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ANALYSIS

The eco-efficiency of tourism

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Abstract

The use of fossil energy is one of the major environmental problems associated with tourism and travel. Consequently, the need to limit fossil energy use has been highlighted as a precondition for achieving sustainable tourism development. However, tourism is also one of the most important sectors of the world economy, and fears have thus been expressed by the tourist industry and its organisations that increasing energy prices (for example, as a result of eco-taxes) could substantially decrease the economic welfare of countries and destinations. In this article, the interplay of environmental damage and economic gains is thus analysed within the context of tourism. Carbon dioxide-equivalent emissions are assessed in relation to the revenues generated, allowing for conclusions about the eco-efficiency of tourism.

Keywords: Air travel; Energy; Climate change; Sustainable tourism; Taxation; Transport; Policy-making

1. Introduction

Sustainable tourism has been a key concept for tourism researchers and tourist industry alike since the early 1990s (cf. Butler, 1993). There is now broad consensus that tourism development should be sustainable; however, the question of how to achieve this remains an object of debate. It is clear that in order to be sustainable, environmental effects of tourism–the focus of this paper–need to be kept below critical threshold levels, which can only be achieved if these can be quantified. A major goal of tourism studies has thus been to quantify the environmental impacts of leisure-related activities and to compare these with acceptable

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levels of pollution. Expressing resource use in terms of energy (MJ), greenhouse gas emissions (carbon dioxide [CO_2] or carbon dioxide equivalents [CO_2-e]), or area-equivalents (ha), studies have sought to evaluate the sustainability of journeys, destinations, or sectors of the tourism industry, such as leisure-related aviation (cf. Ceron and Dubois, 2003; Becken et al., 2002; Gössling, 2000, 2002; Gössling et al., 2002; Høyer, 2001; Patterson, 2003, 2004; Peeters, 2003).

Several conclusions can be drawn from these studies. First, whether using energy consumption, greenhouse gas emissions or area-equivalents as basis for calculations, a substantial share of tourism needs to be seen as unsustainable. Second, the use of fossil fuels and related emissions of greenhouse gases is, from a global point of view, the most pressing environmental problem related to tourism (cf. Graßl et al., 2003; Sala et al., 2000; Thomas et al., 2004). Third, transport contributes overproportionally to the overall environmental impact of leisure-tourism; this is between 60% and 95% at the journey level, and including local transport, accommodation, and activities.

In the light of these insights, there is a given need to reduce greenhouse gas emissions, particularly in the transport sector. This will not be an easy task, as the tourism industry is highly averse to bearing levies designed to curb fossil energy use, opposing, for instance, the introduction of a tax on aviation fuels. In countering the image of an environmentally harmful industry, tourism lobbyists even seek to establish and maintain a discourse portraying tourism as an environmentally neutral, if not beneficial industry, claiming its ecological performance to be superior to other sectors of the global economy (Iwand, 2003). In light of this, the analysis of the tourist industry from an ecological efficiency (or eco-efficiency) perspective can provide new insights. Eco-efficiency is a term coined by the World Business Council for Sustainable Development in 1995, and based on a lifecycle analysis approach to reduce the use of resources and environmental impacts (Cramer, 2000). Eco-efficiency has so far primarily been used in the context of industrial economics to reduce costs and to create new market opportunities with the bi-effect of decreasing the impact on the environment (cf. Cramer, 2000; Dober and Wolff, 1999).

For the purpose of this article, environmental damage per unit of value generation has been chosen as the basis for calculations. Given the global scope of this paper, and not considering local environmental impacts of tourism, carbon dioxide equivalent (CO_2-e) emissions are used as a proxy for environmental damage. The use of equivalent emissions allows consideration of the impacts of air travel, which is important because emissions released at flight altitude (nitrogen oxides, water vapour, and other pollutants) have a larger effect on radiative forcing than those emitted at ground level (cf. Schumann, 2004). As a proxy for value generation, Euro turnover is used. Overall, eco-efficiency as used in this article is thus the ratio of CO_2-e (kg) to turnover (€). Note that we describe eco-efficiencies as "favourable/unfavourable" in order to avoid confusion that can arise from the use of "higher/lower". Calculations do not consider indirect ecological and economic effects. For example, lifecycle energy requirements of tourist infrastructure are excluded, which, if considered, resulted in less-favourable eco-efficiencies. On the other hand, multiplier effects are not included either, which would result in more favourable eco-efficiencies.

Based on these premises, the analysis will focus on the following questions:

1. How much CO_2-e is emitted in the tourism industry to generate one unit of financial value? How do these ratios vary between destinations and countries?
2. How does the eco-efficiency of tourism compare to other sectors of the national and global economy?
3. How can eco-efficiency be used (i) to make judgements on the relative environmental harmfulness of different source markets or forms of tourism, (ii) to assess the sustainability of tourism, or (iii) to develop more sustainable tourism products?
4. Which sectors of the tourism industry need to be considered as particularly harmful for the environment and economically less beneficial?

2. Method

2.1. Eco-efficiency

The calculation of eco-efficiency ratios for any kind of activity, economic sector, or economic region requires two data-sets, one of energy use and another one of economic turnover. As pointed out earlier, indirect energy requirements, costs, or multiplier effects are not considered in this analysis, as none of the existing databases is detailed enough for such advanced calculations. In order to arrive at the ratio of CO_2-e (kg): turnover (€), energy use has to be transformed into CO_2-e emissions. In tourism, energy is used for transport, accommodation and activities. Transport includes travel to and from the destination (Origin to Destination, or O/D transport), as well as travel at the destination. Tourist infrastructure (hotels, roads) is also energy intensive, as is its maintenance. Finally, tourists are involved in various activities that entail energy use.

2.2. Transport

Transport emissions can be calculated for different transport modes and connections, using the following equation:

$$E_{\mathrm{el}} = \sum_m (\beta_m * \varepsilon_m * V_m)$$

Variables are: E_{el}: CO_2–equivalent emissions in kg, β_m: Specific emissions of CO_2 in kg per passenger kilometre (pkm), ε_m: Equivalence factor, V_m: Total transport volume for transport mode (m) in passenger kilometres (pkm).

Data for β and V may be found in two ways: aggregated and disaggregated. The aggregated (top-down) method uses data on the total amount of fuel or energy use and total vehicle kilometres to find average aggregated values for β. The disaggregated method (bottom-up) is based on average values for β, including all kinds of tourism transport vehicles and their average mileage per year. The emission factors used in this analysis are based on recent research carried out in the Netherlands (van Essen, 2003; Eurostat, 2000; Gijsen and van den Brink, 2002; Pulles et al., 2002; SAS, 2004; Uitendaal and Fransen, 2001). Equivalence factors (ε_m) are used to include the climate-relevant effects of other emissions than carbon dioxide. For surface transport (road, rail, and shipping) this factor is about 1.05 (Gugele et al., 2003; Heart and Biringer, 2000). At flight altitude, emissions of NO_x, H_2O, and soot cause positive additional radiative forcing (IPCC, 1999). The equivalence factor for air transport is therefore higher at an estimated 2.7 (with a large degree of uncertainty; cf. Schumann, 2004). The total transport volume for transport mode m (V_m) is calculated using the following equation:

$$V_m = 2* \sum_n N_n * S_n * DF_m * WF_n$$

Variables are: V_m: Total transport volume for transport mode (m) in passenger kilometres (pkm), N_n: Total number of tourists travelling with transport mode m on connection n, S_n: Great circle distance for relation n, DF_m: detour average factor for mode m, WF_n: generalised weight factor for multi-destination travel calculations at journey-, region-, or country level.

