectares. One aspect of the CF is included in the EF: CF translates the amount of CO_2 into the amount of productive land and sea area required to sequester CO_2 emissions, therefore, using a completely different methodology in the calculation.
n. What are the key "bridging" links to other dimensions of sustainability (environmental, social, economic) and are there any explicit hy-	As a component of the Footprint Family of indicators, CF contributes to a thorough analysis of the impact that human production and consumption exert on the environment; CF does so by analysing the atmospheric component of that pressure.

brid measures incorporating multiple dimensions in a single metric (e.g. GHG intensity—GHG emissions per unit of GDP).	
V. ***Institutional Analysis***	
o. Which institutions are currently using the indicator, and for which purposes?	CF is a relatively new indicator; it was developed and applied mostly by research institutes. Outside science, the indicator is not broadly used.
p. What are the driving forces and characteristics that affect institutional adoption (consider this question from the perspectives of political science, sociology and political economy)?	The indicator compliments the Kyoto Protocol's production-based approach of GHG emission accounting of. If the international community adopted the CF into the accounting approach used within the Kyoto Protocol, it would consequently benefit international climate change goals by providing heavily industrializing developing countries with an incentive to join international efforts towards GHG emissions reductions. At the same time, industrialised countries might not be eager to support the indicator's adoption because the responsibility for GHG emissions would be shifted to consumers, most of whom are concentrated in the developed nations.
q. Are there links to international or European laws, conventions or agreements (this could range from an explicit legal requirement to a general policy concern)?	The indicator has direct links to the international and the EU climate change policies aimed at reducing direct and indirect GHG emissions from all sources.
VI. ***RACER Analysis***	
Criteria and Sub-criteria	**Analysis**
Relevant	
POLICY SUPPORT	+ The indicator supports EU and International climate change policy. – The indicator does not provide policymakers with ready policy decisions or concrete recommendations.
IDENTIFICATION OF TRENDS	+ The indicator makes it possible to track changes in GHG emissions over time.
FORECASTING AND MODELLING	+ The indicator could be used to identify unsustainable consumption patterns and serve as an early warning. – If scenarios of future consumption and production were available, it would not be possible to make them precise and detailed enough to calculate the future CF.
SCOPE/LEVELS OF APPLICATION	+ CF can be calculated for GHG emissions caused on different levels: from a household, firm or nation.
Accepted	
STAKEHOLDER ACCEPTANCE	– Developing countries would likely agree to transfer the responsibility of GHG emissions to consumers. Industrialised countries might oppose the use of the indicator because it increases their responsibility for GHG emissions.

Credible	
UNAMBIGUOUS	+ The concept and principle of the CF indicator is easy to understand. – The indicator does not imply any policy-related message or recommendation. However, it provides important information to support political decisions at both the national and international level.
TRANSPARENCY OF THE METHOD	+ The precise methodological steps for CF calculation will be developed to be used within the OPEN:EU project. – In general, several approaches to CF calculation exist.
Easy	
DATA AVAILABILITY	+ A vast amount of the data needed for calculating the CF is being collected in developed and developing countries. – Some data is being collected on a voluntary basis and might not be recent.
TECHNICAL FEASIBILITY	– Substantial effort is needed to set up and update a system of MRIO tables and related environmental extensions.
COMPLEMENTARITY AND INTEGRATION	+ The CF indicator can be further integrated with other Footprint indicators, the Ecological and WFs. The three indicators of the Footprint Family complement one another in assessing human pressure on the planet.
Robust	
DEFENSIBLE THEORY	+ The CF can be applied on different scales as well as to products, processes, companies, industry sectors, individuals, governments, populations, etc. It documents all direct and indirect GHG emissions due to resource use and products (including goods and services). – The use of different approaches results in different values for the indicator.
SENSITIVITY	+ The CF values are sensitive to changes in input variables. – It is a complicated and time-consuming task to set up and update a system of MRIO tables and related environmental extensions. Therefore, the CF should rather be considered as a long-term indicator.
DATA QUALITY	– It is a considerable task to convert data from single countries into a consistent global data set. As a result, data accuracy might be under question and affect the results of the CF calculation.
RELIABILITY	+ Researchers openly exchange the methodology of the CF calculation and the sources and types of input data.´ – The use of different approaches and data sources for the CF calculation might significantly influence the value of the indicator.
COMPLETENESS	+ The CF is designed to calculate all direct and indirect GHG emissions from all types of sources.
Summary appraisal	+ The new calculation method used within the OPEN:EU project improves the informative value and explanatory power of the Footprint indicators. This is particularly true if all three indicators are looked at together. – It is not yet clear who will be responsible for updating the data within the tool once the project has ended.
VII. *Supplemental RACER policy analysis*	
Policy Target	**Does the indicator reflect this target?**

