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MEASURING THE SUSTAINABILITY OF ISLAND TOURISM

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ABSTRACT

The research discussed in this paper looks for an appropriate instrument to evaluate the sustainability of island tourism, taking economic, socio-cultural and ecological aspects into account. Multiple indicator models are suggested by literature such as the Barometer of Tourism Sustainability (BTS) model or the ecological footprint as an indicator of tourism sustainability. Based on a thorough literature review in combination with some further research an indicator index was constructed. Through this indicator index the sustainability of tourism was evaluated for five islands (Cuba, Cyprus, Mauritius, New-Zealand and Sri Lanka). Results show that these islands still have a long way to go to reach a sustainable tourism. Our research showed that aviation is an important factor for tourism sustainability since a large part of tourism's negative ecological impact is due to air transport. A case study about 'Sustainable Aviation' assesses the potential of various alternative fuels for airplanes.

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1. Introduction: sustainability

After the United Nations Conference on Environment and Development (UNCED), held in 1992 in Rio de Janeiro, the concept of sustainable development became a fixed value on the international agenda. This conference, also called 'Earth Summit' produced some official documents such as the Rio-declaration and the well-known Agenda 21 (Cörvers, R.J.M., 2006, p.10). The increased international attention for sustainable development stressed the importance of the incorporation of sustainability issues in governance and the development of the concept of 'sustainable development' was supported by numerous official documents and studies (Salinas Chávez, E., La Osoria, J.A., 2006, p.202).

Any form of production or consumption has implications for sustainability. The discussion about sustainable development should therefore embrace all forms of activity including tourism. Tourism plays a central and decisive role with respect to sustainable development. The first international Conference on Sustainable Tourism was held on Lanzarote in 1995, and supported by the World Tourism Organization (WTO, now the UNWTO United Nations World Tourism Organization).

The consumption and production of the tourism product takes place in areas where the natural or artificial resources are extremely fragile (Cooper, C., et al., 2005, p.261). Additionally, the weight of tourism in the world economy is substantial. The World Tourism Organization (WTO) declares that international arrivals increased with 2% to reach 922 million from 2007 to 2008. International tourism generated 625 billion euro in 2007, which equals 30% of the export of services in the world (www.unwto.org). This strong growth came to an end at the beginning of the current financial and economic crisis. The demand for tourism began to decrease from the middle of 2008 on and the decrease became even more pronounced in 2009 due to deteriorating economies worldwide and the outbreak of the Mexican flue. Despite this downfall it is still clear that tourism's weight in the world economy is not to be neglected.

Tourism is important for many countries but on islands tourism development has been most striking. Countries where tourism's contribution to Gross Domestic Product (GDP) is the highest and who are by consequence the most dependent on tourism, are without a doubt islands (Momsen, J., Scheyvens, R., 2008, p.491).

After World War II the traditional economies on islands were pressured by the industrial development in many continental countries. In the same period the process of decolonization

took off. Traditionally the economy of most islands was supported by the export of specialized agricultural products such as sugar cane, bananas, coffee or cacao. The process of decolonization brought independence to islands but on the other hand these islands lost certainty with respect to guaranteed prices and markets in the former mother countries (D'Ayala, P.G., 1995, p.27). In June 2000 the EU and 78 countries of Africa, the Caribbean and the Pacific Ocean (ACP) signed an agreement that stated that these 78 countries would keep enjoying preferential tariffs and quota for their export products until 2008 (De Groote, P., 2004, p.145). Despite this beneficial agreement it became clear that islands would have to diversify their economies. The ACP-agreement wasn't everlasting and after some time islands would have to be able to compete with international prices. Therefore it isn't surprising that these islands chose tourism as their leading growth sector (D'Ayala, P.G., 1995, p.27). The natural resources and cultural heritage on islands appeal to many tourists. Moreover, the isolated location of islands make the destination attractive, adventurous and exotic. While geographic, cultural, ecological and economic factors make the tourism product offered by islands wanted, it are indeed also these factors that make islands vulnerable to the negative impact of tourism (Krokkanikal, J., et al., 2003, p.426).

For example the isolated location of island destinations offers certain advantages but in the mean time separates the tourist destination from major markets. Furthermore the domestic market is often too small in island economies, due to a small population. This means also that islands can't benefit from economies of scale because of their limited size. Natural resources on islands are often scarce, resulting in a small economic basis. Island economies are thus often dependent on tourism in combination with the export of some primary goods (Momsen, J., Scheyvens, R., 2008, p. 493-494). In sum, islands follow a specialized development pattern or a monoculture or one basket economy. This means inevitably that islands are subject to the ups and downs of international markets, political crises and other external factors beyond their control (D'Ayala, P.G., 1995, p.28). Ecological vulnerabilities are the damage caused to nature by human intervention. The location of islands in relationship with the climate change – i.e. rising sea levels (cf. problems for the Maldives) and other natural disasters (hurricanes, cyclones, tsunamis, etc.) should also be taken into account. Finally tourism consumes a lot of energy and clean water, which may lead to shortages for the local residents (Momsen, J., Scheyvens, R., 2008, p.493-494).

In sum, sustainability is an important concept for island tourism. Since island economies are sustained in large part by tourism, it is very important that the tourist product doesn't devaluate. This can only be realized by carefully planning and managing the sustainable development of island tourism.

