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Life Cycle Assessment in the tourism sector: a literature critical review

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Abstract

Background, Aim and Scope In the last decades, records indicate a high growth rate for tourism, making it one of the most important industries in the world economy. Since estimates outline a consolidation of this trend, an accurate identification and assessment of the environmental impacts related to the life cycle of tourist products is increasingly necessary. Pointing out methodological approaches, particular features and limitations of tourism LCA, this paper reviews the case studies found in the literature on implementations of Life Cycle-based Environmental Assessment tools. The overall objective is to better promote the Life Cycle Thinking approach within the concept of sustainable tourism.

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Keywords: Tourism • Sustainable tourism • Accommodation • Hospitality • Lodging • Leisure • Services • Life Cycle Thinking • Case study

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Life Cycle Assessment in the tourism sector: a literature critical review

Camillo De Camillis, Andrea Raggi, Luigia Petti

1 Background, aim, and scope

Among economic activities, tourism is gathering more and more interest within the scientific community due to its ever-increasing international importance. The high growth rate that has characterized the tourism market over the last decades has, in fact, established the tourism industry as one of the principal sectors of the world economy and estimates for the coming years predict the consolidation of this trend (UNWTO, 2001; Raggi, Petti, 2006a, 2006b; UNWTO, UNEP, 2008).

If, on one hand, a greater incidence of services in the global economy may be considered functional to the economic dematerialization required for environmentally-sustainable development, on the other, it is because of tourism's increasing role that tourist services should be accurately assessed from an environmental viewpoint. Many services are commonly thought to have little impact, due to the modest direct material intensity and the limited polluting emissions in the service's supply phase. Nevertheless, the supply of the inputs required for the service provision may contribute to the significant increase of its overall environmental impact.

Following an in-depth study of international scientific literature on the environmental sustainability of the tourism sector, numerous academic works on methods, tools, and case studies have been identified that tackled the problems linked to the evaluation of the environmental impacts of the sector under different points of view and with different degrees of analysis (Peeters et al., 2007; Hunter and Shaw, 2007; Weaver 2006; Gössling et al., 2005). Very few of these studies were based on a Life Cycle Thinking (LCT) approach, and in particular Life Cycle Assessment (LCA).

In this article, first the procedure followed to carry out the literature review is illustrated, then each case study is critically analyzed, finally results are outlined and discussed and further research perspectives are identified.

2 Main features

The authors searched literature sources – such as scientific papers, books, reports, etc. – through OPACs (On-line Public Access Catalogues), scientific research databases (e.g.: ScienceDirect, Emerald, SpringerLink), sector specific databases (e.g., Leisure Tourism Database, World Tourism Organization), and web search engines. Moreover, proceedings of the main conferences on LCA and on sustainable tourism were reviewed. Then, each case study found in the literature was critically analyzed considering the following characterizing elements, also on the basis of ISO 14044:2006 contents: goals, functional unit, system boundaries, inventory data quality and assessment methods of the environmental impacts, as well as specific features and limitations.

3 Results

The earliest LCA studies in the tourism industry date back to the nineties when a British consultancy agency, the UK Centre for Economic Development (UK CEED), implemented two complete LCAs for the tour operator, British Airways Holidays (BAH), to allow for the environmental life-cycle assessment of two of its major destinations, the Seychelles (Sisman, 1994) and St. Lucia (UK CEED, 1998). Later, Input/Output LCA (IO-LCA) studies were carried out regarding the US (Rosenblum et al., 2000; Horvath, 2000) and the New Zealand (Patterson and McDonald, 2004) tourism industries. The Chinese Natural Science Foundation, moreover, funded LCA studies on tourism in National Parks (Shi et al., 2003). Chambers (2004) used this methodology to compare and analyze the differences between two package holidays in Bulgaria. Raggi et al. (2005) reported and discussed LCA studies on accommodation services provided by two Italian hotels to assess environmental performance and hot spots (Tontodonati, 2002; Petti and Tontodonati, 2002; Mazzoni, 2004; Mazzoni et al.., 2004). Kuo et al. (2005), on the other hand, used LCA to analyze meal-boxes, i.e. the pack of boxed food, which is the main form of food service for tourists in Taiwan. More recently, König et al. (2007) applied comparative LCA to the design of a hotel complex in Portugal, whilst conventional LCA was implemented in Italy for the accommodation and spa services provided by a two-star hotel (Floridia, 2007) and for an entire spa holiday (Corsico, 2007), as also reported by Castellani et al. (2008) and Sala and Castellani (2009). Lastly, LCA methodology was implemented to the accommodation services provided by another Italian hotel (De Camillis et al., 2008).