CLIMATE CHANGE AND CLEAN ENERGY	Yes.
SUSTAINABLE TRANSPORT	Yes.
SUSTAINABLE CONSUMPTION AND PRODUCTION	Yes.
CONSERVATION AND MANAGEMENT OF NATURAL RESOURCES	Partially.
PUBLIC HEALTH	Partially.
SOCIAL INCLUSION, DEMOGRAPHY, AND MIGRATION	No.
GLOBAL POVERTY AND SUSTAINABLE DEVELOPMENT CHALLENGES	No.
INVESTMENT IN RESEARCH AND DEVELOPMENT	Partially.
UNEMPLOYMENT RATE	No.
How does the indicator help measure progress toward the policy targets (marked 'Yes' and 'Partially' above)? What are the advantages of using this indicator?	The indicator measures the GHG emissions and can track the changes in GHG emissions caused by consumption. In this way, the indicator can measure the progress towards the goal of sustainable consumption and production, as well as the goal to significantly reduce GHG emissions.
What are the most important pitfalls of using this indicator as a measure of progress to the policy targets (marked 'Yes' and 'Somewhat' above)?	The CF should not be used alone but with a basket of indicators. Applying the CF only could lead to a situation in which the CF performance improves but other resource use categories are worsened. This could be the case with biofuels, Carbon Dioxide Capture and Storage (CCS) technologies, nuclear energy, etc.
VIII. *Potential Links with Other Indicators*	
What other indicators could be combined in a basket with the one in question to address specific policy challenges relevant to the EU policy framework?	The CF can be further combined with the Ecological and WF indicators in a Family of Footprint indicators, which is one of the objectives within the OPEN:EU project. The Footprint Family is able to allow for the identification of possibilities to reduce GHG emissions without simply shifting the pressure to another category (be it water and land in the case of biofuels or non-renewable resources in the case of CCS and nuclear, etc.). The basket thus allows for the identification of "real" solutions and ensures that problems not be simply shifted around.
IX. SWOT Analysis	
Strengths	• Easy to understand. • CF can take into account all direct and indirect GHG emissions.

	• Robust methodology. • Applicable at various levels.
Weaknesses	• CF is not directly linked to policy changes. • CF should not stand alone.
Opportunities	• Opportunities to improve data quality and availability. • Could further EU policy goals (related to climate change).
Threats	• Lack of standard, transparent methodology. • Its use as a stand-alone indicator would be inadequate. • Since submissions are voluntary, GTAP data might not be of highest quality.

5. SWOT Analysis of Footprint Indicators

The SWOT analysis is a tool to identify strengths, weaknesses, opportunities and threats (in this case) of the Footprint indicators.

5.1. Ecological Footprint (EF)[32]

5.1.1. STRENGTHS

Easy to understand. The EF is easy to understand since it provides a single number to present the complex relationship between consumption and production across multiple types of resource use and at multiple scales. It is widely agreed upon among supporters and critics that summarizing these aspects provides a useful communication/education tool (Giljum et al. 2007).

Relates resource use to carrying capacity. The EF measures resource use and related demand for biocapacity as compared to the earth's carrying capacity. It furthermore links resource use to final consumption; by these means, for example, energy impacts generated to produce a traded good are attributed to the consumer country rather than the producer country (Lenzen et al., 2007). Furthermore, trade data that attributes traded goods to both the consumer and producer countries has been incorporated into the EF through the United Nations Commodity Trade Statistics (COMTRADE) data (Dige, 2006 and Wackernagel et al., 2005). The EF focuses primarily on energy and land use, and is generally sensitive to variables related to individual life-style choices (e.g. diet, transportation, housing).

Comparable over time and among countries. Generally, the EF is comparable over time and among countries, measuring resource use based on global time series data (Giljum et al., 2007). Although EF results themselves are independent of moral judgements, the EF is particularly well suited as an indicator for global environmental justice (e.g. by relating a country's resource use to its own biocapacity, or relating a nation's per-capita EF to the global average per-capita EF). However, the data that will be used within the OPEN:EU project will not be updated annually. Consequently, it will be difficult to compare the EF over time since there is only a limited time series available for comparison.

Related to policy objectives. The EF is related to various policy objectives and could be useful in setting targets to achieve sustainability goals (e.g. ensuring that human production and consumption activities are kept within the ecological boundaries of the planet; achieving a de-coupling between economic growth and resource use / use of biocapacity; reducing environmental impacts from resource use (except for monitoring abiotic resources and most emission sinks)).

Increased data standardisation and methodological improvements. There is increased focus on data standardisation and methodological improvements to the EF calculation. A research agenda to improve National Footprint Accounts calls for sensitivity analysis of the global data sets and independent review of the EF statistics (Kitzes et al. 2009). The global network of partners is dedicated to making the indicator more user friendly, while at the same time ensuring that the relationship between consumption and ecological impacts is based on the best-available data and scientific theory.

[32] The SWOT analysis of the EF is based on Best et al. 2008.

