The Carbon Footprint and Decarbonisation (or not) of Tourism: Insights from Environmentally-Extended Regional Input Output Analysis

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Abstract

Tourism is an important and almost certainly increasing driver of anthropogenic climate change. However, intelligence on the greenhouse gas emissions related to of tourism trips and to destinations is relatively limited, even more so in terms of trends over time. This paper uses an environmentally extended input-output approach to estimate the greenhouse gas emissions arising from tourism to and in Wales, a region of the UK, in 2007 and 2019. We suggest that the overall 'footprint' of tourism is around 3.3 megatons, 8.5% of total territorial emissions, and that there has been a very modest reduction of just over 1% per annum since 2007, with these largely consequent on reduced visitor volumes and on supply chain decarbonisation. This slow progress and the increase in inter-continental visits to Wales over the period suggest tourism here – and probably in most regions – is not embarked upon a climate-responsible transformation.

Key words: Tourism, climate change, decarbonisation, input-output, Wales

1 Introduction

In 2013, tourism was responsible for around 8% of anthropogenic greenhouse gas (GHG) emissions, and this percentage was growing fast (Lenzen *et al*, 2018). Despite this significant contribution, reduction of emissions from tourism sources is only rarely addressed directly in wider climate mitigation policy debates and government strategies. Whilst the last decade has seen an increasing interest in tourism and climate change and a number of studies estimating the carbon footprint of tourism trips, there is little understanding of whether tourism as a societal activity – rather than, say, transport – is moving quickly (or at all) to a climate-responsible, net-zero footing (see Scott & Gössling 2022 for a review of the literature). This paper contributes to this debate by reporting the 'holistic' carbon footprint of tourism in Wales (a region of the UK) in 2019, and then comparing this with a conceptually and statistically similar analysis for 2007.

The analytical complexity and statistical requirements of this assessment and comparison are not insignificant. Tourism makes demands (directly and via supply chains) of the widest range of industries – from agriculture and manufactures, through energy and (particularly)

accommodation and transport, and through to private and public services: visitors' purchases are however rarely separately identified in company revenue statements or national and regional accounting systems. This means the reasons behind tourism-related purchases – and of consequent GHG emissions – are not fully understood. Meanwhile, the tourist makes these economic demands *outside* their place of usual residence (and often country), meaning the tracing and attribution of purchases and consequent GHGs more statistically complex and conceptually uncertain – for example, should trip-related GHGs be allocated to the tourist's place of residence, or the destination region?

These are important statistical, conceptual, and narrative gaps. Firstly, because knowing the relative importance of tourism in the demand for services can help shape their delivery (e.g. a lower carbon 'slow' or active transport system may be more acceptable for tourists than commuters; Fullager *et al* 2012); secondly, because only by fully understanding the 'rationale and reward' behind climate-heating visitor behaviours can governments and firms transform them to climate-neutral behaviours whilst retaining, as far as practicable, their human welfare benefits; and thirdly, because governments cannot effectively shape climate mitigation policy in their countries, or encourage its acceptance, without knowing the relative importance of tourism (and of different types of vistor) in terms of economic and climate (and ideally ecological) benefits and costs.

There is, happily, an internationally agreed methodology for understanding the economic scale, nature and impacts of tourism within a destination economy, consistent with systems of national-accounts (SNA) – the Tourism Satellite Account (or TSA; Frechtling, 2010) – and this Input-Output (IO) based framework has been extended over the last decade to allow measurement of the GHG consequences of visitation, albeit only for current (not capital) purchases, and with limited coverage of public investments (see for example Li et al 2019). Many countries and regions have developed TSAs, and a project linking TSAs with systems of economic-environmental accounting is underway[1]. It is however the case that despite longstanding agreement between governments and agencies regarding the shape and construction of TSAs, their role in shaping tourism policy has, with limited exceptions, been hard to discern at national or sub-national level. This is important because there is little point in undertaking the conceptual and statistical development of environmentally extended IO Tables or TSAs if their results will not influence or inform governments' and wider stakeholders' actions to reduce GHGs from tourism.

This paper thus presents a case study of a region of the United Kingdom; Wales, presenting results from the 2007 and 2019 environmentally extended Input-Output Tables closely related to a regional TSA (Munday *et al*, 2013) to assess whether and how regional tourism

[1] See https://www.unwto.org/standards/statistical-framework-for-measuring-the-sustainability-of-tourism

has decarbonised. Wales has benefitted from a programme of TSAs and tourism environmental accounting for almost two decades, and this programme has given rise to a number of (government supported) economic and environmental impact modelling tools. Moreover, Wales is a region whose government and civic society have long identified sustainable development as of central importance, cementing consideration of the wellbeing of future generations and a high level of environmental protection into legislation Davies, 2017; Netherwood & Flynn, 2021). As a part of the UK where, additionally, there has been regional control over tourism, economic development and environmental policy and legislation for two decades, Wales should be close to a 'best case' for the encouragement of climate-aware tourism. The reality, however, is somewhat different.

