Current Research in Environmental Sustainability 3 (2021) 100079

Contents lists available at ScienceDirect

Current Research in Environmental Sustainability

journal homepage: www.sciencedirect.com/journal/current-research-in-environmental-sustainability

Challenges of national measurement of environmental sustainability in tourism

Nína M. Saviolidis [a,*], David Cook [b,e], Brynhildur Davíðsdóttir [c], Lára Jóhannsdóttir [d], Snjólfur Ólafsson [a]

[a] School of Business, University of Iceland, Gimli, Sæmundargötu 2, 101 Reykjavík, Iceland
[b] Environment and Natural Resources, School of Engineering and Natural Sciences, University of Iceland, 107 Reykjavik, Iceland
[c] Environment and Natural Resources, Faculty of Economics and Faculty of Environment and Life Sciences, University of Iceland, 107 Reykjavik, Iceland
[d] Environment and Natural Resources, School of Business, University of Iceland, Gimli, Sæmundargötu 2, 101 Reykjavík, Iceland.
[e] Faculty of Environment and Life Sciences, University of Iceland, Gimli, Sæmundargötu 2, 101 Reykjavík, Iceland

ARTICLE INFO

Keywords:
Environmental sustainability
Indicators
Iceland
National assessment
Data availability

ABSTRACT

Environmental sustainability indicators are commonly used to assess progress towards sustainability. Assessing environmental impacts associated with a specific economic sector can provide a more detailed view of the effects of economic activities on the environmental performance of a nation. A national indicator set, specifically developed for Iceland, was evaluated for its capacity to capture environmental sustainability impacts from the tourism sector. Iceland's tourism sector is an interesting case because of its recent fast-paced growth and concerns regarding its environmental impacts. The indicator set was evaluated based on two criteria: relevance and measurability in the context of Iceland's tourism sector. Though most of the indicators were relevant to the tourism context, they did not fulfil the measurability criteria due to disaggregation issues, omissions of important topics and lack of data. Partial measurement was possible for 12 out of 23 of the reviewed indicators, e.g., most indicators in the air pollution theme could be measured whereas indicators in the water theme were of limited measurability. A preliminary calculation of the indicators revealed that despite the partial measurement, the impact of tourism was discernible though often underestimated due to limited data. Knowledge building concerning data gaps was one of the derived outcomes of the analytical process. National indicators of environmental sustainability can at best provide only a partial appraisal, and comprehensive evaluation of the tourism sector's impacts demands multi-scale analysis and indicators specific to the sector.

1. Introduction

Environmental sustainability – the central aim of which is to sustain natural capital so as not to overwhelm neither the waste assimilative capacity of the environment nor its regenerative ability – is intrinsic to sustainable development (Goodland, 1995; Goodland and Daly, 1996). To evaluate the current state and progress towards environmental sustainability, assessment is necessary. Environmental sustainability indicators have been widely used to evaluate everything from biodiversity to climate change and resource use (Burger, 2006; EEA [European Environment Agency], 2014a).

Assessing the environmental performance of sectors is a useful way to highlight the contributions and challenges faced by specific components of the economy as regards national environmental sustainability. The sectoral approach can also help to evaluate the trade-offs in the growth and expansion of different sectors and opportunities to improve national performance. However, national level indicators should be able to capture the impact of large-scale economic changes, such as growth in individual economic sectors. Iceland, and specifically the tourism industry, presents an interesting case because of its recent sharp growth in tourism, its small, specialized economy, its geographical position, which necessitates air and cruise travel, and its fragile ecosystems. Iceland's tourism grew at an unprecedented rate (approximately 25% annually) during the study period 2010–2016 and became one of the main pillars of the Icelandic economy, surpassing the more traditional sector of fisheries. The sector's direct contribution to GDP rose from 3.5% in 2010 to 8.4% in 2016 (Statistics Iceland, 2021a).

In this study, we review a nation-specific environmental indicator set

* Corresponding author.
E-mail addresses: nms@hi.is (N.M. Saviolidis), dac3@hi.is (D. Cook), bdavids@hi.is (B. Davíðsdóttir), laraj@hi.is (L. Jóhannsdóttir), snjolfur@hi.is (S. Ólafsson).

https://doi.org/10.1016/j.crsust.2021.100079
Received 18 January 2020; Received in revised form 22 July 2021; Accepted 23 July 2021
Available online 5 August 2021

developed by Cook et al. (Cook et al., 2017) and evaluate its ability to capture sectoral effects using the case of Iceland's tourism sector. The aim of this study is to evaluate whether a previously developed national indicator set captures the tourism sector's main environmental impacts, and thus national environmental sustainability impacts of a rapidly growing sector, and highlight data gaps as a foundation for future research. We then conduct a preliminary calculation of those indicators meeting the evaluation criteria for illustrative purposes as a foundation for future studies.

