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Assessing International Tourism's Global Environmental Impact of Food and Beverages

Ocena globalnego wpływu żywności i napojów z turystyki na środowisko

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Abstract

Tourism harms the environment in many ways and agriculture is of particular importance because of a wide range of negative impacts, the specific spatial conditionality of tourists' consumption, and the change in their eating habits during travel. Despite the urgency of previous research, the environmental requirements of tourist consumption have not yet been quantified. The main aim of the paper is thus quantify in the long term the total amount of food consumed in international tourism and assess its environmental impacts: land use, water requirements, and emitted emissions. Furthermore, we deal with the projection of these impacts associated with meat consumption up to 2050. The investigation uses long-term secondary data on the number of tourists, national diets, and environmental requirements of foodstuffs. According to our research, 15.6 million tonnes of food was consumed globally in 2010 and this amount increased to 24.5 in 2019. Due to COVID-19, the amount decreased by 72%. Although vegetal foodstuffs account for a larger share of the total, the environmental requirements are primarily associated with animal foodstuffs. Compared to daily at-home eating, tourists' consumption patterns, e.g., higher preference for meat or whole grains, increase the environmental requirements by more than 10%. This research serves destination management bodies and concludes that the food environmental impacts should be the subject of adequate measures that would mitigate them and would make tourism more sustainable.

Key words: food consumption; environmental requirements; natural resources; Sustainable development goals; tourism

Streszczenie

Turystyka szkodzi środowisku na wiele sposobów, a rolnictwo ma szczególne znaczenie ze względu na szeroki zakres negatywnych oddziaływań, specyficzną przestrzenną uwarunkowaność konsumpcji turystów i zmianę ich nawyków żywieniowych w trakcie podróży. Wymagania środowiskowe związane z konsumpcją turystyczną nie zostały jeszcze określone ilościowo. Głównym celem artykułu jest zatem określenie ilościowe w dłuższej perspektywie całkowitej ilości żywności spożywanej w turystyce międzynarodowej oraz ocena jej wpływu na środowisko: użytkowanie gruntów, zapotrzebowanie na wodę i emitowane emisje. Ponadto zajmujemy się projekcją tych skutków związanych ze spożyciem mięsa do roku 2050. W badaniu wykorzystano długoterminowe dane wtórne dotyczące liczby turystów, diety poszczególnych krajów oraz wymagań środowiskowych artykułów spożywczych. Z naszych badań wynika, że w 2010 roku na świecie skonsumowano 15,6 mln ton żywności, a w 2019 roku ilość ta wzrosła do 24,5. W związku z COVID-19 ilość ta spadła o 72%. Chociaż roślinne środki spożywcze stanowią większą część całości, wymagania środowiskowe dotyczą przede wszystkim środków spożywczych pochodzenia zwierzęcego. W porównaniu z codziennym jedzeniem w domu, wzorce konsumpcji turystów, np. większa preferencja dla mięsa lub produktów pełnoziarnistych, zwiększają wymagania środowiskowe o ponad 10%. Badanie to służy organom zarządzającym miejscami docelowymi i stwierdza, że wpływ żywności na środowisko powinien być przedmiotem odpowiednich środków, które mogłyby je złagodzić i uczynić turystykę bardziej zrównoważoną.

Słowa kluczowe: spożycie żywności; wymagania środowiskowe; zasoby naturalne; Cele zrównoważonego rozwoju; turystyka

Introduction

Recent decades have seen severe environmental degradation and all human activities are contributing to this. Tourism has proven to be a very important factor in achieving the Sustainable Development Goals (SDGs), e.g., it fosters economic growth through job creation and rises in incomes, promotes local production (Jones et al., 2017) and enhances food security (Hall & Gössling, 2016). Nevertheless, this industry is a double-edged sword that, among other things, stimulates climate change and undermines achieving the SDGs.

The environmental impacts of tourism are not solely in the form of emissions but can vary significantly from local impacts, including damage to vegetation, spreading of weeds and invasive plants (Smith & Kraaij, 2020), biodiversity loss (Hall, 2006) and heavy metal pollution of soil (Ciarkowska, 2018), to regional and global impacts such as land use requirements, production-related emissions and water consumption (Gössling & Peeters, 2015).

An exceptionally relevant factor to the achievement of the tourism-related SDGs is catering because growing crops and raising livestock put pressure on the environment in several ways. Expansion of agricultural areas, emissions, and use of water resources (Hoekstra & Mekonnen, 2012; Poore & Nemecek, 2018) are typical examples of how agriculture harms the environment. For example, indirect water use from food supply was found to be the largest contributor to tourism water footprint in a case study from China (Lee et al., 2021). Tourism pressure through catering manifests itself also in the pollution of natural resources with hormones and antibiotics (Bartelt-Hunt et al., 2011) and the processes of acidification and eutrophication (Poore & Nemecek, 2018). Therefore, unsustainable catering in tourism can directly undermine the achievement of several SDGs: 12 Responsible consumption and production, 13 Climate action, 14 Life below water, and 15 Life on land. Despite the significant negative impacts, the existing literature does not address the impact of catering in tourism on the achievement of the SDGs. The focus is rather on SDG 2 Zero hunger (see, for instance, Ambelu et al., 2018; Degarege & Lovelock, 2018). We address this gap in this research and focus on how the production of food for tourism undermines achieving the aforementioned SDGs.

Research on tourists' diets may seem like a secondary issue because people have to eat regardless of where they currently are. The underlying importance of research on this issue lies in the disruption of usual eating habits as tourists do not eat the way they normally do at home. Secondly, tourism-related food supply is associated with additional energy needed for transport over large distances (Gössling et al., 2011).

One of the primary reasons that tourists eat differently is their specific spatial behaviour and the spatial distribution of catering establishments. Gössling et al. (2011) argue that tourists only move around a limited (attractive) area where they can access a limited number of catering facilities. It is the catering facilities that affect the overall environmental sustainability of a destination through their menus. This is especially evident in the case of international tourists who tend to visit restaurants in proximity to main tourist hubs (Van der Zee & Bertocchi, 2018). In this respect, their food choices are highly constrained to a limited number of meals available. In addition, as the case study from Prague showed, catering facilities close to major tourist attractions have their menu focused on more environmentally demanding foodstuffs (Lochman, 2021).