The total number of tourists travelling with transport mode m includes all travellers arriving with a certain means of transport (aircraft, car, etc.). The great circle distance S_n is the shortest distance between two locations. The detour factor DF_m is used to include distances travelled in addition to the great circle distance. The average detour factors are based on an estimate by Peeters (Table 1). For instance, during take-off and landing, an aircraft will cover additional distances, and there are countries that do not allow foreign aircraft to cross their territory. This causes the aircraft to fly longer distances than the great circle distance. The weight factor WF_n is used to indicate that long-distance tourists may visit several countries during their stay. Only part of their travel impact should therefore be allocated to the country where the tourists arrived. Using Amsterdam as an example,

Table 1
Factors for different transport modes

Transport mode	Emission factor, β_m, for CO_2 (kg/pkm)	Equivalence factor, ε_m	Detour factor, DF
Air (EU)	0.14	2.7	1.05
Air (ICA)	0.12	2.7	1.05
Rail	0.025	1.05	1.15
Car	0.075	1.05	1.15
Coach	0.018	1.05	1.15
Ferry	0.07	1.05	1.05
Cruise ship	0.07	1.05	1.3
Cycle/Moped	0.01	1.05	1.15
Other	0.075	1.05	1.15

EU: European Union, i.e. flights with a maximum range of 2000 km; ICA: Intercontinental Air Transport, i.e. flights with a range greater than 2000 km; Occupancy rates: air: 70% (European Union), 75% (ICA); cars: 50%; long-distance rail: 60%; coach: 75%.

WF$_n$ is calculated as $WF_n = \frac{\overline{LOS\_A_n}}{\overline{LOS\_T_n}}$, with LOS_$A_n$ being the average length of stay within Amsterdam and LOS_T_n being the average total length of the trip (to the Netherlands, Europe, etc.). The length of stay is measured in bed nights (also guest or visitor night). Finally, to capture return-trips, results have to be multiplied by two.

2.3. Accommodation

Energy use in hotels varies considerably, both with respect to the sources of energy used as well as the amount of energy consumed (Table 2; cf. ACCOR, 1998; Becken et al., 2001; Deng and Burnett, 2000; Simmons and Lewis, 2001). The amount of energy consumed in different hotels as well as the environmental impact of their production may thus vary considerably.

As shown in Table 2, average energy consumption per bed night in hotels might be in the order of 130 MJ. Hotels use generally more energy per visitor, as they have energy intense facilities, such as bars, restaurants, and pools, and more spacious rooms. Accommodation establishments in the category ‘pensions’ may have a comparably low number of beds and occupancy rates are assumed to be somewhat lower than those of hotels. Although Becken et al. (2001) found rather high energy-consumption values in bed and breakfast facilities in New Zealand (110 MJ per bed night), a lower average of 50 MJ is used here for all accommodation establishments in this category. Campsites were assumed to have the lowest energy use of all categories with 25 MJ per bed night, while holiday villages were calculated with 90 MJ per bed night. It should be noted that there is a moderate degree of uncertainty, as scientific data on energy use in accommodation establishments is limited. No data is available for self-catering facilities and vacation homes. These are assumed to consume 120 MJ and 100 MJ per bed night.

Table 2
Energy use accommodation, 2001

Accommodation establishment	Energy use per bed night (MJ)	Emissions per bed night (kg CO_2)[a]
Hotels	130	20.6
Campsites	50	7.9
Pensions	25	4.0
Self-catering	120	19.0
Holiday villages	90	14.3
Vacation homes	100	15.9

Source: Gössling (2002).

[a] Based on an emission factor of 43.2 g C/MJ (Schafer and Victor, 1999 for the 1990 world electricity generation mix), or 158.5 g CO_2/MJ.

2.4. Activities

On holiday, tourists are usually engaged in activities. Becken and Simmons (2002) identified activities of New Zealand tourists and calculated their energy-intensity, which ranged between 7 MJ per tourist (visitor centers) and 1300 MJ per tourist (heli-skiing). Given the differences in energy-intensity, it seems difficult to allocate an average amount of energy to each tourist. Gössling (2002) estimated that, on average, 250 MJ per tourist (corresponding to about 40 kg CO_2) are used for ‘activities’ during a longer vacation of international tourists. With the exception of a few particularly quiescent sites (Patterson, 2004), this may be a conservative estimate for most destinations (cf. Becken and Simmons, 2002; Becken et al., 2002).

3. Case studies

3.1. Rocky Mountain National Park

Rocky Mountain National Park (RMNP) is a 106,000 hectare alpine preserve in north-central Colorado (USA), in the Front Range of the Rocky Mountains. The park receives over 3 million visitors annually, and provides the habitat for a large and diverse wildlife population, as well as vegetation including alpine meadows, conifer forests, quaking aspen groves, open woodlands, and fragile alpine tundra. There are many mountain peaks of nearly 4000 m in elevation, including Long’s Peak, the Park’s tallest and a popular climbers’ ascent. RMNP has a strong seasonal variation, with 87% of the annual visitation occurring between May and October. Most visitors come from other parts of the United States, with less than 10% of visitors originating abroad.

A visitor survey was conducted in the summer of 2001 at RMNP. During the survey period, visitors

Table 3
Summary of visitor sampling at Rocky Mountain National Park

Sample size	904	
Average group size	3.8	
Average number of nights	3.0	
Average one-way distance travelled	735 miles	1184 km
Average one-way distance per person	192 miles	309 km
Average travel expenditures per household	€ 576	

Table 5
Summary of accommodation emissions for visitors to Rocky Mountain National Park

Accommodation type	Visitor nights	CO_2-e (kg)
Hotel	5,766,311	90,758,848
Camping	2,904,300	17,595,703
Total accommodation	8,670,611	108,354,551
Accommodation emissions per person		33.72
Total spending—accommodation		€ 239,117,767
Eco-efficiency ratio—accommodation (kg CO_2-e/€)		0.45

were selected randomly in frequently visited areas of RMNP. On selected sampling dates, visitors were approached randomly at the chosen sampling sites, and surveys were distributed to willing respondents, who took the survey with them to be completed and mailed in at a later date. There were 1378 attempts to distribute surveys during the survey period, and 112 were refused, leaving a total of 1266 surveys distributed to Park visitors. At the end of the sampling period, 967 surveys were returned, which amounts to a 70% response rate (or a 76% response rate, net of refusals). The survey included questions about distance travelled, transport mode, accommodation, number of group members, and travel expenses. A summary of survey data is presented in Table 3.

The majority of visitors travelled to the Park by automobile (60%). Including all transport modes, the extrapolation of sampling data to the population of annual Park visitors yielded total CO_2-e emissions of 950 million kg, or 295.7 kg per person. The eco-efficiency ratio for RMNP visitor transport is 4.94 kg CO_2-e/€ (Table 4).

For the nearly 8.5 million visitor nights per year at RMNP, 67% of visitors used hotels for accommodation, and the remaining 33% used campgrounds. There are associated CO_2-e emissions for accommodation of over 105 million kg, or 33.7 kg per person. The eco-efficiency ratio for RMNP visitor accommodation is 0.45 kg CO_2-e/€ (Table 5).