5.1.2. WEAKNESSES

The category 'outside the scope of the Ecological Footprint' covers aspects that are only indirectly included or not included at all in the calculation, and should therefore be covered by complementary indicators.

Oversimplification could lead to lack of clarity for policy makers. The strength of the EF as a simple, single-number indicator is also a potential critical weakness. Experts see the value of the EF as limited to the accounting and communication of over-consumption (see Wiedmann/Barrett 2010, p. 1646f). Furthermore, the EF is limited in its scope since it does not provide information on when ecological limits might be reached related to key ecological services. These simplifications need to be communicated clearly.

Use of global hectares makes 'real' impacts difficult to determine. The EF does not provide information on impacts that can be tied geographically to actual land use. The calculation is based on a 'global hectare' unit, which abstracts from actual land use in order to allow the aggregation of the Footprint at multiple scales. This abstract unit makes it difficult to show the actual environmental impacts of an activity. Consequently, the EF is not a tool that would make it possible to locate any specific impacts in space.

Data quality / gaps and lack of compatibility with existing databases. The majority of data used to calculate the EF stem from UN statistics. Nevertheless, there are still data inconsistencies that need to be better understood. Some of these inconsistencies come from differences in how these data are being collected by countries. Concerning the data used within the EUREAPA tool, either the GTAP or the EXIOPOL data will be used. GTAP data are available for 2004.

Lack of data on traded goods. Until recently, it was not possible to consider the energy impacts of traded goods in the exporting country. Instead, the calculation attributed all impacts to the importing country only. While this method follows the principle of linking resource demand to final consumption, it does not accurately tie the impacts to the biocapacity of the region producing the traded goods. Therefore, of the main goals of the OPEN:EU project is therefore to eradicate this data gap by applying the more complex MRIO model.

Lack of data on tourism. There is a lack of data on tourism renders it necessary to attribute tourism impacts to the visited country, rather than the home country of the tourist. Global Footprint Network recognizes this as a methodological inconsistency (Kitzes et al., 2009).

Difficulties in measuring specific aspects. The current EF does not show a significant overshoot

- of fisheries yields: as of now, this data is not readily available, thus the calculation is based on single-year estimates from the FAO (Kitzes et al., 2009).
- of cropland impacts: while growth yield for forests is determined by natural productivity, this is not the case for cropland. The accounting convention fails to detect unsustainable agricultural practices that may lead to high yields in the short term at the price of long-term degradation of soils and ecosystems (Kitzes et al., 2009).
- of waste flows: in cases where relationships are unclear (e.g. SO_x emissions from power plants that result in acid rain) or data do not exist, the particular waste

flow is excluded, thereby underestimating the EF as compared to biocapacity (Dige, 2006).

Outside the scope of the Ecological Footprint (indirectly included or not included at all in the calculation)

Many aspects of resource use are indirectly addressed in the calculation. These aspects include the following:

- Non-renewable resources (e.g. oil, natural gas, coal, and metals and minerals) are not directly measured. Energy use is only measured indirectly by calculating the area of forest land required to sequester the equivalent amount of CO_2 emissions. Metals and minerals are only covered by the amount of energy (and corresponding land area) used in extraction, processing and use of these non-renewable resources.
- Freshwater resources are only measured indirectly through declining bioproductivity, which is included in the calculation of the amount of available biocapacity.
- Biodiversity is not explicitly considered in the Footprint because it is not directly related to consumption and production. In summary, calculations with the EF do not illustrate the amount of land (and water) areas that would need to be conserved in order to maintain (or even increase) biodiversity. Early studies of the EF at the national level reserved an area of 12% of the total biologically productive area as conservation area for biodiversity. This assumption was ignored in later studies since setting land aside for biodiversity is a political decision and is outside the scope of the original research question that the EF addresses.

  However, in recent years the EF has been officially included in the list of indicators that the Biodiversity Indicator Partnership (BIP) is using to monitor world governments' progress toward the 2010 biodiversity target set by the CBD in 2002. The BIP approaches biodiversity with a Pressure-State-Benefit-Response framework. The EF is one of the indicators of pressure officially used and is thus related to the biodiversity issue in that it is a measure of the human pressure on ecosystems and biodiversity, and time series EF assessments constitute a way to measure how this pressure is changed over time.

Many aspects of resource use are not included in the calculation. The EF is designed to compare human consumption of biological resources against nature's supply of those resources; it is not intended to measure specific environmental impacts. Those aspects that are not addressed at all in the EF are outlined below:

- Non-productive ecosystems (i.e. deserts and icecaps) are not included because they do not have anthropocentrically defined biocapacity.
- Coastal estuaries and wetlands are not considered in the Footprint primarily due to lack of data; however, because they represent such a small percentage of the Earth, their contribution to overall biocapacity is not considered significant (Giljum et al., 2007). Human activity in these critical ecosystems can have significant environmental impacts.
- Toxic substances (e.g. PCBs, dioxins, etc.) are excluded from the EF calculation because their impact is not directly tied to a quantifiable land area and, in addition, would render the calculation meaningless if the time needed to assimilate these chemicals were incorporated on a human timescale (Dige, 2006).

