NTNU – Trondheim
Norwegian University of
Science and Technology

Green Offices - Investigating the Ecological Footprint of Business Services

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MASTER THESIS

for

Student Vera Jelenova

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Green offices - Investigating the Ecological Footprint of business services

Background and objective

WWF's Green Office is an environmental management system for offices developed by WWF-Finland. The aim of this environmental management system is to reduce offices' ecological footprint, which include carbon dioxide emissions, and ultimately reduce burden on the environment, achieve savings and slow down climate change. Green Office is suited for offices, both large and small, private, public and non-governmental organisations in a variety of sectors. After being audited and having completed the requirements of the programme, an office can then get the WWF Green Office certification. WWF-Norway wants to use and apply this management system to drive the sustainability strategy and reduce the footprint of its own office as well as others. However, in the design process, two main gaps were identified:
1) The footprint calculator only assesses the carbon footprint of an office, not the comprehensive ecological footprint;
2) There are no benchmarks for setting reduction targets and as such, offices set their target in subjectively.
These gaps and issues have to be addressed in order to make this system and certification reliable before WWF-Norway uses and apply this system. As such, WWF-Norway wants to develop a comprehensive ecological footprint calculator (based on the current one) using Norway coefficients, and set benchmarks (and targets) for offices in different building categories.

The following tasks are to be considered:

1) Carry out a literature study relevant to the topic of this project.
2) Improve the current WWF Green Office calculator that would allow to obtain an overall assessment of the ecological footprint of an office
3) as well as options for ecological friendly items.
4) Collect information and data needed to define physical units for some of the ecological footprint calculator items.
5) Develop further categorisation of items relevant for decision making.
6) Collect information and data needed to define a functional unit for benchmark study.
7) Provide an ecological footprint case study for WWF office in Oslo with developed ecological footprint calculator.
8) Calculate ecological footprints in Other business activities economy sector for European countries.
9) Discuss a contribution of construction activity to the ecological footprint.
10) Discuss the overall findings of your work, agreement with literature, what are critical variables and assumption, strengths and weaknesses of your methods, and recommendations for further work.
11) Produce the paper.

Learning elements

- Work for an international organization on local/global issues
- Understand the day-to-day challenges of working for an NGO
- Gain technical knowledge on Footprint calculation, surveying, and policy and advocacy work
- Learn research methods and preparation of communication material
- Report writing and presentation skills
- Learn how to structure fact based argument for policy purposes

Contact person

The contact person in the WWF-Norway in Oslo will be: Anne Grefsrud and Paolo Tibaldeschi.

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Within 14 days of receiving the written text on the master thesis, the candidate shall submit a research plan for his project to the department.

When the thesis is evaluated, emphasis is put on processing of the results, and that they are presented in tabular and/or graphic form in a clear manner, and that they are analyzed carefully.

The thesis should be formulated as a research report with summary both in English and Norwegian, conclusion, literature references, table of contents etc. During the preparation of the text, the candidate should make an effort to produce a well-structured and easily readable report. In order to ease the evaluation of the thesis, it is important that the cross-references are correct. In the making of the report, strong emphasis should be placed on both a thorough discussion of the results and an orderly presentation.

The candidate is requested to initiate and keep close contact with his/her academic supervisor(s) throughout the working period. The candidate must follow the rules and regulations of NTNU as well as passive directions given by the Department of Energy and Process Engineering.

Risk assessment of the candidate's work shall be carried out according to the department's procedures. The risk assessment must be documented and included as part of the final report. Events related to the candidate's work adversely affecting the health, safety or security, must be documented and included as part of the final report. If the documentation on risk assessment represents a large number of pages, the full version is to be submitted electronically to the supervisor and an excerpt is included in the report.

Pursuant to "Regulations concerning the supplementary provisions to the technology study program/Master of Science" at NTNU §20, the Department reserves the permission to utilize all the results and data for teaching and research purposes as well as in future publications.

The final report is to be submitted digitally in DAIM. An executive summary of the thesis including title, student's name, supervisor's name, year, department name, and NTNU's logo and name, shall be submitted to the department as a separate pdf file. Based on an agreement with the supervisor, the final report and other material and documents may be given to the supervisor in digital format.

☐ Work to be done in lab (Water power lab, Fluids engineering lab, Thermal engineering lab)
☐ Field work

Department of Energy and Process Engineering, 20. January 2014

Olav Bolland
Department Head

Richard Wood
Academic Supervisor

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Preface

This thesis is a part of the master program of Industrial Ecology at The Norwegian University of Science and Technology (NTNU). This master thesis was carried out in the cooperation with World Wide Fund for Nature (WWF). The work was requested by a branch of the WWF office in Oslo, Norway and took place during the spring semester of 2015.

Representatives from WWF and NTNU met several times during the spring semester of 2015. These meetings took place at the WWF office in Oslo and via Skype. During these meetings the research question was set up and the necessary data were provided.

The name of the thesis is: "Green offices - Investigating the Ecological Footprint of business services". The output is a study of the Ecological footprint structure of the WWF Oslo, Norway office with a link to the Norwegian and European background. The study has a possibility to be used for setting up the sustainable growth benchmarks for office space in Norway.

Trondheim, 2015-05-29

Vera Jelenova

Acknowledgment

I would like to thank the following persons for their great help during this academic year.

1. Richard Wood; Norwegian University of Science and Technology (NTNU), Trondheim
2. Paolo Tibaldeschi; World Wide Fund for Nature (WWF) Norway, Oslo
3. Anne Grefsrud; World Wide Fund for Nature (WWF) Norway, Oslo

V.J.

Abstract

The ecological conservation is a subject of public attention. Among the most discussed issues are (1) the environmental footprint, (2) the biocapacity limits and (3) the ecological overshoot. The Ecological footprint (EF) is an appropriate approach to face the size of the environmental impacts. The nowadays studies are mostly either not related to office space/business environments or they only focus on greenhouse gases. The aim of this thesis is to develop an EF structure suitable for WWF Oslo office case study. In the scope of this project various data from CREEA project and WWF Oslo accounting system were analyzed. Based on the analysis the European Union, Norwegian and WWF Oslo case study about the EF was provided. The analyse presents structure of the EF and the values for all three cases. The results shows the WWF Oslo EF per full time employee as less than half of the Norwegian and the European Union standards. The results shows unequal distributed impacts across identified sectors. According to the results, the main impacts of the WWF Oslo office are from Food and Other Services sectors.

1. Introduction and literature review

Some of the nine planetary boundaries proposed by [Rockstrom et al., 2009] which defines the safe operating space for humanity, have been already crossed (see figure 1.1). Rate of biodiversity loss, climate change and human interference with the nitrogen cycle represent a warning to humanity to take an action.

The sustainable development (SD) concept (see table 1.1) plays a significant role in policy development [Wood et al., 2014]. The approach was introduced by World Commission on Environment and Development (WCED) in 1987 [World Commission on Environment and Development, 1987] and is dependent on several drivers including environmental, economic and social aspects [Cucek et al., 2012].

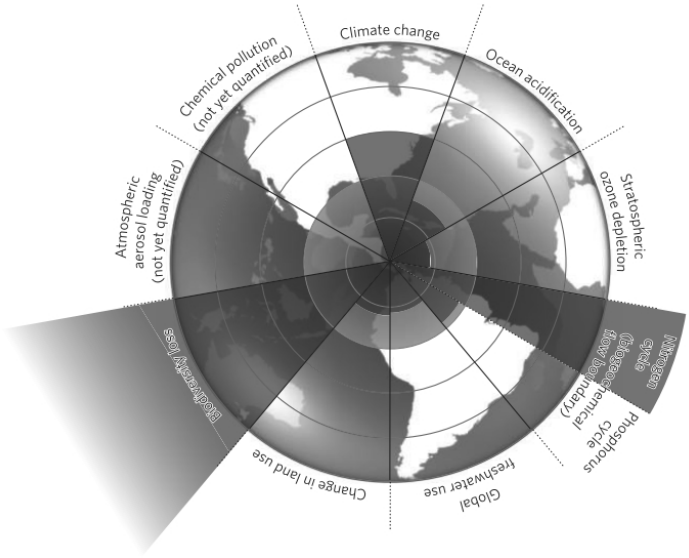

Figure 1.1: Proposed planetary boundaries [Rockstrom et al., 2009]

Name	Definition	Unit	Source
Sustainable development	The needs of the present without compromising the ability of future generations to meet their own needs		[World Commission on Environment and Development, 1987]
The Ecological footprint	Minimum land area necessary to provide the basic energy and material flows required by the economy	Global hectare (Gha)	[Wackernagel and Rees, 1998]
Biocapacity	The capacity of ecosystems to produce useful biological materials and to absorb waste materials	Global hectare (Gha)	[Chiu, 2012]

Table 1.1: Important terms and definitions

The need for a quantitative method able to measure the environment impacts was fulfill in 1992 when the concept of the Ecological footprint (EF) (see table 1.1) was presented by William Rees [Rees, 1992, Wackernagel and Rees, 1998, Bicknell et al., 1998]. One of the main purposes of the "footprinting" is to "identify and communicate potential sources of unsustainability to the general public and to political and corporate decision-makers" [Wiedmann et al., 2007].

The six main types of productive land is accounted into the EF: (1) cropland, (2) grazing land, (3) fishing grounds, (4) forest, (5) carbon uptake land and (6) built-up area [Galli et al., 2012b]. The EF is defined by three drivers: (1) population size, (2) average consumption per person and (3) average EF intensity [Chiu, 2012]. As a benchmark for the EF, the biological capacity (biocapacity) is considered [World Wide Fund for Nature, 2012]. The biocapacity is defined by (1) the amount of biologically productive area available and (2) bioproductivity [Chiu, 2012]. The variation between the global EF and the global biocapacity is known as an ecological overshoot [World Wide Fund for Nature, 2012]. The ecological overshoot in period 1961-2002 is represented by an area above the "Earth's biological capacity" line in figure 1.2 [Wackernagel et al., 2006].

