Tourism and Water Use: Supply, Demand and Security – An International Review

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Tourism and water use: Supply, demand, and security. An international review

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ABSTRACT

This article reviews direct freshwater consumption in tourism from both quantitative and qualitative viewpoints to assess the current water demand of the tourism sector and to identify current and future management challenges. The article concludes that even though tourism increases global water consumption, direct tourism-related water use is considerably less than 1% of global consumption, and will not become significant even if the sector continues to grow at anticipated rates of around 4% per year (international tourist arrivals). The situation differs at the regional level because tourism concentrates traveller flows in time and space, and often-in dry destinations where water resources are limited. Furthermore, the understanding of tourism's indirect water requirements, including the production of food, building materials and energy, remains inadequately understood, but is likely to be more substantial than direct water use. The article concludes that with expected changes in global precipitation patterns due to climate change, it is advisable in particular for already water scarce destinations to engage in proactive water management. Recommendations for managing tourism's water footprint are made.

1. Introduction

In the last 50 years global water use has tripled (Carbon Disclosure Project, 2010a). Water stress affects a large and growing share of humanity, with an estimated 450 million people already living under severe water stress in 1995 (Vörösmarty, Green, Salisbury, & Lammers, 2000). An additional 1.4–2.1 billion people live in water-stressed basins in northern Africa, the Mediterranean region, the Middle East, the Near East, southern Asia, northern China, Australia, the USA, Mexico, north eastern Brazil and the west coast of South America (Arnell, 2004; Vörösmarty et al., 2000), and up to 3.2 billion people would face water stress by 2100 under a 4 °C global climate change scenario (Parry et al., 2009a; Parry, Lowe, & Hanson, 2009b). These figures underline the importance of water management for humanity and are even more significant when bearing in mind the Millennium Development Goal target to halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation (United Nations Development Programme, 2007).

Water stress is a function of renewable fresh water availability, abstraction rates and the share of consumptive use. Global water use is increasing due to population and economic growth, changes in lifestyles, technologies and international trade, and the expansion of water supply systems. The most water-consuming activity is irrigation for agriculture, which accounts for 70 per cent of total water withdrawals and more than 90 per cent of consumptive water use (Bates, Kundzewicz, Wu, &Palutikof, 2008). Agriculture is also the most important factor in the future growth of water consumption (Bates et al., 2008; UNESCO, 2009). While strong growth in water demand can thus be expected, available water resources will decline in many regions because of the depletion of non-renewable fossil water resources (both groundwater and glacial ice), pollution of water bodies and groundwater sources, and climate change leading to declining precipitation levels and increased frequency of drought, increased evaporation, and changes in patterns of runoff (IPCC, 2007; Parry et al., 2009a; Parry et al., 2009b). The Carbon Disclosure Project

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Table 1
Selected water use and tourism parameters.

Country	Total natural renewable water resources (million m^3/year)	Desalinated water (million m^3(note 2)	Reused treated wastewater (million m^3/year) (note 2)	Total water use in 2000 (million m^3/year)	Total household water use (10^6 L/yr)	% of renewable water used	International Tourist arrivals 2000 ('000)	Growth rate tourist arrivals	International Tourist arrivals 2020 ('000)	Average length of stay, 2000	Water use per tourist per day (note 6)	Total Int. t.-related water use, 2000 (million m^3)
Mauritius	2210	0	0	612	16	27.7%	761	5.3	2138	10.4	400	3.17
Cyprus	780	0	11	244	62	31.3%	2470	2.5	4047	11	400	10.87
Malta	51	31.4	1.6	55	33	107.8%	1171	2	1740	8.4	400	3.93
Barbados	80	0	0	84	24	105.0%	548	4.3	1272	10.1	400	2.21
Spain	111,500	–	–	35,635	4576	32.0%	55,916	2.6	93,429	12.9	400	288.53
France	203,700	–	–	39,959	5814	19.6%	75,910	2.3	119,622	7.5	400	227.73
Switzerland	53,500	–	–	2571	276	4.8%	7229	1.7	10,127	8.1	150	8.78
Greece	74,250	–	–	7759	870	10.4%	14,276	2.1	21,633	8.1	400	46.25
Uruguay	139,000	0	0	3146	42	2.3%	1808	5.3	5079	6.9	150	1.87
Tunisia	4560	8.3	20	2726	364	59.8%	7106	3.1	13,086	6.6	400	18.76
Indonesia	2,838,000	0	0	82,773	4458	2.9%	5002	7.7	22,052	12.3	300	18.46
India	1,907,760	0	0	645,837	25,000	33.9%	3915	5.9	12,321	31.2	150	18.32
Ireland	52,000	–	–	1129	128	2.2%	7333	3.8	15,461	7.4	150	8.14
Israel	1670	–	–	2041	624	122.2%	1903	2.3	2999	15	300	8.56
Cape Verde	300	0	0	28	13	9.3%	198	3.6	402	7	300	0.42
Thailand	409,944	0	0	87,065	1655	21.2%	9579	6.9	36,381	7.8	300	22.41
United Kingdom	147,000	0	0	9541	2360	6.5%	29,970	3.4	58,492	8.1	200	48.55
Italy	191,300	–	–	44,372	7980	23.2%	36,513	2.1	55,330	8.1	400	118.30
Denmark	6000	–	–	1267	360	21.1%	4699	3.8	9907	8.1	200	7.61
Portugal	77,400	–	–	11,263	1095	14.6%	12,097	2.1	18,331	6.7	400	32.42
Germany	154,000	–	–	47,052	5093	30.6%	21,500	1.2	27,293	8.1	200	34.83
Finland	110,000	–	–	2478	264	2.3%	3140	3.8	6620	5.9	150	2.78
Brazil	8,233,000	0	0	59,298	11,529	0.7%	5358	5	14,216	12.1	300	19.45
South Africa	50,000	0	0	15,306	2261	30.6%	7518	8	35,041	8.1	300	18.27
Turkey	231,700	0.5	0	37,519	5680	16.2%	20,273	5.5	59,152	10	400	81.09
Bahrain	116	44.1	8	299	53	257.8%	3914	6.6	14,053	2.4	200	1.88
Dominican Republic	20,995	0	0	3386	913	16.1%	3691	5	9793	10	400	14.76
Norway	382,000	–	–	2185	400	0.6%	3859	3.8	8136	8.1	150	4.69
China	2,896,569	–	–	630289	26,275	21.8%	46,809	7.8	210,235	8.1	200	75.83
Morocco	29,000	3.4	0	12,758	1150	44.0%	5843	4.9	15,211	9	200	10.52
Hungary	104,000	–	–	7641	612	7.3%	10,048	0.7	11,552	8.1	200	16.28
Netherlands	91,000	–	–	7944	390	8.7%	10,012	1.9	14,588	2.7	150	4.05
Saudi Arabia	2400	714	217	17,320	1530	721.7%	9100	5.3	25,563	8.1	200	14.74
Austria	77,700	–	–	2112	792	2.7%	19,952	1.2	25,328	4.6	150	13.77
Japan	430,000	0	0	88,432	17,366	20.6%	6728	4.5	16,226	8	200	10.76
United States	3,069,400	–	–	479,293	60,749	15.6%	49,402	3.5	98,300	8.1	300	120.05
United Arab Emirates	150	385	108	2306	504	1537.3%	3907	7.1	15,404	8.1	200	6.33
Malaysia	580,000	0	0	9016	1397	1.6%	16,431	5	43,596	5.8	200	19.06
Sweden	174,000	–	–	2965	1044	1.7%	3133	3.8	6606	8.1	150	3.81
Trinidad & Tobago	3840	0	0	305	204	7.9%	399	4.3	926	8.1	400	1.29
Philippines	479,000	0	0	28,520	4432	6.0%	2623	7.7	11,564	8.8	300	6.92
Egypt	86,800	25	200	68,653	4620	79.1%	8244	7.4	34,373	6	400	19.79
Chile	922,000	0	0	12539	1015	1.4%	2027	4.7	5079	10.1	200	4.09
Bulgaria	21,300	–	–	10,498	417	49.3%	4837	4.6	11,891	8.4	150	6.09
Mexico	457,222	0	0	78,219	13,226	17.1%	21,915	3.6	44,457	9.9	300	65.09
Australia	492,000	–	–	23,932	9490	4.9%	5020	6.4	17,359	26	300	39.16
Republic of Korea	69,700	0	0	18,590	6162	26.7%	6023	4.1	13,453	8.1	200	9.76
Poland	61,600	–	–	16,201	1599	26.3%	15,200	4.2	34,610	4.8	150	10.94
Cuba	38,120	0	0	8204	2548	21.5%	2261	9.2	13,145	10.5	300	7.12
Argentina	814,000	0	0	29,072	4576	3.6%	3895	5.1	10,533	9.9	150	5.78
Russian Federation	4,507,250	0	0	76,686	14,649	1.7%	21,169	6.8	78,909	8.1	150	25.72
Czech Republic	13,150	–	–	2566	1107	19.5%	6336	4	13,883	3.5	200	4.44
Canada	2,902,000	–	–	45,974	8118	1.6%	18,768	3.6	38,073	5.2	150	14.64
Ukraine	139,550	0	0	37,523	4680	26.9%	4406	4.2	10,032	5.3	150	3.50
Romania	211,930	–	–	23,176	2080	10.9%	1430	2.8	2484	2.5	150	0.54
Totals	34,076,497	1212	566	2,886,364	272,674	8.5%	653,575	4.2%	1,501,535	8.5	286	1593

1) WTO (2001): 2) WTO (2001) regional average; 3) WTO (2001): 4) extrapolation based on growth rate; 5) weighted average; 6) Estimate by Gössling (2006). Categories: countries with i) high share of friends & relative related tourism, high percentage of small accommodation establishments or city hotels, high share of mountain tourism: 150 L per tourist per day (t/d), ii) Mediterranean & countries with high percentage of resort hotels: 400 L t/d, iii) other, individual judgement: 200–300 L t/d; 7) extrapolation does not consider increases/decreases in per tourist water use estimates; 8) Peeters and Dubois (2010): 9) source: Dorling (2007); *global average applied in absence of national data, calculation in Gössling (2002a). Table originally presented in Gössling (2006), and based on FAO (2003); WTO (2001, 2003); UNTWO (2010); UNWTO–UNEP–WMO (2008); WWF (2001, 2004).