2. Research methods

The central research question in our investigation is the following :

"What is the meaning of sustainable tourism for islands on their way to sustainable development, taking into account ecological, socio-cultural as well as economic factors?"

This central research question is supported by the following three questions :

1) "Which indicators are appropriate to measure and evaluate the sustainability of tourism on islands?"
2) "How sustainable is current tourism on different islands and how does this situation contrasts with the situation of the traditional unplanned tourism?"
3) "Does there exists an optimal level of sustainability in tourism and if so, which measurements are required to reach this level in island economies?"

A critical literature survey forms the basis of the above research. The research questions will be answered for a sample of five islands, selected from all existing islands, making use of available data sources and information gathered while conducting electronic interviews.

The last section of our research is devoted to sustainable air transport. Islands are per definition surrounded by water and are by consequence less reachable than other tourist destinations. Air transport (and cruise transport) are thus widespread means to reach the island destination. Flight emissions are produced at substantial height and are very damaging to the environment. The summation of existing technologies to make aviation more sustainable as well as the results of the brief economic analysis of bioJet as conducted in the current research will be discussed at the end of this contribution.

3. Literature Review

Sustainability has to deal with economic goals, socio-cultural aspects and last but not least natural heritage (ecology). The impact of tourism from the point of view of these disciplines is discussed in this literature survey.

A lot of attention in literature is paid to the well-known positive consequences of tourism. However we must not forget that the economic impact of tourism may also be negative. According to Mathieson, A. and Wall, G. (1982, p.52) the size of the economic impact of tourism depends on five factors :

- type of tourist facility and attraction;
- volume and level of tourism expenses;
- level of economic development in the region;
- the degree to which tourism expenses are maintained and reinvested in the region;
- level of seasonality.

These factors determine whether or not the economic impact will be positive. The nature and scope of the economic impact depends on geographic and socio-economic structures. A big difference exists between developed and developing countries.

A summary of the most cited economic benefits of tourism opposed to the less familiar negative economic impact of tourism can be found in *table 1.*

Table 1: Positive and negative economic impact of tourism

Economic benefits	Economic costs
• Improvement of the touristic balance of payments • Increase of the GDP • Creation of jobs • Creation of external economies • Stimulation of entrepreneurship	• Inflation • Opportunity Costs • Dependence on tourism • Seasonality • Leakages

Source: own research based on literature review

Since socio-cultural change in a society is caused by many factors of which tourism is one, it isn't evident to determine the socio-cultural impact of tourism. Other factors that influence the socio-cultural change in a society are the role of publicity and the media, the effect of multinationals, the aspirations of different governments, education and immigration (Page, S.J., Connell, J., 2009, p.407).

Despite this difficulty the literature propose some positive as well as negative socio-cultural impacts of tourism. The degradation of material cultural heritage due to car emissions or

vandalism is probably the most known negative impact of tourism when it comes to the socio-cultural aspects (Munsters, W., 2007, p. 102-107). Also visual pollution and noise are often stated negative socio-cultural impacts (ibidem). The ethnocentric attitude of many tourists can bring tensions in the society of the host community. Disrespect for certain religious ceremonies by wearing an inappropriate outfit or making noise illustrates this. The commercialization of people's culture should be paid attention to as well (ibidem). Of course tourism brings also some positive things to a tourist destination. If on the one hand tourism deteriorates the material cultural heritage, on the other hand, it can also lead to the preservation of this cultural heritage. By giving a new tourism function to certain buildings, incomes can be collected from the entrance fees, which can be used for restoration, conservation and maintenance (Munsters, W., 2007, p.93-97). The renewed attention for immaterial cultural heritage by tourism can also be seen as a positive socio-cultural consequence of tourism since it makes residents aware of their own cultural identity (Munsters, W., 2007, p.98-102). Finally tourism can be seen as a process of learning. Tourism brings people of different cultures and backgrounds together. When organized the right way, tourism can lead to a greater acceptance, sympathy and admiration of other communities and cultures (Cooper, C., et al., 2005, p. 246-247).

A touch of unspoiled nature appeals to many tourists. Tour operators like to promote island destinations with bounty beaches and really beautiful fauna and flora. However in many areas tourism was developed without a lot of attention to the conservation of the environment. Any form of industrial development will have an influence on its physical environment. This is especially true for tourism since the production and consumption of the tourist product takes place at the same location. Tourism is recognized as an important contributing sector for the economy of many islands. There is thus a growing awareness of the necessity of protection of the environment and an ecologically sound pattern of tourism development (Cooper, C., et al., 2005, p.195).

Although the negative ecological impact of tourism is dominant in literature, there also are positive aspects of the ecological impact of tourism. These positive and negative ecological impacts are summarized in *table 2.*

Table 2: Positive and negative ecological impact

Negative ecological impact	Positive ecological impact
• Pollution of soil, air and water • Noise • Decrease in visual quality of landscapes • Loss of habitat • Loss of biodiversity • Erosion of soil due to frequent use • Shortage of energy, water and land	• Increased attention for important environmental questions and preservation of the environment : - creation of national parks and protected areas; - protection of beaches and coral reefs; - maintenance of forests.

