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ANALYSIS

Ecological footprint analysis as a tool to assess tourism sustainability

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Abstract

This article has the aim to provide a methodological framework for the calculation of ecological footprints related to leisure tourism. Based on the example of the Seychelles, it reveals the statistical obstacles that have to be overcome in the calculation process and discusses the strengths and weaknesses of such an approach. As many tropical island-states depend heavily on foreign exchange earnings derived from visitors arriving by air, special attention is paid to the use of energy associated with air travel. Furthermore, implications of the findings for national greenhouse inventories are discussed. Finally, as the Seychelles have safeguarded a wide range of ecosystems in protected areas, which are for their existence ultimately dependent on financial resources derived from tourism, the question is raised if long-distance travel can be a means to safeguard biodiversity.

Keywords: Biodiversity; Conservation; Ecotourism; Ecological footprints; Seychelles; Sustainable tourism; Islands

1. Introduction

'Sustainable tourism' has become one of the keywords in the debate on environmentally integrated tourism development, largely a result of the insight that the environmental consequences of this rapidly growing industry can no longer be ignored (e.g., Hunter and Green, 1995). In the past, a number of concepts have been suggested (i) to evaluate the environmental consequences of tourism, such as Environmental Impact Assessments (EIA; e.g. Green and Hunter, 1992); or (ii) to understand which levels of change can be tolerated, such as the carrying capacity concept (CCC) and the limits of acceptable change system (LAC) (O'Reilly, 1986; McCool, 1994). However, EIA, CCC, and LAC focus on changes occurring in the local environment, largely ignoring the global consequences of travel. A number of recent publications (Becken et al., 2002; Gössling, 2000, 2002;

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Høyer, 2000) have pointed out, though, that transport (particularly air traffic) is responsible for the majority of the environmental impacts associated with long-distance tourism, for example more than 90% of a typical journey's contribution to climate change (Gössling, 2000). Existing concepts are thus insufficient to make clear statements about the sustainability of particular forms of travel or the sustainability of certain destinations. The same is true for 'ecotourism', which is characterised by integrated planning involving local communities. By definition, ecotourism is not harmful to the environment and thus largely understood as sustainable (e.g., Fennell, 1999). It is thus proposed and supported as a favourable development path by environmental organisations and institutions as dissimilar as the World Wide Fund for Nature and the World Bank (cf. World Bank, 1998; WWF, 1995). However, even ecotourism projects often seem to ignore the global environmental aspects of travel. Ecotourism may thus be sustainable on the local level (in the sense that it puts a minimum threat to local ecosystems through the conversion of lands, trampling, collection of species, etc.), but it may in most cases not be sustainable from a global point of view. In the light of this, the article seeks to discuss ecological footprint analysis (EFA) as a concept to assess sustainability in tourism and to test the hypothesis of ecotourism as a sustainable form of tourism. The focus of the article is on leisure tourism as opposed to business tourism according to definitions as provided by the World Tourism Organisation.

The Seychelles have been chosen as the study site because they have based their marketing on the image of a pristine, exclusive eco-destination that seriously attempts to integrate environmental conservation and development. As a high-value destination, the islands attract a particularly wealthy clientele.

2. Tourism and environmental conservation in the Seychelles

The Seychelles is a republic of 115 islands in the south-western Indian Ocean. The total land area comprises 455 km^2, with a surrounding exclusive economic zone (EEZ) of 1,374,000 km^2 (Kawaley, 1998; Shah, 1995). As in other tropical developing countries, tourism began in the late 1960s with the rise of civil aviation and reached a first peak in 1980, when 71,762 tourists visited the islands (MTCA, 2001). However, tourist numbers declined again in the following years (1980–1983) as a result of economic recession in the European source markets, rising airfares, poor marketing and competition from other tropical destinations (Gabbay and Ghosh, 1997). To address the difficult situation, existing tourist facilities were upgraded and new high-class facilities constructed in a rather unique effort to establish a high-value tourism. Simultaneously, marketing in the source countries was intensified. As a result of this strategy, tourist numbers exceeded 100,000 in 1990. Again, in 1991, the Gulf War had negative consequences for tourist arrivals. New governmental campaigns thus aimed at diversifying markets, and in 2000, tourist numbers totalled 130,000 (MISD, 2001a,b). By 2010, 200,000 visitors per year are expected to visit the country (MTCA, 2001). Simultaneously, a major program is currently underway to upgrade hotels and guesthouses with the aim to turn the Seychelles into a 'three to five star destination' (A. Volcere, 2001, personal communication).

The Seychelles have a number of advantages over other tropical destinations: crime is virtually absent, there is no begging, and tourists are neither confronted with extremely poor people nor with hassling in shops or on the beaches. Tropical diseases like Malaria do not exist, the climate is stable and seasonality low, there are no tropical storms, and the great number of small bays and beaches makes it possible to distribute the tourists in a multitude of locations. The economy is diversified, also building on a strong fisheries industry, and the culture seems resistant to the tourist's cultural influences (cf. Wilson, 1994). The tourist infrastructure is mixed, consisting of large hotels and guesthouses in local ownership, which leads to the more even distribution of the monetary benefits derived from tourism. Finally, the natural beauty of the island, the great number of endemic and/or unique birds and plants, and the variety of possible activities (big game fishing,

snorkelling, scuba diving, etc.) make the islands attractive even from this point of view. For all these reasons, the Seychelles have been able to attract the high-value segment of international tourism, with prices per bed-night reaching from US$40 in guesthouses to US$ 1955 per bungalow in Frégate Island, the most expensive resort hotel in the world. Tourism has contributed to make the Seychelles one of the wealthiest nations in Africa with a per capita GDP of US$ 10,600 (in 1998, PPP US$), ranking 53 in the United Nations' Human Development Index (UNDP, 2002).