2 Background: Climate Change, Tourism & Decarbonisation

2.1 The Transformative Imperative of Climate Change

As Scott and Gössling (2022) show, the tourism academy has been relatively slow (in any great number) to tackle the question of how tourism interacts with the climate. This is despite the fact that the impacts of tourism on the environment have been at issue for many decades (e.g. Wagar, 1964; Wenkam, 1975; Cohen, 1978). These early studies focused on the protection of local ecology and environmental amenities and similar concerns have informed a longstanding (two decades or more) strand of inquiry which seeks to understand whether visitor destinations might lose attractiveness or viability following the impacts on local ecology or weather consequent on anthropogenic climate change. Destinations at risk range from the lowest coasts and seas (Jarratt & Davies, 2020; Moreno & Amelung, 2009 and Arabadzhyn et al, 2021) to the highest mountains (Moen & Fredman, 2007; Scott *et al*, 2003; Nyaupane & Chhetri, 2009). The potential impacts of climate change *on* tourism have led to more systematic suggestions as to how destinations and the industry might cope (Becken & Shuker, 2019; Scott, 2021).

Coping is however, not enough. Because tourism, particularly international tourism, requires very long-distance mechanised travel, rarely low-carbon, and significant consumption of economic resources at destinations, tourism must transform its enabling supply technologies, and tourists their behaviours to become climate-responsible – effectively, for most tourism zero carbon (Hall, 2021). This is not, it seems, going well. Higham et al (2021) note the lack of any strong and coordinated drive toward actual (rather than 'offset enabled') climate mitigation, from either within the industry or from supporting transport, and point to industry stakeholders focussed largely on volume growth and ignoring resilience, and with directly climate-affected voices unheard. Becken *et al* in 2020 concluded that tourism was

still not well integrated into wider climate change policy. Meanwhile, Gössling & Scott (2018) point to a 'decarbonisation impasse' at the highest level of tourism leadership, where uncertainty is used as a rationale for avoiding action, and Becken (2019) focussed on six reasons why tourism decarbonisation is so difficult – not least its deep rooting in the existing framework of globalised growth-oriented economics.

Added to the above issues is the fragmentation inherent in behaviours that take residents outside their usual environment (and reference economy) for a short period, thus resulting spending and GHG emissions across polities, in and between destination and home, and this raising serious issues of climate communication, management and accounting. One way of understanding these impacts and relevant ameliorative actions is clearly from the perspective of the visitor themselves; the whole trip. Here there has been some progress.

2.2 Accounting for the whole-trip climate impacts of tourism

Tourism environmental accounting is unlike many other approaches to climate accounting, or indeed eco-footprinting, which largely allocate impacts according to the *residence* of firms or people, or where emissions originate (see for example Tubiello et al 2013; Rees, 2018). Instead, the TSA process – and its climate and modelling extensions – encourages a focus on the nature and behaviours of the economic entity (the visitor) at the time of, or in furtherance of the trip (Frechtling, 2010). Whilst this adds some conceptual complexity (and lots of statistical strife) it is perfectly sensible: we can only hope to understand and change behaviours if we focus on the rationale behind them; for example Rico *et al* (2019) use a carbon life cycle approach to assess the carbon footprint of Barcelona, and Khanal *et al* (2022) use econometric time series for Australia. Here, TSAs, Input-Output and linked modelling approaches (principally Computable General Equilibrium, CGE) can, data permitting, paint the fullest climate and economic picture of the whole trip, transparently including direct and indirect effects (bespoke to reference regions), treating emissions similarly wherever emitted, and helping governments, tourism agencies, businesses and visitors be clear on where the emissions 'hotspots' of the trip occur (Sun *et al*, 2019) – and thus where to focus ameliorative effort.

Authors have applied these techniques in a range of contexts. Recently, for example Pham et al (2022) integrated IO, TSAs and Australian greenhouse gas inventories to report touristic GHG emissions for over a dozen Queensland destinations across eight emitting sectors, and Shi and Yu (2021) employed EE-IO to estimate that 73% of China's touristic CO2 footprint arose from energy generation. Ragab & Meis (2016) examined the Egyptian accommodation industry, usefully extending the TSA analysis to energy and water use (with negative results in terms of tourists' resource intensity). The technique has been applied to

visitor-attracting sports events (Jones, 2008) and even alongside eco-footprinting (Collins *et al*, 2009). These studies show both that it is possible to estimate the GHGs consequent on a tourism trip; that they are significant (relative to, for example, local residents' emissions); and also that they tend to arise from outside the 'tourism sector' of hotels and attractions – for example in transport and energy supply. Showing that tourism trips are a climate problem, and revealing the proximate and indirect causes is, however only part of the story. Are these emissions reducing, and if so, are they reducing as quickly as they must?

