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Life-cycle assessment of international vacation packages

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MASTER THESIS

for

Student Anna Veselkova

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Life cycle assessment of international vacation packages

Livsløpsvurdering av internasjonale pakkereiser

Background and objective

To high-income populations in Norway and elsewhere, international package travels have become popular opportunities for experiencing other cultures or gaining a temporary break from everyday routines or local climate. Such package travels typically involve international travels by air, which are known to have high carbon footprints. They also typically involve hotel stays, and may also involve other transport activities and the provision of a number of other services such as meals or insurance. In a life-cycle perspective, all such activities cause environmental impacts. The aim of this project is to provide insights into the environmental impacts of international vacation packages, taking a life-cycle view of activities involved.

The tasks are:

(1) A short literature review of existing life-cycle assessment literature on products or services that are relevant for international vacation packages;
(2) selection of activities to be investigated in this work (at the minimum, this should include air travel and hotel stays);
(3) compilation of life-cycle inventories for the selected activities;
(4) life-cycle assessment of international vacation packages based on the data collected for individual activities; and
(5) discussion of results.

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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, 14. January 2014

Olav Bolland
Department Head

Edgar Hertwich
Academic Supervisor

Research Advisor: PostDoc Anders Arvesen

Abstract

This thesis aims to perform a Life Cycle Assessment in order to explore environmental impacts associated with a vacation package. It identified the phases of the holiday that generated the largest impact, the most significant impact categories and quantified the impacts generated.

The results of LCA have demonstrated that impacts from the vacation package occur in all of the eighteen midpoint impact categories, with the largest contributions from air travel and electricity consumption. Further assessment has shown that there are variations in impacts (specifically, GHG emissions), depending on the destination and the length of stay. At the same time, it has been found that GHG emissions from air travel are not directly proportional to the distance flown. Overall, the study has confirmed that viewing tourism as low impact industry is misleading.

Significant gaps in tourism related research and data were identified. While a relatively large number of studies focused on impacts from air travel, the research on the hotel stay and tourist activities is much more limited. Literature research also showed that there are a very few studies related to use of LCA in tourism and specifically LCA of a holiday package. It was found that several important elements of the vacation package were not covered enough in the literature such as for example tourist activities, waste generation, and food consumption.

Possibilities and barriers for future research were also identified. It was suggested that more studies on different types of vacation packages would make results of impact assessment more representative. However, in order to conduct comprehensive LCAs of holiday packages, current major gaps in available data need to be filled.

Preface

This master thesis was prepared during the last semester of study for *MSc Program Industrial Ecology*.

Herewith I would like to thank my supervisor, *Edgar Hertwich*, and my co-supervisor, *Anders Arvesen*, for their patience and consideration during writing of this thesis.

Special thank you I would like to give to *Anders Arvesen* for his guidance and comments regarding the technical part of this work.

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1 Introduction and Motivation

Climate change is considered to be one of the most serious environmental threats to sustainable development. Adverse impacts are expected on human health, economic activity, food security and access to water, natural resources and the environment, and physical infrastructure (IISD, 2002). There is solid scientific evidence to suggest that despite technological improvements as well as other operational and economic measures to reduce greenhouse gas (GHG) emissions, there could be still change in the climate, and the potential consequences might be significant.

Intergovernmental Panel on Climate Change initially assessed possible impacts of climate change (storms, heat waves etc.) in 1999, and the most recent update of these assessments was made in 2007. According to the latest report, climate change will be experienced worldwide. It is emphasized that mitigation or adaptation actions need to be taken immediately in order to address the effects of climate change (ICAO, 2013).

In addition to everyday mobility for working, shopping and leisure purposes, holiday mobility has become increasingly important. Holiday travel and short stay trips have become an integral part of the modern life styles. While not long time ago traveling used to be a privilege, nowadays traveling and tourism is a mass activity in the western society (Bohler et al., 2006). Over past six decades tourism has experienced continuous expansion and diversification, and is now one of the largest and fastest growing economic sectors worldwide (UNWTO, 2014). Tourism is of high economic importance for industrialized countries while being of equal importance for developing countries that have become tourist destinations. In real figures, globally tourism is responsible for 9% of GDP, and the industry employs 9% of the world’s workforce. Though the industry appears vulnerable to occasional economic or geopolitical shocks, international tourist arrivals have shown virtually uninterrupted growth, increasing from 25 million in 1950 to 528 million in 1995, and 1087 million in 2013. According to UNWTO’s long term forecast Tourism Towards 2030, this trend is expected to continue with increase in international tourist arrivals by 3.3% a year from 2010 to 2030, reaching 1.8 billion by 2030 (UNWTO, 2014).

The sheer size of the industry along with strong growth naturally implies the need to consider its environmental impacts. Currently, UNWTO estimates that tourism is responsible for around 5% of CO_2 emissions, which makes it an important contributor to global climate change. By 2035, under "business as usual" scenario these emissions are projected to increase by 130% (UNWTO, 2010).

However, some studies argue that considering the radiative forcing effect, the share of tourism contribution to climate change can be up to 12.5% (Scott at al., 2010). Radiative forcing of climate is a measure used to quantify the climate impact of some phenomena. It is formally defined by IPCC as "the change in net (down minus up) irradiance (solar plus longwave; in W m^{-2}) at the tropopause after allowing for stratospheric temperatures to readjust to radiative equilibrium, but with surface and tropospheric temperatures and state held fixed at the unperturbed values" (IPCC, 1996 cited in Lee, 2009). Some studies quantified the effect of aviation emissions on RF. The nature of the RF effect and its relation to air travel will be discussed in the last section of this thesis.

The data discussed above contradict the commonly shared view among many researchers and general public that tourism industry has low environmental impact. Rather, it is becoming now a shared vision that tourist activities are strongly related to the environment. On the one hand, this is due to the fact that the natural environment itself can be considered as a major input resource to the processes of tourism industry. On the other hand, current boom in tourism industry may severely increase its overall impact on the environment (De Camillis et al., 2012).

In 2013, travel for holidays, recreational purposes and other forms of leisure accounted for just over half of all international tourist arrivals as shown in Figure 1.1.

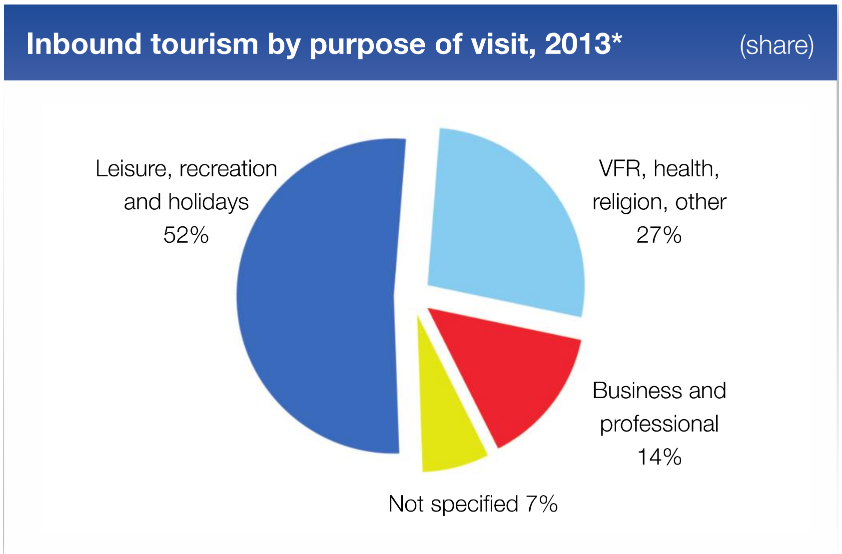


Figure 1.1 : Inbound tourism by purpose of visit, 2013 (UNWTO, 2014)

Therefore one can argue that environmental impacts arising specifically from holiday travel can be significant. From environmental perspective, the overall number of trips, travel destinations and distances as well as the choice of transport is the most crucial. In order to achieve sustainability of a holiday travel, it is important to focus on journey to and from holiday destination and particularly on transport modes with high environmental impact such as airplane and private car. Currently, air travel is the most popular means of transport in international tourism. According to UNWTO, in 2013 around 53% of all travelers reached their destination by airplane (Figure 1.2).

Importantly, the trend has been for air transport to grow at a somewhat faster pace than surface transport, so the share of air transport in international tourism continues to gradually increase (UNWTO, 2014).

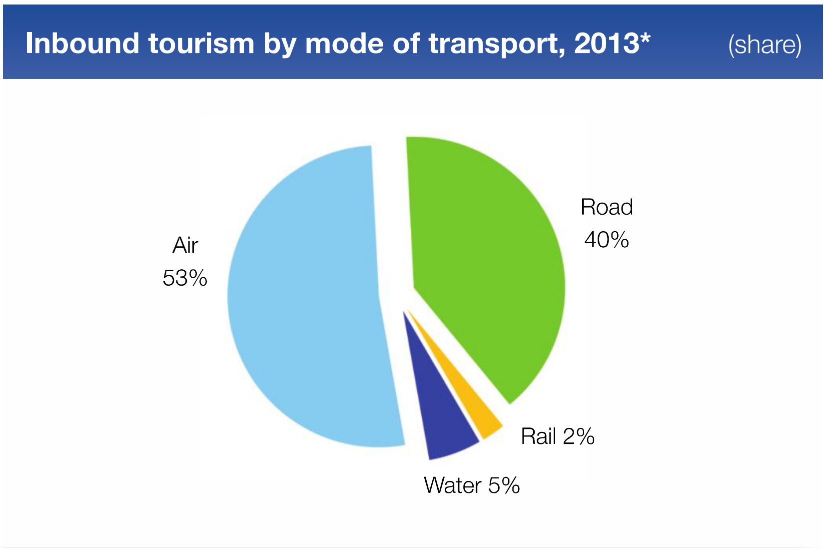


Figure 1.2 : Inbound tourism by mode of transport, 2013 (UNWTO, 2014)

Many studies have been devoted to evaluating environmental impacts from tourism at the holiday destination without accounting for effects of traveling to these places. They further propose strategies for developing green and sustainable tourism and for protection of ecologically sensitive regions (Bohler et al., 2006).

In this thesis Life Cycle Assessment is used to explore the environmental impacts of a vacation package. The objectives of the study were to assess the environmental damage caused by a typical vacation package undertaken by Norwegian tourists. In particular, it was considered important to identify the phases of the holiday that generate the largest impact, the categories of the most significant impact and quantify, where possible the impact generated. Further this thesis aimed at comparing a few vacation packages in terms of distance against the length of stay at the destination, in order to identify and analyze the relation if any. Another purpose was to quantify total GHG emissions from short/medium haul and long haul vacation travel, and compare GHG emissions from hotel stay in different countries. In addition, the study aimed at identifying and discussing the gaps in data and research related to environmental impacts from holiday packages and making suggestions for future studies.

2 Literature Review

Increasing international importance of travel and tourism as an economic activity attracts more and more interest from the scientific community. Tourism industry has been growing strongly over the last decades eventually becoming one of the principal sectors of the world economy and this trend is expected to continue in the future. In contrast with other service sectors of the global economy that may be considered as functional in the economic dematerialization required for environmentally sustainable development, tourist services should be carefully assessed from environmental viewpoint due to their growing importance (De Camillis et al., 2010). Though the common thinking is that many services have little environmental impact due to limited level of direct resource input, their overall impact can be significantly increased along the supply chain due to supply of inputs they require. It has been established that the understanding of tourism's contribution to climate change by both the general public and tourism experts in quite limited. This is mainly due to the fact that there is a lack of effective environmental assessment techniques, which would allow quantifying GHG emissions occurring because of tourist activities. Therefore, it is important to adapt existing methodologies from other disciplines to bridge this gap (Filimonau et al., 2011).

2.1 Environmental Impact Assessment of Tourism in Context of Climate Change

Tourism is a special sector that is characterized by the combination of actions and behaviors within different areas. For example, the tourism sector uses energy for the transport of visitors to and from, as well as within, destinations, in accommodation facilities and for a range of tourist activities. As a result of that most of this energy comes from fossil fuels, energy use in tourism is linked to emissions of GHGs (Scott et al., 2010).

As tourism impacts occur across different areas, the sustainability of this sector has become increasingly important, paying particular attention to consumption within the sector and its environmental impacts (Arcese et al., 2013).

Gossling defined tourism as "... the sum of the phenomena and relationships resulting from travel and stay of non-residents..." (Gossling, 2002 cited in Arcese et al., 2013). In 2011, tourism contribution to worldwide Gross Domestic Product (GDP) was around 5%. Environmental assessments of tourism have demonstrated that tourism's industry contribution to global climate change is significant accounting for up to 6% of human-induced carbon dioxide emissions (Scott et al., 2010). As presented in Figure 2.1, projections made for 2035 show that increase is expected in air transport and accommodation sub-sectors. Several studies have found that among holiday travel components transport was the largest contributor generating between 50% and 97.5% of the total GHG emissions caused by tourism activities (Byrnes & Warnken, 2006, Peeters, Gossling and Becken, 2006). As it would be expected, most of GHG emissions occur due to air travel to/from destination, while the share of the other tourism components is believed to have a marginal value. While this is true for long-haul travel, which implies carbon intensive flights over longer distances, such expectations are not necessarily correct for short-haul holidays. At the same time, research has demonstrated that longer stays at the destination are normally preferred in terms of eco-efficiency as the tourism activities at the destination are believed to have low carbon footprint. However, other aspects of holiday stay at the destination need to be considered. For example, extensive use of overland means of transport, a luxury all-inclusive hotel, and energy intensive activities may lead to a significant quantity of GHG emissions generated at the destination, which outweigh the carbon footprint of transportation to/from the destination (Filimonau et al., 2011).

	2005		2035[2]	
Sub-sectors	CO_2(Mt)	%	CO_2(Mt)	%
Air transport	515	40%	1631	53%
Car transport	420	32%	456	15%
Other transport	45	3%	37	1%
Accommodation	274	21%	739	24%
Activities	48	4%	195	6%
Total	**1,307**	**100%**	**3059**	**100%**
Total world (IPCC 2007c)	**26,400**			
Tourism contribution	5%			

Source: UNWTO-UNEP-WMO (2008).

Figure 2.1 : Distribution of emissions from tourism by sub-sector (adopted from Scott et al., 2010)

Presumably, the contribution of tourism to climate change will remain high in the future, and this is supported by two strong growth trends that characterize this sector. Firstly, increase in income and general economic stability in some parts of the world ensured that there are a growing number of people participating in both domestic and international tourism, and that the number of international tourist trips will continue to grow exponentially in the coming years as well. The other important factor is that the nature of holiday itself for individual travelers has changed. People choose more frequent and shorter stay holidays, travel farther distances which increases the use of high-energy transportation, and stay in more luxurious hotels. As a result, traveling on a per trip basis became much more energy intensive. With growing number of trips and increase in accommodation capacity worldwide, and the growing energy intensity of most trips, substantial increase in future emissions from tourism sector is expected. This is true even considering recent advances in technology, which improved energy efficiency of both air and surface transport and of accommodation facilities (Scott et al., 2010).

Though in theory the reduction potential for energy use and GHG emissions from transportation to/from the destination is important, in practice it is limited due to numerous socio-economic and technological constraints. By contrast, it is considered that GHG emissions mitigation at the destination has a high potential because of the flexibility in choosing energy supply mix and other options to improve energy and environmental performance. Therefore, holiday travel components that take place at the destination are considered the most significant dimensions of the tourism industry open to impact assessment and mitigation measures (Filimonau et al., 2011).

The recent research conducted for the Norwegian travel market (Virke, 2014) shows that the current main tourism market is in short-haul and domestic destinations with projections for future growth. Short-haul tourism is not clearly defined in the literature due to that definitions consider various transport modes and geographical locations. However, traditionally differentiation between short-, medium- and long-haul distances is done from the standpoint of air travel. For instance, the UK Department for Environment, Food and Rural Affairs considers as short-haul flights those, which are typically up to 3700 km in length. This statement is broadly supported by definition proposed by Jardine, 2005 who classifies short-haul flights as those less than 3500 km (Filimonau et al., 2014). Therefore, most destinations in Spain, with exception of the Canary Islands, which are popular among Norwegian travelers, can be regarded as short-haul travel. There is an evidence of growing demand for vacation packages to short-haul destinations among Norwegian tourists including all-inclusive hotel stays (NRK, 2014). With almost one million holiday packages to destinations in southern Europe sold in Norway in 2013 and a growth of 18% for holidays in Spain in one year, it calls for a more comprehensive analysis of short-haul holidays (Virke, 2014). While acknowledging the high GHG emissions of long-haul flights, it is nevertheless important to better understand the carbon significance of short-haul holidays and accurately quantify the contribution of their specific components, including travel, to the overall GHG emissions and environmental impacts associated with holiday packages (Filimonau et al., 2014).

Due to its economic and environmental relevance the need has emerged to develop strategies for the sustainability of the sector, focused on the reduction of emissions from transportation and accommodation (UNWTO, 2010).

2.2 The Holiday Package as an Object for Assessment of Environmental Impacts of Tourism

According to the United Nations World Tourism Organization (UNWTO, 2008), “tourism comprises the activities of persons travelling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes”. Though no general consensus exists in the scientific community on the definition of tourism as a separate industry, it has been argued that tourism is a conglomerate of products distinguishable from the other industries. It is emphasized that tourism output is a complex product that includes a wide range of goods and services interacting to fulfill both tangible (e.g. hotel, restaurant, air travel and intangible parts (e.g. scenery, mood) of a tourist experience (De Camillis et al., 2012).

Filimonau et al. (2011) consider the holiday package to be at the intermediate scale in the tourism product hierarchy. It represents an aggregation of different components or travel choices such as modes of transportation, types of accommodation and activities, offered to tourists as an integrated product. It has been also suggested that individual tourism products, such as “all-inclusive” holiday packages, are the most suitable units for environmental assessments in tourism. This is due to better availability and accuracy of consumption and pollution data required for environmental assessment that can be supplied by providers of tourism products and services such as for example tour operators, hotels and airlines. On the other hand, larger scale tourism sustainability assessments are considered significantly less accurate due to the diversity of products and services involved in the evaluation process.

The literature reports a few attempts to evaluate the environmental impacts of the entire holiday package (Chambers, 2004; Peng & Guihua, 2007; WWF-UK, 2002; Castellani & Sala, 2012; Filimonau et al., 2013). The studies used different evaluation methods and focused on specific types of environmental impacts (e.g., assessing indirect GHG emissions associated with holiday package). Some studies were devoted to environmental appraisal of all-inclusive packages but are incomplete as some components have been omitted. However, there is a need for comprehensive assessments because only in this case it is possible to define which components of a travel package result in largest environmental impacts. Finding the magnitude of environmental impacts and establishing the main causes is necessary in order to develop strategies for impact reduction (Becken & Patterson, 2006).

The necessity to conduct sustainability appraisals of holiday packages can further be justified by their significant share in national and global travel market (Filimonau et al., 2011). The survey of Norwegian travel market reports that 1.25 million vacation packages were sold in 2013, which is 4% more than the previous year. At the same time, vacation packages to southern European destinations almost reached one million and demonstrated an increase of 13% in 2013 as compared to 2012. Figure 2.2 demonstrates growth in international scheduled and charter flights in Norway since 2003.According to Virke, international travel represented 30.4% of Norwegian air traffic in 2013, increase of 8% since 2003 (Virke, 2014).

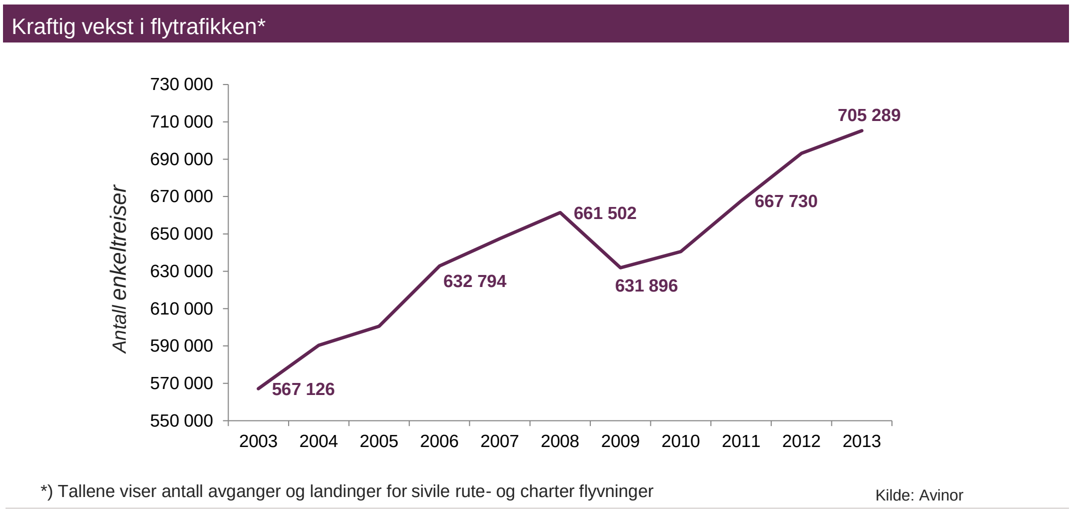


Figure 2.2 : Increase in flight traffic in Norway (Virke, 2014)

The vacation packages continue to play an important role in the Norwegian travel market. Globally, some travel agents become specialized in holiday package tours, which make a significant share of their revenues (Filimonau et al., 2011).

At the same time, many international providers of travel services, such as travel agents, airlines and hotel chains consider sustainability a strategic issue and demonstrate a sense of environmental responsibility. This helps achieving social status and creating competitive market advantages. The outcomes of environmental assessment of holiday packages can be utilized in company’s sustainability reports and provide valuable insight in which areas providers of travel services can improve their environmental performance (see for example, Scandic, 2014 and TUI Travel, 2011). Environmental and sustainability concerns expressed by tourist companies, increase with business size. It can be explained by the requirements to the large companies to display their environmental and social commitments and achievements. Besides, they have more financial resources available and need to maintain a good brand image (Filimonau et al., 2011).

When the data for this study were collected, it has been found that large chain-affiliated hotels demonstrate more awareness of environmental and sustainability issues and provide more information regarding their sustainability policy than individually owned and managed accommodation facilities. However, the number of smaller hotels that want to run their business in a more sustainable way is constantly increasing. It can be assumed that tourism businesses especially with international activities may be interested in environmental assessments of their products and services.

2.3 Life Cycle Assessment in Tourism

The literature research identified only a few studies that used LCA method in evaluating environmental performance of tourism and tourism-related activities. Four of these applied original LCA methodological framework to different aspects of tourism industry. One study evaluated environmental performance of meal boxes in tourism catering (Kuo, Hsiao and Lan, 2005), König et al. (2007) focused on LCA of hotel complex under construction in Portugal but this study had modeling approach (and did not measure the impacts directly), and De Camillis, Petti and Raggi (2008) and Sara, Raggi, Petti and Scimıa (2004) conducted LCA of hotel buildings in Italy. The latter conducted full assessment of hotel operation but excluded indirect impacts arising from hotel construction and manufacturing of equipment. Neither of the studies assessed the holiday package as a whole. Besides, these studies are not available in public domain, along with other work on LCA in tourism conducted in Italy (Filimonau et al., 2011).

More research has been found in literature that did not use directly conventional LCA method but rather applied a life cycle perspective to tourism sector. Specifically, World Wild Life Fund-UK (2002) and Chambers (2004) employed life cycle approach to an EFA of holiday packages. These studies are quite dated now; in addition they have been qualitative in nature, did not consider all phases of tourism’s life cycle and did not provide enough details.

The most recent examples of LCA applied specifically to a holiday package include a study by Castellani & Sala (2012) that compared EF and LCA methods in assessment of tourist activities. Kuo and Chen (2009) quantified environmental impacts for the entire tourism sector of the Penghu Island in Taiwan. Finally, Filimonau et al. (2013) utilized hybrid DEFRA-LCA approach to calculate direct and indirect GHG emissions of the holiday package in Algarve.

Though some progress has been made in applying LCA methodology to tourism, the research in this field is still at initial stage. In particular, no comprehensive environmental assessment of all elements of a holiday package using conventional LCA has been done to date. Yet, such analysis seems useful for designing policy measures and encouraging business actions. The outcomes of LCA could be also communicated to tourists to make them aware of environmental impacts of their travel behavior and provide information that would help them making responsible holiday decisions. LCA appraisals of holiday packages also may be used to create inventory systems of the most and least environmentally "friendly" holidays. This can be further used to develop eco-labels or other standards that would serve the purpose of informing tourists and influencing their decisions when purchasing a holiday package (Filimonau et al., 2011).

3 Method and Data Inventory

3.1 Life Cycle Assessment Method

Life Cycle Thinking (LCT) is a quantitative approach which includes a broad range of methodologies and instruments for sustainability assessment that aim at taking into account all life cycle phases of a product (e.g. extraction of the raw materials, pre-production processes, production, consumption, and end-of-life). Though LCT was initially conceived for products, it can also be applied to services. LCT is a helpful approach for sustainability assessment mainly because of its comprehensiveness. This characteristic makes LCT a unique perspective to detect potential shifts of economic, environmental and social burdens from one phase of the life cycle to another, from a certain geographical area to another, and from one sustainability issue to another (De Camillis et al., 2012).

Several methodologies and instruments for environmental assessment have been developed so far under the LCT framework. Life Cycle Assessment (LCA) is the most known method to assess the potential environmental impact of a product or service in terms of individual environmental impact categories (e.g. global warming, human and environmental toxicity, natural resource depletion, ozone layer depletion, summer smog, etc.) and along its life cycle phases (De Camillis et al., 2012). Consoli et al. defined LCA as: ‘‘an objective process to evaluate the environmental burdens associated with a product, process or activity by identifying and quantifying energy and materials used and wastes released to the environment, to assess the impacts and to evaluate opportunities to effect environmental improvements.’’ This definition is consistent with ISO 14040, which stipulates that LCA involves compiling data on inputs and outputs, and evaluating and interpreting environmental impacts (Kuo and Chen, 2009).

As defined in ISO 14040:2006 and ISO 14044:2006 and presented in Figure 3.1, LCA application process consists of four steps:

- Goal and scope definition,
- Life Cycle Inventory analysis (LCI),
- Life Cycle Impact Assessment (LCIA),
- and Life Cycle Interpretation

The goal and scope definition of an LCA identifies the objectives of the analysis and provides a comprehensive description of the product system in terms of “functional unit” and "system boundaries". The functional unit is a qualitative measure of a product or service system's performance that enables alternative goods or services to be compared and analyzed. The system boundaries can be defined as unit processes linked to each other to perform one or more defined functions. In addition, the environmental impact categories and assessment methods are selected in this LCA step according to the purpose of the study (De Camillis, et al., 2012).

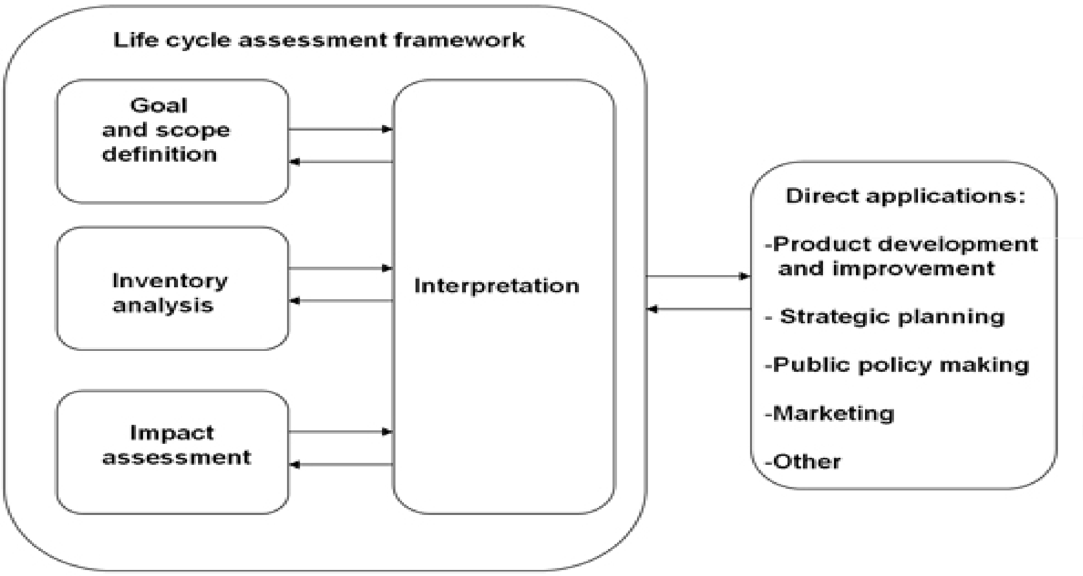


Figure 3.1 : Life Cycle Assessment framework (Lewis, 2013)

In this study, the life cycle is defined in the perspective of a vacation package, which represents a tourism product (or tourism service). In accordance with the aim of the study, two distinct functional units were introduced. Firstly, functional unit is defined as a trip of one week undertaken by one tourist to the Canary Islands including transportation, which constitutes a tourism product, and environmental loads were calculated per tourism product. Such holiday in a 4 star hotel accommodation represents the average characteristics of a vacation package at the particular destination. Secondly, the functional unit of one visitor night was used. Calculating environmental loads per visitor night was necessary for additional analysis that compared vacation packages with different duration.