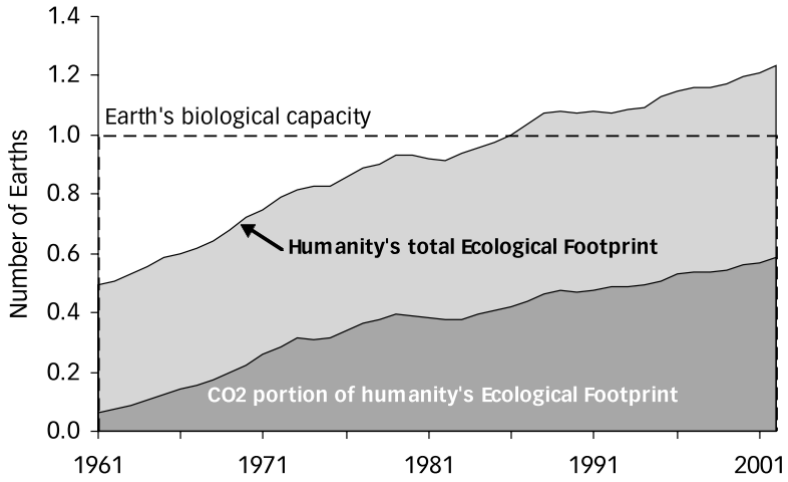

Figure 1.2: The ecological overshoot, 1961-2002, [Wackernagel et al., 2006]

The EF can be applied in different scales [Li et al., 2008, Ewing et al., 2010]:

(1) Low resolution (global scale and nations):

The major initiator for the EF of nations is The World Wide Fund for Nature (WWF). In the Living Planet Reports (published every second year) the WWF tracks the EFs of nations (1961-2010) [World Wide Fund for Nature, 2012, 2014]. In another case, [Kratena, 2008] linked the German national EF account with the input-output (IO) model. [Moran et al., 2008] presented the measurement of the national sustainable development by the EF for 93 countries.

(2) Medium resolution (regions and cities):

The two main approaches for the EF assessment in sub-national scale have been identified: (2.1) the top-down compound method and (2.2) the bottom-up component method. The compound method takes the national EF data and scales it down to reflect the situation in the higher resolution [Geng et al., 2014, Moore et al., 2013]. The advantage for this method is the data availability, however the ability to reflect the impact of local policy and action is limited [Geng et al., 2014]. The bottom-up component method allocates the local data. Two sub-approaches have been presented: (2.2.1) (monetary) IO analysis and (2.2.2) direct estimates of energy and material by using local data [Moore et al., 2013]. Examples of the EF studies in this scale are: [Hopton and White, 2012], [Bagliani et al., 2008], [Wackernagel, 1998], [Geng et al., 2014].

(3) High resolution (enterprises, schools, families or industries):

Several case studies related to universities with EF analysis were published [Venetoulis, 2001,

Flint, 2001, Li et al., 2008, Nunes et al., 2013]. Some of the EFs of universities and campuses were compared in the paper [Klein-Banai and Theis, 2011]. No literature describing case studies using multi regional input-output (MRIO) method related to the EF analysis of the office space is known to the author of this work. Nevertheless, the office space studies with different methodologies are available. Among others: (3.1) The university office-workstation of Democritus University of Thrace study related to the LCA methodology and Carbon footprint (CF). The inventory analysis includes: (a) electronic equipment, (b) furniture, (c) consumables and (d) energy [Gaidajis and Angelakoglou, 2011]. (3.2) Another study deals with the CF measurement of the office space in UK. The main criteria in this study are (a) building operations and (b) transport [van de Wetering and Wyatt, 2010]. These studies deal only with the CF, therefore the system boundaries are narrower compare to the study which investigates the whole EF. The major difference between this thesis and the studies mentioned above is the possibility to include the consumption/expenditures from the economy service sector.

Studies about environmental impact assessment which use the IO methodology can be recognized. The case study of NTNU is one of them. The CF of different faculties and departments were calculated by using environmental extended input-output (EEIO) model [Larsen et al., 2013]. For further explanation of EEIO model see [Murray and Wood, 2010]. The MRIO methodology (see chapter 2) was used for example for the CF calculations of UK households. In this study the topic of the expenditure allocation (one of the main issues of this thesis) is discussed [Druckman and Jackson, 2009].

The EF method has been criticized since the publication due to its limitations. In the global scale, the EF gives more accurate results. One of the main issues is oversimplification of the problem [Wood and Lenzen, 2003], which can lead to the misinterpretation of the results at the regional level [van den Bergh and Verbruggen, 1999]. Several methodologies of EF are available, but the results are not able to provide information for the policy makers [Wiedmann and Barrett, 2010]. The theory of the EF focuses only on environmental aspect of SD (as mentioned above) [Galli et al., 2012b]. Therefore it excludes the influence of human health and the question of well-being society [Cucek et al., 2012]. Thus the EF is not able to provide a comprehensive analysis of unsustainability [Lenzen and Murray, 2001]. The paper [Fiala, 2008] presents the EF as a concept which is not able to address the sustainability of consumption but it only estimates

the production inputs for a given consumption level. [Solli et al., 2012] refers to three scopes of the assessment: (1) direct emissions, (2) purchase of energy and (3) all other indirect emission. The authors of that paper claims that any serious assessment needs to include all three scopes and that is one of the goals for this thesis.

Service sector is an important contributor to the total EF. Even if the emission intensities are lower per unit of output compare to the other sectors of the economy, the total contribution to the EF is significant [Gadrey, 2011]. For example, the Norwegian structure of the GDP in 2013 is presented in figure 1.3. Service sector represents more then half of the total GDP in Norway [Central Intelligence Agency, 2015]. [Gadrey, 2011] claims that in the countries where service sector plays a main role in the national economy, the EF is higher than in less developed countries. Specific studies with focus on the service sector were published. Among other the CF study of service sector in Uruguay [Schürmann, 2008]. According to [Wackernagel et al., 1999], the accounting of ecological flows and services summarized in a single number may be useful for the GDP measures.

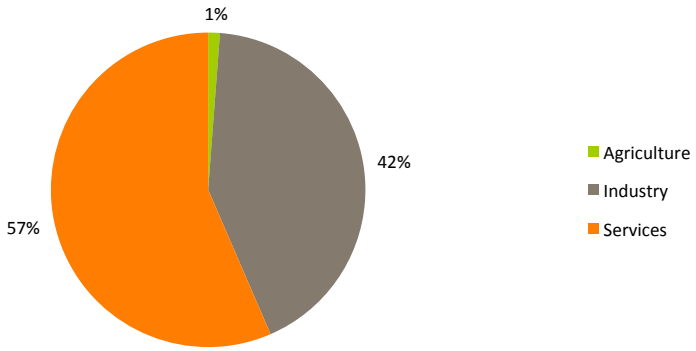

Figure 1.3: GDP composition by sector of origin for Norway in 2013 [Central Intelligence Agency, 2015]

The environmental-friendly behavior needs to be assessed on both national and individual or business level [Galli et al., 2012b, United Nations Environment Programme, 2013]. In general, for the local level the trend is to lead public for decreasing the personal environmental impact. The media release information how to decrease personal footprint (for example) by eating less meat, sorting the trash or turning of water during brushing teeth. To change the per-

sonal habits is praiseworthy and each small action is accounted. But it is not the only way how to contribute. The behaviour at home and at work can differ for many reasons. For examle to turn of the light at home is easier, because it decrease the electricity bill. On the other hand, not to turn of the light at the end of working day does not affect the personl expenses.

The aim of this study is to analyse the EF caused by the business services sector in (1) european level, (2) national level and (3) local level. The study brings an approach which aims and highlights the problem of environmental impacts due to the services which has became more serious during the last decades. The general tendency in Europa is shifting from a production activity to service sector. The EF of a sector represents an office related activity is approched by using the IO methodology (see chapter 2).

This thesis deals with the environmental aspect of the SD. The developed structures of the EF provide an environmental impact assessment of the specific sector for (1) European Union (EU), (2) Norway and (3) for a specific office in Norway (WWF Oslo). These cases represent the situation in three different scales (as mentioned above) therefore it is possible to observe the changes in structure of the EF by scaling down.

The EE-MRIO model was used for analyzing economic data and establishing the amount of direct and indirect environmental impacts due to the consumption of goods and services. The study has been developed as a product of Master thesis in the Industrial Ecology Program at the Norwegian University of Science and Technology (NTNU).
The main objectives of this Master's project are:

1. Improve the EF calculator from previous study to allow an overall assessment of the EF of an office

2. Calibrate the EF calculator tool and develop further categorization of items relevant for decision making

3. Research a possibility to add an option for ecological friendly items to the structure of the EF

4. Collect information and data needed to define a functional unit for benchmark study

5. Model the office space EF for countries in EU and for Norway

6. Provide the EF case study for WWF office in Oslo

The literature review collects information and data needed to define a functional unit for the benchmark study. The sensitivity analysis shows the usefulness of implementation the ecological friendly options. This thesis presents case studies for EU and Norway and a case study by using the top-down IO analysis method in a high resolution, the study of EF for the WWF office in Oslo.

In order to compare impacts from the business services sector in the European Union (EU) and Norway with the local aspect represented by WWF Oslo office, the normalized results have to be calculated. The normalized factor has to be defined. The consumption categories used for the EU and Norway cases have to be customized for the representative office (WWF Oslo) accounting system.

The rest of the report is organized as follows. Chapter 2 gives an introduction to the research methodology including the sensitivity analysis as well as the case studies of EU, Norway and WWF Oslo office with the benchmarks calculations. Finally, Chapter 3 provides the results, conclusion and discussion.

2. Methods

Two main methods can be recognized as suitable approaches for analyzing environmental impacts due to a production chain of consumption: (1) Life cycle assessment (LCA) and (2) Environmental extended multi-regional input-output (EE-MRIO) analysis. According to [Turner et al., 2007], the MRIO accounting approach is the most appropriate method of calculating the EF. The IO approach was chosen as a basic model for this study also due to higher data availability in monetary unit compare to the data availability in physical unit.

The IO model was developed by Wassily Wassilyovich Leontief in 1930s and 1940s [Leontief, 1986]. Later the framework was extended and the method was applied to the analysis of environmental impacts [Leontief, 1970, Solli et al., 2012]. Nowadays IO analysis is a well-known economic tool, which is used for studying relations between various sectors on regional or national economic base. A primary advantage of this standard method is the fact that the IO analysis model can be in uniform manner applied for different populations [Bicknell et al., 1998]. The method is able to calculate direct and indirect impacts due to an arbitrary final demand placed upon the system [Solli et al., 2012].

The EF calculations are based on a MRIO model (as mentioned above). The MRIO analysis is an appropriate methodological framework for the EF calculations [Wiedmann, 2009],[Turner et al., 2007]. This model represents interconnections among industries, which vary by location and production. "A MRIO table records the flow of products from each industry in each country as a producer to each of the industries in each of the countries as consumers" [Murray and Wood, 2010]p.168. Thus the MRIO model is appropriate to estimate the EF of consumption with the option to track the emission flow through regions along the supply chain [Wiedmann et al., 2007].

2.1 Mathematical background

The multiple-country accounting framework is used in this study. The regions refer to the national accounting system of 48 countries/regions. The supply and use tables for each of the country is represented by 200 products and 163 industries [Wood et al., 2014].