2.3 Assessing progress in decarbonisation

We have already noted the increasing call for the transformative decarbonisation of tourism. Little evidence exists however as to whether this call is in any way impactful. What evidence does exist is not hopeful. Lenzen et al (2018) show that although between 2009-13 tourism reduced in carbon intensity, the increase in tourism volumes and value more than outweighed this reduction, leading to an increased footprint. Li et al (2019) report a similar picture for Beijing between 2007-2012. Sun *et al* (2022) report that Norway's (direct) tourism emissions increased 3.2% per annum between 2007 and 2019, despite national emissions seeing a (small) reduction. Whilst, then a number of countries made *some* progress in both absolute decoupling of GDP from GHG emissions through the noughties (Habert *et al* 2020), there is no evidence that this happened for the tourism that is centred in some of these countries (Lenzen *et al*, 2018) – perhaps unsurprising given the barriers to change and policy integration described in Section 2.1 above.

Some of the barriers however described by Becken (2019) might be lower in smaller polities that are more strongly focussed on environmental sustainability, where there are (relatively) close relationships between industry and government, and between levels of government, and where there is a legal framework that mandates globally responsible governance. The remainder of this paper examines the decarbonisation of tourism in one such polity.

3 Why Wales? tourism policy and accounting in a 'sustainable region'

As a partly autonomous region of the UK since 1999, Wales has an ability, increasing over time with further devolution, to place 'clear water' between policies enacted in London and Cardiff. Consecutive Welsh Governments (Labour or Labour led) have done so not least by forging a policy path that is (somewhat) more leftist than UK governments, and significantly more environmentally aware. The Senedd (Welsh Parliament) has long had a legal duty to consider sustainability in its approach, and by 2015 this orientation resulted in the Wellbeing of Future Generations (2015) Wales Act, which required 44 Welsh public agencies to consider future wellbeing (of all people) in regulatory, legal and policy development, and in

their implementation (Davies, 2017). This Act was followed in 2016 with an Environment Act aimed at protecting Wales' natural resources and ecosystems, and the global climate.

Alongside a focus on sustainable development, Welsh Governments have long been focussed on tourism as a key economic sector, spending considerable efforts on marketing and destination management to lever its mountains, beaches and castles, and since the late 1990s, the recognition of Cardiff as an 'event destination' city. Although initially a primarily economic endeavour, by 2010, the Welsh Government, regional tourism agencies and local authorities were recognising the need for ecologically and climate sustainable tourism development (Munday et al 2013). These efforts progressed along a number of avenues;

- The encouragement of green tourism accreditation amongst hotels, guest houses, self-catering operators and visitor attractions, including GTBS and the bespoke to Wales 'green dragon[2]' scheme.
- The development of a suite of sustainable tourism indicators, intended to complement Wales' wider sustainable development indicators, and applicable to destinations and municipalities[3]
- Support for the development of an environmentally extended Tourism Satellite Account, and a related Tourism Impact Model that could provide estimates of the direct and indirect economic value and environmental consequences of tourism in Wales, and of individual types of tourist and of discrete events (Jones, 2013).

These avenues of statistical and policy development were varying in success and duration (see Section 5) However, the tourism satellite account and associated (input-output) modelling was a significant resource for government and academia, being used to assess the overall value of tourism in Wales in 2007 and 2011, to estimate the carbon footprint of tourists in (and travelling to) Wales (Jones, 2013), and notably informing the government Major Events strategy[4]. The statistical framework was used to estimate, *ex ante*, the economic impact of a number of sporting and cultural effects including the carbon footprint of a global-scale motorsport event (Collins et al 2009). A later TSA construction (for 2013) was used to examine the different productivity and profitability of locally- versus non locally-owned tourism businesses (Xu et al, 2020). Despite this widespread use, the TSA was not fully re-estimated beyond the 2007 base year. However, the derivation of Input-Output Tables for Wales for base year 2019, including the estimation of tourism demand vectors on a similar conceptual and statistical basis to 2007 means that we can now address the

[2] https://www.groundwork.org.uk/services/green-dragon/
[3] No longer available online
[4] https://gov.wales/event-wales-major-events-strategy-2010-2020 - the modelling was used by the Government to estimate the likely regional impacts of events requiring subsidy.

question; has tourism in this 'sustainable' region become any less carbon emitting – or carbon-intense – in the intervening dozen years?