Most visitors to Rocky Mountain National Park participate in wildlife viewing and leisure driving. More than 70% of survey respondents indicated that the activities of viewing conifer forests, viewing wildflowers, and driving over Trail Ridge Road were either "important" or "very important" to their decisions to visit RMNP. Approximately 90% of visitors went hiking or walking on nature trails, while 14% of visitors participated in adventure activities such as mountain climbing or rock climbing. Most visitors are from outside Colorado, and over 60% used the visitor centre facilities for information and environmental interpretation. The associated CO_2-e emissions for visitor activities at Rocky Mountain National Park total 76 million kg, or 24 kg per person. The eco-efficiency for RMNP visitor activities is 2.12 kg CO_2-e/€ (Table 6).

In all, 3.2 million annual visitors to Rocky Mountain National Park generate 1.1 billion kg of CO_2-e emissions associated with their tourist visits to the Park. The eco-efficiency of RMNP tourism is 2.43 kg CO_2-e/€. A summary of CO_2-e emissions for RMNP

Table 4
Summary of transport emissions for visitors to Rocky Mountain National Park

	Transport volume (km)	CO_2-e (kg)
Air travel for trips<2000 km	1,258,347,175	475,655,232
Air travel for trips>2000 km	735,110,208	238,175,707
Automobile travel	3,000,385,110	236,280,327
Total transport	4,993,842,493	950,111,267
Transport emissions per person		295.66
Total spending—transport		€ 192,277,119
Eco-efficiency ratio—transport (kg CO_2-e/€)		4.94

Table 6
Summary of activity emissions for visitors to Rocky Mountain National Park

Activity type	Number of visitors	CO_2-e (kg)
Hiking/guided walks	2,945,082	53,915,000
Adventure (climbing)	466,869	4,429,000
Visitor centers	1,928,077	2,246,000
Leisure driving (Trail Ridge Road)	2,570,769	15,589,000
Total visitor activities	7,910,797	76,179,000
Activity emissions per person		23.71
Total spending—activities		€ 35,960,671
Eco-efficiency ratio—activities (kg CO_2-e/€)		2.12

tourism is presented in Table 7. Note that a comparative summary of the parameters considered in all case studies can be found in Table 10.

3.2. Amsterdam inbound tourism

Amsterdam is the fourth largest tourist attraction in the world within the 'city-breaks' market (short 1–4 day trips to a city destination). Eight million tourists–staying at least one night in Amsterdam–and nine million day-visitors travelled to Amsterdam in 2002. The visitors stayed a total of 39 million days and came from a variety of countries and regions in the world. They spent 4.8 billion (including accommodation and local transport, excluding O/D-transport). The greenhouse gas emissions of these visitors include O/D-transport (travel from the place of permanent residency to Amsterdam), local transport within Amsterdam, accommodation, and activities. For O/D-transport, factors in Table 1 have been used. Somewhat different factors were used for local transport in Amsterdam (Table 8):

Table 7
Summary of CO_2-e emissions for visitation at Rocky Mountain National Park

Transport/accommodation/activities	CO_2-e (kg)
Transport emissions	950,111,267
Accommodation emissions	108,354,551
Activity emissions	76,179,000
Total emissions	1,134,644,818
Total emissions per person	353.09
Total spending	€ 467,355,557
Tourism eco-efficiency ratio (kg CO_2-e/€)	2.43

Table 8
Distances travelled and factors for local transport in Amsterdam in 2002

Mode	Estimated average distance per day (km)	Emission factor, β_m, for CO_2 (kg/pkm)	Equivalence factor, ε_m
Urban public transport	20	0.075	1.05
Walking/Cycling	5	0.000	n.a.
Taxi	10	0.153	1.05
Private car	25	0.115	1.05
Other	15	0.115	1.05

The estimated average distance per day is the average distance as travelled by visitors actually using the mode. The emissions factors for local transport are higher as for O/D-transport due to shorter distances between stops and less efficient driving speeds.
Source: van Essen (2003) (for emission factors).

A survey of 10 Amsterdam hotels conducted by Peeters revealed that energy consumption in Amsterdam seems lower than the values provided in Table 1, possibly a result of the confined space of city hotels. The average amount of CO_2-e emissions per guest night was found to be 8 kg. Activities in Amsterdam include some 20 categories, from walks along the canals to visiting cafés, restaurants, museums, and concerts, or relatively short excursions by coach. Concomitant CO_2-e emissions are from 0 (a walk) to almost 8 kg (visit of a discotheque). As many visitors to Amsterdam are on a round trip, only part of their international flight emissions should be attributed to the city. A weight factor (WF) is thus applied. The average length of stay in Amsterdam is 3.7 days for tourists and one day for day-visitors. The total trip length for international visitors varies between 5 and 10 days for Europeans and up to 20 days for tourists from other continents.

The analysis of CO_2-e emissions shows that O/D transport accounts for 93% of the total, while accommodation contributes with 4%, activities with 2%, and local transport with 1%. As O/D transport emissions form the major part of total emissions, only these and accommodation emissions are considered in the calculation of eco-efficiency (see Table 10). Fig. 1 shows that a large share of CO_2-e emissions is caused by comparably few countries. For example, visitors from the USA alone account for 40% of the total, followed by Australia/New Zealand (12%) and the UK (11%). Note that although domestic tourists cause less than 2% of total CO_2-e emissions, they are

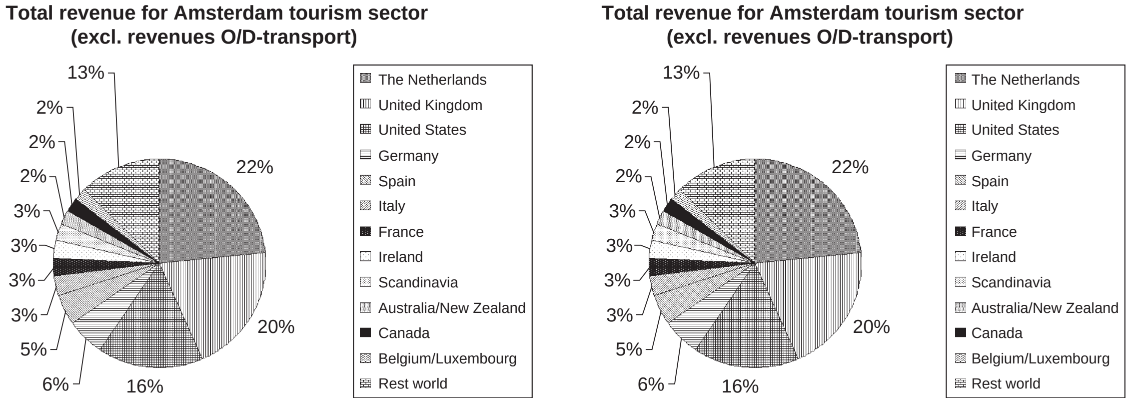

Fig. 1. CO_2-e emissions for O/D transport and revenues (excluding transport) by country, Amsterdam.

the most important "market" in terms of visitor numbers.

Revenues are calculated based on results of a visitor survey carried out by the Amsterdam Tourist Board in 2001/2002 (Amsterdam Tourist Board 2002). The reported daily spending by tourists varies between 60 (Eastern Europe) and 130 (USA). Fig. 1 shows the total revenue by country of origin. It becomes obvious that domestic visitors are the most important, accounting for 22% of the total. They are followed by tourists from the UK (20%), the USA (16%) and Germany (6%).