Tourism is the second major source of foreign exchange earnings for the Seychelles, and a pristine environment is understood as the precondition for attracting an exclusive, wealthy clientele. Consequently, the Seychelles are unique in their efforts to conserve the environment. Currently, half of the terrestrial surface of the islands is being preserved in protected areas—more than in any other country in the world (A. Volcere, 2001, personal communication). However, very little of the Seychelles' ecosystems has not been transformed by human activities, and serious doubts have been expressed about the effectiveness of environmental conservation (cf. Lindén and Lundin, 1997). For example, the development of coastal areas continues, and shark jaws and teeth, marine organisms like white, blue, red and black corals, as well as shells and conchs are sold as souvenirs in substantial numbers. The collection of shells and parts of corals is also a popular tourist activity difficult to control. In the early 1990s, certain fish species like the red snapper were reported to become difficult to find, possibly a sign of overexploitation (Wilson, 1994). However, recent control and monitoring measures might have improved the situation, and the new Environment Management Plan of Seychelles 2000–2010 is a comprehensive document aiming at the implementation, continuation and extension of environmental conservation towards 'sustainable development' (MET, 2001).

3. Method

Ecological footprints aim at expressing—using space equivalents—the appropriation of biologically productive area by individuals or nations. The idea of the concept is to compare the area required to support a certain lifestyle with the area available, thus offering an instrument to assess if consumption is ecologically sustainable (Wackernagel and Rees, 1996; Chambers et al., 2000). This survey builds on the methodological framework developed by Wackernagel et al. (1999a,b), which relates human consumption and waste production to six major components of productive space: arable land, pasture, forest, sea space, built-up land and fossil energy land. While the first three of these categories are self-explaining, built-up land refers to spaces where the biological productivity is not used or usable because these areas have been covered with human artefacts such as roads, buildings or amusement parks. Built-up land differs from the other categories because it does not represent biomass that can be used, but rather 'destroyed biological capacity' (Wackernagel et al., 1999a). Fossil energy land represents 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. The amount of CO_2 released per burnt unit of fossil energy depends on the energy source. Accordingly, 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 (WWF et al., 2000). In addition to these rather precise estimates of the footprint of different fossil energy sources, this study attempts to include the additional global warming potential of emissions at flight altitude. Air travel deserves special consideration in the calculation process because its emissions are released in 10–12 km height in the upper troposphere and lower stratosphere, where they have a larger impact on ozone, cloudiness and radiative forcing than they do at the Earth's surface (IPCC, 1999). Aircraft emissions thus need to be weighted with a factor of 2.5–3.0 to include their additional warming potential (IPCC, 1999). In order to account for these effects, the energy footprint of air transport has been weighted with a factor of 2.7 (cf. Høyer, 2000).

In order to aggregate the different categories of space to a total footprint, the areas are multiplied

by 'equivalence factors' (Wackernagel et al., 1999a). These factors inform about the category's relative yield (measured in primary or green biomass productivity) as compared with world-average space, which is given the equivalence factor of 1. Average arable land is, for example, 3.2 times more biologically productive than world-average space, and is therefore multiplied with a factor 3.2. The equivalence factors for each category of space, based on recent revisions in the Living Planet Report (WWF et al., 2000), are shown in Table 1.

To calculate the ecological footprint of the roughly 117,690 international leisure tourists, who visited the Seychelles in the year 2000 (calculated from MISD, 2001a), resource and area use were divided into the categories 'transport', 'accommodation', 'activities', and 'food and fibre consumption'.

'Transport' comprises all travel related to the vacation, including travel to/from airports, return-flights, and all travel at the destination. The corresponding ecological footprint needs to consider both energy and infrastructure requirements. The infrastructure needed to travel to the Seychelles consists mainly of roads, railways, parking sites and airports. Similar infrastructure requirements are needed in the Seychelles. The area required per tourist is calculated by dividing the 'total leisure tourist area' by the number of leisure tourist departs/arrivals in the year 2000. The 'total leisure tourist area' is defined as the total area needed for infrastructure in the travel process minus the percentage statistically used by business travellers or non-tourists. To give an example, the international airport in the Seychelles is built on about 110 ha (including parking sites, etc.). However, only 74% of the arrivals at the airport are by leisure tourists. Thus, area use amounts to 81.4 ha or 6.92 m^2 per tourist (based on 117,690 leisure tourist arrivals).

In order to compute the energy footprint of travel, the following calculations were made: in 2000, more than 80% of all visitors to the Seychelles came from Europe, almost all of them by means of air transport (MISD, 2001a). Table 2 shows the most important European source countries.

To reach this destination, tourists will first of all travel to the airport. Only limited information was available on the different means of transport used and the distances travelled in the source countries. Calculations were thus based on data provided by Busch and Luberichs (2001) for Germany. Flight distances were calculated by considering national connecting flights in the source countries, international flights (including direct ones and indirect ones via hubs such as Nairobi, Dubai, etc.), and connecting flights within the Seychelles' territory by helicopter and aircraft. The total distance flown by all tourists was calculated by aggregating the flight distances of all tourists. In order to achieve this, visitor flows were retraced. Data provided by MISD (2001a) distinguishes the origin of different tourist groups. In addition, all airlines operating flights to the Seychelles were contacted to calculate the number of tourists on different routes. The number of passengers on each route to the islands was then multiplied by flight distance (return

Table 1
Equivalence factors (based on relative biomass yield)

World average space	1.0
Fossil energy land (newly planted forest area needed to absorb emitted CO_2)	1.8
Built up land (required for roads, houses, playgrounds, golf courses, etc.)	3.2
Arable land (for growing crops)	3.2
Pasture (for grazing animals)	0.4
Sea space (for harvesting fish and other sea food)	0.1
Forest area (for producing wood for furniture, paper etc.)	1.8

Source: WWF et al. (2000).