Tourists focus their consumption mainly on meat-based food and dairy products, which generally have higher ecological footprints and less on vegetables and fruit (Wang et al., 2020), which generally have lower ecological footprints (Poore & Nemecek, 2018). Moreover, the amount of food consumed differs compared to at-home consumption: tourists consume at least 0.5 kg more food per day (Gössling & Peeters, 2015), also waste more food (Wang et al., 2018, Li et al., 2019).

Environmental impact assessments of tourism have primarily focused on the direct use of natural resources (e.g., water use in hotels or emissions from air transport), rather than the indirect use, including food consumption. Although several studies with a similar focus have been conducted, global tourists' food consumption and its environmental requirements (ER) remain an unresolved issue. We address this gap and quantify the issues since the recognition of the ER of food should be an essential part of destination management. This research is important for its original methodology, which, unlike other similar studies, reflects the diets of different nationalities and also establishes a diet pattern of tourists based on Wang et al. (2020).

The first objective is to calculate the amount of food consumed by international tourists globally since 2010. The second objective of this research is to quantify the overall ER of tourism-related food consumption based on the average diets in different countries around the world. Emphasis is placed on the different impacts of vegetal and animal products on the environment which, in general, have a different order of magnitude (Poore & Nemecek, 2018). Finally, the last objective is to quantify the amount and ER of meat consumed by international tourists up to 2050 since, as previous literature showed, meat consumption is a significant risk of achieving the SDGs. Our research questions are therefore following:

1. How much food have tourists consumed since 2010??
2. What are the ER of international tourists' food consumption?
3. How will consumption of meat products evolve by 2050?

Literature review

There are already several studies dealing with the assessment of the overall tourism-related requirements of (selected) natural resources. These studies, which can be defined as global and local (or regional), with the latter being more common, are presented below.

The first global environmental assessment of tourism identified is the work of Gössling et al. (2012), which is thematically focused on water use. The authors used for their calculation the data from UNESCO (2009), but it is a very rough estimate that does not consider the different eating habits of individual tourists by nationality as each country has specific eating habits. Neither does the authors' analysis quantify how many litres of water in total were used globally for tourism-related food production. Considering the finding that the direct water use is only something between 80 and 2,000 litres per tourist per day and that, as the authors conclude in the paper, food is perhaps the most relevant factor in water use, research on this issue is of particular importance.

Gössling and Peeters (2015) focus on the quantification of how much energy, emissions, freshwater, land use, and food use were required by tourists in 2010. In addition, the research provides a projection of ER up to 2050. In terms of food use, 39.4 Mt (million tonnes) of food was consumed globally, and this is expected to more than double to 82 Mt by 2050. The calculation of the food consumed is based on the simple principle of multiplying the global number of guest nights (21.86 billion) by 1.8 kg of food, which represents the average amount of the food consumed per tourist per day. Neither in this case, are the dietary patterns of individual countries considered. An important observation that emerges from the study is that the calculations of land use, freshwater use, and energy do not take into account food production: thus the resulting amount, as the authors state themselves, reflect only partially the real ER, and they stress that *food represents the resource use area in which the least research has been conducted, calling for considerable research efforts in the future* (p. 647).

The calculation of both direct and indirect tourism-related natural resource extraction has been addressed by Hadjikakou et al. (2013), but only at the regional level (Mediterranean) and with a focus on water resources. The calculation is based on the creation of a hypothetical menu consisting of specific foods, the quantity of which is further multiplied by the average requirements of their production. While this reflects the local way of eating, it completely ignores the common local consumption patterns and the fact that tourists can cook the food that they are used to. The results confirmed the relevance of conducting further research on quantifying the food consumed as this factor proved to have by far the most significant impact on the total water consumption.

Li (2018) came up with a similar methodology for evaluating the water footprint in China's region: to calculate it, the author identified a total of four types of tourists to whom he attributed four different dietary structures; or Zhang and Tian (2022), who use exclusively secondary data that only considers the diets of residents, even though the research is solely focused on inbound tourists. Food consumption also appeared to be the most important factor in Cazcarro et al. (2014), where the total water footprint of tourism in Spain was shown to reach 7 km^3, with food being the main contributor (39%); and in Lee et al. (2021) investigation in China, where indirect water use accounts for 65% of the total tourism water supply.