In order to calculate the eco-efficiency of different markets, CO_2-e emissions are divided by revenues. Fig. 2 shows that this factor is as low as 0.09 kg CO_2-e/€ for the Netherlands, and reaches a value of 3.18

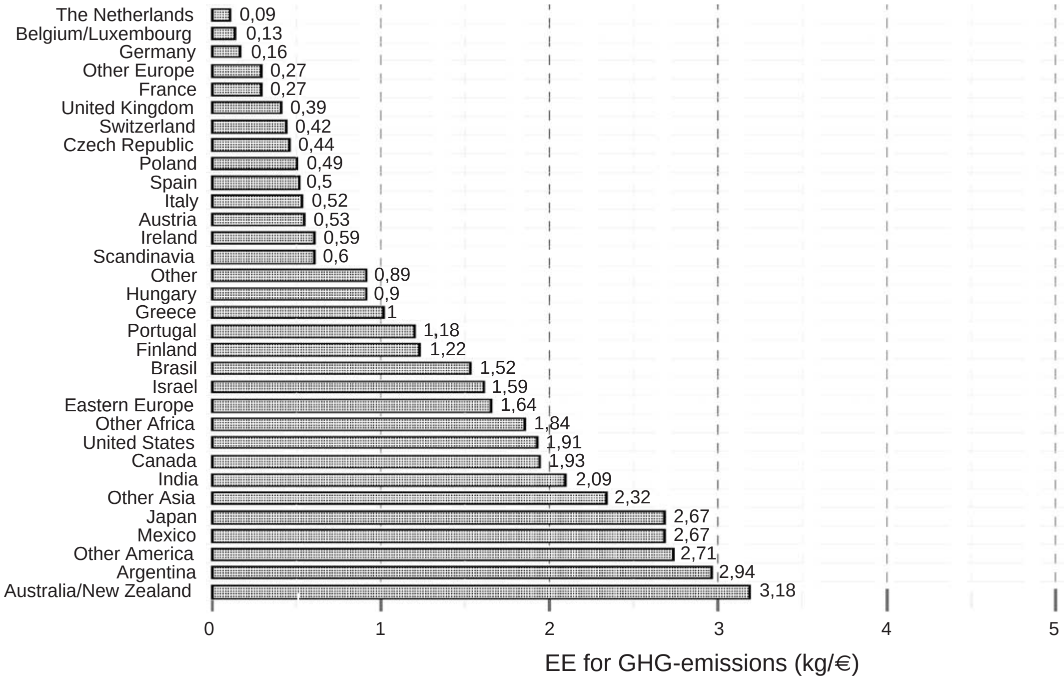

Fig. 2. Eco-efficiency by source market for Amsterdam, 2002.

kg CO_2-e/€ for Australia/New Zealand. This represents a factor of 85 difference in the eco-efficiency of the markets. The calculation includes all revenues within Amsterdam and weighted revenues from O/D-transport (Table 10).

Given the fact that the eco-efficiency of different tourist markets varies to such a large extent, one strategy to reduce the environmental impact of tourism to Amsterdam would be to replace markets with an eco-efficiency above average by those markets with an eco-efficiency below average. Currently, the demand for accommodation in Amsterdam is greater than the city's supply, and there is thus an opportunity to re-structure markets (e.g. by adjusting marketing campaigns). However, any restructuring needs to consider that the overall revenue from certain markets is of importance. For example, the USA have a rather unfavourable eco-efficiency, but a decrease in arrivals from the USA would also entail a substantial loss of revenue as the country accounts for a large share of overall tourist arrivals and hence tourism-derived income. Any pro-environmental restructuring of existing markets would thus need to consider economic aspects and structural dependencies. Given this situation, no marketing, less marketing, current marketing, or strong marketing are recommended (Table 9).

For example, the USA is an important market in terms of revenues, but they also have a very unfavourable eco-efficiency. As dependency on this market is very high (and thus a potential risk), future marketing should be cautiously reduced. Japan, Australia, New Zealand, Canada, and Asia are of less importance for the Netherlands in terms of revenue. As the eco-efficiency of these countries is unfavourable, there should be no marketing-campaigns in these countries. Of those countries with low environmental impact, the large and economically important markets UK and Netherlands should be maintained, and marketing thus be continued on current levels. Small markets whose growth should be encouraged by strong marketing campaigns include Germany, Belgium, France, Austria, and Switzerland.

Table 9
CO_2-e emissions and revenues by market, 2002

	Large market	Small market
Unfavourable eco-efficiency	Less marketing: USA	No marketing: Japan Australia/New Zealand Canada Asia
Favourable eco-efficiency	Current marketing: United Kingdom Netherlands	Strong marketing: Germany Belgium France Austria Switzerland

3.3. France

The case study is based on a national data set, the "Enquête aux frontieres", which is a survey of 100,000 tourists crossing French borders. The survey provides information on country of origin, means of transport used (when crossing the border), length of stay, region(s) visited, and preferred environments (i.e., urban, coastal, mountainous). The data used is from 1997, when the last survey suitable for the calculations in this article was carried out. Since then international tourism arrivals to France have grown by 20%. Statistics of expenses are provided by the Banque de France and the Ministry of Tourism (Maison de la France, personal communication 2004). Note that these do not include the cost of transport to France.

Transport distances for each nationality are calculated by using a starting point based on the spatial distribution of the respective countries' population. For each nationality, one or two entry points are chosen. For air transport, this is Paris (Charles de Gaulle airport), for surface-bound transport the most relevant border city adjacent to the visiting country. For each nationality, a distance is then determined between the point of entry and each of the visited 20 regions (i.e. considering both O/D transport and travel within France). Within the regions, the reference arrival point reflects the distribution of tourists within the region. However, while it is possible to differentiate the means of transport used by nationality, it is not possible to distinguish the means of transport used to reach the destination regions. For example, the analysis cannot consider whether Germans do travel more often by plane to the Mediterranean than they do to Alsace.

Road transport distances are calculated as real distances (derived from www.viamichelin.com 2004), which are also used for the calculation of distances travelled by rail. These are not adjusted by a detour factor. Furthermore, it should be noted that for transcontinental visitors who visit France and other European countries, total mileage to reach Europe (O/D travel) is taken into account. A weight factor is not used (as in the Amsterdam case study), which explains much of the difference between the results of this case study and the Amsterdam one. Not using a weight factor thus implies a small error, although–according to the Enquête aux frontiers–only 11% of all international tourists to France proceed to other European countries. As tourists can visit several regions during their stay in France, there is a potential problem of double-counting. To correct this, the number of stays in France was divided by the sum of stays in French regions for each nationality, resulting in a correction factor that was applied for analysis. Note that emissions from accommodation and activities are not considered in this study (Table 10). The eco-efficiencies calculated thus need to be seen as too favourable.

Fig. 3 shows that tourists from America and Asia account for 75% of the emissions, although they represent only 10% of the visitors and 24% of the revenue generated by foreign tourists.

Eco-efficiency ranges between 0.13 kg CO_2-e/€ for Swiss tourists (frequent visits to the close-by Alps, high expenditure) and 16 kg CO_2-e/€ for Latin American tourists (long travel distance, moderate expenditures). More generally, two categories of visitors can be distinguished, short haul and long haul tourists. The eco-efficiency of European tourists (short haul) is generally lower than 1.5 kg CO_2-e/€, while overseas visitors are generally above 3.5 kg CO_2-e/€. A more thorough analysis reveals further differences between the two categories. Fig. 4 is a combination of 3 parameters: total tourist expenditure by source country, total CO_2-e emissions, and eco-efficiency. The size of the bulb is proportional to the eco-efficiency (the bigger, the less efficient).