The IO model is described by equation 2.1 where the regional inter-industry requirements and final demand are introduced. Each submatrix $\mathbf{A}^{rs}$ represents the relationship between industries/products trade from country r to country s. $\mathbf{x}^s$ is the vector for total output in each sector and $\mathbf{Y}^{rs}$ is the trade from industries in country r to final consumers in country s. The coefficient m represent number of industries/products [Peters, 2008].

$$\begin{pmatrix} \mathbf{x}^1 \\ \mathbf{x}^2 \\ \mathbf{x}^3 \\ \vdots \\ \mathbf{x}^m \end{pmatrix} = \begin{pmatrix} \mathbf{A}^{11} & \mathbf{A}^{12} & \mathbf{A}^{13} & \cdots & \mathbf{A}^{1m} \\ \mathbf{A}^{21} & \mathbf{A}^{22} & \mathbf{A}^{23} & \cdots & \mathbf{A}^{2m} \\ \mathbf{A}^{31} & \mathbf{A}^{32} & \mathbf{A}^{33} & \cdots & \mathbf{A}^{3m} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \mathbf{A}^{m1} & \mathbf{A}^{m2} & \mathbf{A}^{m3} & \cdots & \mathbf{A}^{mm} \end{pmatrix} \begin{pmatrix} \mathbf{x}^1 \\ \mathbf{x}^2 \\ \mathbf{x}^3 \\ \vdots \\ \mathbf{x}^m \end{pmatrix} + \begin{pmatrix} \Sigma_r \mathbf{Y}^{1r} \\ \Sigma_r \mathbf{Y}^{2r} \\ \Sigma_r \mathbf{Y}^{3r} \\ \vdots \\ \Sigma_r \mathbf{Y}^{mr} \end{pmatrix} \tag{2.1}$$

The multipliers $\mathbf{M}$ (nxm) for indirect (burden from the production) and direct (burden from straightforward use) impact assessment were calculated. The land types and greenhouse gas emissions n per unit of final consumption of commodities m produced by industry sectors across all regions define the dimensions of $\mathbf{M}$ [Lenzen et al., 2003].

$\mathbf{M}_{indirect}$ is calculated as:

$$\mathbf{M}_{indirect} = \mathbf{F} * (\mathbf{I} - \mathbf{A})^{-1} \tag{2.2}$$

where $\mathbf{F}$ (nxm) is the environmental intensity matrix describing the impact per unit for each footprint n and each product m. $\mathbf{A}$ (mxm) is the requirement matrix and $\mathbf{I}$ (mxm) is the unity matrix [Lenzen et al., 2003]. The environmental intensity matrix $\mathbf{F}$ (gha/million Euro) has specific values for each country, each land type and each process. The $\mathbf{F}$ matrix is calculated as:

$$\mathbf{F} = \mathbf{C} * \mathbf{S} \tag{2.3}$$

where **C** (nxo) is the conversion factor matrix in gha/kt and **S** (oxm) represents the stressor matrix in kt/million Euro. o represents number of resources in **S** and **C** matrices. The conversion factor is country and land type specific and is calculated as:

$$\mathbf{C} = \mathbf{EQF} * \mathbf{k}^{-1} \tag{2.4}$$

where **EQF** (gha/wha) is the Equivalent factor and **k** (kt/wha) is the country specific conversion factor. This **EQF** represents the weight of the different land use types based on their relative world average bioproductivity. The country specific conversion factor **k** scales the national productivity to the global one for each of the land type [Galli et al., 2012a].

$\mathbf{M}_{direct}$ is defined as:

$$\mathbf{M}_{direct} = \Phi_d * (diag(\Sigma_{mr}\mathbf{Y}))^{-1} \tag{2.5}$$

where Φ_d vector represents the total direct impact for each product consumed. It includes for example the emissions associated with the combustion of gasoline by households or the combustion of gasoline by vehicles. The indirect/direct impact multiplier vector for the investigated country is extracted from $\mathbf{M}_{indirect}/\mathbf{M}_{direct}$.

The sum of the multipliers (represented by the six main components of the EF) gives the total EF multiplier $\mathbf{m}_e$ (1xm) vector which includes vectors for all countries:

$$\mathbf{m}_e = \mathbf{m}_c + \mathbf{m}_{cl} + \mathbf{m}_{gl} + \mathbf{m}_m + \mathbf{m}_{iw} + \mathbf{m}_{fl} \tag{2.6}$$

where $\mathbf{m}_c$ is the carbon uptake multiplier, $\mathbf{m}_{cl}$ is the cropland multiplier, $\mathbf{m}_{gl}$ is the grazing land multiplier, $\mathbf{m}_m$ is the marine multiplier, $\mathbf{m}_{iw}$ is the inland water multiplier and $\mathbf{m}_{fl}$ is the forest land multiplier. The six main components of the EF in this study differ compared to the definition by [Galli et al., 2012b]. The built-up land multiplier is excluded due to lack of data while the fishing grounds component is split into two different multipliers (fresh water and marine water).

The total footprint vector (mx1) for a specific case is then calculated as:

$$\mathbf{footprint}_{EU} = diag(\mathbf{m}_{footprint}) * \mathbf{y}_{EU} \tag{2.7}$$

$$\mathbf{footprint}_{Norway} = diag(\mathbf{m}_{footprint}) * \mathbf{y}_{Norway} \tag{2.8}$$

$$\mathbf{footprint}_{WWF} = diag(\mathbf{m}_{footprint}) * \mathbf{y}_{WWF} \tag{2.9}$$

where $\mathbf{m}_{footrpint}$ represents a specific multiplier vector for investigated type of footprint. The $\mathbf{y}_{EU}$ vector (mx1) represents the expenditures of the "Other business activity" sector in the EU (equation 2.7), $\mathbf{y}_{Norway}$ (mx1) represents the "Other business activity" sector in Norway (equation 2.8) and $\mathbf{y}_{WWF}$ (mx1) represents the expenditures of the WWF Oslo (equation 2.9).

$$footprint_{total} = sum(\mathbf{footprint}) \tag{2.10}$$

The total value for a specific footprint $footprint_{total}$ is calculated as a sum of the corresponding **footprint**.

2.2 The Ecological footprint structure development

The EF structure is based on data from the EXIOBASE 2.0 IO database. This database is a product of the CREEA (Compiling and Refining Environmental and Economic Accounts) project and is build on the Eurostat's classification, CPA 2002 (Statistical Classification of Products by Activity) [Eurostat Statistics, 2009, Wood et al., 2010, 2014]. The EXIOBASE 2.0 has a clear environmental and resource focus with high levels of detail in primary production [Wood et al., 2014]. Harmonized data compiled in this database originates from 2007. As mentioned above, the database consists of data for 48 regions (27 countries from EU included) and 200 products/163 industries represent each of the country. More information about EXIOBASE 2.0 can be found in [Wood et al., 2014].

The structure development of the EF takes a significant place in this thesis. The process to reach the final structure had two stages:

(1) The first stage took a place mainly during the autumn semester. The derivable of the project was an EF calculator with structure representing the EU national accounting system. First, the seven main consumption sectors were identified. The categories reflect the expenditure distribution in the national scale. The aim of this project is to develop a tool, which would be able to calculate the EF from office space activity consumption in Norway. Therefore data for the

Norwegian national economy was used in the first stage of the development. The process is presented in figure 2.1. The office space belongs to the “Other business activities” sector from the CREEA project. Therefore information about this sector were used as a reference data. It is one of the 163 sectors represents the EU national accounting system. The assumption that this sector has the same distribution in expenditure between consumptions categories as a regular office in Norway was applied. Data about expenditures in the “Other business activities” sector and other data necessary for calculating the multipliers were taken from the CREEA project (it guarantees data consistency in the first stage). The EF for each sector was calculated. The EFs were compared and all 200 products sectors were divided into the 7 groups according to their value, corresponding multiplier and the essence of each of the 200 sectors. The multipliers and expenditures for each subcategory within the group differ significantly. Sectors with missing multiplier or with zero expenditure in "Other business activities" sector were excluded. For the rest the weighted average multipliers were calculated for each subcategory in each group. As the weight the expenditures in the “Other business activities” sector in national scale were used. According to the norwegian condition, the expenditures for electricity was split into energy consumption and net expenditures. The option for Norwegian electricity mix was also added. The multiplier for the electricity mix consists of several electricity sources. It has the same magnitude as the expenditures from “Other business activities” sector for each type of electricity source. More information about the first stage are presented in the previous Project report.

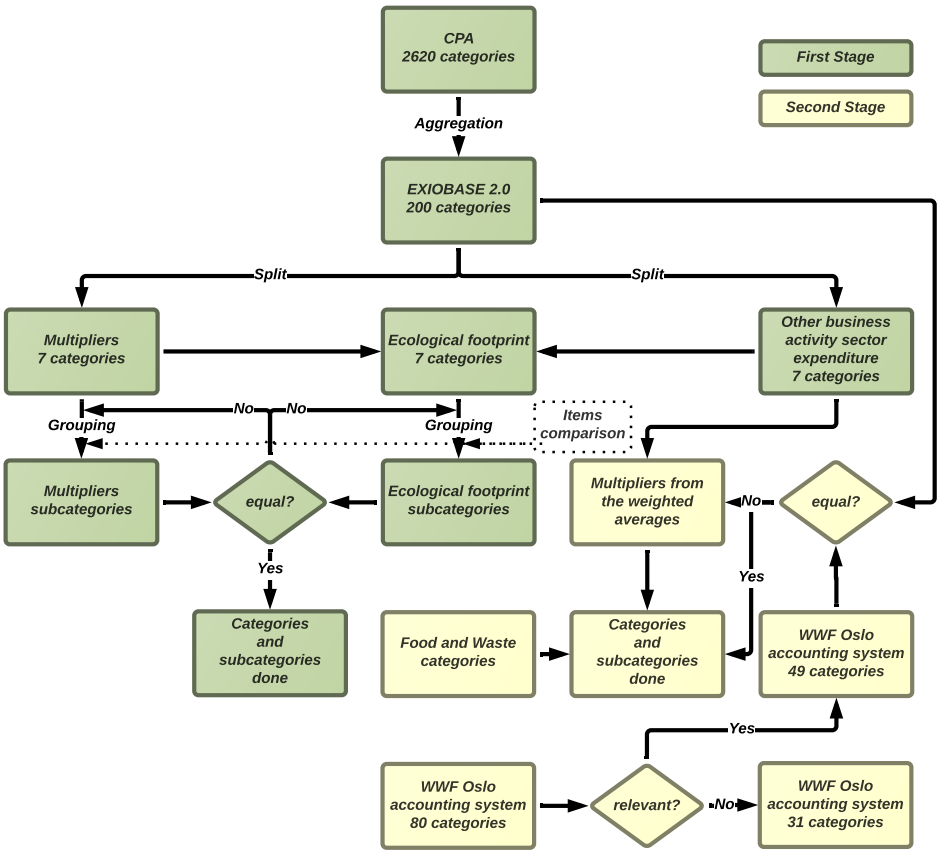

Figure 2.1: Structure development of the ecological footprint calculator in the first and in the second stage

(2) Second stage of the structure development had to be added. During the process was realized that the structure from the first stage does not suite to the purposes of the local environment. The accounting system of the WWF Oslo significantly differs compare to the first stage structure. Therefore a new structure of the consumption sectors from WWF Oslo accounting system was used. The assumption that the accounting system of WWF Oslo is similar to accounting system of offices with similar size was accepted. Therefore it is possible to use the structure for different studies regarding EF of an office similar to WWF Oslo.