Table 2
Tourist source countries, 2000

Country of origin	Number of arrivals	Total (%)
France	28,282	22
Italy	19,951	15
Germany	17,720	14
UK and Eire	16,458	13
Switzerland	5001	4
USA	4746	4
Scandinavia	4329	3
		74

Source: MISD (2001b).

flights) to calculate the total flight distance. Some assumptions had to be made in this process to account for connecting national flights and flights via hubs. However, the major problem in the calculation process turned out to be the limited availability of data for international flights; despite the fact that all airlines operating flights to the Seychelles were contacted, data was made available for only 1029 of the 1124 take offs at the international airport in Mahé. This leaves the substantial number of 95 take offs and 16% of all passengers unaccounted for, resulting in a certain degree of uncertainty and inaccuracy. Average distances flown per tourist on these unknown flights were calculated based on the data for the known flights. Energy use was computed by applying a conversion factor of 2.0 MJ per passenger km (pkm) (cf. Lundli and Vestby, 1999; Lenzen, 1999; Schafer and Victor, 1999). The results may nevertheless be conservative, because a certain percentage of the unknown flights may have been private aircraft by Russian or Arab tourists arriving with small, relatively energy-intensive aircraft (K. Henri, 2001, personal communication). Finally, distances travelled within the Seychelles' territory were calculated, including the use of rented cars, taxis, bus/coach, public transport, helicopter, aircraft and boat. For this, data was collected from the Seychelles helicopter services, travel providers, the Management and Information Systems Division (MISD, 2001a), and the Seychelles Tourist Office (2000). Fig. 1 illustrates the main inter-island connections (helicopter, aircraft and boats).

As for 'accommodation', the tourist footprint consists of the area required for rooms/apartments, gardens, restaurants, etc. and the fossil energy land to account for energy use (including mainly heating/cooling, air conditioning, cooking, illumination, cleaning: and the desalination of seawater). Note that the use of beaches is included in built land calculations. In order to calculate the total area required by accommodation establishments, these were divided in eight categories simple and luxury guesthouses, one to two, three to four, and five star hotels, self-catering, private and boat. It was assumed that a certain area was used per bed in each of these categories, based on data provided by 11 accommodation establishments in the Seychelles (Hörstmeier, 2002, unpublished data) and data collected by Gössling (2002). Built-up land requirements per bed amount to 60 m^2 in simple guesthouses, 200 m^2 in luxury guesthouses, 100 m^2 in one to two star hotels, 300 m^2 in three to four star hotels, 2000 m^2 in five star hotels, 300 m^2 in self-catering apartments, 50 m^2 in private houses, and 15 m^2 in boats (the last including harbour area). Finally, the number of beds existing in each category (Hörstmeier, 2001, unpublished data) was multiplied by land use per bed. As for energy requirements, total energy use was calculated by multiplying energy use per bed-night in each accommodation establishment category with the number of bed nights in each category (based on Gössling, 2002; Hörstmeier, 2001, unpublished data; UK CEED, 1994). Energy requirements per bed night amount to: 30 MJ (simple guesthouses), 40 MJ (luxury guesthouses), 40 MJ (one to two star hotels), 70 MJ (three to four star hotels), 110 MJ (five star hotels), 50 MJ (self-catering), 30 MJ (private), and 40 MJ (boat). Note that this excludes the energy used for construction and maintenance of the accommodation establishments, access roads, etc. as well as the energy required to provide both goods needed to maintain tourist flows (computers, beds, televisions, etc.), the infrastructure to choose and book the journey (travel agency/travel provider, information materials, guide books), and the additional resource requirements of the staff. The full indirect effects of imported goods or appropriated services are thus not captured in the analysis, leading to conservative results.

'Activities' include the visitation of specific locations for recreational purposes and may be generally divided into attractions (museums, visitor centres, botanical gardens, etc.), entertainment (cinema, bar, shopping, etc.), and sport activities (diving, jet boating, golf, etc.) (Becken and Simmons, 2002). In this study, the following activities/locations were considered: diving, deep-sea fishing, excursions by boat, museums/visitor centres (e.g., in national parks, tea plantations), the Botanical Garden, and the 'Artist Village Creole'. These are associated with a built-up land and/or an energy-footprint. However, the footprint of the built-up