Total Int tourism-related water use 2020 (million m^3)	Int. Tourism-related water use as % of total 2000	Int. Tourism-related water use as % of total 2020	Share of domestic water for int. tourism 2000	Domestic water use (note 9)	Domestic tourism (trips, note 8)	Net domestic tourism water use per night	Total domestic tourism water (million m^3)	Total Tourism water use	Domestic tourism share of domestic water use	International tourism share of domestic water	Total share
8.89	0.52%	1.45%	20.17%	13	632380	197	3.08	6.25	19.64%	20.17%	39.81%
17.81	4.45%	7.30%	17.43%	78	258138	184	1.24	12.11	1.99%	17.43%	19.42%
5.85	7.15%	10.63%	11.89%	83	212068	183	0.78	4.71	2.35%	11.89%	14.24%
5.14	2.64%	6.12%	9.40%	78	162749	184	0.72	2.93	3.06%	9.40%	12.46%
482.10	0.81%	1.35%	6.31%	112	47853461	178	260.46	548.99	5.69%	6.31%	12.00%
358.87	0.57%	0.90%	3.92%	97	110581890	181	355.60	583.33	6.12%	3.92%	10.03%
12.30	0.34%	0.48%	3.18%	38	13174153	67	17.06	25.85	6.18%	3.18%	9.36%
70.09	0.60%	0.90%	5.32%	79	8782982	184	31.12	77.37	3.58%	5.32%	8.89%
5.26	0.06%	0.17%	4.46%	12	1453856	73	1.73	3.60	4.11%	4.46%	8.57%
34.55	0.69%	1.27%	5.15%	38	4010240	192	12.10	30.86	3.32%	5.15%	8.48%
81.37	0.02%	0.10%	0.41%	21	79200275	146	337.50	355.96	7.57%	0.41%	7.98%
57.66	0.00%	0.01%	0.07%	24	359906297	70	1872.88	1891.21	7.49%	0.07%	7.56%
17.16	0.72%	1.52%	6.36%	33	1094255	68	1.32	9.46	1.03%	6.36%	7.39%
13.49	0.42%	0.66%	1.37%	99	6826685	130	31.66	40.22	5.07%	1.37%	6.45%
0.84	1.49%	3.01%	3.16%	26	176207	145	0.42	0.84	3.22%	3.16%	6.38%
85.13	0.03%	0.10%	1.35%	27	28396535	145	76.10	98.51	4.60%	1.35%	5.95%
94.76	0.51%	0.99%	2.06%	40	51729235	92	91.55	140.11	3.88%	2.06%	5.94%
179.27	0.27%	0.40%	1.48%	139	102717268	172	340.31	458.62	4.26%	1.48%	5.75%
16.05	0.60%	1.27%	2.11%	67	7739837	87	12.90	20.51	3.58%	2.11%	5.70%
49.13	0.29%	0.44%	2.96%	110	7312650	178	20.72	53.14	1.89%	2.96%	4.85%
44.21	0.07%	0.09%	0.68%	62	118930724	88	200.48	235.31	3.94%	0.68%	4.62%
5.86	0.11%	0.24%	1.05%	51	10128860	65	9.20	11.98	3.49%	1.05%	4.54%
51.61	0.03%	0.09%	0.17%	65	116616298	137	458.80	478.25	3.98%	0.17%	4.15%
85.15	0.12%	0.56%	0.81%	50	27165910	140	73.11	91.37	3.23%	0.81%	4.04%
236.61	0.22%	0.63%	1.43%	81	33131820	184	144.64	225.73	2.55%	1.43%	3.97%
6.75	0.63%	2.26%	3.57%	75	158505	85	0.08	1.96	0.15%	3.57%	3.72%
39.17	0.44%	1.16%	1.62%	106	4309247	179	18.29	33.06	2.00%	1.62%	3.62%
9.89	0.21%	0.45%	1.17%	89	8525806	57	9.38	14.07	2.35%	1.17%	3.52%
340.58	0.01%	0.05%	0.29%	20	455490233	96	840.58	916.41	3.20%	0.29%	3.49%
27.38	0.08%	0.21%	0.91%	38	13141443	92	25.94	36.46	2.26%	0.91%	3.17%
18.71	0.21%	0.24%	2.66%	62	1251864	88	2.11	18.39	0.34%	2.66%	3.00%
5.91	0.05%	0.07%	1.04%	24	16682315	70	7.50	11.56	1.92%	1.04%	2.96%
41.41	0.09%	0.24%	0.96%	65	15882165	87	26.57	41.31	1.74%	0.96%	2.70%
17.48	0.65%	0.83%	1.74%	98	10888857	55	6.59	20.36	0.83%	1.74%	2.57%
25.96	0.01%	0.03%	0.06%	136	300132715	73	414.86	425.62	2.39%	0.06%	2.45%
238.87	0.03%	0.05%	0.20%	209	625357944	108	1302.09	1422.14	2.14%	0.20%	2.34%
24.95	0.27%	1.08%	1.26%	174	4206132	65	5.28	11.61	1.05%	1.26%	2.30%
50.57	0.21%	0.56%	1.36%	58	8778800	88	10.68	29.74	0.76%	1.36%	2.13%
8.03	0.13%	0.27%	0.36%	117	17711966	52	17.56	21.37	1.68%	0.36%	2.05%
3.00	0.42%	0.98%	0.63%	157	869956	169	2.82	4.11	1.38%	0.63%	2.02%
30.53	0.02%	0.11%	0.16%	56	28072134	139	81.38	88.30	1.84%	0.16%	1.99%
82.50	0.03%	0.12%	0.43%	66	26114735	187	69.54	89.33	1.51%	0.43%	1.93%
10.26	0.03%	0.08%	0.40%	65	7133925	87	14.88	18.98	1.47%	0.40%	1.87%
14.98	0.06%	0.14%	1.46%	52	1086473	65	1.40	7.49	0.34%	1.46%	1.80%
132.04	0.08%	0.17%	0.49%	130	54439380	124	158.79	223.87	1.20%	0.49%	1.69%
135.40	0.16%	0.57%	0.41%	487	27840371	53	90.53	129.69	0.95%	0.41%	1.37%
21.79	0.05%	0.12%	0.16%	130	43960097	74	62.57	72.33	1.02%	0.16%	1.17%
24.92	0.07%	0.15%	0.68%	41	8983700	67	6.83	17.78	0.43%	0.68%	1.11%
41.41	0.09%	0.50%	0.28%	225	6065600	105	15.87	22.99	0.62%	0.28%	0.90%
15.64	0.02%	0.05%	0.13%	120	27991886	51	33.51	39.29	0.73%	0.13%	0.86%
95.87	0.03%	0.13%	0.18%	102	69776802	55	73.37	99.09	0.50%	0.18%	0.68%
9.72	0.17%	0.38%	0.40%	109	2881736	78	1.88	6.31	0.17%	0.40%	0.57%
29.70	0.03%	0.06%	0.18%	259	45477126	23	12.99	27.63	0.16%	0.18%	0.34%
7.98	0.01%	0.02%	0.07%	96	13706940	56	9.64	13.14	0.21%	0.07%	0.28%
0.93	0.00%	0.00%	0.03%	93	7203059	56	2.41	2.95	0.12%	0.03%	0.14%
3531.48	0.06%	0.12%	0.58%		2992316683	143	7681.43	9274.56	2.82%	0.58%	3.40%

(2010b) reports that future water shortages are an increasing concern for the world's largest companies, with more than half of the firms responding to a survey expecting problems with water in the next five years, including disruption from drought or flooding, declining water quality, increases in water prices, and fines and litigation relating to pollution incidents.

Tourism is both dependent on fresh water resources and an important factor in fresh water use. Tourists need and consume water when washing or using the toilet, when participating in activities such as ski or golf tourism (snowmaking and irrigation), when using spas, wellness areas or swimming pools. Fresh water is also needed to maintain the gardens and landscaping of hotels and attractions, and is embodied in tourism infrastructure development, food and fuel production (Chapagain & Hoekstra, 2008; Gössling, 2001; Hoekstra & Hung, 2002; Pigram, 1995; Worldwatch Institute, 2004). Recreational activities such as swimming, sailing, kayaking, canoeing, diving, or fishing are take place at lakes and rivers, which also form important elements of the landscapes visited by tourists (Gössling, 2006; Hall & Härkönen, 2006; Prideaux & Cooper, 2009). Many forms of tourism are also indirectly dependent on water, including, for instance, winter tourism (white winter landscapes), agritourism or wildlife tourism. Changes in the availability or quality of water resources can consequently have a concomitant detrimental impact on tourism, with many documented examples indicating the enormous costs associated with the ecological restoration of ecosystems such as the Everglades or Great Lakes in North America (UNESCO, 2009).

In light of this, the article examines tourism-related freshwater use and its significance for the sustainable use of freshwater resources. Tourism is typically overlooked as a salient sector in global scale discussions of water use and this paper examines whether this is justified by using a review of tourism-related water use studies to estimate fresh water consumption in tourism at the country level. The paper also provides a review of the wide range of fresh water uses in tourism, documented use conflicts, and discusses management issues related to water provision, abstraction, and efficient use of fresh water.