Source: own research based on literature review

4. Models

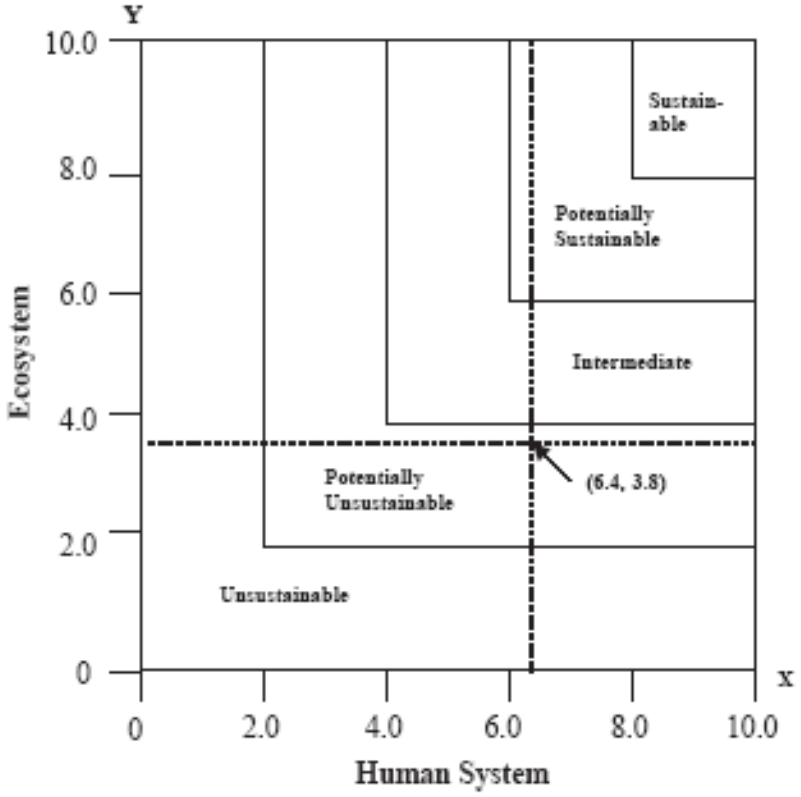
To reach a sustainable situation, the negative effects with respect to economy, sociology, culture and ecology have to be minimized and the positive effects should be maximized. In order to improve the sustainability of an island destination, an integrated system should be developed through which one can measure and evaluate these effects. The measurement and evaluation of the degree of sustainability of an island destination can occur through a collection of indicators. Literature offers certain propositions regarding the choice of these indicators.

The Barometer of Tourism Sustainability (BTS) and the AMOEBA of Tourism Sustainability Indicators (ATSI) model are both interesting models to measure progress in the sustainability of tourism. These indicator models are supported by a conceptual framework existing of a number of systems, dimensions and indicators. Ko (2005) proposes a number of steps to

create this conceptual framework in order to establish the BTS- and ATSI-models. BTS- and ATSI-models are mostly praised for their visual representation of indicator results.

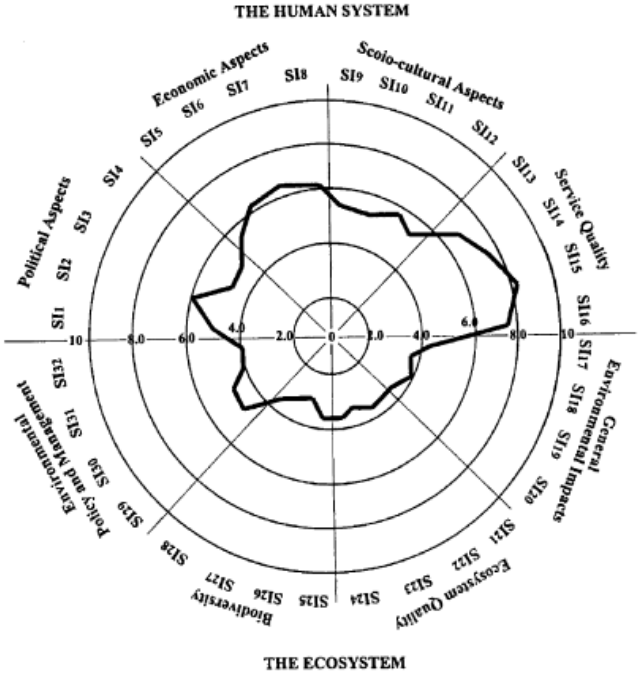
The BTS-model shows a general level of sustainability while the ATSI-model distinguishes the level of sustainability on each indicator. *Figures 1 and 2* give a example of a BTS-model and an ATSI-model based on hypothetical data.

Figure 1: The BTS-model



Source : Ko, T.G., 2005, p.440

Figure 2: The ATSI-model



Source : Ko, T.G., 2005, p.44

The Limits to Acceptable Change (LAC) model is also often cited in the literature. This model is based on 2 concepts : Tourism Carrying Capacity (TCC) and Recreational Opportunity Spectrum (ROS). The LAC-model consist of nine steps and this step-process should lead to the definition of the desired conditions for an area and of the needed management actions to maintain these conditions or to restore them. The LAC-framework looks for relationships between the existing and desired conditions and relies on the judgment of management for the implementation of suited strategies when problems are identified (Ahn, B., et al., 2002, p.3-4).

The Tourism Penetration Index (TPI), developed by McElroy & de Albuquerque (1992), aims to measure the degree of tourism penetration in an area. The TPI is a simple index, based on three independent but inevitably connected subindices. These subindices measure the amount of economic, socio-cultural and ecologic penetration in a tourist destination (McElroy, J.L., de Albuquerque, K., 1998, p.151).