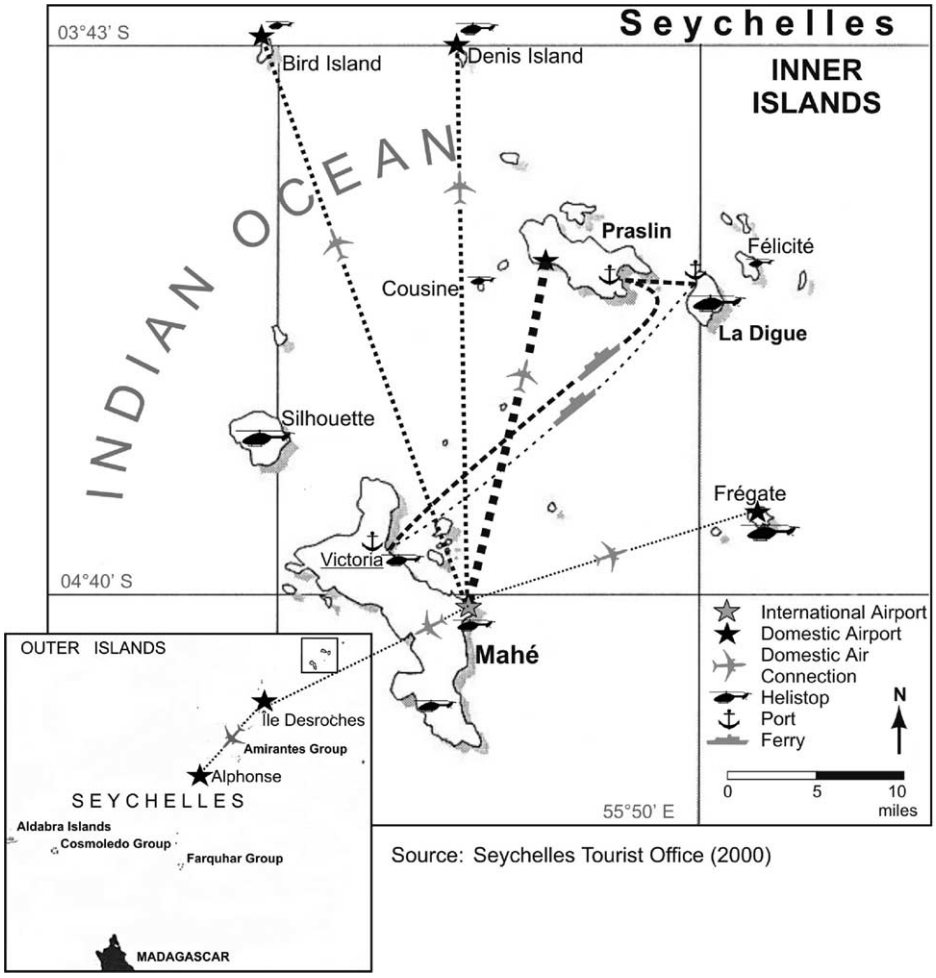

Fig. 1. Inter-island connections 2000.

land for activities appeared to be minor (< 0.1 m^2 per tourist) and was neglected in the calculation process except for the two golf courses in Mahé and Praslin, which comprise an area of about 90 ha. The energy footprint (excluding transport to/from the attraction) was calculated based on information made available by travel providers, BirdLife International (an NGO responsible for the management of two protected islands), and the Ministry of Environment and Transport (MET, 2001).

Finally, 'food and fibre consumption' assesses the footprint of food and fibres, based on cropland, productive sea space, forest and pasture. However, in the case of the Seychelles, this proved to be difficult due to the poor official statistical database and the unwillingness of the tourist industry to provide data. To overcome this problem, it was assumed that the quality and quantity of the food consumed at the destination is similar to consumption at home. Evidence suggests that there is at least some similarity (cf. Gössling, 2001). Similar assumptions were made for fibres (including clothes, forest products, etc), an argument supported by the fact that handicrafts and other shopping stand for more than 7% of an average tourist's total expenditure during a trip to the Seychelles (Archer and Fletcher, 1996). In the following, the footprint of food and fibre consumption was calculated based on national data

(WWF et al., 2000) and aggregated for the seven largest tourist groups (representing 74% of all tourist arrivals). Before entering the calculation, the figures on the annual average appropriation of space for food and fibre consumption in these nations were scaled down to 10.4 days (the average length of stay in the Seychelles). The additional energy requirements for producing and transporting food and fibres to the Seychelles were not included in these calculations, neither were the spatial implications of solid waste or nutrient loads to the sea.

For the remaining 26% of tourists (originating from both richer and poorer countries), it was assumed that their footprint for food and fibre corresponded to the average footprint of the seven largest tourist groups. This is based on the hypothesis that even tourists coming from less wealthy countries will themselves belong to the wealthier proportion because they have the financial means to travel on vacation to the Seychelles. Hence, these were assumed to have a lifestyle similar to that of citizens in industrialised countries.

4. Footprint calculation

As explained above, each tourist's total ecological footprint consists of the aggregated categories built-up land, fossil energy land, arable land, pasture, forest and sea space. The following tables show the calculation of the total ecological footprint of an average holiday with an average length of stay of 10.4 days (MISD, 2001a).

Table 3
Built-up land footprint

Category	ha per cap per year
Roads	0.0002
Airports	0.0009
Accommodation	0.0015
Activities (golf courses)	0.0008
Total footprint on built up land	0.0033
Equivalent area in world average space	0.0105

According to the results of the analysis, the land directly used for tourist infrastructure (built-up land) is surprisingly small, on average 105 m^2 per tourist (Table 3). This can be explained by the fact that roads, airports, accommodation establishments, etc. are used by a great number of tourists per year, leading to a rather small per capita built-up area demand.

In comparison, the ecological footprint of fossil energy land is substantial, amounting to 17,373 m^2 (1.73 ha; Table 4). About 97.5% of this footprint is a result of air travel.

The average footprint for food and fibre consumption (10.4 days, Table 5) is 1086 m^2, excluding the energy requirements for transporting food and fibres to the Seychelles. Note the effects of the different equivalence factors for arable land (3.2) and sea space (0.1) in the transformation to hectares of world average space.