2. Water availability and use by country and sector

Fresh water availability is unevenly distributed between countries and within countries, where water scarce and water abundant watersheds can be only a hundred kilometres apart. For example, renewable per capita water resources range from 10 m^3 per year in Kuwait to more than 1,500,000 m^3 in the State of Alaska in the USA (in 2000; Food and Agriculture Organization (FAO), 2010). While many countries have vast water resources, desalination has become of major importance in some large industrialized countries such as the United States, Italy, Spain, as well as a range of island states. Some countries, particularly islands, have also started to import fresh water with tanker ships, including Bahamas, Antigua and Barbuda, Mallorca, the Greek Islands, South Korea, Japan, Taiwan, Nauru, Fiji and Tonga (Black & King, 2009; UNESCO, 2009).

The FAO distinguishes agricultural, domestic and industrial fresh water consumption. On global average, approximately 70 per cent of water use is for agriculture, 20 per cent for industrial and 10 per cent for domestic purposes, including households, municipalities, commercial establishments and public services (UNESCO, 2009; see also Bates et al., 2008). Considerable differences in these shares exist within countries and on an averaged per capita basis. For example, daily domestic water use varies between 12 L per capita in Bhutan (in 2000) and 1226 L (in 2005) per capita in Australia. On a global average, domestic water use is in the order of 160 L per capita per day (Gössling, 2006; based on WRI, 2003).

However, the impact of water use is dependent on abstraction rates in comparison to renewable water resources, and the share of consumptive uses. For instance, only about 10% of water used for snowmaking will sublimate or evaporate, while 90% will return to the regional water cycle (Smart & Fleming, 1985). In cases where water can be re-used, as is often the case with grey water, changed water properties (temperature, toxic components) can be more relevant in sustainability terms than the amount of water actually consumed.

As shown in Table 1, great differences exist between the most important tourism countries in terms of renewable water resources, desalination capacity, use of treated wastewater, and overall water use. For example, in countries such as Bahrain, Barbados, Israel, Malta, Saudi Arabia and the United Arab Emirates, water use exceeds renewable water resources by up to a factor 15. In many other countries, such as Poland, Republic of Korea, Ukraine, Mauritius, Germany, South Africa, Cyprus, Spain, India, Morocco, Bulgaria or Tunisia, a significant share of renewable water resources is used. In these, as well as other countries, considerable problems can be expected in the future, when water consumption is likely to grow. Furthermore, the values in Table 1 mask that in many countries water scarcity exists at the regional and local scale, but is not reflected in national water use statistics.

Table 1 also shows that international tourism generally accounts for less than 1 per cent of national water use. Barbados (2.6 per cent), Cyprus (4.8 per cent) and Malta (7.3 per cent) are exceptions, and indicate that islands with high tourist arrival numbers and limited water resources are more likely to face water conflicts. This becomes even more obvious when calculating the share of tourism-related water consumption in comparison to domestic water use, and when water consumption by domestic tourism is also considered. As shown in Fig. 1, the proportion of water consumption by the tourism sector is typically below 5 per cent of domestic water use, but can be as high as 40 per cent (Mauritius). In the 54 countries included in this analysis, comprising the world's most important tourism countries (by arrivals) and a sample of highly tourism-dependent islands (high percentage of GDP), the tourism sector was found to represent greater than 10 per cent of domestic water use in 19 of them. This finding suggests that national-scale discussions of water security should not overlook tourism as a sector.

By 2020, tourism's contribution to water use is likely to increase with i) increased tourist numbers, ii) higher hotel standards and iii) the increased water-intensity of tourism activities (cf. UNWTO–UNEP–WMO, 2008, see also Tables 2 and 5 below). The World Tourism Organization (2003) maintains projections of its *Tourism 2020 Vision* (WTO, 2001) and forecasts over 1.56 billion international arrivals by the year 2020. To these figures, about 5 times the number of domestic tourism trips would have to be added, assuming the current (2005) ratio of international to domestic tourism (cf. UNWTO–UNEP–UNWTO, 2008). Higher average hotel standards, identified as a trend by UNWTO–UNEP–WMO (2008), are likely to go along with increasing water use, because of spas, wellness areas, or swimming pools, but also greater indirect water demands for higher-order foods and an increase in average fossil fuel use per trip. Growth in water-intense tourism activities, such as golf or skiing, will also lead to greater water consumption in the sector. For example, the US and EU countries added over 3000 new golf courses each between 1985 and 2010, with much of this development in areas with limited water resources (e.g., Arizona, Texas, Spain) (Scott, Hall, & Gössling, 2011). Future development of new courses is anticipated to be strongest in China, the Mid-East, South East Asia, South Africa and Eastern Europe; many of which are expected to face water shortages in the decades ahead (Arnell, 2004; Bates et al., 2008). Although the number of ski areas and skiable terrain has increased slowly over the past 25 years (with the exception of some emerging markets such as China), the proportion of skiable terrain covered by snowmaking has grown substantially (OECD, 2007; Scott, 2005) and

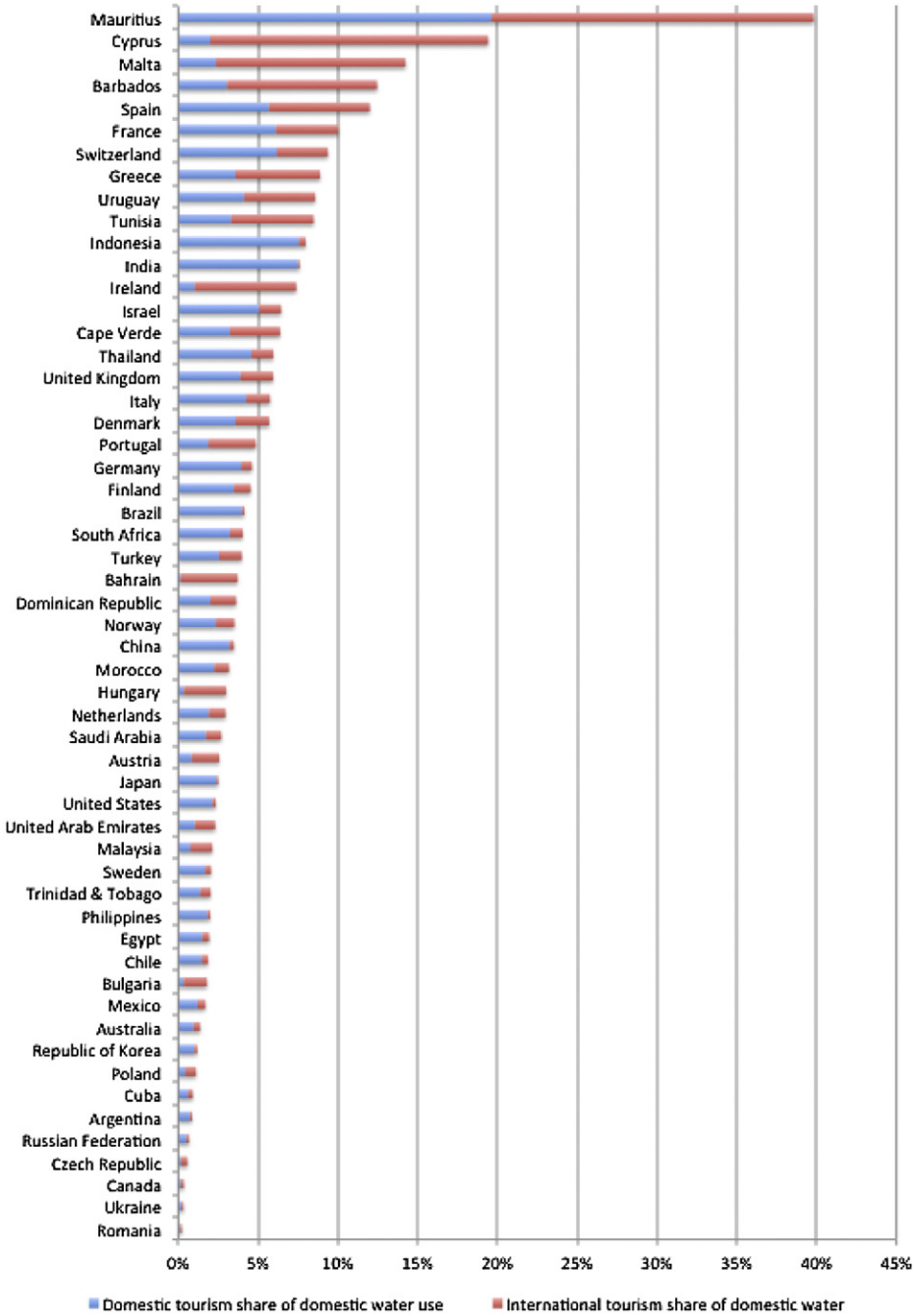

Fig. 1. Share of domestic and international tourism in national domestic water use.

this trend is expected to continue as ski areas seek to reduce their vulnerability to recent climate variability.

These developments must also be considered against the background of observed and anticipated changes in hydrological cycles anticipated under climate change, including:

1. Observed changes in large-scale hydrological cycles over the past 50–100 years include, regional changes in precipitation patterns, changes in precipitation intensity and extremes, reduced snow cover and widespread melting of glacial ice, as well as changes in soil moisture and runoff.
2. Climate models project annual increases in precipitation in the high latitudes and parts of the tropics, and decreases in sub-tropical and lower mid-latitude regions.
3. Climate models also project an increase in annual average river runoff and water availability in high latitudes and some wet tropical areas, and decreases over dry regions at mid-latitudes and in the dry tropics.
4. Increased precipitation intensity and variability are also projected, resulting in greater likelihood of flooding and drought in many areas.
5. Higher water temperatures and changes in extremes, including floods and droughts, will affect water quality and exacerbate many forms of water pollution.
6. Changes in water quantity and quality would also affect food availability, stability, access and utilization.
7. The operation of existing water infrastructure, including hydropower, structural flood defences, drainage and irrigation

Table 2
Water use per tourist per day, various tourism contexts.