4 The carbon footprint of tourism in Wales

4.1 A Word on Methodology & Data

This section reports the carbon footprint of tourism in (and to) Wales using environmentally extended input-output tables (but with fuel burn separately estimated) with tourism demands separated from (Wales domestic) household or export demand as required. In common with other approaches that require multiplier analysis, the tables are in an industry-by-industry symmetrical format. The overall approach to the derivation of the Input-Output Tables for Wales is described in WERU (2010), and the further manipulation of these Tables to comprise an environmentally extended TSA (that can also capture emissions related to travel to and from the reference region) is reported in Jones (2013). Further key conceptual, data and policy issues discussed in Munday et al (2013). The compilation of the 2019 IO Tables is presented in the Jones (2022).

The tourism (including excursion day visits) spending data sources upon which our estimate of regional tourism demand (and hence in part GHG emissions) are based are reported in detail in Jones (2022). Modest manipulations are required to these data to make them 'fit' into the regional tourism account; for example, disaggregation into narrower SICs, price/tax adjustments and the reattribution of margins and imports. These modifications are undertaken with reference to UK Analytical Input-Output structures, family spending and travel surveys[5]. There are, however, a number of key differences between the earlier and current estimation; in general, these are not improvements.

- Firstly, the thematic coverage of UK-household tourism surveys has, since the 2007 estimation become less useful for the compilation of TSAs and related IO accounts. Effectively the survey (sponsored by UK and UK-regional tourist boards) was refashioned in 2015 and no longer divides aggregate trip expenditures by individual tourism (and other) commodities and services. Thus, the data presented in the 2019 Account use 2015 by-category spending adjusted to sum to 2019 total trip expenditure,
- The 2007 results were based on an 88 industry/commodity breakdown unique to Wales. For 2019, the SICs are now in a more standard UK IO 64 group format, easing estimation and spatial comparability, but losing detail with hospitality sectors,

[5] Again, see Jones (2022).

- Data on the *within-Wales* (during-trip) travel behaviours of staying visitors (important to assess mileage and hence GHGs consequent on the burning of vehicle fuels) was, for 2007, taken from a survey by Welsh Government that has not been repeated; hence 2019 per-trip mileage estimates from (household) travel surveys are applied to 2019 visitor trip volumes, and then GHGs estimated using estimates of GHG emissions per vehicle kilometre for 2019.

These data limitations are only partially balanced at by the publication (since base year 2010/11) of the UK Tourism Satellite Account[6] which provides detail on the spending of tourists in the UK and is a useful new source and triangulation for regional TSA and tourism IO compilation. Overall, the sense is that it is now more difficult to do this work than a decade ago (See Section 5).

Moving to the 'environmental' extension of our input output structure, we focus here on the basket of greenhouse gas emissions, reported, as is usual, in units of carbon dioxide equivalence ($CO2_e$). These data are incorporated in the tables as a non-financial 'input' to each of the 64 sectors in the productive process (i.e., in the same fashion as, for example, labour units), with Leontief manipulation reporting carbon-consequences from the supply side based on the level of tourism-related production and carbon intensity of each industry. Additional processes are required to capture the GHGs resultant on the burning of fuels for touristic purposes in (especially) aircraft and private vehicles: these emissions are not captured in (our) territorial supply-side account. This is undertaken (as in Jones, 2013) by deriving origin-destination matrices for visitors to Wales by mode and by UK-region (VisitBritain, 2020) and, for international visitors, by country (ONS, 2020). Appropriate ratios of passenger-km to GHG are then applied to the estimated mileages, although it is important to note that this does not imply our method is a full multi-regional IO (MRIO) approach: we are able, through partial integration with UK IO Tables and the World Input Output Database Environment project (Corsatea *et al* 2016), to capture global supply-side emissions outside of Wales only partially. Our accounting for fuel burn-consequent emissions together with all (direct and indirect) territorial emissions is, however, likely to cover the vast majority of GHGs for tourism activities.

Whilst remembering the above data and methodological caveats, we can thus estimate the overall carbon footprint consequent on (UNWTO-definition) tourism in and to Wales in 2019, and provide some indicative comparisons with the prior 2007 estimates.

[6] https://www.gov.uk/government/statistics/uk-tourism-satellite-account-tsa

4.2 The Carbon Footprint of Wales' Tourism in 2019

Table 1 presents our estimate of the carbon emissions associated with touristic activities in Wales, and consequent on visitor journeys to Wales, as well as providing contextual information on economic impacts (these latter being direct plus 'type 2' indirect; Miller & Blair 2009). These emissions totalled 3.35 Megatons of carbon dioxide equivalents.