The system boundary is regarded as the whole trip of one tourism product. In other words, the life cycle of a vacation package starts when tourists travel to the destination and ends at the point when tourists return to their original point of departure after finishing their whole trip. That way, the system boundary for the holiday package in the Canary Islands was established similar to other tourism LCA studies that followed the 'door-to-door' concept suggested by Chambers (2004), which represents a 'cradle-to-grave' approach employed in

LCA studies.

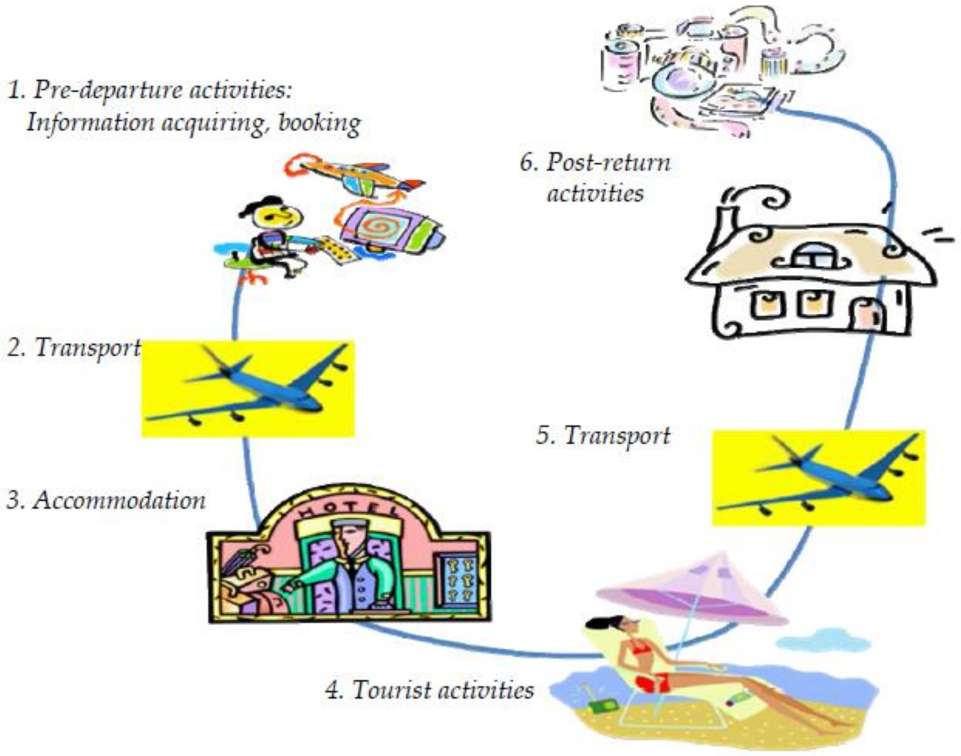


Figure 3.2 : Life cycle of tourist experience (adopted from De Camillis et al., 2012)

Figure 3.2 shows one possible way to establish system boundaries. Though this way of defining tourist experience life cycle can be a useful template to study some tourism forms, it should be adjusted for the package holidays (De Camillis et al., 2012).

The reviewed holiday package system included all product stages or holiday travel elements starting with the departure of tourists from home to their return. Travel to/from airport in the origin country (Norway) is not a traditional element of a holiday package, as it is usually organized by tourists independently, and it was therefore excluded from the scope of analysis. The preparatory and post-return activities were excluded from analysis due to data availability and the assumption of their insignificant contribution to the total GHG emissions from a holiday package (Filimonau et al., 2013).

Once the goal and scope of the study have been defined, the next step in the LCA process is to compile an inventory of the environmental loads potentially occurring along the product or service life cycle. Life cycle inventory (LCI) is a methodology for estimating the consumption of resources and the quantities of waste flows and emissions caused by or otherwise attributable to a tourism product’s life cycle. Consumption of resources and generation of waste (emissions) are likely to occur during each sector when tourists travel to, stay at and leave from the destination. Hence, the whole travel process of tourists is regarded as the system boundary of the life cycle inventory in this study. (Kuo og Chen, 2009).

Inventory Analysis and Impact Assessment phases are the most important in the LCA process as during these phases the majority of data are collected, processed and transformed into results. Based on the LCI, impacts can be calculated using several different approaches and software. In this study, LCA tool Arda was used to connect the LCI information with relevant processes in the Ecoinvent database and to conduct impact assessment. The result of the inventory calculation is normally a very long list of emissions and consumed resources. In order to systemize and interpret the results, an LCIA procedure is necessary. Such procedure implemented in Arda is the ReCiPe interpretation method that is aimed at transforming the long list of LCI results into a limited number of indicator scores. These indicator scores show the degree of impact on an environmental impact category. The ReCiPe method uses indicators at two levels: eighteen midpoint indicators and three endpoint indicators (LCIA-ReCiPe, 2014). In this study, the results were calculated for the eighteen midpoint impact categories.

Requirements matrix allows quantifying the material inputs per unit of output between the different production processes. The matrix consists of background and foreground where the foreground specifies the requirements that are directly related to the functional unit and the background matrix represents the requirements of all indirect or upstream elements in the supply chain that can be called upon by foreground processes. These two matrices are connected through the background to foreground matrix, thus establishing a model framework. This framework allows measuring the impacts from the entire supply chain for a given function or product based on intermediate requirements (Lewis, 2013).

Once the matrix is established, the following equation is used to calculate the total output from all processes for a given final demand:

$$Ax + y = x$$

$$x = (I - A)y^{-1}$$

Where: $L = \ (I - A)^{-1}$ or the Leontief inverse (Lewis, 2013)

The environmental impacts of a final demand are calculated based on a stressor matrix that categorizes emissions per unit output. This matrix allows distinguishing the emissions intensities between foreground and background. In addition, the characterization matrix can be also established in order to convert emissions of different substances that have similar environmental impacts into relative equivalents.

For example, impact of different GHG’s can be expressed through GWP 100 measured in CO_2 equivalents (Lewis, 2013).

Having established stressor and characterization matrix, the next step is to derive total impact which is expressed as

$$d = CSLy$$

It is also possible to divide total impacts by process or by stressor:

$$D_{pro} = CS\widehat{Ly}$$

$$D_{str} = C\widehat{SLy}$$

Figure 3.3 represents a nomenclature commonly used in LCA.

Sets	**pro**		**Processes**
	str		**Stressors**
	imp		**Impact categories**
Matrices and variables	A	*(pro x pro)*	Matrix of inter process requirements
	y	*(pro x 1)*	Vector of external demand of process
	x	*(pro x 1)*	Vector of outputs for a given external demand
	L	*(pro x pro)*	The Leontief inverse. Matrix of outputs per unit of external demand
	F	*(str x pro)*	Matrix of stressor intensities per unit output
	e	*(str x 1)*	Vector of total emissions generated for a given external demand
	E	*(str x pro)*	Matrix of emissions generated from each process for a given external demand
	C	*(imp x str)*	Characterization matrix
	d	*(imp x 1)*	Vector of impacts generated for a given external demand
	D_{pro}	*(imp x pro)*	Matrix of impacts generated from each process for a given external demand
	D_{str}	*(imp x str)*	Matrix of impacts generated from each stressor for a given external demand

Figure 3.3 :LCA Nomenclature (adopted from Lewis, 2013)

The vacation package results in many environmental impacts and consumption of various resources. Therefore, it is important to decide which indicators should be selected to provide a simplified representation of environmental loads. In general, tourism represents a composite service sector with three principal elements: travel, accommodation, and activities. Environmental loads can arise from each of these three elements due to the consumption of natural resources and the production of wastes. The selected indicators depend largely on availability of data and purpose of the study.

Environmental impacts in all eighteen impact categories were calculated. The impacts within climate change category were calculated specifically for various elements of the holiday package as one of the aims of the study was to evaluate GHG emissions associated with holiday travel. From this perspective, emissions generated from traveling to the destination, and energy consumption by the hotel during tourists' stay was expected to be the most important.

Life cycle inventory data for transportation included distances tourists travel by airplane, coach and private car. In accommodation sector, the values for energy consumption, electricity use, water demand, and solid waste discharge were analyzed.

In addition, a daily breakfast at the hotel was assumed and the inventory data on food consumption were collected. Finally, tourist activities were evaluated in terms of GHG emissions.

LCI of the product or service system analyzed makes a basis for Life Cycle Impact Assessment step (LCIA), which aims at delivering the indicators that express the potential environmental performance of the overall system analyzed. More specifically, LCIA includes the following steps:

- Connecting environmental loads to the selected impact categories (classification step);
- Calculating figures of the impact category indicators selected in the goal and scope definition (characterization step).

Such steps of LCIA as normalization, grouping and weighting were not performed in this thesis. Finally, the Life Cycle Interpretation step aims to evaluate the outputs of the LCI and the LCIA steps along the LCA application procedure. This step basically comes up with considerations in relation to the goal and scope of the study, highlights the study limitations and provides conclusions.

3.2 Data Inventory

3.2.1 Selecting Holiday Destination and Accommodation Type

Holiday package tour to Spain was selected as object of the study. The selection of the tourist product and destination was based on the popularity of the destination. Although Norwegian travelers choose various destinations around the world, recent survey conducted by Virke shows that 94% of all vacation packages sold in Norway in 2013 were to European destinations (Figure 3.4).

Totalt 1,25 millioner solgte pakkereiser i 2013 – økning på 4 prosent fra 2012

Afrika	43 183	-34 %
Asia	21 690	-70 %
Europa	1 168 112	11 %
Nord-Amerika	4 219	-15 %
Oceania	58	115 %
Sør-Amerika	5 278	94 %
Totalt	1 242 539	4 %

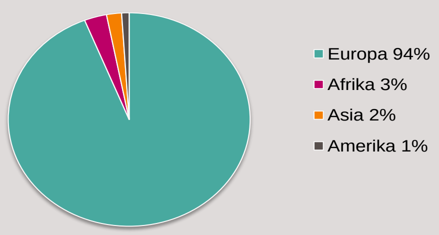


Figure 3.4 : number of vacation packages sold in Norway in 2013(Virke, 2014)

According to Dagbladet Reise, in summer 2013 Greece was the top destination in Europe for Norwegians that chose holiday package, having 277000 visitors, followed by Turkey (260000 visitors) and Spain (168000). While Greece has seen almost 40% more tourists as compared to Spain, it is emphasized that the popularity of this destination is limited to the summer months (DagbladetReise, 2013). The same is applicable to Turkey, while Spain including the Canary Islands is reported to be the destination that remains popular with Norwegian travelers around the year. Figure 3.5 demonstrates that over 500000 vacation packages to Spain have been sold in Norway in 2013, and the popularity of this destination has been continuously increasing (Virke, 2014).

In Spain, the top destinations for package travel offered by Norwegian tour operators include resorts in the Balearic Islands (Mallorca and Menorca), cities situated on Costa del Sol (Malaga, Murcia and Alicante), Barcelona as well as the Canary Islands. In 2010, over one million Norwegian tourists visited Spain, and 36% of them chose the Canary Islands as their destination (VG, 2012).

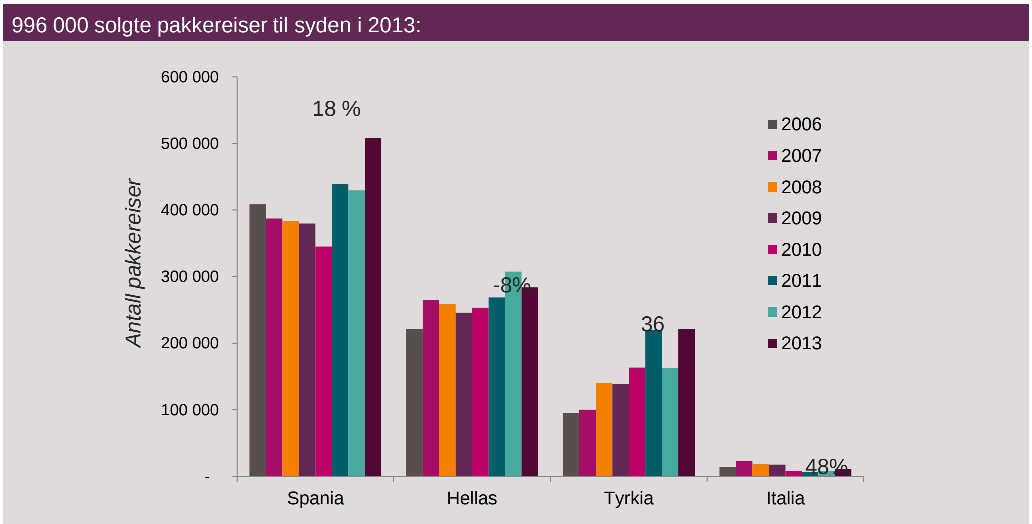


Figure 3.5 : Vacation packages to Spain, Greece, Turkey and Italy sold in Norway in 2013 (Virke, 2014)

The survey conducted by the Norwegian tour operator Star Tour in 2012 demonstrated that Norwegians pay close attention to the hotel standard when it comes to their holidays. The whole 31 % of respondents stated that they choose the hotel with a minimum standard of 4 stars (Startour, 2012).

Based on the information provided by travel surveys and with focus on the main objective of the present study, which was to evaluate environmental impacts of a typical vacation package from Norway, it was decided to choose a 4 star hotel in the Canary Islands as an example for the case study. The choice of the destination affects all of the components of the vacation package, first and foremost the travel distance. At the destination, one needs to account for specific properties that are typical for this location, when it comes to estimating environmental impacts of accommodation facilities and tourist activities that are included in the holiday package. For example, it is important to know whether the electricity for a hotel is produced from renewable or non-renewable sources, or what type of fuel is usually used in rental cars. This type of values is difficult to find, as they are very specific and require very detailed information.

In addition, research on the climate change contribution of different elements of holiday travel is limited (Chenoweth, 2009). The number of studies is small and their geographical scope is narrow which hampers better understanding of the GHG emissions attributed to different holiday choices in popular tourist destinations. Therefore the research outcomes of existing studies cannot be directly projected onto other geographies as the carbon intensity of fuels and energy production varies considerably from region to region. For example, Becken (2002) and Becken et al. (2003) conducted their studies in New Zealand, where electricity production is based to large extent on renewable energy (Becken and Patterson, 2006). This suggests a lower carbon intensity of both electricity-driven transport and energy use in hotels in New Zealand if compared to those European countries where the role of renewables in national energy balances is less pronounced (Filimonau et al., 2014). Some studies, such as the study by Chenoweth (2009), used the global average GHG emission coefficients for converting the energy consumption in hotels and fuel combustion in vehicle engines into carbon impacts. The applicability of the global average coefficients is limited because of the clear geographical variations in carbon intensity. Furthermore, other studies also rely upon outdated energy use data from the early and mid-1990s (see, for instance, Becken and Patterson, 2006), which fail to account for technological developments (Filimonau et al., 2014).

Therefore, the inventory data were collected specifically for chosen destination where it was possible, especially for processes that were expected to have significant impacts in terms of GHG emissions such as air travel and energy consumption in the hotel. Other values were obtained from the literature and were assumed to be the tourism industry’s average for a given type of accommodation and recreation activities.

3.2.2 Travel

Basic data for transport processes are from the Ecoinvent database (Ecoinvent Centre, 2009). These each represent the average fleet of transport and includes not only the operation of the means of transport, but also its construction and raw materials as well as the infrastructure (road, airport, etc.) and maintenance. The air travel was a return flight from Oslo to Gran Canaria calculated as Great Circle distance (TUI Travel, 2011). The Great Circle method allows calculating the distance between the point of origin and destination from a database of the airport longitude and latitudes providing a high degree of accuracy. Some methodologies use a factor to adjust this distance to account for deviation from a perfect route that may occur when the airplanes try to avoid severe weather conditions and stack around the destination airport (Jardine, 2009).

Along with travel distance, the fuel consumption data are required in order to estimate total amount of fuel burn for the flight and consequently calculate the emissions. These largely depend on the assumption what type of plane would typically undertake a flight of such distance. The flights are categorized in Ecoinvent into short/medium haul (intra-Europe flights with distance of 500 km) and long-haul flights (6000 km). For the short/medium haul flights an Airbus A320 passenger aircraft with a typical capacity of 150 seats is assumed (Ecoinvent, 2007). The respective process selected from Ecoinvent database was transport of passenger aircraft within Europe, although the flying distance from Oslo to Gran Canaria is on average 50% longer than to other popular European destinations such as Rhodes and Mallorca. Distances from Norway to popular destinations and fuel consumption are presented in Figure 3.6.

Popular destinations – fuel consumption in litres/pax

Base: 2009/2010 figures and great circle distance, 100% load factor

Stockholm	**Km**	**B737-800**	**B757-200**	**B767-300**
To Mallorca	2477	61,6	65,5	71,8
To Rhodes	2687	66,8	71	77,9
To Gran Canaria	4337	107,8	114,6	125,7
To Phuket	8694	-	-	252
Copenhagen	**Km**	**B737-800**	**B757-200**	**B767-300**
To Mallorca	1931	48	51	56
To Rhodes	2435	60,5	64,4	70,6
To Gran Canaria	3805	94,6	100,6	110,3
To Phuket	8995	-	-	260,7
Oslo	**Km**	**B737-800**	**B757-200**	**B767-300**
To Mallorca	2369	58,9	62,6	68,7
To Rhodes	2910	72,3	76,9	84,3
To Gran Canaria	4105	102,1	108,5	119
To Phuket	9075	-	-	263
Helsinki	**Km**	**B737-800**	**B757-200**	**B767-300**
To Mallorca	2777	69	73,4	80,5
To Rhodes	2668	66,3	70,5	77,3
To Gran Canaria	4700	116,8	124,2	136,2
To Phuket	8312	-	-	240,9

Figure 3.6 : Distances from Scandinavian capitals and fuel consumption on flights to popular destinations (TUI Travel, 2011)

The data on the bus transfer was also extracted from TUI Nordic report and assumed a return journey of 50 kilometers from the airport in Gran Canaria to a hotel in the city center. The corresponding Ecoinvent process was transport by coach in Europe. Both air travel and bus transfer is expressed in passenger- kilometers which excluded the need for applying the load factor (i.e. to account for occupancy of the vehicle).

3.2.3 Accommodation

Apart from traveling to the destination, the other important component of holiday package under evaluation was a hotel stay. As mentioned in section 3.2.1, a 4 star hotel was selected to represent a typical accommodation in Gran Canaria. In accordance with the aim of the study and defined functional unit, the calculations were performed either per person per night (electricity consumption and cleaning services) or per person per 7 nights stay (laundry services). These values were assumed irrespective of the hotel accommodation size and the number of persons sharing the room, i.e. the same assumptions would apply to a facility that could accommodate 30 guests or to the one accommodating 100 guests. Rather, the hotel category was to influence some of the foreground processes such as energy and water consumption, and cleaning and laundry. As conducting a survey to collect the data for a specific hotel was not within the scope of this thesis, the inventory data were mostly obtained from open sources and extracted from various research articles. As the number of studies focused on life cycle assessment of holiday is low the data availability was quite limited.

The energy consumption of a hotel includes electricity consumption for lightning, air conditioning, dishwashers, fridge, lift, TVs, computers, etc.). The Ecoinvent process was selected as electricity mix in Spain. The data on electricity consumption varied greatly between different sources, being as low as 15 kWh per visitor night according to TUI Nordic sustainability report (as a goal for all TUI Blue Village hotels) to 40 kWh per visitor night. It was therefore decided to consider electricity consumption of 25 kWh per visitor night. In addition, heating was estimated at 5 kWh per guest night (TUI Travel, 2011). The electricity used for the laundry services was accounted for separately.

The foreground processes also included detergents consumption and laundry service that was estimated in kWh per person per laundry. The hotel quality standards state that in a 4 star accommodation cleaning of the guest rooms is performed daily, and bed linen and towels are replaced at least twice during a one-week stay (or every three days). These standards were adopted as reference for the hotel stay (Hotel Services, 2011).

Clearly, cleaning and laundry services are not provided individually to each visitor by the hotel, but are performed according to schedule and in amounts depending on the number of guests. As it was not possible to establish separately exact amount of cleaning materials and laundry detergent used per guest per night, the inventory data from Castellani et al. was adopted. It was assumed 0.14 kg of detersives and detergents per person per night, and 0.16 kWh per person per laundry service. One vacation package of 7 nights would therefore require 7 detersive and detergent processes and 2 laundry services (based on the assumption that bed linen and towels are replaced at least twice a week).

3.2.4 Food Consumption

The environmental impacts of food are difficult to estimate, because the eating habits vary from person to person. The strains of the daily diet depend on many factors. For example, it is important to consider the proportion of meat, dairy and frozen products, how often exotic products are used, number of hot meals per day, etc. However, the number of meals per day outside home can be distinguished, for example the meals eaten on the restaurants. Depending on the activity, climate and type of holiday a different number of meals per day can be included in the calculation.

The tour operators in Norway offer various vacation packages, from so called “flight plus hotel” to all-inclusive holidays. Most offers allow tourists themselves to decide if they want to have meals included in their stay. For this study, the assumption was made that only one daily meal - breakfast, is included in the vacation package, and it would be provided by the hotel. The choice was made based on two assumptions. Firstly, all-inclusive packages constitute a relatively small share of vacation packages sold in Norway. Tourists most often would select the cheapest available option, which only includes flight and accommodation. Secondly, it was assumed that most tourists will have breakfast every day during their vacation, and it is likely to happen at the hotel since a 4 star hotel standard assumes a restaurant and a buffet breakfast. Besides, it seemed unreasonable to assume that tourists will go to local cafes or restaurants specifically for breakfast. Therefore, a hotel stay with daily breakfast was considered as basis for this study.

The values for food consumption were taken from Castellani and Sala (2012) for a 4 star hotel. A number of food items were selected that are typically included in breakfast, and consumption measured in kg per person per night in a 4 star accommodation. The items included in the inventory were bread, milk, cheese, vegetable spread (as the emissions data for butter were not available), fruit and vegetables, vegetable oil, and coffee and tea. As explained by Castellani, the data were expressed “per tourist per day”, i.e. the amount of food that each tourist consumes during one day of stay at the destination. In general, data were collected from local data sources and tourist related statistics. However, for some consumption categories (e.g. food and waste) specific data for tourism were not available, so the average consumption of one tourist was approximated to the average consumption of local people (assuming that a tourist usually tries to consume what is locally available). Data about food were derived using official regional statistics about household expenditures and collected data about average food price (Castellani, 2014). It can be argued that such approach can provide very approximate values for food consumption in hotels, and especially if only breakfast is considered. Nevertheless, these values can help generally understand consumption patterns.

Further, the impacts data were derived from various sources for different food products. The literature research showed that the data on CO_2 emissions from food products varies a lot between sources and are quite limited. At the same time, no comprehensive research on other GHG emissions was found in literature. Therefore, it was decided in present study to only include impacts from breakfast in the climate change category. Few studies used LCA method to estimate CO_2 emissions from food production. For some of the food products values from the LCA Food database were used, while others were taken directly from the literature. Finally, it was modeled in the way that the impacts from all food products were summarized and gave the resulting impact for one breakfast per person per night. Table 3.1, presents the food items included in inventory and corresponding CO_2 emissions per kg of product.

Additional important factors are for the leftovers. Presumably, in all-inclusive offerings, in which the food is available the whole day mostly through a buffet, more food leftovers remain accumulated as compared to the restaurants or at home. Some studies estimate that additional food scrap would be around 15%. However, in this study it was decided that food leftovers would be insignificant as it was only one meal per day and are assumed to have been included in the food consumption data.

Product	Unit	Consumption hotel 4*	Kg CO_2 eq/kg	Source
Bread	Kg	1.25E-01	0.84	LCA Food, 2007
Milk	Kg	1.06E-01	1.5	Flysjo, 2012
Cheese	Kg	1.67E-02	9.8	Flysjo, 2012
Eggs	Kg	7.20E-03	5	Vries and de Boer, 2010
Vegetable oil	Kg	1.53E-02	3.83	LCA Food, 2007
Fruits & vegetables	Kg	2.64E-01	0.82	Gossling et al., 2011
Coffee, tea & cacao	Kg	8.54E-03	17	Curran, 2012
Sugar	Kg	2.11E-02	0.96	LCA Food, 2007
Detersives & detergents	Kg	1.40E-01	-	-
Laundry services	kWh	1.60E-01	-	-

Table 3.1 : Food consumption for breakfast and corresponding CO_2 emissions per kg of food product (Castellani and Sala, 2012)

3.2.5 Tourist Activities

The carbon footprint from tourist activities has never been holistically assessed (Becken and Simmons, 2002), predominantly due to difficulties with data collection and systematization. Another reason is the small relative contribution of tourist activities to the total carbon footprint from tourism, circa 3–5% (UNWTO, 2007a cited in Filimonau et al., 2013). The two studies found in the literature that attempted to evaluate environmental impacts from tourist activities used similar approaches to data collection. Filimonau et al. (2013) conducted a tourist survey among 43 participants upon their departure, including questions about day-to-day activities undertaken by participants during their stay. Kuo and Chen (2009) also used a tourist survey when studying tourist activities of visitors to Penghu Island. In the present study, the tourist activities were selected from the list provided by The CarboNZero travel and tourism calculator (Landcare research, 2010) and the number of tourist activities per vacation package was assumed similar to the study of Filimonau et al. for holiday package in Algarve. This is because both studies looked into impacts from holiday package at the beach destination in the same geographical region; therefore the tourist activities were assumed quite similar. The holiday package in Algarve was for duration of 10 days, which is also comparable with the length of stay considered in this thesis. The overview of the tourist activities is presented in Table 3.2.

Emissions derived from Landcare research are all GHG emissions that are converted to carbon dioxide equivalents. Although the CarboNZero travel and tourism calculator assumes that most of the emissions measured for travel, accommodation and activities are carbon dioxide, it accounts for other relevant greenhouse gases as well (Landcare research, 2010).

Visits to the beach are usual part of the tourist stay at the seaside destinations. Although it does not entail any direct GHG emissions, getting to/from the beach does. It can also be assumed that tourist use local transport for other activities such as going to the shopping mall. Therefore, it is necessary to include such process as transport related to tourist activities to assess the whole magnitude of impacts associated with a vacation package. As the direct measurement at the specific location was not possible, the values for this were obtained from case study conducted by Filimonau et al. for holiday package in Algarve.

Tourist activities	Number of visits/km	Kg CO_2 eq/visit	Source
Aqua park	1	1.5	Landcare research, 2010
Dining out	2	1.3	Filimonau et al., 2011
Shopping	1	0.6	Landcare research, 2010
Water activity, boating	1	15.31	Landcare research, 2010
Nature activity, hiking	1	1.65	Landcare research, 2010
Beach	2	0	Filimonau et al., 2013
Car rental	50 km		Filimonau et al., 2013
Transport related to tourist activities	Coach = 35 km; bus = 21 km; taxi = 14 km		Filimonau et al., 2013

Table 3.2 : Tourist activity and GHG emissions in kg CO2 equivalents

Finally, car rental as a typical tourist activity was also included in the assessment. The relevant Ecoinvent process was transport of passenger car expressed in passenger-kilometers. This way it was assumed that the car was used by one tourist and total environmental loads associated with car rental were calculated per tourist per vacation package. It is acknowledged that the total number of kilometers driven can vary significantly depending on location and needs of tourists. For purpose of present study, an average of 50 km was assumed.

3.2.6 Data Inventory Limitations

The comprehensiveness of data attributed to different elements of the reviewed holiday package varies. The emissions from transport were appraised holistically and in full detail as most of input data were readily available. The assumptions were made regarding airport transfer distance and distances covered with rental car, however it was expected that these elements would only contribute a small share to the overall impact. The emissions from air travel did not include the radiative forcing effect as it is not accounted for in Ecoinvent database. However, the radiative forcing effect and its magnitude will be discussed in more detail in the following section.

The assessment of environmental impacts from a hotel stay is less rigorous. First of all, the values for the energy consumption of a hotel are rather approximate. For example, the variation for electricity consumption is from 15 kWh/visitor night (as reported by TUI travel for the group’s own Blue Village hotels) to 44 kWh/guest night (Scandic, 2014). The data for heat consumption were very limited. Theoretically, for a comprehensive appraisal of energy requirements of a holiday package it is necessary to obtain specific figures directly from hotel energy bills or such.

Further, only the operation phase of the hotel was considered. This implies that emissions from construction and dismantling stages of the hotel building life cycle were not taken into account. This limitation is due to data availability but also because the main focus of assessment was a holiday package purchased by a tourist, and inclusion of hotel structure into LCA could expand the system too far thus generating problems of allocation. In the processes associated with the hotel stay only use phase of the machinery. Omitted were for example manufacturing phase of laundry machinery, equipment or furniture at the hotel (Castellani and Sala, 2012).