- Future biocapacity is not considered, rather the EF focuses on the present relationship between consumption and production, which can be compared with previous EFs to show overall trends.
- Social aspects of sustainability, such as, health, social equity, and quality of life, are not considered in the EF. The EF is not intended to be an indicator of social, economic and political aspects of sustainability; rather it is designed as an indicator to measure humans' overall consumption of biological resources and compare it to the Earth's regenerative capacity.

5.1.3. OPPORTUNITIES

Relevance for strategic policy-makers. The EF is relevant for various EU policies, such as the EU Sustainable Development Strategy, the EU Environmental Action Plans or the EU Thematic Strategy on Resource Use. However, included in the EUREAPA tool there is the opportunity of delivering added value for strategic policy makers since the tools allows for comparisons between the effects of different policy options.

5.1.4. THREATS

Lack of unbiased, high-quality data. In order to be useful to government, the EF needs to be unbiased and rely on the best-available high-quality data. Global Footprint Network is making multiple efforts to create lasting collaboration between NGOs and government in order to improve underlying data sources and improve the methodology for specific resource use (e.g. fisheries yields and traded goods). It is important to note that at the global level, differences exist in data collection among countries. Eurostat can help ensure that similar underlying data is used for countries within the European Union and EFTA countries.

Use as a stand-alone indicator would be inadequate. Although the EF conveys an effective and simple message on its own, it is important to consider the EF within a 'basket of indicators' to ensure that the full range of ecological and social aspects of resource use are considered.

Table 4: Summary of key findings from SWOT analysis for the Ecological Footprint

	Helpful to achieving policy objectives	**Harmful to achieving policy objectives**
Internal attributes of the Ecological Footprint	**Strengths** Easily understood by the public. Condenses many aspects of resource and land use into one indicator. Can be applied at multiple scales.	**Weaknesses** Lack of transparency (e.g. calculations are not always reproducible). Data quality problems and some underlying assumptions are controversial. Oversimplification could lead to lack of clarity for policy makers. Several environmental impacts not included.
External conditions for developing strengths and overcoming weaknesses	**Opportunities** Relevant for strategic policy-makers when included in the EUREAPA tool.	**Threats** Need for high-quality, unbiased data. Needs to be used within a 'basket of indicators'. Resources needed to improve methodology and implement it.

5.2. Water Footprint (WF)

5.2.1. STRENGTHS

Further development vis-à-vis conventional water statistics ("indirect water use"): Traditionally, statistics on water use focus on measuring 'water withdrawals' and 'direct water use'[33], i.e. blue water. The WF accounting method takes a much broader perspective. First of all, the WF measures both direct and indirect water use; the latter refers to the water use in the supply chain of a product. The WF thus links final consumers and intermediate businesses and traders to the water used throughout the whole production chain of a product. This is relevant because the direct water use of a consumer is generally small if as compared to their indirect water use, and the operational water use of a business is generally small as compared to the supply-chain water use. So, the picture of actual water dependency of consumers and businesses can change radically. The WF method further differs in that it looks at water consumption (as opposed to withdrawal); here, consumption refers to the part of water withdrawal that is lost through evaporation, i.e. the part of water withdrawal that does not return to the system from which it was withdrawn. Furthermore, the WF goes beyond looking at blue water use only (i.e. use of ground and surface water). It also includes a green WF component (use of rainwater) and a grey WF component (polluted water). Thus, it integrates water use and pollution over the complete production chain.

One clear parameter. The WF provides a single value (fresh water consumption) to represent the complex relationship between consumption and production across multiple types of resource uses and at multiple scales.

Comparable over time and among countries. The WF is also comparable over time and among countries, measuring resource use based on global time series data. In the OPEN:EU project, a tool is developed that is already equipped with the data necessary to calculate the WF. Policy Makers only need to insert a few policy-related variables to see what impact on the WF a policy change or modification would have.

Applicable at various levels. While the analyses in the OPEN:EU project focus on national and multiregional WFs, one major strength of the WF is that its approach can generally also be applied to products, single households or companies.

In accordance with policy objectives. One of the core political and environmental objectives of the European Union is to address water scarcity and droughts. A nation's WF gives insight into the level of water consumption from the production of goods and services and thereby is an indicator measuring a nation's efforts in water productivity and efficiency.

In order to draw all relevant conclusions from the information that the WF provides, on-site impact assessments have to be carried out when it comes to assessing the concrete environmental and social impacts of water use for a specific production process.

