ESTIMATING THE DIRECT AND INDIRECT WATER USE OF TOURISM IN THE
EASTERN MEDITERRANEAN

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Abstract

The impact of tourism activities on local water resources remains a largely understudied issue in environmental and sustainable tourism management. The aim of the paper is to present a simple methodology that allows an estimate of direct and indirect local water use associated with different holiday packages and to then discuss relevant management implications. This is explored through the creation of five illustrative examples of holidays to semi-arid eastern Mediterranean destinations: Cyprus (2), Turkey, Greece and Syria. Using available data on water use associated with different forms of travel, accommodation and tourist activities, indicative water footprints are calculated for each of the illustrative examples. Food consumption by tourists appears to have by far the most significant impact on the overall water footprint and this aspect of water use is explored in detail in the paper. The paper also suggests a way of employing the water footprint methodology along with import/export balance sheets of main food commodities to distinguish between the global and local pressure of tourism demand on water resources. Water resource use is likely to become an increasingly important issue in tourism management and must be considered alongside more established environmental concerns such as energy use, using methodologies that can capture direct as well as supply chain impacts.

Keywords: water footprint; sustainable tourism; sustainability trade-offs; water scarcity.

1. Introduction

Water issues have been gaining importance on the global political agenda in recent years (UN-Water, 2006; UN-Water, 2010; World Water Assessment Programme, 2009). However, despite water being an issue of global importance, water scarcity issues are inherently local. Water availability on a global scale appears to be sufficient to satisfy human needs, as withdrawals account for less than 10% of the available renewable freshwater resources (Oki and Kanae, 2006). The problem lies in the unequal distribution of global water resources across space and time (Postel et al., 1996). Furthermore, it is often extremely difficult to assess whether water scarcity is caused by insufficient supply or excess demand (Rijsberman, 2006). Demand for water also varies in different places, as it is a factor of development, societal values and human behaviour (Molle and Mollinga, 2003). Policies to manage water resources efficiently must, therefore, be developed locally in order to take into account the context-specific pressures and their interactions.

The impact of tourism on water use, and vice versa, is still an understudied and often overlooked area (Gössling, 2005; Gössling, 2006; Gössling et al., 2012). This is partly because of the fact that environmental sustainability in recent years appears to have become almost synonymous with taking action to limit carbon emissions. On-going attention on climate change has led to an increasing body of research on carbon emissions from tourism, and in particular from air travel (Becken, 2002; Chenoweth, 2009; Gössling, 2000; Gössling et al., 2010b). This research has focused on the importance of both adaptation and mitigation against climate change, highlighting tourism's high dependency on the natural environment and the climate (Scott et al., 2008; Scott and Becken, 2010; Simpson et al., 2008).

Although global warming is, arguably, the most serious environmental concern on a global scale, environmental sustainability is a multifaceted concern. There have been some attempts

to calculate the universal impacts of tourism by making use of the Ecological Footprint (EF) concept (Gössling et al., 2002; Hunter, 2002; Hunter and Shaw, 2007), which translates resource consumption and waste generation into an equivalent land area. Although the EF offers a more comprehensive indicator of environmental impact compared to the widely used Carbon Footprint (CF), it still only provides an aggregate measure of environmental impact that does not distinguish between local and global environmental pressures. It must therefore be used alongside other locally based indicators (Hunter and Shaw, 2007). Furthermore, the EF does not explicitly consider water use as water cannot be expressed in terms of global hectares that make up the EF calculation (WWF/ZSL/GFN, 2006).

The increased awareness paid to energy issues should serve as a platform towards better understanding and management of these other environmental pressures. The impact of tourism on water resources should be viewed as a key local sustainability challenge that requires appropriate management interventions, especially in water scarce destinations. The water situation is likely to become more acute in the future with climate change expected to threaten the reliability of both the quantity and quality of water supplies (World Water Assessment Programme, 2009). This provides a further impetus for linking water issues with the existing concern on climate change adaptation.

According to Gössling (2002), the lack of research with a specific focus on water and tourism may also be attributable to a lack of available data. Even within the water policy domain, there has been very limited research on tourism-related water demand compared to other water uses (Tortella and Tirado, 2011). This is due to demand for water from the tourism industry appearing to have a negligible impact compared to other water users such as agriculture, industry and households, with global figures suggesting that international tourism accounts for less than one per cent of national water use (Gössling et al., 2012). However, what this seemingly small figure cannot capture is the spatially and temporally concentrated nature of tourism activity (Emmanuel and Spence, 2009; Essex et al., 2004; Gössling, 2005).