The data found for tourist activities appraisal cannot be considered exhaustive. Studies found in the literature did not have a holistic approach to measuring environmental impact from tourist activities. Most researches attempt to measure energy consumption of different activities per tourist and consequently calculate GHG emissions (Becken, 2001; Kuo og Chen, 2009). For the purpose of this thesis, such approach was not considered feasible. At the same time, conventional LCA of tourist activities using available software was not possible because the necessary processes are missing from the Ecoinvent database.

Finally, the impact assessment for all of the impact categories was not conducted for all of the foreground process included into the system. The food consumption in form of breakfast and the tourist activities (except the car rental process) was only modeled in terms of GHG emissions.

4 Results and Discussion

4.1 Contribution of Various Elements of a Vacation Package to Climate Change

As part of the analysis it was decided to evaluate the contribution of various elements of the holiday package specifically to climate change category. As explained in methods and data section , the vacation package can be broadly categorized into transportation, hotel stay and tourist activities. Each of these elements was further subdivided into a few processes as shown in Figure 4.1.

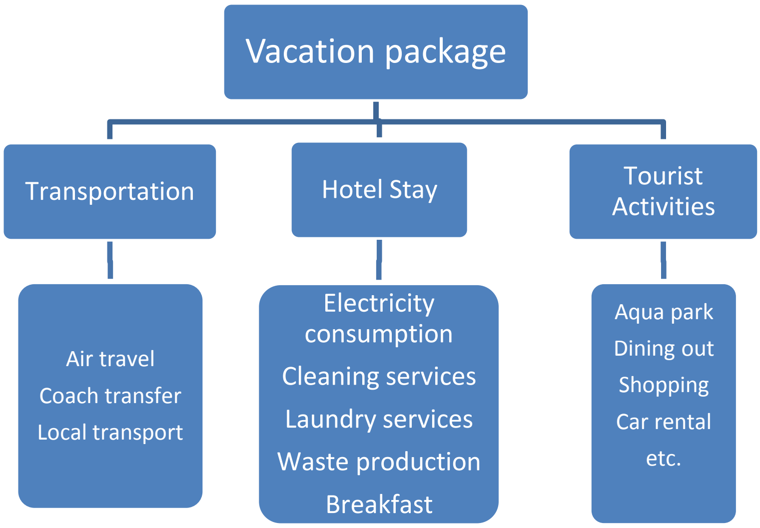


Figure 4.1 : Overview of a vacation package

Figure 4.2 demonstrates percentage contribution of the different elements to total GHG emissions from the vacation package. In order to deliver more representative results, GHG emissions from different sub-elements were summarized. As calculated by the present study (see Appendix), one vacation package of 7 nights in the Canary Islands with stay at the 4 star hotel with breakfast generated a total of 1566.4 kg CO_2 eq GHG emissions. When the distribution of emissions across different elements of holiday package is examined, the analysis suggests that 88% of this is attributable to air travel to/from the destination. This value is in accordance with other studies, which concluded that at least 70% of total GHG emissions generated from holiday package come from getting to/from the destination (Filimonau et al., 2013, Castellani and Sala, 2012).

Air travel is followed by the hotel stay that generates around 158.9 kg CO2 eq (10 % of the total GHG emissions). The emissions were calculated for the hotel stay inclusive of electricity consumption, heating, laundry services, cleaning services, water consumption, waste disposal, and breakfast. This share of 10% is comparable with the ones found in the literature (see, for example, Filimonau et al., 2013). However, comparison of both absolute and relative values with other studies can be problematic. Firstly, emissions generated from the hotel stay depend heavily on the duration of the holiday package. The longer stays result in higher total electricity consumption, higher demand for cleaning agents etc. if the whole vacation package is accounted for. This is confirmed by the sensitivity analysis presented later in this section that compared emissions from three vacation packages for duration of 7, 10 and 14 nights (Table 4.1). Secondly, different studies include or exclude certain data based on the data availability or the purpose of the study. For example, Filimonau et al. did not account for waste generation in their analysis of the vacation package. The reason for this was that the data were not available for the specific accommodation unit under review. In this project, the waste produced by the hotel itself was not considered, however an average value from the literature was used for waste generated by tourist during their stay.

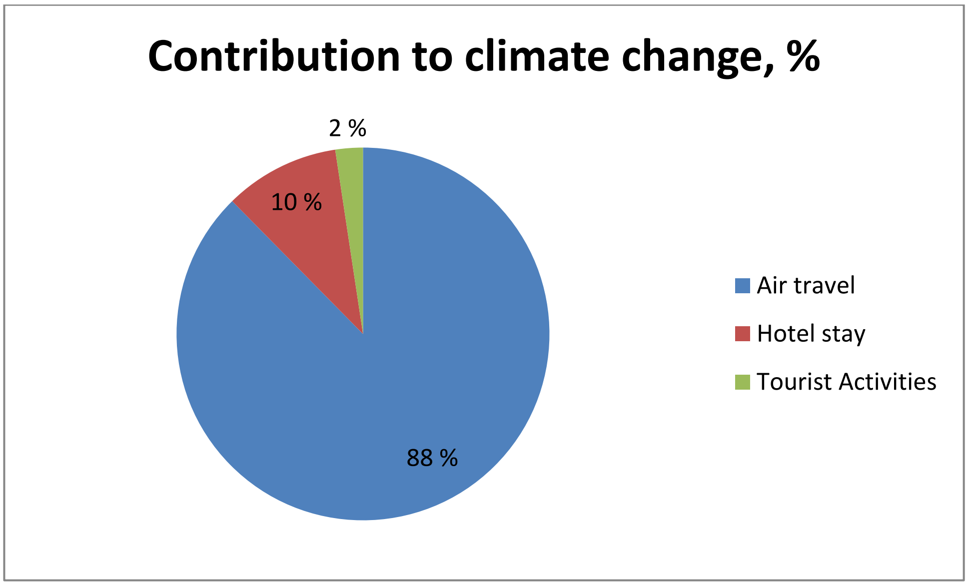


Figure 4.2 : Contribution of various elements of the holiday package to climate change category, %

It should be acknowledged though that amounts of waste could vary between accommodation types and countries, as well as depending on the nature of the vacation package. If “all-inclusive” hotel is considered, the food wastage can be more significant. Therefore, figure for emissions associated with waste production cannot be considered precise but is still representative.

Destination/ distance	Length of stay	Total CO_2	Share CO_2 flight	Share CO_2 Hotel stay	Share CO_2 Tourist Activities
Canary Islands 4105 km	7 nights	1566,359	1370.2 (88%)	158.9 (10%)	37.3 (2%)
Mallorca 2369 km	10 nights	1053,874	790.7 (75%)	223.2 (21%)	37.3 (4%)
Mallorca 2369 km	14 nights	1143,171	790.7 (69%)	312.5 (28%)	37.3 (3%)

Table 4.1: GHG emissions from vacation packages of 7, 10 and 14 nights, kg CO2 eq

The results of the analysis also confirm that the share of tourist activities in the total impact from holiday package is rather insignificant. In this case, it constituted only about 2.2% of the total GHG emissions. Importantly, almost half of these originate from transportation represented by car rental and use of local transport. Although this figure is in agreement with scientific literature (see Filimonau et al., 2013), the share of tourist activities can lower or increase. Firstly, this process can be represented by many different activities, which are less or more carbon intensive. Secondly, it is challenging to select specific activities for the study as they vary greatly depending on the destination, holiday budget and personal preferences of tourists. For example, extended car rental or frequent participation in motorized water activities can significantly increase the share of GHG emissions from this element. However, given that the relative contribution from tourist activities is low, it was not considered feasible to extend the analysis changing the types of activities or their frequency.

Finally, another important outcome of the study was that airport transfer at the destination did not have any significant contribution to total GHG emissions from the holiday package as compared with other elements. It represented less than 0.5% of the total GHG emissions and therefore was omitted in the graphical representation of results. Though traveling to the airport in departure country was excluded from the analysis, it can be expected that the effect of this element would be also negligible.

4.2 Contribution of Different Processes to Various Impact Categories

Figure 4.3 provides an overview of the contribution of various processes to different impact categories. Predictably, air travel contributes more than 50% to most of the impact categories, with the highest impacts (more than 80%) occurring in ozone depletion, fossil depletion, climate change, natural land transformation, and photochemical oxidant. Another important process is electricity consumption during hotel stay, which contributes circa 85% to water depletion, over 75% to freshwater eutrophication, almost 90% to ionizing radiation, around 60% to human toxicity and over 40% to agricultural land occupation. It can be noted that waste disposal has significant effect in two impact categories, freshwater ecotoxicity (contributing around 40%) and marine ecotoxicity (30%). The results show that detersives and detergents used for cleaning at the hotel contribute significantly (over 40%, in similar proportion as air travel) to terrestrial ecotoxicity and have similar share of impact as electricity consumption in agricultural land occupation impact category.

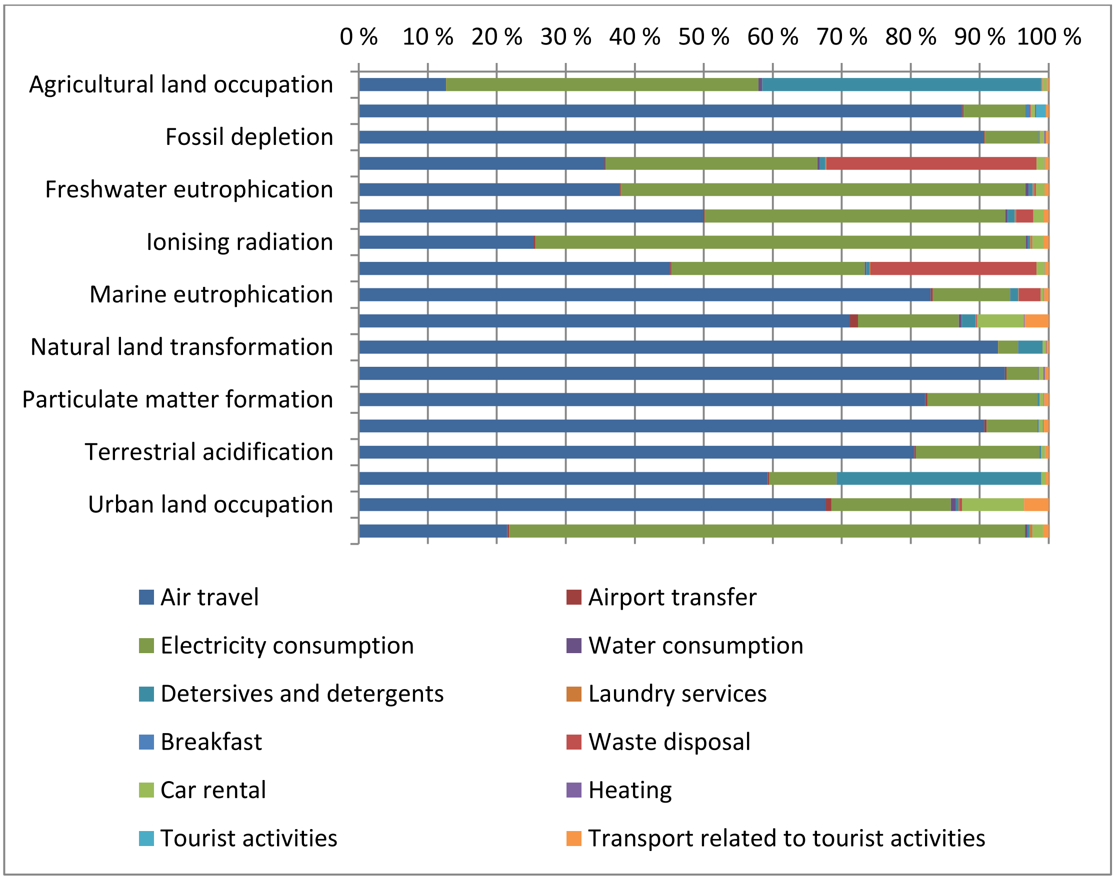


Figure 4.3 : Relative contribution of foreground processes to different impact categories

At the same time, airport transfer, processes related to hotel stay such as water consumption, laundry services and breakfast, as well as tourist activities contribute comparatively little (less than 5%) to most of the impact categories. The contribution analyses demonstrates that the highest impacts in ten of the impact categories come from transportation element of the vacation package in form of air travel, followed by car rental process, while airport transfer and use of local transportation at the destination are negligible. The hotel stay contributes significantly to eight impact categories out of eighteen, in form of electricity consumption, waste disposal and the use of detersive and detergents. The impacts from transport element of the travel package are naturally associated with climate change, fossil fuels and metal depletion, and air pollution, while staying at the hotel mostly depletes land and water resources.

4.3 Structural Path Analysis

Structural path analysis has been conducted using Arda software for several impact categories. As reported in section 4.2, the highest impact to most of the categories is from air travel. The analysis has demonstrated that in climate change category 75% of the total GHG emissions from the vacation package arise from operation of the passenger aircraft. Hard coal burned in power plant in electricity consumption accounts for more than 4% of the total GHG emissions.

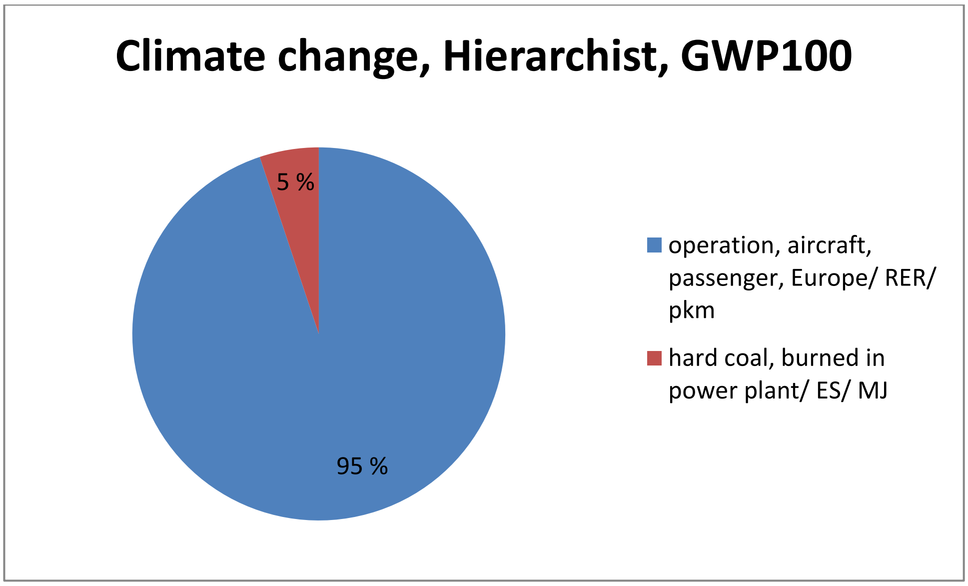


Figure 4.4 : Climate change, Hierarchist, GWP 100

At the same time, agricultural land occupation, freshwater ecotoxicity, terrestrial ecotoxicity and water depletion are dominated by other processes.

Structural path analysis has demonstrated that detersives and detergents are responsible for just over 40% of the total impact in agricultural land occupation category. Of this, almost 28% of the impact comes from harvesting of coconuts used for production of coconut oil while 7.5 % from processing palm fruit bunches at farm. Electricity consumption process takes around 50% of the impact in agricultural land occupation. This impact arises from hardwood (20%) and softwood (11%) standing, in forest. Part of the hardwood is further turned into hard coal burned in power plant for electricity production. 17.8% of the impact from hardwood and softwood in form of wood chips mix from industry which is further delivered to produce electricity at cogeneration.

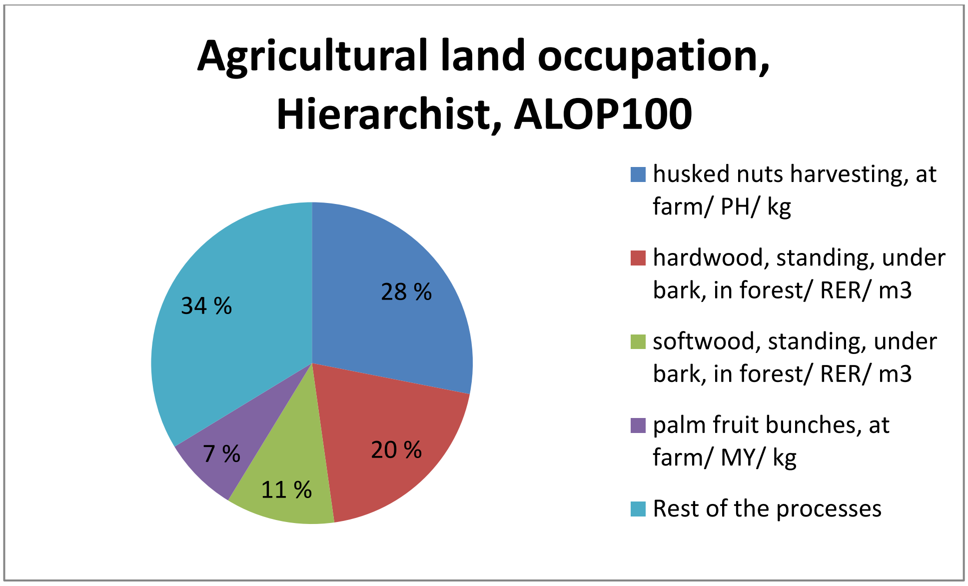


Figure 4.5 : Agricultural land occupation, Hierarchist, ALOP100

Freshwater ecotoxicity is approximately equally affected by air travel, electricity production and waste disposal. As shown in Figure 4.6 & Figure 4.7, 24% of the total impact arises from disposal of municipal solid waste to sanitary landfill, and 14.2 % from disposal of municipal solid waste to municipal incineration, thus making waste production responsible for almost 30% of the impact. Due to electricity consumption by hotel, 9.24% of the impact comes from disposal of spoil from lignite mining, in surface landfill, and 5.03% from disposal of spoil in coal mining in surface landfill from production of hard coal in mine. Air travel contributes to freshwater ecotoxicity with 7.39% coming from discharge of produced water on shore from crude oil production.

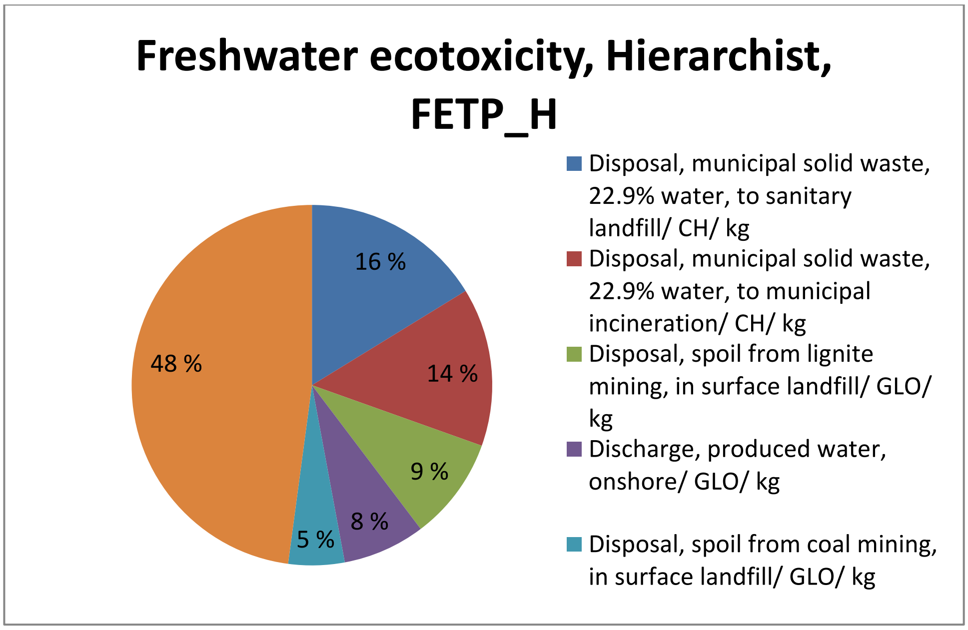


Figure 4.6 : Freshwater ecotoxicity, Hierarchist, FETP_H

As displayed in Figure 4.7, terrestrial ecotoxicity is mostly affected by air travel process, where 34.8% of the impact occurs due to disposal of drilling waste to landfarming from well for exploration and production due to crude oil production to derive kerosene which serves as fuel for airplanes. Another significant impact occurs due to use of detersive and detergents, where 28.9% of the impact comes from palm fruit bunches processing at farm, used to derive palm kernel oil and palm oil, the most important components of fatty alcohol sulfate mix which is used as basis for detergent production. Operation of the aircraft is responsible for 7.2 % of impact to terrestrial ecotoxicity, while electricity consumption contributes 6.7% through disposal of wood ash mixture to landfarming.

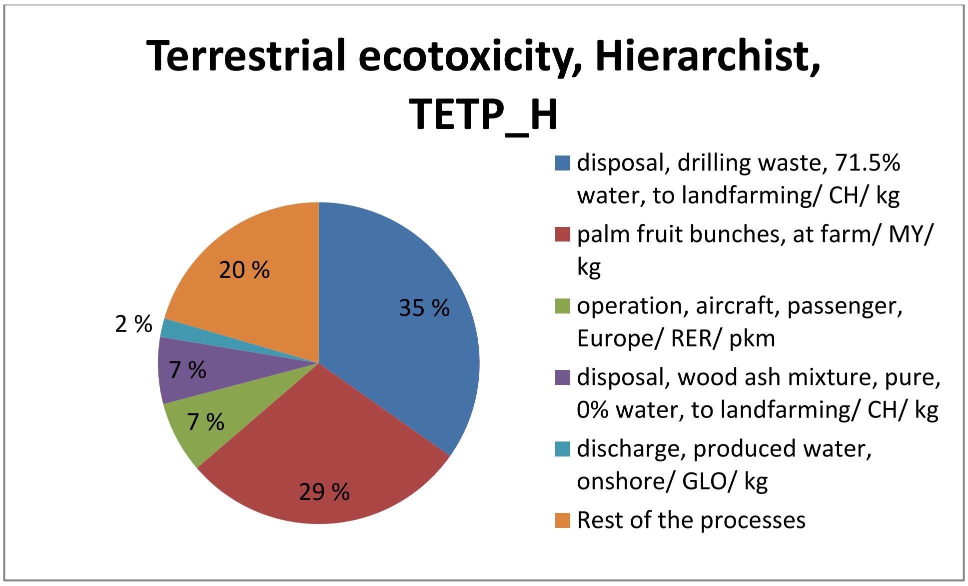


Figure 4.7 : Terrestrial ecotoxicity, Hierarchist, TETP_H

Finally, in water resource depletion category (Figure 4.8) 61.5 % of the total impact occurs due to that electricity consumed is produced from hydropower resources.

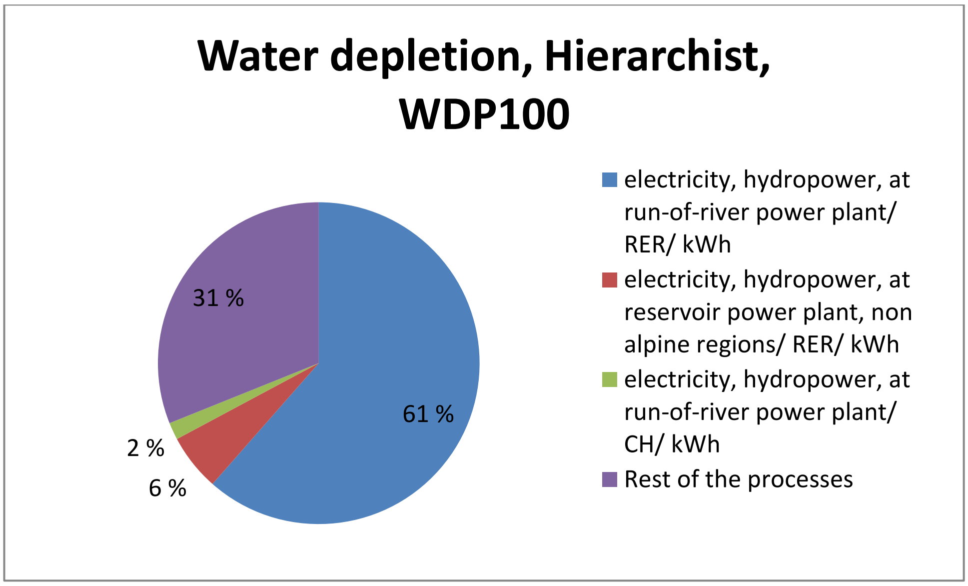


Figure 4.8 : Water depletion, Hierarchist, WDP100

4.4 Direct and indirect GHG emissions from air travel

The results showed that for the holiday package under review the total GHG emissions generated by air travel were 1370 kg CO_2 equivalents, of which 1175 Kg CO_2 equivalents, or around 85% were direct emissions. Direct emissions are those associated with the use phase/operation of a product or service.

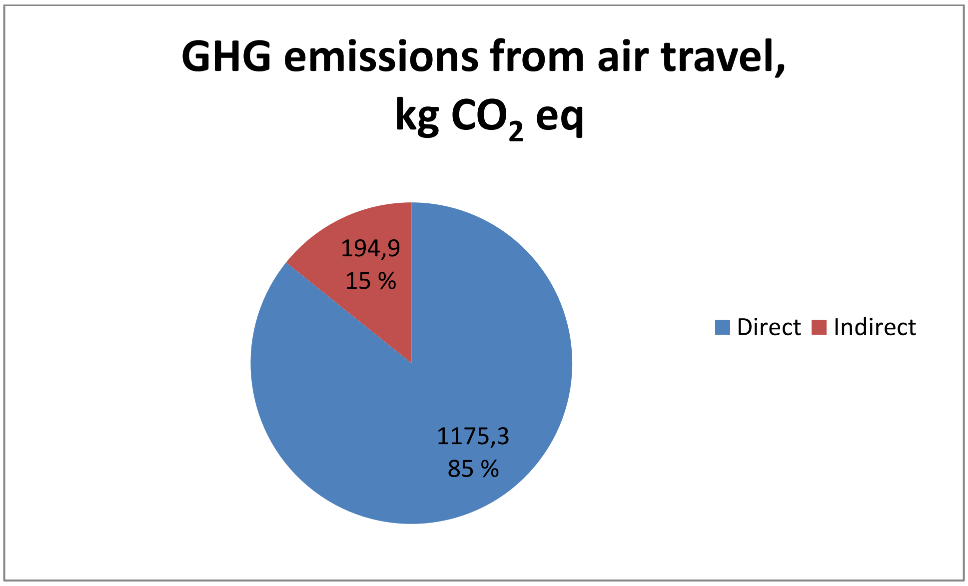


Figure 4.9 : Direct and indirect GHG emissions from air travel

The indirect emissions arise from the non-use phases of a product or service life cycle; it is also included in the capital goods and infrastructure necessary to extract, transport and refine raw materials, manufacture a product or service, deliver it to a final user, regularly maintain and finally dispose of it. Analysis of both direct and indirect GHG emissions represents the "well-to-wheels" approach to environmental assessment of the fuel chain.

In the case of tourism transport the direct GHG emissions originate from vehicle's operation, i.e. fuel combustion in the aircraft's engine (Filimonau, 2013). The aircraft operation component in Ecoinvent database contains all the processes that are directly associated with the operation of the aircrafts. The indirect processes are further distinguished into processes that summarize environmental impacts from aircraft fleet and airport infrastructure processes. (Ecoinvent, 2007). Indirect GHG emissions also arise from the non-operational phases of the fuel life cycle, i.e. fuel production, storage, delivery and distribution (Filimonau, 2013).

The aircraft fleet as presented in Ecoinvent contains processes describing the vehicle life cycle (except the operation phase) such as manufacturing of the aircraft and parts, aircraft maintenance and support as well as disposal of aircrafts and parts. The factual data are limited to production of aircrafts, while operation and maintenance data are part of the airport infrastructure component. Besides, the disposal of aircrafts has not been taken into account due to its presumably low share in total environmental impact and because of limited data availability regarding disposal of aircrafts. The passenger aircraft fleet for short and medium haul transport is represented by Airbus A320 with a typical capacity of 150 seats (Ecoinvent, 2007).

The airport infrastructure sub-component comprises stages of the airport infrastructure life-cycle including airport construction, airport operation and maintenance as well as airport dismantling. Expenditures due to airport construction, maintenance and demolition are included. Airport operation component includes data regarding clearing services and infrastructure expenditures within the area of the airport. Air traffic related activities (traffic to and from the airport) and infrastructure (operation of multi-storage car parks for passengers and airport stuff) were not accounted for.

Clearing of the aircraft is associated with various transport services for which a variety of vehicles are used. Whilst both conventional road vehicles and airport specific vehicles are in operation, the life cycle data for the latter are not available.