The Sustainable Performance Index (SPI), developed by Castellani, V., and Sala, S. (2009, p.1-10) might be a better alternative for the TPI because it makes use of more indicators and

represents the relationship between an indicator and sustainability correctly by distinguishing indicators that contribute to sustainability and those that threaten sustainability.

The ecological footprint as an indicator for sustainable tourism is only recently discussed in literature. The first articles about the use of the ecological footprint as an indicator for sustainable tourism were published in 2002 (Gössling, S., et al., 2002, p.199-211; Cole,V., Sinclair, A.J., 2002, p. 132-141; Hunter, C., 2002, p.7-20). The ecological footprint translates data about patterns of household consumption to bio-productive space needed to produce these goods and ecological services. The idea of the concept is based on the comparison of the area needed to sustain a certain lifestyle with the area available (Patterson, T.M., et al., 2008, p.410). The methodological framework of the ecological footprint analysis (EFA) is based on six important components of productive space (Gössling, S., et al., 2002, p.201) : arable land, pasture, forest, sea space, built-up land and fossil energy land. The human consumption and the accompanying waste production is related to these six types of land (ibidem). Built-up land refers to spaces where the biologically productive capacity isn't used or can't be used because these areas have been covered with human artifacts such as roads, buildings or amusement parks (ibidem). The area of newly planted forest that one would need to set aside in order to store the carbon dioxide (CO_2) released into the atmosphere by human activities, is

represented by fossil energy land (ibidem). The amount of CO_2 produced per burnt unit of fossil energy, however, depends on the energy source used. One hectare of fossil energy land can annually sequester the CO_2 derived from 56 GJ (coal), 73 GJ (liquid fossil fuels) or 96 GJ (fossil gas) of energy (ibidem). Besides the energy souce, the height at which emissions are released is of importance when calculating the area needed to balance the presence of these gases in the atmosphere. Therefore air transport is given special attention while calculating the ecological footprint.

Before aggregating the different areas of land to a final footprint, one should take the equivalence and yield factors into account in order to correct for differences in productivity between different categories of land and for the difference between local and global productivity within one category of land. To calculate the ecological footprint of a tourist destination, the use of land is divided into various categories such as transport, accommodation, activities, food and fibres consumption and waste. Not all studies mention

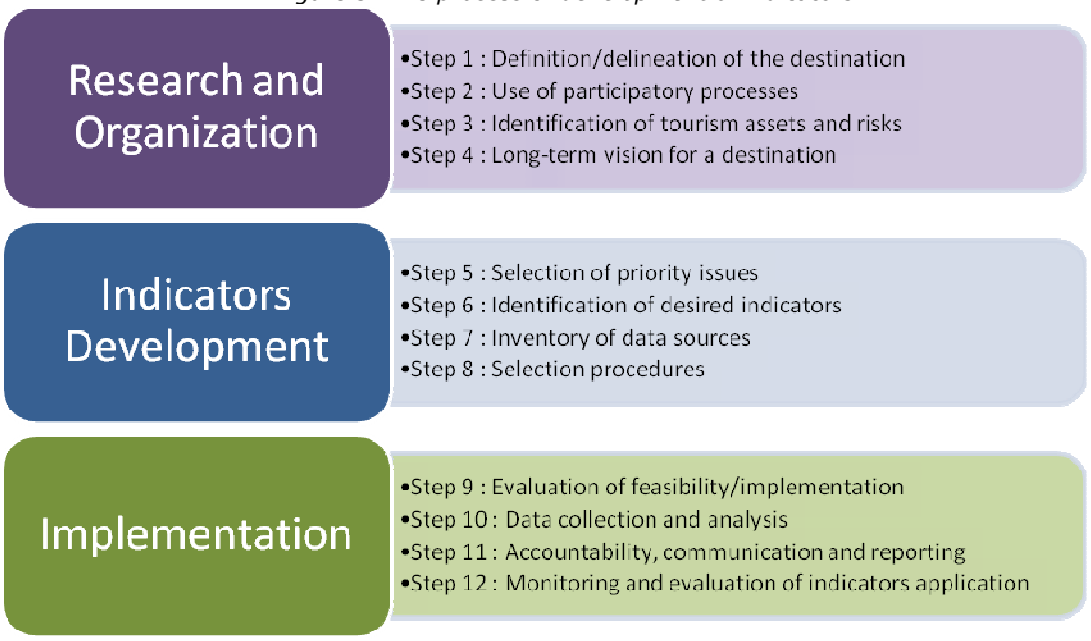
every category and sometimes different categories are taken together (Gössling, S. et al.,2002, p.202; Patterson, T.M.,et al., 2007, p.749-750; Patterson, T.M., et al., 2008, p.412).

One can calculate the ecological footprint per tourist or the ecological footprint of the tourist destination. However in order to calculate the ecological footprint, a detailed database is necessary. Moreover the calculations are complex. That's why Hunter, C., and Shaw, J., (2007, p.46-57) offer an alternative and simple calculation method for the **net** ecological footprint (correcting for the lack of generation of an ecological footprint at home while on holidays) per tourist based on existing data sources. These authors depart from average national data of the ecological footprint, provided by the World Wildlife Fund (WWF) relying on two alternative assumptions. On one hand, one can assume that a tourist on average holds on to the consumption pattern he has in his residence country but on the other hand the assumption that a tourist takes over the consumption pattern of the host country might be more appropriate. After choosing an assumption the calculation method becomes rather simple.