Fig. 4 shows that there are markets of great economic importance and unfavourable eco-efficiency (North America), such with little economic importance and highly unfavourable eco-efficiency (Latin America), and markets with relatively large economic importance and very positive eco-efficiency (Switzerland). The results show that for very short distances, a high level of expenditures noticeably improves eco-efficiency, but this is very quickly offset as distances grow. For example, Spanish tourists have the most unfavourable eco-efficiency in Europe despite a high level of expenditures (€ 70/day). This is clearly a result of the size of the country, with rather long travel distances to France, boosting air transport. However, the analysis also points at the limits of eco-efficiency

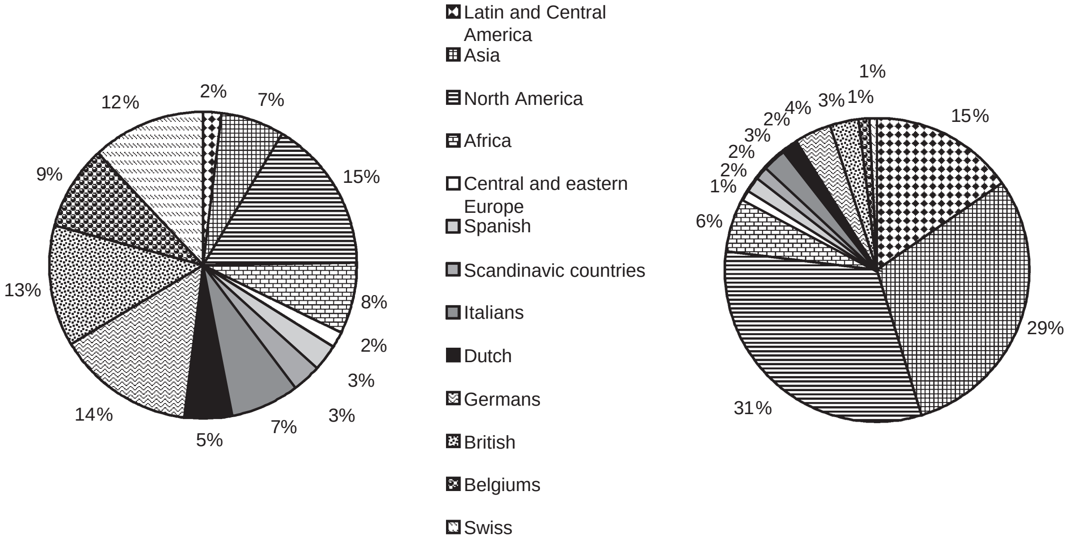

Fig. 3. Tourist expenditure (left) and CO_2-e emissions (right), inbound tourism, France.

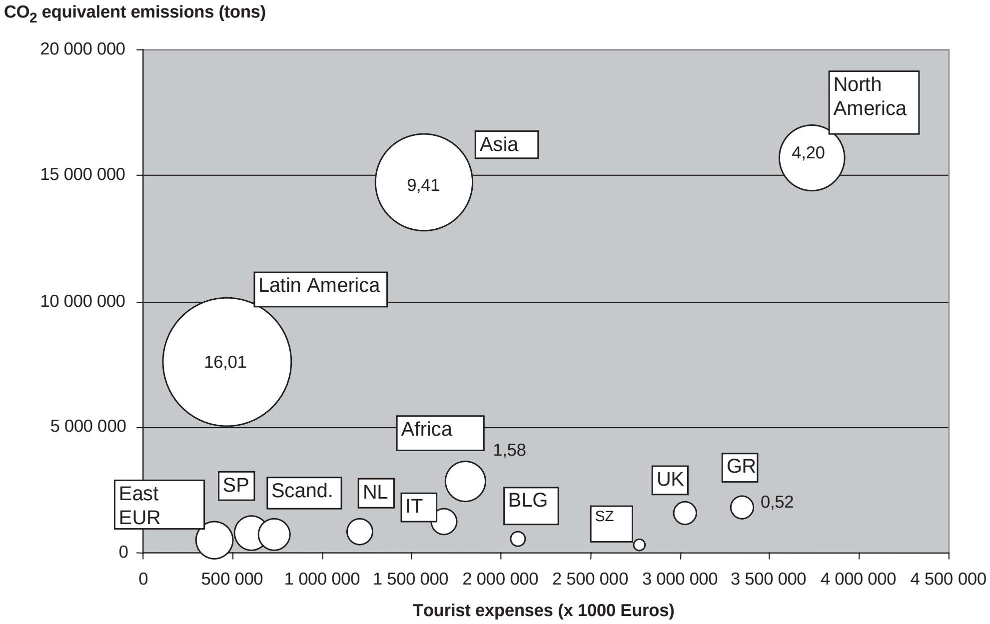

Fig. 4. Position of origin markets with regards to eco-efficiency.

as a measure for sustainability. For instance, Dutch tourists travel rather short distances and spend comparably little money, resulting in a mediocre eco-efficiency. Nevertheless, they are important for France as they often visit rural areas, where their expenditures–although minor–have great importance for the local economy. As for overseas countries, great differences in the eco-efficiency were found, ranging from 3.5 kg CO_2-e/€ (USA) to 16 kg CO_2-e/€ (Latin America). Note that even the lowest figure (3.5 kg CO_2-e per Euro revenue) is roughly six times the average of European countries. Clearly, distance is the most important variable influencing eco-efficiency. For example, although Japanese tourists spend more than those from the USA, they have a less-favourable eco-efficiency.

The analysis also hints at the importance of surface-bound means of transport. For example, the eco-efficiency of Eastern European countries such as Poland is comparable to that of Scandinavia or Spain, although these tourists spend less than half on a per capita per day basis. The reason for this is that they more often travel by bus than other tourists, and energy use per tourist is thus relatively low. Should Eastern European tourists arrive more frequently by car or aircraft in the future, emissions will increase substantially. In the context of the EU enlargement, infrastructure decisions, transport pricing policies, and taxation systems will strongly affect the future situation.