This particular indicator set was chosen for two reasons: a) to the best of the authors' knowledge there are no other environmental sustainability indicator sets that have been developed specifically for the Icelandic context. Olafsson, Cook, Davidsdottir and Johannsdottir (Olafsson et al., 2014) presented all the major arguments for why consideration of national context is important in the development of indicator sets especially, in the case of nations with small but highly specialized economies (Jóhannesson et al., 2018). Olafsson et al.'s (Olafsson et al., 2014) review of four different indices (Environmental Vulnerability Index, Environmental Performance Index, Ecological Footprint and Happy Planet Index) showed that overall they were too generic and did not include important criteria specific to the national context thus misrepresenting Iceland's environmental sustainability performance Additionally, b) the indicator set evaluated here is comprehensive in scope and was formed through a mixture of bottom-up stakeholder consultation and top-down expert judgment concerning indicator selection. Though there have been studies focused on measuring the environmental impacts of tourism in Iceland, none of them have done so in a comprehensive manner and most of them focus on specific regions and specific (albeit locally important) environmental issues [e.g. (Ólafsdóttir and Runnström, 2013; Ólafsdóttir and Runnström, 2015; Schaller, 2014; Sharp et al., 2016)].

There are several reasons for the choice of tourism as the sector of focus for this study. First, tourism has been in the international spotlight as regards sustainable development. The year 2017 was declared the year of sustainable tourism for development by the United Nations (UN [United Nations], 2015). In addition, tourism is directly implicated in three of the 17 Sustainable Development Goals (SDGs) – in particular, goals: 8 (on sustainable economic growth and employment: 8.9), 12 (on sustainable consumption and production: 12.b) and 14 (on sustainable use of oceans: 14.7) (World Tourism Organization and United Nations Development Programme, 2017). Tourism may also be relevant to other SDGs even where not explicitly stated (Boluk et al., 2017; UNWTO, 2017).

Tourism is frequently promoted for its positive impacts on economies, employment and job creation; however, it has become increasingly recognized that tourism has a number of negative effects on the environment. Those effects range from local pressures e.g. the depletion of local water resources and pollution to global issues such as land-use change and greenhouse gas emissions (Reddy and Wilkes, 2013; Schott, 2010). Local impacts are site-specific and differ from area to area, often depending on the level of development and the degree of implementation of planning and management schemes.

Most research to date has focussed on single destinations and local issues (Buckley, 2012; Budenau et al., 2016). Recently, however, there has also been increased awareness of global environmental change and its “two-way” relation to tourism (UNWTO, 2017). The relationship between tourism and the environment is complex as tourism both contributes to, and is affected by, environmental change at regional and global scales (Buckley, 2011; Gössling and Hall, 2006). In general, tourism is a resource-intensive sector, but this has only recently become more widely acknowledged (Gössling and Peeters, 2015).

The paper is structured as follows; the literature review part of the paper provides a short overview of the role of indicators in environmental sustainability evaluations in tourism studies (Section 2.1), the context of this study (Iceland's tourism) (Section 2.2) and an overview of the main studies that have examined tourism environmental impacts in Iceland (Section 2.3). The next sections provide a summary of the indicator set under review (Section 3), the evaluative criteria (Section 4). The evaluation (Section 5) and the results of its application are provided in Section 6 and 7 (summary evaluation). Finally, the discussion and conclusion are presented in Sections 8 and 9, respectively.

2. Literature review

2.1. The role of indicators in environmental sustainability evaluations in tourism studies

Sustainable tourism is ineffective unless the current state of affairs and progress towards sustainability can be measured (Miller and Twinning-Ward, 2005). There have been previous attempts to develop sustainability indicators for tourism on various levels ranging from well-defined areas (such as national parks and tourism resorts) (Blackstock et al., 2008), to municipalities (Dymond, 1997; Vera Rebollo and Ivars Baidal, 2003; Feleki et al., 2020), to nation states (Horng et al., 2012), destinations (Perez et al., 2017) and supply chain-based assessments (Ling, 2015). A few studies have also attempted global assessments but have been based on other assessment tools (e.g. (Hall et al., 2015)). There are also numerous assessments using different tools that have been applied to tourism, such as Life Cycle Assessment and the Ecological Footprint (e.g. (Sharp et al., 2016; Michailidou et al., 2016)), but these are not under consideration in this study which focuses on environmental sustainability indicators.