Finally the indicator project of the WTO has contributed a lot to the literature on the measurement of the sustainability of tourism. The WTO is active in the area of development and implementation of indicators of tourism sustainability since 1992 (WTO, 2004, p.9). The work done from 1992 till 2004 was combined in the 2004 publication '*Indicators of Sustainable Development for Tourism Destinations : a Guidebook'* (ibidem). This publication

contains a framework that can be followed when developing a set of indicators for a certain destination. This framework contains 12 steps of development which are summarized in *figure 3.*

Figure 3: The process of development of indicators



Source : WTO, 2004, p.21

5. Applied research: case study for 5 islands

Methodology

In the current study a comparison of the sustainability of tourism is established between 5 islands. In order to do so an indicator index is constructed based on the different indicator models discussed in the literature review. The aim is to develop an instrument that informs policy makers in a simple and clear way about the sustainability of a touristic island destination to allow them to make informed decisions that guarantee the further existence of tourism on that island.

1) The choice of the island sample is based on criteria of location, data availability and the economic importance of tourism. Based on these criteria the islands Cyprus, Cuba, Mauritius, New Zealand and Sri Lanka were chosen to take part in the sample (*table 3*). To answer our research question 2 “How sustainable is current tourism on different

islands and how does this situation contrasts with the situation of the traditional unplanned tourism?" "the situation of 2005 of the five selected islands will be compared to the situation in 1999, in order to detect a trend.

Table 3 : Sample choice

Africa	America	Asia	Europe	Oceania
Mauritius	Cuba	Sri Lanka	Cyprus	New-Zealand

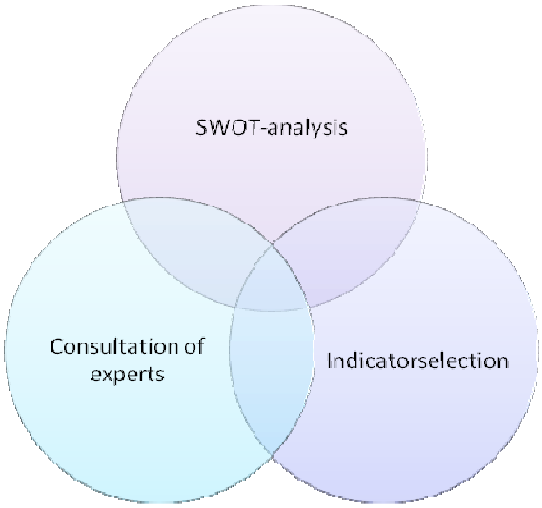
Source: own research and selection

The indicator index constructed in this study is mainly based on the SPI but instead of twenty indicators, this model includes only six due to time and data constraints. Two indicators are devoted to each of the three dimensions (economic, socio-cultural and ecologic).

With respect to the ecological dimension two indicators based on the ecological footprint ('ecological footprint due to air transport per international tourist' and 'average ecological footprint per equivalent resident') were chosen and for these indicators the selection procedure stated below wasn't followed.

The identification and selection of the indicators happened also somewhat different from the SPI-model (*figure 4*). The indicator selection process of the SPI is focused on the evaluation of sustainability at a local scale while the aim of this study is to establish an evaluation on national scale. This means that there cannot be paid attention to indicators who are bound to a specific location, since comparability would be lost. Instead of making an objective analysis of the local situation and consulting local stakeholders, as is done in the SPI-process, this study tries to conduct interviews with important authors in the domain of measurement of tourism sustainability in order to gain insight in the important issues faced with, when measuring the sustainability of island tourism. Unfortunately the response rate of was very low (1 out of 16). Although a higher response rate was expected, the low response rate wasn't a disaster. The information Prof. Jerome McElroy provided in his interview was very valuable for the current research given his international background.

Figure 4: Conceptual framework for the selection of indicators



Source: own research

Based on the answers of the interview conducted with Prof. McElroy in combination with literature a SWOT-analysis for island tourism was done as step 2 in the indicator selection process. The results of this SWOT-analysis can be found in *figure 5.*

As a final step in the indicator selection process, the remaining four indicators were chosen based on the information obtained in the previous steps in combination with data availability. The indicators 'Employment in Travel & Tourism (direct +indirect) per 100 international tourists' and 'Export income of international tourists and tourist goods per international tourist (2000 US $)' were chosen to represent the economic dimension. The lack of data made the selection of socio-cultural indicators very difficult and finally 'Number of tourists per 1.000 residents' and 'Net migration ratio' were selected.

Figure 5: SWOT-analysis of island tourism

Source : Interview Prof. McElroy; WTO, 2004, p.34; WTO, 2004, p.253-256

After having chosen the six indicators of the index, the value of these indicators is standardized to make interpretation easy. In order to standardize the indicators, minima and maxima values need to be chosen for each indicator. However there was tried to take in account mainly objective criteria, the selection of minima and maxima values is inevitably subject to some subjectivity of the researcher. *Tables 4 and 5* show the values of the six indicators for each island for 1999 and 2005. *Table 6* gives the selected minima and maxima values for the six indicators. These are assumed to be stable in time.

Having set the minima and maxima values for all indicators, the standardization of the indicators can begin. For the indicators 'Net migration ratio', 'Export income of international tourists and tourist goods per international tourist (2.000 US $)' and 'Employment in Travel

& Tourism (direct +indirect) per 100 international tourists' a high score on the indicator indicates sustainability. For the economic indicators this relationship is clear but we shortly explain the reasoning with respect to 'Net migration ratio'.