The significant diversity of most of the case studies, as regards the service systems investigated and the time reference, have made any comparison difficult. In particular, the different time reference of the Life-Cycle-based approaches, besides having potentially affected the results of the different studies because of the technological changes occurring over time in some of the processes considered, also influenced the methodology adopted considering its significant development over recent years. However, in order to outline a general framework of the methodological approaches followed, the main elements that characterize each work are given below, with the exception of a case study (Shi et al., 2003) for which no detailed documentation has been found or made available so far.

3.1 LCA of a tourist destination: the Seychelles (Sisman, 1994)

Methodology Qualitative approach to the life cycle oriented environmental assessment of tourist services.

Product Package holiday offered by the tour operator British Airways Holidays (BAH) in the Seychelles considering that most tourists spend their holiday in more than one island.

Objectives The assessment of the environmental impacts of the package holiday considered in order to define actions for environmental improvement to be carried out by various stakeholders.

Functional unit Not clearly defined.

System boundaries The life cycle phases included in the foreground system are: construction of tourism infrastructures, infrastructure management, transport of goods and tourists within the Seychelles' spacial boundaries, resource use and consumption, and waste disposal. The spacial boundaries of the system correspond to the geographical boundaries of the tourist destination, while the temporal boundaries are from tourist arrival at the destination until departure from the same airport.

Data quality The information used for this LCA are almost always of a qualitative nature. If quantitative, they are derived from interviews conducted with hotel managers.

Environmental impact assessment methodology The environmental impacts were assessed qualitatively with a matrix approach by life cycle stages and by impact category.

Specific features The study is one of the first attempts to apply a life-cycle-oriented environmental assessment to services in general. In the LCIA, a few environmental impact categories that are normally disregarded by the assessment methods commonly used in the most widely-used LCA software were considered. Among these categories are aesthetic impact, noise pollution and the destruction of coral reefs.

Main limitations A predominantly qualitative approach was followed which is somewhat distant from the current LCA methodology and from how it has been shaping up since the early 90s. The difference between environmental burdens and impacts is not clearly highlighted. The latter are exclusively associated with unit process outputs, and not inputs. A number of impact categories have been neglected (e.g., ozone layer depletion, acidification, human toxicity, etc.). Moreover, the environmental impact assessment method is very subjective. In the study, resource consumption by tourists was regarded as a process in itself rather than an input to tourism services. Finally, the allocation issue was not addressed, despite being needed in several processes (e.g., road maintenance, airport construction, etc.).

3.2 LCA of a tourist destination: St. Lucia (UK CEED, 1998)

Methodology Qualitative approach to life cycle oriented environmental assessment of tourist services.

Product Package holiday offered on the island of St. Lucia by the tour operator BAH. Guests stay at a hotel and the average holiday duration is from 7 to 14 nights.

Objectives The assessment of the environmental impacts associated with the general tourist product offered in the considered destination in order to define measures for environmental improvement to be taken by the various stakeholders, to compare the all-inclusive package with the basic one.

Functional unit Not clearly defined.

System boundaries The life cycle stages considered are the same as the Sisman's study (see section 3.1) with the addition of the phase of air transportation of passengers to the destination and return.

Data quality The information used for the LCA is almost always of a qualitative nature. If quantitative, it is derived from literature or questionnaires.

Environmental impact assessment method Both in the LCA referring to the generic tourist product, and in the comparative LCA of alternative tourist products, the assessment of environmental impacts was carried out following a qualitative matrix approach.