Country/region	Accommodation type	Water use per tourist per day	References
Mediterranean	Mostly hotels	250 L	Grenon and Batisse (1991), quoted in GFANC (1997)
Mediterranean	Campsites	145 L	Scherb (1975), quoted in GFANC (1997)
Mediterranean	All accommodation	440–880 L	WWF (2004)
Benidorm, Spain	Campsites	84 L	Rico-Amoros, Olcina-Cantos, and Sauri (2009)
Benidorm, Spain	1 star hotel	174 L	Rico-Amoros (2009)
Benidorm, Spain	2 star hotel	194 L	Rico-Amoros (2009)
Benidorm, Spain	3 star hotel	287 L	Rico-Amoros (2009)
Benidorm, Spain	4 star hotel	361 L	Rico-Amoros (2009)
Tunisia	Hotels	466 L	Eurostat (2009)
Morocco	Apartment	180 L	Eurostat (2009)
Morocco	3 star hotel, or villa	300 L	Eurostat (2009)
Morocco	4 star hotel	400 L	Eurostat (2009)
Morocco	5 star hotel	500 L	Eurostat (2009)
Morocco	Luxury 5 star hotel	600 L	Eurostat (2009)
Sarigerme, Turkey	4 star hotel	400 L–>1000 L	Antakyali et al. (2008)
Sharm El Sheikh, Egypt	Hotels/resorts	≤500 L (per bed)	Hafez & El Manharawy (2002)
Sharm El Sheikh, Egypt	5 star hotels	1410–2190 L (per room)	Lamei et al. (2006) in Lamei (2009)
Sharm El Sheikh, Egypt	Hotels	400 L	Lamei, Tilmant, et al. (2009) and Lamei, von Münch, et al. (2009)
Zanzibar, Tanzania	Guesthouses	248 L	Gössling (2001)
Zanzibar, Tanzania	Hotels	931 L	Gössling (2001)
Zanzibar, Tanzania	Hotels & guesthouses	685 L (weighted average)	Gössling (2001)
Jamaica	Unclear	527–1596 L (average 980 L)	Meade and del Monaco (1999), quoted in Bohdanowicz and Martinac (2007), and Antakyali et al. (2008)
Thailand		913–3423 L (per room)	CUC and AIT (1998), quoted in Bohdanowicz and Martinac (2007)
Philippines	4 star hotel	1802 L (per room)	Alexander (2002)
Philippines	Unclear	1499 L (per room)	Alexander and Kennedy (2002), quoted in Bohdanowicz and Martinac (2007)
Hong Kong	Hotels	336–3198 L (per room)	Deng and Burnett (2002)
Australia	Hotels	750 L (per room)	Australian Institute of Hotel Engineers (1993), quoted in Bohdanowicz and Martinac 2007
Australia	Large Hotels	300 L (per room)	The Natural Edge Project (2008)
Melbourne, Australia	Various	227–435 L	City West Water (2006)
USA	Unclear	382–787 L (per room)	Davies and Cahill (2000), quoted in Bohdanowicz and Martinac (2007)
Las Vegas, USA	Hotels/resorts	303L	Cooley, Hutchins-Cabibi, Cohen, Gleick, and Heberger (2007)
Seattle, USA	Hotels – various	378–1514L (per room)	O'Neill, Siegelbaum and The RICE Group (2002)
Germany	Unclear	90–900 L (average 340 L)	Despretz (2001), quoted in Bohdanowicz & Martinac 2007 and Antakyali et al. (2008)
Germany	Unclear	275 L	Nattrass and Altomare (1999), quoted in Bohdanovicz and Martinac (2007)
Scandinavia	Hilton chain	516 L	Bohdanovicz and Martinac (2007)
Scandinavia	Scandic chain	216 L	Bohdanovicz and Martinac (2007)
Coastal Normandy, France	Second home	102 L	Langumier and Ricou (1995)
Coastal Normandy, France	Campsite	92 L	Langumier and Ricou (1995)
Coastal Normandy, France	Hotel-restaurant	259 L	Langumier and Ricou (1995)
Coastal Normandy, France	Hotel	175	Langumier and Ricou (1995)
Coastal Normandy, France	Other tourist accommodation	115 L	Langumier and Ricou (1995)
Coastal Normandy, France	Main home	114 L	Langumier and Ricou (1995)

systems, and water supply and treatments systems will be affected by these ongoing and future climate-induced hydrological changes. (Bates et al., 2008)

Examination of the countries where tourism represents a more substantive sectoral user of water, i.e. the 19 countries in Table 1 where tourism represents >5% of total use, revealed that 12 of 19 are projected to have lower annual precipitation and lower annual runoff under climate change (a 15 model ensemble mean for the SRES A1B scenario for the 2080s – IPCC, 2007). When increased evaporation is also considered, 15 of 19 countries are projected to have reduced annual soil moisture. While further analysis is needed to examine whether the seasonal timing of increased precipitation in 7 of the 19 countries coincides with peak tourism arrivals and could therefore potentially contribute to alleviating tourism-induced water use pressure, in the majority of countries where tourism is a more significant sectoral water user, climate change is projected to exacerbate current water demand and scarcity problems. Sub-national scale analysis reveals additional climate change-induced water challenges emerge for some prominent and emerging tourism destinations, including in the southwestern USA, southern Australia, central-coastal Brazil, the Middle East, and central and southern China.

Throughout many of the regions where reduced runoff and soil moisture are projected, drought frequency and intensity are also projected, which will further test water supply systems in extreme

years. For example, in large parts of the European Mediterranean, the current 1 in 100 year drought is projected to occur once a decade in the latter part of the 21st century (IPCC, 2007). Furthermore, Black and King (2009) identify a range of important tourism countries that will be chronically short of water by 2050, including Tunisia, Malta, Morocco, South Africa, Cyprus, Maldives, Singapore, Antigua and Barbuda, St. Kitts and Nevis, Dominica, and Barbados.

Overall, these figures illustrate that even though water use in the tourism sector is typically less than 1 per cent of national water use, the situation may be different on the regional level, particularly where water may already be scarce and the number of tourists is substantial. In the future, tourism in many regions will face considerably greater problems with regard to water availability and quality due to increasing water use and climate change. As these changes are likely to affect individual tourism businesses in water scarce regions in particular, the following section will review water uses in tourism to establish the major categories of water use (and where water management initiatives might best be focused) and provide a better understanding of the water footprints of various types of holidays.

3. Water use by tourists

In comparison to other economic sectors, such as agriculture, there are no specific regional or national water use statistics for tourism, and tourism-related water use is still under investigated. The following sections discuss the range of estimates for direct (Accommodation, Activities) and indirect water use (fossil fuel use for transports, food, infrastructure) available in the literature.

3.1. Accommodation

The literature suggests water consumption rates in a range between 84 and 2000 L per tourist per day, or up to 3423 L per bedroom per day (Table 2). A considerable share of these volumes can be staff related, with for instance Lamei, Tilmant, van der Zaag, and Imam (2009) and Lamei, von Münch, van der Zaag, and Imam (2009) reporting use values of 250 L per day per person in staff housing and 30 L per day for each staff during working hours. Overall, there is a tendency for higher-standard accommodation to consume significantly higher water volumes, with Bohdanowicz and Martinac (2007) finding highest water use rates in hotels with spas and large or multiple swimming pools (see also Table 5). Water-intensive facilities typically have landscaped grounds, requiring irrigation. Higher laundry volumes per guest per day are a result of sport and health centres, as well as affected by textile quality and/or weight of laundry items, including very large towels for spa facilities or beach use. On global average, it has been suggested that an international tourist consumes 222 L per day (Gössling, 2005), but evidence from the newer studies summarized in Table 2 suggests this estimate should be considered conservative.

With regard to water use categories and shares, various factors are found to influence water use, including the geographical location of accommodation establishments (climate zone, urban-rural) as well as the hotel structure (high-rise, resort style) and comfort standard (e.g. campsite, 1–5-star hotel). According to one study of hotels in a tropical environment (Zanzibar, Tanzania – Gössling, 2001), most water in hotels was used for continuous irrigation of gardens (50 per cent, or a weighted average of 465 L per tourist per day), a result of the poor storage capacity of the soils, high evaporation, and plant species not adapted to arid conditions. In contrast, in guesthouses, the second dominant accommodation category, irrigation accounted for only 15 per cent of the total water use (37 L per tourist per day). The major proportion of water in guesthouses was spent for direct uses including taking showers, flushing the toilet, and the use of tap water (55 per cent, 136 L per tourist per day), with a corresponding consumption of 20 per cent or 186 L per tourist per day in hotels. The higher demand of hotel guests was found to be a result of additional showers taken after swimming, and more luxurious bathroom facilities. Swimming pools represented another important factor of water use, accounting for about 15 per cent of the water demand of hotels (140 L per tourist per day). Indirectly, swimming pools added to laundry, for example when additional towels were handed out to guests. Guesthouses in the study area did not have swimming pools, which can partially explain lower water use rates. Laundry accounts for about 10 per cent (25 L per tourist per day) of the water used in guesthouses and 5 per cent (47 L per tourist per day) in hotels. Cleaning adds 5 per cent to the water demand in both guesthouses (12 L per tourist per day) and hotels (47 L per tourist per day). Finally, restaurants in guesthouses account for 15 per cent of the water used in guesthouses (37 L per tourist per day) and for 5 per cent (47 L per tourist per day) in hotels (Gössling, 2001).