The WWF accounting system includes 80 categories. First, the categories representing incomes were excluded. Then the categories not relevant for the EF calculation (which are outside the system boundaries) were excluded. 49 categories were selected for the further use (see Appendix A). Each of the reminded categories was linked to the product category from the CREEA project.

Some of them were possible to directly link to the CREEA classification, respectively to relevant multiplier (see section 2.1). Some of the WWF Oslo accounting system categories were a combination of several CREEA categories. For each of these cases was necessary to recognized all belonging CREEA categories. The WWF Oslo expenditure was split between the categories according to the expenditures from the national level in the "Other business activities" sector. The EF for each part was calculated separately and then summed up. Also the multipliers for each of the WWF Oslo categories were defined. Several exceptions were recognized:
(1) The WWF Oslo office does not provide food for the employees. Therefore this food is not included in the accounting system. Data for the total expenditures for food was collected beside the accounting system and is included in the calculation, because the first stage of the study confirmend that food is significant contributor in the EF.
(2) The Energy category needs two different values of expenditure (as mentioned above). Therefore data for electricity were gathered out of the accunting system in order to get both values.
(3) Category Waste is the only one in physical units in the calculator structure. Data for this category were also gathered outside the accounting system. The expenditures for waste still take place in the accounting system. It is accounted in the category Other Services- Other expenses (among others). It is not possible to distinguish between these components. In order to substract this expenditures from the calculation (avoid duble counting), the relative differences between expeditures in the Norwegian national accounting system for the "Other business activity" sector were used (around 6%). Figure 2.1 represents the overview of the new structure (multipliers) development. The list of the categories and their content can be found in Appendix A.

The comparison of the structures from the first and from the second stage is presented in table 2.1. Some categories (Food, Waste, or Energy) are same for both stages. But the structure of others (especially Other Services and Travel) has been significantly changed. In the second stage some new categories were identified (IT and Telecommunication, Office Maintenance).

First Stage		Second Stage	
Category	**Subcategory**	**Category**	**Subcategory**
Food	no subcategory	**Food**	no subcategory
Waste	no subcategory	**Waste**	no subcategory
Energy	Electricity	**Energy**	Electricity Heat
Transport	Land traffic Air traffic Water traffic Post and telecommunication Other expenditures related to transport	**Transport**	Fuels and vehicles Transport of people Transport of goods
Other Goods	Paper Furniture Electronic Construction Other	**Other Goods**	no subcategory
Other Services	no subcategory	**Other Services**	Marketing Other
Other	no subcategory	no category	
no category		**Office maintenance**	no subcategory
no category		**IT and Telecommunication**	IT hardwere Other

Table 2.1: Categories recognized in the first and in the second stage of the EF calculator categorization process

2.3 The case studies

For the study of the WWF Oslo office activities year 2013 was chosen. The main reason for this decision the availability of data. Appendix A includes the expenditures of WWF Oslo structured into its accounting system categories for year 2013. Number of full time employees (FTE) for the business sector in the EU and Norway and for the WWF Oslo office are presented in table 3.1. With this data was possible to calculate the total EF and also the total EF/FTE, which was used to define benchmark for all three cases.

The EF/FTE for Norway and for the EU were analysed. These results gave an option to compare the WWF Oslo results with Norwegian average, respectively with the EU average. Data about expenditures from "Other business activity" sector (see [European Commission]) from CREEA project was used for the calculations. As a final demand $\mathbf{y}_{EU}$ (the amount of money spent) was used a sum of values from the "Other business activity" sector for each of the EU country in flow matrix $\mathbf{Z}_{EU}$ (which represents the total amount of money required in one sector from another sector).

$$\mathbf{Z}_{EU} = \mathbf{A} * diag(\mathbf{x}_{EU}) \tag{2.11}$$

The $\mathbf{A}$ is the requirement matrix and $\mathbf{x}_{EU}$ is the total output (see section 2.1). The total EF was divided by number of full time employee (FTE) working in this sector in the EU (equation 2.12), therefore the standard for the EU was established.

$$footprint_{perFTE,EU} = footprint_{total,EU} * FTE_{EU}^{-1} \tag{2.12}$$

Number of employees is included in the $\mathbf{F}_{EU}$ matrix which was calculated as:

$$\mathbf{F}_{EU} = \mathbf{S} * diag(\mathbf{x}_{EU}) \tag{2.13}$$

where $\mathbf{S}$ is the stressor matrix. Different types of FTE were presented in matrix $\mathbf{F}_{EU}$. These data was summed up and then values for "Other business activity" sector were picked up (see figure 2.2). It gave a value for the total amount of FTE in EU working in "Other business activity" sector. The same procedure was used for case of Norway.

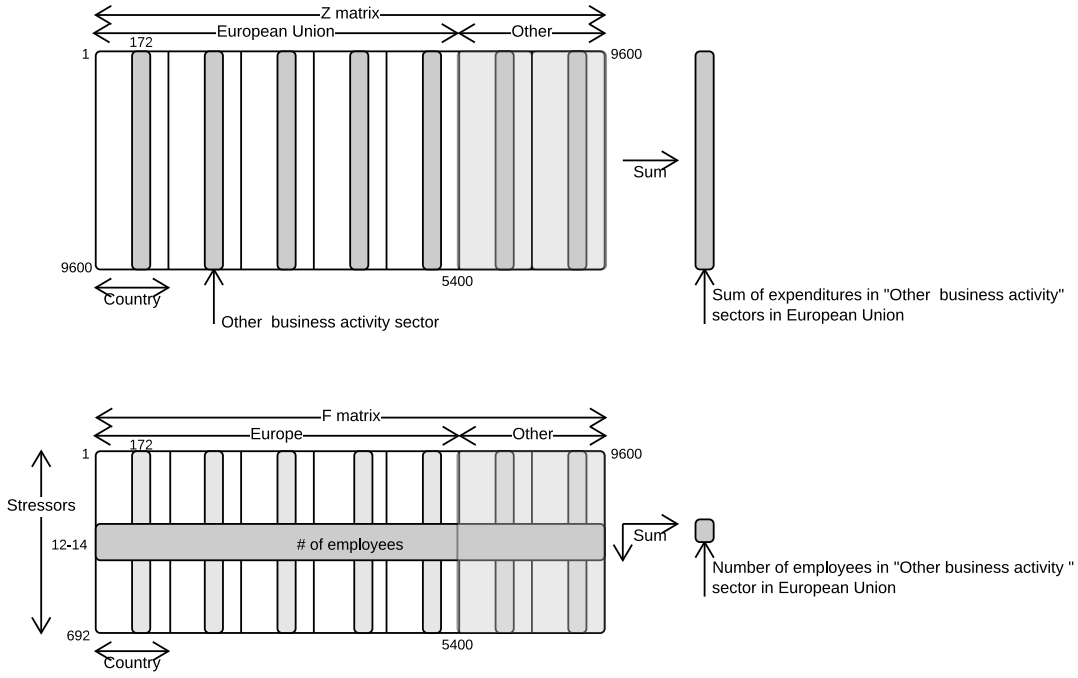

Figure 2.2: The flow matrix **Z** and the impact matrix **F** descriptions

The structure of the footprint was defined by $\mathbf{H}_x$ matrix (m x number of consumption categories). This binary matrix $\mathbf{H}_0$ consists of 0 and 1 values, where 1 represents the allocation of the impact to the relevant category. The $\mathbf{H}_0$ matrix was used for structure of the footprint for Norway and the EU. The $\mathbf{H}_1$ matrix includes additional information about the impact distribution between the categories and was used for the WWF Oslo case study. By multiplying the total footprint vector **footprint** by $\mathbf{H}_x$, the consumption categories are defined as each single columns of the $\mathbf{FOOTPRINT}_{categories}$ matrix (m x number of consumption categories) (see equation 2.14).

$$\mathbf{FOOTPRINT}_{categories} = diag(\mathbf{footprint}) * \mathbf{H}_x \tag{2.14}$$

Important factor for the volume of the EF due to the office activity is a place where the office is placed. In the case where the company does not owns the building where the office is located

and only pays a rent, the EE-MRIO model covers these expenditures by “Real estate services” category. In the case the company owns the building, the value of the property is covered in the IO table, specially in the “Value added” section (more information can be found in [Murray and Wood, 2010]).

2.4 Inflation rate, different currency and physical units

The data in the EXIOBASE 2.0 are from 2007 and are presented in Euro. The annual Euro inflation rates in period 2008-2014 (see table 2.4) were identified in order to keep the current monetary value [Eurostat Statistics, 2014]. The target country is Norway therefor the required unit for the appropriate data currency is the Norwegian kroner (NOK). The annual average ratios between Euro and NOK were recognized (see table 2.4) [Den norske Bank, 2014].

The data requirements for the Waste category are in physical units. The CREEA project provides the multipliers in Gha/ton, therefor the impact can be calculated directly [Wood et al., 2010]. In order to keep option to use data in monetary or physical units for Energy sector, the annual average price for kWh of electricity was used, see table 2.4 [Statistics Norway, 2015].

	Annual average inflation rate		Annual Euro to NOK exchanger	Price for NOK/kWh of electricity
Year	%	Coefficient		
2007		1.000	8.016	0.631
2008	3.4	0.966	8.226	0.749
2009	2.3	0.944	8.739	0.715
2010	2.3	0.922	8.008	0.874
2011	1.2	0.911	7.797	0.842
2012	0.4	0.907	7.481	0.671
2013	2	0.889	7.806	
2014	1.9	0.872	8.357	

Table 2.2: The annual coefficients for the Euro inflation rate [Eurostat Statistics, 2014], for the Euro-NOK conversion [Den norske Bank, 2014] and for the Norwegian annual average price for kWh of electricity [Statistics Norway, 2015]

2.5 Sensitivity analysis for eco-friendly products

Eco-friendly products have recently become a popular public topic. Eco-friendly products have usually higher price than non-eco-friendly products [Kianpour et al., 2012]. The EF calculations use mainly monetary units, therefore the use of the eco-friendly goods increases the total EF instead of its reduction. The EF structure deals with this problem mainly in cases for: (1) paper (2) furniture and (3) food consumption. This section shows the difference between the total EF of the WWF Oslo office (see section 2.3) due to price changes for items mentioned above. The assumption that WWF Oslo in the basic case uses the non-eco-friendly products is made (see figure 2.3).

Paper: According to the Center for a New American Dream survey the difference between prices for a virgin and 30% post-consumer waste (PCW) paper is 8% and for 100% PCW paper is 36%[Responsible Purchasing Network].

Furniture: For the differentiation between prices for eco-labelled and no eco-labelled products an assumption was taken from [Veisten, 2007]. The assumption here was that the price would increase by 10% or by 25% compare to the basic price.