Can be compared with and is similar in methodology and information to other indicators. The Water Footprint concept is part of a larger family of concepts that have been developed in the environmental sciences over the past decade. The EF is a measure of the use of bio-productive space (hectares). The CF measures the amount of GHGs produced, using CO_2 equivalents (in kg or t). The WF measures water use (in cubic metres per year). These three indicators are complementary since they measure completely

[33] See http://www.waterFootprint.org/?page=files/FAQ_Technical_questions, retrieved 3 August 2010.

different environmental aspects related to human natural resource use. Methodologically, there are many similarities between the different Footprints, but each has its own peculiarities with regards to the uniqueness of the subject considered. The importance of specifying space and time is the most typical for the WF. It is necessary because the availability of water varies highly across space and time, so that water appropriation should always be considered in its local context.[34]

Addresses the world-wide environmental implications of local economic activity. Similar to the concept of the EF, the WF focuses on water consumed for the consumption of goods and services within a defined geographic area (can be a country, but also a region or a city), also considering the water consumption outside a country caused by the demand of products in the country concerned. This makes the WF particularly well suited to address the global impacts of a certain industry or consumer group.

5.2.2. WEAKNESSES

Lack of transparency. In order to be reliable, the calculation method on which the WF is based has to be made transparent. Often, WFs are conveyed without revealing the method or concrete calculation process behind it.

Also, the calculation of the WF often relies on data that are not standardised for use by the WF. The data upon which the calculation is based is often not made transparent and thus the quality of the calculation is hard to assess. This weakness will be improved by the methodology chosen in the OPEN:EU project based on an input-output analysis and the use of economic data robust sources and water consumption data from the UN Food and Agriculture Organisation.

It will be difficult for policy makers to develop objectives based on the results of the WF. Also, the concrete impacts of water consumption are not the same everywhere; such impacts also depend on whether green or blue water is consumed. The green, blue and grey WF should be documented separately. Thus, the WF is not easy to interpret.

Differences in data use and assumptions. In order for governments to adopt the WF as an official statistic, it is crucial that the indicator be science-based and objective. WF results are affected by data sources, choice of input variables and the methodologies chosen for calculating certain factors. Elaborately calculated WFs based on the item-by-item method, i.e. finding out the water consumption required by the production of the products consumed in a country, is especially vulnerable to data faults. As the choice of data sources will arguably affect the results of any indicator, it is important that these choices be transparent and consistently adopted. Further, some of the WF calculations are under-documented. These procedures would need to be more thoroughly documented and tested to ensure that they meet the validity criteria of governmental statistical offices. Assumptions need to also be carefully documented and, in some cases, revised.

The OPEN:EU tool, based on the input-output methodology, uses data from the GTAP.

Oversimplification could lead to a lack of clarity for policy makers. The strength of the WF as a simple, single-number indicator is also a potential critical weakness. The underlying accounting concept, including the boundaries of the system to be analysed and the reasons why certain aspects of resource use are included and others are not, is far less well known by the broader public than the simple 'headline indicator'; this may

[34] See http://www.waterFootprint.org/?page=files/FAQ_Technical_questions, retrieved 12 August 2010.

lead to confusion about what the final, overall indicator actually measures and how it can be interpreted.

Furthermore, the concrete figure of water use alone does not tell much about the social and environmental impacts. The information given by the WF has to be further processed by a concrete impact assessment (about certain products, etc.) in order to gain insight into the real local impacts.

Often missing the distinction between Green and Blue water consumption. The WF principally includes Green, Blue and Grey Water dimensions in the final value. However, the concrete values of the different dimensions are often not given; instead, only the overall number (an addition of the different water uses) is provided. In this case, deeper conclusions about the impact of the production of goods cannot be easily deduced given that, in some areas, rain water is available in abundance while it is very scarce in other areas. For the purpose of policy formulation, it is essential to explicitly distinguish and present the various WF components (see Hoekstra 2009, p. 1968). An example of a study where the three WF components are explicitly shown is the Cotton Footprint study by Chapagain et al. (2006) (see Hoekstra 2009, p. 1968).

It has been recognised that the three WF components have different characteristics; this means that simply adding them causes some loss of information. The main difference between green and blue water is that they are different in their scopes of application. Green water can be productively used only for crop and natural biomass production; while blue water can be used for irrigating crops as well as for various other types of domestic, agricultural and industrial water use (see Hoekstra 2009, p. 1968).

For developing strategies for sustainable water use, one will need to use the more detailed layer of information (blue, green, grey) embedded in the composite WF indicator.[35]

Further development of the methodology. As requested e.g. by WWF, there is the need to develop a coherent methodology, especially when it comes to calculating the water input for industrial products. In this field, the data use is also highly important. Given that calculators of Footprints refer to different industrial data on production processes, the calculation of the WF will be influenced. There seems to be difficulty in harmonising the WF with National Environmental Statistics. This reduces the ability to compare results and to integrate the Footprint accounts into statistical systems of national government agencies and Eurostat.