Therefore, the emission data only represent operation emissions. In addition, the yearly diesel consumption was accounted for to obtain emissions of the fuel chain. Aircraft clearing also included emissions data from de-icing activities for both sealed area and aircraft. Finally, the airport operation and land use have been considered. Operation of the airport requires heat and electricity consumption for buildings and aircraft maintenance. According to Ecoinvent, most of the heat consumed at the airport is generated on site using natural gas and oil. In addition, water consumption, wastewater and waste disposal were included.

Air transport is a special sector where operational lifetime of an aircraft is relatively long and the vehicles are used extensively. For example, the average service lifetime of a typical passenger Boeing 737 aircraft is about 25-30 years (Boeing, 2013). This implies frequent refurbishments and renovations, which will also results in significant GHG emissions. Just like any other infrastructure, airports have even more extended lifetime and therefore are even more likely to undergo more regular and substantial renovations.

The aircraft fleet and airport infrastructure include processes with numerous interfaces to other Ecoinvent unit processes (materials and energy). Therefore, the environmental loads associated with these processes are calculated when these data are linked to the referring processes in the Ecoinvent database. These loads are often referred to as indirect environmental impacts of transportation (Ecoinvent, 2007).

The Ecoinvent database is limited to the processes mentioned above. However, it is possible to distinguish other components that can result in indirect GHG emissions. For example, it is possible to consider operation of an airline, electricity use in company's offices, etc.

4.5 Comparing GHG emissions from electricity consumption of different vacation packages

	Bulgaria	**Spain**	**Portugal**	**Greece**	**China**	**Brazil**
Distance, km	2189	2369	2872	2910	8578	10421
Total GHG, kg CO_2 eq	1108.9	1053.9	1299.1	1492	2505.9	2415.8
GHG from air travel	730.7	790.7	958.6	971.3	1843.5	2239.6
GHG from Electricity consumption	315.3	200.2	277.5	457.7	599.8	113.6

Table 4.2 : Overview of GHG emissions from different vacation packages

The LCA of the holiday package has demonstrated that the greatest impacts in terms of GHG emissions arise from air travel followed by the hotel stay in the form of electricity consumption. Initially, Spain was selected as holiday destination as to demonstrate the impacts of a “typical” vacation undertaken by Norwegian tourist.

Further, it was considered relevant to find out how the magnitude and composition of GHG emissions would change if other destination were selected. Expected were changes in GHG emissions from air travel due to variation in flying distance as well as in GHG emissions in electricity consumption. Therefore, the impact calculation was carried out for a few countries normally popular with Norwegian tourists. Compared were Portugal, Greece, Bulgaria, China, Brazil and Spain. While China and Brazil do not represent typical holiday destinations, they were included as examples of long haul travel since no relevant processes are available in Ecoinvent for Thailand and Mexico, which would make a more relevant choice. It was considered useful to conduct the impact assessment of the long haul destination as it demonstrated the magnitude of aviation emissions. The other elements of the vacation package were not altered, as their impact was already found insignificant. The duration of the holiday was set at 10 days for all packages.

On the contrary, the GHG emissions associated with electricity consumption at the hotel demonstrated significant variation between the countries. Emissions from electricity consumption were the highest in China and the lowest in Brazil. It is a well-known fact that China relies heavily on fossil fuels, and 66% of the electricity production in the country comes from coal (US EIA, 2014). Therefore, GHG emissions are linked to coal mining and burning of coal in power plants. Interestingly, electricity consumption of the hotel in Brazil appeared to be lower than in European destinations. This can be explained by the fact that hydropower accounted for 80% of electricity generation in Brazil, with only smaller amounts coming from fossil fuels, nuclear, other renewables and other fuel resources (US EIA, 2014).

Among European countries, electricity consumption of the hotel in Greece generates 457.7 kg CO_2 eq. This value is 40% higher than for Portugal, and 56% higher than for Spain. The reason for such difference is the primary energy source that is used in a country for electricity production. In Greece, 45.1% of electricity was produced from coal in 2010, while the share of hydropower was only about 11% (Trading Economics, 2014). At the same time, according to Eurostat, 2011, in Portugal 53.2% of electricity came from renewable energy sources. The newer data are available for Spain, which reported 54% of electricity from renewable energy sources, mostly wind power, in 2013 (Clean Technica, 2013). In Bulgaria, 48.5% of electricity was produced from solid fuels, followed by nuclear power (32.7%), while renewable energy sources constituted only 13.8% (Eurostat, 2011).

4.6 Sensitivity to Distance Flown

The results of impact assessment revealed that total GHG emissions are about two times higher for long haul travel than for European destinations, naturally due to longer flying distance. The European destinations under review have approximately the same flying distance from Oslo, therefore the emissions from air travel were comparable. However, the results have also demonstrated that there is no linear dependence between the distance of the flight and GHG emissions.

The average energy consumption and hence emission strongly depend on aircraft size and flight distance, since the energy consumption is the highest in the start phase (Ecoinvent, 2007). The fuel burned by an airplane is attributed to different sections of the flight, which each use fuel at different rates (Figure 4.10).

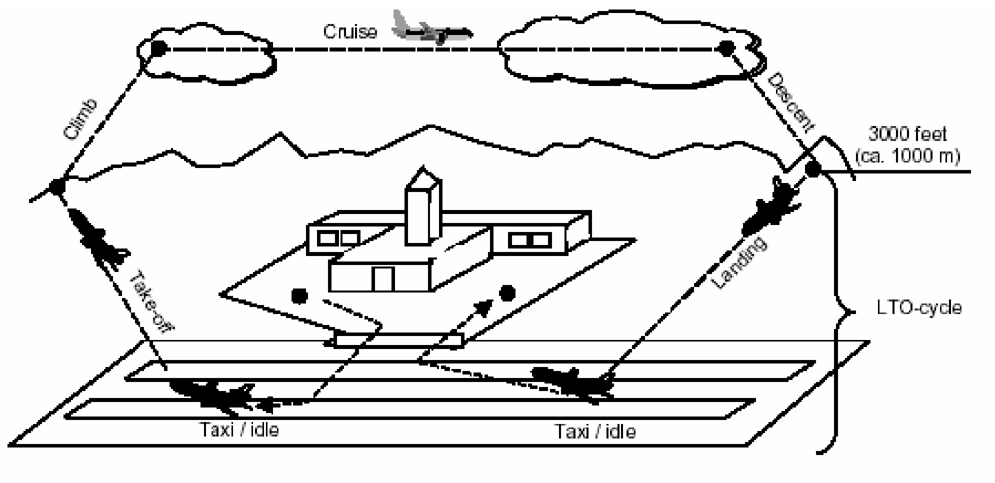


Figure 4.10 : Phases of flight of aircraft (adopted from Jardine, 2005)

Emissions occur during different phases of the flight. Firstly, the so called landing and take-off cycle (LTO), which comprises all activities near the airport that take place below the altitude of 1000 m. This includes taxi-out, take-off and climb out, and at the end of the flight the landing approach and taxi-in. This is the fuel required by the aircraft to go into the air and down again, and the amount is constant irrespective of the flight length. The specific fuel consumption is significantly higher during LTO phase, as ascents require much more intense fuel burn than cruising at constant altitude. Secondly, the climb, cruise and descent cycle (CCD), which is defined as all activities that take place at altitudes above 1000 m. This fuel use accounts for the bulk of the flight distance, and directly depends on the flight length

(Jardine, 2005).

There is a difference in share of LTO of the total trip length for short-medium and for long-haul flights. The Ecoinvent transport report suggests that for an intra-Europe flight of 500 km distance, around 40% of fuel is consumed during LTO phase. For an intercontinental flight of 6000 km this share drops to around 4.5% (Ecoinvent, 2007). For example, this can explain the fact that though flying distance to Brazil is 3.62 times longer than to Portugal, the CO2 emissions from the flight are only 2.33 time s higher. Another example is provided by Jardine, 2009 that studied the dependence of CO2 emissions per seat for different plane types and distance flown (Figure 19).

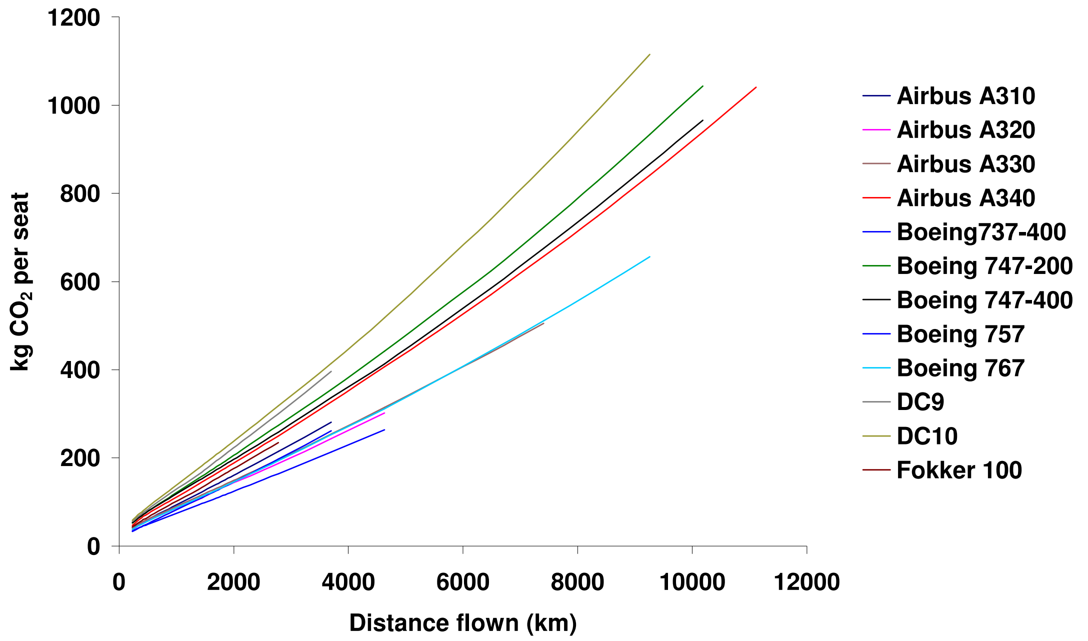


Figure 4.11 : Emissions per seat as function of distance for different plane models (adopted from Jardine, 2009)

Figure 4.11 shows that the relationship between emissions and distance travelled for a specific plane type is not linear. This is due to emissions associated with take- off part of the flight. As a result, short flights have a much higher emissions per km flown as a greater proportion of emissions arise from take-off section of the flight (Jardine, 2009).

These variations are accounted for in Ecoinvent through having two different processes for intra-Europe and intercontinental flights. However, the choice of the distances in Ecoinvent is debatable. It seems unreasonable to assume a distance of 500 km for all intra-Europe flights. While it is valid for flights between major cities in Central Europe, the other points on the European continent are more remote from each other. It could help improve the accuracy of the impact assessment if values for medium-haul flights (up to 3500 km) were added.

Another issue here is the composition of the flight fleet. Emissions strongly depend on the chosen plane model because the variation in efficiency of different airplanes can reach the factor of 2 for the most and least efficient plane flying the same distance. Assumptions based on older datasets are likely to lead to an overestimate in emissions as newer, more efficient planes are no represented (Jardine, 2009).

4.7 Effects of Aviation on Radiative Forcing and Climate

Emissions from different types of vehicles (cars, trains, ships and aircraft) interact with atmosphere in a complex manner. In addition to carbon dioxide, which is stable greenhouse gas, nitrogen oxides, carbon monoxide and organic particles are emitted to the atmosphere. These species are highly reactive and do not persist for long in atmosphere but they affect the concentration of long living greenhouse gases such as ozone and methane. Additionally there are short living substances like black carbon and sulfur dioxide which contribute to contrail formation and might have a radiative effect. Atmospheric emissions from air transport influence the stratospheric water vapor concentration that affects the formation of cirrus clouds (Lee et al., 2009).

Owing to different lifetimes of these emissions, they affect the climate on different timescales. The complex and complicated interaction mechanisms influence the atmosphere in diverse manner, some steadily increase the temperature of the earth while some lead to lower temperatures. Due to this fact, no research until now has been able to reflect on the contribution of each mode transport for individual gases and evaluate the impact of different modes of transportation on climate. While assessing the impacts of aircraft emissions it is of vital importance to consider meteorological and chemical conditions in the atmosphere as they may initiate some mechanism of climate change. (Luftfart og klima, 2011)

However, the effects of single species are quite well studied and documented in the literature. For example, CO_2 emissions lead to positive radiative forcing and thus warming of the atmosphere. CO_2 is likely to provide the warming effect for hundreds of years after its release, due to its longest living time. Therefore in longer prospective CO_2 emission from aviation transport will have the greatest climate impact.

NOx emissions result in the formation of tropospheric ozone via atmosphere chemistry, which gives positive RF and results in warming effect. In addition, NOx emissions have two other important effects (1) formation of persistent linear contrails (2) formation of aircraft-induced cirrus clouds. They lead to both positive and negative RF depending upon atmospheric conditions but overall they are considered to have positive RF effect. i.e they result in warming of the atmosphere. Cirrus clouds, ozone and contrails have much stronger warming effect than CO_2 in first years of their release, but due to short lifetimes temperature changes quickly and in a span of 5-15 years the effect is less than that of CO_2.

Emissions of various particles also have significant impact on the atmosphere. Emission of water vapor and soot particles can cause a direct positive RF (warming). Whereas, emission of sulfate particles, originating from presence of sulfur in fuel, leads to direct negative RF having a cooling effect on the atmosphere. Particles released from aircrafts engines may act as nuclei for cloud condensation and seed cirrus cloud formation, which can either decrease or increase the number of ice particles and affect both the emissivity of the cirrus clouds and albedo. This effect can lead to either positive or negative RF effects (cooling/warming) and the sign is rather uncertain (Lee et al., 2009)

5 Conclusions

The study has confirmed that viewing tourism as an industry having relatively low environmental impact can be debatable. Although tourism can impact upon a range of environmental issues, greenhouse gas emissions from aviation currently seem to be the most important and intractable issue (Chambers, 2004).

Life Cycle Assessment was used to study environmental impacts associated with a typical vacation package undertaken by a Norwegian tourist. The impacts were evaluated for different activities comprising a vacation package, which were broadly categorized into travel, accommodation and tourist activities. Life cycle impact assessment has demonstrated that impacts from the vacation package occur in all of the eighteen midpoint impact categories. Analysis showed as expected that travel element of the holiday package in form of air transport has the highest contribution to most of the impact categories, followed by the hotel stay in form of electricity consumption, waste disposal and detersive and detergents used for cleaning and laundry services at the hotel. The impact from tourist activities was found to be insignificant.

Further, the study compared different vacation packages with purpose of understanding how travel distance (i.e. chosen destination) and length of stay at the destination affect GHG emissions from the vacation package. The contribution of air travel to GHG emissions was about 70% for the vacation package in Mallorca with shorter flying distance to destination and longer duration of stay, rising up to 88% for a one week vacation package in the Canary Islands. It was found that though the package to the Canary Islands has the shortest duration of stay (7 nights), the total GHG emissions from that package were the highest because of significantly longer flying distance as compared to Mallorca. Decrease in flying distance by around 40% results in decrease of the total GHG emissions from the vacation package by 27%, even considering that duration of stay in Mallorca was assumed twice as long (14 nights).

It should be acknowledged that the data inventory for the hotel stay and tourist activities and relevant assumptions made were not explicit. Due to limited data availability, values for electricity and water consumption as well as waste discharge were extracted from literature and were not adjusted for a specific country or type of accommodation. Assumptions regarding hotel stay and tourist activities were the same for all vacation packages. Such approach may not be considered absolute as there are certainly variations in vacation packages depending on where holidays take place and the duration of stay. For example, it can be argued that for a 14 days stay the amount of activities may not be the same as for 7 days stay and should be increased proportionally which will result in higher amount of GHG emissions. The same applies to the hotel stay as two hotels of the same category (4 star in present study) may still have different facilities and provide different services to tourists. As it was mentioned before, an all-inclusive vacation package is likely to result in higher total GHG emissions, where a bigger share will be attributed to the hotel stay. Yet, the contribution from tourist activities and hotel services was found negligible and it was not expected that altering input data for these elements of the holiday package will affect significantly final results.

The study has also calculated and compared GHG emissions for different vacation packages as function of flying distance and electricity production in various countries. The results show that the GHG emissions from air travel are not directly proportional to the flying distance due to the higher fuel burn associated with take-off and landing phase of the flight. The GHG emissions from electricity consumption depend strongly on the type of fuel that is used to produce electricity in the country. The study found that a 10 days hotel stay in Greece would generate 56% more GHG emissions than a stay in Spain and 40% more than staying at a hotel in Portugal.

The study has revealed that some issues associated with holiday package have not been discussed enough in the literature. While a relatively large number of studies focused on impacts from air travel, the research on the hotel stay and tourist activities is much more limited. For example, it appeared challenging to collect information regarding use of chemicals by the hotel industry. Apparently, hotels use various detergents, bleaches and disinfectants in addition to special substances that are used for cleaning the swimming pools. Contribution analysis and structural path analysis have demonstrated that the largest impact from the use of detergents occurs in agricultural land occupation and terrestrial ecotoxicity due to production of coconut and palm kernel oil. Yet, the cleaning agents are normally flushed with water to the sewage system therefore some impacts to freshwater resources could be expected. Further research regarding the usage of chemicals by hotels along with information about water treatment techniques is necessary as it would improve the quality of contribution analysis (Chambers, 2004).

The thesis tried to consider the full range of environmental impacts associated with a typical vacation package and provided an insight into travel behavior of Norwegian tourists. Recent travel surveys (Virke, 2014, Statistics Norway, 2014, Euromonitor, 2014) all found that the outbound departures from Norway were increasing in past years and will continue to increase in the future. Strong Norwegian economy and poor climate conditions positively affect departures to warmer countries as for example those in southern Europe. In addition, new routes and more departures to cheaper destinations offered by low cost carriers with strong promotional campaigns also increased the outbound tourism, particularly to closer destinations such as Spain. The last but not the least, European financial crises also made some countries more attractive to Norwegian tourists and contributed to longer stays at the destination (Euromonitor, 2014).

The research has shown that the market for vacation packages, though stable and growing, has a tendency for becoming more diverse. Strong competition among travel retailers and consumers demanding holiday packages that suit their specific needs has pushed travel agents to offer holiday packages to unique and exotic destinations. However, the share of exotic holiday packages to long haul destinations is less than 5% (Virke, 2014), and considering unstable situation in some parts of the world, strong growth in this segment cannot be expected.

All factors combined, it can be assumed that the travel pattern of Norwegian tourist is unlikely to change significantly in the coming years. Vacation packages to short and medium haul destinations will remain the most popular type of holiday. Since the preferences are often based on the price, it is likely that travelers would be choosing between shorter vacation in the more remote destination and longer vacation in a destination that is closer. Encouraging tourist to select holidays at closer destination would increase the sustainability of holiday travel. In the context of present study, travel choices of Norwegian tourists have lower environmental impacts as they do not select long haul destinations.

6 Recommendations for Future Research

Further research on environmental impact of tourism could look into various directions. Generally, more studies on different types of vacation packages would ensure more representative results that would make use to industry. Yet, as it has been proven that currently the greatest impact arises from air travel, it seems more relevant to compare different types of holiday packages rather than simply evaluate its environmental impacts. One possibility here would be looking into all inclusive packages and comparing them with so called responsible, or ecotourism package over a range of prices. Further, life cycle analysis of specific elements of a holiday package such as different means of transportation and especially accommodation could be also beneficial. At present it seems that with the highest attention being paid to GHG emissions from flights, impacts arising from the hotel stay can go underestimated. It also seems reasonable to expand the LCA of the holiday package by including the impacts from hotel building, but at present no explicit data on hotel construction are available in literature.

Finally, environmental impacts of a range of tourist activities and food consumption during holidays can be subjects to another study. No comprehensive assessment or LCA of tourist activities have been done to date. The same applies to food consumption during holiday. Both tourist activities and food consumption were estimated only in terms of GHG emissions in present study. It can be expected though that the range of impacts from these elements is greater and influences other impact categories than climate change as well. In order to build a good inventory of tourist activities and food consumption further detailed research is needed that also accounts for regional variations.

In general, the low number of LCA studies found in the literature calls for an assumption that there are either significant barriers to implementing this approach or the limited awareness of LCA in tourism's drivers (De Camillis et al., 2010). The barriers might be related to the complicated nature of the tourism system as well as the lack of specific LCA databases for tourism and related sectors. One example of the significant gap in data is that while transport and energy related processed were modeled easily using Ecoinvent database, this was not the case for most of the accommodation, activities and food-related processes which to date are not present in Ecoinvent. There is also quite low consideration given by the tourism industry and researches to the environmental impact categories that are usually taken into account in impact assessment methodologies.

6. Recommendations for Future Research

Further developing methodological approaches and guidelines as well as possibly integrating LCA with other environmental assessment tools could expand and promote applicability of LCA studies within the tourism sector. In addition, further synergies should be investigated regarding environmental appraisal of all elements of the holiday package along with specific tools that focus on the economic and social aspects of sustainability of tourism.

7 References

1) Adam Johnston (2013). Clean Technica, 2013, available at *http://cleantechnica.com/2013/05/08/fifty-four-of-spains-electricity-generation-in-april-from-renewables/*

2) Anna Flysjö (2012). *Greenhouse gas emissions in milk and dairy product chains: improving the carbon footprint of dairy products*. PhD thesis, Aarhus University

3) Becken S. (2001). Energy consumption of tourist attractions and activities in New Zealand. Summary report of a project undertaken by Landcare Research and Tourism Research and Education Centre (TREC), Lincoln University.

4) Becken, S., & Simmons, D.G. (2002). *Understanding energy consumption patterns of tourist attrac- tions and activities in New Zealand*. Tourism Management, 23(4), 343–354

5) Becken, S., Patterson, M., (2006). *Measuring national carbon dioxide emissions from tourism as a key step towards achieving sustainable tourism*. Journal of Sustainable Tourism 14 (4), 323–338

6) Bulgaria Energy market. Eurostat, 2011, available at *http://ec.europa.eu/energy/gas_electricity/doc/bg_energy_market_2011_en.pdf*

7) Byrnes, T.A. and Warnken, J. (2006). '*Greenhouse gas emissions from marine tours: A case study of Australian tourboat operators*'. Journal of Sustainable Tourism, 14(3), pp. 255–270

8) Camillo De Camillis, Andrea Raggi and Luigia Petti (2010). *Tourism LCA: State of the art and perspectives, The International Journal of Life Cycle Assessment*, Volume 15, Issue 2, pp 148-155

9) Camillo De Camillis, Paul Peeters, Luigia Petti and Andrea Raggi (2012). *Tourism Life Cycle Assessment (LCA): Proposal of a New Methodological Framework for Sustainable Consumption and Production, Visions for Global Tourism Industry - Creating and Sustaining Competitive Strategies*, Dr. Murat Kasimoglu (Ed.), ISBN: 978-953-51-0520-6

10) Chenoweth, J. (2009). *Is tourism with a low impact on climate possible? Worldwide Hospitality and Tourism Themes*, 1(3), 274–287

11) Christian N. Jardine (2005). *Calculating the environmental impact of aviation emissions*. Environmental change institute

12) Christian N. Jardine (2009). *Calculating the Carbon Dioxide Emissions of Flights*. Environmental Change Institute

13) Country report: China (2014), US Energy Information Administration, available at *http://www.eia.gov/countries/analysisbriefs/China/china.pdf*

14) Country report: Travel and Tourism in Norway (2014). Euromonitor International, available at *http://www.euromonitor.com/travel-and-tourism-in-norway/report*

15) Daniel Scott , Paul Peeters & Stefan Gössling (2010). *Can tourism deliver its "aspirational" greenhouse gas emission reduction targets?,* Journal of Sustainable Tourism, 18:3, 393-408, DOI: 10.1080/09669581003653542

16) David S. Lee (2009). *Aviation and Climate change*, Earthscan

17) Electricity production in Greece. Trading economics, 2014, available at http://www.tradingeconomics.com/greece/electricity-production-kwh-wb-data.html

18) Emily Boyd, Michael Lisowski, Lisa Schipper, Malena Sell, Richard Sherman (2002). *Earth Negotiations bulletin, International Institute for Sustainable Development*, 2002

19) Gabriella Arcese, Roberto Merli and Maria Claudia Lucchetti (2013). *Life Cycle Approach: A Critical Review in the Tourism Sector*, The 3rd World Sustainability forum

20) Helen Jiang (2013). *Key finding on airplane economic life. Boeing commercial airplanes*, 2013

21) Hotel Quality Standards, AA Hotel Services, 2011, available at *https://www.theaa.com/resources/Documents/pdf/business/hotel_services/aa_hotel_quality_standards.pdf.*

22) ICAO Environmental report (2013). *Aviation and climate change*. ICAO, 2013

23) Innsikt Utsyn Sommerferien. Virke, 2014

24) Jon Martin Denstadli, Arne Rideng. *Reisevaner på fly*, TØI, 2011

25) Kirsten M. Buzzi (2013). *Her er sommerens mest populære ferieland*, Dagbladet Reise, available at *http://www.dagbladet.no/2013/01/19/tema/reise/charterferie/syden/sol_og_badeferie/2530535*

26) Landcare research (2010), available at *http://www.landcareresearch.co.nz/home*

27) LCA Food database (2007)

28) LCIA-ReCiPe, 2014, available at *http://www.lcia-recipe.net/project-definition*

29) M. de Vries, I. J. M. de Boer (2010). *Comparing environmental impacts for livestock products: A review of life cycle assessments*. Livestock Science, Vol. 128. Issues 1-3, pp 1-11

30) Mari Ann Curran (2012). *Life Cycle Assessment Handbook: A Guide for Environmentally Sustainable Products*, Wiley, 2012

31) Marianne Tronstad Lund, Terje Berntsen, Jan Fuglestvedt (2011). *Luftfart og klima. En oppdatert oversikt over status for forskning på klimaeffekter av utslipp fra fly*, CICERO, 2011

32) Nae-Wen Kuo & Pei-Hun Chen (2009). *Quantifying energy use, carbon dioxide emission, and other environmental loads from island tourism based on a life cycle assessment approach*, Journal of Cleaner Production 17, 1324–1330

33) Ny rekord: *Over en million nordmenn til Spania*. VG, 2012, available at *http://www.vg.no/forbruker/reise/reiseliv/ny-rekord-over-en-million-nordmenn-til-spania/a/10024799/*

34) Peeters, P., Gossling, S., & Becken, S. (2006). *Innovation towards tourism sustainability: Climate change and aviation. International Journal of Innovation and Sustainable Development*, 1(3), 184–200

35) Peng, L., & Guihua, Y. (2007). *Ecological footprint study on tourism itinerary products in Shangri-La, Yunnan Province, China*. Acta Ecologica Sinika, 27(7), 2954–2963.