Furthermore, not enough attention has been paid to linkages between tourism and other economic sectors. In a recent publication, Gössling et al. (2012) stress the importance of recognising both direct and indirect water demand from tourism, where direct water use refers to the water used by accommodation and daily activities whereas indirect water use refers to uses such as fossil fuels and diet. Previous studies of water use in the tourism sector have largely focused on water use by tourist infrastructure such as hotels, swimming pools, spas, golf courses and water parks (Charara et al., 2010; De Stefano, 2004; Gössling, 2001; Hof and Schmitt, 2011; Kotios et al., 2009; Rico-Amoros et al., 2009; Tortella and Tirado, 2011), all of which are components of direct water use. Even though the literature does refer to a water demand multiplier effect (Emmanuel and Spence, 2009) whereby increased tourist numbers exert a higher water demand in other economic sectors through consumption of goods and services, no studies have attempted to examine and discuss the implications of this water use in any detail.

The Mediterranean is the world's leading holiday destination with 30% of international arrivals and 25% of global revenues from international tourism (De Stefano, 2004). As a high value user of water, a single day of insufficient water supply could severely affect the public image and reputation of any tourist destination. Water scarcity could become the limiting factor for tourism development, with severe economic consequences (Gössling, 2006). The Mediterranean has been identified as a climate change and water scarcity hotspot

(Christensen et al., 2007; Scott et al., 2008). At the same time, tourism arrivals worldwide are expected to maintain an increasing trend in the long term (UNWTO, 2010).

The tourism sector is highly heterogeneous and offers a plethora of different products which cater for different tastes, budgets and times of the year. These different products have different water use implications. Recent studies from Mallorca have shown that the mass tourism product, so often associated with its negative aesthetic impact on the landscape, actually registers much lower water consumption per capita compared to so-called ‘quality tourism’ (Hof and Schmitt, 2011; Rico-Amoros et al., 2009; Tortella and Tirado, 2011). The principal development of the present paper is to build on these papers by including estimates, for different tourism products, of the indirect water use from different elements of the tourism sector and exploring the role of diet – which according to Gössling et al. (2012) accounts for a significant percentage of total water use. The creation of five hypothetical holiday packages based on a series of assumptions allows the use of published data to explore a methodology that captures both direct and indirect water use. This enables a detailed breakdown of how tourist choices impact water use and highlights important areas to be targeted through management interventions.

The paper is structured as follows: section two reviews the methodology employed in quantifying the impact of tourism on local water resources and recognises important assumptions and necessary limitations inherent in the calculations. Section three compares and discusses the results from the different holiday packages. The final section (section four) concludes the paper by examining in more detail the important elements that account for differences between the holiday packages, and by discussing the importance as well as the practical and policy implications of considering water use alongside other environmental impacts of tourism.

2. Methodology

2.1 Introducing the water footprint and virtual water concepts

A way of accounting for water use by tourism is through the use of the Water Footprint (WF) methodology (Hoekstra, 2003), which has been used to calculate water use on an international (Chapagain and Hoekstra, 2004; Hoekstra and Chapagain, 2007) or corporate scale (Ercin et al., 2011) and to suggest potential ways in which water savings may be achieved. The WF is a consumption-based indicator of water use which divides the footprint of a consumer into water directly consumed for drinking, washing and cooking (operational footprint) plus the water content (embedded water) of all the products consumed (supply-chain or indirect footprint) (Hoekstra et al., 2009). The latter is known as Virtual Water (VW) (Allan, 1998) and essentially refers to the volume of water used to grow, produce, package and ship commodities such as grains and livestock products. Indirect water use far exceeds direct use by around an order of magnitude (Ridoutt and Pfister, 2010).

The WF methodology (Hoekstra et al., 2011) is increasingly being used to illustrate the global dimensions of water consumption (Hoekstra and Mekonnen, 2012), taking into account trade in goods between countries. According to Velázquez et al. (2011), the VW and WF concept can be applied to specific services such as tourism activities. Tourism is not an economic sector in the traditional sense, characterised by its strong backward linkages

(purchasing links) with other sectors (Briassoulis, 1991; Dwyer and Forsyth, 2008; Jones and Munday, 2004). Furthermore, with approximately one-third of all tourist expenditure being used to buy food (Gössling et al., 2010a; Torres, 2003), tourists consume a significant amount of VW through their diet. As a sector where products and services are purchased from other sectors and are often shipped in or imported from other regions or countries, tourism appears to be ideally suited to the WF methodology.

2.2 Overview of proposed methodology for calculating the WF

Five holiday packages have been constructed (Table 1) and their associated WFs have been calculated using existing secondary data sources. This is similar to the approach followed by Hunter & Shaw (2007) to outline the potential use of the EF in tourism research. Although the holiday packages are hypothetical and should only be seen as indicative, they have been designed in such a way as to allow the reader to appreciate how a range of different choices in terms of transport, accommodation, diet and leisure activities affect water use. Varying the duration of the holiday examples (from a week to a month) allows for a comparison between the daily footprint and the total footprint of each holiday.