On a more general level, the WF Homepage conveys the following statement about methodological concerns: "The methods for WF accounting have been published in peer-reviewed scientific journals. In addition, there are also practical examples available of how one can apply the methods to calculate the WF of a specific product, an individual consumer, a community or a business or organisation. In generic sense there is agreement about the definition and calculation of a WF. However, every time one applies the concept in a situation not done before new practical questions arise. These are practical questions like: what should be included and what can be excluded, how to deal with situations where the supply chain cannot be properly traced, what water quality standards to use when calculating the grey WF, etc. Discussion therefore focuses on how to handle those practical issues".[36]

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[35] See http://www.waterFootprint.org/?page=files/FAQ_Technical_questions, retrieved 13 July 2010.

[36] See http://www.waterFootprint.org/?page=files/FAQ_Technical_questions, retrieved 13 July 2010.

Lack of a distinction between sustainable and unsustainable water use. In WF analyses, appropriated water volumes are added without making a distinction between sustainable and unsustainable water use. In one case, a certain volume of water may have little effect on the local ecosystem; in another case, the same volume of water use can greatly exceed a critical point.

The WF alone, therefore, does not give insight into the concrete local impacts of water consumption and has to be accompanied by concrete impact assessments. However, the WFN is currently working on methodologies to consider water availabilities and water scarcities in the evaluation of WF results.

Outside the scope of the WF (not included or indirectly in the calculation)

The WF only reflects the level of water consumption of a nation, company, etc. The WF does not reflect other ecological issues such as biodiversity or energy.

The WF only yields a number regarding water consumption, but does not directly give insight into the environmental and social impacts of that consumption.

5.2.3. OPPORTUNITIES

This section identifies those aspects of the institutional, political, intellectual and technological environments that could help to improve the WF, lead to its successful adoption or accomplish both.

Relevance to EU policy. In order to set and achieve measurable targets, indicators need to be identified that measure progress. According to the Sixth Environmental Action Programme and the Resource Strategy, the EU will develop sustainability targets to meet the overarching goals of the Sustainable Development Strategy and the UN Commission on Sustainable Development.

The Water Footprint is relevant to water management policy and, more generally, to resource policy. The Water Footprint can also help to anticipate water scarcity, thus also making it socially relevant.

Window of opportunity. There is a window of opportunity to shape the WF into an indicator that is useful to the European Union. The indicator can be used to guide EU water policy and to measure progress.

5.2.4. THREATS

This section identifies those aspects of the institutional, political, intellectual and technological environments that could hinder successful adoption.

Lack of international data. In order to be useful to governments, the WF needs to be unbiased and rely on the best-available, high-quality, scientifically accurate data. It is important to note that at the global level, differences exist in the data chosen and in data collection techniques among countries.

Lack of specialist personnel and resources. In order to further develop and improve the approaches of the WF (methodology, data quality and implementation), resources are required. A step in the right direction is the WFN, dealing with improving the coherence of the WF methodology. Critical debate on the findings of this network and coherent uptake of the results would smoothen the process of dealing with problems and inconsistencies with the WF calculation and interpretation.

Use as a stand-alone indicator would be inadequate. Although the WF conveys an effective, simple message on its own, it is important to consider the WF within a 'basket of indicators' to be sure that the full range of ecological and social aspects of resource use are considered.

Table 5: Summary of key findings from SWOT analysis for the Water Footprint

	Helpful to achieving policy objectives	**Harmful to achieving policy objectives**
Internal attributes of the Water Footprint	**Strengths** One clear parameter. Includes direct <u>and</u> indirect water use (progress to standard water statistics). Allows for comparison between countries.	**Weaknesses** Lack of transparency (e.g. calculations are not always reproducible). Data quality problems and some underlying assumptions are controversial. Often missing the distinction between Green and Blue Water Consumption. Oversimplification could lead to a lack of clarity for policy makers.
External conditions for developing strengths and overcoming weaknesses	**Opportunities** Up-take of WF as one basis for the further development of EU Water Policy. Improve and harmonise methodological approaches.	**Threats** Specialist personnel and resources lacking to accompany large-scale up-take of the WF. Use as stand-alone indicator is inadequate.

5.3. Carbon Footprint (CF)

5.3.1. STRENGTHS

Easy to understand. The CF measures the amount of emissions of all GHG that are directly or indirectly caused by an activity or a product. It takes into account the whole supply chain and, therefore, demonstrates the degree to which consumption in one country is responsible for GHG emissions in another.

Inclusion of all direct and indirect GHG emissions. On a related note, the CF can include all direct and indirect GHG emissions since GHG emissions caused by both production and consumption are calculated. Therefore, the entire supply chain throughout the economy can be traced.

Good data availability updated on a yearly basis. Generally, different data sets collected by national and international organisations can be used in order to calculate the CF; these are usually updated on a yearly basis (e.g. national environmental accounts). However, the data used for the new methodology used within the EUREAPA tool are only updated every three to four years.