Figure 1 - The Carbon Footprint of Wales' Tourism 2019

	Day Visits	UK Tourists	Inter-national	All Visitors
Greenhouse Gas Emissions (tCO2e):	**1,277,475**	**914,459**	**1,153,206**	**3,345,141**
Percent of Wales territorial	*3.3%*	*2.4%*	*3.0%*	*8.6%*
UK Supply side & supply chain	737,783	328,566	44,266	1,110,615
Travel to/from Wales	-	237,392	1,082,980	1,320,372
Travel within Wales	539,692	348,501	25,961	914,154
Trip Volume (m)	84.0	10.6	1.0	96
Gross Value Added (£m)	2,280	1,222	172	3,674
Percent of Wales	*3.4%*	*1.8%*	*0.3%*	*5.5%*
Workforce Employment (FTEs)	77,527	42,734	5,539	125,800
Percent of Wales	*5.6%*	*3.1%*	*0.4%*	*9.0%*
Per Trip Impacts				
Gross Value Added (£)	27.1	115.3	167.8	38.4
Employment per 1,000 trips (FTE)	0.9	4.0	5.4	1.3
CO2e (kg)	15.2	86.3	1,127.2	35.0
GHG Efficiency of Economic Impact				
GVA per tonne of CO2e (£)	1,785	1,336	149	1,098
Tonnes of CO2e per 1,000 FTE jobs	16.5	21.4	208.2	26.6

Just under 40% of these emissions arose from the activities of day trippers/excursionists[7], although these comprised over 85% of all touristic trips in 2019, so per-trip impacts were relatively modest. UK-resident tourists (including Wales-resident) were responsible for just over a quarter of GHG emissions, and international visitors the remaining third. In terms of 'where' the emissions arose, a third were from Welsh businesses and in their supply chains (including for energy); around 40% from travel fuel to and from the region; and 27% from travel fuel within Wales. In terms of 'per trip' impacts, a single day-trip resulted in 15kg of

[7] Due to limitations in the source data, we assume all excursionists in Wales are Wales-resident, and all excursions by Wales residents are inside Wales.

CO2e; a UK-overnight trip 86kg, and an international visit, 1.13 tonnes of CO2e. For international visitors, well over 90% of the trip CO2e was consequent on trip-related travel to and from Wales.

The extended tourism satellite account allows us to compare the economic benefits of tourism and its carbon consequences within the same analytical framework. This analysis reveals that in terms of whole-trip greenhouse gas emissions, international visitors are far more climate-damaging than either UK-resident tourists or day visitors per unit of value added (and employment created): only £149 was created in Wales for each tonne of CO2e emitted by international visitors, whilst this figure was £1,785 for excursionists and £1,336 for staying UK-resident tourists.

4.3 Progress toward Climate-Responsible Regional Tourism 2007-2019

Perhaps uniquely we are able for Wales to compare the climate-effects of regional tourism across an extended period using conceptually, methodologically and data-source comparable approaches, albeit with the (sometimes significant) caveats discussed in 4.1 above. In summary, progress has been modest at best. Overall, we suggest that the climate emissions resulting from tourism in Wales reduced by around 15% between 2007 and 2019 – only a little over 1% reduction per annum. Clearly, this is not good news for a 'sustainable' region like Wales that recognises (legally) its climate responsibility – and which is currently trying to address the 'stubborn issue' of growing international tourism arrivals[8].

The reported nature and behaviours of visitors to Wales and the changes in estimates of supply-side GHGs between these periods can give us some insight into the origins of the (slow) reduction. As we can see from Figure 2., the overall reduction in GHGs hides significant changes in the drivers of those emissions..