Example one (luxury golf holiday) can be considered, at least *a priori*, to be the luxury tourism example, whereas example two (camping holiday) is the more intuitively low impact example. Examples three (budget beach holiday), four (up-market beach holiday) and five (backpacking holiday) are considered to fall in between in terms of luxury and environmental impact intensity, and are in line with commercially available packages offered by travel agencies in the UK. The holiday examples are set in semi-arid destinations in the eastern Mediterranean region. Paphos (Cyprus), Bodrum (Turkey) and Mykonos (Greece) are all mass tourism resorts, especially popular with UK tourists. Turkey, Cyprus and Greece were all in the top ten most searched-for destinations for UK summer departures for 2011, according to the Skyscanner website (Skyscanner, 2011). Polis (Cyprus) is a popular camping destination in the region whereas Damascus is chosen as the base for a longer holiday, where the aim is to travel around Syria for sightseeing and discovering local culture. All chosen destinations already suffer from some degree of water scarcity with serious questions regarding future availability (Chenoweth et al., 2011).

Cyprus and Syria both have available renewable water resources below the water scarcity threshold of 1500–1700 m³/capita (Falkenmark et al., 1989; Yang et al., 2003). Greece with 7000 m³/capita (Iglesias et al., 2007) and Turkey with 3280 m³/capita (Yang et al., 2007) are considerably above this threshold value at the country level. However, most Aegean islands including Mykonos are extremely water scarce (Gikas and Angelakis, 2009; Gikas and Tchobanoglous, 2009; Sofios et al., 2008). Bodrum has been one of the prime international tourism destinations in Turkey in the last two decades (Gezici et al., 2006; Tosun, 2001) and is increasingly faced with water issues. These destinations have also been chosen to allow an appreciation of the role of trade and its potential to minimise impact on local water resources. Cyprus is amongst a group of water-scarce countries that have a large external water dependency (Hoekstra and Mekonnen, 2012), with Greece also being a net importer of grains and animal products (FAO, 2010). On the other hand, Turkey and Syria have very low ratios of VW import to renewable resources (Yang et al., 2007).

{ Table 1 }

The basic WF methodology for calculating industrial footprints (Hoekstra et al., 2009; Hoekstra et al., 2011) is applied to tourism by using four principal direct and indirect water use categories as identified in Gössling et al. (2012). The associated WF in l/person/day for each of the five holiday examples is calculated using:

$$WF = directWF + indirectWF = (AF + ACF) + (DF + FF) \quad (1)$$

where WF = total water footprint, AF = accommodation footprint, ACF = activity footprint, DF = diet footprint and FF = fuel footprint.

All illustrative examples assume Manchester in the UK as the point of origin. The reason for the choice of Manchester was two-fold. Firstly, most people in the UK do not live immediately adjacent to a major international airport such as London Heathrow and thus the selection of a non-London starting point better encompasses the type of journey the majority of tourists are likely to take. Secondly, the south of the UK is technically water scarce as a result of a very high population and limited water resources. By choosing a source region in the north of the country, one can safely assume that the tourist is travelling from a water plentiful area to a water scarce area. Section 2.3 describes the sources of secondary data used as well as methodological considerations and assumptions required for the estimation of each of the terms in equation (1).

2.3 Water footprint calculations and assumptions

2.3.1 Direct WF

The operational water footprint is composed of the water intensity of the accommodation (AF) and the WF of any activities pursued by the tourist (ACF). AF is the term on which most research has focused to date, both in tourist accommodation (Hof and Schmitt, 2011; Rico-Amoros et al., 2009; Statzu and Strazzera, 2011) and hotels (Bohdanowicz and Martinac, 2007; Charara et al., 2010; Deng and Burnett, 2002; Gössling, 2001). Estimates for different classes of accommodation are usually available through a combination of room numbers and occupancy rates from hotel surveys along with total water consumption from water authorities. However, figures for specific countries are not readily available to allow consistent comparisons and so this study has used figures from Eurostat (Eurostat, 2009) .

The estimates for AF for examples one, three and four are based on the Eurostat figures shown in Table 2 for different accommodation types, whereas AF estimates for examples two and five are 84 l/person/day and 197 l/person/day respectively. The latter estimates are based on average figures from campsites in Mallorca (Rico-Amoros et al., 2009), and on 2007 FAO figures for domestic water consumption in Syria (FAO, 2011a) – since this holiday example involves staying in a local house. The estimates are conservative but all fall within the 84–2000 litres per person per day range suggested in Gössling et al. (2012) for tourist accommodation.

{Table 2}

An attempt is also made to account for the WF of certain activities that are likely to be pursued in each holiday package through the *ACF*. Attributing water use from activities such as golf and water parks to individual tourists is challenging. This study made adjustments on the figures suggested by Gössling et al. (2012) who recommend a water footprint of 10-30 l/tourist/day used for tourism-related activities. Examples two, three and five do not entail water-intensive activities and are assigned an average *ACF* of 20 while example four is assigned an *ACF* of 30 to reflect visits to water parks and swimming pools.