Robust methodology. The CF is clearly defined within the OPEN:EU project and is robust. However, there are also other standards to measure the GHG emissions from goods and services such as, for instance, the Publicly Available Specification (PAS) 2050. Since June 2007, PAS 2050 has been being developed and it is now ready to be used. Its aim is to measure the embodied GHG emissions of goods and services in order to allow organisations to improve their climate change related performance.[37] Furthermore, the Product Carbon Footprint (PCF) Project "develops approaches for systematically assessing and communicating implemented and intended emission reductions" and common international standards are sought for the assessment and communication of product related carbon emissions.[38] In this context it is noteworthy that an ISO working group is currently drafting an ISO standard for CF calculations.

Applicable at various levels. Basically, one strength of the CF is that the methodology can also be applied in order to measure resource use at regional and local scales, as well as the product, individual, and enterprise-levels. However, since the CF will be incorporated in the EUREAPA tool within the OPEN:EU project, disaggregation is only possible for the EU and EU Member States.

5.3.2. WEAKNESSES

No direct link to policy changes. As mentioned in the RACER analysis, the CF relies on MRIO tables which are time-consuming and difficult to update. Therefore, although the input data are updated on a yearly basis (see above), the output is not necessarily updated at the same speed. Consequently, the indicator cannot be directly linked to policy changes and should be considered as a long-term indicator rather than as an indicator that is able to track short-term changes.

Outside the scope of the Carbon Footprint (indirectly or not included in the calculation)

CF should not stand alone. The CF can theoretically act as a stand-alone figure. However, it focuses exclusively on GHG emissions data while possibly neglecting other important environmental impacts (JRC/EC 2007, p. 2). If the CF stands alone, environmental burdens may be shifted to other, non-carbon impacts.

5.3.3. OPPORTUNITIES

Relevance to EU policy. During the last few years, climate policy has become more and more important, culminating in the foundation of a DG Climate within the European Commission in 2010. The strength of the CF is that it measures all GHG that are directly or indirectly caused by an activity or a product. Only with this knowledge can we start to optimize the levels of GHG emissions. Since the CF captures both products and services, it provides information for policies aimed at the industry as well as at the private sector.

Window of opportunity. The OPEN:EU project marks a window of opportunity to shape the CF into an indicator that is useful to the European Union, assuming it is used in combination with other indicators. The indicator can be used to guide EU climate policy and to measure progress.

Should be combined with other indicators. As mentioned earlier, the CF should not stand alone since it may neglect other negative non-carbon impacts on the environment and because it does not take a holistic approach. Consequently, the CF should be combined with other indicators.

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[37] See http://www.bsigroup.com/en/Standards-and-Publications/How-we-can-help-you/Professional-Standards-Service/PAS-2050/PAS-Aim-and-Scope/, retrieved 13 July 2010.

[38] See http://www.pcf-projekt.de/main/at-a-glance/, retrieved 13 July 2010.

5.3.4. THREATS

Lack of a standard, transparent methodology. If a standard, transparent methodology cannot be fully developed or is used inconsistently, it could significantly hinder the successful adoption of the CF. Although efforts have been made to streamline the methodology for the CF, different approaches are still being used due to various institutions having made their own efforts to streamline it.[39]

Use as a stand-alone indicator would be inadequate. Although the CF may stand as an indicator alone, it is recommended that it be used in combination with other indicators (see above).

Quality of data. The data quality might be insufficient since the GTAP data are important for the indicator and they are collected on a voluntary basis. Consequently, it cannot be assured that these data are 1) of the best quality and 2) sufficiently available.

Table 6: Summary of key findings from SWOT analysis for the Carbon Footprint

	Helpful to achieving policy objectives	**Harmful to achieving policy objectives**
Internal attributes of the Carbon Footprint	**Strengths** Easy to understand. CF can take into account all direct and indirect GHG emissions. Robust methodology. Applicable at various levels.	**Weaknesses** CF is not directly linked to policy changes. CF should not stand alone.
External conditions for developing strengths and overcoming weaknesses	**Opportunities** Opportunities to improve data quality and availability. Could further EU policy goals (related to climate change).	**Threats** Lack of standard, transparent methodology. Use as a stand-alone indicator would be inadequate. GTAP data might not be of highest quality since submissions are voluntary.

[39] For instance the PCF Project, see http://www.pcf-projekt.de/main/background/product-carbon-Footprint/?lang=en, retrieved 7 July 2010.

6. Conclusions

This report summarised the EU and international policy objectives in the field of environment and sustainable development, focusing on resource use, water and climate policies.

6.1. The Footprint Family and the indicators' policy relevance

As the overview has shown for environmental policy in general, the EU SDS and 6EAP are the most important framework documents. Furthermore, water policy is mainly characterised by the Water Framework Directive (WFD), marking the umbrella for the EU water policy. The WFD is characterised by a management approach focusing on river basins.

A quite dominant legislative piece within the EU climate policy is the EU ETS. Furthermore, climate policy is increasingly becoming a cross-cutting issue and is being reflected in various policy fields. The different aspects linked to climate (mitigation, adaptation, energy use, carbon market) lead to a wide variety of policies and different regulatory approaches. Concerning climate policy, the Kyoto Protocol and the UNFCCC are among the most important drivers for climate policy at the EU level, though they stem back to the international level.