Food: For the average price difference the study based on data collected by Colby College students was used[Pillsbury]. 21 different products and its prices were observed. For each of the products, the difference in price between organic and non-organic version was calculated. The average of these values was used as a data for the analysis.

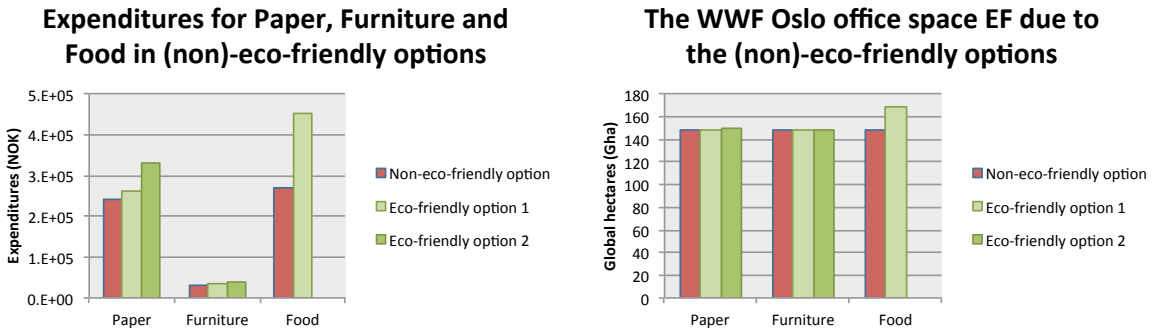

Figure 2.3: The changes comparison of expenditures and the related total EF for WWF Oslo office space.

3. Results

3.1 The European Union and Norway

The study showed that the EF due to the activity in the "Other business activity" sector is 1.58e+08 Gha for the EU and 1.70e+06 Gha for Norway. The results were normalized by number of FTE related to the same sector. A FTE in the EU is responsible for 7.07 Gha per year and one FTE in Norway contributes by 8.16 Gha (see table 3.1).

Indicator		**Indicator**	
WWF Oslo related expenditures	1.56e+07 NOK	EF - EU	1.52e+08 Gha
Number of FTE WWF Oslo	43	EF - Norway	1.70e+06 Gha
Number of FTE Norway	2.07e+05	EF - WWF Oslo	1.54e+02 Gha
Number of FTE EU	2.14e+07	EF per FTE - EU	7.07 Gha
Inflation coefficient	0.8892	EF per FTE - Norway	8.16 Gha
Euro to NOK conversion	7.8058	EF per FTE - WWF Oslo	3.58 Gha

Table 3.1: The key values of the analysis

According to the Global Footprint Network, the personal EF of consumption in 2007 was 5.56 Gha per person in Norway. The European average in 2007 was 4.68 Gha per capita [Ewing et al., 2010]. This data indicates that the EF from the office activity is higher than the personal footprint per capita, as both cases proved. It is important to mention that these two approaches are not directly comparable. The EF of the business services refers to a producer, which supplies products to consumers. Therefore some of the impact of business sector is embodied in final consumption.

The structure of the EF due to the activity in the “Other business activity” sector is similar for the EU case and for the case of Norway. These results were expected because both studies belong to the same continent and the conditions within Europe do not differentiate significantly.

Figure 3.1 shows the structure of the EF for the EU and Norway by looking on different footprints. The CF is the major contributor to the total EF for both cases. The CF contributes by 63% in the EU context and by 74% in the case of Norway. The second and third main important components of the EF are Forest land footprint and Cropland footprint.

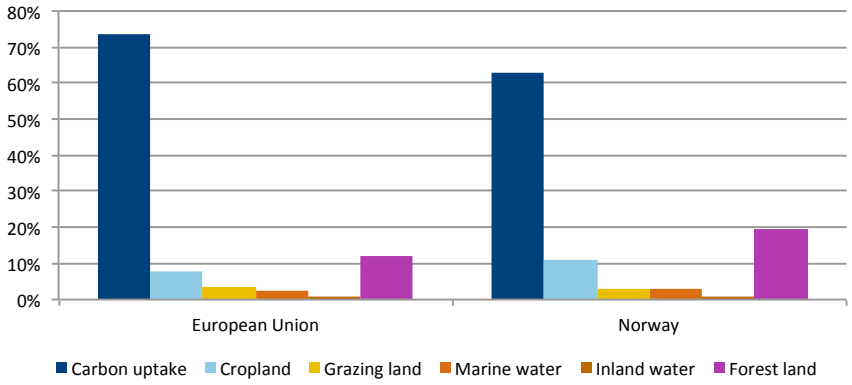

Figure 3.1: Structure of the Ecological footprint for the European Union and Norway by different footprints

The categories from the previous Project were used to investigate the structure of the EF from the perspective of different consumption sectors for Norway and for the EU. As the figure 3.2 shows, the main sectors are same for both cases even if the distribution differs more significantly than for the different footprints analysis. The two main sectors are (1) Other Goods and (2) Other services with more then 80% of the total EF in Norway and more than 70% in the EU.

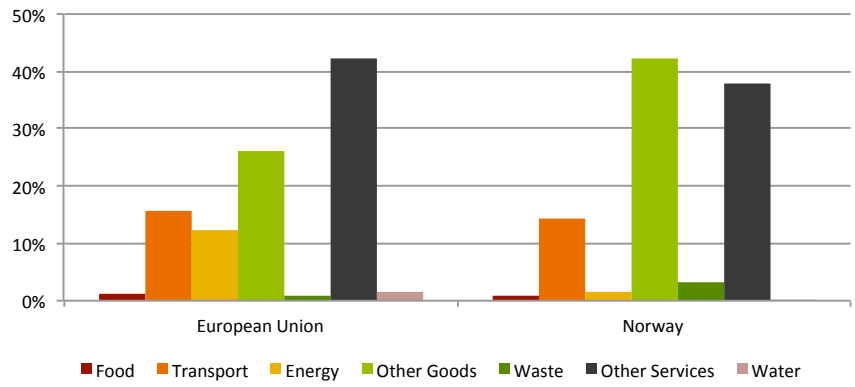

Figure 3.2: Structure of the Ecological footprint for the European Union and Norway by different consumption sectors

The structure of different footprints is similar and is presented in figure 3.3. The CF is the main component of the EF in both cases. The structure of the EF is therefore related to the structure of the CF. The Transport, Other Goods and Other Services consumption categories represent the majority of the impact in the CF, and also in the total EF. The three mentioned consumption categories are also the main contributors to the Forest footprint. The third main footprint is Cropland. A significant factor here is Food sector. That is expected because of the space demand for harvesting. The main difference between the EU and Norway case is in the CF due to the Energy consumption category. The contribution in the EU is significantly higher than for a case of Norway. The decarbonisation process used in Scandinavia is the main reason for such a variation. In Norway, the Energy sector contributes only by 1% from the total EF. In the EU the Energy sector represents 10% of the total EF. The difference in impact due to the energy consumption between Norway and the EU is significant. This is caused mostly by the different energy sources. In Norway 96% of the electricity production is hydropower, the EU has 48% electricity from fossil fuels sources (and only 15% from hydropower) [International Energy Agency, 2013].

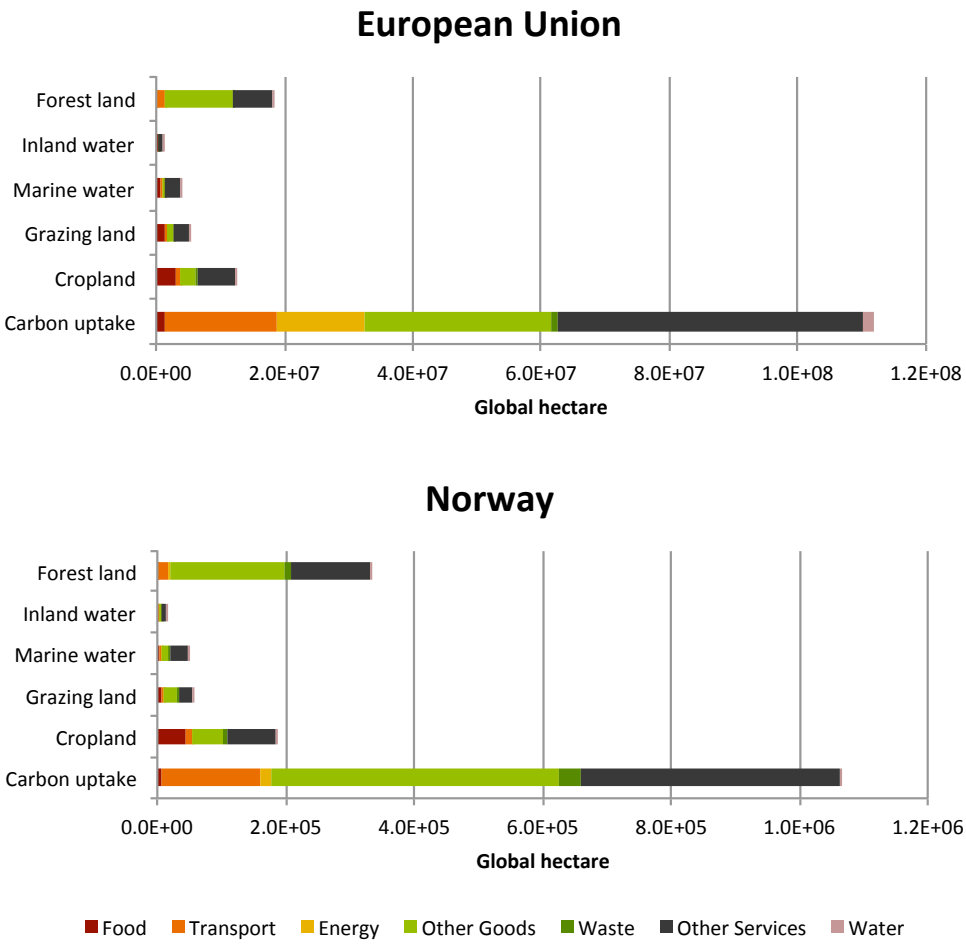

Figure 3.3: Structure of the footprints for the European Union and Norway by different consumption sectors

3.2 WWF Oslo office

The total EF due to the WWF Oslo office activity in 2013 was calculated as 154.12 Gha (see table 3.1). This value covers direct and indirect impacts to the environment due to the expenditures by WWF Oslo office related to the functioning of the office (15.6 million NOK) and impact due to the waste production by the office (2.4 ton).

The result was normalized by the number of FTE related to the office. The EF/FTE for WWF Oslo was calculated as 3.58 Gha (see table 3.1). This and values for the EU and Norway give the benchmarks for an assessment of environmental impacts due to the activities in a specific office

in Norway, respectively (in this case) in the WWF Oslo office.