A comparison of the eco-efficiency of urban and rural environments shows that urban tourism has, relatively to other tourist spaces, a more favourable eco-efficiency for tourists from distant source markets, whereas this is the opposite for neighbouring countries: urban tourism is the most eco-efficient market for distant countries, the least for neighbouring countries. This paradox is a result of the tendency of neighbouring countries to participate in short urban trips, although in urban environments, tourists often use busses and trains. Germans spend 44% of their short stays and 21% of their long stays in urban environments, while US citizens spend 89% and 68% respectively in urban environments. For the latter, this results in a more favourable eco-efficiency because staying in a town (often close to the airport) entails lower emissions. Note, however, that the eco-efficiency of overseas tourists is generally far less favourable than that of neighbouring countries, with overseas tourists in mountainous and coastal environments having the least favourable eco-efficiency. More specifically, a look at the eco-efficiency of travel to different environments reveals that there is no

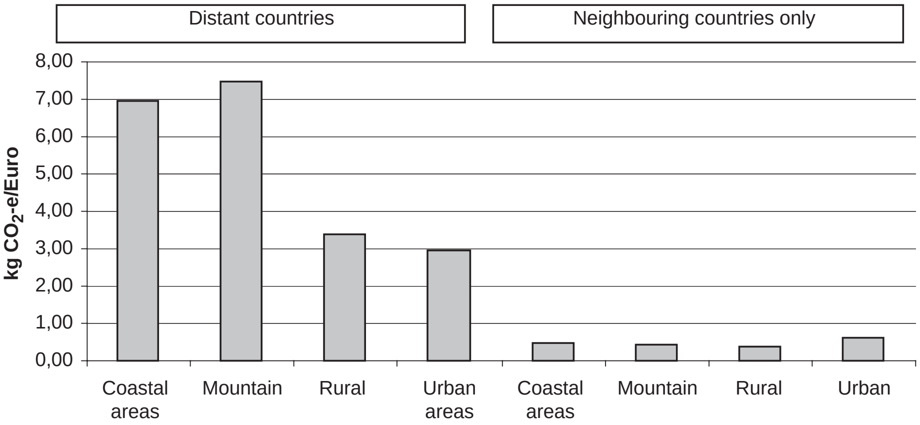

Fig. 5. Eco-efficiency of travel to different environments, France.

difference between these figures for neighbouring countries (Fig. 5).

More generally, long stays are more eco-efficient than short stays, since the impact of transport to the destination is distributed over a longer period. Nevertheless some categories of short stays have a better eco-efficiency than many long stays. For example, within neighbouring countries, no long stays supersede in eco-efficiency the short stays of the Swiss in towns and in the mountains, and only the long stays of the British in the countryside and of the Belgians in towns have a better eco-efficiency than the short stays of the Swiss in the countryside (Fig. 6).

3.4. Seychelles

The Seychelles are located in the Indian Ocean, with most visitors arriving by means of air transport. Out of 132,246 international tourist arrivals in 2002, 97.7% were by aircraft and 2.3% by sea. In terms of markets, Europe is the most important source region, accounting for 79.9% of all arrivals, the remainder falling on Africa (10.5%), Asia (6.5%), America (2.8%), and Oceania (0.3%). Five countries are of particular importance, the United Kingdom (with Eire), France, Germany, Italy, and Switzerland. Together, they account for 62.6% of all

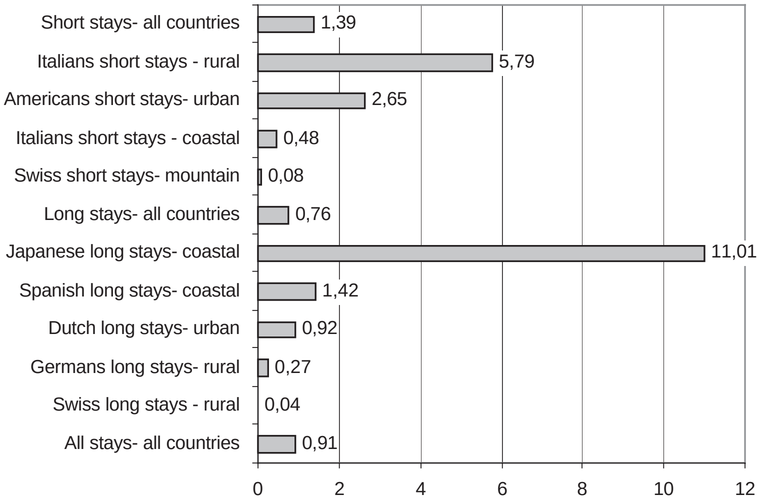

Fig. 6. Eco-efficiency of short versus long stays, different environments.

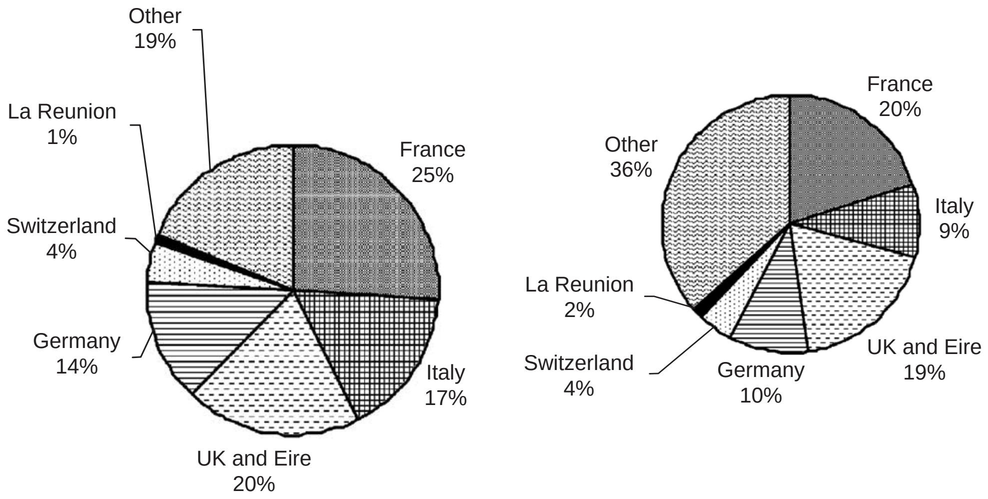

Fig. 7. CO_2-e emissions and revenue by country, 2002.

tourist arrivals. In terms of purpose of visit, the majority of the tourists come for leisure (88.5%), with 0.4% having both leisure/business motives, 4.9% arriving for business reasons, and the remainder (6.2%) being on transit. As the database does not distinguish business and leisure travellers, and those arriving by sea/air, the following calculations imply a small error. All data is derived from immigration/embarkation cards (MISD, 2004a), and expenditures are based on four tourist surveys (MISD, 2004b). Note that only expenditures for the most important source countries are available.

The analysis of CO_2-e emissions shows that O/D transport accounts for 96%, while accommodation contributes with 2%, other transport with 2%, and activities with less than 1% (for calculations see Gössling et al., 2002). According to this calculation, the 132,246 international tourists arriving in 2002 entailed 0.63 million tons of CO_2-e emissions. As shown in Fig. 7, a few countries account for the majority of emissions (including all transport, accommodation and activities; Table 10). For example, France generates 25% of all emissions, followed by UK/Eire (20%), Italy (17%), and Germany (14%). Together, these generate more than three-quarters of the total. Note that countries summarized in "other" are highly heterogeneous, including other European countries, Africa, Asia, America, and Oceania. Domestic tourism is not considered, as the islands are small, and locals do not usually stay in hotels.

The reported daily spending per tourist varies between €39.4 by Italians and €76.2 by tourists from Great Britain/Eire (MISD, 2004b; excluding O/D transport and accommodation). Fig. 7 shows the total revenue by country of origin. It becomes obvious that France and UK/Eire are the most important markets, each accounting for about one-fifth of the total revenues. They are followed by Germany and Italy, which account for about 10% each. Note that the total revue of €82.6 million is calculated based on expenditures per visitor by country. The figure needs to be seen as an estimate; the sum also differs from other official statistics, as the total is dependent on several factors, such as the exchange rate used, and differences in the assumed length of stay (embarkation cards vs. surveys). Purchases of foreign exchange reported by the Central Bank of Seychelles, for example, are far higher (cf. MTCA, 2001).