Many indicator sets have been developed for different dimensions of sustainability in tourism i.e. multi-dimensional and integrated sets (see (Kristjánsdóttir et al., 2018) for a review). From a meta-analysis of 27 recent sustainable tourism indicators studies (from 2000 to 2015) it can be seen that, on the whole, the economic and social dimensions outweighed the environmental dimension as regards the number of indicators chosen (Agyeiwaah et al., 2017). Within the environmental dimension, water quality and solid waste management were the two indicators most frequently included in the reviewed studies and energy conservation was only present in one quarter of those studies (Agyeiwaah et al., 2017).

Some studies' indicator frameworks are meant to assess the tourism sector's management performance with indicators (e.g. (Roberts and Tribe, 2008)), such as the presence of a stated company policy, management plans or memberships in environmental certification schemes and corresponding managerial targets. This approach is not without merit, but it is inappropriate for the purposes of environmental performance assessment because it does not measure actual environmental impact. Policies and plans do not always correlate with proper implementation (Pridham, 1999) and, thus, it is difficult to assess performance above professed participation in management schemes (Steger, 2000).

Other studies include indicators which conflate environmental sustainability with tourists' satisfaction levels with perceived environmental quality (Hughes, 2002). However, environmental issues are not always clearly visible or felt, leaving out too many important aspects of environmental sustainability. Furthermore, an approach which attempts to assess environmental quality by tolerance levels based exclusively on subjective experience carries too many risks to both human health and ecosystems (Buckley, 1999).

Finally, studies with more comprehensive sets of environmental indicators often rely on aggregation and the creation of composite scales (e.g. (Blancas et al., 2010; Choi and Sikaraya, 2006)) which tends to reduce the weight and significance of those indicators in the overall assessment. It is, also, not clear how the weighting procedures are decided upon. A recent review of studies that used a weighting procedure to construct composite indicators for sustainable tourism, found that none of the reviewed studies provided “a sound explanation for the choice of a particular weighting procedure” (Mikulic et al., 2015), p. 312. Composite indicators have, also, been criticized for being too

complicated in their use and too difficult in their interpretation (Mitchell, 1996).

Perhaps the most comprehensive framework of sustainability indicators for tourism to date, was published by the European Commission in 2017 but is also multi-dimensional. As regards environmental sustainability, this framework includes local as well as global environmental impacts with a set of 17 core environmental indicators (seven more than the economic and five more than the social indicators) (COM, 2017). Thus, there is proportionally more importance placed on environmental sustainability within the European Tourism Indicator System (ETIS). However, there are drawbacks to the ETIS approach: a) the use of a balanced approach which, theoretically and practically undermines the importance of environmental sustainability and, b) some of the indicators measure initiatives taken by companies to protect the environment but not the impact or effectiveness of those initiatives. However, the ETIS does not capture the contribution of a key sector's impacts on national environmental sustainability which was the primary investigative aim of this study.

2.2. Iceland's tourism sector

As a 103.000 sq.km. island state situated in the North Atlantic Ocean with just over 350.000 inhabitants, it is one of the most sparsely populated countries in Europe. Nearly 80% of the country is uninhabited and most of the human settlements in Iceland are in the lowlands and on the coastline (CBI [The Central Bank of Iceland], 2016).

Iceland's tourism industry has undergone fast-paced growth in recent years and is now one of the three main pillars of the Icelandic economy alongside fisheries and heavy industry. The number of foreign tourists in Iceland has nearly quadrupled since 2010 – from 488,600 tourists in 2010 to 1,792,200 in 2016. The number of foreign tourists in 2017 was 2,195,271, a ratio of 6 to 1 tourist per local resident and a 24% increase in the number of visitors since 2016. Tourism's share in foreign exchange earnings (as measured by the export of goods and services) has outpaced that of other sectors and was at 39.2% in 2016 (ITB [Icelandic Tourist Board], 2017).