In summary, an average tourist's journey to the Seychelles requires more than 1.8 ha of world average space to maintain the necessary resource

Table 4
Fossil energy land footprint

Energy footprint for liquid fossil fuel	73.0839 GJ/ha per year
Fossil fuel consumption for air transport	25.4655 GJ per cap
Corresponding footprint on fossil energy land	0.3484 ha per cap per year
Footprint for air transport on fossil energy land (adjusted with a factor 2.7)	0.9408 ha per cap per year
Fossil fuel consumption for other transport	1.1873 GJ per cap
Corresponding footprint on fossil energy land	0.0162 ha per cap per year
Fossil fuel consumption for accommodation	0.5958 GJ per cap
Corresponding footprint on fossil energy land	0.0082 ha per cap per year
Total ecological footprint on fossil energy land (transport and accommodation)	0.9652 ha per cap per year
Equivalent area in world average space	1.7373 ha per cap per year

Table 5
Food and fibre consumption footprint

Tourists' country of origin	Arable land (ha per cap per year)	Pasture (ha per cap per year)	Forest (ha per cap per year)	Sea space (ha per cap per year)
France	0.0123	0.0670	0.0074	0.0402
Italy	0.0117	0.0917	0.0057	0.0353
Germany	0.0516	0.0168	0.0066	0.0000
UK and Éire	0.0141	0.0946	0.0066	0.0235
Switzerland	0.0068	0.0749	0.0071	0.0248
USA	0.0131	0.0801	0.0202	0.0256
Scandinavia	0.0108	0.0618	0.0211	0.1377
Weighted average footprint	0.0198	0.0692	0.0081	0.0315
Areas expressed in world average space	0.0632	0.0277	0.0145	0.0032
Total EF of food and fibre consumption, expressed in world average space	0.1086	–	–	–

flows and to off set the contribution of greenhouse-gas emissions to global warming (Table 6).

Extrapolating the footprint of a typical journey to the Seychelles (10.4 days) to 1 year, results in an area of more than 65 ha of global average space. This can be compared with the average footprints of citizens of industrialised nations, which amounts to between 5 and 11 ha of world average space (excluding travel abroad, Wackernagel et al., 1999b). In other words, an average holiday in the Seychelles corresponds to 17–37% of the annual footprint of a citizen of an industrialised country. However, the biologically productive area available on a global per capita level is only 2 ha (setting aside 12% of the global area for biodiversity protection, WWF et al., 2000). A single journey to the Seychelles thus requires almost the same area as available per human being on a global scale.

Table 6
Total ecological footprint

Areas expressed in world average space equivalent	ha per cap per year
Fossil energy land	1.7373
Built up land	0.0105
Arable land	0.0632
Pasture	0.0277
Sea space	0.0032
Forest	0.0145
Aggregated footprint per tourist	1.8564
Aggregated footprint of all tourists	218,482
Extrapolated vacation footprint (1 year)	65015

5. Discussion

Modern travel is characterised by globalisation: major airlines have agreed upon strategic alliances and serve an increasing number of remote destinations, isolated countries such as Libya and Saudi Arabia have joined international travel markets, and visa regulations have been liberalised in many countries. Tourists themselves have more travel experiences and can compare destinations. Consequently, growth in long-distance travel has outpaced conventional travel in most industrialised countries, with a substantial share of international tourist arrivals now taking place by means of air transport (WTO, 2000). Simultaneously, growth in accommodation supply seems to be greater than growth in demand, particularly in tropical destinations. Finally, travellers themselves have become more critical in comparing prices, and comparably cheap last minute travel has increased substantially in recent years. This development mirrors a process of increasing competition between destinations, and can also be seen as an indicator of the growing inter-changeability of destinations. Particularly destinations in the tropics become replaceable because sun–sand–sea travel choices are increasingly made on the basis of two factors

only: travel (flight) duration and hotel standard. Considering these trends, the Seychelles are unique in their effort to not become a mass-tourism destination and to attract the high-value segment of international tourism.

The Seychelles are also unique with respect to environmental conservation. The islands have protected a proportionally larger area than any other country in the world, and tourism development and ecosystem conservation seem in balance. Within the current world system, the conservation of ecosystems is achieved by setting aside protected areas. As economic activities are restricted in these areas, conservation is generally perceived as entailing 'costs', both through the non-use of areas ('opportunity costs') and the direct costs for management, monitoring, etc. A recent estimate by James et al. (1999) puts the latter at 2.8 US$ per hectare per year in developing countries. Conservation is thus based on the notion that it can only be achieved through a continuous flow of funds, and is in the case of the Seychelles at least partly dependent on income derived from tourism.

With respect to these aspects, the EFA of tourism in the Seychelles leads to a number of insights. First, the environmental integrity achieved in the islands is based on a trade-off. Protected areas largely contribute to the image of a green, pristine and sustainable destination that attracts wealthy tourists. Consequently, tourism is the second largest foreign exchange earner and contributes directly and indirectly to the financing of protected areas. For example, about 11,000 tourists visited the protected islet Cousin Island in 1999, generating over US$ 200,000—a sum large enough to cover all management costs (K. Henri, 2001, personal communication). However, foreign exchange earnings are also the precondition for the import of a vast array of resources such as wood, vegetables or fruits, which can only to a limited degree be exploited locally due to poor soils and the protection status of many areas. Souvenirs such as shells and corals are even imported from other developing countries, leading to the creation of 'souvenir hinterlands'. The ecological 'costs' of environmental protection are reflected in the footprint analysis, which reveals that the Seychelles are dependent on a large ecological hinterland to maintain the tourist system: comparing the terrestrial protected area (about 230 km^2) with the ecological hinterland (2184 km^2) sheds some light on the magnitude of this trade-off.