An exception was made for example one in which golf was the predominant activity. The study used a figure of 3500 m³ per day from Eurostat (2009) for an 18-hole golf course in a Mediterranean setting, as well as the average number of visitors over the last two years (around 4000) in a popular golf resort in the Paphos area of Cyprus. This works out as 875 l per tourist per day. Golf courses in tourist destinations will cater almost exclusively for tourism demand¹, meaning that the estimated range in Gössling et al. (2012) may be too conservative when it comes to golf tourism.

2.3.2 Indirect WF

In order to estimate the *DF*, the study devised hypothetical daily menus suited to each holiday example (see Supplementary Table 1). These variants are, of course, a simplification of the tourist diet, which would be expected to be more varied in reality as the tourist would not be expected to consume the same foods every day. Moreover, we assume that the calorie consumption of each example equals around 3442 kcal, which is the average daily calorie consumption for the UK for 2005-2007 according to the FAO (2011b). This ignores differences in nutritional needs of individuals as well as the fact that, when on holiday, individuals may indulge more in food than they would back at home. However, an average value was required in order to allow comparisons between the different examples.

The menus are made up of ingredients such as eggplants, tomatoes, olive oil, chickpeas, and lentils in addition to grains and meats which feature in popular eastern Mediterranean dishes. It is assumed that tourists consume mostly local dishes. Considering the recent familiarity and popularity of Mediterranean dishes in the UK, this appears to be a reasonable assumption. Using the open source dieting software CRON-O-Meter², the quantities were adjusted to ensure the set caloric intake was met for each example.

In order to perform the calculations, the study uses the virtual water contents (VWCs) for each ingredient (see Supplementary Table 1) as estimated in Mekonnen & Hoekstra (2010a; 2010b; 2011). These figures are expressed in m³ per ton and include estimates of blue, green and grey water for each agricultural product in each country taking into account local climatic conditions, production efficiencies as well as the origin of imports. Blue water refers to water in rivers, lakes and aquifers (Savenije, 2000). Green water is the soil moisture in the unsaturated soil zone (Falkenmark and Rockström, 1993) and is the main source of water in rainfed agriculture. Grey water is defined as the volume of water needed to dilute the load of pollutants associated with the production of a certain good or service and is used as an indicator of pollution (Ercin et al., 2011). The present paper considers only the blue and green water components. Grey water was excluded on the grounds that it is a theoretical rather than

¹ This is confirmed by the high ratio of tourists to permanent members.

² Available at <http://cronometer.com/>.

an actual measured volume (Morrison et al., 2010) which relies heavily on assumptions and estimations (Galli et al., 2012).

The daily *DF* is given by adding up all the individual VWCs of each ingredient consumed (multiplied by the weights shown in Supplementary Table 1), following equation (2):

$$DF = \sum_{i=1}^n P_n (BW + GW) \quad (2)$$

where P_n = weight of each food product consumed (g), BW = blue water (l/g) and GW = green water (l/g).

The *DF* requires further manipulation as the study seeks to calculate the local WF component. This distinguishes between food products sourced from within the country and products imported from abroad. The VWC of imported goods is assumed to be equal to that of goods produced within the destination country, which is consistent with the savings perspective defined in Renault (2002). This is a significant assumption, as climate and production efficiencies vary markedly around the world. Nevertheless, in the absence of detailed trade data, this assumption is commonly employed in national and regional WF studies (Zhang et al., 2011; Zhao et al., 2009).

The local diet footprint (*LDF*) is calculated using the ratio of locally-produced food products as shown in equation (3) below. It is estimated by dividing the locally-sourced available quantity of a good (local production minus any exports) by the total quantity of a good available in the country (locally-sourced available quantity in addition to imports)³. The study uses data on production, exports and imports from the FAOSTAT trade balance sheets for 2007 (FAO, 2010). The *LDF* is found by multiplying the *DF* by the ratio indicating food produced locally, *RLP*, as shown in equation (3) below:

$$LDF = DF \times RLP = DF \times \left(\frac{LP - E}{LP - E + I} \right) \quad (3)$$

where *LDF* = local diet footprint, *RLP* = ratio of locally-produced food products, LP = locally produced food (tons), E = exports (tons) and I = imports (tons).

An important assumption made is the use of the national trade balance. In reality, the *RLP* is likely to vary depending on the region as well as between different restaurants and hotels. Furthermore, for pulses, vegetables and fruit, the study has used averaged values for the most commonly eaten products instead of individual commodity values in order to capture a possible range of tourist choices. The drawback of this choice is that these averages cannot account for the wide range of VWCs between products. With regards to animal product consumption, tourists in Cyprus and Greece are assumed to consume equal amounts of all kinds of commonly eaten meat (pork, chicken, beef, lamb and goat) whereas tourists in Syria and Turkey would consume equal amounts of all meat excluding pork which is not eaten in Muslim countries. This ignores personal preferences by providing an averaged value.