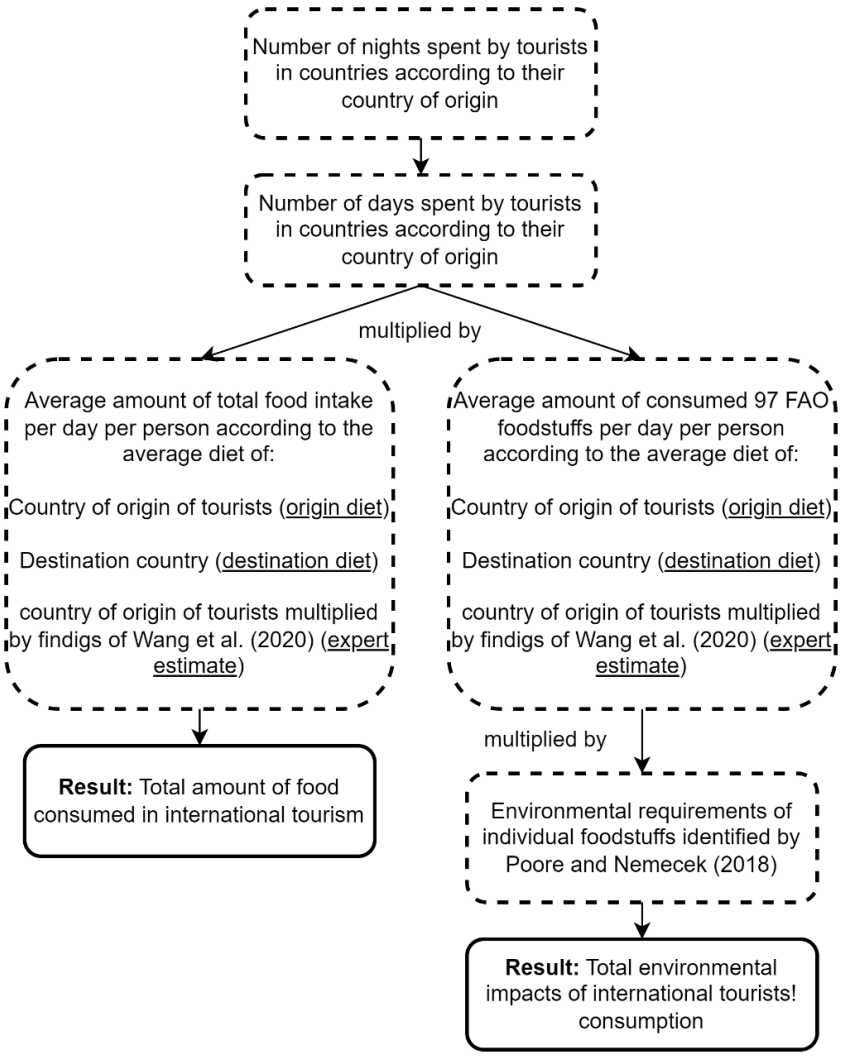
Examples of arguably very precise quantifications of natural resource use can be found in other regional assessments. For instance, in China's Mount Huangshan region (Zhang et al., 2017) a total of 3.51 million m^3 of water was used to produce food for tourists in 2012. The quantity was calculated based on interviews with the tourists visiting the destination focusing on what food they consumed during their visit as well as on secondary data addressing food water requirements per unit of food. An even more detailed approach comes from Lhasa, Tibet (Li et al., 2020): in this case, the authors worked with local catering facilities to accurately measure the weight of foodstuffs that were sold in each catering facility. The amount of food consumed was then multiplied by secondary data.

The authors of the aforementioned studies agree that food consumption and production are key and much-overlooked factors in tourism's environmental impacts. We attempt to expand the existing literature to encourage more interest in these issues. The reviewed articles are linked by a relatively simple but, given their nature, unavoidable methodology. The authors use secondary data dealing with the average amount of food consumed and ER of food which they multiply by meals ordered by tourists, experimental menus, etc. The global amount of food consumed has only been calculated in one study so far (Gössling & Peeters, 2015), and this estimate needs to be updated not only because it is outdated (the calculation was as of 2010) but also because of the lack of detail in the methodology. In this research, not only do we consider tourists' specific diets according to their place of origin and the place of arrival but also the findings of other authors who studied dietary changes during travel and at home. In the next step, we calculate the environmental impacts of the food consumed, which is missing in the existing literature despite a consensus among the authors that such research is necessary.

Materials and methods

In the first phase, we needed data on the number of days tourists spent at destinations globally. For this purpose, we used the *Accommodation: Guests and Overnights* data from UNWTO (2022a). The dataset contained information on tourism for a total of 220 territorial units (hereinafter referred to as countries). We obtained data from 2010 to 2021 so we also could observe the drop caused by COVID-19.

Figure 1. The calculation of tourism-related food consumption and its ER (Own elaboration)



In the first place (see Figure 1), we obtained the numbers of overnight stays of non-resident tourists in all types of accommodation establishments based on their nationality. Since we needed to find how many days they spent, we added up the data on the number of nights spent with the number of tourists. If the data on overnight stays was not available, we obtained other present data. For instance, if only the number of tourists was available, we multiplied this number by the global average length of stay, which is 5.6 (Gössling et al., 2018).

In the second phase, we determined the average diet of each observed country, for both countries of origin of tourists and countries of arrival. This was done using the FAO (2022) data, specifically the *Food supply quantity* indicator, which, while not quantifying diets precisely, measures food availability instead of real food consumption. The dataset contains data for 99 foodstuffs and their quantities. All items, except for categories of *Infant food* and *Alcohol, Non-Food*, were included in the calculation of tourism's environmental impacts. For countries not included in the FAO database, we assigned average dietary values for the entire region.

To calculate the total amount of food consumed, the number of days spent in each country was multiplied by the amount of food available per person per day representing the average daily diet of a particular country.

We decided to consider three tourists' eating patterns. The first calculation of the global tourists' food consumption considers the average diet in the country of arrival (hereinafter referred to as *destination diet*), i.e., the number of days spent was multiplied according to residents' average diets. The second calculation considers tourists' average

diet in their country of origin (hereinafter referred to as *origin diet*). The assumption is that, following a normal average diet, the total amount of food consumed should be between these two values: the diet of the country of origin is to some extent influenced by the typical diet of the country of arrival. However, as mentioned in this article's theoretical introduction, tourists tend to have different eating patterns. Thus, the third calculation considers this finding, and the method of its quantification follows the findings of Wang et al. (2020). According to their results, meat consumption by tourists increased by 11.5%. Furthermore, the consumption of seafood, whole grains, fats/sweets, and dairy products increased by 2.8%, 20.3%, 11.5% and 9.9% respectively. On the other hand, the consumption of vegetables and fruit decreased by 15.5% and 17.6% respectively. The 97 entries in the FAO database have been classified into these categories. The final food weights calculated based on the typical diets in the tourists' countries of origin were then multiplied by the dietary changes identified in the research by Wang et al. (2020) according to the relevant categories (the third calculation hereafter referred to as *expert estimate*). Foods that could not be classified in these categories were not multiplied. The final result is three estimates of the weight of food consumed in international tourism: the origin country diet, the destination country diet, and the expert estimate.