If tourism is to safeguard a species or an ecosystem, the question arises of how large an ecological hinterland is acceptable to achieve protection and which level of resource-depletion can be tolerated. This becomes clear considering energy use: global warming, to a large extent a result of emissions from transportation, will be an important factor leading to the extinction of species in the future (Sala et al., 2000). The vulnerability of the Seychelles in this respect is obvious: the 1997–1998 El Niño, for example, had severe impacts on the climate of the Indian Ocean. In March and April 1998, seawater temperatures increased on average by 1.5 °C above values measured during the same period in 1997. Following the event, coral mortality ranged from 50 to 90% over extensive areas of shallow reefs in the Seychelles. In some areas around the main island Mahé, mortality was even close to 100% (Lindén and Sporrong, 1999). Climate change is also likely to lead to substantial sea-level rise in the future (IPCC, 2001). As long-distance travel contributes substantially to global warming, the current understanding of tourism as a sustainable economic activity needs to be revised. This is paramount because there seems to be a general consensus about the suitability of tourism as a road to sustainable development among international organisations and institutions (e.g. WTO, 1997; WWF, 1995; World Bank, 1998).

Small islands located in the periphery of the world economy may have great difficulties establishing viable transport and communication links. They have to import a great range of basic goods and products, and they have usually limited local resources to be sold in return for foreign exchange earnings. It has thus been argued that tourism is a suitable means to integrate remote regions into the world economy and even finance the necessary infrastructure in this process (airports, etc.) (cf. Briguglio et al., 1996). In the case of the Seychelles, this remoteness is even actively promoted. Slogans such as 'unique by a thousand miles' and 'as pure as it gets' have characterised successful marketing

campaigns in recent years. With the advent of tourism, it also has become viable to establish industrial production units (e.g. a brewery and a soft-drink/juice factory) to satisfy the increased demand of both the local population and the growing number of international tourists. Tourism thus generates new centres of accumulation on an industrial basis. This is problematic because these are dependent on ecological hinterlands, i.e. new supplying peripheries (cf. Gössling, 2001).

The footprint analysis also revealed that the major environmental impact of travel is a result of transportation to and from the destination: more than 97% of the energy footprint is a result of air travel. This implies that current efforts to make destinations more sustainable through the installation of energy-saving devices or the use of renewable energy sources can only contribute to marginal savings in view of the large amounts of energy used for air travel. Any strategy towards sustainable tourism must thus seek to reduce transport distances, and, vice versa, any tourism based on air traffic needs per se to be seen as unsustainable. Obviously, these insights also apply to ecotourism based on long-distance travel. However, as the footprint occurring within the destination was found to be small, regional tourism involving only short transport distances may often be sustainable from an ecological point of view.

From a local perspective it is also worth noting that upper class hotels seem to have a substantially larger ecological footprint than guesthouses. For example, the Lemuria Resort, a new five-star hotel with 240 beds and 410 employees, is spread over an area of 110 ha (this includes a golf course). Statistically, this amounts to more than 4580 m^2 per bed (or ca. 2290 m^2 excluding the golf course). The energy-requirements of the hotel are confidential, but seem remarkable: Priscilla Shi Shun, Guest Relation Supervisor, indicates that the resort 'uses more energy than the entire rest of the island' with its 6500 inhabitants and its more than 1500 beds in hotels and guesthouses. Other resource requirements are also substantial: the entire hotel is, for its large wooden parts, built with tropical wood (teak) from Indonesia. The furniture is made in Bali, finished in Mauritius, and afterwards transported to the Seychelles. There are a beauty-parlour, an air-conditioned gym and a sauna with a small chilled pool. The apartments are equipped with a TV set, air-conditioner, hair dryer, fan, fridge, safe, electric mosquito-coils, and stereo. Bathrooms include shower, toilet, tub and bidet.

With respect to national greenhouse inventories, a difficult situation seems to arise with tourism. This is because national energy inventories usually aggregate the amount of energy used by its citizens, excluding energy use abroad. Similarly, previous footprint studies have relied on national and international statistics of production, energy use and trade, thus excluding international tourism. Part of the material and energy use entailed in international travel has thus been accounted for in the host countries. As the vast majority of international tourists is from the industrialised countries, the 'true' footprint of the residents of many countries may have been substantially underestimated (with the opposite being the case in countries primarily receiving tourists, such as tropical island states). With respect to travel, one may argue that the flight to and from the Seychelles should be included in the national energy use and greenhouse gas inventories of the source countries. Vice versa, the opinion might also be raised that the country earning from tourism should also be made responsible for the 'ecological costs' of travel. However, following a similar line of reasoning, it would also be possible to discuss the responsibility of oil exporting countries for global greenhouse gas emissions because these profit economically from the selling of fossil fuels. Obviously, such an approach is unproductive. Furthermore, sustainable development will ultimately aim at changing individual lifestyles, e.g., reducing per capita energy and resource use. It thus seems reasonable to integrate travel abroad in national footprint calculations. This should be done rather urgently, because the United Nations Framework Convention on Climate Change (UN-FCCC) does not cover emissions from bunker fuels, i.e. those sold in harbours (e.g., heavy fuel oil) and in airports (e.g., jet fuel; Olsthoorn, 2001).