Tourism in Iceland is predominantly nature-based and most tourists claim that they visit the country for its natural attractions (ITB [Icelandic Tourist Board], 2017; Csagoly et al., 2017). As such, natural resources, as the Icelandic tourism sector's main product, are of strategic importance to the sector.

2.3. Environmental effects of tourism in Iceland

Environmental sustainability has been recognized as one of the major challenges for the Icelandic tourism sector, in part because environmental issues - though recognized as important - have not been adequately transposed into policies and/or implementation of said policies is lacking (Huijbens et al., 2014; Sutherland and Stacey, 2017).

The local and issue-driven focus of the Icelandic studies is in line with most studies undertaken in the field of sustainable tourism often reflecting the need to collect data and information for specific administrative units, e.g. national parks (Torres-Delgado and Saarinen, 2014; UNWTO, 2016). This is not to say these issues are not important but there is a need to provide a more comprehensive view of tourism's environmental impacts in Iceland. This section presents a short overview of environmental issues relating to the tourism sector in Iceland and environmental assessment studies that have been done so far.

The majority of studies that have been carried out in Iceland have been based on the principles of “carrying capacity” defined as the level of use an area can accommodate in terms of ecological limits (Buckley, 1999). Studies of this sort have been carried out since 1999 in Iceland and have been site and issue-specific, often focused on the degradation of soil and vegetation at popular and/or fragile locations (MII [Ministries of Industry and Innovation], 2018). Carrying capacity is a limited tool for environmental assessment because it depends to a large extent on meeting tourists' preferences and expectations rather than determining actual limits of use in an area or destination (Buckley, 1999). This can then lead to a spiral of development as preferences change with increasingly more tolerant users visiting the sites (Buckley, 1999). Most studies anticipate and warn against this particular drawback either by recommending that impact be determined by tourists with the highest demands on a site's attractiveness (Ólafsdóttir and Haraldsson, 2015) or, that management plans and policies be very explicit about the types of tourists they intend to attract (Sæþórsdóttir, 2013). Carrying capacity assessments can be strengthened by wide stakeholder participation to determine acceptable limits (i.e. how much change and impact are acceptable) and complimented with a set of site-specific indicators to measure impacts, especially in terms of the regenerative capacity of ecosystems (Coccossis and Mexa, 2004).

Due to the fact that Iceland's tourism is mostly nature-based most of the monitoring of impacts takes place in its protected areas. The Environment Agency of Iceland releases annual reports of the state of protected areas in Iceland; in the most recent report, the increased number of visitors is listed as a threat factor in nearly all the red-listed sites (EAI [Environment Agency of Iceland], 2017).

One of the key local environmental pressures from tourism in Iceland is the degradation of soil and vegetation due to the increase in the numbers of visitors in recent years (OECD [Organization for Economic Cooperation and Development], 2014). A number of studies have estimated the possible impact and/or extent of recreational trampling and the erosion of trails and tracks in popular destinations and national parks in the country [e.g. (Ólafsdóttir and Runnström, 2013; Ólafsdóttir and Runnström, 2015; Schaller, 2014)]. Due to the sensitivity of vegetation in Iceland, even relatively low levels of degradation of vegetation and soil around popular hiking trails can have serious consequences for the underlying soil bank as it is left exposed to wind and water, leading to further degradation spreading to larger areas (Arnalds and Thorsson, 2012). In addition, off-road driving, although legally banned in Iceland, is a frequent occurrence. Tracks formed by motorized vehicles can both degrade the landscape and lead to soil erosion (EAI [Environment Agency of Iceland], 2021). Finally, due to the recent decrease in tourism's high seasonality popular (and often protected) sites do not have the time to recover between periods of visitation (EAI [Environment Agency of Iceland], 2017).

Other local environmental concerns related to tourism include concerns about biodiversity and, in particular, various threats to flora and fauna. For example, bird populations can come under threat when exposed to increasingly larger numbers of visitors. However, these threats can be successfully managed by restricting access to certain areas at nesting times (OECD [Organization for Economic Cooperation and Development], 2014). These areas can be determined based on the detailed assessments provided by the IINN (Skarphéðinsson et al., 2016).