We calculated the environmental impacts using the data collected by Poore and Nemecek (2018). The work includes the ER (land use, greenhouse gases, and freshwater withdrawals weighted by local water scarcity) of the production of 45 types of food, these impacts corresponding to the entire life cycle of the products. This database does not completely overlap with the FAO (2022) database. In some cases, we assigned the foods missing in the Poore and Nemecek database the ER of an immediately related food: for example, palm oil values were attributed to palm kernel oil values. We assigned the remaining foodstuffs the median ER by the food type: animal-based and vegetal-based. In the final phase, the ER were multiplied by the amount of individual foodstuffs consumed according to the three mentioned consumption scenarios: origin diet, destination diet, and expert estimate.

Finally, we intended to calculate the future ER of meat consumption since meat is the major contributor to it. To achieve that, we projected the overnight growth in individual countries by the average growth rate of tourism arrivals in world regions. According to UNWTO (2022b), the number of tourists in 2023 will reach the same level as in 2019. For 2022 we have therefore calculated the number of overnights as half the number between 2021 (i.e., the last year for which the number of overnights was determined from UNWTO data) and 2023.

For the following years, we multiplied the number of overnights in the previous year by the average growth rate. Also, we had to project the FAO data into the future. For this purpose, we only consider poultry, pork, beef, and lamb as only these types of meat were considered by Whitton et al. (2021), who examined rising meat consumption in relation to GDP. They found increasing meat consumption is directly proportional to GDP growth, and for every USD 9,795 per capita per year, annual meat consumption increases by 1 kg. Once the value of GDP reaches USD 40,000 the amount of meat consumption is already stagnant. In this regard, we used World Bank (2023) data to determine the current GDP values and also the GDP growth, and following the results of the mentioned research, we calculated the GDP value until 2050 and therefore the amount of meat consumed (based on the growth from the year 2021) and its ER in the same timeframe. Finally, we multiplied the long-term projection of the number of overnights, the weight of meat consumed in each country based on the destination and origin diet, and finally the average ER of the selected types of meat. We excluded the expert estimate from this calculation because we believe that we cannot simply transfer the findings of Wang et al. (2020) to this purpose.

Results

Current consumption and its ER

We have observed that food consumption by international tourists increased by a full 56% between 2010 and 2019. In absolute terms, this is an average increase from 15.5 million tonnes to 24.2 million tonnes (Figure 2). Regarding the different types of diets, the consumption scenario of the origin diet has increased the most, i.e., tourists continue their eating habits in a destination. However, the difference is only four-tenths of a percent compared to the expert estimate. Since 2010, there has been a gradual increase in consumption by a few percentage points. COVID-19 caused a significant decline in food consumption as a result of the restrictive measures that paralyzed travel. In 2020, there was a reduction in food consumption of approximately 72% compared to 2019. The decline continued until 2021, which was also largely influenced by restrictive measures.

Considering world regions (defined by the UNWTO) and the expert estimate, tourists from North America have the highest share of food consumed (22% as of 2010 and 33% as of 2021). Figure 3 shows that significant changes in share occurred during the pandemic period due to travel measures that have been restrictive to varying degrees in different regions. For example, strict restrictive measures in China meant that the share fell from 18% to 2%. Furthermore, an interesting decline occurred in other regions, which had until then seen a slight increase in their share. For the main tourist regions, a stagnating or even decreasing trend (Northern Europe) can be observed. On the contrary, the regions with the lowest share, which we classify as other regions (15 regions in total), are regions with underdeveloped tourism (African regions) or small island regions that are geographically remote and have low capacity (Micronesia). However, these regions have shown slow growth over the long term.

Figure 2. Amount of food consumed by international tourists (own calculations based on Gössling et al., 2018; Wang et al., 2020, FAO, 2022; UNWTO, 2022a)

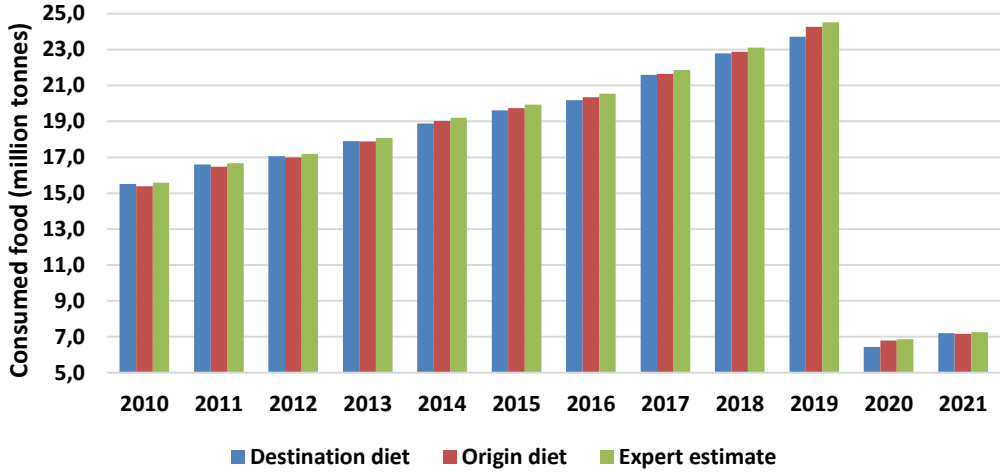
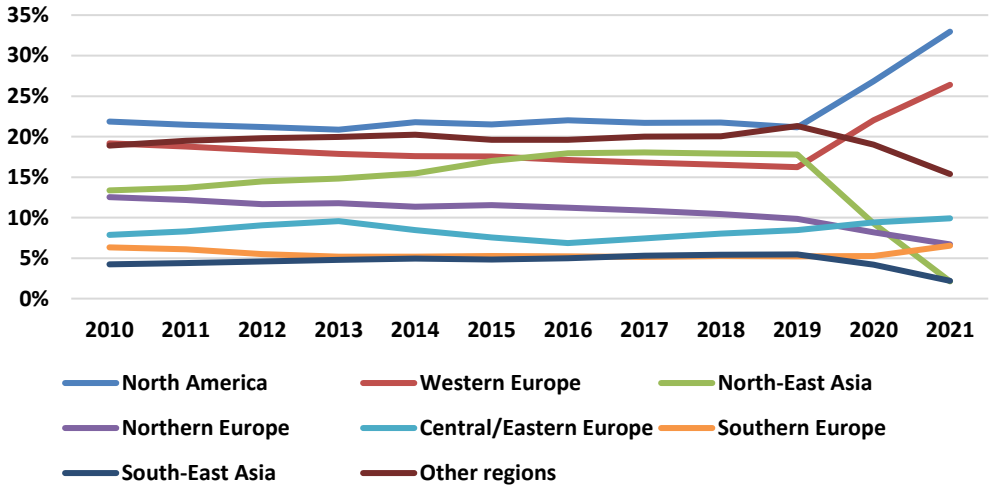