36) Spielman, M., Bauer, C., Dones, R., Tuchschmid, M. (2007). *Transport services, ecoinvent report No14. Swiss Center for Life Cycle Inventories*, Dubendorf, 2007

37) Stefan Gössling and Paul Upham (2009). *Climate change and avaiation: Issues, challenges and Solutions*, Earthscan, 2009

38) Stefan Gössling, Brian Garrod, Carlo Aall, John Hille and Paul Peeters (2011). *Food management in tourism: Reducing tourism's carbon 'foodprint'*. Tourism Management 32, 534-543

39) Stor reiseundersøkelse. Startour, 2012, available at *http://www.startour.no/Footer/presse2/Presse22/291012-Stor-reiseundersokelse2/*

40) Susanne Bohler, Sylvie Grischkat, Sonja Haustein, Marcel Hunecke (2006). *Encouraging environmentally sustainable holiday travel*, Transportation Research Part A 40 (2006) 652–670

41) Sustainability and the environment. Scandic, 2014

42) Sustainable development report TUI Nordic 2010/2011, TUI Travel, 2011

43) Tom Chambers (2004). *Environmental Assessment of a "mass tourism" package holiday and "responsible tourism" package holiday using life cycle assessment and ecological footprint analysis*, master thesis

44) Tor Risberg, Slik blir ferieåret 2014. NRK, 2014 Available at *http://www.nrk.no/livsstil/slik-blir-feriearet-2014-1.11425911*

45) *Tourism and the millennium development goals (2010).* World Tourism Organization, 2010

46) Tyler Lewis (2013). *A Life Cycle Assessment of the passenger air transport system using three flight scenarios*, master thesis, NTNU, 2013

47) *UNWTO Tourism highlights (2014).* World tourism organization, 2014

48) Valentina Castellani (2014). Email communication

49) Valentina Castellani and Serenella Sala (2012). *Ecological Footprint and Life Cycle Assessment in the sustainability assessment of tourism activities*, Ecological Indicators 16, 135–147

50) Viachaslau Filimonau , Janet E. Dickinson , Derek Robbins & Maharaj Vijay Reddy (2011). *A critical review of methods for tourism climate change appraisal: life cycle assessment as a new approach, Journal of Sustainable Tourism*, 19:3, 301-324, DOI: 10.1080/09669582.2010.527345

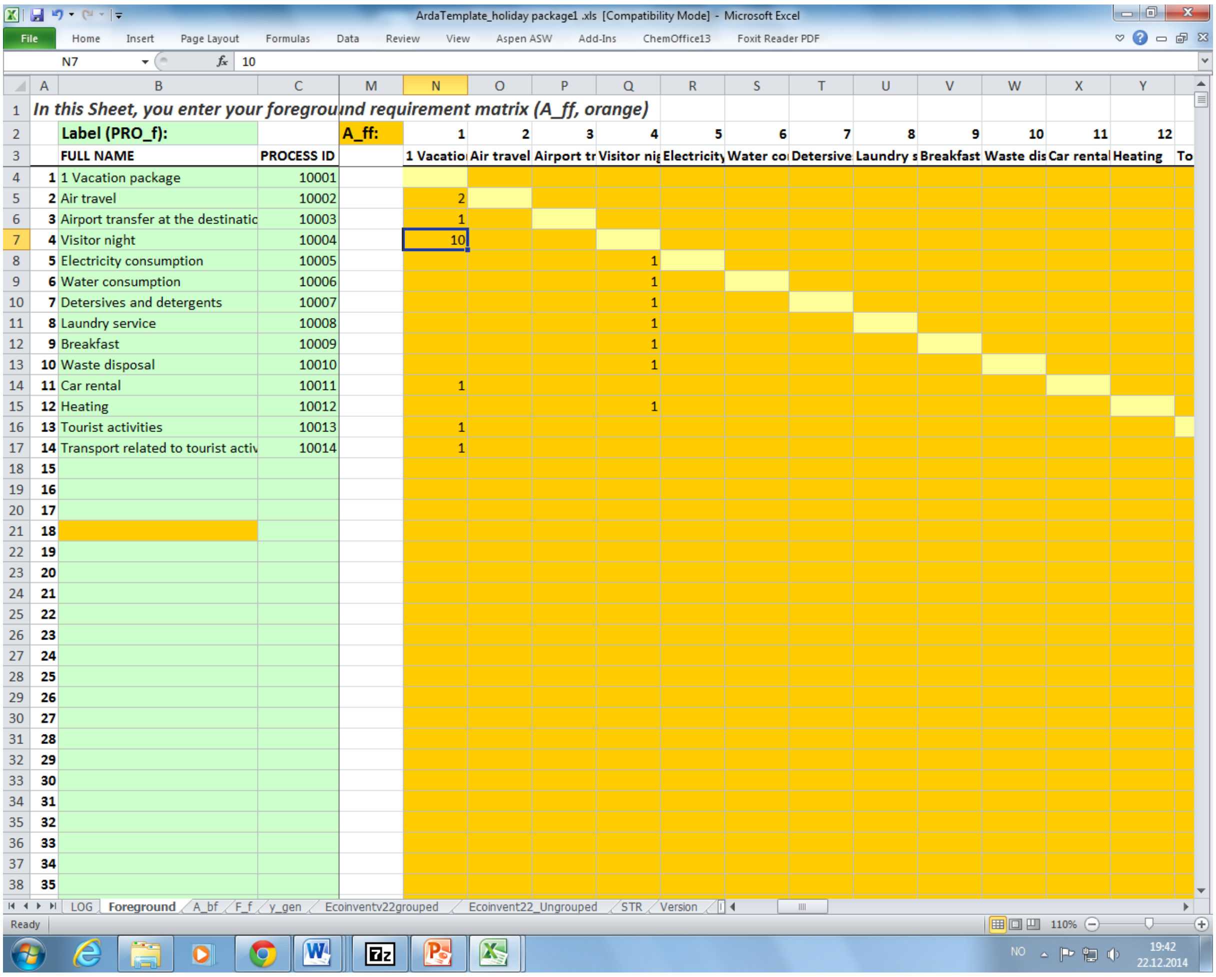
51) Viachaslau Filimonau, Janet Dickinson, Derek Robbins, Maharaj Vijay Reddy (2013). *The role of 'indirect' greenhouse gas emissions in tourism: Assessing the hidden carbon impacts from a holiday package tour*, Transportation Research Part A 54, 78–91

52) World Wild Life Fund–UK (2002). *Holiday footprinting. A practical tool for responsible tourism.*

8 Appendix

Figures 8.1-8.15 show some of the input data and the results of calculations. For the full overview of results please refer to attachment to this master thesis.

8.1 Foreground and Background Matrices



ArdaTemplate_holiday package1 .xls [Compatibility Mode] - Microsoft Excel

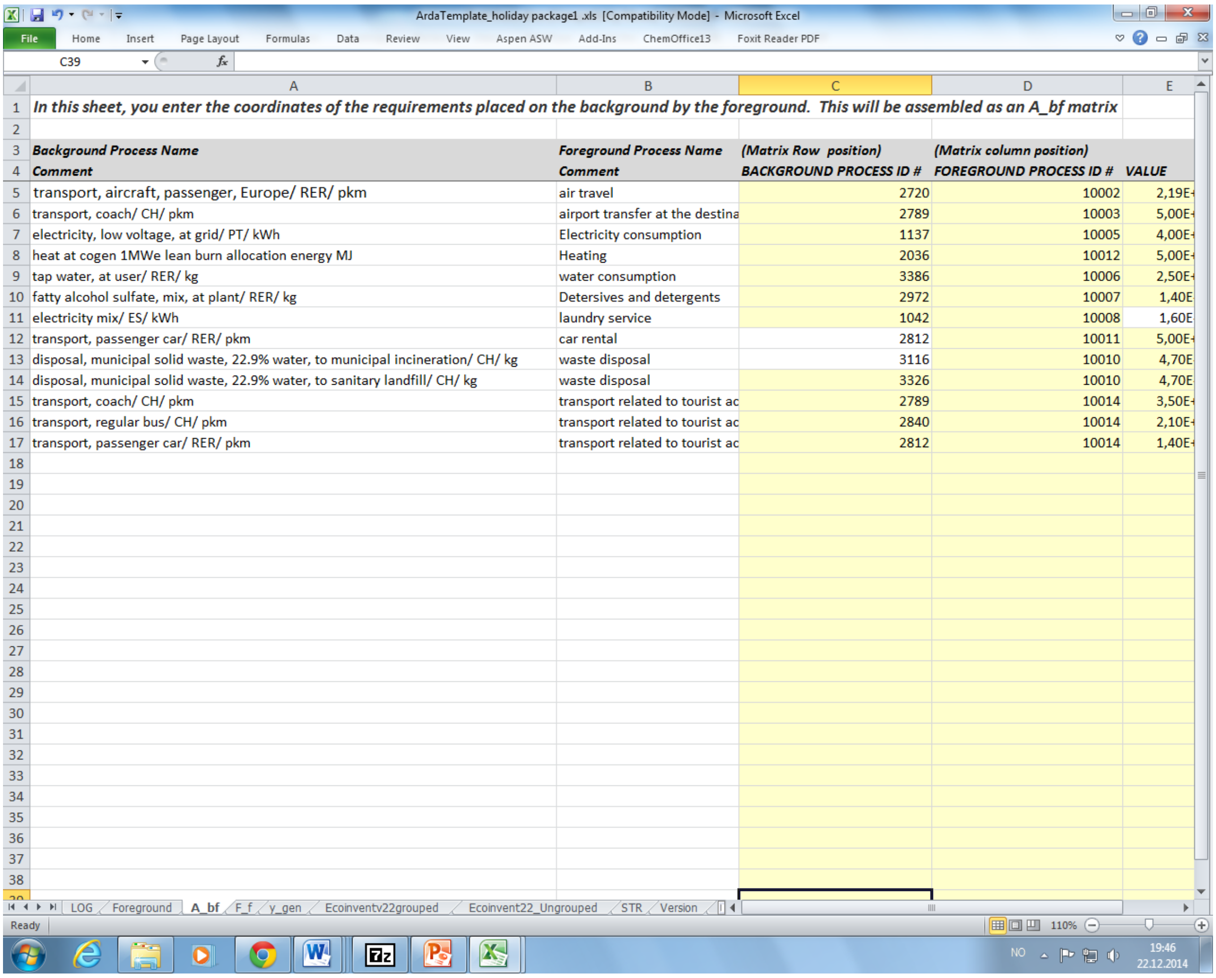
N7 | fx 10

In this Sheet, you enter your foreground requirement matrix (A_ff, orange)

	A	B	C	M	N	O	P	Q	R	S	T	U	V	W	X	Y
2		Label (PRO_f):		A_ff:	1	2	3	4	5	6	7	8	9	10	11	12
3		FULL NAME	PROCESS ID		1 Vacatio	Air travel	Airport tr	Visitor nig	Electricity	Water co	Detersive	Laundry s	Breakfast	Waste dis	Car rental	Heating To
4	1	1 Vacation package	10001													
5	2	Air travel	10002		2											
6	3	Airport transfer at the destinatic	10003		1											
7	4	Visitor night	10004		10											
8	5	Electricity consumption	10005					1								
9	6	Water consumption	10006					1								
10	7	Detersives and detergents	10007					1								
11	8	Laundry service	10008					1								
12	9	Breakfast	10009					1								
13	10	Waste disposal	10010					1								
14	11	Car rental	10011		1											
15	12	Heating	10012					1								
16	13	Tourist activities	10013		1											
17	14	Transport related to tourist activ	10014		1											
18	15															
19	16															
20	17															
21	18															
22	19															
23	20															
24	21															
25	22															
26	23															
27	24															
28	25															
29	26															
30	27															
31	28															
32	29															
33	30															
34	31															
35	32															
36	33															
37	34															
38	35															

LOG | Foreground | A_bf | F_f | y_gen | Ecoinventv22grouped | Ecoinvent22_Ungrouped | STR | Version

Figure 8.1 : Foreground requirement matrix

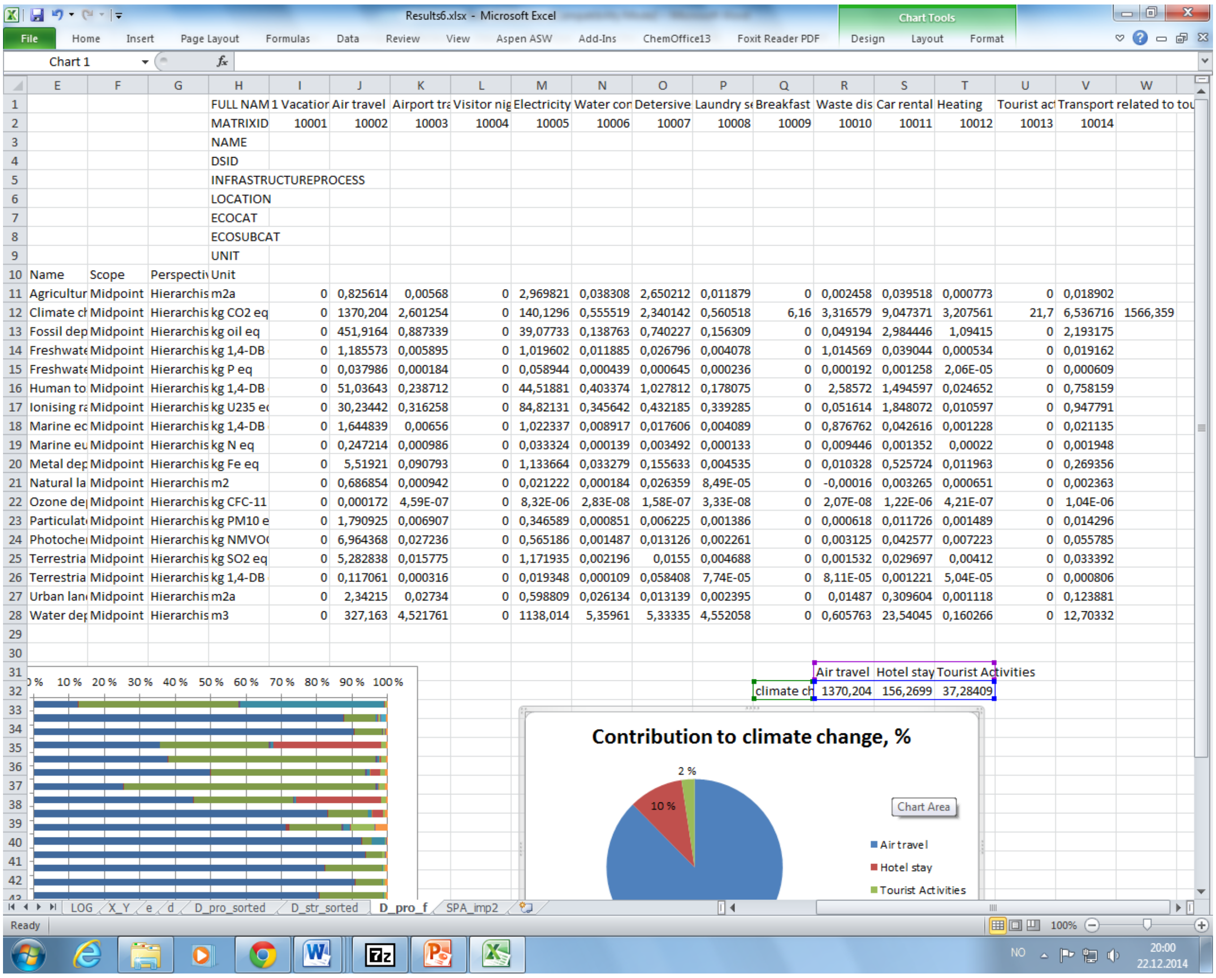


In this sheet, you enter the coordinates of the requirements placed on the background by the foreground. This will be assembled as an A_bf matrix

	A	B	C	D	E
3	***Background Process Name***	***Foreground Process Name***	***(Matrix Row position)***	***(Matrix column position)***	
4	***Comment***	***Comment***	***BACKGROUND PROCESS ID #***	***FOREGROUND PROCESS ID #***	***VALUE***
5	transport, aircraft, passenger, Europe/ RER/ pkm	air travel	2720	10002	2,19E
6	transport, coach/ CH/ pkm	airport transfer at the destina	2789	10003	5,00E
7	electricity, low voltage, at grid/ PT/ kWh	Electricity consumption	1137	10005	4,00E
8	heat at cogen 1MWe lean burn allocation energy MJ	Heating	2036	10012	5,00E
9	tap water, at user/ RER/ kg	water consumption	3386	10006	2,50E
10	fatty alcohol sulfate, mix, at plant/ RER/ kg	Detersives and detergents	2972	10007	1,40E
11	electricity mix/ ES/ kWh	laundry service	1042	10008	1,60E
12	transport, passenger car/ RER/ pkm	car rental	2812	10011	5,00E
13	disposal, municipal solid waste, 22.9% water, to municipal incineration/ CH/ kg	waste disposal	3116	10010	4,70E
14	disposal, municipal solid waste, 22.9% water, to sanitary landfill/ CH/ kg	waste disposal	3326	10010	4,70E
15	transport, coach/ CH/ pkm	transport related to tourist ac	2789	10014	3,50E
16	transport, regular bus/ CH/ pkm	transport related to tourist ac	2840	10014	2,10E
17	transport, passenger car/ RER/ pkm	transport related to tourist ac	2812	10014	1,40E

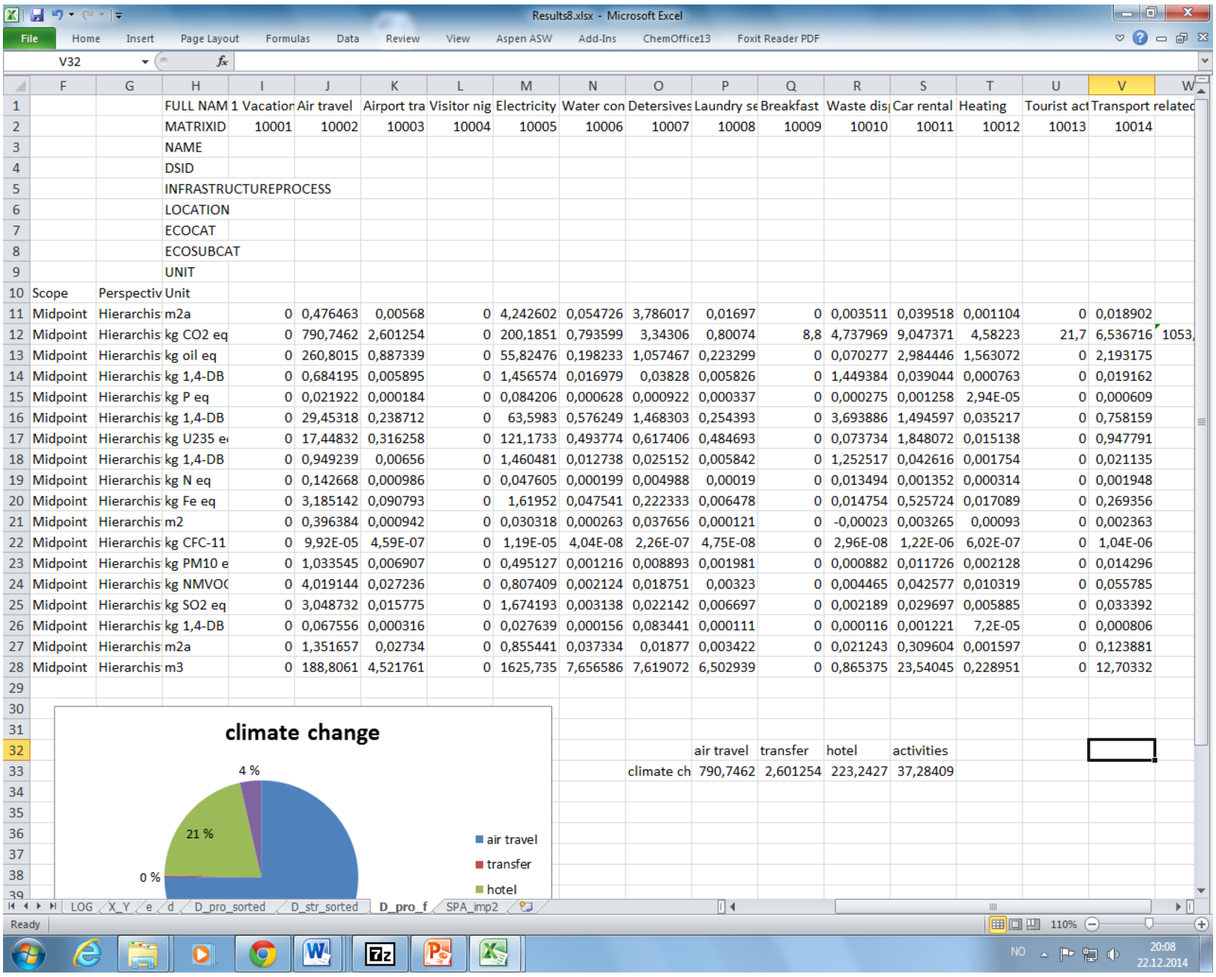
Figure 8.2 : Requirements placed on the background by the foreground

8.2 Results of Life Cycle Analysis for Different Vacation Packages



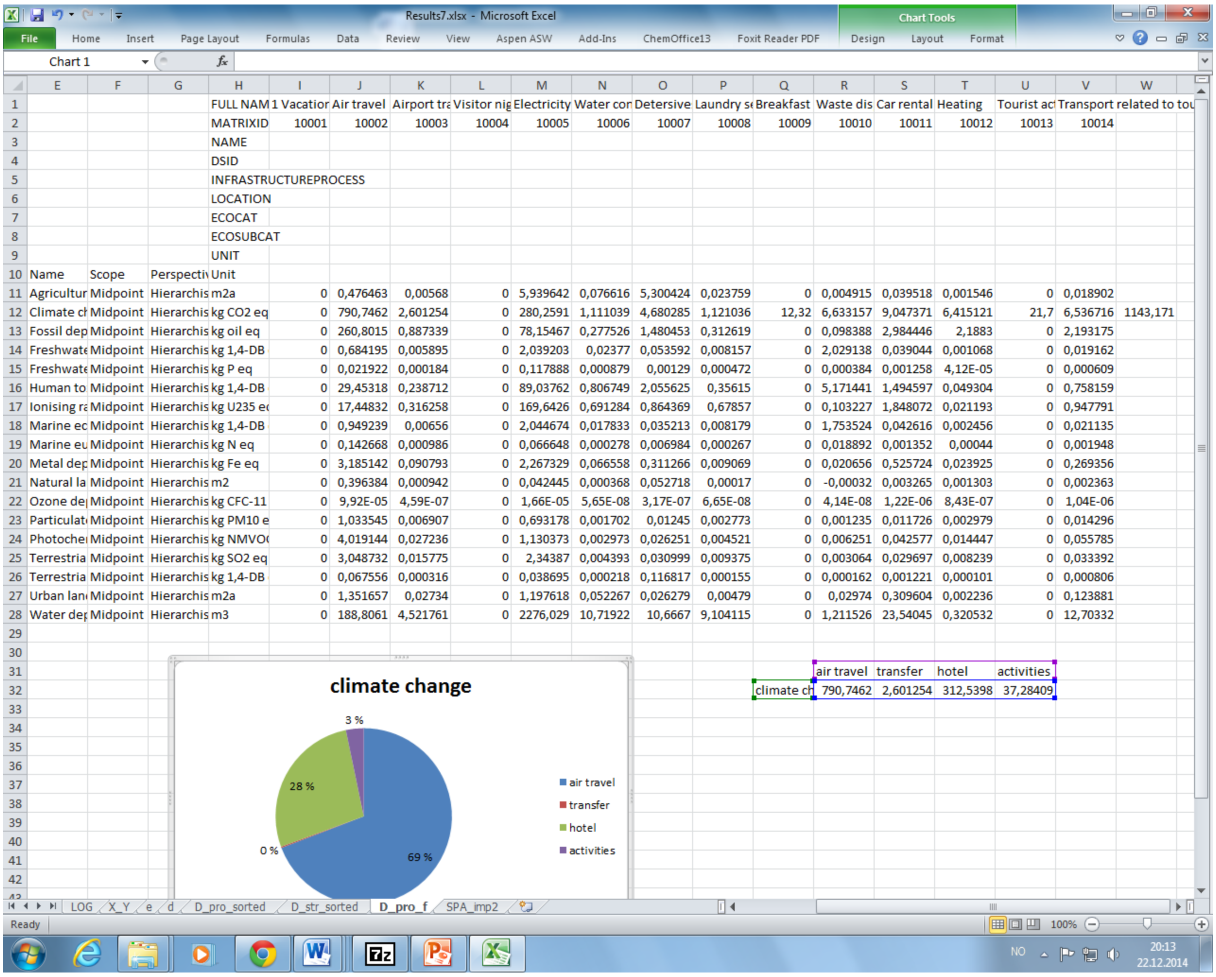
	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1				FULL NAM	1 Vacatior	Air travel	Airport tra	Visitor nig	Electricity	Water cor	Detersive	Laundry se	Breakfast	Waste dis	Car rental	Heating	Tourist act	Transport	related to tou
2				MATRIXID	10001	10002	10003	10004	10005	10006	10007	10008	10009	10010	10011	10012	10013	10014	
3				NAME															
4				DSID															
5				INFRASTRUCTUREPROCESS															
6				LOCATION															
7				ECOCAT															
8				ECOSUBCAT															
9				UNIT															
10	Name	Scope	Perspectiv	Unit															
11	Agricultur	Midpoint	Hierarchis	m2a	0	0,825614	0,00568	0	2,969821	0,038308	2,650212	0,011879	0	0,002458	0,039518	0,000773	0	0,018902	
12	Climate ch	Midpoint	Hierarchis	kg CO2 eq	0	1370,204	2,601254	0	140,1296	0,555519	2,340142	0,560518	6,16	3,316579	9,047371	3,207561	21,7	6,536716	1566,359
13	Fossil dep	Midpoint	Hierarchis	kg oil eq	0	451,9164	0,887339	0	39,07733	0,138763	0,740227	0,156309	0	0,049194	2,984446	1,09415	0	2,193175	
14	Freshwate	Midpoint	Hierarchis	kg 1,4-DB	0	1,185573	0,005895	0	1,019602	0,011885	0,026796	0,004078	0	1,014569	0,039044	0,000534	0	0,019162	
15	Freshwate	Midpoint	Hierarchis	kg P eq	0	0,037986	0,000184	0	0,058944	0,000439	0,000645	0,000236	0	0,000192	0,001258	2,06E-05	0	0,000609	
16	Human to	Midpoint	Hierarchis	kg 1,4-DB	0	51,03643	0,238712	0	44,51881	0,403374	1,027812	0,178075	0	2,58572	1,494597	0,024652	0	0,758159	
17	Ionising ra	Midpoint	Hierarchis	kg U235 ec	0	30,23442	0,316258	0	84,82131	0,345642	0,432185	0,339285	0	0,051614	1,848072	0,010597	0	0,947791	
18	Marine ec	Midpoint	Hierarchis	kg 1,4-DB	0	1,644839	0,00656	0	1,022337	0,008917	0,017606	0,004089	0	0,876762	0,042616	0,001228	0	0,021135	
19	Marine eu	Midpoint	Hierarchis	kg N eq	0	0,247214	0,000986	0	0,033324	0,000139	0,003492	0,000133	0	0,009446	0,001352	0,00022	0	0,001948	
20	Metal dep	Midpoint	Hierarchis	kg Fe eq	0	5,51921	0,090793	0	1,133664	0,033279	0,155633	0,004535	0	0,010328	0,525724	0,011963	0	0,269356	
21	Natural la	Midpoint	Hierarchis	m2	0	0,686854	0,000942	0	0,021222	0,000184	0,026359	8,49E-05	0	-0,00016	0,003265	0,000651	0	0,002363	
22	Ozone de	Midpoint	Hierarchis	kg CFC-11	0	0,000172	4,59E-07	0	8,32E-06	2,83E-08	1,58E-07	3,33E-08	0	2,07E-08	1,22E-06	4,21E-07	0	1,04E-06	
23	Particulat	Midpoint	Hierarchis	kg PM10 e	0	1,790925	0,006907	0	0,346589	0,000851	0,006225	0,001386	0	0,000618	0,011726	0,001489	0	0,014296	
24	Photoche	Midpoint	Hierarchis	kg NMVO	0	6,964368	0,027236	0	0,565186	0,001487	0,013126	0,002261	0	0,003125	0,042577	0,007223	0	0,055785	
25	Terrestria	Midpoint	Hierarchis	kg SO2 eq	0	5,282838	0,015775	0	1,171935	0,002196	0,0155	0,004688	0	0,001532	0,029697	0,00412	0	0,033392	
26	Terrestria	Midpoint	Hierarchis	kg 1,4-DB	0	0,117061	0,000316	0	0,019348	0,000109	0,058408	7,74E-05	0	8,11E-05	0,001221	5,04E-05	0	0,000806	
27	Urban lan	Midpoint	Hierarchis	m2a	0	2,34215	0,02734	0	0,598809	0,026134	0,013139	0,002395	0	0,01487	0,309604	0,001118	0	0,123881	
28	Water dep	Midpoint	Hierarchis	m3	0	327,163	4,521761	0	1138,014	5,35961	5,33335	4,552058	0	0,605763	23,54045	0,160266	0	12,70332	
29																			
30																			
31														Air travel	Hotel stay	Tourist Activities			
32													climate ch	1370,204	156,2699	37,28409			

Figure 8.3 : Impacts generated from a 7 nights vacation package to the Canary Islands