Another key environmental pressure arises from tourism-specific construction activities and infrastructure development. Construction can have several environmental impacts from direct land-based impacts and increased greenhouse gas emissions during the construction phase and embodied emissions in materials, to increased natural resource consumption (e.g. water and energy). The number of hotel rooms in Iceland increased by 217 in 2014, by 874 in 2015 and by 1036 in 2016 (Statistics Iceland, 2021b); a 50% increase in rooms is expected in the capital and a 20% increase in the countryside by 2020 (Kolbeinsson, 2017). In addition, Keflavík airport has doubled in size since the early 2000s partly because it also serves as an airport hub with about 30% of passengers being through passengers. Alongside these, is also the construction of tourism-specific facilities at popular destinations e.g. toilets, road construction and other facilities. No studies have been done in Iceland that take these indirect impacts into account. Road construction can also lead to degradation of landscapes by providing increased access to sensitive areas (Ólafsdóttir and Haraldsson, 2015).

Relevant to the issue of road construction and infrastructure is

Iceland's transportation system which, in terms of most frequent mode of travel within the country, is dominated by the private car. Many tourists in Iceland rely on rental cars for travelling around the country. Alongside the rapid increase of visitors there has also been a rapid increase of rental cars from just below 5.000 cars in 2006 to about 20.800 cars in 2016, with an unprecedented proportional increase of 35% between the years 2015 and 2016 (Íslandsbanki Research, 2017). The increase in cars can be associated with higher levels of traffic congestion and air pollution, especially in the capital (EFLA, 2017) and greenhouse gas emissions (IPCC, 2018).

Environmental issues tend to cross geographical boundaries and as such it is also important to consider larger scale issues such as climate change when assessing tourism sustainability (Muscardo and Murphy, 2014). Gren and Huijbens (Gren and Huijbens, 2014) point out that there is no mention of climate change or global environmental change in Iceland's Tourism Policy for 2011–2020, thus creating "a blank space" (p. 12) between destination level environmental concerns and wider global concerns. This is especially noteworthy considering that Iceland's tourism is to a large extent dependent on international aviation and travel by private cars within the country.

In addition, cruise ship tourism has increased considerably in recent years from 28.000 cruise ship passengers in 2001 to nearly 145.000 passengers in 2018 (AIP [Associated Icelandic Ports], 2018). A number of negative environmental impacts including air pollution, polluting discharge and greenhouse gas emissions have been associated with cruise ships (Johnson, 2010) but these effects have yet to be measured in Iceland.

One recent study estimated the carbon footprint of all inbound tourism to Iceland and found greenhouse gas emissions from tourism to have tripled from 2010 to 2015. This was mainly due to transport, specifically, fuel combustion from road transport (20–30%) and aviation (70%) since most tourists arrive to the country by plane (Sharp et al., 2016). Emissions from aviation according to UNFCCC's international bunker fuel data have more than doubled since 2000 and were 924.68 Kt CO2e in 2016 (the last submission year) (UNFCCC [United Nations Framework Convention on Climate Change], 2016).

The scarcity and the lack of comprehensiveness of available studies assessing the environmental sustainability of tourism in Iceland underscores the usefulness of indicators as an assessment tool for the sustainability performance of its tourism sector (ITB [Icelandic Tourist Board], 2017). In what follows, a national level indicator set is evaluated to determine whether it can capture impacts from Iceland's tourism sector on environmental sustainability.

3. Summary of indicator set under evaluation

The study reviewed here [i.e. (Cook et al., 2017)] developed a methodology for selecting environmental indicators to assess environmental sustainability performance at the national level using the case study of Iceland. A two-stage approach was utilized with both bottom-up focus group interviews and top-down expert assessment in the selection of indicators, alongside a thorough review of existing indicator sets. The 23 selected indicators were structured into six thematic categories (see Table A1 in Appendix A).

The evaluation of national performance on environmental sustainability proceeded on an indicator by indicator basis and utilized a system of traffic lights and radar charts for trend and target-based indicators as a way of summarizing performance results. The study focused on the performance assessment of Iceland and Norway as illustrative case studies (Cook et al., 2017).

4. Criteria for evaluation and boundaries for application to tourism

In this paper, the indicator set which resulted from the Cook et al. study (Cook et al., 2017) is applied to the case of Iceland's tourism sector to evaluate whether a national-level indicator set can capture the impacts of a rapidly growing sector and to identify where there is a need for improved data collection.

In reviewing the indicator set, the following two criteria were used to determine the capacity of each nation-level indicator for capturing tourism's environmental impacts in Iceland:

1. Relevance of each indicator to environmental sustainability in the Icelandic tourism context i.e. is the indicator capturing pertinent information? (Janoušková et al., 2015)
2. Measurability in the Icelandic tourism context. Measurability refers to how the values are measured and the extent to which the indicator is measuring reality as accurately as possible (Bauler et al., 2007).