Figure 3. Amount of food consumed by international tourists (expert estimate) by world regions (own calculations based on Poore & Nemecek, 2018; Gössling et al., 2018; Wang et al., 2020; FAO, 2022; UNWTO, 2022a)



Tourists primarily consume plant-based foodstuffs. The share of animal-based food in tourists' diets is approximately one-third of the total. Thus, in 2019, tourists consumed 7.3 million tonnes of animal-based foodstuffs in the destination diet scenario and 7.7 million tonnes in the origin diet scenario. The expert estimate is noticeably higher at 8.4 million tonnes, as this diet is characterised by just an increase in the proportion of animal-based foodstuffs in the diet. The share has been increasing slightly over the long term (Figure 4), especially since 2019. This is due to the long-term increase in animal-based foods in diets, but also to the increase in the proportion of tourists from European and North American countries in pandemic times, where people consume higher amounts of animal-based foods.

Although animal-based foods account for only one-third of global tourist consumption, their environmental demands outweigh the statistics (Table 1). The land use and emissions requirements of animal foodstuffs amount to approximately three-quarters of the total requirements of the food consumed, but the requirements for water resources are lower, below two-thirds. This is because of the significant requirements of rice on water resources, which is an important part of the diets of Asian nations in particular and therefore also of specific destinations.

ER have naturally increased since 2010. As of 2019, they have increased by approximately 50% and the decrease due to COVID-19 corresponds to the decrease in total consumption, i.e., by approximately 72% as of 2019. If we consider the expert estimate, which we perceive as the most relevant one, to satisfy the consumption of tourists, 134,782 square kilometres of land, 10.0 cubic kilometres of weighted freshwater withdrawals resources, and 90.6 million tonnes of CO_{2e} were needed in 2019. Of the diets observed, these are the highest requirements. On the contrary, the lowest demands are observed in the case of the destination diet.

The average ER (in total, land use, emissions and water) by tourists' origin (expert estimate) is almost identical to the amount of food consumed. North America has the highest share, followed by Western Europe and North-East

Asia, where there has been a significant drop in share. ER have been declining for a long time in developed European regions (Figure 5). The increase in shares in the pandemic period is probably due to less restrictive measures in European countries and thus generally higher tourist numbers compared to non-European regions. South, South-East and North-East Asia regions have a higher share of water use compared to land use and emissions due to above-average consumption of water-intensive rice.

Figure 4. Animal-based food as a percentage of total consumption (own calculations based on Gössling et al., 2018; Wang et al., (2020; FAO, 2022; UNWTO, 2022a)

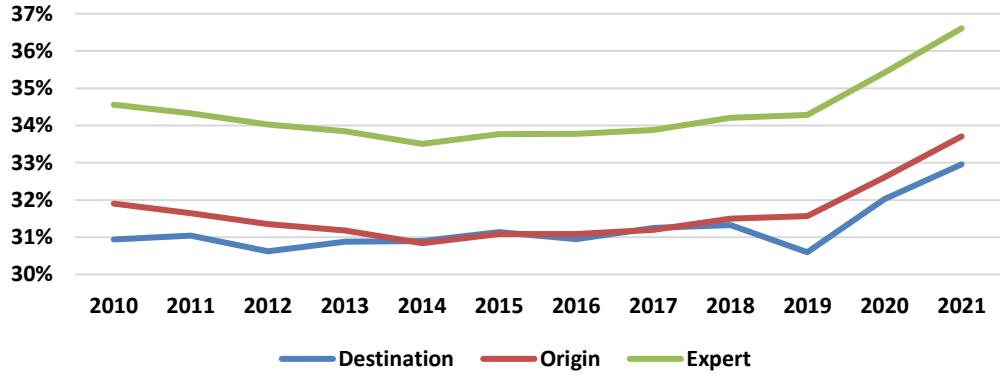
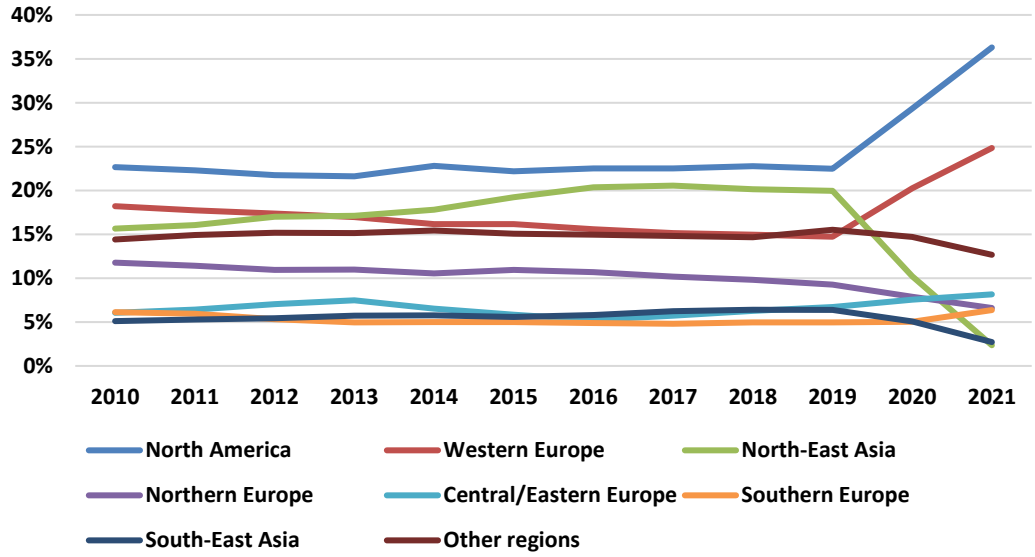