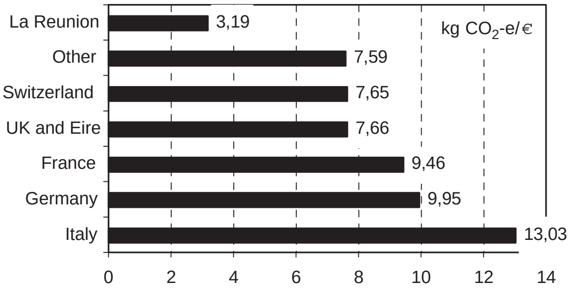

Fig. 8. Eco-efficiency by source market for the Seychelles, 2002.

In order to calculate the eco-efficiency of different markets, CO_2-e emissions are divided by revenues. Fig. 8 shows that this factor is as high as 3.19 kg CO_2-e/€ for visitors from La Reunion, and reaches a value of 13.03 kg CO_2-e/€ for Italians. The large differences between the European source countries are largely dependent on two factors, expenditure per day and average length of stay. For example, Swiss visitors stayed on average 11.9 days, spending € 57 per day, while Italian tourists only stayed 9.2 days, spending € 42 per day in 2002. These differences seem to be marginal, but result in 58% higher CO_2-e emissions per Euro revenue for Italian visitors. Note that eco-efficiencies are generally less favourable because the revenue from staying at hotels is only partially considered in the database provided by the Management and Information Systems Division (MISD, 2004b).

Future marketing strategies should have the primary goal to increase both the average length of stay of visitors as well as their expenditure per day. As shown by the example of Swiss/Italian tourists, an increase in average length by 2.7 days (22%) and in expenditure per day by € 15 (27%) will increase eco-efficiency by 58%. This is even of greater importance, as the average length of stay for European countries varies substantially. For example, tourists from the UK stayed on average 11.5 days in 2000, 9.6 in 2001, and 10.4 days 2002, while German tourists stayed for 13.7 days in 2000, 14.3 days in 2001, and 13.8 days in 2002. Given these fluctuations, it seems difficult to suggest a focus on a particular European market to improve the overall eco-efficiency of tourism in the islands. Clearly, the eco-efficiency of tourists arriving from Europe is very unfavourable even in the case of high spending countries such as Switzerland and the UK, while dependency on these markets is high. Apart from campaigns with the primary aim to increase the average length of stay, options to attract more visitors from La Reunion and other countries in the Western Indian Ocean should thus be explored.

3.5. Val di Merse

Val di Merse is located in the Province of Siena in Tuscany, Italy. The valley has a size of 508 km^2, a population of 13,600, and is dominated by rural agrarian activities. Tourist arrivals in Siena have grown 250% in the past 7 years to a total of 2,020,000. Whether tourism presents an eco-efficient alternative to investment in other sectors (manufacturing, agriculture, wine production) of the regional economy depends on tourism's eco-efficiency in comparison, as well as the composition of source markets (short or long haul). Currently, the largest share of tourists is domestic (31%), followed by visitors from Germany (22%), Great Britain (11%), The Netherlands (10%), and the USA (5%). The remaining 21% arrive from other European countries.

In the following, only emissions from O/D transport and accommodation are considered (Table 10). Tourism in Val di Merse is largely nature-based and relaxation-oriented, which results in very low energy use for activities (Patterson, 2004). For accommodation, an average of 20 kg CO_2-e is assumed per guest-night, the average length of stay being 5.35 days. The results show that the USA is responsible for 26% of CO_2-e emissions, followed by Germany (18%), Italy (13%), The Netherlands (7%), and Great Britain (6%). About half of the remaining 30% are from other European tourists, and half from tourists from other continents. As country-specific data is not available,

Table 10
Overview of calculations

	CO_2-e				Expenditures			
	Local transport	O/D transport	Accommodation	Activities	Local transport	O/D transport	Accommodation	Activities
Rocky Mountain NP	yes	no	yes	yes	yes	no	yes	yes
Amsterdam	no, <1%	yes	yes*	no (<6%)	yes	yes*	yes	yes
France	no, <1%	yes	no	no	yes	no	yes	yes
Seychelles	yes	yes	yes*	yes	yes	no	yes**	yes
Val di Merse, Tuscany	no	yes	yes	no	yes	no	yes	yes

No: data not included; yes: data included; *estimate; **only partially considered.

an average expenditure of € 72 per day per visitor has been used for calculations. This includes accommodation, food, activities, and car rental (APT, 2000; Patterson, 2004). Note that the use of an average expenditure per tourist reduces differences between the markets, as only two parameters–travel length and means of transport–influence the results. Assuming revenues of € 0.05/pkm for transport, eco-efficiency varies between 0.4 kg CO_2-e/€ for Italian visitors and 4.0 kg CO_2-e/€ for Australians and New Zealanders. The average eco-efficiency of tourism in Val di Merse is 0.85 kg CO_2-e/€. This rather low ratio is primarily a result of the small share (10%) of non-European tourists visiting the area.

3.6. Overview

Finally, an overview of the calculations is provided in Table 10. For a comprehensive analysis, both CO_2-e emissions and € turnover of local transport, O/D transport, accommodation and activities should be considered; data for each of these categories, however, is not in all cases available. This implies certain restrictions in the comparability of the case studies (for discussion, see case studies).

4. Discussion

Four questions were raised with respect to the eco-efficiency of tourism, which will be discussed in the following based on the results of the case studies. First, how much CO_2-e is emitted by the tourism industry to generate a unit of financial value? And do eco-efficiency ratios vary between destinations and countries? The case studies show that eco-efficiencies can vary substantially. As the example of France illustrates, EE ranges from a low of 0.04 kg CO_2-e/€ for Swiss tourists in the French countryside to a maximum of 16.01 kg CO_2-e/€ for Latin American visitors. Hence, the eco-efficiency of different tourist types in France varies by a factor of 400. All case studies show that travel distance to the destination is the most relevant factor contributing to an unfavourable eco-efficiency, and among different means of transport, air travel causes the most unfavourable eco-efficiencies. Factors influencing eco-efficiency in a favourable way are longer average lengths of stay and higher expenditures per day. Overall, and in order of importance, travel distance, means of transport, average length of stay, and expenditures per day are the factors influencing eco-efficiency.

Second, the question was raised whether tourism had a more favourable eco-efficiency than other sectors of the world economy. The World Gross Product was € 27.4 trillion in 1999, which can be compared to CO_2 emissions of 22.9 trillion kg (including fossil fuel burning and cement production; UNEP and Earthscan, 2002). Based on data by Houghton et al. (2001), Peeters calculated a global equivalence factor of 1.4 (excluding emissions from land use changes). The adjusted (CO_2-equivalent) world average eco-efficiency would thus be in the order of 1.18 kg CO_2-e/€, which can be compared to the results of the case

Table 11
Eco-efficiencies: tourism and global economy

	Eco-efficiency (kg CO_2-e/€)			Share of tourism with EE above world average (%)
	Average	Min	Max	
World	1.2	–	–	–
Amsterdam (including accommodation emissions; excluding transport revenues)	1.1	0.1	6.0	30
Amsterdam (including transport revenues)[a]	0.9	0.1	3.2	35
France (excluding transport revenues)	2.1	<0.1	16.1	n.a.
Seychelles (excluding transport and partially accommodation revenues)	7.6	3.2	13.0	100
Val di Merse (including transport revenues and accommodation emissions)	0.9	0.4	4.0	10
Rocky Mountains	2.43	–	–	n.a.

n.a.: no data available to calculate share.