When indicators fulfilled the criterion of relevance, an assessment of measurability was carried out which also highlighted data gaps. A fully measurable indicator includes data from all the relevant tourism components (e.g. fuel emissions from all tourism vehicles, rental cars, coaches, snowmobiles etc.); a partially measurable indicator includes data for at least one relevant tourism component (e.g. fuel emissions from rental cars); limited measurability refers to there being no data available or that data has not been disaggregated for the sector by the relevant data collection authorities. The evaluation in Section 5 proceeds on a thematic basis, indicator by indicator, to assess relevance and measurability. Following the evaluation, an application of those indicators that met both criteria was carried out for illustrative purposes as well as a summary evaluation to compare the results of our study (sectoral effects – Table 7) to the indicator set that we are evaluating (national environmental sustainability – Table 8). The summary evaluation followed the approach of Cook et al. (Cook et al., 2017) where a rolling 3-year average (starting with the years 2012, 2013 and 2014, depending on data availability) was used to determine trend-based progress towards or away from environmentally sustainable outcomes. The traffic lights are as follows:

GREEN = improving

YELLOW = little or no change

RED = deteriorating

GREY = no data available for a given year

When the change in an indicator was less than 1% point from one 3-year average to the next it was designated by a yellow traffic light. Grey traffic lights designate missing data (see Section 7 for the results).

4.1. Study boundaries

Tourism as a sector is diverse and includes different components (sub-sectors) which together comprise the tourism sector. It is important to delineate the boundaries for this study. Outbound activities were excluded since the focus was on the impact of tourism in Iceland on national level indicators, not of Icelandic tourists abroad. Table A2 in Appendix A lists all the components that make up the tourism sector according to internationally accepted statistical classifications for tourism adapted for the Icelandic sector (Frenţ, 2015).

5. Evaluation of indicator set and assumptions for application to tourism

In this section each thematic category and associated indicators selected by Cook et al. (Cook et al., 2017) were reviewed with respect to the evaluation criteria listed in the previous section. Tables 1–6 summarize the evaluation while additional information is in the text.

Table 1
Energy performance indicators and review comments.

Indicator	Measure	Comments
Carbon intensity of heat and electricity generation	Total GHG emissions (tCO_{2e}) per GWh_e of combined heat and electricity generation	Relevant. Partially measurable.
Energy intensity of economic activity	Total primary energy supply (ktoe) per unit of national GDP	Relevant. Partially measurable.
Renewable energy generation	Percentage of renewable energy (including waste recovery) as share of primary energy supply	Relevant. Limited measurability.

Table 2
Waste management indicators and review comments.

Indicator	Measure	Comments
Total volume of municipal waste generation	Total generation of municipal waste (thous. tonnes)	Relevant. Partially measurable.
Recycling of municipal waste	Percentage of municipal waste recycled	Relevant. Limited measurability.
Waste sent to landfill	Percentage of municipal waste sent to landfill	Relevant. Limited measurability.

Table 3
Air quality and pollution indicators and review comments.

Indicator	Measure	Comments
Total emissions of sulphur oxide (SOx)	Total measured in thousands of tonnes of SOx, only from man-made sources	Relevant. Limited measurability.
Total emissions of nitrogen oxide (NOx)	Total measured in thousands of tonnes of NOx, only from man-made sources	Relevant. Partially measurable.
Total emissions of PM 2.5	Total measured in thousands of tonnes of PM 2.5, only from man-made sources	Relevant. Partially measurable.
Total emissions of PM 10	Total measured in thousands of tonnes of PM 10, only from man-made sources	Relevant. Partially measurable.
Total emissions of carbon monoxide (CO)	Total measured in thousands of tonnes of CO, only from man-made sources	Relevant. Partially measurable.
Total emissions of non-methane volatile organic compounds (NMVOC)	Total measured in thousands of tonnes of NMVOC, only from man-made sources	Relevant. Partially measurable.
Total greenhouse gas emissions	Total measured in million tonnes of CO_2 equivalent ($MtCO_2e$) including and excluding land use, land use change and forestry (LULUCF)	Relevant. Partially measurable.
Carbon intensity of economic activity	Total GHG emissions (tCO_{2e}) per unit of national GDP	Relevant. Partially measurable.

Table 4
Water quality and pollution indicators and review comments.