	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1			FULL NAM	1 Vacation	Air travel	Airport tra	Visitor nig	Electricity	Water con	Detersives	Laundry se	Breakfast	Waste dis|	Car rental	Heating	Tourist act	Transport related	
2			MATRIXID	10001	10002	10003	10004	10005	10006	10007	10008	10009	10010	10011	10012	10013	10014	
3			NAME															
4			DSID															
5			INFRASTRUCTUREPROCESS															
6			LOCATION															
7			ECOCAT															
8			ECOSUBCAT															
9			UNIT															
10	Scope	Perspectiv	Unit															
11	Midpoint	Hierarchis	m2a	0	0,476463	0,00568	0	4,242602	0,054726	3,786017	0,01697	0	0,003511	0,039518	0,001104	0	0,018902	
12	Midpoint	Hierarchis	kg CO2 eq	0	790,7462	2,601254	0	200,1851	0,793599	3,34306	0,80074	8,8	4,737969	9,047371	4,58223	21,7	6,536716	1053,
13	Midpoint	Hierarchis	kg oil eq	0	260,8015	0,887339	0	55,82476	0,198233	1,057467	0,223299	0	0,070277	2,984446	1,563072	0	2,193175	
14	Midpoint	Hierarchis	kg 1,4-DB	0	0,684195	0,005895	0	1,456574	0,016979	0,03828	0,005826	0	1,449384	0,039044	0,000763	0	0,019162	
15	Midpoint	Hierarchis	kg P eq	0	0,021922	0,000184	0	0,084206	0,000628	0,000922	0,000337	0	0,000275	0,001258	2,94E-05	0	0,000609	
16	Midpoint	Hierarchis	kg 1,4-DB	0	29,45318	0,238712	0	63,5983	0,576249	1,468303	0,254393	0	3,693886	1,494597	0,035217	0	0,758159	
17	Midpoint	Hierarchis	kg U235 e	0	17,44832	0,316258	0	121,1733	0,493774	0,617406	0,484693	0	0,073734	1,848072	0,015138	0	0,947791	
18	Midpoint	Hierarchis	kg 1,4-DB	0	0,949239	0,00656	0	1,460481	0,012738	0,025152	0,005842	0	1,252517	0,042616	0,001754	0	0,021135	
19	Midpoint	Hierarchis	kg N eq	0	0,142668	0,000986	0	0,047605	0,000199	0,004988	0,00019	0	0,013494	0,001352	0,000314	0	0,001948	
20	Midpoint	Hierarchis	kg Fe eq	0	3,185142	0,090793	0	1,61952	0,047541	0,222333	0,006478	0	0,014754	0,525724	0,017089	0	0,269356	
21	Midpoint	Hierarchis	m2	0	0,396384	0,000942	0	0,030318	0,000263	0,037656	0,000121	0	-0,00023	0,003265	0,00093	0	0,002363	
22	Midpoint	Hierarchis	kg CFC-11	0	9,92E-05	4,59E-07	0	1,19E-05	4,04E-08	2,26E-07	4,75E-08	0	2,96E-08	1,22E-06	6,02E-07	0	1,04E-06	
23	Midpoint	Hierarchis	kg PM10 e	0	1,033545	0,006907	0	0,495127	0,001216	0,008893	0,001981	0	0,000882	0,011726	0,002128	0	0,014296	
24	Midpoint	Hierarchis	kg NMVOC	0	4,019144	0,027236	0	0,807409	0,002124	0,018751	0,00323	0	0,004465	0,042577	0,010319	0	0,055785	
25	Midpoint	Hierarchis	kg SO2 eq	0	3,048732	0,015775	0	1,674193	0,003138	0,022142	0,006697	0	0,002189	0,029697	0,005885	0	0,033392	
26	Midpoint	Hierarchis	kg 1,4-DB	0	0,067556	0,000316	0	0,027639	0,000156	0,083441	0,000111	0	0,000116	0,001221	7,2E-05	0	0,000806	
27	Midpoint	Hierarchis	m2a	0	1,351657	0,02734	0	0,855441	0,037334	0,01877	0,003422	0	0,021243	0,309604	0,001597	0	0,123881	
28	Midpoint	Hierarchis	m3	0	188,8061	4,521761	0	1625,735	7,656586	7,619072	6,502939	0	0,865375	23,54045	0,228951	0	12,70332	
32											air travel	transfer	hotel	activities				
33										climate ch	790,7462	2,601254	223,2427	37,28409				

Figure 8.4 : Impacts generated from a 10 days vacation package to Mallorca

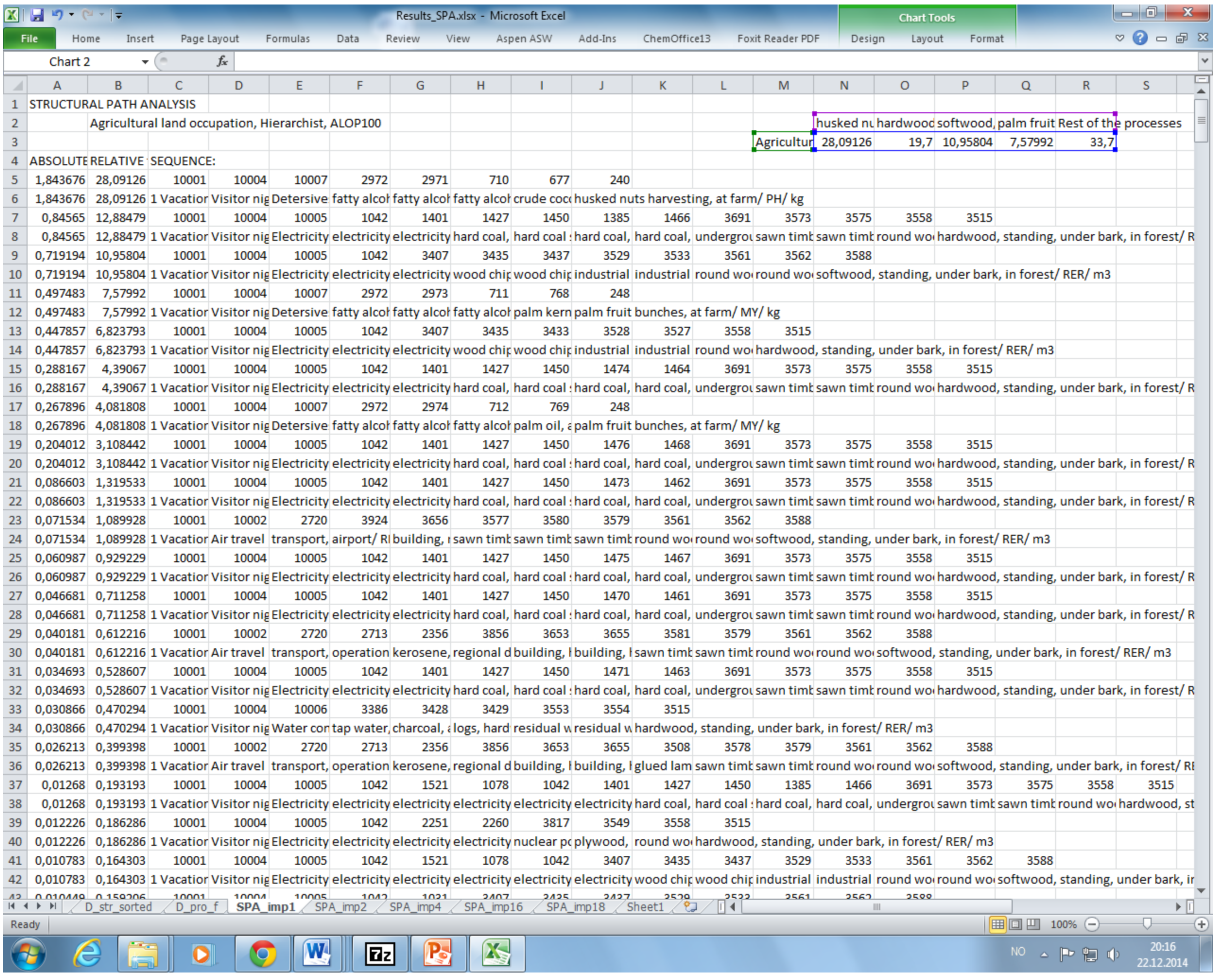


	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1				FULL NAM	1 Vacatior	Air travel	Airport tra	Visitor nig	Electricity	Water con	Detersive	Laundry se	Breakfast	Waste dis	Car rental	Heating	Tourist act	Transport related to tou	
2				MATRIXID	10001	10002	10003	10004	10005	10006	10007	10008	10009	10010	10011	10012	10013	10014	
3				NAME															
4				DSID															
5				INFRASTRUCTUREPROCESS															
6				LOCATION															
7				ECOCAT															
8				ECOSUBCAT															
9				UNIT															
10	Name	Scope	Perspecti	Unit															
11	Agricultur	Midpoint	Hierarchis	m2a	0	0,476463	0,00568	0	5,939642	0,076616	5,300424	0,023759	0	0,004915	0,039518	0,001546	0	0,018902	
12	Climate ch	Midpoint	Hierarchis	kg CO2 eq	0	790,7462	2,601254	0	280,2591	1,111039	4,680285	1,121036	12,32	6,633157	9,047371	6,415121	21,7	6,536716	1143,171
13	Fossil dep	Midpoint	Hierarchis	kg oil eq	0	260,8015	0,887339	0	78,15467	0,277526	1,480453	0,312619	0	0,098388	2,984446	2,1883	0	2,193175	
14	Freshwate	Midpoint	Hierarchis	kg 1,4-DB	0	0,684195	0,005895	0	2,039203	0,02377	0,053592	0,008157	0	2,029138	0,039044	0,001068	0	0,019162	
15	Freshwate	Midpoint	Hierarchis	kg P eq	0	0,021922	0,000184	0	0,117888	0,000879	0,00129	0,000472	0	0,000384	0,001258	4,12E-05	0	0,000609	
16	Human to	Midpoint	Hierarchis	kg 1,4-DB	0	29,45318	0,238712	0	89,03762	0,806749	2,055625	0,35615	0	5,171441	1,494597	0,049304	0	0,758159	
17	Ionising ra	Midpoint	Hierarchis	kg U235 ec	0	17,44832	0,316258	0	169,6426	0,691284	0,864369	0,67857	0	0,103227	1,848072	0,021193	0	0,947791	
18	Marine ec	Midpoint	Hierarchis	kg 1,4-DB	0	0,949239	0,00656	0	2,044674	0,017833	0,035213	0,008179	0	1,753524	0,042616	0,002456	0	0,021135	
19	Marine eu	Midpoint	Hierarchis	kg N eq	0	0,142668	0,000986	0	0,066648	0,000278	0,006984	0,000267	0	0,018892	0,001352	0,00044	0	0,001948	
20	Metal dep	Midpoint	Hierarchis	kg Fe eq	0	3,185142	0,090793	0	2,267329	0,066558	0,311266	0,009069	0	0,020656	0,525724	0,023925	0	0,269356	
21	Natural la	Midpoint	Hierarchis	m2	0	0,396384	0,000942	0	0,042445	0,000368	0,052718	0,00017	0	-0,00032	0,003265	0,001303	0	0,002363	
22	Ozone de	Midpoint	Hierarchis	kg CFC-11	0	9,92E-05	4,59E-07	0	1,66E-05	5,65E-08	3,17E-07	6,65E-08	0	4,14E-08	1,22E-06	8,43E-07	0	1,04E-06	
23	Particulat	Midpoint	Hierarchis	kg PM10 e	0	1,033545	0,006907	0	0,693178	0,001702	0,01245	0,002773	0	0,001235	0,011726	0,002979	0	0,014296	
24	Photoche	Midpoint	Hierarchis	kg NMVO	0	4,019144	0,027236	0	1,130373	0,002973	0,026251	0,004521	0	0,006251	0,042577	0,014447	0	0,055785	
25	Terrestria	Midpoint	Hierarchis	kg SO2 eq	0	3,048732	0,015775	0	2,34387	0,004393	0,030999	0,009375	0	0,003064	0,029697	0,008239	0	0,033392	
26	Terrestria	Midpoint	Hierarchis	kg 1,4-DB	0	0,067556	0,000316	0	0,038695	0,000218	0,116817	0,000155	0	0,000162	0,001221	0,000101	0	0,000806	
27	Urban lan	Midpoint	Hierarchis	m2a	0	1,351657	0,02734	0	1,197618	0,052267	0,026279	0,00479	0	0,02974	0,309604	0,002236	0	0,123881	
28	Water dep	Midpoint	Hierarchis	m3	0	188,8061	4,521761	0	2276,029	10,71922	10,6667	9,104115	0	1,211526	23,54045	0,320532	0	12,70332	

	air travel	transfer	hotel	activities
climate ch	790,7462	2,601254	312,5398	37,28409

Figure 8.5 : Impacts generated from 14 days vacation package to Mallorca

8.3 Results of Structural Path Analysis for Different Impact Categories



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	STRUCTURAL PATH ANALYSIS																		
2		Agricultural land occupation, Hierarchist, ALOP100												husked nu	hardwood	softwood,	palm fruit	Rest of the processes	
3													Agricultur	28,09126	19,7	10,95804	7,57992	33,7	
4	ABSOLUTE	RELATIVE	SEQUENCE:																
5	1,843676	28,09126	10001	10004	10007	2972	2971	710	677	240									
6	1,843676	28,09126	1 Vacatior	Visitor nig	Detersive	fatty alcoh	fatty alcoh	fatty alcoh	crude coco	husked nuts harvesting, at farm/ PH/ kg									
7	0,84565	12,88479	10001	10004	10005	1042	1401	1427	1450	1385	1466	3691	3573	3575	3558	3515			
8	0,84565	12,88479	1 Vacatior	Visitor nig	Electricity	electricity	electricity	hard coal,	hard coal :	hard coal,	hard coal,	undergrou	sawn timb	sawn timb	round wo	hardwood, standing, under bark, in forest/ R			
9	0,719194	10,95804	10001	10004	10005	1042	3407	3435	3437	3529	3533	3561	3562	3588					
10	0,719194	10,95804	1 Vacatior	Visitor nig	Electricity	electricity	electricity	wood chip	wood chip	industrial	industrial	round wo	round wo	softwood, standing, under bark, in forest/ RER/ m3					
11	0,497483	7,57992	10001	10004	10007	2972	2973	711	768	248									
12	0,497483	7,57992	1 Vacatior	Visitor nig	Detersive	fatty alcoh	fatty alcoh	fatty alcoh	palm kern	palm fruit bunches, at farm/ MY/ kg									
13	0,447857	6,823793	10001	10004	10005	1042	3407	3435	3433	3528	3527	3558	3515						
14	0,447857	6,823793	1 Vacatior	Visitor nig	Electricity	electricity	electricity	wood chip	wood chip	industrial	industrial	round wo	hardwood, standing, under bark, in forest/ RER/ m3						
15	0,288167	4,39067	10001	10004	10005	1042	1401	1427	1450	1474	1464	3691	3573	3575	3558	3515			
16	0,288167	4,39067	1 Vacatior	Visitor nig	Electricity	electricity	electricity	hard coal,	hard coal :	hard coal,	hard coal,	undergrou	sawn timb	sawn timb	round wo	hardwood, standing, under bark, in forest/ R			
17	0,267896	4,081808	10001	10004	10007	2972	2974	712	769	248									
18	0,267896	4,081808	1 Vacatior	Visitor nig	Detersive	fatty alcoh	fatty alcoh	fatty alcoh	palm oil, a	palm fruit bunches, at farm/ MY/ kg									
19	0,204012	3,108442	10001	10004	10005	1042	1401	1427	1450	1476	1468	3691	3573	3575	3558	3515			
20	0,204012	3,108442	1 Vacatior	Visitor nig	Electricity	electricity	electricity	hard coal,	hard coal :	hard coal,	hard coal,	undergrou	sawn timb	sawn timb	round wo	hardwood, standing, under bark, in forest/ R			
21	0,086603	1,319533	10001	10004	10005	1042	1401	1427	1450	1473	1462	3691	3573	3575	3558	3515			
22	0,086603	1,319533	1 Vacatior	Visitor nig	Electricity	electricity	electricity	hard coal,	hard coal :	hard coal,	hard coal,	undergrou	sawn timb	sawn timb	round wo	hardwood, standing, under bark, in forest/ R			
23	0,071534	1,089928	10001	10002	2720	3924	3656	3577	3580	3579	3561	3562	3588						
24	0,071534	1,089928	1 Vacatior	Air travel	transport,	airport/ RI	building, r	sawn timb	sawn timb	sawn timb	round wo	round wo	softwood, standing, under bark, in forest/ RER/ m3						
25	0,060987	0,929229	10001	10004	10005	1042	1401	1427	1450	1475	1467	3691	3573	3575	3558	3515			
26	0,060987	0,929229	1 Vacatior	Visitor nig	Electricity	electricity	electricity	hard coal,	hard coal :	hard coal,	hard coal,	undergrou	sawn timb	sawn timb	round wo	hardwood, standing, under bark, in forest/ R			
27	0,046681	0,711258	10001	10004	10005	1042	1401	1427	1450	1470	1461	3691	3573	3575	3558	3515			
28	0,046681	0,711258	1 Vacatior	Visitor nig	Electricity	electricity	electricity	hard coal,	hard coal :	hard coal,	hard coal,	undergrou	sawn timb	sawn timb	round wo	hardwood, standing, under bark, in forest/ R			
29	0,040181	0,612216	10001	10002	2720	2713	2356	3856	3653	3655	3581	3579	3561	3562	3588				
30	0,040181	0,612216	1 Vacatior	Air travel	transport,	operation	kerosene,	regional d	building, h	building, h	sawn timb	sawn timb	round wo	round wo	softwood, standing, under bark, in forest/ RER/ m3				
31	0,034693	0,528607	10001	10004	10005	1042	1401	1427	1450	1471	1463	3691	3573	3575	3558	3515			
32	0,034693	0,528607	1 Vacatior	Visitor nig	Electricity	electricity	electricity	hard coal,	hard coal :	hard coal,	hard coal,	undergrou	sawn timb	sawn timb	round wo	hardwood, standing, under bark, in forest/ R			
33	0,030866	0,470294	10001	10004	10006	3386	3428	3429	3553	3554	3515								
34	0,030866	0,470294	1 Vacatior	Visitor nig	Water con	tap water,	charcoal, a	logs, hard	residual w	residual w	hardwood, standing, under bark, in forest/ RER/ m3								
35	0,026213	0,399398	10001	10002	2720	2713	2356	3856	3653	3655	3508	3578	3579	3561	3562	3588			
36	0,026213	0,399398	1 Vacatior	Air travel	transport,	operation	kerosene,	regional d	building, h	building, h	glued lam	sawn timb	sawn timb	round wo	round wo	softwood, standing, under bark, in forest/ RE			
37	0,01268	0,193193	10001	10004	10005	1042	1521	1078	1042	1401	1427	1450	1385	1466	3691	3573	3575	3558	3515
38	0,01268	0,193193	1 Vacatior	Visitor nig	Electricity	electricity	electricity	electricity	electricity	electricity	hard coal,	hard coal :	hard coal,	hard coal,	undergrou	sawn timb	sawn timb	round wo	hardwood, st
39	0,012226	0,186286	10001	10004	10005	1042	2251	2260	3817	3549	3558	3515							
40	0,012226	0,186286	1 Vacatior	Visitor nig	Electricity	electricity	electricity	electricity	nuclear po	plywood,	round wo	hardwood, standing, under bark, in forest/ RER/ m3							
41	0,010783	0,164303	10001	10004	10005	1042	1521	1078	1042	3407	3435	3437	3529	3533	3561	3562	3588		
42	0,010783	0,164303	1 Vacatior	Visitor nig	Electricity	electricity	electricity	electricity	electricity	electricity	wood chip	wood chip	industrial	industrial	round wo	round wo	softwood, standing, under bark, in		
43	0,010449	0,159206	10001	10004	10005	1042	1031	3407	3435	3437	3529	3533	3561	3562	3588				

Figure 8.6 : SPA Agricultural land occupation

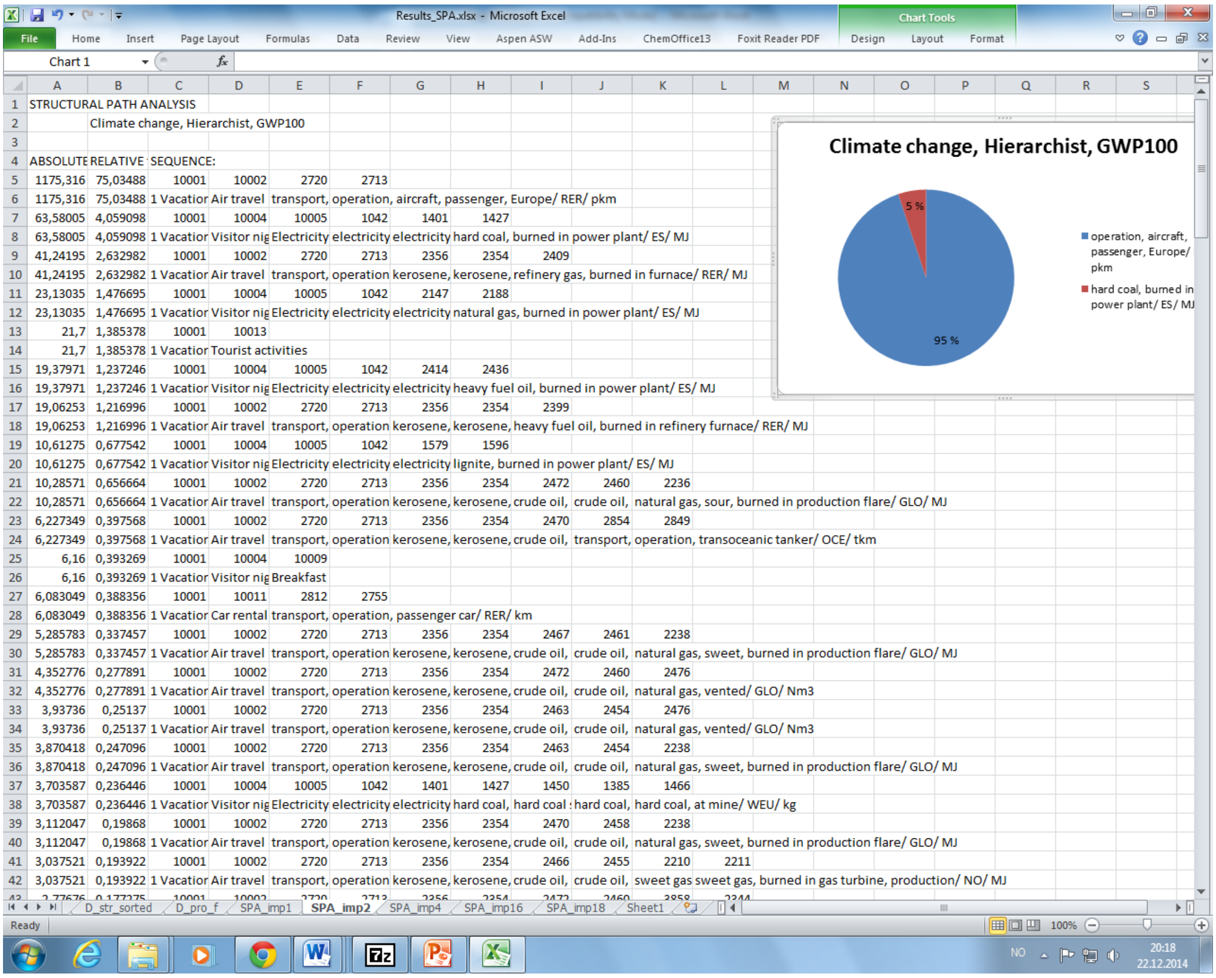


Figure 8.7 : SPA Climate change

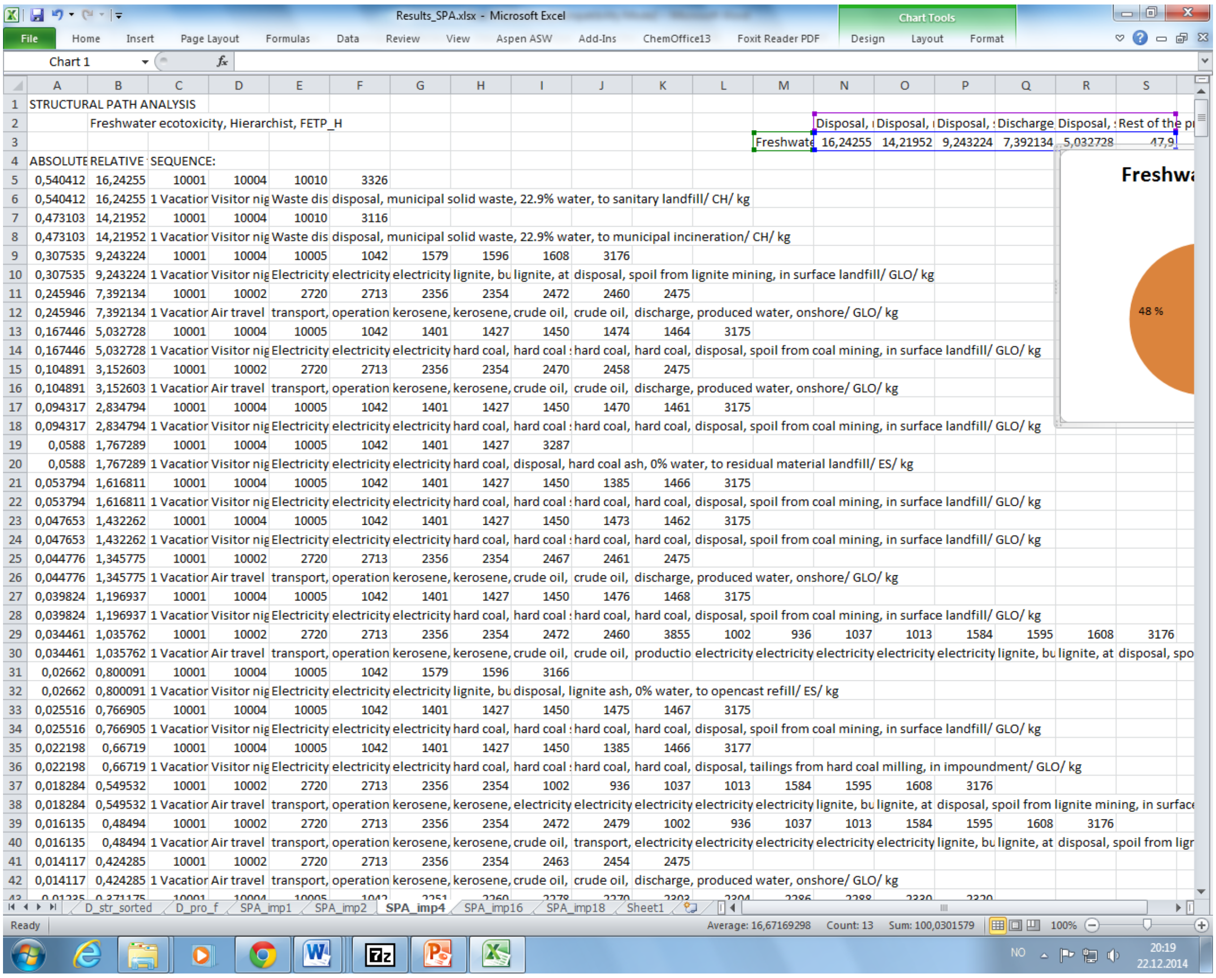
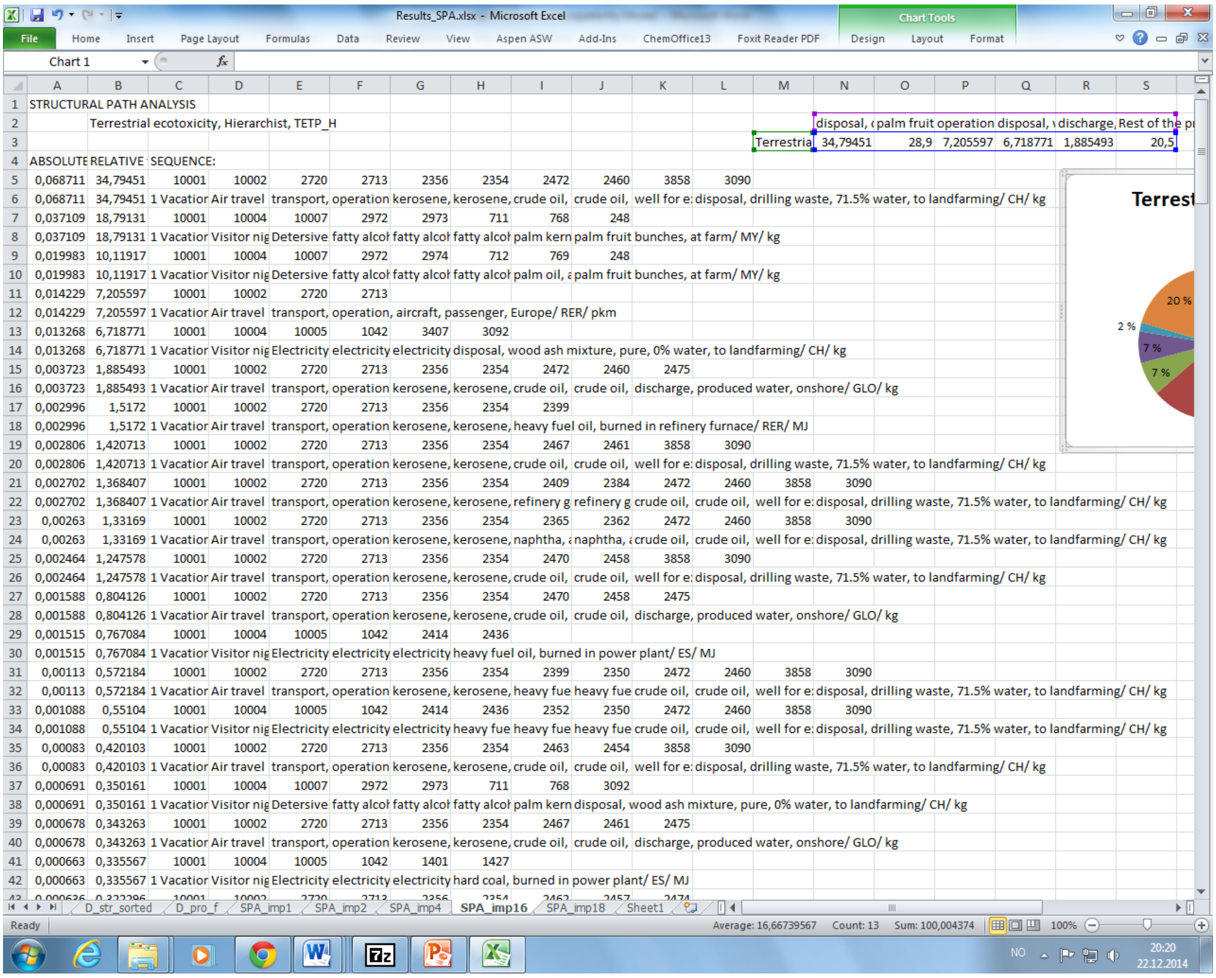
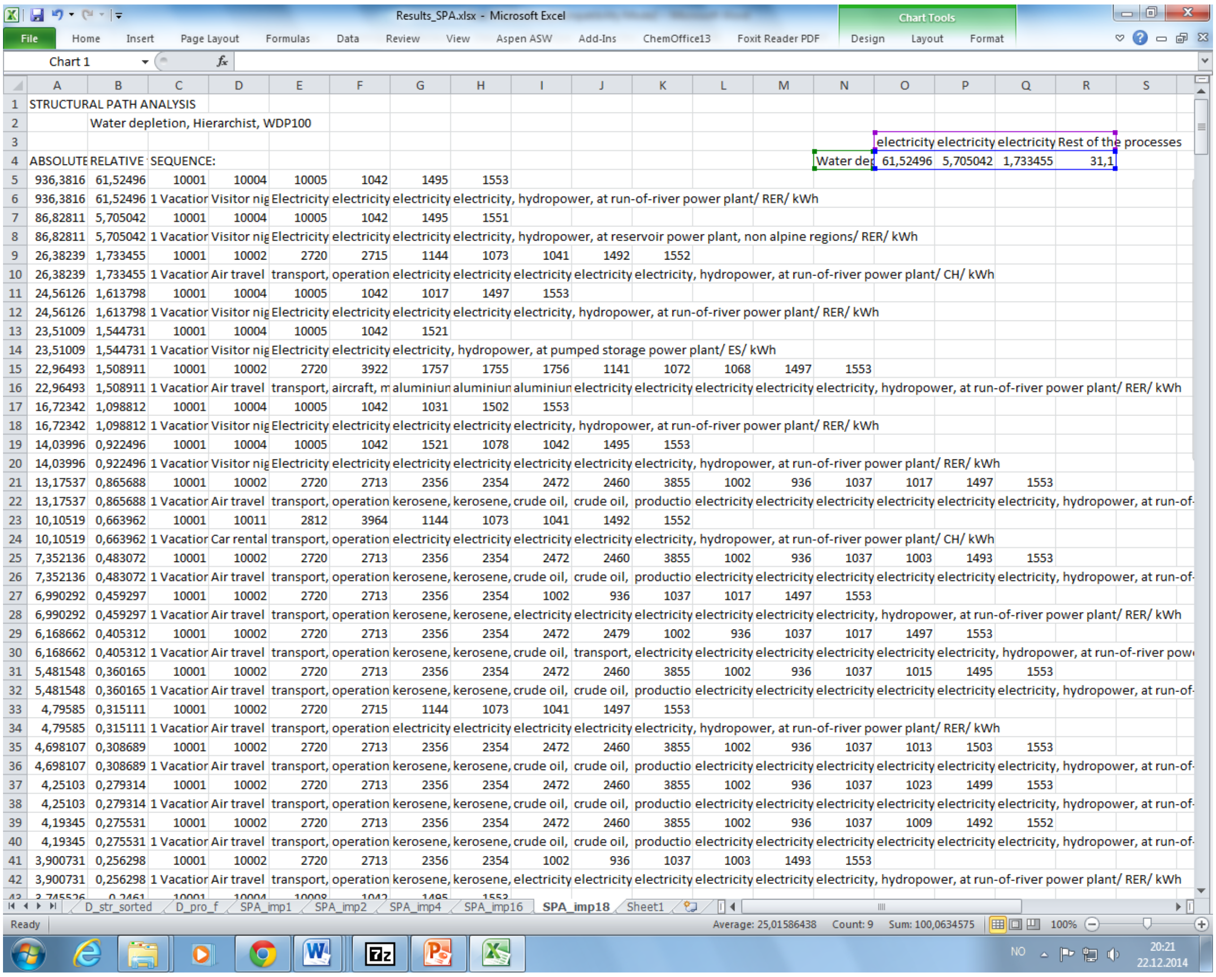