The calculations show that even if the EF/FTE from "Other business activity sector" is higher for Norway than for the EU (see figure 3.4), the CF/FTE for the EU and for Norway are relatively similar (see figure 3.5). In comparison with WWF Oslo, the EF/FTE is significantly smaller than the EU and Norwegian averages.

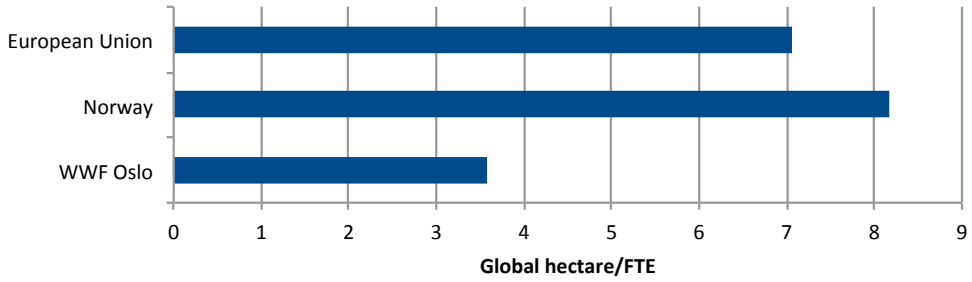

Figure 3.4: Ecological footprint per full time employee for WWF Oslo, Norway and the European Union

The distribution between the footprints differs for each of the case. Figure 3.5 presents the contribution of different footprints into the total EF/FTE. The values per FTE are lower in all types of footprints for WWF Oslo compare to the EU and Norway. This general founding is caused by the awareness of the actions for reducing the environmental impacts. It shows that the expenditure per FTE is lower in WWF Oslo office. Even though the WWF Oslo office uses eco-friendly products, the results does not reflect these actions (for more information about the eco-friendly product influence see section 4.3.

For all three cases the CF plays the main role. Other significant participants are (1) Cropland footprint and (2) Forest land footprint. As mentioned above the main reason for differences especially in the CF is the various energy mix used in Norway and in the EU.

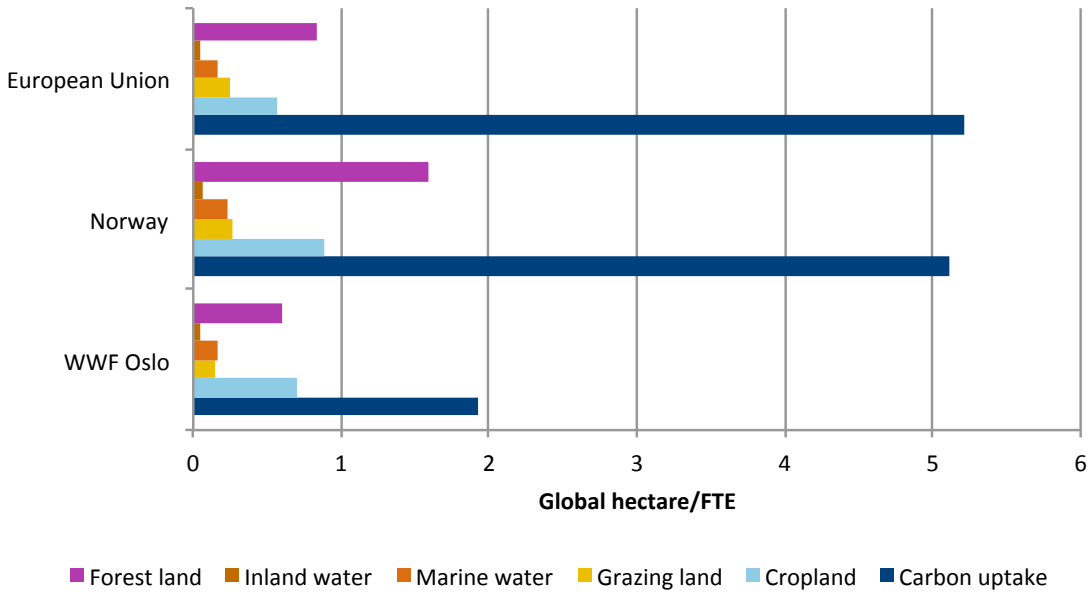

Figure 3.5: The footprints per full time employee

One of the goals of this analysis was to investigate the structure of the EF by consumption sectors due to the office activity. From the 80 categories in the WWF Oslo accounting system the irrelevant items were subtracted and the calculation was performed with the last 49 categories. Full list of the items is given in Appendix A. Each of the reminded items was evaluated and added to the relevant category. The 8 main sectors were identified: (1) Food, (2) Waste, (3) Energy, (4) Transport, (5) IT and Telecommunication, (6) Office Maintenance, (7) Other Goods and (8) Other Services. The results showed that the expenditures and the EF are not distributed equally among the aggregated categories (see figure 3.6).

The main contributor is Other Services sector with 41% from the total EF and 58% from the total expenditures. Food, Transport, IT and Telecommunication and Other Goods sectors contribute to the total EF between 13-15%. The rest (Energy, Waste and Office maintenance) have not significant influence on the total EF as sectors. Anyway, the Energy sector would become to be important factor by focusing on the CF and in a case study outside Norway (because of the electricity mix). The waste category is a special case focusing on waste management and recycling. For WWF Oslo the impact from Waste sector is very low, it could be caused by the employees' awareness about the environmental related questions. Office maintenance contributes

only 2% to the total EF, but it includes one of the TOP10 expenditures category (third place) and also one of the TOP10 EF's category (first place): Office rent. The list of TOP10 contributors to the EF are presented in table 3.2.

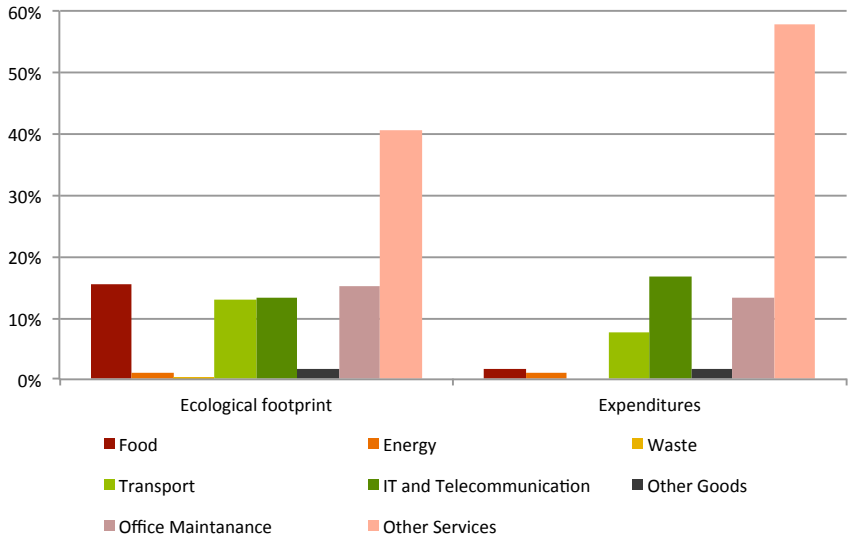

Figure 3.6: Structural composition of the Ecological footprint and the expenditures of WWF Oslo office

	TOP10 Ecological footprints	**Gha**	**Sector**
1	Office rent	21.16	Office Maintanance
2	Advertising new donors	19.45	Other Services
3	Travel expenses without VAT	17.91	Transport (people)
4	Marketing and PR	14.21	Other Services (Marketing)
5	Acquisition of new donors	7.86	Other Services
6	Printing and binding	4.85	IT and Telecomunication
7	IT consulting services	4.31	IT and Telecomunication
8	IT hardware	3.97	IT and Telecomunication
9	Mobile phones purchase and usage	2.53	IT and Telecomunication
10	Campaigns existing members	2.33	Other Services (Marketing)

Table 3.2: TOP10 contributors to the Ecological footprint from the WWF Oslo office

The TOP7 categories in the list of expenditures includes same items as a TOP7 list of the EF contributors (see table 3.2). It means that the money spent by the office is in a direct correlation with the caused environmental impact.

The Food category can be considered as a special case. Event though the expenditures represent only 2% from the total amount, the EF became to have the highest value (28.8 Gha) in the list of the EF contributers. Because of the data source for food expenditure differs (it is not included in the WWF Oslo accounting system) and for the calculation was available only one total value, the food item was excluded from the TOP10 list. The TOP7 list (included Food category) represents 71% of the total EF and 62% of the total expenditures.

Figure 3.7 presents the consumption sectors contribution to the different footprints. The structure of the footprints correlates with the structures in the EU and Norway cases. Main difference is in the Cropland footprint where the Food sector in WWF Oslo case increases the impact in this footprint. The difficulties with Food sectors are explained above. The same figure also shows that the main impact in the CF is the Other Services sector. This correlates with results presented in figure 3.6 and also with figure 3.3, where the structures for the EU and Norway are displayed.

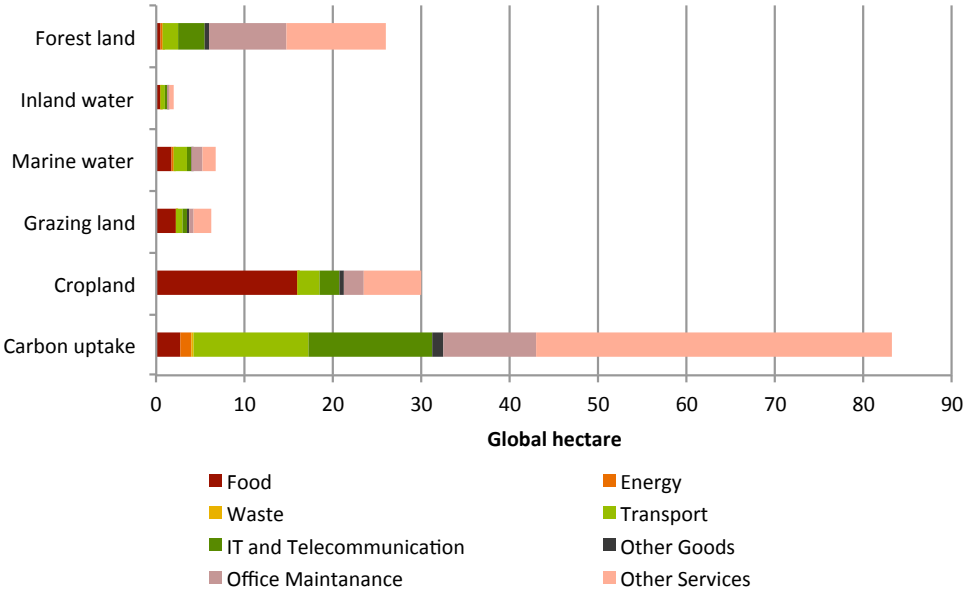

Figure 3.7: Structural composition of the footprints in the way of different consumption sectors

The 100% chart (see figure 3.8) represents contribution of each footprint to the expenditure sectors. The majority of the EF is represent by the CF for all sectors except the Food sector. Here the Cropland footprint takes the place of the main footprint. This fact correlates with results in figure 3.7, where is visible that the Food sector is the main contributor in Cropland footprint.