³ Note that for animal products an additional correction was also made for the ratio of local to total (including imported) fodder with the exception of goat and lamb which were assumed to have been raised on pastures.

The final component of the total WF is the WF associated with fuel, given by FF in equation (1). Fuel production is particularly water intensive (Wu et al., 2009b). Gössling et al. (2012) propose an estimated requirement of 750 l for every 1000km of travel by air or car. These are averaged figures and do not take into account variations in factors such as the age of the oil well, the recovery technology employed and the degree of produced water recycling and reuse, all of which are known to significantly affect water consumption in oil exploration and production (Wu et al., 2009a). FF is calculated using these estimated figures along with the distances travelled by air (return trip) and public transport or car at the destination shown in Table 3.

{Table 3}

2.3.2 Local WF

Using the local LDF (see section 2.3.1), the present study distinguishes between total WF and local WF (LWF). The AF and ACF are assumed to come from local blue water and require no further manipulation. The FF is not considered to be part of the local WF as all countries in the region rely heavily on foreign sources of oil. The LWF is, therefore, calculated using equation (4).

$$LWF = LDF + AF + ACF \quad (4)$$

3. Results and discussion

3.2 Water footprints

{Table 4}

3.2.1 Individual illustrative example results

Example one (luxury golf holiday in Paphos, Cyprus)

Example one has the highest percentage of direct WF and is also the example with the lowest DF. This is a result of the luxury accommodation and the activities (golf), which together contribute 16% to the total WF. Example one has the highest daily total WF of all the examples with 8940 l per day, but has a relatively low impact on local water resources (3510 l per day) because of the high percentage of imported food in Cyprus.

Example two (Camping holiday in Polis, Cyprus)

This example has the highest percentage of indirect water use (99%). Example two has by far the lowest local WF (only 1000 l per day) as a result of a lack of animal products in the diet in addition to the budget accommodation and lack of water-intensive facilities. Assuming most food imports come from water-rich countries where agriculture is rain-fed and, recognising that it is the local WF that contributes to water scarcity at the country scale, the choice of accommodation with lower water intensity becomes significant.

Example three (Budget beach holiday in Bodrum, Turkey)

82% of the total WF is local WF in this example and since accommodation only contributes around 3% to the total WF, this comes mostly from the diet. The LDF is usually inversely correlated to the amount of food imported by the destination countries. This is reflected in the fact that, whilst the daily total WF from example three is low at only 5790 l (with only example four having a lower daily total WF with 5460 l), this example actually has the highest daily local WF with 4750 l.

Example four (Up-market beach holiday in Mykonos, Greece)

In contrast to example three, example four has the highest total WF (65 500 l) but has the lowest daily total WF (5460 l) even though the accommodation was 4-star, mainly because of a low DF. The DF in that case was the lowest of all examples because of moderate meat consumption. Further savings in WF could have been achieved with more basic accommodation as the accommodation makes up 7% of the total WF in this case.

Example five (Backpacking holiday in Syria)

Example five ranks the highest in terms of total WF with 232 000 l, mainly as a result of the longer duration of the holiday. Example five also has the second highest daily total WF with 8290 l, a large part of which is local WF. Under this example, the longer holiday results in a higher overall impact on water resources at the destination. Where the diet is high in meat and the meat tends to be locally produced, as in the case of Syria, the pressure on local water resources is even greater.

3.2.1 Synthesis of results

The final results for each holiday (Table 4) show that indirect WF dominates the WF in all illustrative examples. Most of this comes from the DF which ranges from 75% to 95% of the total WF. AF, although much lower in absolute terms than the DF, accounting for only 1-7% of the total WF, is still an important component because it is always local and requires blue water, which has a higher opportunity cost than green water (Aldaya et al., 2010) as it can be used for both agricultural or non-agricultural activities (Renault, 2002). FF, on the other hand, may account for up to 10% of the total WF as in the case of example three; however this water is rarely local water. The range of daily WFs (5790 – 8940 l) calculated in this paper is very much in agreement with the figures proposed in Gössling et al. (2012), who suggest a daily WF of 5000-7500 L, with only examples one and five having a slightly higher daily WF compared to the suggested range.