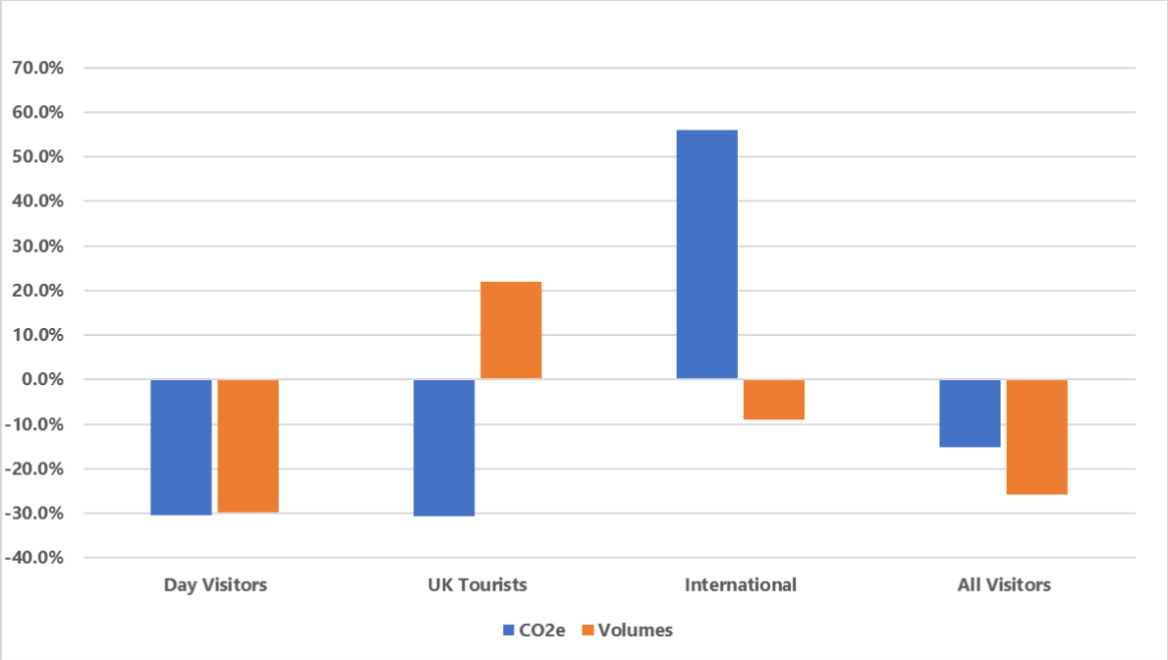
- Overall tourism-related GHGs dropped by around 15% between 2007 and 2019. Whilst this largely mirrors the reported change in volumes of tourism in Wales, there have been significant changes in the *composition* of visitors, meaning that these smaller volumes (and lower GHG) actually support[9] a slightly higher percentage of Welsh GVA – up from 5.1% to 5.5%,
- Reported touristic day visitor/excursionist numbers have dropped from 119m to 84m, and our estimate of resulting $CO2_e$ has fallen similarly. However, whilst there was little change in the mode of travel reported in visitor surveys, reported distances increased, although this increase was counterbalanced by reduced supply chain

[8] https://gov.wales/welcome-wales-priorities-visitor-economy-2020-2025
[9] Directly, and indirectly along supply chains etc.

emissions, and by improved fuel efficiency (and thus lower per-passenger CO2) of vehicles,

- UK (including Welsh) resident tourists saw volumes increase by around 20% but CO2e decrease by over 30%. Whilst two-thirds of this decrease in per-trip GHGs was due to supply chain effects, the remainder was due to lower estimates of distances travelled by staying visitors whilst within Wales. For this element however, data sources changed between 2007 and 2019; consequently this improvement may reflect different surveys and estimation approaches between the two years, rather than significant behaviour change,
- Volumes of international arrivals to Wales declined by around 10% but consequent GHG emissions increased by over 50%. This was due to very different visitor origins between 2007 and 2019 – a doubling of visitors from Asia; an increase of 40% from North America; and a decrease of 10% from Europe.
- All visitors benefitted from a relative drop (per £ spent) in supply chain emissions. Whilst it is difficult to be definitive (due to changes in data sources and improved methods 2007-19) it is likely that much of this improvement relates to the decarbonisation of electricity supply in Wales and the UK, feeding through, for example, as accommodation and attractions demand electricity to service visitors.

Figure 2 Visitor Volumes and GHGs, 2007 - 2019



Our reported drop in tourism-related GHGs between 2007 and 2019 is then welcome – especially in view of increased economic value – but, at 1.25% per annum (over 2007

baseline) not enough to suggest climate-responsible tourism is ‘around the corner’ – or even necessarily possible. Foe example, per-trip emissions have declined in part due to reductions in within-Wales supply chain GHGs, with these then in turn most likely resulting mostly from the (UK-wide) reduction in electricity grid carbon intensity [Welsh Government, xxxx], but modal shift towards lower carbon travel is not evident in the visitor surveys. Meanwhile, the most notable result from our 2007-19 comparison is the steep increase in the emissions of international visitors to Wales, despite reducing volumes. Visitation became more international – indeed, more intercontinental – in the decade or so under investigation. With ‘net zero’ aviation an extremely long way off (Abrantes et al 2021), this is worrisome.