Table 4: Value of the six selected indicators for the 5 islands of the sample (1999))

1999	Cuba	Cyprus	Mauritius	New-Zealand	Sri Lanka
I_1	1,17	0,57	1,24	1,71	1,28
I_2	-	5,19	4,52	5,32	4,58
I_3	25,36	4,24	21,02	16,68	126,13
I_4	1.231,61	811,33	1.302,58	1.804,96	1.519,11
I_5	164,83	4.043,50	547,09	444,20	29,40
I_6	-3	7,6	-0,3	2,3	-4,3

I_1 : Ecological footprint due to air transport per international tourist' (gha)

I_2 : Average ecological footprint per equivalent resident (gha)

I_3 : Employment in Travel & Tourism (direct +indirect) per 100 international tourists

I_4 : Export income of international tourists and tourist goods per international tourist (US $, year 2000)

I_5 : Number of tourists per 1.000 residents

I_6 : Net migration ratio

Table 5: Value of the six selected indicators for the 5 islands of the sample (2005)

2005	Cuba	Cyprus	Mauritius	New-Zealand	Sri Lanka
I_1	1,04	0,57	1,26	1,69	1,11
I_2	5,35	5,15	4,26	5,41	4,47
I_3	16,88	4,06	19,01	11,89	102,37
I_4	960,19	710,91	1.394,1	1.625,85	1.441,81
I_5	207,50	3582,06	645,60	619,13	32,57
I_6	-2,9	7,1	0	5,1	-4,6

I_1 : Ecological footprint due to air transport per international tourist' (gha)

I_2 : Average ecological footprint per equivalent resident (gha)

I_3 : Employment in Travel & Tourism (direct +indirect) per 100 international tourists

I_4 : Export income of international tourists and tourist goods per international tourist (US $, year 2000)

I_5 : Number of tourists per 1.000 residents

I_6 : Net migration ratio

Table 6: Overview of the minima and maxima values of the six indicators

	I_1	I_2	I_3	I_4	I_5	I_6
Minimum	0,06	0,48	0,17	21	0	-40,9
Maximum	3,41	9,99	366,8	7.635	5.000	5

I_1 : Ecological footprint due to air transport per international tourist' (gha)

I_2 : Average ecological footprint per equivalent resident (gha)

I_3 : Employment in Travel & Tourism (direct +indirect) per 100 international tourists

I_4 : Export income of international tourists and tourist goods per international tourist (US $, year 2000)

I_5 : Number of tourists per 1.000 residents

I_6 : Net migration ratio

Sources for tables 4,5 and 6: own research

Growth in tourism can lead to important changes in the environment. Some inhabitants cannot cope with this change and by consequence leave the island. On the other hand tourism can also make the island attractive for foreigners who wish to immigrate. Immigration thus can be related to the attractiveness of an island while emigration can be associated with the dissatisfaction of local residents. A negative net migration ratio means there is more emigration than immigration and is related to unsustainability, a positive net migration ratio is thus considered sustainable.

To standardize the above mentioned indicators the following formula is used:

$$Z_{ij} = (X_{ij}-v_i)/((V_i-v_i)/(S_i-s_i)) \quad (1)$$

where X_{ij} : value of the i-th indicator for the j-th island
V_i : maximum value of the i-th indicator
v_i : minimum value of the i-th indicator
S_i : standardized maximum value, here 10
s_i : standardized minimum value, here 0
Z_{ij} : standardized value of the i-th indicator for the j-th island

The indicators of the ecologic dimension have a negative relationship with sustainability. A high score on the indicator means unsustainability and vice versa. For these indicators the next formula is used for standardization:

$$Z_{ij} = (V_i-X_{ij})/((V_i-v_i)/(S_i-s_i)) \quad (2)$$

where X_{ij} : value of the i-th indicator for the j-th island
V_i : maximum value of the i-th indicator
v_i : minimum value of the i-th indicator
S_i : standardized maximum value, here 10

s_i : standardized minimum value, here 0

Z_{ij} : standardized value of the i-th indicator for the j-th island

Finally the indicator 'Number of tourists per 1.000 residents' remains. For this indicator the relationship between the indicator and sustainability is two-sided. Up to a certain value, a high score is equal to sustainability. There is a need of tourists in order to build a sustainable tourism sector. After a certain value, the amount of tourists will become a disturbing factor for local residents and a high score on the indicator will be associated with unsustainability. The switching value is set at 200. Below the value of 200 formula (1) applies, and above formula (2) is of order.

Results

Tables 7 and 8 present our research results. The standardized values of the six indicators for the five islands of the sample are shown for 1999 as well as for 2005. The maximum score of the index is 60. For both investigated years the score of all islands lies below 30, meaning that there is a long way to go before reaching sustainable tourism at these islands. According to our index tourism in Mauritius is the most sustainable of all analyzed islands, for both 1999 as 2005. Although Mauritius is the leading island, it's score decreased from 28,17 in 1999 to 27,96 in 2005. Sri Lanka and New Zealand are also unable to improve their score of 1999. Cyprus scores the lowest of all islands of the sample but is able to improve it's score of 1999 in 2005. For Cuba this comparison in time is difficult because of a lack of data in 1999. Despite this inconvenience we can carefully say that also Cuba would improve it's score since the score for most indicators is higher in 2005 than in 1999. When analyzing the results, the poor results on the economic dimension are striking. This points to the great importance of the economic dimension for islands, as was indicated by Prof. McElroy in the interview.