3.3 The importance of the diet footprint

{Figure 1}

As the most significant component of the overall WF, the *DF* is explored in more detail in Figure 1. In Figures 1a and 1b, the total WF is split into local green water, local blue water, total green water and total blue water. Figure 1a shows that, with the exception of example two, the green water content of food exceeds blue water by around ten times. It also

highlights the fact that Cyprus (examples one and two) and Greece (example four) import a significant percentage of the food they consume. Subtracting local blue water and local green water from total blue water and total green water respectively, reveals the amount of local water ‘saved’⁴ from importing food, as shown in Figure 1b. Example three (Turkey) registers much lower savings from trade compared to the other examples. Figures 1c and 1d show the combined total (green and blue) for each of the examples, divided into the different diet components. This highlights the fact that animal products such as meat and dairy are significantly more water intensive compared to plant-derived products.

Meat and dairy account for over 75% of the *DF* in all the holiday packages except example two (vegan diet). Comparing, for instance, the local WF against the total WF of examples one and five shows how water intensive meat imports are, as they account for more than 50% of the total WF. This is illustrated by the significant green water savings in Figure 1b. Fruit and vegetables in the vegan example (example two) appear to have a surprisingly high total WF. This also translates into high green and blue water savings (fruit and vegetables tend to be irrigated in the Mediterranean) as shown in Figure 1b. The unexpectedly high *DF* in example two is mostly a result of pulses and vegetables in Cyprus having very high WFs (especially blue WF) according to the figures in Mekkonen & Hoekstra (2010a, 2010b, 2011).

Diet appears to stand out as an obvious area that warrants further research. Estimating the *DF* for different tourist groups would require extensive interviewing to determine food preferences, something visitation surveys are currently unlikely to cover in sufficient detail. Sourcing local food is usually seen as a means to promote economic linkages between tourism and agriculture, thus enhancing the benefits of tourism to the economy (Soler, 2008; Telfer and Wall, 1996; Torres, 2003). However, attempts to boost local production and reduce economic leakage could contribute to water shortage at the destination, especially where tourists demand products that are unsuitable to local environmental conditions. Destinations in arid places can maximise economic return in certain cases by importing water-intensive agricultural products from abroad to complement investments in more water-efficient accommodation. Nevertheless, high energy embodied in imported products could result in a large additional CF. Where food is sourced from has significant repercussions on the WF, the CF as well as the number of jobs likely to be impacted in the agricultural sector.

3.4 WF considered alongside other environmental impacts: management implications

Tourists are often unaware of local water scarcity and cannot be expected to compromise the quality of their hard-earned holiday by making pro-environmental choices (Miller et al., 2010). Improving the inherent efficiency with which the tourism sector uses water becomes a key requirement not only to minimise the impact of the sector on the environment but also to ensure its survival through continued use of the resource. Moreover, any attempt or policy aimed at reducing the water impact of tourism must be compatible with other sustainability targets such as carbon emissions reduction.

Many policies that promote energy savings also bring water savings. This is seen in areas in accommodation facilities and hotels where there is a strong financial incentive to conserve

⁴ Even though the import of virtual water cannot actually result in real water savings (Antonelli et al., 2012; Wichelns, 2010a), the option to import food products is assumed to provide water scarce countries with improved food and water security (Antonelli et al., 2012).

both water and energy (Deng and Burnett, 2002). It is also well understood that an increasing range of facilities such as water parks and golf courses requires additional energy and water (including non-conventional sources such as desalination) to operate (Abrams and Hall, 2010; Gleick, 1994; Griffiths-Sattenspiel and Wilson, 2009). However, water and energy use in areas such as diet, fuel and activities are not as well understood partly because the majority of the footprint lies in the supply-chain. This creates both synergies and trade-offs between water and energy savings.

The diet footprint is one of the most complex areas. The overall quantity consumed as well as the percentage of animal products are directly correlated with higher energy and water use. The results show that recommendations from Gossling et al. (2010a) aimed at lowering tourism's food-associated CF such as promoting vegetarian dishes, reducing portions, minimising waste, buying less rice and beef while buying more potatoes, chicken and pork in their place would, in most cases, also lead to a lower WF. On the other hand, as previously discussed, imported products can have high CFs, creating a trade-off in relation to the local water savings.

Other potential trade-offs are biofuels and non-conventional water uses such as desalination and wastewater treatment. Research has shown that any assessments of bioenergy potentials must also consider the increase in demand for land and scarce water resources (Berndes, 2002). Similarly, desalination or reclaimed water may help satisfy local water needs (Liu et al., 2012) and alleviate pressure on water bodies and ecosystems (Kalavrouziotis and Drakatos, 2004) but require considerable energy. Appreciating potential synergies and trade-offs between proposed energy- and water-saving practices requires that the full spectrum of water impacts is explored and understood in a local context.

3.4 Assumptions, limitations and future method refinements

This paper provides an example of how currently available data may be used to estimate the WF of different tourism choices. The paper has built on recent work by Gössling et al. (2012) who have highlighted that even though direct water use may appear to be more relevant for water management at the destination, indirect water use accounts for the majority of the overall amount of water used. By breaking down the individual components of direct and indirect use and applying them to different holiday packages, the approach has allowed further emphasis on the role of food consumption as the most significant form of indirect water use.