Understanding the drivers of this changing international visitation pattern is difficult – not least because the UK International Passenger Survey that provides origin and destination volumes is a visitor, *not* a tourism survey. It includes, for example, people arriving in the UK for permanent migration, for short term work, and for other purposes – with no information on purpose of trip available at UK-regional scale. Pertinently for Wales, the data also include arrivals by non-UK resident students, and indeed by their visiting or accompanying families. Wales, in common with other parts of the UK, has seen a steep increase in the numbers of Asian (and especially Chinese), students in the last decade, and such ‘non-recreation’ visits will contribute to the increased volumes and $CO2_e$ we report under ‘international’ visitors here. Whilst students (at least on the one-year Master’s courses favoured by international students in Wales) are properly counted as tourists under UNWTO frameworks, their trip rationale and behaviours differ from the leisure tourism that is the focus of regional economic or climate policy – indeed in a similar way to business or family visitors (whose nature is also data-challenged at regional scale). This conflation within data sources (and hence input-output and TSA structures) may reduce the effectiveness of interventions aimed at improving the environmental (or economic) performance of ‘tourism’ policy.

5 Discussion: Understanding the speed of climate-responsible tourism transformation

As a functional final demand, often invisible in official statistics, placing *tourism* within the framework of legal and policy commitments to net-zero – especially at lower spatial or governance scale – is quite difficult. This analysis shows that even in this sustainability oriented, global-North region, tourism emissions were not falling anywhere near fast enough, at 1.25% per annum, to contribute proportionately to keeping societal emissions low enough to enable ‘Paris compliance’, or net-zero by 2050 (Scott & Gössling, 2021). Moreover, a significant proportion of these emissions reductions come from reduced volumes, electricity grid improvements, and some (apparent) reductions in distances travelled that will quickly be

exhausted in terms of tourism-decarbonisation impact (Jones, 2013). Conversely. International distances and emissions increase. Any transformation – or beginnings of such – in the nature of tourism in Wales remains invisible. We suggest there are a number of reasons for this.

Firstly, and despite impressive rhetoric and a distinctive legal framing, Wales has made limited progress in decarbonisation more generally over the relevant period. Outside of lower carbon electricity supply[10] and successes in recycling, decarbonisation – in transport, industry and buildings – has been modest to invisible. Visitors in Wales of course use the largely the same infrastructures and economic supply as residents; if the regular, cheap and renewably-electrified trains are not there for commuters, neither are they for visitors. It is notable that despite the lauding of the landmark Future Generations Act as the potential enabler of a 'sustainable' Wales (Davies, 2017), the on-the-ground impacts of this Act have been so-far fairly limited, resulting in modest changes of operation and incremental improvements by it's 44 target public bodies (Netherwood & Flynn, 2021). This (ongoing) failure to 'make sustainable' or decarbonise the 'bones' of the region means tourism cannot itself move toward net zero at any speed.

Secondly, tourism within the study period rather disappeared from the regional policy context. Commitments to sustainable tourism measurement, including the development of indicator sets, and further TSAs went unfulfilled following a change of responsible Minister, never (so far) to return. The regional statistical base from which to understand and model the economic and environmental impacts of tourism, and from which to model decarbonisation options, regressed over the period. Relevant teams within the civil service were dispersed, and (fairly typically for governments) new, more 'topical' policy foci emerged. For example in Wales the creative economy and clusters have arguably taken the policy focus from tourism, albeit with the ability to understand and audit such activities' economic value or environmental impact (for example via cultural and creative satellite accounts) far behind that of tourism (Lyons, 2022).

Thirdly, at regional scale politicians do not have control over a number of levers that might move tourism to a more sustainable footing. As Jones (2013) points out, key elements of tourism economic supply that are subject to regional policy – here hotels and public transport – are not the biggest contributors to carbon emissions, and hence even stellar environmental performance (for example, if all hospitality and attractions were renewably powered) would not excise the bulk of emissions. Instead, key drivers of GHGs are influenced only by (here UK) state-level policy – for example the role of key UK airports used to access Wales, including Heathrow and Bristol, or the level of duty on private fuel in the UK. Whilst regional

[10] In Wales, largely a shift from coal to gas; see Welsh Government (2022) for a report on net-zero progress

policymakers can influence visitor behaviours indirectly, for example in terms of modal shift via parking charges, subsidies for electric vehicle charging or a reluctance to build new roads (see Welsh Government, 2022), such actions may only change behaviours at the margin, and in the longer term.

A *fourth* and very relevant issue, not unique to Wales, also relates to the perceived cost-benefit balance in taking (any) action which might serve to reduce the volume of visitors to the region, and consequent economic impact. Despite the COVID19 pandemic and resultant increase in 'UK staycation' trips having brought to the fore the significant environmental and social impacts of over-tourism in Wales (Thackray, 2019), recent debates on the implementation of a tourist tax have resulted in a robust response from both the industry and opposition politicians, who see the potential for Wales to 'lose out' economically vis-à-vis competitor regions (Glyn Jones, 2022). Given tourism is not especially high on the Welsh Government agenda, addressing its climate impacts via robust policy might well constitute too much political pain for uncertain benefit[11].