Table 7: Results of the sustainability analysis for the five islands of the sample (1999)

1999	Cuba	Cyprus	Mauritius	New-Zealand	Sri Lanka
I_1	6,69	8,48	6,48	5,07	6,36
I_2	-	5,05	5,75	4,91	5,69
I_3	0,69	0,11	0,57	0,45	3,44
I_4	1,89	1,23	2,00	2,79	2,34
I_5	8,24	1,99	9,28	9,49	1,47
I_6	3,82	4,89	4,09	4,35	3,69
Total	**-**	**21,75**	**28,17**	**27,07**	**22,98**

I_1 : Ecological footprint due to air transport per international tourist' (gha)

I_2 : Average ecological footprint per equivalent resident (gha)

I_3 : Employment in Travel & Tourism (direct +indirect) per 100 international tourists

I_4 : Export income of international tourists and tourist goods per international tourist (US $, year 2000)

I_5 : Number of tourists per 1.000 residents

I_6 : Net migration ratio

Source: own research

Table 8: Results of the sustainability analysis for the five islands of the sample (2005)

2005	Cuba	Cyprus	Mauritius	New-Zealand	Sri Lanka
I_1	7,07	8,48	6,42	5,13	6,87
I_2	4,88	5,09	6,03	4,82	5,80
I_3	0,46	0,11	0,51	0,32	2,79
I_4	1,23	0,91	1,80	2,11	1,87
I_5	9,98	2,95	9,07	9,13	1,63
I_6	3,83	4,84	4,12	4,64	3,66
Total	**27,46**	**22,37**	**27,96**	**26,14**	**22,61**

I_1 : Ecological footprint due to air transport per international tourist' (gha)

I_2 : Average ecological footprint per equivalent resident (gha)

I_3 : Employment in Travel & Tourism (direct +indirect) per 100 international tourists

I_4 : Export income of international tourists and tourist goods per international tourist (US $, year 2000)

I_5 : Number of tourists per 1.000 residents

I_6 : Net migration ratio

Source: own research

To improve the score on the index, islands might target nearby markets for promotional campaigns and stop promotional activities in markets far away. Hereby the ecological footprint caused by air transport can be reduced. Another approach might be to invest in the development of technologies that minimize the pollution of air transport such as alternative fuels. To improve the score on indicator 2 islands might opt to use more alternative energy in the hotels and resorts or provide tourists with leaflets with tips to reduce their consumption of energy and water and help preserve nature. A numerus clauses (like on the Seychelles) in combination with an exclusive image might be a way to improve the score on the economic indicators. In addition this strategy is a solution for socio-cultural problems. Controlling the number of tourist can benefit tourism by increasing satisfaction of local residents.

6. Case study : 'Sustainable air transport'

Island tourism is for a large part dependent on air transport, that's why a solution for the environmental problems caused by aviation is fiercely needed in order to attain sustainable tourism on islands. The aviation already booked enormous progress in reducing it's impact on the environment. The aerodynamics of airplanes, the achievements of modern motors and the operational improvements within air companies and airports have made air plains 70% more efficient than 40 years ago (ATAG, 2009, p.7). Although these technological improvements have reduced the fuel efficiency per passenger kilometer of airplanes below that of many cars, the emissions of air transport will increase because of the enormous growth in the number of air travellers (ibidem). This means that other solutions will have to be found to reduce air transport emissions.

The aviation is investigating the potential of alternative fuels. Safety must hereby have the greatest priority. In addition certain sustainability criteria have to be taken into account. In the current study five alternative fuels are evaluated with the focus lying on the criterion of the reduction of greenhouse gasses.

Liquid Hydrogen (LH_2) is praised as the best alternative for petroleum from an ecological point of view because the oxidation of H_2 doesn't lead to the release of CO_2 emissions. However in order to be able to use LH_2 in an airplane, some changes to the air plane design are needed. The long product cycles of airplanes and the enormous sunk costs are important barriers to technological change (Kivits, R., et al., 2010, p. 200). In addition, to produce LH_2 a lot of energy and pure water is needed. For these reasons LH_2 doesn't immediately offer a short-term alternative for kerosene.

Methanol of ethanol aren't suited for use as a commercial fuel for aviation because of their bad weight and volume properties. Moreover the use of ethanol in aviation needs an adaption of the airplane design. The CO_2 -emissions of the use of methanol as an aviation fuel are even higher than those produced when using the traditional Jet-A fuel. These factors show that alcohols aren't much of a green alternative to Jet-A fuel. The use of synthetic fuel in aviation has certain advantages and disadvantages but is in general seen as unsustainable, especially in relation to the current climate change. Electricity isn't considered as an immediate substitute of fossil fuels because of the low energy density of batteries when compared to that of fossil fuels, which is very high. In addition, the electricity has to be produced with green energy in

order to meet the sustainability criteria. Another issue is the need of change to the air plane design. In spite of these difficulties, a few experiments with electricity (solar panels) as an alternative to kerosene already have been conducted. Finally biofuels are considered a short-term alternative for Jet-A fuel since no changes need to be made to the airplane design.