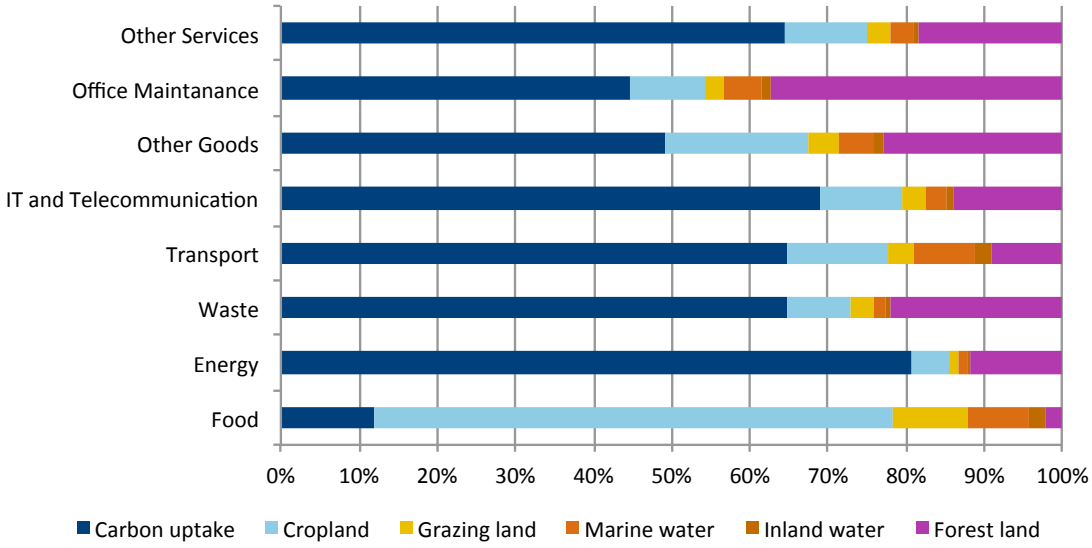

Figure 3.8: Structural composition of the EF of each sector in the way of different footprints

Figure 3.9 shows different structure of the WWF Oslo EF in the way of impact due to domestic and international trade. The EF due to the imported goods (international trade) is higher (more then 65% of total EF) than the EF caused by the domestic activity. The domestic impacts are higher for Cropland footprint and Marine and Inland water. Almost 80% of the CF is due to import.

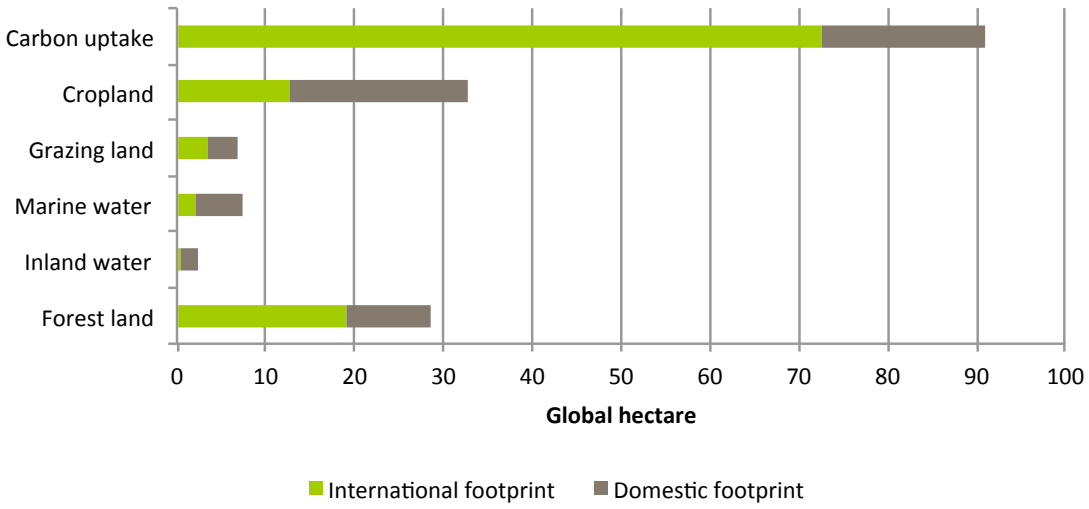

Figure 3.9: Impacts due to the domestic activity and international trade for each footprint

3.3 Sensitivity analysis

The sensitivity analysis for the eco-friendly products was performed. The aim of this analysis was to recognize the importance of eco-friendly initiatives in the scope of office activity by using IO model. Three products were taken into the account: (1) Paper, (2) Furniture and (3) Food. Figure 2.3 presents the differences between the expenditures and therefore EF for each product. On the left site is a comparison of WWF Oslo expenditures by purchasing (1) product without the eco label and two options (2,3) for products with eco-friendly label. On the right site is the related total EF for WWF Oslo office activities. For the Paper and Furniture products the difference is insignificant. The Food category shows a small difference in the total EF (Due to the lack of data, for Food category was used only one eco-friendly option). The difference is approximately 12%. Therefore the action for Food category would be appropriate. Due to the luck of data (as mentioned above) was not possible to get more accurate information about the food consumption in the WWF Oslo office.

4. Discussion

4.1 Structure development and results

The developed calculator was used as a tool to analyse the structure of the EF belongs to "Other business activity" sector in the EU and in Norway. The calculator was based on the structure of the EXIOBASE database. This structure does not fit the requirements about friendly use of the calculator requested by WWF Oslo (see figure 2.1). Therefore the new structure had to be developed (see table 2.1). The WWF Oslo accounting system was used as a base for the new structure. Even if the structures from both stages are similar, an inaccuracy can appear in the comparison of the results for EU and Norway with results for WWF Oslo. Also, because the structure of the footprint was customized specifically for WWF Oslo case, the differences in the accounting systems for other future cases can lead to problems.

During the second stage (see figure 2.1), the new multipliers were calculated by using the weighted averages. As a weight were used the relevant expenditures in "Other business activity" sector in Norway. This assumption may cause inaccuracy in the multiplier values, therefore the total EF may be distorted.

4.2 Actions to reduce EF

The WWF is an organisation focuses on conservation and environmental issues. Therefore the WWF Oslo employees have already taken actions in order to reduce the environmental burden due to their activity. The results in this study declare this conclusion. But there is always space for improvement. The results from the WWF Oslo office study show the wide range of

the EF sources. Different activities and different purchases required by WWF Oslo office needs different actions in order to be able to reduce the impact due to this behaviour.

The main contributor to the total EF is the CF. Within this footprint the major impact is due to the Other Services sector, especially action taken due to the marketing activity (more than 60%). This category covers among others also advertising new donors and public relations (two main contributors). In order to reduce the total EF, the focus should be pointed into this sector.

The second main contributor to the total EF is the Cropland footprint, which is caused mainly due to the Food sector. The reason for this result could be due to the problem described in section 4.3. The WWF Oslo office has a strong policy about the sustainable behaviour but because of lack of data it was not possible to recognize actions related to Food sector which had been taken. Anyway, the Food sector offers a big potential for decreasing the Cropland footprint and therefore the total EF.

4.3 Strengths and weaknesses of the model

The EEIO methodology assumes a linear relationship between amount of emission due to the expenditures. Therefore the model is not able to behave according to the price variation between the sectors. This is the problem mention in sections 2.5 and 3.3. The environmental friendly items with higher price will leads to the increase of the EF. This linear relationship is revers compare to the real situation. In the EF scope the differences would not be that significant for the purchase of goods, but it still has a level of inaccuracy. In the case of the Food sector, the influence on the total results could be significant. The further development is required to solve this problem. One of the options is to apply coefficients for the most relevant items in question of environmental friendly labels. These coefficients would decrease the EF due to the item purchased accordingly to the level of the ecofriendly upgrade.

Another weakness of the model is price variation between sectors which were aggregated. The price varies, therefore the monetary unit is not as representative of the environmental impacts of the product groups as a physical unit.

The EEIO model uses data from year 2007. In order to precise the data, the coefficients for

inflation rate were used. Also, the model is based on data in Euro. Therefore the conversion between NOK and Euro was used. These transformations could leads to the inaccuracy in the data set.

By using the CREEA EE-MRIO model the consistency between the IO tables and the stressors are guaranteed. By using information about FTE also from the same dataset, the benchamrks are validated. Another strenths of this approach is the required data availibility. By using the office accounting system, the approach avoids the actions for data gathering from different sources. The analysis can be done stright forward and does not required period of time for preparation even if it works on annual base.

5. Summary and Conclusions

To summarize, the EE-MRIO model was used to established the EF of the WWF Oslo office. The IO model shows the advantages especially in data consistency and data availability. The structure of the EF had to be change according to the WWF Oslo accounting system, therefore the EF calculator developed in previous study was not possible to use.

The EF value for the case of WWF Oslo office is lower compare to the Norwegian and European Union averages in the same sector, which were also calculated within this study by using same methodology. It shows that the investigating office has taken actions to reduce its environmental impact. As normalization factor was used a value of FTE for each of the cases: (1) WWF Oslo office, (2) Norway, (3) European Union. The structure of the EF was defined by using the accounting system of the WWF Oslo office. The structure development took into the account the application of the EF structure in future studies related to office activity for businesses with similar size as WWF Oslo.

The most important footprint is the CF, which represents more than half of the total EF. The main sector responsible for the environmental impact is Other Services sector. The most relevant WWF accounting system categories for the total EF are: (1) Food, (2) Office rent and (3) Advertising new donors. The sensitivity analysis was used to prove that eco-friendly option does not significantly affect the total EF results.

5.1 Recommendations for Further Work

The study is lacking data for eco-friendly products, especially in the Food sector. Including the eco-friendly coefficient would make the results more accurate. In this study was decided to

exclude data about travel to and from work from the system boundaries. To include this sector would make the study more general. Also the question about the relevance of the building where the office is placed was not taken into the system boundaries. The type of building would also affect the total EF.

This thesis applied the calculator from previous project for a real case study. The calculator has not been tested and the correlation between the calculator structure and WWF Oslo accounting system is uncertain. Also the uncertainty of data availability for the sensitivity analysis study plays a role and demand further research.

During the process the goal of the thesis had to be changed. Due to the lack of time, the study about the sustainable development benchmarks had to be skipped. The main goal become to provide a study about the structure of the EF caused by the EU, Norway and the WWF Oslo office with the option to use the structure of the EF for other studies of a similar office space as the WWF Oslo office. The sustainable development benchmarks study is a next appropriate step to follow.