Table 1. ER of animal foodstuffs as a proportion of total ER for 2019 (own calculations based on Poore & Nemecek, 2018; Gössling et al., 2018; Wang et al., 2020; FAO, 2022; UNWTO, 2022a)

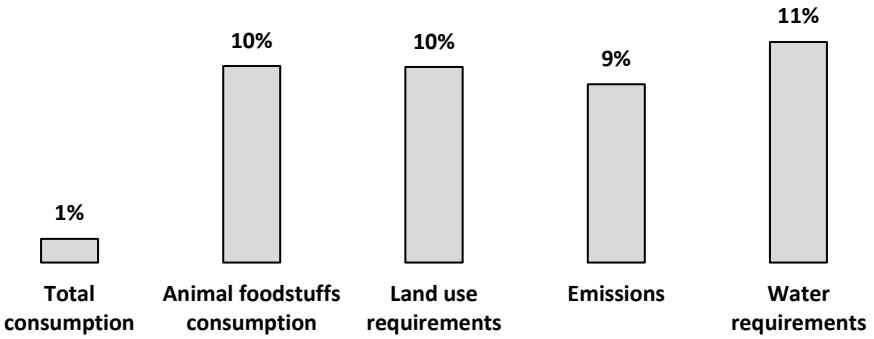
Diet type	Land use	Water	Emissions
Destination diet	75,8%	59,6%	76,4%
Origin diet	76,3%	61,6%	76,9%
Expert estimate	77,1%	60,8%	77,9%

Figure 5. Average ER (expert estimate) by world regions (own calculations based on Poore & Nemecek, 2018; Gössling et al., 2018; Wang et al., 2020; FAO, 2022; UNWTO, (2022a)



An important indicator is the change in ER between the original diet and the expert estimate, which is based on the origin diet and reflects the change in tourists' eating habits in a destination according to the findings of Wang et al. (2020). The identified change in dietary patterns resulted in an increase in consumption of only one percent in the most recent year, 2021. The reason for this is that some foods are preferred by tourists while travelling (meat, dairy products) and some are reduced (vegetables). The ER are considerably higher compared to the quantity of food eaten and roughly correspond to the increase in consumption of animal foodstuffs (Figure 6). In absolute terms, this is an increase of 3,607 square kilometres, 2.2 million tonnes of CO_{2e}, and 0.3 km^3 of the weighted water resources.

Figure 6. Change of indicators between origin diet and expert estimate (own calculations based on Poore & Nemecek, 2018; Gössling et al., 2018; Wang et al., 2020; FAO, 2022; UNWTO, (2022a)

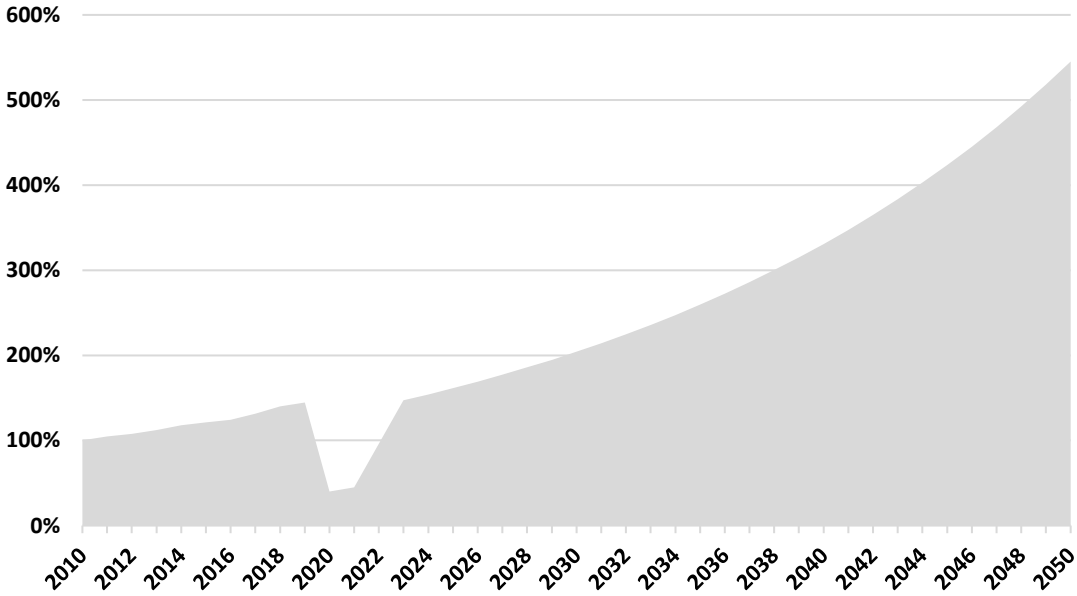


Long-term projection of meat consumption ER

Based on our calculations, we estimate that the number of overnights will increase 6.6 times between 2010 and 2050 to just under 47 billion overnights. First, we calculated that the amount of meat consumed has increased from 1.4 million tonnes in 2010 to 2.1 (destination diet) and 2.2 million tonnes (origin diet) respectively in 2019, according to the available data. COVID-19 contributed a 73% decrease to 0.6 for both consumption scenarios. From this year onwards, based on our calculations, there is already a gradual increase of around 5% each year. The situation in 2050 corresponds to 5.7 (destination diets) respectively 5.6 times (origin diets) the situation in the first year of monitoring. A precondition for this development is the continuation of current trends in tourism development and the rapid regeneration of tourism, which is predicted by the UNWTO (2022b) itself.