International policy objectives are inscribed in a series of international conventions defining development and sustainability goals. Furthermore, concrete international objectives and regimes also exist in the field of water (often regarding certain water streams) and climate.

Against this background, the solidity of the Footprint Indicators (Ecological Footprint, Water Footprint and Carbon Footprint) was analysed. It turned out that all three Footprint Indicators are valuable and may inform decision-making. The EF compares the demand placed by humans on the Earth's ecosystems with its capacity to regenerate. While the WF measures the use of freshwater resources, the CF measures GHG emissions. Consequently, all are useful for assessing the progress being made towards the EU's environmental policy objectives.

However, all of the Footprint Indicators have different strengths and weaknesses, as shown in the following table.

Table 7: Comparison of Strengths and Weaknesses of the Footprint Indicators

	Strengths	Weaknesses
Ecological Footprint	+ Easy communication of complex issues. + Can be applied at multiple scales.	– Not a forecasting tool. – Limited data quality.
Water Footprint	+ Easy communication of complex issues. + Can be used at various levels, including the local level.	– Limited data quality and up-to-datedness of data. – Certain aspects of the methodology still under debate.
Carbon Footprint	+ Good data availability. + Easy to use and understand.	– Not able to show short-term trends. – Lack of standardised methodology.

Source: Ecologic Institute.

All of the Footprint Indicators reflect only one part of the whole picture. For instance, the WF only reflects water use and the CF only covers GHG emissions; the negative impacts of a product, process or policy that are not connected to water or carbon issues may not be taken into account. The EF draws a bigger picture, but nevertheless only shows a part of the whole reality. Consequently, none of the indicators can be used as a stand-alone-indicator. Since it can be assumed that it will not be possible to capture the overall environmental impact in one single index, a small basket of indicators is probably the best approach for measuring the overall environmental impacts of production and consumption.

However, if they are used together as a basket of indicators, they still do not cover all aspects. For instance, impacts on human health, biodiversity, the quality of land use as well as air quality are not captured by the Footprint Family. Consequently, they can only serve as a basis for information. Often, the HDI serves as an additional indicator in relation to the Footprint indicators since it covers social and health related aspects.

This is even more crucial because all of them are numerical indicators made up of a single number. These numbers, however, need to be seen within their appropriate contexts and interpreted. For instance, the extent to which freshwater is used may be judged differently depending on whether it is a water rich country or one characterised by droughts.

The Footprint Family of indicators may inform decision-making processes because they are easy to understand, generally easy to use and are useful for expressing sometimes complex issues. However, this simplicity also marks the limited usefulness of the Footprint Family of indicators since they can only help to inform decision-makers and are not able to represent the only source of information.

We therefore recommend using the Footprint Family of indicators in a set as a basis to information policy-making. It has to be stressed that they need to be seen in context and interpreted carefully. Moreover, we recommend undertaking an impact assessment in addition to paying attention to the Footprint Indicators since an impact assessment serves to reflect the whole range of potential impacts in a variety of policy fields. This information forms the foundation for decision-making processes; the EU can reach a one planet economy only when properly informed.

6.2. EUREAPA Tool

The OPEN:EU project is developing the EURAPA tool, a tool to inform policy makers on the impacts of potential policies. The EUREAPA tool will use data on what products citizens from each of the 27 EU countries are buying (the current consumption profile), combined with data on where these products are made and how efficient production techniques are to calculate the direct and indirect environmental impact of goods and services consumed in the EU.[40]

The production efficiency of 87 world regions is known as well as where goods consumed in the EU are produced. Consequently, the tool will be able to tell us where the impact from goods and services consumed in the EU occurs throughout the world. The environmental impact will be measured using the Carbon Footprint (including all GHGs), Ecological Footprint and Water Footprint.

[40] While other methodologies (e.g. the national Footprint accounts) are not designed to evaluate product and process-level Footprints because it does not allocate demand on biocapacity by the type of economic capacity, the OPEN:EU project will be filling exactly this gap.

The impact will be reported individually for each country as well as for the EU as a whole. It cannot be reported below a national level (e.g. region, city, local authority) because the consumption data is not currently available at this level of disaggregation.

The tool could be used to identify which goods or services cause the most environmental impact (“hotspots”) in order to help prioritise policy intervention. It could also be used to find countries with a lower consumption impact and identify the best practices that were used to create a lower impact.

Furthermore, the tool could be used to look at the effect of different consumption profiles on the environmental indicators. The user will be able to change the consumption profile in the tool (e.g. a change that might occur as a result of a proposed policy) and the tool will calculate how this changes the environmental impact. This will help to assess the relative effects of different policy approaches and help to prioritise them.

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7th Framework Programme for Research and Technological Development.
The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement N° 227065.

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