Figure 8.8SPA Freshwater ecotoxicity



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	STRUCTURAL PATH ANALYSIS																		
2		Terrestrial ecotoxicity, Hierarchist, TETP_H												disposal, (	palm fruit	operation	disposal, \	discharge,	Rest of the p
3													Terrestria	34,79451	28,9	7,205597	6,718771	1,885493	20,5
4	ABSOLUTE	RELATIVE	SEQUENCE:																
5	0,068711	34,79451	10001	10002	2720	2713	2356	2354	2472	2460	3858	3090							
6	0,068711	34,79451	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	crude oil,	crude oil,	well for e:	disposal, drilling waste, 71.5% water, to landfarming/ CH/ kg							
7	0,037109	18,79131	10001	10004	10007	2972	2973	711	768	248									
8	0,037109	18,79131	1 Vacatior	Visitor nig	Detersive	fatty alcoh	fatty alcoh	fatty alcoh	palm kern	palm fruit bunches, at farm/ MY/ kg									
9	0,019983	10,11917	10001	10004	10007	2972	2974	712	769	248									
10	0,019983	10,11917	1 Vacatior	Visitor nig	Detersive	fatty alcoh	fatty alcoh	fatty alcoh	palm oil, a	palm fruit bunches, at farm/ MY/ kg									
11	0,014229	7,205597	10001	10002	2720	2713													
12	0,014229	7,205597	1 Vacatior	Air travel	transport, operation, aircraft, passenger, Europe/ RER/ pkm														
13	0,013268	6,718771	10001	10004	10005	1042	3407	3092											
14	0,013268	6,718771	1 Vacatior	Visitor nig	Electricity	electricity	electricity	disposal, wood ash mixture, pure, 0% water, to landfarming/ CH/ kg											
15	0,003723	1,885493	10001	10002	2720	2713	2356	2354	2472	2460	2475								
16	0,003723	1,885493	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	crude oil,	crude oil,	discharge, produced water, onshore/ GLO/ kg								
17	0,002996	1,5172	10001	10002	2720	2713	2356	2354	2399										
18	0,002996	1,5172	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	heavy fuel oil, burned in refinery furnace/ RER/ MJ										
19	0,002806	1,420713	10001	10002	2720	2713	2356	2354	2467	2461	3858	3090							
20	0,002806	1,420713	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	crude oil,	crude oil,	well for e:	disposal, drilling waste, 71.5% water, to landfarming/ CH/ kg							
21	0,002702	1,368407	10001	10002	2720	2713	2356	2354	2409	2384	2472	2460	3858	3090					
22	0,002702	1,368407	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	refinery g	refinery g	crude oil,	crude oil,	well for e:	disposal, drilling waste, 71.5% water, to landfarming/ CH/ kg					
23	0,00263	1,33169	10001	10002	2720	2713	2356	2354	2365	2362	2472	2460	3858	3090					
24	0,00263	1,33169	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	naphtha, a	naphtha, a	crude oil,	crude oil,	well for e:	disposal, drilling waste, 71.5% water, to landfarming/ CH/ kg					
25	0,002464	1,247578	10001	10002	2720	2713	2356	2354	2470	2458	3858	3090							
26	0,002464	1,247578	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	crude oil,	crude oil,	well for e:	disposal, drilling waste, 71.5% water, to landfarming/ CH/ kg							
27	0,001588	0,804126	10001	10002	2720	2713	2356	2354	2470	2458	2475								
28	0,001588	0,804126	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	crude oil,	crude oil,	discharge, produced water, onshore/ GLO/ kg								
29	0,001515	0,767084	10001	10004	10005	1042	2414	2436											
30	0,001515	0,767084	1 Vacatior	Visitor nig	Electricity	electricity	electricity	heavy fuel oil, burned in power plant/ ES/ MJ											
31	0,00113	0,572184	10001	10002	2720	2713	2356	2354	2399	2350	2472	2460	3858	3090					
32	0,00113	0,572184	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	heavy fue	heavy fue	crude oil,	crude oil,	well for e:	disposal, drilling waste, 71.5% water, to landfarming/ CH/ kg					
33	0,001088	0,55104	10001	10004	10005	1042	2414	2436	2352	2350	2472	2460	3858	3090					
34	0,001088	0,55104	1 Vacatior	Visitor nig	Electricity	electricity	electricity	heavy fue	heavy fue	heavy fue	crude oil,	crude oil,	well for e:	disposal, drilling waste, 71.5% water, to landfarming/ CH/ kg					
35	0,00083	0,420103	10001	10002	2720	2713	2356	2354	2463	2454	3858	3090							
36	0,00083	0,420103	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	crude oil,	crude oil,	well for e:	disposal, drilling waste, 71.5% water, to landfarming/ CH/ kg							
37	0,000691	0,350161	10001	10004	10007	2972	2973	711	768	3092									
38	0,000691	0,350161	1 Vacatior	Visitor nig	Detersive	fatty alcoh	fatty alcoh	fatty alcoh	palm kern	disposal, wood ash mixture, pure, 0% water, to landfarming/ CH/ kg									
39	0,000678	0,343263	10001	10002	2720	2713	2356	2354	2467	2461	2475								
40	0,000678	0,343263	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	crude oil,	crude oil,	discharge, produced water, onshore/ GLO/ kg								
41	0,000663	0,335567	10001	10004	10005	1042	1401	1427											
42	0,000663	0,335567	1 Vacatior	Visitor nig	Electricity	electricity	electricity	hard coal, burned in power plant/ ES/ MJ											
43	0,000636	0,322296	10001	10002	2720	2713	2356	2354	2462	2457	2474								

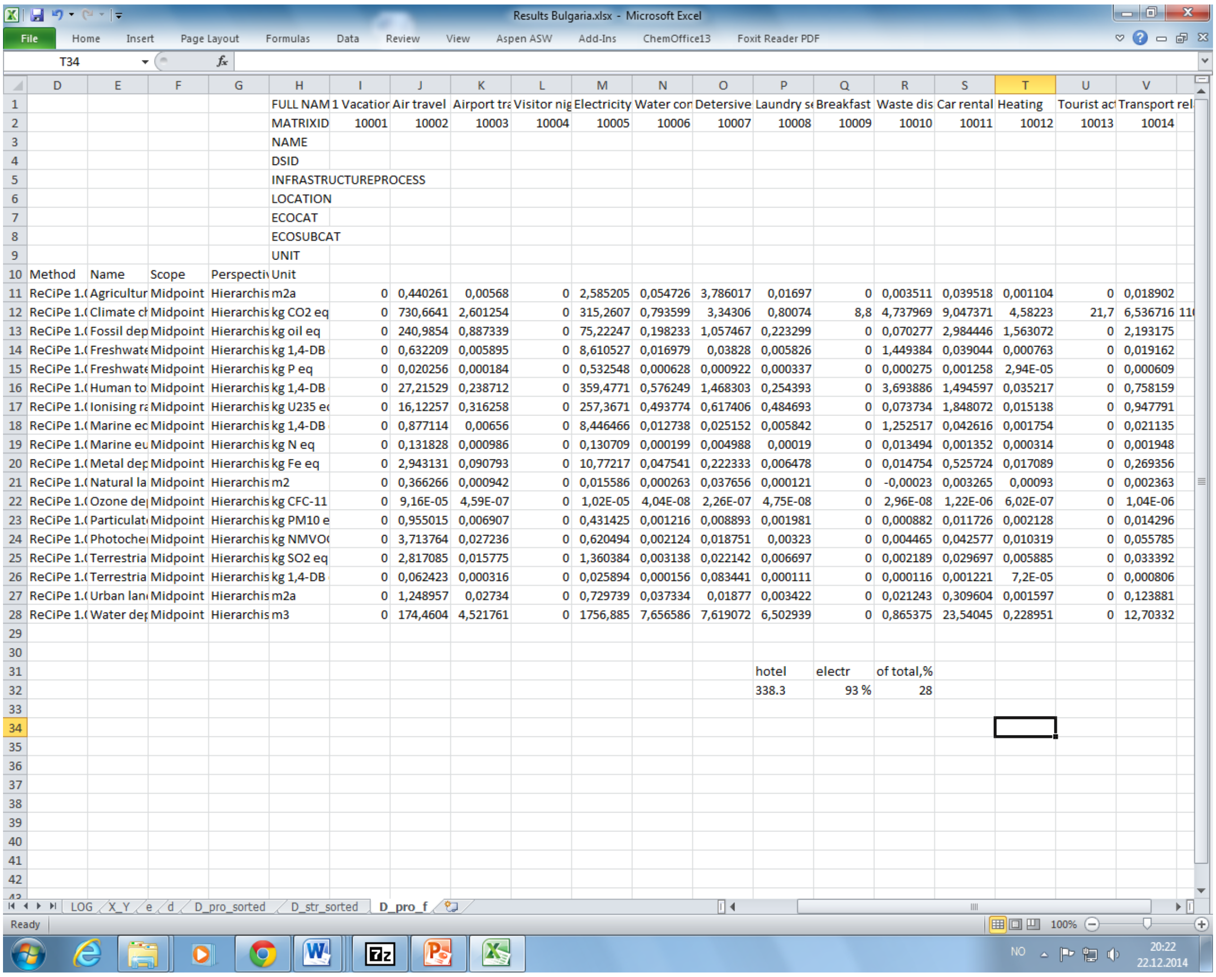
Figure 8.9 : SPA Terrestrial ecotoxicity



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	STRUCTURAL PATH ANALYSIS																		
2		Water depletion, Hierarchist, WDP100																	
3															electricity	electricity	electricity	Rest of the processes	
4	ABSOLUTE	RELATIVE	SEQUENCE:											Water dep	61,52496	5,705042	1,733455	31,1	
5	936,3816	61,52496	10001	10004	10005	1042	1495	1553											
6	936,3816	61,52496	1 Vacatior	Visitor nig	Electricity	electricity	electricity	electricity, hydropower, at run-of-river power plant/ RER/ kWh											
7	86,82811	5,705042	10001	10004	10005	1042	1495	1551											
8	86,82811	5,705042	1 Vacatior	Visitor nig	Electricity	electricity	electricity	electricity, hydropower, at reservoir power plant, non alpine regions/ RER/ kWh											
9	26,38239	1,733455	10001	10002	2720	2715	1144	1073	1041	1492	1552								
10	26,38239	1,733455	1 Vacatior	Air travel	transport,	operation	electricity	electricity	electricity	electricity	electricity, hydropower, at run-of-river power plant/ CH/ kWh								
11	24,56126	1,613798	10001	10004	10005	1042	1017	1497	1553										
12	24,56126	1,613798	1 Vacatior	Visitor nig	Electricity	electricity	electricity	electricity	electricity, hydropower, at run-of-river power plant/ RER/ kWh										
13	23,51009	1,544731	10001	10004	10005	1042	1521												
14	23,51009	1,544731	1 Vacatior	Visitor nig	Electricity	electricity	electricity, hydropower, at pumped storage power plant/ ES/ kWh												
15	22,96493	1,508911	10001	10002	2720	3922	1757	1755	1756	1141	1072	1068	1497	1553					
16	22,96493	1,508911	1 Vacatior	Air travel	transport,	aircraft, m	aluminiun	aluminiun	aluminiun	electricity	electricity	electricity	electricity	electricity, hydropower, at run-of-river power plant/ RER/ kWh					
17	16,72342	1,098812	10001	10004	10005	1042	1031	1502	1553										
18	16,72342	1,098812	1 Vacatior	Visitor nig	Electricity	electricity	electricity	electricity	electricity, hydropower, at run-of-river power plant/ RER/ kWh										
19	14,03996	0,922496	10001	10004	10005	1042	1521	1078	1042	1495	1553								
20	14,03996	0,922496	1 Vacatior	Visitor nig	Electricity	electricity	electricity	electricity	electricity	electricity	electricity, hydropower, at run-of-river power plant/ RER/ kWh								
21	13,17537	0,865688	10001	10002	2720	2713	2356	2354	2472	2460	3855	1002	936	1037	1017	1497	1553		
22	13,17537	0,865688	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	crude oil,	crude oil,	productio	electricity	electricity	electricity	electricity	electricity	electricity, hydropower, at run-of-		
23	10,10519	0,663962	10001	10011	2812	3964	1144	1073	1041	1492	1552								
24	10,10519	0,663962	1 Vacatior	Car rental	transport,	operation	electricity	electricity	electricity	electricity	electricity, hydropower, at run-of-river power plant/ CH/ kWh								
25	7,352136	0,483072	10001	10002	2720	2713	2356	2354	2472	2460	3855	1002	936	1037	1003	1493	1553		
26	7,352136	0,483072	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	crude oil,	crude oil,	productio	electricity	electricity	electricity	electricity	electricity	electricity, hydropower, at run-of-		
27	6,990292	0,459297	10001	10002	2720	2713	2356	2354	1002	936	1037	1017	1497	1553					
28	6,990292	0,459297	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	electricity	electricity	electricity	electricity	electricity	electricity, hydropower, at run-of-river power plant/ RER/ kWh					
29	6,168662	0,405312	10001	10002	2720	2713	2356	2354	2472	2479	1002	936	1037	1017	1497	1553			
30	6,168662	0,405312	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	crude oil,	transport,	electricity	electricity	electricity	electricity	electricity	electricity, hydropower, at run-of-river pow			
31	5,481548	0,360165	10001	10002	2720	2713	2356	2354	2472	2460	3855	1002	936	1037	1015	1495	1553		
32	5,481548	0,360165	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	crude oil,	crude oil,	productio	electricity	electricity	electricity	electricity	electricity	electricity, hydropower, at run-of-		
33	4,79585	0,315111	10001	10002	2720	2715	1144	1073	1041	1497	1553								
34	4,79585	0,315111	1 Vacatior	Air travel	transport,	operation	electricity	electricity	electricity	electricity	electricity, hydropower, at run-of-river power plant/ RER/ kWh								
35	4,698107	0,308689	10001	10002	2720	2713	2356	2354	2472	2460	3855	1002	936	1037	1013	1503	1553		
36	4,698107	0,308689	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	crude oil,	crude oil,	productio	electricity	electricity	electricity	electricity	electricity	electricity, hydropower, at run-of-		
37	4,25103	0,279314	10001	10002	2720	2713	2356	2354	2472	2460	3855	1002	936	1037	1023	1499	1553		
38	4,25103	0,279314	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	crude oil,	crude oil,	productio	electricity	electricity	electricity	electricity	electricity	electricity, hydropower, at run-of-		
39	4,19345	0,275531	10001	10002	2720	2713	2356	2354	2472	2460	3855	1002	936	1037	1009	1492	1552		
40	4,19345	0,275531	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	crude oil,	crude oil,	productio	electricity	electricity	electricity	electricity	electricity	electricity, hydropower, at run-of-		
41	3,900731	0,256298	10001	10002	2720	2713	2356	2354	1002	936	1037	1003	1493	1553					
42	3,900731	0,256298	1 Vacatior	Air travel	transport,	operation	kerosene,	kerosene,	electricity	electricity	electricity	electricity	electricity	electricity, hydropower, at run-of-river power plant/ RER/ kWh					

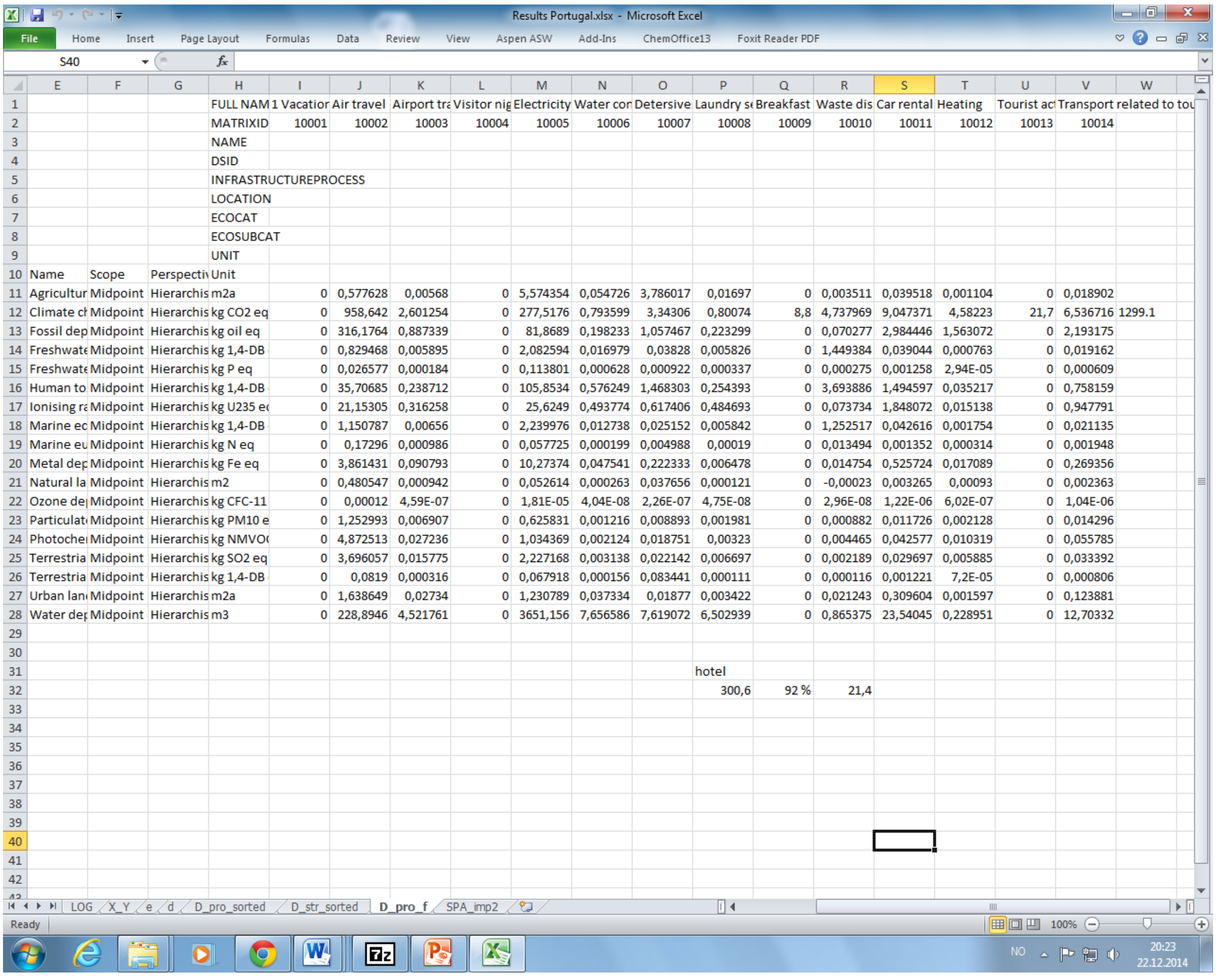
Figure 8.10 : SPA Water depletion

8.4 Calculated GHG Emissions from Various Vacation Packages as A Function of Flying Distance and Electricity Consumption



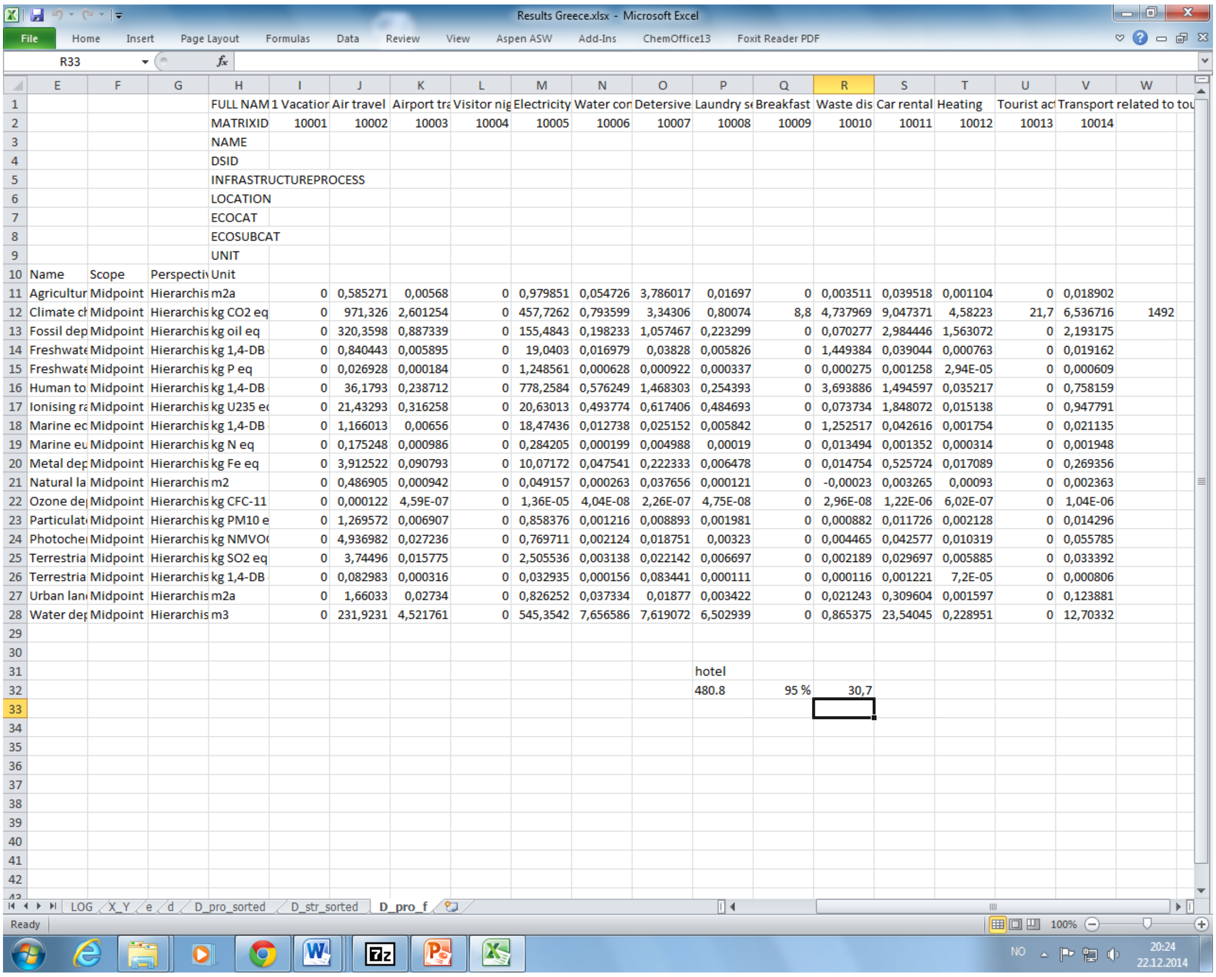
	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1					FULL NAM	1 Vacatior	Air travel	Airport tra	Visitor nig	Electricity	Water con	Detersive	Laundry se	Breakfast	Waste dis	Car rental	Heating	Tourist act	Transport rel	
2					MATRIXID	10001	10002	10003	10004	10005	10006	10007	10008	10009	10010	10011	10012	10013	10014	
3					NAME															
4					DSID															
5					INFRASTRUCTUREPROCESS															
6					LOCATION															
7					ECOCAT															
8					ECOSUBCAT															
9					UNIT															
10	Method	Name	Scope	Perspecti	Unit															
11	ReCiPe 1.(	Agricultur	Midpoint	Hierarchis	m2a	0	0,440261	0,00568	0	2,585205	0,054726	3,786017	0,01697	0	0,003511	0,039518	0,001104	0	0,018902	
12	ReCiPe 1.(	Climate ch	Midpoint	Hierarchis	kg CO2 eq	0	730,6641	2,601254	0	315,2607	0,793599	3,34306	0,80074	8,8	4,737969	9,047371	4,58223	21,7	6,536716	11(
13	ReCiPe 1.(	Fossil dep	Midpoint	Hierarchis	kg oil eq	0	240,9854	0,887339	0	75,22247	0,198233	1,057467	0,223299	0	0,070277	2,984446	1,563072	0	2,193175	
14	ReCiPe 1.(	Freshwate	Midpoint	Hierarchis	kg 1,4-DB	0	0,632209	0,005895	0	8,610527	0,016979	0,03828	0,005826	0	1,449384	0,039044	0,000763	0	0,019162	
15	ReCiPe 1.(	Freshwate	Midpoint	Hierarchis	kg P eq	0	0,020256	0,000184	0	0,532548	0,000628	0,000922	0,000337	0	0,000275	0,001258	2,94E-05	0	0,000609	
16	ReCiPe 1.(	Human to	Midpoint	Hierarchis	kg 1,4-DB	0	27,21529	0,238712	0	359,4771	0,576249	1,468303	0,254393	0	3,693886	1,494597	0,035217	0	0,758159	
17	ReCiPe 1.(	Ionising ra	Midpoint	Hierarchis	kg U235 e(	0	16,12257	0,316258	0	257,3671	0,493774	0,617406	0,484693	0	0,073734	1,848072	0,015138	0	0,947791	
18	ReCiPe 1.(	Marine ec	Midpoint	Hierarchis	kg 1,4-DB	0	0,877114	0,00656	0	8,446466	0,012738	0,025152	0,005842	0	1,252517	0,042616	0,001754	0	0,021135	
19	ReCiPe 1.(	Marine eu	Midpoint	Hierarchis	kg N eq	0	0,131828	0,000986	0	0,130709	0,000199	0,004988	0,00019	0	0,013494	0,001352	0,000314	0	0,001948	
20	ReCiPe 1.(	Metal dep	Midpoint	Hierarchis	kg Fe eq	0	2,943131	0,090793	0	10,77217	0,047541	0,222333	0,006478	0	0,014754	0,525724	0,017089	0	0,269356	
21	ReCiPe 1.(	Natural la	Midpoint	Hierarchis	m2	0	0,366266	0,000942	0	0,015586	0,000263	0,037656	0,000121	0	-0,00023	0,003265	0,00093	0	0,002363	
22	ReCiPe 1.(	Ozone de	Midpoint	Hierarchis	kg CFC-11	0	9,16E-05	4,59E-07	0	1,02E-05	4,04E-08	2,26E-07	4,75E-08	0	2,96E-08	1,22E-06	6,02E-07	0	1,04E-06	
23	ReCiPe 1.(	Particulat	Midpoint	Hierarchis	kg PM10 e	0	0,955015	0,006907	0	0,431425	0,001216	0,008893	0,001981	0	0,000882	0,011726	0,002128	0	0,014296	
24	ReCiPe 1.(	Photoche	Midpoint	Hierarchis	kg NMVO(	0	3,713764	0,027236	0	0,620494	0,002124	0,018751	0,00323	0	0,004465	0,042577	0,010319	0	0,055785	
25	ReCiPe 1.(	Terrestria	Midpoint	Hierarchis	kg SO2 eq	0	2,817085	0,015775	0	1,360384	0,003138	0,022142	0,006697	0	0,002189	0,029697	0,005885	0	0,033392	
26	ReCiPe 1.(	Terrestria	Midpoint	Hierarchis	kg 1,4-DB	0	0,062423	0,000316	0	0,025894	0,000156	0,083441	0,000111	0	0,000116	0,001221	7,2E-05	0	0,000806	
27	ReCiPe 1.(	Urban lan	Midpoint	Hierarchis	m2a	0	1,248957	0,02734	0	0,729739	0,037334	0,01877	0,003422	0	0,021243	0,309604	0,001597	0	0,123881	
28	ReCiPe 1.(	Water dep	Midpoint	Hierarchis	m3	0	174,4604	4,521761	0	1756,885	7,656586	7,619072	6,502939	0	0,865375	23,54045	0,228951	0	12,70332	
31													hotel	electr	of total,%					
32													338.3	93 %	28					