Of the observed diets, the destination diets' ER grew more slowly. Land use requirements increased 5.3 times and emissions increased 5.4 times. In contrast, water resources require more in this scenario, here the quantity increased by 5.7 times. In the case of the origin diet, the increase is almost identical for all the requirements - when rounded up, it reaches 5.5 times. The differences between the percentage increases in ER between 2010 and 2032 are only in units of percentage points. The gradual, average development of all ER is shown in Figure 7. The year 2010 is a base year and therefore has a value of 100%. A doubling of the baseline value will occur in the two years 2029 and 2030. Some slowing of the trend may occur if tourism saturates in Europe and GDP per capita per year reaches USD 40,000, which indicates stagnation in meat consumption, in currently developing countries.

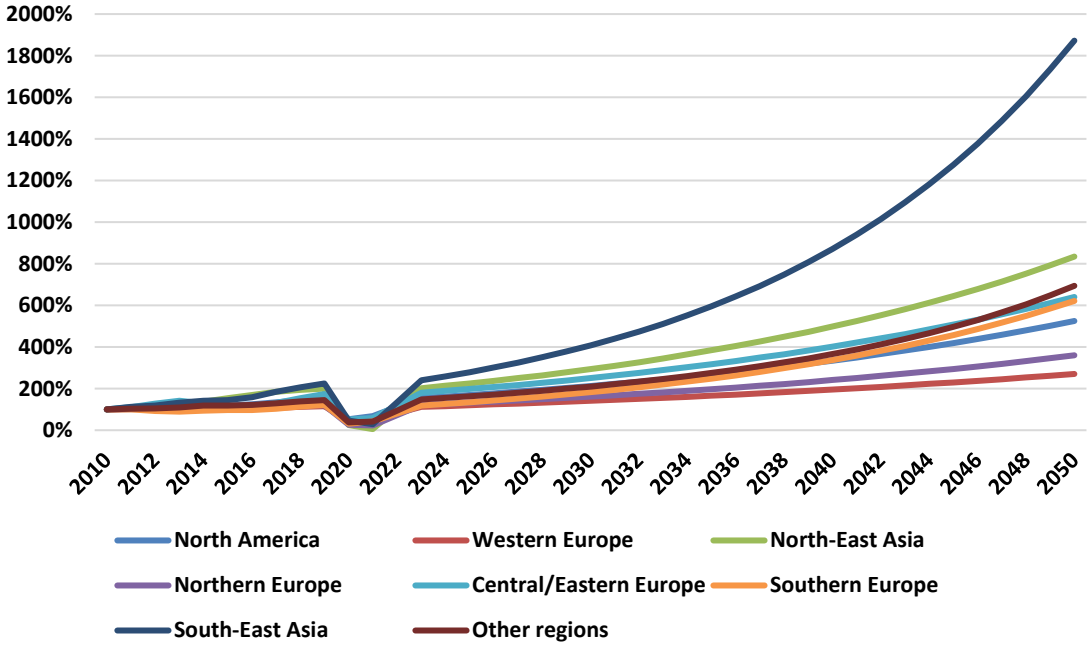
Figure 7. Average growth of ER (own calculations based on Poore & Nemecek, 2018; Gössling et al., 2018; Wang et al., 2020; Whitton et al., 2021; FAO, 2022; UNWTO, 2022a; World Bank, 2023)



Finally, for the selected regions of origin of tourists, where the highest share of the total consumption of international tourists was observed in the previous chapter, here (Figure 8) we also evaluate the long-term prediction of the ER of meat consumption (based on origin diet). The regions with the most significant growth are primarily those in Asia, which are not yet among the group of countries with high GDP per capita. However, South-East Asia's reported growth of just under 2,000% is not the highest among the regions. Within the Other regions, South

Asia is the top region with an average growth of 3,557%. European regions are somewhat stagnant, due to stagnating meat consumption but also to the steady development of tourism. Asian countries are characterised by more dynamic growth in the number of tourists. Environmental demands are also increasing significantly in South America.

Figure 8. Average growth of ER by world regions (own calculations based on Poore & Nemecek, 2018; Gössling et al., 2018; Wang et al., 2020; Whitton et al., 2021; FAO, 2022; UNWTO, 2022a; World Bank, 2023)



Discussion

The significant contribution of animal products to environmental impacts is confirmed by previous assessments of the impacts of tourism-related consumption. For example, in Lhasa (Li et al., 2020), although vegetal products accounted for nearly half (47%) of the food consumed, they contributed to only 16% of the arable land requirements generated by the total food consumption in 2015. Li (2018) also studied the different water requirements in terms of vegetal and animal products according to different types of tourists (also in terms of tourists' place of origin) and concluded that high-calorie-dominated diets are almost five times more water-intensive. Moreover, the author urges to design of specific policies that would reduce high-calorie food intake in tourism. For example, the problem of excessive consumption of environmentally challenging foods is also addressed by Gössling et al. (2011): to reduce the carbon footprint, he proposed so-called food management, the essence of which is, among other things, to integrate at least one vegetarian meal into the menu, to offer less rice and beef or to train employees to recommend less carbon-intensive meals to the customers – all of which is in accordance with the responsible consumption promoted by the SDG 12.

Concerning our findings and the findings of the other authors mentioned in the previous paragraph, this method of food management could be a suitable solution to tourism's environmental impacts, especially in restaurants located in attractive tourist areas. In the case study of Prague (Lochman, 2022), it was found that menus of catering facilities in Prague's most tourism-exposed area are dominated by meat-based dishes: only one-fifth of each menu contains vegetarian dishes. In addition, the very structure of local menus nudges customers to select rather meat-based dishes. At the same time, a higher proportion of vegetarian meals may increase the likelihood that customers will order them. Specifically, Garnett et al. (2019) found that doubling the proportion of vegetarian meals on the menu from 25 to 50% increased their sales by 15 percentage points. The findings obtained by Lochman (2022) are in line with the current findings of Huang et al. (2022), who learned, based on analysing 126 destination restaurants' websites, that destination restaurants do not usually commit themselves to sustainability. The authors argue that the main reason is that *such restaurants are already so high profile in their food offer and with long wait lists for seat availability that the promotion of sustainability is not needed for either loyalty or pricing* (p. 15).