Considerably different results were presented by Smith, Hargroves, Desha, and Stasinopoulos (2009) for hotels in Australia, where major areas of water usage included guest rooms (42%), followed by kitchens (16%), laundry (15%), public toilets (12%), cooling towers (10%), irrigation (3%) and swimming pools (2%; no absolute water use figures presented). Yet another study of two hotels in Seattle, USA identified kitchens and public areas as the major factor in water use, followed by guest showers, guest toilets, laundry, leaks, cooling towers, guest floor ice and guest sinks (O'Neill, Siegelbaum, & the RICE Group, 2002). Finally, a study of water use in the Iberotel Sarigeme Park hotel in Turkey found that kitchen and laundry together constituted the largest water use (30 per cent), followed by swimming pools (20–25 per cent), and guest rooms (12 per cent) (Antakyali, Krampe, & Steinmetz, 2008).

Deng and Burnett (2002) undertook a study of water use in hotels in Hong Kong, assessing water use performance by using a Water Use Index (WUI, m^3/m^2), which is defined as the total annual water consumption divided by the total floor area of a hotel. The study found:

- The WUIs varied significantly from one hotel to another, the maximum 7.7 m^3/m^2 and the minimum 2.1 m^3/m^2, with the average being 4.5 m^3/m^2. This reflects the diversified water use situations in Hong Kong hotels.
- The averaged WUI for the ten hotels with an in-house laundry was significantly higher (5.1 m^3/m^2) than that for the other seven hotels (3.6 m^3/m^2).
- The average WUI for five-star hotels was 5.1 m^3/m^2, and those for four-star and three-star hotels were 4.1 and 3.3 m^3/m^2, respectively. This again confirms that higher-class hotels consume more water than lower-class hotels.

3.2. Activities

Various tourist activities add to water use, with prominent examples being golf and skiing where snowmaking is utilized. The consumption of water by golf courses varies considerably, depending on soils, climate and golf course size (Baillon & Ceron, 1991; Ceron & Kovacs, 1993; Throssell, Lyman, Johnson, Stacey, & Brown, 2009). For instance, a standard golf course may have an annual consumption of 80,000 m^3–100,000 m^3 in the North of France and 150,000 m^3–200,000 m^3 in Southern France. Much higher values can be found in dry and warm climates. For instance, Van der Meulen and Salman (1996) report that an 18-hole golf course in a Mediterranean sand dune system is sprinkled with

0.5–1 million m^3 of fresh water per year. In a large-scale study of golf courses in the USA, Throssell et al. (2009) found annual water use varied from an average of 52,000 m^3 in the Northeast to 566,000 m^3 in the desert states of the Southwest. Likewise, snowmaking can be highly water intense. In France, for instance, snowmaking accounted for 19 million m^3 of water use in 2007, of which about 70 per cent is runoff (Badré, Prime, & Ribière, 2009). Snowmaking in the US in 2004/05 was estimated to use approximately 60 million m^3 (Scott et al., 2011), but could be substantially higher as the assumptions used in the analysis were conservative.

Convention, event and attractions infrastructure can add to water demand (e.g. Meyer & Chaffee, 1997; Sebake & Gibberd, 2008; Zaizen, Urakawa, Mutsumoto, & Takai, 2000). For example, a study of the Millennium Dome in London indicated that in 2000, each of the six million visitors used about 22 L of water, 48 per cent of this for toilet flushing, 32 per cent for cleaning and canteen use, 13 per cent for hand washing, and 7 per cent for urinal flushing (Hills, Briks, & McKenzie, 2002).

3.3. Infrastructure

Although there is insufficient research of water within the life-cycle of tourism infrastructure, Roselló-Batie, Molá, Cladera, and Martinez (2010) report that the use and construction of buildings are responsible for 17 per cent of water consumption worldwide. In a life cycle analysis of three hotels in the Balearic Islands they found that water accounted for about 5 per cent of the total mass of the construction materials. According to Low (2005), concrete is the second most consumed material in the world after water, with Van Oss and Padovani (2003) estimating that the annual worldwide water consumption for cement hydration is approximately one billion m^3 of water. Tourism's contribution to this is likely to be substantial given that the major end uses of concrete are residential buildings (31 per cent), highways and roads (26 per cent) and industrial and commercial buildings (18 per cent) with increasing second home ownership being a significant driver of increased demand in building materials (Low, 2005).

3.4. Fuel use

As outlined by UNESCO (2009) energy and water use are interlinked, as water is needed for energy production (e.g. thermoelectric cooling, hydropower, minerals extraction and mining, fuel production, emission controls). Energy is also used for water production (pumping, transport, treatment, desalination). In particular fuel production is water-intense, with the Worldwatch Institute (2004) reporting that it takes 18 L of water to produce 1 L of gasoline. As air travel entails an average energy consumption of 4.1 L of fuel per passenger for every 100 km of flight distance (UNWTO–UNEP–WMO 2008), the average international air-based tourist trip over 7600 km (return distance) would consequently lead to embodied, "virtual" water use of 5600 L. This would be equivalent of the direct water use associated with a stay in a higher-standard resort hotel over a 14-day period (at 400 L per tourist per day).

Biofuels, currently seen by industry as having the greatest potential for providing sustainable fuels, in particular for air transport (e.g. IATA, 2009), will also increase water use. For instance, UNESCO (2009: 11) reports that 44 km^3 or 2 per cent of all irrigation water are already allocated to biofuel production, with the realization of all current national biofuel policies and plans requiring an additional 180 km^3 of irrigation water. Water use for the production of bioethanol from sugarcane, corn, sugar beet, wheat and sorghum tripled between 2000 and 2007, and production of biodiesel from oil- and tree-seeds such as rapeseed, sunflower, soybean, palm oil, coconut and jatropha even increased 11-fold between 2000 and 2007. The production of 1 L of liquid biofuels currently takes on global average 2500 L of water. Most of these biofuels are consumed in the European Union, the United States and Brazil, now including 23 per cent of maize production in the US (ethanol production) or 47 per cent of vegetable oil produced in the EU (biodiesel) - and necessitating higher imports of vegetable oil to meet domestic consumption needs. Yet, biodiesel accounts for only 3 per cent of fuel use in the European Union so far (UNESCO, 2009).

3.5. Food

Considerable amounts of water are also embodied in food consumption. UNESCO (2009) reports, for instance, that depending on local climate, cop varieties and agricultural practices, it takes 400–2000 L of water to produce 1 kg of wheat or 1000 to 20,000 L of water to produce one kg of meat, depending on animal, feed and management. Based on these figures, it is estimated that daily water requirements to support human diets range from 2000 to 5000 L of water per person per day, with an estimate of 1 L of water for 1 kcal of food. Of importance in the context of tourism is the fact that tourists may consume a greater share of higher-order, protein-rich foods with greater water footprints, while also requiring additional energy for transport by air over large distances, for instance in the case of small islands (Gössling Garrod, Aall, Hille, & Peeters, 2011). In conclusion, a 14-day holiday may involve water use for food exceeding 70 m^3 of water.

Overall, water use in tourism can be considerable, and higher than currently assumed in the literature. As shown in Table 3, indirect water use is likely to be more relevant than direct uses, within particular food consumption and fuel use constituting important consumption categories – also because a higher share of this water use appears to be consumptive, i.e. lost to regional water cycles and unavailable for re-use, for instance as grey water. Moreover, Table 3 reveals that overall water use embodied in a holiday will vary considerably, depending in particular on hotel standard, distance to the destination, as well as the type and amount of food consumed. These results would indicate that water management in tourism should look beyond direct water use, and have a close look at "sustainable" solutions currently seen as promising, such as the greater use of biofuels in global transports.

4. Further aspects of tourism and water consumption

The following sections examine in more detail three important aspects of the sustainability of global tourism-related water use, including i) spatial and temporal aspects of water use, ii) changes in water quality, and iii) competing water uses.

The world's major tourism flows occur between six regions, North America, the Caribbean, Northern and Southern Europe, North East Asia and South East Asia (WTO, 2003). Of the 715 million international tourist arrivals in 2002, 58 per cent took place within

Table 3
Water use categories and estimated use per tourist per day.

Water use category – direct	L per tourist per day
Accommodation	84–2000
Activities	10–30
Water use category - indirect	L per tourist per day
Infrastructure	n.a.
Fossil fuels	750 (per 1000 km by air/car)
Biofuels	2500 (per 1 L)
Food	2000–5000
Total per tourist per day	Estimated range: 2000–7500

Europe, 16 per cent in North and South East Asia and 12 per cent in North America. Together they represent 86 per cent of all international tourist arrivals. Within sub-regions, about 87 per cent of all international arrivals in Europe are from Europe itself (some 350 million arrivals), while 71 per cent of international arrivals are regionally in the Americas (92 million), and 77 per cent in the Asia Pacific region (88 million). Six major tourist flows characterize international travel: Northern Europe to the Mediterranean (116 million), North America to Europe (23 million), Europe to North America (15 million), North East Asia to South East Asia (10 million), North East Asia to North America (8 million) and North America to the Caribbean (8 million).

Because tourists use more water when on holiday, here estimated at an average of 300 L per day (direct water use), than at home (160 L per day), tourism increases global water use; an argument also supported by Eurostat (2009: 16):

> Water consumption by hotels is far higher than household consumption, due largely to the collective consumption of water in hotels (watering of gardens that must be kept attractive, daily cleaning of rooms, filling of swimming pools, kitchen and above all, doing the laundry). Furthermore, holidaymakers have a 'pleasure' approach to the shower or bath and generally use more water than they would normally.

Furthermore, each tourist travelling to another region increases water use in the destination, while there is possibly a concomitant reduction of water use at home (Gössling, 2005). Fig. 2 indicates that tourism causes water use shifts from water-rich to water-poor areas at large continental scales (shifts from Northern to Southern Europe, shifts from Europe and North America to the Caribbean), but possibly also at regional scales (e.g. shifts to coastal zones, cf. Eurostat, 2009). Given the limited understanding of water use in various regions, as well as actual reductions at home, the actual geographic changes in water use because of tourism remain somewhat uncertain.