Lastly, as has been suggested throughout this analysis, statistical structures are, at regional/NUTS1 level (and possible higher) simply inadequate to describe in detail the nature and behaviour of visitors – and sometimes even their volumes. Tourism remains the Cinderella of environmental statistics. Despite the efforts of the UNWTO in developing the Mainstreaming Sustainable Tourism agenda, and supporting a number of global pilots, the steep data demands of tourism satellite accounts and related (input-output, CGE and other) modelling approaches, together with the lack of investment in tourism surveys in many or most national and regional polities, means the links between touristic behaviours and policies and the wider decarbonisation agenda are not well understood.

Given the above, it is perhaps unsurprising to note the lack of necessary progress in the decarbonisation of regional tourism in Wales. If, however, this is the best that can be done in this 'future generations aware' and relatively prosperous (on the global scale) region, and one armed with a strong legal framework for sustainability-oriented change, what about everywhere else?

6 Conclusions: Where next?

This paper has used a regionally bespoke and environmentally extended Input-Output structure, enhanced by the disaggregation of tourism demand data and by separate analysis of visitors' travel fuel burn to estimate a (reasonably holistic) carbon footprint of tourism to

[11] Notably, however, the related issue of second home ownership in Wales has risen quickly up the political agenda, but with this focussed on the negative social and cultural impacts of 'excessive' second home ownership in honeypot locations.

and in Wales in 2019. We find total emissions to be around 3.3Mt – around 8.5% of territorial emissions in that year. Moreover, comparing similar analysis undertaken for 2007 shows (with some caveats) that the rate of decarbonisation – only a little more than 1% per annum – does not adequately contribute to regional, UK-national or global efforts that seek to restrict warming to under two degrees centigrade.

Our analysis is important because it firstly, analyses the impacts of tourism at a relevant policy scale – here a 'NUTS 1' type region with control over (some) tourism and climate policy – and secondly, aggregates greenhouse gas impacts both at the destination, and involved in travel to and from it. Add to this the time series analysis, and we can see that actual emissions are simply not falling fast enough – even accounting for methodological caveats between the two annual analyses. Visitors as whole became more inter-continental over the 2007-19 period under study. Thus, absent some very unlikely air-fuel developments, or a deep faith in offsetting and carbon removal technologies, tourism faces transformative change if it is to become climate responsible.

Given COVID-19, the pace and the nature of this climate transformation is hard to judge, but in Wales little has changed in policy to move the dial from the too-slow (and possibly ultimately limited) reduction in tourism-related GHG emissions. Some regional policies, such as the abandonment of new road building, may have a marginal effect, as might the current debate spurred by over-tourism during the pandemic period. We suggest a number of reasons for this, including a lack of control over travel-relevant levers such as excise taxes and (for Wales) airports policy; a lack of long-term focus on tourism; and a consequent unwillingness to expend political capital in a potentially contentious (and vote-losing?) arena. There is also the longstanding issue that tourism advocates, ministers and experts (both climate-hawks and doves) are simply not at the 'top table' of policymaking, nor of statistical development and survey resourcing – an issue that long predates concerns about the climate emergency (Bryan *et al* 2006). The lack of data, and hence understanding and intelligence, on visitors motivations, movements, behaviours and spending within (here) the UK is notable, with data collection left almost wholly to the industry rather than the Office for National Statistics (with the exception of the welcome but extremely broad brush UK Tourism Satellite Account, and the rather narrowly focussed International Passenger Survey[12]).

The lack of salience of tourism in key policymaking areas, and the lack of holistic understanding around how visitor trips impact upon the climate, means that, as Jones (2013) suggested, tourism is in the position of waiting for wider societal changes to occur before it can become climate responsible. In the best case, this might involve the development of technologies and behaviours that protect the experiential benefits of tourism

[12] The IPS does not even routinely ask visitors about their spending patterns when in the UK.

to participants (and indeed extend participation) and the economic benefits to destinations, whilst achieving true net-zero. More likely, however, tourism firms and supporting organisations – and visitors themselves – will be blindsided as climate-related restrictions (or indeed energy-related costs) render long distance travel in general more difficult, expensive, exclusive, and infrequent. The COVID-19 crisis was (and still is) an example of how challenging unforeseen disruption can be. An industry and tourism-policy focus on resilience, redundancy and foresight, and the encouragement of nearer and longer-dwell trips that have higher economic value for lower climate cost – together with a robust focus on where destinations and firms *can* reduce their contributions to greenhouse gas emissions might be a very good idea.

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