Specific features In addition to the specific characteristics already reported for Sisman's study (see section 3.1)), we must stress that this second analysis commissioned by BAH reports what appears to be the first definition of a holiday in an LCA viewpoint: «a holiday is a complex "product", assembled from a series of goods and services that enables a person to spend time at leisure at a given destination» (UK CEED, 1998). Assessments of economic and socio-cultural issues were also included.

Main limitations In addition to the shortcomings highlighted in the previous study, the authors themselves recognize the limitation of not having included the processes which are extrinsic to the tourist destination in the system boundaries; examples of those processes are the production of goods imported by the tourism industry (such as food growing and distribution) and activities that take place after the holiday (such as photo development)..

3.3 IO-LCA of the US hotel industry (Rosenblum et al., 2000)

Methodology IO-LCA.

Product The analyzed area of interest is tourist hotels.

Objectives The assessment of direct and indirect effects of services on the economy and the environment. In particular, the environmental impacts of the following service industries were compared, besides the hotel sector: trucking and courier services, retail trade, colleges and universities.

Data quality The data used are from literature. In particular economic data are from the US Input/Output tables (U.S. Department of Commerce, 1997, Lawson, 1997).

Environmental impact assessment method The following parameters and indexes were adopted:

resource use, including electricity, fuel use, ore and fertilizer consumption;

total energy consumption, including consumption of electricity and fuels;

toxic emissions (Toxics Release Inventory - TRI), based on release of 650 toxic chemicals to air, water, land and underground wells;

hazardous waste generation amounts from the Resource Conservation and Recovery Act (RCRA) data set;

indicator of potential toxicity (CMU-ET) (it weights emissions of different chemicals using relative toxicity based on threshold limit values for health and safety of workers);
some common pollutants (e.g., SO_2, VOCs, etc.).
global warming potential (CO_2 equiv.).

Specific features The study is characterized by the large number of economic sectors considered: the US economy is made up of 485 sectors.

Main limitations The methodology of environmental impact assessment is diverse: both synthetic indices and rough environmental burdens are used. The study is inconsistent as regards time: economic and environmental data refer to different years.

3.4 LCA of tourist package holidays in Bulgaria (Chambers, 2004)

Methodology LCA integrated with ecological footprint analysis.

Product The study compares two package holidays in the following destinations: Slanchev Bryag and the Rhodope Mountains. The first, chosen for its mass tourism, in particular as a seaside resort, is located on the west coast of the Black Sea and stretches out for around 8 km with over 100 hotels and an accommodation capacity of around 30,000. The second destination, chosen for its responsible tourism, is a prime example of ecotourism with organized excursions and environmental education.

Objectives The comparative assessment of the environmental impacts linked to two package holidays belonging to contrasting service types: mass tourism and responsible tourism. The first type does not traditionally concern itself with its economic, social or environmental impacts, while the second takes particular care to correct its negative social and environmental impacts.

Functional unit The data were collected “per study group per package”, even if the mass tourism package holiday lasted three days less than the second package holiday.
In order to analyze the eco-efficiency of the hotels, the data inherent to these establishments were also analyzed, not merely for the relevant afore-mentioned reference flow, but also as regards the impacts generated “per passenger per night” and “per passenger per package”.

System boundaries All processes linked to the holiday were included in the boundaries of the product systems compared: from the moment in which a guest leaves his/her home until his/her return. The author named this type of study “door to door”. More specifically, the process units included in the foreground system are: passenger travel from home to departure airport and vice versa, airport services, flights, transfers, accommodation and other tourist activities.

Data quality Data were gathered through direct interviews, literature analysis or calculated using computing systems (for the defining of the distances covered by the aeroplanes).

Environmental impact assessment method Indicators were chosen to supply a simplified representation of the environmental impacts: energy use, food consumption, solid waste production, water use, release of chemicals and waste cooking oil. The ecological footprint analysis joined the above listed indicators for the comparative evaluation.

Special features The responsible tourism case study highlights the significant role of tour operators in educating customers to respect the environment. Unlike other studies, the author used a definition of tourism to outline the boundaries of the systems to be compared.