Is EFA a suitable means to analyse tourism sustainability? In the context of the Seychelles, it can be assumed that most other approaches to assess sustainability (EIA, LAC) may have arrived at a positive view: locally, large land areas are conserved in protected areas, and the environmental impacts of tourism are monitored and continuously minimised. EIA or LAC may thus be seen as suitable concepts to investigate local environmental change, but they cannot assess sustainability from a more comprehensive (global) point of view. This is because tourism seems to often draw on extensive hinterlands, and because global environmental change (e.g., global warming) is not captured in these concepts. EFA, on the other hand, is not a suitable means to understand the local environmental consequences of tourism, and it can make no clear statements about the relative value of land. For example, a certain area might be ecologically valuable due to its richness in endemic species. It may thus be a conservation priority, even though its preservation might create an ecological hinterland elsewhere. It should also be noted that the assessment of local environmental change and the setting of maximum carrying capacities or threshold levels is always based on personal values concerning the appropriateness of change (Lindberg et al., 1997; Lindberg and McCool, 1998), which is difficult to capture in EFA. In contrast, global models and agreements exist about, for example, tolerable levels of greenhouse gas emissions. Limits to change such as these can be captured very well in EFA, and the concept can be used to make clear statements about sustainability in these contexts. However, EFA is often difficult to apply because it requires a detailed database on consumption and biomass yield figures. Such data is often difficult to obtain due to insufficient statistical databases, lack of transparency or unwillingness to cooperate. With respect to greenhouse gas inventories, the calculation of energy use associated with air traffic may also prove to be a complicated task. Particularly in developing countries, the application of models such as provided by Becken et al. (2002) or the one suggested in this article may thus often turn out to be difficult or impossible. However, such difficulties should be seen as an inherent problem of any study dependent on detailed statistical information. In case these limitations can be overcome, EFA could be a meaningful tool for assessing tourism sustainability, particularly if combined with 'local' approaches such as EIA or LAC.

6. Concluding remarks

The Seychelles are unique in their effort to attract high-value tourists, which has made it possible to successfully compete with other destinations in the tropics, to generate foreign exchange earnings of substantial volume, and to implement large protected areas excluding economic activities. This has contributed to the image of a pristine, sustainable destination. However, the footprint analysis revealed that this success is based on a trade-off because a large ecological hinterland is needed to maintain the system. Furthermore, high-value tourists might generate the largest foreign exchange earnings per capita (Archer and Fletcher, 1996), but they also seem to be characterised by the highest resource use per capita. Development towards a three to five star destination may thus further increase the ecological footprint of the islands. In the future, sustainability research should thus aim at identifying the tourist groups with the highest resource use, both with respect to local resource use and travel patterns. In order to become more sustainable, destinations should seek to attract clients from close source markets.

Environmental conservation based on funds derived from long-distance tourism remains problematic and can at best be seen as a short-term solution to safeguard threatened ecosystems (cf. Gössling, 1999). Moreover, the environmental impacts of long-distance travel may have detrimental consequences for ecosystems. As stated earlier, the 1998 El Niño had devastating consequences for coral reefs in the Seychelles. This poses the question of the consequences of environmental degradation for tourism. Coral bleaching may currently be accepted as a 'natural phenomenon' by scuba divers, but the degradation of many reefs, even visible for the untrained observer, could nevertheless influence the tourist's percep-

tion of the Seychelles as an environmentally pristine destination in the long run. Environmental degradation, the attractiveness of the islands as a pristine destination, and the tourist's role in the degradation process are thus part of the same process.

From a global sustainability and equity perspective, air travel for leisure should be seen critically: a single long-distance journey such as the one investigated in this survey requires an area almost as large as the area available on a per capita basis on global average. This sheds new light on the environmental consequences of long-distance travel, which have rather seldom been considered in the debate on sustainable tourism. Taking these results seriously, air travel should, from an ecological perspective, be actively discouraged.

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References

Archer, B., Fletcher, J., 1996. The economic impact of tourism in the Seychelles. Annals of Tourism Research 23 (1), 32–47.

Becken, S., Simmons, D.G., 2002. Understanding energy consumption patterns of tourist attractions and activities in New Zealand. Tourism Management, in press.

Becken, S., Frampton, C., Simmons, D., 2002. Analysing international tourist flows to estimate energy use associated with air travel. Journal of Sustainable Tourism 10 (2), 114–131.

Briguglio, L., Butler, R., Harrison, D., Filho, W.L., 1996. Sustainable Tourism in Islands and Small States. Pinter, London.

Busch, H., Luberichs, J., 2001. Reisen und Energieverbrauch. Academia Verlag, Sankt Augustin, Germany.

Chambers, N., Simmons, C., Wackernagel, M., 2000. Sharing Nature's Interest. Earthscan, London.

Fennell, D.A., 1999. Ecotourism. An Introduction. Routledge, London.

Gabbay, R., Ghosh, R., 1997. Tourism in the Seychelles. Discussion Paper 97.08. Centre for Migration and Development Studies, Department of Economics, The University of Western Australia, Perth.

Gössling, S., 1999. Ecotourism—a means to safeguard biodiversity and ecosystem functions? Ecological Economics 29, 303–320.

Gössling, S., 2000. Sustainable tourism development in developing countries: some aspects of energy-use. Journal of Sustainable Tourism 8 (5), 410–425.

Gössling, S., 2001. Tourism, environmental degradation and economic transition: interacting processes in a Tanzanian coastal community. Tourism Geographies 3 (4), 230–254.

Gössling, S., 2002. Global environmental consequences of tourism. Global Environmental Change, in press.

Green, H., Hunter, C., 1992. The environmental impact assessment of tourism development. In: Johnson, P., Thomas, B. (Eds.), Perspectives on Tourism Policy. Mansell, London.

Høyer, K.G., 2000. Sustainable tourism or sustainable mobility? The Norwegian case. Journal of Sustainable Tourism 8 (2), 147–160.

Hunter, C., Green, H., 1995. Tourism and the Environment. A Sustainable Relationship. Routledge, London.