[a] At € 0.05 per pkm.

studies (Table 11). An eco-efficiency above world average means that CO_2-e emissions per € turnover are higher than on world average.

All case studies show that there is a substantial share of tourism with an eco-efficiency less favourable than the world average. Based on the calculation of visitor arrivals by country, this share can range from 10% (Val di Merse) to 35% (Amsterdam) to 100% (Seychelles). Vice versa, a large share of tourism has an eco-efficiency more favourable than the world average (90% in the case of Val di Merse), even though evidence from our case studies suggests that tourism contributes to a less-favourable eco-efficiency on the global level, because the share of tourism with very unfavourable eco-efficiencies seems to push average values upwards. Particularly poor developing countries focusing on international tourism as a source of income may “buy” development at the cost of a comparably large global environmental impact. From an eco-efficiency point of view, one might thus generally question tourism originating in industrialized countries as a sustainable development tool for poor countries. This deserves mention because tourism is increasingly proposed as such by the tourist industry (Iwand, 2003), its organizations (WTO, 2002, 2004), and scientists (cf. Scheyvens, 2002). There is also evidence that long-haul tourism is on the increase, outpacing growth of short-haul tourism. Tourism is thus developing towards less-favourable global average eco-efficiencies.

However, in countries such as the Seychelles and also in rural areas of industrialized countries such as France, tourism may often be one of few options for economic development, and may thus be of overall importance for social welfare. One shortcoming of using eco-efficiency to assess tourism’s sustainability is therefore its limited suitability to make statements on the relative importance of revenues generated in certain locations or regions. While destination marketing in France could focus on European arrivals in the future, and thus have the potential to become sustainable, such a strategy will clearly not be possible for the Seychelles in the absence of close-by markets. Countries with unfavourable eco-efficiencies should thus seek to explore alternative development options (in the Seychelles, for example, tourism is only one of several pillars of the national economy) and try to attract a larger share of tourists with more favourable eco-efficiencies. Travellers from the developed world, on the other hand, should be encouraged to more consciously choose destinations.

This leads to the third question raised in this article: can eco-efficiency be used to make judgements on the integrated ecological/economic performance of different source markets? All case studies in this survey allow the identification of beneficial markets with favourable eco-efficiencies in juxtaposition to markets with unfavourable eco-efficiencies. For example, in Amsterdam and France, US tourists have a very unfavourable eco-efficiency, but they also form an important market share. In combination with the analysis of the relative overall economic importance of these markets, conclusions can be drawn as to which markets should be promoted or abandoned. The case study of Amsterdam, for example, shows that marketing in the USA should be reduced, and even stopped in Asia, Canada, Australia/New Zealand, and Japan. Marketing should instead focus on Germany, Belgium, France, Austria, and Switzerland. However, decisions of whether or not to promote certain markets should–as in the case of France–also consider the environments visited. Overseas tourists visiting rural and urban environments, for example, have a far more favourable eco-efficiency than those visiting coastal and mountainous environments. Furthermore, as shown for Rocky Mountain National Park, certain elements of a journey might have a particularly unfavourable eco-efficiency. For example, while the eco-efficiency for “accommodation” is below world average in RMNP, “activities” are clearly above, a result of high energy use and comparably low revenues. Overall, the case studies suggest that eco-efficiency can be an advanced tool to assess the combined environmental and economic performance of tourism, and it can help to reduce the environmental impacts of this industry in the economically most feasible way.

In order to use eco-efficiency as an assessment tool of sustainability, a benchmark for sustainability has to be found. According to different sources, sustainable emissions of CO_2 need to be some 80% lower than current emissions (cf. Graßl et al., 2003; Hasselmann et al., 2003; Thaler et al., 2000). Theoretically, a sustainable average world eco-efficiency would thus entail 80% less emissions per € of financial value generated. Given the current eco-efficiency of 1.18 kg CO_2-e/€, a sustainable EE would thus be in the order of 0.24 kg CO_2-e/€. Accordingly, tourism would on global average have to reach an eco-efficiency of 0.24 kg CO_2-e/€ in order to become sustainable. Nevertheless, as average values imply distribution above and below the mean, a share of tourism would remain unsustainable. On the journey level, the value of 0.24 kg CO_2-e/€ could thus serve as a benchmark for individual travel decisions. For instance, if tourists based their travel decisions on eco-efficiencies, all journeys with a value below or equal to 0.24 kg CO_2-e/€ could be depicted as sustainable, which would aid aware consumers in the destination decision-making process. However, under a scenario of growing global economic turnover, eco-efficiency ratios will need to continuously decrease, as total emissions need to remain constant at a sustainable level.

Finally, the question was raised whether it would be possible to identify sectors of the tourism industry that are particularly harmful for the environment and economically less beneficial. In terms of a general finding, the case studies suggest that the longer the travel distance, the less favourable becomes the eco-efficiency. Long stays improve eco-efficiency, as do high expenditures per day, although these two factors need to be particularly high in order to counter the negative effect of long travel distances.

5. Conclusions

The analysis has shown that tourism is not necessarily environmentally more beneficial than other economic activities, as claimed by the tourist industry. However, the case studies indicate great variations in eco-efficiencies, dependent on source and destination countries, tourist cultures, and the environments chosen for vacation (e.g. urban, mountain, etc.). For example, to generate one unit of financial value in the Seychelles, concurrent emissions of CO_2-e are seven times larger than the world average, while in France, some types of tourism have an eco-efficiency ratio less than one-tenth of the world average. Overall, the comparably small share of tourism with a particularly unfavourable eco-efficiency (e.g. tourism based on long-distance travel) seems to substantially increase tourism's world average eco-efficiency. With respect to sustainability, this article thus confirms earlier findings that air travel needs to be seen as the most problematic global environmental impact of tourism (cf. Gössling et al., 2002; Peeters, 2003). Clearly, short travel distances are a precondition for sustainability. More generally, our analysis reveals that travel distance and mode of transport are the most important factors influencing eco-efficiency. Eco-efficiencies can be positively influenced by an extended length of stay and higher expenditures per day.

Overall, we conclude that eco-efficiency is a useful concept to analyse the combined environmental and economic performance of tourism. The concept can help to assess the relative importance of different tourism sectors in terms of environmental impacts and financial value generation, and thus provide insights of how to improve its environmental performance in the economically most feasible way. The concept has also proved to be applicable on very different levels, including day-visits, journeys and destinations. It may be used to evaluate the eco-efficiency of destinations/markets, to identify "problematic" aspects of a journey (transport, accommodation, or activities), and to reveal differences between different forms of tourism (e.g., adventure-, nature-, eco-, cultural-, beach tourism) or tourist types (e.g. elderly rich, young adventurers, etc.). Eco-efficiency calculations may even help to make decisions in carbon emission trading, should the scheme be applied to economic sectors, such as tourism. Problems in applying the eco-efficiency concept arise from the need to gather detailed data on transport, accommodation, and activities, as well as revenues for the different source markets. This might often prove to be difficult. A more comprehensive use of the concept including indirect environmental impacts and economic multiplier effects is even more difficult. Furthermore, using eco-efficiency, we cannot make statements on the distribution of revenues, social (equity) aspects, or the importance of hazardous and toxic substances. Despite these shortcomings, eco-efficiency could become a more widely used tool for re-structuring tourism towards sustainability.

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