Figure 8.11 : Impacts generated from vacation package to Bulgaria



	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1				FULL NAM	1 Vacatior	Air travel	Airport tra	Visitor nig	Electricity	Water con	Detersive	Laundry se	Breakfast	Waste dis	Car rental	Heating	Tourist act	Transport related to tou	
2				MATRIXID	10001	10002	10003	10004	10005	10006	10007	10008	10009	10010	10011	10012	10013	10014	
3				NAME															
4				DSID															
5				INFRASTRUCTUREPROCESS															
6				LOCATION															
7				ECOCAT															
8				ECOSUBCAT															
9				UNIT															
10	Name	Scope	Perspecti	Unit															
11	Agricultur	Midpoint	Hierarchis	m2a	0	0,577628	0,00568	0	5,574354	0,054726	3,786017	0,01697	0	0,003511	0,039518	0,001104	0	0,018902	
12	Climate ch	Midpoint	Hierarchis	kg CO2 eq	0	958,642	2,601254	0	277,5176	0,793599	3,34306	0,80074	8,8	4,737969	9,047371	4,58223	21,7	6,536716	1299.1
13	Fossil dep	Midpoint	Hierarchis	kg oil eq	0	316,1764	0,887339	0	81,8689	0,198233	1,057467	0,223299	0	0,070277	2,984446	1,563072	0	2,193175	
14	Freshwate	Midpoint	Hierarchis	kg 1,4-DB	0	0,829468	0,005895	0	2,082594	0,016979	0,03828	0,005826	0	1,449384	0,039044	0,000763	0	0,019162	
15	Freshwate	Midpoint	Hierarchis	kg P eq	0	0,026577	0,000184	0	0,113801	0,000628	0,000922	0,000337	0	0,000275	0,001258	2,94E-05	0	0,000609	
16	Human to	Midpoint	Hierarchis	kg 1,4-DB	0	35,70685	0,238712	0	105,8534	0,576249	1,468303	0,254393	0	3,693886	1,494597	0,035217	0	0,758159	
17	Ionising ra	Midpoint	Hierarchis	kg U235 ec	0	21,15305	0,316258	0	25,6249	0,493774	0,617406	0,484693	0	0,073734	1,848072	0,015138	0	0,947791	
18	Marine ec	Midpoint	Hierarchis	kg 1,4-DB	0	1,150787	0,00656	0	2,239976	0,012738	0,025152	0,005842	0	1,252517	0,042616	0,001754	0	0,021135	
19	Marine eu	Midpoint	Hierarchis	kg N eq	0	0,17296	0,000986	0	0,057725	0,000199	0,004988	0,00019	0	0,013494	0,001352	0,000314	0	0,001948	
20	Metal dep	Midpoint	Hierarchis	kg Fe eq	0	3,861431	0,090793	0	10,27374	0,047541	0,222333	0,006478	0	0,014754	0,525724	0,017089	0	0,269356	
21	Natural la	Midpoint	Hierarchis	m2	0	0,480547	0,000942	0	0,052614	0,000263	0,037656	0,000121	0	-0,00023	0,003265	0,00093	0	0,002363	
22	Ozone de	Midpoint	Hierarchis	kg CFC-11	0	0,00012	4,59E-07	0	1,81E-05	4,04E-08	2,26E-07	4,75E-08	0	2,96E-08	1,22E-06	6,02E-07	0	1,04E-06	
23	Particulat	Midpoint	Hierarchis	kg PM10 e	0	1,252993	0,006907	0	0,625831	0,001216	0,008893	0,001981	0	0,000882	0,011726	0,002128	0	0,014296	
24	Photoche	Midpoint	Hierarchis	kg NMVOC	0	4,872513	0,027236	0	1,034369	0,002124	0,018751	0,00323	0	0,004465	0,042577	0,010319	0	0,055785	
25	Terrestria	Midpoint	Hierarchis	kg SO2 eq	0	3,696057	0,015775	0	2,227168	0,003138	0,022142	0,006697	0	0,002189	0,029697	0,005885	0	0,033392	
26	Terrestria	Midpoint	Hierarchis	kg 1,4-DB	0	0,0819	0,000316	0	0,067918	0,000156	0,083441	0,000111	0	0,000116	0,001221	7,2E-05	0	0,000806	
27	Urban lan	Midpoint	Hierarchis	m2a	0	1,638649	0,02734	0	1,230789	0,037334	0,01877	0,003422	0	0,021243	0,309604	0,001597	0	0,123881	
28	Water dep	Midpoint	Hierarchis	m3	0	228,8946	4,521761	0	3651,156	7,656586	7,619072	6,502939	0	0,865375	23,54045	0,228951	0	12,70332	
31												hotel							
32												300,6	92 %	21,4					

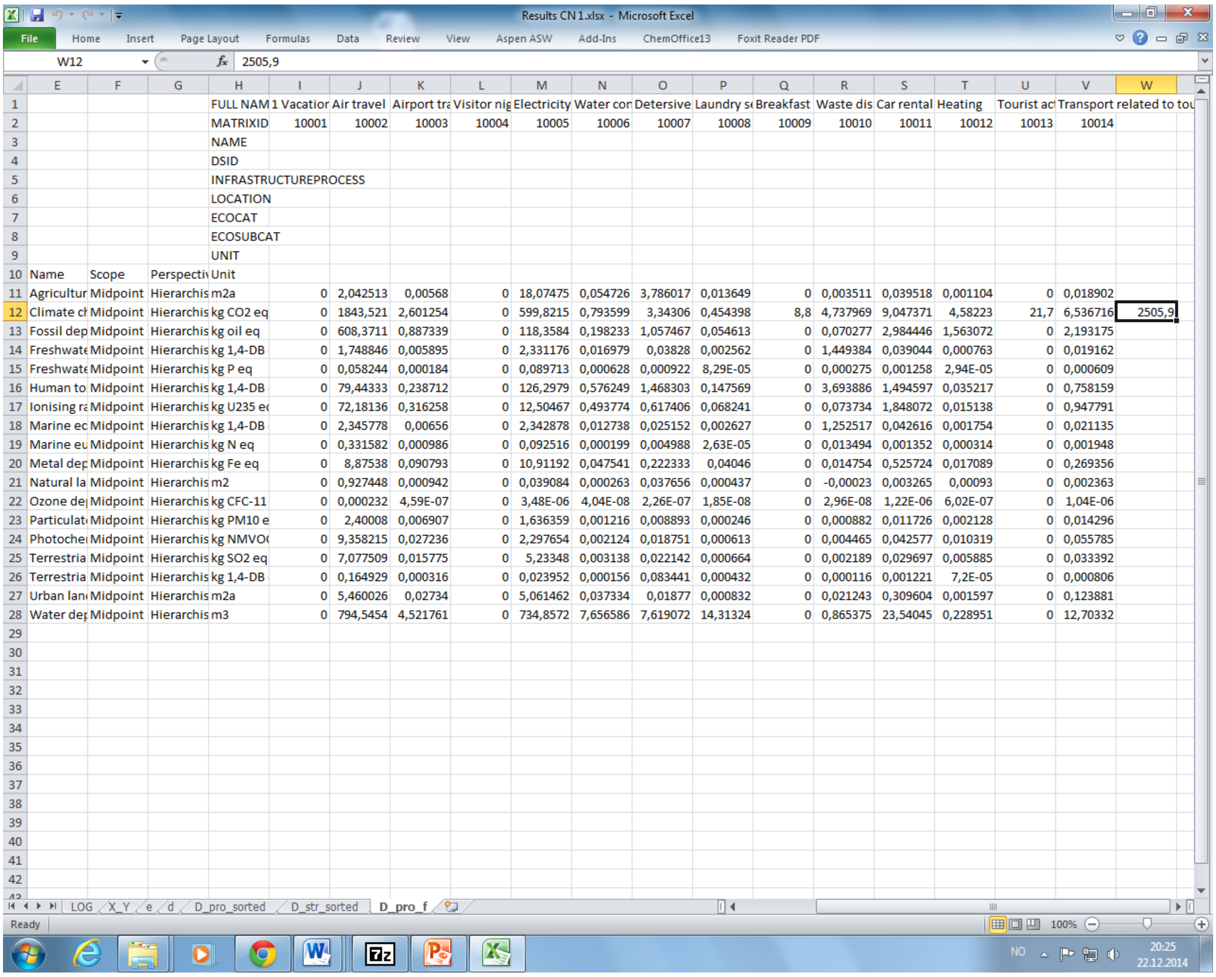
Figure 8.12 : Impacts generated from vacation package to Portugal



Results Greece.xlsx - Microsoft Excel

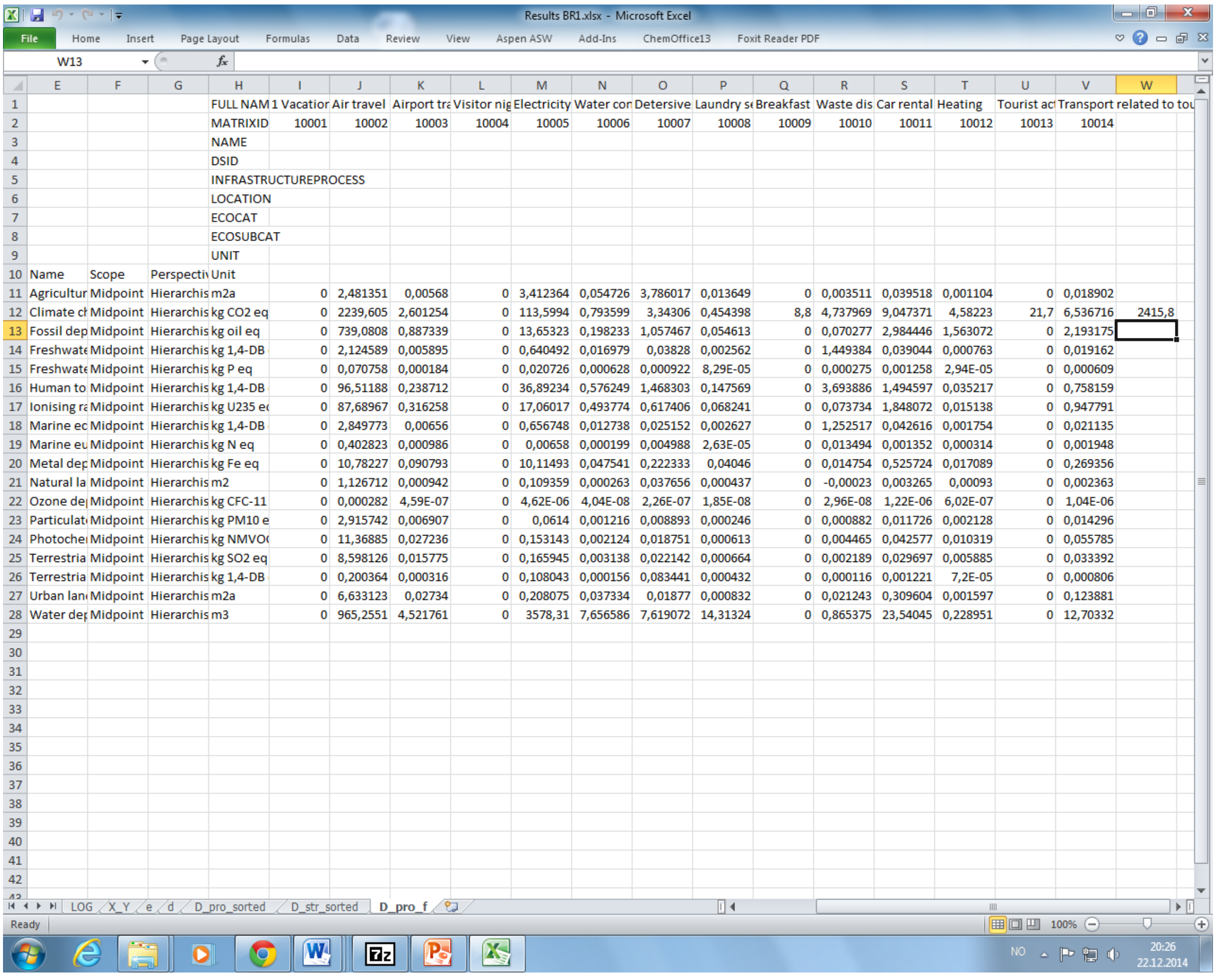
	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1				FULL NAM	1 Vacatior	Air travel	Airport tra	Visitor nig	Electricity	Water cor	Detersive	Laundry se	Breakfast	Waste dis	Car rental	Heating	Tourist ac	Transport related to tou	
2				MATRIXID	10001	10002	10003	10004	10005	10006	10007	10008	10009	10010	10011	10012	10013	10014	
3				NAME															
4				DSID															
5				INFRASTRUCTUREPROCESS															
6				LOCATION															
7				ECOCAT															
8				ECOSUBCAT															
9				UNIT															
10	Name	Scope	Perspecti	Unit															
11	Agricultur	Midpoint	Hierarchis	m2a	0	0,585271	0,00568	0	0,979851	0,054726	3,786017	0,01697	0	0,003511	0,039518	0,001104	0	0,018902	
12	Climate ch	Midpoint	Hierarchis	kg CO2 eq	0	971,326	2,601254	0	457,7262	0,793599	3,34306	0,80074	8,8	4,737969	9,047371	4,58223	21,7	6,536716	1492
13	Fossil dep	Midpoint	Hierarchis	kg oil eq	0	320,3598	0,887339	0	155,4843	0,198233	1,057467	0,223299	0	0,070277	2,984446	1,563072	0	2,193175	
14	Freshwate	Midpoint	Hierarchis	kg 1,4-DB	0	0,840443	0,005895	0	19,0403	0,016979	0,03828	0,005826	0	1,449384	0,039044	0,000763	0	0,019162	
15	Freshwate	Midpoint	Hierarchis	kg P eq	0	0,026928	0,000184	0	1,248561	0,000628	0,000922	0,000337	0	0,000275	0,001258	2,94E-05	0	0,000609	
16	Human to	Midpoint	Hierarchis	kg 1,4-DB	0	36,1793	0,238712	0	778,2584	0,576249	1,468303	0,254393	0	3,693886	1,494597	0,035217	0	0,758159	
17	Ionising ra	Midpoint	Hierarchis	kg U235 ec	0	21,43293	0,316258	0	20,63013	0,493774	0,617406	0,484693	0	0,073734	1,848072	0,015138	0	0,947791	
18	Marine ec	Midpoint	Hierarchis	kg 1,4-DB	0	1,166013	0,00656	0	18,47436	0,012738	0,025152	0,005842	0	1,252517	0,042616	0,001754	0	0,021135	
19	Marine eu	Midpoint	Hierarchis	kg N eq	0	0,175248	0,000986	0	0,284205	0,000199	0,004988	0,00019	0	0,013494	0,001352	0,000314	0	0,001948	
20	Metal dep	Midpoint	Hierarchis	kg Fe eq	0	3,912522	0,090793	0	10,07172	0,047541	0,222333	0,006478	0	0,014754	0,525724	0,017089	0	0,269356	
21	Natural la	Midpoint	Hierarchis	m2	0	0,486905	0,000942	0	0,049157	0,000263	0,037656	0,000121	0	-0,00023	0,003265	0,00093	0	0,002363	
22	Ozone de	Midpoint	Hierarchis	kg CFC-11	0	0,000122	4,59E-07	0	1,36E-05	4,04E-08	2,26E-07	4,75E-08	0	2,96E-08	1,22E-06	6,02E-07	0	1,04E-06	
23	Particulat	Midpoint	Hierarchis	kg PM10 e	0	1,269572	0,006907	0	0,858376	0,001216	0,008893	0,001981	0	0,000882	0,011726	0,002128	0	0,014296	
24	Photoche	Midpoint	Hierarchis	kg NMVO(	0	4,936982	0,027236	0	0,769711	0,002124	0,018751	0,00323	0	0,004465	0,042577	0,010319	0	0,055785	
25	Terrestria	Midpoint	Hierarchis	kg SO2 eq	0	3,74496	0,015775	0	2,505536	0,003138	0,022142	0,006697	0	0,002189	0,029697	0,005885	0	0,033392	
26	Terrestria	Midpoint	Hierarchis	kg 1,4-DB	0	0,082983	0,000316	0	0,032935	0,000156	0,083441	0,000111	0	0,000116	0,001221	7,2E-05	0	0,000806	
27	Urban lan	Midpoint	Hierarchis	m2a	0	1,66033	0,02734	0	0,826252	0,037334	0,01877	0,003422	0	0,021243	0,309604	0,001597	0	0,123881	
28	Water dep	Midpoint	Hierarchis	m3	0	231,9231	4,521761	0	545,3542	7,656586	7,619072	6,502939	0	0,865375	23,54045	0,228951	0	12,70332	
31												hotel							
32												480.8	95 %	30,7					

Figure 8.13 : Impacts generated from vacation package to Greece



	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1				FULL NAM	1 Vacatior	Air travel	Airport tra	Visitor nig	Electricity	Water con	Detersive	Laundry se	Breakfast	Waste dis	Car rental	Heating	Tourist act	Transport related to tou	
2				MATRIXID	10001	10002	10003	10004	10005	10006	10007	10008	10009	10010	10011	10012	10013	10014	
3				NAME															
4				DSID															
5				INFRASTRUCTUREPROCESS															
6				LOCATION															
7				ECOCAT															
8				ECOSUBCAT															
9				UNIT															
10	Name	Scope	Perspecti	Unit															
11	Agricultur	Midpoint	Hierarchis	m2a	0	2,042513	0,00568	0	18,07475	0,054726	3,786017	0,013649	0	0,003511	0,039518	0,001104	0	0,018902	
12	Climate ch	Midpoint	Hierarchis	kg CO2 eq	0	1843,521	2,601254	0	599,8215	0,793599	3,34306	0,454398	8,8	4,737969	9,047371	4,58223	21,7	6,536716	2505,9
13	Fossil dep	Midpoint	Hierarchis	kg oil eq	0	608,3711	0,887339	0	118,3584	0,198233	1,057467	0,054613	0	0,070277	2,984446	1,563072	0	2,193175	
14	Freshwate	Midpoint	Hierarchis	kg 1,4-DB	0	1,748846	0,005895	0	2,331176	0,016979	0,03828	0,002562	0	1,449384	0,039044	0,000763	0	0,019162	
15	Freshwate	Midpoint	Hierarchis	kg P eq	0	0,058244	0,000184	0	0,089713	0,000628	0,000922	8,29E-05	0	0,000275	0,001258	2,94E-05	0	0,000609	
16	Human to	Midpoint	Hierarchis	kg 1,4-DB	0	79,44333	0,238712	0	126,2979	0,576249	1,468303	0,147569	0	3,693886	1,494597	0,035217	0	0,758159	
17	Ionising ra	Midpoint	Hierarchis	kg U235 ec	0	72,18136	0,316258	0	12,50467	0,493774	0,617406	0,068241	0	0,073734	1,848072	0,015138	0	0,947791	
18	Marine ec	Midpoint	Hierarchis	kg 1,4-DB	0	2,345778	0,00656	0	2,342878	0,012738	0,025152	0,002627	0	1,252517	0,042616	0,001754	0	0,021135	
19	Marine eu	Midpoint	Hierarchis	kg N eq	0	0,331582	0,000986	0	0,092516	0,000199	0,004988	2,63E-05	0	0,013494	0,001352	0,000314	0	0,001948	
20	Metal dep	Midpoint	Hierarchis	kg Fe eq	0	8,87538	0,090793	0	10,91192	0,047541	0,222333	0,04046	0	0,014754	0,525724	0,017089	0	0,269356	
21	Natural la	Midpoint	Hierarchis	m2	0	0,927448	0,000942	0	0,039084	0,000263	0,037656	0,000437	0	-0,00023	0,003265	0,00093	0	0,002363	
22	Ozone de	Midpoint	Hierarchis	kg CFC-11	0	0,000232	4,59E-07	0	3,48E-06	4,04E-08	2,26E-07	1,85E-08	0	2,96E-08	1,22E-06	6,02E-07	0	1,04E-06	
23	Particulat	Midpoint	Hierarchis	kg PM10 e	0	2,40008	0,006907	0	1,636359	0,001216	0,008893	0,000246	0	0,000882	0,011726	0,002128	0	0,014296	
24	Photoche	Midpoint	Hierarchis	kg NMVO	0	9,358215	0,027236	0	2,297654	0,002124	0,018751	0,000613	0	0,004465	0,042577	0,010319	0	0,055785	
25	Terrestria	Midpoint	Hierarchis	kg SO2 eq	0	7,077509	0,015775	0	5,23348	0,003138	0,022142	0,000664	0	0,002189	0,029697	0,005885	0	0,033392	
26	Terrestria	Midpoint	Hierarchis	kg 1,4-DB	0	0,164929	0,000316	0	0,023952	0,000156	0,083441	0,000432	0	0,000116	0,001221	7,2E-05	0	0,000806	
27	Urban lan	Midpoint	Hierarchis	m2a	0	5,460026	0,02734	0	5,061462	0,037334	0,01877	0,000832	0	0,021243	0,309604	0,001597	0	0,123881	
28	Water dep	Midpoint	Hierarchis	m3	0	794,5454	4,521761	0	734,8572	7,656586	7,619072	14,31324	0	0,865375	23,54045	0,228951	0	12,70332	

Figure 8.14 : Impacts generated from vacation package to China



	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1				FULL NAM	1 Vacatior	Air travel	Airport tra	Visitor nig	Electricity	Water cor	Detersive	Laundry se	Breakfast	Waste dis	Car rental	Heating	Tourist act	Transport	related to tou
2				MATRIXID	10001	10002	10003	10004	10005	10006	10007	10008	10009	10010	10011	10012	10013	10014	
3				NAME															
4				DSID															
5				INFRASTRUCTUREPROCESS															
6				LOCATION															
7				ECOCAT															
8				ECOSUBCAT															
9				UNIT															
10	Name	Scope	Perspecti	Unit															
11	Agricultur	Midpoint	Hierarchis	m2a	0	2,481351	0,00568	0	3,412364	0,054726	3,786017	0,013649	0	0,003511	0,039518	0,001104	0	0,018902	
12	Climate ch	Midpoint	Hierarchis	kg CO2 eq	0	2239,605	2,601254	0	113,5994	0,793599	3,34306	0,454398	8,8	4,737969	9,047371	4,58223	21,7	6,536716	2415,8
13	Fossil dep	Midpoint	Hierarchis	kg oil eq	0	739,0808	0,887339	0	13,65323	0,198233	1,057467	0,054613	0	0,070277	2,984446	1,563072	0	2,193175	
14	Freshwate	Midpoint	Hierarchis	kg 1,4-DB	0	2,124589	0,005895	0	0,640492	0,016979	0,03828	0,002562	0	1,449384	0,039044	0,000763	0	0,019162	
15	Freshwate	Midpoint	Hierarchis	kg P eq	0	0,070758	0,000184	0	0,020726	0,000628	0,000922	8,29E-05	0	0,000275	0,001258	2,94E-05	0	0,000609	
16	Human to	Midpoint	Hierarchis	kg 1,4-DB	0	96,51188	0,238712	0	36,89234	0,576249	1,468303	0,147569	0	3,693886	1,494597	0,035217	0	0,758159	
17	Ionising ra	Midpoint	Hierarchis	kg U235 ec	0	87,68967	0,316258	0	17,06017	0,493774	0,617406	0,068241	0	0,073734	1,848072	0,015138	0	0,947791	
18	Marine ec	Midpoint	Hierarchis	kg 1,4-DB	0	2,849773	0,00656	0	0,656748	0,012738	0,025152	0,002627	0	1,252517	0,042616	0,001754	0	0,021135	
19	Marine eu	Midpoint	Hierarchis	kg N eq	0	0,402823	0,000986	0	0,00658	0,000199	0,004988	2,63E-05	0	0,013494	0,001352	0,000314	0	0,001948	
20	Metal dep	Midpoint	Hierarchis	kg Fe eq	0	10,78227	0,090793	0	10,11493	0,047541	0,222333	0,04046	0	0,014754	0,525724	0,017089	0	0,269356	
21	Natural la	Midpoint	Hierarchis	m2	0	1,126712	0,000942	0	0,109359	0,000263	0,037656	0,000437	0	-0,00023	0,003265	0,00093	0	0,002363	
22	Ozone de	Midpoint	Hierarchis	kg CFC-11	0	0,000282	4,59E-07	0	4,62E-06	4,04E-08	2,26E-07	1,85E-08	0	2,96E-08	1,22E-06	6,02E-07	0	1,04E-06	
23	Particulat	Midpoint	Hierarchis	kg PM10 e	0	2,915742	0,006907	0	0,0614	0,001216	0,008893	0,000246	0	0,000882	0,011726	0,002128	0	0,014296	
24	Photoche	Midpoint	Hierarchis	kg NMVO(	0	11,36885	0,027236	0	0,153143	0,002124	0,018751	0,000613	0	0,004465	0,042577	0,010319	0	0,055785	
25	Terrestria	Midpoint	Hierarchis	kg SO2 eq	0	8,598126	0,015775	0	0,165945	0,003138	0,022142	0,000664	0	0,002189	0,029697	0,005885	0	0,033392	
26	Terrestria	Midpoint	Hierarchis	kg 1,4-DB	0	0,200364	0,000316	0	0,108043	0,000156	0,083441	0,000432	0	0,000116	0,001221	7,2E-05	0	0,000806	
27	Urban lan	Midpoint	Hierarchis	m2a	0	6,633123	0,02734	0	0,208075	0,037334	0,01877	0,000832	0	0,021243	0,309604	0,001597	0	0,123881	
28	Water dep	Midpoint	Hierarchis	m3	0	965,2551	4,521761	0	3578,31	7,656586	7,619072	14,31324	0	0,865375	23,54045	0,228951	0	12,70332	

Figure 8.15 : Impacts generated from vacation package to Brazil