International Panel on Climate Change (IPCC), 1999. In: Penner, J.E., Lister, D.H., Griggs, D.J., Dokken, D.J., McFarland, M. (Eds.), Aviation and the Global Atmosphere. A Special Report of IPCC Working Groups I and III. Cambridge University Press, Cambridge.

International Panel on Climate Change (IPCC), 2001. In: Houghton, J.T., Ding, Y, Gripps, D.J., Noguer, M., van der Linden, P.J., Dai, X., Maskell, K., Johnson, C.A. (Eds.), Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

James, A.N., Gaston, K.J., Balmford, A., 1999. Balancing the Earth's accounts. Nature 401, 323–324.

Kawaley, I., 1998. Implications of the exclusive economic zone and EEZ management for Seychelles, a small midocean Island Commonwealth Territory. Ocean Development and International Law 29, 225–264.

Lenzen, M., 1999. Total requirements of energy and greenhouse gases for Australian transport. Transportation Research Part D 4, 265–290.

Lindberg, K., McCool, S., 1998. A critique of environmental carrying capacity as a means of managing the effects of tourism development. Environmental Conservation 25 (4), 291–292.

Lindberg, K., McCool, S., Stankey, G., 1997. Rethinking carrying capacity. Annals of Tourism Research 24, 461–465.

Lindén, O., Lundin, C.G. (Eds.), 1997. The journey from Arusha to Seychelles. Successes and failures in integrated coastal zone management in Eastern Africa and island states. Proceedings of the Second Policy Conference on Integrated Coastal Zone Management in Eastern Africa and Island States, Seychelles 23–25 October.

Lindén, O., Sporrong, N., 1999. Coral reef degradation in the Indian Ocean. Status reports and project presentations.

SAREC Marine Science Program, Department of Zoology, Stockholm University.
Lundli, H.-E., Vestby, S.E., 1999. Luftfart och miljø. En sammenlikning mellom fly og andre transportmidler for energi, utslipp og areal. Rapport 9/99. Western Norway Research Institute, Sogndal.
Management and Information Systems Division (MISD) 2001a. Seychelles in Figures. Victoria, Seychelles.
Management and Information Systems Division (MISD) 2001b. Visitor and Hotel Statistics, Victoria, Seychelles.
McCool, S., 1994. Planning for Sustainable nature dependent tourism development: the limits of acceptable change system. Tourism Recreation Research 19 (2), 51–55.
MET (Ministry of Environment and Transport), 2001. Environment Management Plan of Seychelles 2000–2010. Victoria, Seychelles.
MTCA (Ministry of Tourism and Civil Aviation), 2001. Vision 21. Tourism Development in the Seychelles 2001–2010. Victoria, Seychelles.
Olsthoorn, X., 2001. Carbon dioxide emissions from international aviation: 1950–2050. Journal of Air Transport Management 7, 87–93.
O'Reilly, A.M., 1986. Tourism carrying capacity—concept and issues. Tourism Management 7, 254–258.
Sala, O.E., Chapin, F.S., III, Armesto, J.J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L.F., Jackson, R.B., Kinzig, A., Leemans, R., Lodge, D.M., Mooney, H.A., Oesterheld, M., Poff, N.L., Sykes, M.T., Walker, B.H., Walker, M., Wall, D.H., 2000. Global biodiversity scenarios for the year 2100. Science 287, 1770–1774.
Schafer, A., Victor, D.G., 1999. Global passenger travel: implications for carbon dioxide emissions. Energy 24, 657–679.
Shah, N.J., 1995. Managing coastal areas in the Seychelles. Nature and Resources 31 (4), 16–33.
Seychelles Tourist Office, 2000. Visitor information material. Frankfurt, Germany.
UK CEED (UK Centre for Economic and Environmental Development), 1994. A life-cycle analysis of a holiday destination: Seychelles. British Airways Environment Report No. 41/94. Cambridge, UK, CEED.
United Nations Development Programme (UNDP), 2002. Available at: http://www.undp.org/hdr2000/english/book/back1.pdf.
Wackernagel, M., Rees, W.E., 1996. Our Ecological Footprint: Reducing Human Impact on the Earth. New Society Publishers, Gabriola Island, BC.
Wackernagel, M., Lewan, L., Borgström Hansson, C., 1999a. Evaluating the use of natural capital with the ecological footprint: applications in Sweden and Subregions. Ambio 28, 604–612.
Wackernagel, M., Onisto, L., Bello, P., Callejas Linares, A., López Falfán, I.S., García, J.M., Guerrero, A.I.S., Guerrero, M.G.S., 1999b. National natural capital accounting with the ecological footprint concept. Ecological Economics 29, 375–390.
Wilson, D., 1994. Unique by a thousand miles. Seychelles tourism revisited. Annals of Tourism Research 21, 20–45.
World Bank, 1998. Think Tank Group and World Tourism Organization Examine Role of Tourism in Development. News Release No. 98/1853/S, 25 June 1998, Washington, DC.
WTO (World Tourism Organisation), 1997. Tourism is one of the environment's best friends. Secretary-General Addresses Special Session of United Nations. Press Release 24 June 1997, New York.
WTO (World Tourism Organisation), 2000. Statistical Yearbook of Tourism, Madrid.
WWF (World Wide Fund for Nature), 1995. Ecotourism: conservation tool or threat. Conservation Issues 2 (3), 1–10.
WWF (World Wide Fund for Nature), United Nations Environment Programme (UNEP), World Conservation Monitoring Centre (WCMC), 2000. Redefining Progress (RP), The Centre for Sustainability Studies, 2000. Living Planet Report. Jonathan, L. (Ed.), World Wide Fund for Nature. Gland, Switzerland.