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A. Data

	Name	Expenditure [NOK]
1	Acquisition of new donors	1,047,000
2	Advertising new donors	2,600,000
3	Audit fees	251,000
4	Bank charges	348,000
5	Books	5,100
6	Campaigns existing members	312,000
7	Cleaning	142,100
8	Consultancy fees (salary)	279,000
9	Electricity heating	Special category
10	Entertaining guests	52,500
11	Freight courier	No expenditure
12	Furniture and fixtures	1,200
13	Gifts for employees	18,200
14	Insurance liability and equipment	52,100
15	IT consulting services	890,000
16	IT hardware	162,500
17	IT software	320,000
18	IT supplies (rekvisita)	82,000
19	Job advertisements	287,000
20	Lawyer and consulting fees	237,000
21	Layout and design	408,000
22	Magazines	3,000
23	Maintenance equipment	No expence
24	Maintenance office	118,000
25	Marketing and PR	1,900,000
26	Meetings courses training fees for staff	277,000
27	Membership and private donors	No expenditure
28	Membership fees	141,000
29	Mileage allowance	2,066
30	Mobile phones purchase and usage	184,000

Table A.1: WWF Oslo office space expenditures in 2013 (1/2)

	Name	Expenditure [NOK]
31	Newspapers	50,200
32	Office rent	1,800,000
33	Office supplies (rekvisita)	38,500
34	Other donor maintenance expenses	146,000
35	Other expenses	28,000
36	Other personnel costs	83,000
37	Pictures and video purchase and rent	98,662
38	Postage office (frankeringsmaskin)	207,033
39	Postage other	No expenditure
40	Press clippings and market surveys	232,650
41	Printer copy machine usage	107,655
42	Printing and binding	544,000
43	Purchase of goods	No expenditure
44	Seminars and courses organized by WWF	384,000
45	Taxi	15,400
46	Telephone fax internet	101,000
47	Travel expenses without VAT	967,000
48	Web-related services	136,000
49	Webshop maintenance	105,000

Table A.2: WWF Oslo office space expenditures in 2013 (2/2)

	Name		Name
1	Corporate donations/sponsors	17	Ovf innt. FRA tidl. år CFW (-)
2	Corporate donations/sponsors VAT	18	Per diem allowance
3	Corporate members VAT	19	Private donations restricted
4	Corporate partners	20	Project transfers abroad non-WWF
5	Corporate partners VAT	21	Project transfers abroad WWF
6	Fees VAT	22	Project transfers domestic non WWF
7	Legacies	23	Refund VAT
8	Licensing VAT	24	Rent revenue
9	Lotteries and grass root	25	Rounding off VAT (Øreavrunding mva)
10	Min of Environment	26	Trusts and foundations
11	Min of Foreign Affairs	27	Underuse previous year
12	NORAD		(Underforbruk fra året før)
13	Other direct contributions	28	Webshop and other sales non VAT
14	Other government funding	29	WebShop and other sales VAT
15	Other government funding for use abroad	30	WWF Intl contribution
16	Other WWF contributions	31	WWF Sweden contribution

Table A.3: Categories from WWF Oslo accounting system excluded from the calculations

WWF Oslo categories	Code	CREEA categories	EF_multiplier_Norway gha/m€ per year
Food			
	4	Vegetables, fruit, nuts	593.4278132
	5	Oil seeds	1801.250567
	8	Crops nec	2549.650419
	10	Pigs	505.6349244
	14	Raw milk	656.9248332
	47	products of Vegetable oils and fats	530.4357362
	48	Dairy products	398.4801108
	49	Processed rice	173.8479828
	52	Beverages	217.1327045
	53	Fish products	1533.198812
Energy			
Energy - Electricity	128	Electricity by coal	1527.348737
	129	Electricity by gas	3187.969403
	131	Electricity by hydro	35.58074665
	132	Electricity by wind	36.32000234
	133	Electricity by petroleum and other oil derivatives	920.2940512
	134	Electricity by biomass and waste	511.3950599
Energy - Electricity services	139	Electricity nec	76.8188019
	140	Transmission services of electricity	43.53469278
	141	Distribution and trade services of electricity	44.3906867
Energy - Heat	148	Steam and hot water supply services	710.6817414
	146	Biogas	63.73257798
Waste			
Watse - Paper	177	Paper waste for treatment: incineration	95.91944698
	191	Paper for treatment: landfill	104.0218293
Watse - Plastic	178	Plastic waste for treatment: incineration	84.04943988
	192	Plastic waste for treatment: landfill	121.7948494
Waste - Inert/metal/hazardous waste	179	Intert/metal waste for treatment: incineration	102.3873442
	193	Inert/metal/hazardous waste for treatment: landfill	102.0515109
Waste - Other	176	Food waste for treatment: incineration	102.2018764
	180	Textiles waste for treatment: incineration	95.28522918
	181	Wood waste for treatment: incineration	95.38213914
	182	Oil/hazardous waste for treatment: incineration	95.81813739
	186	Food waste for treatment: composting and land application	99.13985679
	188	Food waste for treatment: waste water treatment	140.5879875
	189	Other waste for treatment: waste water treatment	128.6378775
	190	Food waste for treatment: landfill	104.755976
	194	Textiles waste for treatment: landfill	108.8100249
	195	Wood waste for treatment: landfill	107.5015328
Transport			
Fuels and vehicles			
Motor Gasoline	67	Motor Gasoline	92.49715982
Gas/Diesel Oil	72	Gas/Diesel Oil	92.58194648
Liquefied Petroleum Gases (LPG)	75	Liquefied Petroleum Gases (LPG)	92.47733313
Sale and maintanane of vehicles	158	Other land transportation services	79.25380804
Transport of people			
Air transport	162	Air transport services (62)	182.0623223
Water transport	160	Sea and coastal water transportation services	347.1570189
Taxi	159	Transportation services via pipelines	102.1903712
Railway transport	157	Railway transportation services	54.44390384
Mileage allowance	198	Other services (93)	67.10886398
Travel expenses without VAT	162	Air transport services (62)	182.0623223
	156	Hotel and restaurant services (55)	144.0068133
	174	Education services (80)	31.45007667
Travel agencies fees	163	Supporting and auxiliary transport services; travel agency services (63)	139.3219839

Table A.4: Structure of the calculator after second stage (1/3)

WWF Oslo categories	Code	CREEA categories	EF_multiplier_Norway gha/m€ per year
Transport of goods			
Postage office (frankeringsmaskin)	164	Post and telecommunication services (64)	77.77576818
Postage other	164	Post and telecommunication services (64)	77.77576818
Freight courier	164	Post and telecommunication services (64)	77.77576818
IT and telecomunication			
IT hardware			
IT hardware	119	Office machinery and computers (30)	214.4378344
IT supplies (rekvisita)	63	Printed matter and recorded media (22)	78.33392275
Mobile phones purchase and usage	121	Radio, television and communication equipment and apparatus (32)	120.8499137
Other			
IT consulting services	170	Computer and related services (72)	42.53866107
IT software	170	Computer and related services (72)	42.53866107
Web-related services	170	Computer and related services (72)	42.53866107
Webshop maintenance	170	Computer and related services (72)	42.53866107
Telephone fax internet	164	Post and telecommunication services (64)	77.77576818
Printer copy machine usage	170	Computer and related services (72)	42.53866107
Printing and binding	63	Printed matter and recorded media (22)	78.33392275
Other Goods			
Books	62	Paper and paper products	98.87144938
Magazines	62	Paper and paper products	98.87144938
Newspapers	62	Paper and paper products	98.87144938
Furniture and fixtures	125	Furniture; other manufactured goods n.e.c. (36)	171.1634642
Gifts for employees	155	Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods (52)	77.16887409
Purchase of goods	155	Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods (52)	77.16887409
Entertaining guests	155	Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods (52)	77.16887409
	156	Hotel and restaurant services (55)	144.0068133
Office supplies (rekvisita)	155	Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods (52)	77.16887409
Other personnel costs	170	Computer and related services (72)	42.53866107
	155	Food Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods (52)	77.16887409
Water	149	Collected and purified water, distribution services of water (41)	115.7108783
Office maintanance			
Cleaning	172	Other business services (74)	65.66066292
Office rent	168	Real estate services (70)	103.1825188
Maintenance equipment	170	Computer and related services (72)	42.53866107
Maintenance office	155	Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods (52)	77.16887409

Table A.5: Structure of the calculator after second stage (2/3)

WWF Oslo categories	Code	CREEA categories	EF_multiplier_Norway gha/m€ per year
Other Services			
Marketing			
Advertising new donors	172	Other business services (74)	65.66066292
Campaigns existing members	172	Other business services (74)	65.66066292
Layout and design	170	Computer and related services (72)	42.53866107
Marketing and PR	172	Other business services (74)	65.66066292
Other			
Audit fees	172	Other business services (74)	65.66066292
Bank charges	165	Financial intermediation services, except insurance and pension funding services (65)	26.07284179
Acquisition of new donors	164	Post and telecommunication services (64)	77.77576818
	162	Air transport services (62)	182.0623223
	172	Other business services (74)	65.66066292
	170	Computer and related services (72)	42.53866107
	198	Other services (93)	67.10886398
	63	Printed matter and recorded media (22)	78.33392275
Membership and private donors	196	Membership organisation services n.e.c. (91)	83.915912
Membership fees	196	Membership organisation services n.e.c. (91)	83.915912
Other donor maintenance expenses	164	Post and telecommunication services (64)	77.77576818
	162	Air transport services (62)	182.0623223
	172	Other business services (74)	65.66066292
	165	Financial intermediation services, except insurance and pension funding services (65)	26.07284179
Consultancy fees (salary)	172	Other business services (74)	65.66066292
Lawyer and consulting fees	172	Other business services (74)	65.66066292
Insurance liability and equipment	164	Post and telecommunication services (64)	77.77576818
	166	Insurance and pension funding services, except compulsory social security services (66)	21.85142048
Job advertisements	172	Other business services (74)	65.66066292
Pictures and video purchase and rent	63	Printed matter and recorded media (22)	78.33392275
Press clippings and market surveys	171	Research and development services (73)	45.2092159
Meetings courses training fees for staff	174	Education services (80)	31.45007667
Seminars and courses organized by WWF	174	Education services (80)	31.45007667
Other expenses		Food	
	172	Other business services (74)	65.66066292
	125	Furniture; other manufactured goods n.e.c. (36)	171.1634642

Table A.6: Structure of the calculator after second stage (3/3)

B. Acronyms

CF Carbon footprint

CPA 2002 Statistical Classification of Products by Activity 2002

CREEA Compiling and Refining Environmental and Economic Accounts

EEIO Environmental Extended Input Output

EE-MRIO Environmentally extended multi-region input-output

EF Ecological footprint

EU European Union

FTE Full time employee

Gha Global hectare

IO Input Output

LCA Life cycle assessment

MRIO Multi-Regional input output

NOK Norwegian kroner

NTNU The Norwegian University of Science and Technology

SD Sustainable development

WWF World Wide Fund for Nature; World Wildlife Fund