Main limitations Although the importance of evaluating the local impacts were highlighted, they were only included partially among the evaluation indicators. Despite the fact that a considerable effort was made to collect data, those regarding certain processes are lacking. For example, as far as the phase of tourist activities of the holiday in Slanchev Bryag is concerned, the data collection is limited to the energy used during tourist transfers, while the environmental burdens of other tourist activities (e.g., restaurants, nightclubs, shops and so on) are neglected. The allocation issue is not dealt with even if the necessity within different processes can be recognized.

3.5 IO-LCA of the New Zealand tourism sector (Patterson, McDonald, 2004)

Methodology IO-LCA.

Product The tourism industry was not described by the authors.

Objectives One of the prime objectives was to assess the direct, indirect and future environmental effects of the New Zealand tourism sector. The study was also carried out so as to develop the knowledge of sustainable tourism identifying the links between the environment and the economy.

System boundaries All the inputs supplied by other sectors to the tourism sector were identified and quantified. The system boundaries are from the moment in which the tourists leave their home until their return. The study does not include the impacts linked to the goods imported from overseas due to lack of data available. The inability to control the environmental impacts linked to these goods was revealed as justification for this exclusion.

Data quality The data used are from official statistical sources (Statistics New Zealand, 1999) and the period of reference of the study is 1997/1998.

Environmental impact assessment method In the application of the IO-LCA, the following indicators of environmental pressure were used: energy (TJ), water use (m^3), BOD_5 (kg), nitrate discharges (kg), phosphorus discharges (kg), water discharges (m^3) land use (ha) and CO_2 (t).

Special features Through a scenario analysis, the future environmental impacts of the sector analyzed were estimated. Economic considerations were made along with the environmental ones.

Main limitations The analyzing of the future scenarios combined the predictions regarding the number of visitor arrivals (1997–2007) with the environmental data gathered for the 1997/1998 period, thus assuming an absence of technological evolution towards more eco-efficient processes.

3.6 LCA of meal box packaging in Taiwan (Kuo et al., 2005)

Methodology Conventional LCA.

Product The study is on meal boxes. More specifically, the product is made up of packaging – in paper, polystyrene or polypropylene – inside of which there is rice, meat (pork or chicken) and three or four types of vegetables. Most mass tourists in Taiwan use these meal boxes for lunch, especially when on the go.

Objectives Comparative assessment of the environmental impacts generated by the three types of meal box packaging so as to identify which is preferable from an environmental point of view.

Functional unit One piece of meal box packaging for each of the three types of material which it can be made of.

System boundaries The process units considered are production and end-of-use management of the meal box packaging. None of the processes linked to food production are included in the system boundaries.

Data quality The authors do not describe the data quality in depth, mentioning merely the Boustead database and the LCA software used to model the inventory.

Environmental impact assessment method Although the study stops at the LCI phase, environmental burdens were classified for the following environmental impact categories: energy and material consumption, air pollution, water pollution and waste production.

Special features The authors propose, for the food products, the integration of LCA and Hazard Analysis Critical Control Point (HACCP), a consolidated methodology for food safety management. This integration could facilitate the collection of inventory data. In order to draw economic conclusions from the LCI results on the three products compared, environmental costs were used in terms of energy and material supply and pollution control . These costs were obtained from literature.

Main limitations The study only considered the three types of packaging, excluding the foods because of lack of data and because of too much effort required for their collection. Moreover, use and end-of-life phases are not

adequately taken into account. The impact categories are too generic and not thorough (e.g., air pollution could include global warming, ozone layer depletion, acidification, winter and summer smog, etc.). Although the characterization phase was not implemented, the authors compare the products not only in terms of environmental burden, but also environmental impact.

3.7 LCA of accommodation services in three Italian hotels (Raggi et al., 2005; De Camillis et al., 2008)

In this paragraph three case studies will be presented. Their analysis has been consolidated as their characteristics are quite similar.

Methodology Conventional LCA according to the relevant ISO standards.