The present paper makes an original contribution to understanding how a combination of factors such as dietary choices, local water scarcity, local agricultural efficiency and the import/export balance of food commodities play determine the overall impact on water resources at the destination region. Nevertheless, the significant number of assumptions and the results obtained also highlight that this methodology is somewhat simplistic and should only be seen as a first step in the right direction. As Hunter & Shaw (2007) previously concluded with regards to the EF, this study highlights the need to collect 'real world' primary data for water resources consumed along the whole supply chain of tourism products and services.

Another important consideration is that the VW and WF concepts have received some criticism on the grounds that they fail to recognise the significance of factors other than water

availability, such as land endowments or other inputs, which influence policy decisions with regards to the production and trade of commodities (Gawel and Bernsen, 2011; Wichelns, 2010a, 2010b). This is a valid argument and, for this reason, the WF is a useful water accounting concept best used alongside other indicators of environmental impact.

The estimated WF in this paper is the gross WF as opposed to a net WF that would subtract the WF used had the tourist remained at home during the trip from the calculated figures. Gössling (2006) and Gössling et al. (2012) have argued that, even though on a global level tourism tends to shift water consumption from water-rich to water-poor areas, the water saved in the source regions partly compensates for overuse of local water resources in the destination regions. However, water scarcity is largely a local problem and water saved in the source regions does not benefit local water problems at the destination. Consequently, the net footprint concept is more relevant for indicators of global environmental impact such as EF and CF with the gross footprint being more relevant for indicators of local environmental impact such as the WF at the destination.

Life-cycle thinking allows policymakers and destination managers to better appreciate synergies and trade-offs between policies which are often designed to promote either sustainable energy use or sustainable water use. Few studies to date have considered environmental impacts (including both carbon emissions and water use) from the entire supply side chain in addition to onsite impacts (Lundie et al., 2007; Patterson and McDonald, 2004). Considering the combination of impacts is the direction in which future studies need to be undertaken. Furthermore, a more comprehensive analysis requires that the impacts of tourism on water and energy are considered in relation to the economic costs and benefits of tourism. This allows estimates of eco-efficiency (Becken and Patterson, 2006; Gössling et al., 2002) and water productivity (Gleick, 2003) that estimate trade-offs between profitability and environmental impacts of different types of tourism.

Sustainable tourism management must be seen as an important part of the broader environmental management domain. Travelling for business and leisure has become an important aspect of life in the developed world, and is also rapidly on the increase in the developing world (UNWTO, 2010). A holiday often comes as a hard-earned break and may result in a more extravagant consumption behaviour compared to consumption patterns at home. In an environmental sustainability sense, tourism can be viewed as a spatially and temporally explicit increase in population which, in most cases, is composed of individuals whose consumption patterns are likely to have higher environmental impact than those of local residents. Especially in places where tourism is an important economic activity, tourism must be seen as a significant user of water and other environmental resources and both direct and indirect impacts must be quantified and managed to maintain sustainable consumption patterns.

4. Conclusion and summary

The study highlights the importance of indirect water use in the tourism sector as well as the potential of life-cycle type water footprint calculations to complement existing CF and EF methodologies. The methodology outlined in the article has suggested ways in which to account for both the global and the local pressure of tourism demand on water resources using the import/export balance in food commodities. It has also explored the aspect of diet in more detail in order to understand how different elements of tourists' diets contribute to the overall footprint. The illustrative examples used in this paper have had to be based on several assumptions regarding tourist diet and choices. It is envisaged that additional primary data (through detailed visitation surveys and environmental audits at the resort scale) will allow further development of the methodology proposed in this study. This would then allow for more reliable estimates of the WF of different types of tourist.

A combination of a flight closer to home and a largely vegetarian diet can make a significant difference in lessening the overall impact of a holiday example. The type of accommodation appears to be the second most important factor that contributes to a more sustainable holiday, with budget accommodation having much lower footprints compared to luxury accommodation. Diet is, perhaps, easier and more readily modified compared to flight or accommodation choices. Bearing in mind the magnitude of the indirect water demand of tourism related to food consumption, policymakers and destination managers are faced with the challenge of managing this demand more sustainably, whilst also ensuring that tourist satisfaction remains largely unaffected.

Water use has so far been neglected compared to carbon but is likely to become an important parameter of sustainable tourism in the foreseeable future, not only where water is currently scarce but also where climate change is expected impact local water resources. Estimates like those presented in this paper are only the very beginning of this process, and greater refinement of the methodology and collection of data are certainly needed.

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Tables

Table 1. Hypothetical tourist scenarios used in the study.