The difference between the origin diet and the expert estimate confirmed the relevance of research on tourism-related food consumption as different dietary patterns during travel, identified in the research of Wang et al. (2020), caused a 9–11% increase in ER even though it only cased 1% increase in total food consumption. We consider this difference as one of the most important findings of this research.

In this research, we worked with several projections of diets, which distinguishes it from the research of Zhang and Tian (2022), who worked with only one projection, namely the assignment of the dietary patterns of residents to tourists. We believe that this approach is insufficient because the origin diet is naturally to some extent influenced by the destination diet. In addition, tourists waste more food (Wang et al., 2018, Li et al., 2019) and usually consume preferred foods in different quantities, which is why we added the expert estimate projection (Wang et al., 2020). However, similar to Gössling and Peeters (2015), we still see the understanding of tourists' consumption behaviour as an insufficiently explored topic that should be at the centre of future research, including the identification of factors that influence tourists' behaviour.

The amount of food consumed in tourism estimated by Gössling and Peeters (2015) for 2010 is 39.4 Mt. By 2050 this amount is expected to reach 82.0 Mt. They investigated both, domestic tourism and international tourism, and thus we consider our estimate as highly in accordance with their estimates. They also estimate the amount of water used indirectly. According to their calculations, tourism indirectly uses approximately 120 cubic kilometres of water. According to our results, water for food supply for international tourism would contribute only about 5% of this estimate, which is disproportionate. An important difference lies in the methodology, as our calculations consider scarcity-weighted freshwater withdrawals, while Gössling and Peeters (2015) consider sums of grey, blue, and green water. More importantly, there are other indirect factors than just food-related water.

The ER of food consumption can be expected to grow. The first reason is natural, the number of tourists has been increasing in the long term. Another reason is the increasing consumption of environmentally challenging meat and dairy products in China (He et al., 2016) and the increasing consumption of animal-based protein in India (Sans & Combris, 2015), representing heavily populated countries with a large outbound and inbound tourism potential. As stated by Rosi et al. (2017), an omnivorous diet has worse ER compared to vegetarian and vegan diets in terms of carbon, water, and ecological footprints.

The global environmental impacts of food production and its connection to the SDGs are, as far as we know, completely absent from the existing research on tourism. In the case of environmental assessments, the only exceptions are studies focusing regionally, although they focus only on evaluating, e.g., the use of water resources. The observed significant ER of animal-based foodstuffs, which are disproportionate to their share in the volume of food consumed, justify the implementation of relevant measures undertaken by stakeholders to reduce the volume of their consumption.

Conclusions and limitations

International tourists consumed around 15.5 Mt of food in 2010, and by 2019, the amount increased to an average of 24.2 Mt. COVID-19 reduced this amount to only 6.7 Mt. By comparison, the UN World Food Programme delivered 4.4 Mt of food in 2019 (WFP, 2020). We consider the most accurate estimate to be the expert estimate indicating that tourists consumed 24.5 Mt of food. Still, this estimate has some shortcomings because the authors' study was conducted considering American domestic tourists only. Projecting their results onto, e.g., Asian tourists, who are unsurprisingly highly represented in our sample, may bias the estimate not only of the quantity of food consumed but also of the environmental impacts.

Considering the expert estimate and the last year that wasn't affected by the pandemic, the total ER of international tourism food consumption have been quantified at 134,782 square kilometres of land use, 90.6 Mt of CO_{2e} and 10.0 cubic kilometres of water. By comparison, land use requirements are greater than the size of Greece; nearly 20 million typical passenger vehicles emit 92 Mt of CO_2 (EPA, 2022a); and a fifth of U.S. households consume 10.8 cubic kilometres of water annually (U.S. Census Bureau, 2021; EPA, 2022b). In this light, we stress that the SDGs 12 Responsible consumption and production, 13 Climate action, 14 Life below water and 15 Life on land should not be overlooked in the literature focusing on sustainable tourism development.

Particular attention should be paid to SDG 12 Responsible Consumption and Production because animal-based diets are found to be a major contributor to the observed international tourism's ER. Although tourists consume more vegetal products, more than double compared to animal products, its ER are lower: in the case of the expert estimate, they only contribute to 22% of land use requirements and 23% of emissions. The share of water requirements is lower as 43% of the total water use was needed to produce vegetal products. This is due to the very intensive water requirements of rice – which, along with nuts, is the most water-intensive vegetal foodstuff (Poore & Nemecek, 2018). Furthermore, meat consumption will rise steeply, both because of the increasing number of international tourists and because of the increasing proportion of meat in diets, particularly in developing countries that currently have a GDP per capita below USD 40,000 (South and South-East Asia).

One of the limitations, to a certain extent, is the use of the FAO data, which although closest to the average diets in each country, do not fully correspond to them: they show food availability per person in a given year. The values are therefore higher than the daily average of 1.3 kg (excluding beverages) assumed by Gössling and Peeters (2015), however, the average diets used could be more in line with the reality as people eat (Göosling & Peeters, 2015) and waste (Wang et al., 2018, Li et al., 2019) more food as tourists. A similar problem arose with the UNWTO (2022a) data as the information available varies significantly from country to country.

For the sake of sustainable tourism development, the impact assessment of a similar policy to previously mentioned food management defined by Gössling et al. (2011) should be conducted. We believe that the understanding of the impact of a hypothetical policy widely implemented in a given destination aiming at curbing excessive meat consumption would be an opportune future research design. If measures to reduce meat consumption do not negatively affect the attractivity of a destination, it could be another opportunity to ensure a balance between the environmental and economic dimensions of a destination's development and to get closer to achieving SDG 12. Such assessments should be in accordance with local context. For instance, measures reducing rice consumption should be elaborated in regions where this consumption prevails.

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