Exacerbating these findings is that tourists may often arrive during the dry season, when rainfall drops to a minimum and water availability is restricted (e.g. Eurostat, 2009; Gössling, 2001; WWF, 2004). For instance, in the French Départment of Charente-Maritime, water use is reported to be 126 per cent higher on the coast and 260 per cent higher in the islands of Ré and Oléron in July/August than on annual average (IFEN, 2000). Strong seasonality in combination with arrival peaks during dry season might thus put considerable strain on available water resources, particularly in generally dry regions. This interrelationship is shown in Fig. 3 for Zanzibar, Tanzania where tourist arrivals are highest when rainfall drops to a minimum. This is the period when most water is needed by the tourist industry and recharge of the aquifers through rain is lowest. Similar relationships between water scarcity and tourist arrival peaks have been found in the Mediterranean (Eurostat, 2009).

While overall water use thus increases in the dry season, per capita water use is likely to decline, as there are water uses that have to be maintained irrespective of guest numbers (gardens, cleaning, pools). A distinction between fixed and variable water use, the latter referring to water use that is related to occupancy rates (taking showers, toilet use, laundry), thus appears to be meaningful. Fig. 4 exemplifies water consumption and occupation rate ratios of hotels in Tunisia, indicating that higher occupation rates reduce averaged water consumption rates per tourist per day. Similar relationships were also found by Antakayali et al. (2008), who found considerably higher water use per guest occurred in low

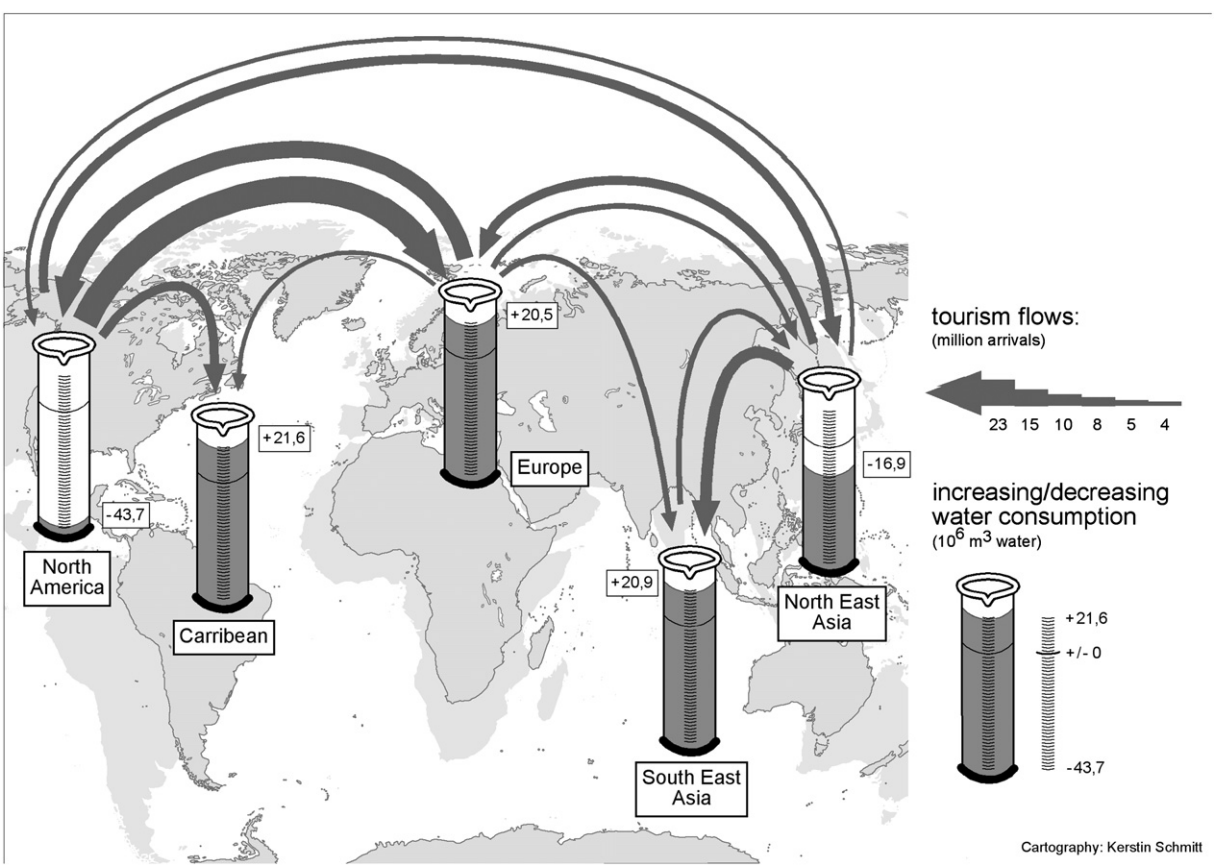

Fig. 2. Tourism-related shifts in global water use. Source: Gössling (2005)

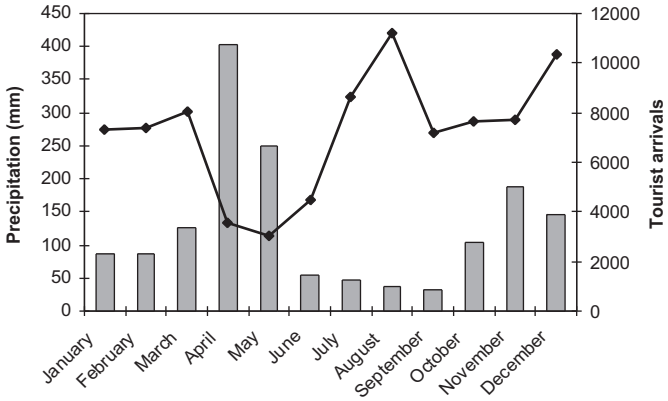

Fig. 3. Water availability and tourist arrivals in Zanzibar, Tanzania. Source: Gössling (2001)

occupancy periods. In early summer months water use per guest exceeds 1000 L per guest per day, dropping to 400 L when occupancy rates are high.

Given these findings, a last concern is whether tourism-related water abstractions are sustainable, and whether these interfere with other uses or users. Where tourism-related fresh water demand is significant, the sector can add considerable pressure on available fresh water resources, particularly when these are concentrated in regions with few or no fossil water resources, low aquifer renewal rates, and few or no surface water sources, such as many coastal zones and islands (e.g. Gössling, 2002b; Rodriguez Diaz, Knox, & Weatherhead, 2007). In such areas, tourism-related water consumption may also compete with local demands. For instance, weighted average water use in villages on the east coast of Zanzibar was found to be in the order of 48 L per capita per day, whereas weighted average water use in accommodation in this area was 685 L per tourist per day (Gössling, 2001). Similar figures indicating higher water use by tourists than residents have also been reported for Lanzarote, Spain, where tourist water consumption is four times that of residents (Medeazza, 2004). Second home tourism has also been recognised as placing pressure on water supplies and water quality, potentially leading to conflicts between permanent residents and temporary visitors (Medina, 1990; Müller, Hall, & Keen, 2004). In a study of Mayne Island, British Columbia, Thompson (2008) found that permanent residents perceived that seasonal second home residents were decreasing the availability and sustainability of water resources (Langumier & Ricou, 1995).

Competition for water also occurs between economic sectors, such as tourism and agriculture. In Spain, for instance, the value added to water by tourism can be 60 times higher than in the agricultural sector (Auernheimer & González, 2002; quoted in Downward & Taylor, 2007), putting tourism in a position to outcompete agriculture for water. Eurostat (2009: 9) reports that in the Mediterranean summer high season, use conflicts exist between agriculture, hydro-electricity production and household consumption, with tourist facilities sometimes being given priority in the supply of water.

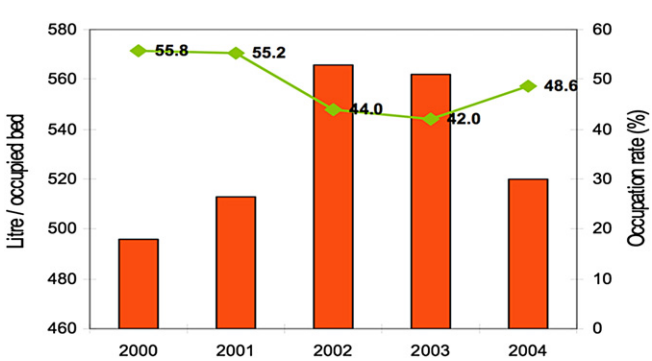

Fig. 4. Water consumption and occupation rate of hotels in Tunisia. Source: Eurostat (2009).

Even more serious can be water use conflicts between countries. The combination of growing populations, demands of water for industry and tourism, and increasingly unpredictable water supply combined with pre-existing political and religious tensions makes the Middles East – Israel, Jordan, the Palestinian Authority, Egypt, and parts of Lebanon and Syria especially vulnerable to water security issues (Hall, Timothy, & Duval, 2004; Lipchin, Pallant, Saranga, & Amster, 2007):

> The water question is crucial in Israel, where water resources are particularly scarce. The massive use of surface water pumped from the Sea of Galilee has considerable environmental and social impacts, such as drying up of the Jordan and the Dead Sea, and tensions with neighbouring Jordan, which also depends on this resource (Eurostat, 2009: 21).