Scenario	Location	Accommodation	Local travel means	Diet	Duration
1. Luxury golf holiday	Paphos, Cyprus	5-star hotel	Medium car (2 occupants)	Meat-rich	7 nights
2. Walking/hiking	Polis C., Cyprus	Camping site	Small car (4 occupants)	Vegan	9 nights
3. Budget beach holiday	Bodrum, Turkey	2-star apartment	-	Western diet	9 nights
4. Relaxing beach holiday	Mykonos, Greece	4-star hotel	-	Holiday diet	12 nights
5. Backpacking	Syria	Local house	Public transport	Local diet	28 nights

Table 2. Water consumption standards by accommodation in Morocco (adapted from Eurostat, 2009).

Water consumption standards in Morocco (litre/bed-night)	
Luxury 5-star hotel	600
5-star hotel	500
4-star hotel	400
3-star hotel	300
Apartment	180

Table 3: Distances used to calculate the WF of travel (Sources: www.webflyer.com for international flights and www.mapcrow.info for intra-country travel).

Origin	Destination	Return distance (km)
Manchester	Larnaca	6920
Manchester	Pafos	6800
Manchester	Bodrum	5800
Manchester	Mykonos	5500
Manchester	London	527
London	Damascus	7120
Larnaca	Pafos	260
Pafos	Polis	80

Table 4: Water footprints for each hypothetical scenario.

Scenario	DF		AF		FF		ACF		Local WF		Total H ₂ O	H ₂ O / day
	m ³	%	m ³	%	m ³	%	m ³	%	m ³	%	m ³	m ³
1	46	75	4.4	7	5.6	9	5.6	9	24.6	39	62.6	8.94
2	56.6	91	0.6	1	5.1	8	0	<0.5	9.04	14	63.8	7.08
3	45.3	87	1.6	3	5.2	10	0	<0.5	42.7	82	52.1	5.79
4	56.3	86	4.6	7	4.6	7	0	<0.5	31.5	48	65.5	5.46
5	220.4	95	4.6	2	7.0	3	0	<0.5	12.5	54	232	8.29

where DF = diet footprint, AF = accommodation footprint, FF = fuel footprint, ACF = activity footprint.

Note : 1m³ = 1000 l

Figures

Figure 1. Detailed water footprints for each of the different holiday scenarios. The charts show the relative contribution of blue and green water as well as contribution of different food groups to the daily DF.

Supplementary Table I. Simplified daily food menus for the 5 scenarios taking into account local dishes where appropriate.

	Scenario 1 - Cyprus	Scenario 2 - Cyprus	Scenario 3 - Turkey	Scenario 4 - Greece	Scenario 5 – Syria
Breakfast	200g bread + 2 eggs + 150g milk + 50g cheese	200g bread + 50g olives + 40g nuts + 200g fruit + 250ml soy milk	200g breakfast cereal + 200g milk + 250g orange juice	200g bread + 2 eggs + 150g milk + 50g cheese + 250g orange juice	200g bread + 50g olives + 60g hummus + 50g labneh cream cheese
Lunch	200g meat + 120g salad + 10g olive oil + 200g potatoes + 100g yoghurt	200g bread + 120g salad + 100g hummus ²	100g meat + 100g lentils + 200g tomatoes + 150g onions + 100g beans + 100g bread	200g bread + 120g salad + 100g ham + 100g cheese	200g lentils + 200g tomatoes + 150g onions + 100g beans + 200g rice
Afternoon snack/drink	200g ice-cream + 1 pint (570g) beer	100g dried fruit + 50g dark chocolate	200g fruit + 200g ice-cream	200g ice-cream	200g fruit
Dinner	200g meat (pork/lamb/chicken/beef) or fish + 100g bread + 100g onions + 100g eggplants + 200g wine + 200g fruit	50g lentils + 200g tomatoes + 150g onions + 50g beans + 50g chickpeas + 150g bread + 200g cooked rice + 200g fruit	200g meat (chicken/lamb/beef) + 50g bread + 20g garlic + 100g chickpeas + 50g eggplants + 100g yoghurt + 1pint (570g) beer	200g meat (pork/lamb/chicken/beef) or fish + 50g bread + 100g yoghurt + 20g garlic + 100g onions + 100g eggplants + 2 pints (1040g) beer	200g meat (lamb or beef) kebab + 120g salad + 100g pitta bread + 85g baklava (butter, sugar, flour, nuts)
Total calories ¹ (kcal)	3317	3388	3462	3392	3372
Total water footprint (l)	6697	6417	5057	4696	7876
Water footprint per calorie (l/kcal)	2.02	1.89	1.46	1.38	2.34

Notes: ¹ Calorie values were obtained using the open source dieting software CRON-O-Meter v0.9.7.

² 100g hummus is assumed to contain 60g chickpeas, 20g sesame paste, 10g lemon juice and 10g olive oil.

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