Products Accommodation services in: hotel Prestige in Montesilvano, Abruzzo (Tontodonati, 2002; Petti and Tontodonati, 2002), hotel Dante in Cervia, Emilia Romagna (Mazzoni, 2004; Mazzoni et al., 2004), hotel Duca d'Aosta in Pescara, Abruzzo (De Camillis et al., 2008).

Objectives The objectives of the LCA studies are as follows: identification of the environmental hot spots of accommodation services; support to the implementation of environmental management systems; increase experience to define the Product Category Rules (PCRs) for Type-III environmental labelling.

Functional unit Accommodation service referred to a one-night stay.

System boundaries All hotel activities were considered in the system boundaries. As regards the main service of hospitality, the following process units were considered: cleaning (rooms, halls, bathrooms, restaurant, bedding, towels, etc.), transporting of bedding and towels (if not washed internally), heat and power production and use, waste release and management, production and transport of materials and products used (complimentary objects, toilet paper, detergents, etc.). In addition, guest transport to and from the hotel was included. The production of durable goods – capital goods employed by the hotel – and the construction of the building with the processes linked to them were not included in the system boundaries.

Data quality The inventory data were gathered directly in the hotels and the facilities of some suppliers (e.g., laundries, printer's, etc.) through site visits, direct interviews with management and staff, direct contact with suppliers.

Environmental impact assessment method The data gathered were processed using GaBi 4 software. The environmental issues were assessed according to the CML96 and CML2001 methods.

Special features The authors implemented "modular" LCAs in which each service (module) supplied by the hotel was assessed individually. Thus, the environmental impacts within the product system can be calculated totalling

the impact of all the services (modules) considered in the study (e.g., catering, sauna, pool, etc.) (Petti et al. 2004).

To improve the environmental performances of the hotels, service changes were proposed (e.g., towel and bedding laundering only if requested by guests). The analysis of the improvement scenarios allowed for the evaluation of the advantages and disadvantages linked to the introduction of these proposals.

Main limitations The authors had difficulty defining the cut-off rules, due to a great number and variety of materials and products used by the accommodation services, as well as, in certain cases, the data collection for various processes (e.g., food production and transport).

3.8 LCA of hotel structures in Portugal (König et al., 2007)

Methodology LCA implemented through LEGEP software, which is based on a life cycle approach.

Product The study compared three sets of constructions (types A, B and C) for a hotel (surface area: 33,600 m², volume: 78,450 m³). The construction type A used traditional materials and techniques (e.g., rammed earth walls) and the following technical equipments: wood-fuelled heating systems, solar thermal collectors to provide 30% of hot water needed, no air-conditioning. Type B, on the other hand, combined traditional materials with industrialized techniques (e.g., walls with layers of clay stones and porosized bricks) and was characterized by the following technical equipments: heating and hot water with gas, photovoltaic to provide 30% of power consumption, no air-conditioning. Lastly, type C used conventional materials and techniques (e.g., reinforced concrete and synthetic insulation materials) using the following technical equipments: heating and hot water from fossil fuels (oil), air-conditioning.

Objectives The methodology is used to compare the environmental impacts linked to three types of alternative hotel constructions. The methodology was applied at the end of the design phase to select the best design from an environmental point of view.

Functional unit The three constructions were compared on the basis of the entire structure of the building with the various technical equipments.

System boundaries The following processes included in the building's life cycle were considered: construction, maintenance, use (cleaning), restructuring, end-of-life demolition (a service life of 80 years was assumed).

Data quality The inventory was compiled by using databases contained in the LEGEP software: ECOINVENT, Baustoff Ökoinventare (Kohler and Klingele, 1995) and a specific database on construction products created by the LEGEP software house.

Environmental impact assessment method The following indicators were used to assess the environmental impacts: climate change (kg CO_2 eq./m²), acidification (kg SO_2 eq./m²), eutrophication (kg PO_4 eq./m²), and non-renewable energy (MJ/m²).

Special features The study highlights the necessity to use a specific LCA software for building design and the importance of preventing environmental impacts, acting at the design phase.
Main limitations The indicators chosen for the characterization phase referred only to four environmental impact categories.