Even though not investigated in further detail in this article, a final aspect of relevance is tourism's influence on water quality. Tourism can contribute to improvements in water quality, for instance when sewage treatment systems are built that can also process so far untreated local wastewater, or when municipalities decide to build treatment systems to improve local water quality to meet tourist expectations of pristine environmental conditions. However, in most regions, tourism appears to contribute to declining water quality. One region where the lack of sewage treatment systems is well documented is the Mediterranean. Scoullos (2003) reports that only 80 per cent of the effluent of residents and tourists in the Mediterranean is collected in sewage systems with the remainder being discharged directly or indirectly into the sea or to septic tanks. However, only half of the sewage networks are actually connected to wastewater treatment facilities with the rest being discharged into the sea. The United Nations Environment Programme Mediterranean Action Plan Priority Actions Programme (UNEP/MAP/PAP, 2001) estimated that 48 per cent of the largest coastal cities (over 100,000 inhabitants) have no sewage treatment systems, 10 per cent possess a primary treatment system, 38 per cent a secondary system and only four per cent a tertiary treatment system (Hall, 2006). Anecdotal evidence suggests that the direct discharge of wastewater from coastal towns and resorts into the sea is also practiced in many other countries outside the European Union, and in particular small island states (Hlavinek, Winkler, Marsalek, & Mahrikova, 2011). While this is not directly relevant to fresh water quality, tourism can thus contribute to a decline in the environmental assets it is dependent upon – lost opportunities to apply for a Blue Flag beach- or similar beach and seawater quality label could be an example of this.

The amounts of sewage and wastewater generated by tourism can be large, as tourism is usually concentrated in comparably small areas. For instance, Chan (2005) reported that the Hong Kong hotel sector generated more than 12 million m^3 of sewage in 2003. Data provided by Antakyali et al. (2008) for Turkey suggests that approximately 40 to 50 per cent of the supplied water was returned to the sewer system. Tourism wastewater contains nutrients, as well as chlorinated swimming pool water and chemicals used to dissolve fats and oils (Kuss, Graefe, & Vaske, 1990; Lazarova, Hills, & Birks, 2003). Its impact on ecosystems will depend on concentrations, ocean conditions, and currents, but nutrient discharges are particularly critical in the tropics, where coastal waters are typically oligotrophic (D'Elia & Wiebe, 1990). Positive changes in nutrient content trigger increased primary production and growth of

macroalgae, with potentially negative consequences for ecosystems and tourism activities (e.g. Englebert, McDermott, & Kleinheinz, 2008; Tomascik & Sander, 1986).

In summarizing the above findings, tourism is only relevant in a few countries as a significant factor in national water use. The volumes abstracted by the sector are usually dwarfed by water use in agriculture and industry. However, the situation can be dramatically different when water demand is concentrated in time and space, and when trends in water consumption are considered. Further, water demand is likely to increase in the future due to climate change and its consequences for water availability, and increasing water use due to growth in tourist arrivals, higher average per tourist water consumption, and more water-intense activities. Tourism's contribution to water use should thus be assessed critically at the destination level, where it may often be a significant factor in water (over) use. Globally, indirect water use in tourism is likely to be more relevant than direct water use and deserves more attention in the future. Overall, results would call for water management measures to be implemented on a broad basis in tourism, particularly in dry regions. The role of climate change in exacerbating water scarcity in some regions may be considered in this context as well.

5. Water management

Previous sections have shown that the impact of tourism on fresh water availability and quality is dependent on a wide range of factors, such as the relative abundance and quality of water in the respective tourism region, current and anticipated future water abstraction rates and the share of non-consumptive versus consumptive uses, the seasonal and spatial character of water abstraction, competing uses, and the treatment of sewage and wastewater. This means that local or regional water capacity assessments and water use audits are needed to understand and put in perspective the role of tourism as a potentially unsustainable agent in water use (for assessments see e.g. Bohdanowicz & Martinac, 2007; O'Neill, Siegelbaum, & the RICE Group 2002; Cooley et al., 2007). Once such audits have detailed water consumption by use category, recommendations can be made, which businesses and local water agencies can implement within the framework of regional water use plans.

Currently, water use inventories are usually not available for destinations (regions or countries), even though they are an important precondition for water management (Eurostats, 2009). In adding complexity, effects of climate change can be modelled for regions and integrated in water use scenarios to identify suitable strategies to deal with water stress in the future (for an example see Kent, Newnham, & Essex, 2002; Essex, Kent, & Newnham, 2004). Depending on outcomes, destination managers and tourism stakeholders can re-consider their business plans, including perspectives on (emerging) politics. For instance, in the European Union, water abstraction for golf courses will become increasingly regulated through national policy implementation of the European Water Framework Directive (European Union, 2000). Generally, water management can be based on two strategies, i.e. demand side management (reducing water use), and supply side management (increasing water provisions) (Bates et al., 2008).

5.1. Demand side management

All tourist facilities can save substantial amounts of water. For instance, Cooley et al. (2007) estimate that hotels can reduce indoor water consumption by 30 per cent by installing water-efficient fixtures. There is even greater potential to reduce outdoor water demand. Somewhat lower estimates of efficiency gains are provided in O'Neill, Siegelbaum and the RICE Group (2002), suggesting average reduction potentials of 10–20 per cent, though up to 45 per cent in individual hotels. A number of specific measures as discussed in the literature are presented in the following.

5.1.1. Gardens

Where irrigation is an important factor in water use, landscaping can considerably reduce irrigation needs. For instance, Smith et al. (2009) suggest that minimising water consumption in landscaping can conserve 30–50 per cent of water. Measures include installation of water metres to monitor water use, selection of drought resistant plants and grasses, mulching of garden beds to reduce evaporation, installation of drip irrigation systems with electronic controllers and moisture sensors, and the use of rain or grey water for irrigation. In many locations use of indigenous plants for landscaping purposes along with appropriate garden designs may reduce the need to irrigate altogether (Carmody, 2007; Harris & Varga, 1995; Thompson, 2008).

5.1.2. Pools

Pools can be responsible for considerable water consumption, and the most important measure is consequently to reduce their size and to avoid large pool-landscapes when designing hotels. Likewise, fountains, waterfalls or other features increasing evaporation should be avoided. Pool night covers can reduce evaporation in hot climates, while drainage barriers can collect overflows and direct them back to the pool (Smith et al., 2009). For energy- and water conservation details regarding heating, ventilation and air-conditioning (HVAC), cooling towers, laundry and other aspects of water use see e.g. Gössling et al. (2011), O'Neill & Siegelbaum and the RICE Group (2002), Smith et al. (2009), and Cooley et al. (2007).

5.1.3. Guest rooms

In tourism facilities and accommodation guest rooms, toilets, showerheads and faucet flow restrictors can be replaced with efficient ones. Given the proportion of water use related to toilet flushing, the use of dual flush, reduced flush and dry composting toilets can significantly reduce water usage (Carmody, 2007; Kavanagh, 2002; Thompson, 2008). For instance, the most efficient toilets can use as little as 1 L for a "miniflush", compared to up to 12 L for older models. It is also possible to use recycled water to flush toilets and urinals (Hills et al., 2002; Lazarova et al., 2003). Efficient and low flow showerheads can use less than 7 L per minute, compared to 13 L used by older ones. Faucet flow restrictors can reduce water consumption by half to 2.5 L per minute (e.g. O'Neill, Siegelbaum, & the RICE Group, 2002). Usually, these changes will be highly economical (Table 4).

5.1.4. Kitchens

Kitchens use water for washing and preparing food, thawing food and cleaning dishes. Changing cooking practices, use of efficient dishwashers and pre-rinse spray valves with smaller nozzles to achieve higher water velocity, use of boiler less food steamers and efficient ice-makers, as well as flow control regulators at sinks and basins can significantly reduce water use while being highly economical (Smith et al., 2009).

5.1.5. Activities

Golf courses can engage in soil moisture measurements to control and optimize water use (Rodriguez Diaz et al., 2007), reduce irrigation in excess of what the turf needs; consider specific playing surface requirements (Balogh & Walker, 1992); reduce playing surfaces, i.e. return to smaller greens and more narrow fairways, accept fairways and greens that "pitch" less; change turf species to less water demanding or salt tolerant ones (Ceron & Kovacs, 1993); use grey water or treated water for irrigation, and stop watering altogether when and where it is not indispensable (Ceron, 1990; Hawtree, 1983).

Table 4
Typical water-savings per guest room of a hotel in Australia.

Component	Best Practice	Existing Usage	Saving per room		Supply & installation Cost	Description	Payback Period (years)
			kL/year	$/year			
Showers	9 L/min (AAA Rated)	15 L/min	28	$100	$50–$120	New showerhead, plus option of flow control	0.5–2
Toilet	6/3 dual flush	11 L	17	$30	$400	New pan and cistern	>5
Basin	6 L/min	12 L/min	5.3	1$5	$20–$40	Flow control in spout or in taps	1.3–2.6
Cleaning	–	–	3.7	$10	0	Typical saving	0
Total:			54	$155	$470–$560	–	0–2.6

Source: Sydney Water (2001), quoted in Smith et al. (2009)

Treated wastewater can also be used for watering parks and gardens as well as snowmaking (Tonkovic & Jeffcoat, 2002).

5.1.6. Management

Management can focus on educational programmes for staff, and informative signs on how to save water, addressing tourists. Measuring water consumption and establishing benchmarks (Table 5) can help to better understand consumption patterns. With regard to indirect water use, destinations can seek to reduce average travel distances and to increase the average length of stay, as well as to consider the choice of foods offered. Water-saving measures will also help to reduce sewage, for which treatment with closed organic matter flow cycles should be the standard (Appasamy, 1993). Greater use of recycled water for non-potable uses is also a way of reducing pressure on water supplies and is attracting increased interest from water management authorities and tourism businesses (Gikas & Tchobanoglous, 2009a, 2009b; Hills et al., 2002; Lazarova et al., 2003).