Technical feasibility is one thing, but in order to be used at large scale an alternative fuel also needs to be economically viable. A simple theoretical comparison was conducted between a flight on BioJet and the same flight on kerosene (Jet-A). The studied flight leaves in Larnaca (Cyprus) and has destination London (United Kingdom). The flight distance is calculated at 3.259 km. Based on the assumptions taken, and excluding the costs of the investment, the analysis shows that at the present, Jet-A fuel is still the cheapest alternative (*table 9*). However this could rapidly change. When the European Emission Trading Scheme (ETS) becomes obligatory for the aviation in 2012, our analysis shows that BioJet will be the cheapest alternative based on the assumptions made (*table 10*).

Table 9: Comparison of the fuel cost/passenger between Jet-A and BioJet for a flight from Larnaca to London

Flight Larnaca (Cyprus)-London (United Kingdom)

		BioJet *(HRJ)*	Jet-A
Fuel price($/l) *(1)*		0,8	0,62
Distance flight (km) *(2)*		3.259	3.259
Fuel consumption (kg/passenger km) *(3)*	Take off/landing	0,076	0,076
	normal flight altitude	0,025	0,025
Distance take off/landing (km) *(3)*		250	250
Density (kg/l) *(4)*		0,86	0,783
Number of passengers		500	500
Fuel usage (kg) *(5)*		47.112,50	47.112,50
Fuel usage (l) *(6)*		54.781,98	60.169
Fuel cost ($) *(7)*		43.826	37.305
Fuel cost/passenger ($/passenger) *(8)*		87,65	74,61

(1) : Biojet : Source : IATA, 2009, p.47
Jet A : Source : IATA, 2009, p.47 ; IATA, 2008, p.37
(2) : Source : www.travelmath.com/flight-distance/
(3) : Source : www.compenco2.be/content.aspx?lang=EN&l=005
(4) : Biojet : Source: Alptekin, E., Canakci, M., 2008, p.2624

Jet A : Source: IPCC, 1999, hfst.7

*(5) : Fuel usage (kg) = ((Fuel consumption take off/landing (kg/passenger km) * Distance take off/landing (km) * Number of passengers) + (Fuel consumption normal flight altitude (kg/passenger km) * (Distance flight (km) – Distance take off/landing (km)) * Number of passengers))*

(6) : Fuel usage (l) = Fuel consumption (kg) / Density (kg/l)

(7) : Fuel cost ($) = Fuel use (l) * Fuel price ($/l)

(8) : Fuel cost/passenger ($/passenger) = Fuel cost ($) / Number of passengers

Source: own research

Table 10: Comparison of the fuel cost/passenger between Jet-A- and bioJet for a flight from Larnaca to London, taken into account the cost of emissions

Flight Larnaca (Cyprus) - London(United Kingdom)		
		Jet-A
Number of passengers *(1)*		500
Fuel usage (kg) *(1)*		47.112,5
Fuel cost, cost of emission rights excluded ($) *(1)*		37.305
Emissions in CO_2-equivalent (kg/kg fuel) (2)	Flight < 500 km	2,99
	Flight > 500 km	8,97
Emissions in CO_2-equivalent (ton) (3)		422,60
Price CO_2-emission rights ($/ton)		26,5
Cost CO_2-emission rights ($) *(4)*		11.199
Fuel cost, cost of emission rights included ($) *(5)*		48.504
Fuel cost/passenger ($/passenger), cost of emission rights included *(6)*		97

(1) : See table 8

(2) : Source : http://www.co2gift.be/content.aspx?l=009.001&lang=NL&group=1

*(3) : Emissions in CO_2-equivalent (ton) = Fuel usage (kg) * Emissions in CO_2-equivalent (kg/kg fuel)*

*(4) : Cost CO_2-emissionrights ($) = Emissions in CO_2-equivalent (ton) * Price CO_2-emission right ($/ton)*

(5) :Fuel cost, cost of emission rights included ($) = Fuel cost, cost of emission rights excluded ($) + Cost CO_2-emission rights ($)

(6) : Fuel cost/passenger ($/passenger), cost of emission rights included = Fuel cost, cost of emission rights included ($) / Number of passengers

Source: own research

7. Conclusions

In this research paper an indicator index was developed, with the aim of measuring the sustainability of tourism on islands. This index consisted out of 6 indicators, of which 2 represented the respective economic, ecologic and socio-cultural dimension. To fully measure the sustainability of island tourism, at least 4 indicators per dimension are recommendable. However this wasn't possible for this study because of great differences in the statistics available for each island. In addition, because of the lack of consistence between national tourism statistics some very general indicators had to be chosen. This was particularly problematic for the socio-cultural dimension.

With respect to the ecological indicators we note that these indicators, based on the ecological footprint, integrate a lot of ecological aspects in one number. Therefore the information obtained is somewhat difficult to interpret. Concerning the economic indicators, there can be argued that statistics should not only pay attention to contribution of Travel & Tourism to GDP but also it's contribution to Gross National Product (GNP), so that one can measure the leakages to foreign multinationals. Next, we acknowledge that the score of the islands on this sustainability analysis is strongly dependent on the choice of the minima and maxima values for each indicator. This should be taken into account when interpreting the results.

We can conclude that the large differences between the national tourism statistics of each islands forms a big barrier for the establishment of an indicator index to measure island sustainability. Therefore we argue for the international harmonization of national tourism statistics. In spite of these constraints, we believe that the current study offers a valuable applied contribution to the literature in the domain of measurement of tourism sustainability on islands.

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