3.9 LCA of accommodation and spa services of an Italian hotel (Floridia, 2007)

Methodology Conventional LCA.
Products Tourist structures and services of hotel Terme Belvedere in Abano Terme, Veneto.

Objectives The objectives of the LCA studies are as follows: assessment of the environmental damages generated by a hotel building along its life cycle (from the construction to the change of use, till the demolition phase); identification of environmental hot-spots to define potential improvement actions and management strategies for structures and services provided (i.e., accommodation and spa services).

Functional unit Because hotels are complicated systems, due to several processes involved within their life cycle, the authors decided to outline a functional unit considering the following elements: building dimension, which mainly affects material consumption, management and disposal; number of tourist stays per year, which are strongly related to operating stage of hotel structures; opening period of the hotel; life span of structures.

System boundaries The life cycle model was focused on the life of hotel structures from cradle to grave. In fact, the following phases were included in the system boundaries: extraction of raw materials; manufacturing of building products; building construction; use and management of structures, including activities of hotel maintenance; end of life of building materials.

Data quality Primary data on the usage of the hotel building for accommodation and spa services (e.g., consumption of energy, water and products, and waste production) were collected directly on site. As regards the building construction phase, architects and technical experts collaborated to identify materials and to estimate quantities because no bill of quantities was available. Moreover, energy consumption by the machinery and equipment used in the building yard (e.g., crane, cement mixer, etc.) was calculated on the basis of data sheets and time estimations. Finally, databases included in the SimaPro 7.0 software, as well as surveys were used to complete the LCA inventory.

Environmental impact assessment method Eco-indicator 99, EDIP 96-2003 and EPS 2000 methodologies were used for the LCIA phase.

Special features This case study being mainly focused on the building life cycle can be seen as an interesting case. Moreover, environmental impacts were assessed through more than one methodology in order to have a more comprehensive assessment of results – EPS 2000, for instance, was chosen because it considers also water consumption – and to assure a better reliability of LCIA results.

Main limitations The first special feature pointed out in the previous point could also be a limitation of this study. In fact, focusing on structures, and not on tourists, to define system boundaries could lead not to take into adequate account other processes, such as transport and other tourist activities, which could also be affected by the decisions and choices of hotel managers. The amount of primary data collected highlights a lack of databases in this sector and in others connected; this would inevitably increase the time required for the method implementation.

3.10 LCA of a standard holiday in a spa destination in Italy (Corsico, 2007)

Methodology Conventional LCA.

Products A standard holiday in the spa destination Abano – Montegrotto Terme, Veneto.

Objectives Assessment of the environmental damages generated by a normal tourist during a weekly holiday in a spa resort. More specifically, the aims of this study are: the identification of the holiday phases responsible for most environmental impacts; the identification of the most significant impact categories; the definition of potential improvement actions which can be implemented by stakeholders to reduce the environmental impacts of holidays.

Functional unit One week of a standard spa holiday in Abano – Montegrotto Terme including transport services to reach and leave the tourist destination.

System boundaries The holiday life cycle was modelled in two main systems: transport services and all the tourist activities carried out in the spa destination. On the one hand, transport system included guest movements by car, train and flight. On the other, accommodation, excursions, restaurant and spa services were identified as specific processes of the tourist system.

Data quality Primary data were collected and used for tourist activities. Moreover, databases included in the SimaPro 7.0 software mainly provided data on transport services and energy production.

Environmental impact assessment method Eco-indicator 99, EDIP 96-2003 and EPS 2000 methodologies were used for the LCIA phase.

Special features Besides the already mentioned benefits (see section 3.9) in using more than one impact assessment method, this case study confirmed, as Chambers' experience also did (see section 3.4), that LCA can also be implemented to package holidays. A scenario analysis has been implemented to compare different transport modes which can be chosen by tourists.

Main limitations Because tourism is a complicated system, the author of this case study faced significant difficulties in outlining functional unit and system boundaries.

4 Discussion

A critical analysis of the literature revealed considerable dissimilarity as regards the methodology application: from the choice of the specific instrument – conventional LCA, IO LCA, etc. – to the definition of objectives, the study object and other methodological choices.