Overall, reducing water use will usually be economical. Fortuny, Soler, Cánovas, & Sánchez (2008) show, for instance, that many water-saving technologies such as flow limiters on taps and showers, or lavatory cisterns with reduced flush options have short payback times between 0.1 and 9.6 years, making them economically attractive (see also Table 4). However, as pointed out by Prettenthaler and Dalla-Via (2007), low water costs are a potential barrier to action, which have, for instance, been quantified at 0.6 per cent of turnover in Steiermark, Austria (Prettenthaler & Dalla-Via, 2007) or 1.6 per cent of turnover in Morocco (Eurostat, 2009). This needs to be considered in water politics, which may focus on steering consumption through increases in costs, and where considerable increases in water prices may be demanded to raise awareness and to engage stakeholders pro-actively in water-saving measures.

5.1.7. Supply side management

Various technical options are available to increase available water capacities. For instance, prospecting and extracting groundwater can supply additional water in situations where sufficient water resources are available while further attention can be given to using recycled water for non-potable urban uses such as toilet flushing (Lazarova et al., 2003). In the case of small islands, this may also include water abstraction from further inland, and distribution to coastal zones through pipelines (e.g. Bates et al., 2008; Gössling, 2001). However, groundwater is extremely vulnerable to water pollution as a result of poor sewage and water treatment infrastructure, while many coastal aquifers are also increasingly vulnerable to salinification as a result of sea-level rise often associated with ground subsidence, itself due to excessive use of groundwater. Reservoirs and dams can increase storage capacities for areas or entire regions, while rainwater storage in cisterns can be a viable alternative for smaller hotels. Where only limited amounts of water are used, sealed plant beds can be used to remove nutrients from wastewater (cf. Gössling et al., 2011: 140–141). Desalination and wastewater reuse have been advocated as the best technological alternatives for arid region destinations such as Lis Cabos, Baja California Sur, Mexico (Pombo, Brecada, & Aragón, 2008).

Desalination might currently be the most widely considered option to enhance water resources, but it increases energy consumption and, in many areas not connected to the national grid, the dependence on imports of fuels to run generators, leading to considerable additional emissions of greenhouse gases. Desalination is also costly, and can involve energy use of 3–12.5 kWh of electricity, corresponding to emissions of 1–10 kg CO_2 per m^3 of water, with lower values referring to state-of-the-art desalination plants (Gude, Nirmalakhandan, & Deng, 2010; Sadhwani & Veza, 2008). Some forms of desalination, such as distillation, can even involve energy use of 25–200 kWh of electricity per m^3 (Black & King, 2009). Gude et al. (2010) argue that using renewable energy sources for desalination may not always be economical, particularly when involving small-scale installations, while combined grid-renewable energy plants can produce freshwater with lower emissions and at competitive costs. Bermudez-Contreras, Thomson, and Infield (2008) consider renewable energy powered desalination systems as economically viable in water-scarce areas (for costs see also Kavanagh, 2002).

More generally, the costs of dealing with current and future water demands under serious climate change scenarios are likely to be considerable. Downward and Taylor (2007), for instance, report that meeting southern Spain's anticipated water requirements of an additional 1.063 billion m^3 per year will cost €3.8 billion. In Australia, actual and anticipated payments for national water initiatives, treatment plants to supply recycled water, pipelines and drought aid payments to communities will total US$4.75 billion in the period 2001–2015 (Bates et al., 2008). Globally, Parry et al. (2009a) estimate that dealing with water scarcity because of climate change will cost an additional US$9–11 billion per year. While Parry et al. (2009a) emphasise that this is likely to be an under-estimate of the costs for adaptation, it is worth noting that the sum does not include costs to tourism-related lost assets such as lakes, rivers and streams, lowering or loss of amenity values, or deteriorating water quality (e.g. Blakemore & Williams, 2008; Englebert et al., 2008; Oliveira & Pereira, 2008). Even if only a share of these costs would fall on tourism, these would nevertheless advocate serious climate policy to curb emissions and greater efforts in water management by businesses.

Table 5
Benchmarks for hotel managers of the ACCOR group.

Consumption (m^3)	Per occupied room	Per meal	Gardens (per m^2)
Formule 1	0.14	n.a.	0.3
Etap	0.20	n.a.	0.3
Ibis	0.26	0.05	0.3
Mercure	0.34	0.08	0.3
Novotel	0.31	0.08	0.3
Sofitel	0.58	0.15	0.3

Source: ACCOR (1998).

As outlined, many tourism stakeholders are likely to perceive adaptation to climate change as being less costly, given that they only deal with direct operational costs. For instance, new seawater desalination plants can produce freshwater at costs as low as €0.45–€0.52 per m^3 over the 15–20 year design life of the facility (Albiac et al., 2003; cited in Downward & Taylor, 2007). This would indicate that additional costs in water scarce areas for providing even high levels of water to tourists is not likely to act as an incentive for water conservation in coastal areas, as per tourist per day costs may on average increase by less than €1. Consequently, it is important for tourism stakeholders to understand that the overall costs of inaction are far greater than technical adaptation costs, because they may irreversibly affect important tourist assets and create unstable socio-economic situations in many parts of the world.

6. Discussion and concluding remarks

Tourism depends to a considerable degree on water, which is both a resource needed to provide services related to basic human needs, such as hygiene or food, as well as a precondition for fuel production, and an asset essential for a wide range of tourist activities, such as swimming in lakes or pools, or golf and winter sports. Furthermore, water is a central element of tourism landscapes in various forms, from irrigated hotel gardens to white winter landscapes, to lakes and streams embedded in park landscapes. Limited water availability, poor water quality or media portrayal of a water crisis can consequently do great harm to the image of tourism destinations (Hall, 2010; Hall & Stoffels, 2006).

In comparison to water use in other economic sectors, tourism is usually less relevant, because in virtually all countries of the world, agriculture dwarfs tourism-related water consumption. However, in some countries, as well as regionally, tourism can be the main factor in water consumption. In such areas, it can increase direct pressure on already diminished water resources and compete with other economic sectors as well as the subsistence needs of local populations (Thiel, 2010). In addition, tourism can also contribute to a decline in downstream or destination water quality and potable water supplies as a result of poor or no treatment of wastewater, which then enters aquifers and the water system (Dillon, 1997; Kocasoy, Mutlu, & Aylin Zeren Alagöz, 2008). Significantly, in a number of increasingly water-scarce regions such as the Mediterranean, the concentration of tourism in time and space as a result of seasonal tourist demand, can place enormous pressures on domestic and industrial water supplies as well as wastewater infrastructure, often at a period when they are least able to cope. Such situations also highlight the importance of analysing tourism's water demands at an appropriate temporal and spatial scale rather than just relying on assessments conducted on an annual or national basis.

Results provided in this article suggest that direct water use in tourism is anything from 80 to 2000 L per tourist per day, with a tendency for larger, resort-style hotels to use significantly more water than smaller, less luxurious establishments. Depending on geographical location and environmental and/or climate conditions, the main water-consuming factors are irrigated gardens, swimming pools, spa and wellness facilities, as well as golf courses, followed by cooling towers (where used), guest rooms and kitchens. However, while direct water use is more relevant for water management in the destination, indirect water use is responsible for a greater contribution to the overall amount of water used. In particular, food and fuel production have been shown to have comparably large water footprints: transport to the destination alone can more than double direct water use. Food is, perhaps, the most relevant factor in water use, though people eat whether they travel or not, and the addition tourism makes to water use through the consumption of higher-order food is not as yet identified.

Given the global growth in tourism, the trend towards higher-standard accommodation and more water-intense activities, which are likely to coincide with changes in the global climate system leading to declining water resources in many regions, pressure on water resources and related water conflicts are bound to increase in many destinations. As a consequence, tourism development in many areas of the world may become less sustainable or no longer feasible. This may be due to foregone opportunities to carry out certain tourism activities, declining water levels or lack of fresh water availability, costs associated with provisions of fresh water, or declining water quality. Impacts will ultimately depend on several factors, including the relative scarcity of fresh water in tourism areas, also with regard to seasonal aspects, competition with other economic sectors such as agriculture (e.g. Downward & Taylor, 2007), institutional contexts such as water policies, as well as the structure of the water industry (profit or social benefits) and of the tourist industry (small guesthouses or large resort hotels). Such situations will clearly require a more integrated approach to tourism's role in water management at a catchment level than what has hitherto been the case (Hall & Härkönen, 2006; Matias, Gago, & Boavida, 2008). Furthermore, the increasing competition between tourism and other users, including the water rights and the food and water security of local people in a number of destinations raises fundamental questions about the ethics and politics of water access.

In order to adapt to inevitable changes in water availability, as well as to mitigate its own contribution to climate change and its pressure on limited water resources, tourism needs to engage in energy and water management, focusing on policy (e.g. compliance with national greenhouse gas reduction goals, building codes, measurement and charging of water consumption), management (e.g. including measures to reduce water use, treat sewage and reuse water), research and development (e.g. to implement renewable energy-driven desalination; understanding the religious, philosophical and ethical issues of wastewater recycling and reuse), as well as education and behavioural change to encourage tourists and staff to engage in water-saving measures.

Even though a clear picture of the overall costs associated with unsustainable water use in tourism still has to emerge, it seems beyond doubt that most of the measures that can reduce water use are economical and that investments to ensure sustainable water use will help to secure a future for tourism. In the same way that life cycle analysis is beginning to investigate the full energy and emissions impacts of tourism infrastructure and transportation, so it also needs to be conducted with water consumption. Investments in sustainable technologies and water conservation management are thus key strategies to be pursued. However, it is likely that strong policy environments are required to achieve this, including the expanded use of economic incentives and appropriate water pricing to encourage water conservation. This is because the tourism industry is not likely to make water use a key priority by itself, given the low cost of water in comparison to other operational costs.

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