The objectives of the study are a critical factor for the choice of the specific instrument to be adopted and the related methodological approaches. If IO LCA may be used to assess, compare and steer environmental policies for tourism, conventional LCA may be used by a wide range of stakeholders and for different purposes. For example, specific tourism organizations and tour operators would mainly use LCA to: assess environmental performance to identify hot spots; support the improvement of environmental performance through the comparison of innovative environmental technologies, compare the environmental performance of tourist products; support eco-design choices, and support green marketing.

On the other hand, governmental organisations might use the tool to: assess the environmental performances of a tourist destination to identify hot spots; support the drawing-up of local marketing plans for tourism; assess the environmental weight of each different form of tourism developed in the area; compare mobility plans for an environmental viewpoint; environmentally compare waste management scenarios in order to define a local management plan for wastes; assess, plan and forecast environmental impact scenarios if integrated with Strategic Environmental Assessment (SEA), Environmental Impact Assessment (EIA) and even with Geographic Information System (GIS); support the Green Public Procurement; support the implementation of Environmental Management Systems, such as ISO 14001:2004 and EMAS. Finally, NGOs might use LCA to support their environmental campaigns.

Another critical aspect in tourism LCA studies is the definition of the system boundaries. This issue may profoundly affect subsequent LCA phases – inventory analysis (LCI) and environmental impact assessment (LCIA) – providing different result interpretations.

The choice of the environmental impact assessment method, finally, is very important because tourists are particularly sensitive to local environmental issues – such as, for example, noise pollution, hydro-geological disruption, and smell pollution – which are seldom considered in current LCIA methods.

Finally, the low number of studies found in the literature might indicate significant obstacles in adopting this approach or tourism's drivers' limited awareness of LCA. Obstacles may include: complexity of the tourism system; implementation time being too long because of a lack of specific LCA

databases for tourism and related sectors; the tourism industry's low consideration of the environmental impact categories generally considered in impact assessment methodologies.

5 Conclusions

Literature on tourism LCA has shown several methodological challenges, as well as a number of opportunities to be developed. Therefore, several aspects related to the LCA methodology should be seriously taken into account by analysts in implementing LCA in this industry. These aspects mainly are: a clear identification of the object(s) to be analyzed; the related issue of the system-boundary definition; data availability and quality; and, the opportunity to adopt non-conventional methodological approaches that are able to consider the space and time distribution of the environmental impacts, or that are able to adequately consider indirect impacts. An LCA modular approach (Petti and Tontodonati, 2002; De Camillis et al, 2008) could also be used by analysts to model tourist systems in detail and to compare specific activities.

6 Perspective

A number of methodological approaches and guidelines should be developed in order to favour the applicability and spread of LCA within the tourism sector (Raggi and Petti, 2006b, Raggi et al., 2008a, 2008b). Firstly, because tourism is a complicated system with a wide range of services and products involved, the study object(s) must be clearly identified. It is necessary to produce a systematic definition and classification of tourist services to facilitate their modelling in LCA studies. Closely linked to this is the issue of scope definition and the related accurate identification of which processes should be included within the system boundaries. This sector shares the problem of LCA data availability and quality with numerous other industries. Careful consideration is needed to decide whether it is necessary to put together an ad hoc database or whether those existing may be at least partially shared with most of the applications in the tourism sector. On the other hand, given the strong link between tourist services and the specific characteristics of a territory, a careful evaluation should be made on the need to use primary data. It may also be useful to consider the use of non-conventional methodological approaches that make it possible to emphasize a proper distribution of impacts over time and space. This aspect is particularly important in tourism, which is often characterized by a concentration of environmental loads over time and space. Furthermore, non-conventional LCA methodologies (for instance, hybrid approaches) would make it possible to better take into consideration indirect impacts, which are typical of service industries, without compromising the level of detail which characterizes the conventional process-LCA. Lastly, it is necessary to look into the possibility of integrating LCA methods with other instruments, such as support tools in planning, design and development (e.g., EIA, SIA, QFD, etc.) and in communications and marketing (e.g., various forms of eco-labelling).

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