Indicator	Measure	Comments
Fresh and groundwater abstraction	Percentages of fresh and groundwater abstraction as proportion of long term average available water	Relevant. Limited measurability.
Wastewater treatment	Percentage of population connected to urban wastewater receiving at least secondary treatment	Relevant. Limited measurability.

Table 5
Land use, agriculture and fisheries indicators and review comments.

Indicator	Measure	Comments
Pesticide use	Total pesticides applied to crops and seeds expressed in tonnes per thousand hectares of agricultural land	Relevant. Partially measurable.
Fertilizer consumption	Total fertilizer consumption (nitrogen and phosphates) expressed in tonnes per thousand hectares of agricultural land	Relevant. Partially measurable.
Sustainability of fish stocks	Average ratio of aggregated stock landings to abundance measured by scientific stock assessments	Not relevant.

Table 6
Biodiversity, forests and soils indicators and review comments.

Indicator	Measure	Comments
Endangered species	Total number of threatened species on the red list	Relevant. Limited measurability.
Forest increment and fellings	Fellings as percentage share of net natural increment	Not relevant.
Protection of areas	Total land and marine area of the International Union for the Conservation of Nature (IUCN) protected areas (km^2)	Relevant. Limited measurability.
Soil erosion rates	Soil erosion by water and air (tonnes per hectare per year)	Relevant. Limited measurability.

5.1. Energy performance

For this thematic category, three indicators were chosen in the original set. All three were deemed relevant to the tourism context in Iceland as tourism accommodation uses energy and most tourism establishments are connected to the national energy grid. In addition, the road passenger transport component of tourism is nearly exclusively based on oil use in Iceland (NEA [National Energy Authority], 2021) (see Table 1).

Carbon intensity of heat and electricity is relevant and partially measurable. A large percentage of both electricity generation (nearly 100%) and heat production (97%) in Iceland in 2015 was based on renewable energy sources (OECD and IEA [International Energy Agency], 2017). In this paper the share of greenhouse gas emissions from combined heat and electricity of local residents versus tourists based on their respective populations and length of stay was estimated. Average length of stay was calculated through figures given in self-report surveys by both local residents and international tourists covering the period 2011–2016 (ITB [Icelandic Tourist Board], 2021).

Energy intensity of economic activity is relevant in the context of the tourism industry especially as regards the oil consumption of rentals, coaches and other tourism-specific vehicles, but there is scant data on the oil consumption of tourism-specific vehicles. Although data is available at the national level on the average fuel consumption of cars in Iceland from 2006 to 2015 (NEA [National Energy Authority], 2021) data relating to the average consumption of a rental vehicle is based on an estimated fig. (Íslandsbanki Research, 2016). The estimated figure was used to derive the fuel consumption of rental cars for the years 2011–2016 taking into account the amount of registered rental cars (Statistics Iceland, 2021c).

Finally, regarding *renewable energy generation,* the indicator is relevant since tourism establishments are for the most part connected to the national energy grid (ITSO [Icelandic Transmission System Operator], 2021). However, measurability is limited as there is no available data on the number of establishments connected to the grid or the amount of electricity they use.

5.2. Waste management

For this thematic category there were three indicators chosen in the original set. All three were deemed relevant to the tourism context in Iceland (see Table 2). However, measurability is limited since the

tourism industry cannot be adequately isolated from other waste sources in the municipal waste stream. Accommodations and the food/beverage industry are both included in the municipal waste stream but data is not collected separately for tourism-specific components. According to an expert at the Environment Agency of Iceland (which oversees data collection for waste), the municipal waste stream includes all businesses and public institutions, and, as such, it can be assumed that it overestimates waste volumes for certain components of the tourism industry (B. Stefánsdóttir, personal communication, April 14, 2021).

The effects of tourism's growth on municipal waste generation have been previously demonstrated in the literature (Mazzanti and Zoboli, 2009; Arbulú et al., 2015). In this paper, a simple regression analysis showed that GDP significantly predicted municipal waste generation, $\beta = 0.0001299$, t (19) = 9.51, $p < .001$. The overall model fit was $R^2 = 0.82$, F (1,20) = 92.56, $p < .001$. The regression equation was therefore used to predict the volume of municipal waste using tourism's direct GDP values (see Section 6.2).

5.3. Air quality and pollution

For this thematic category eight indicators were chosen in the original set designed for national evaluation. All eight were deemed relevant to the Icelandic tourism context especially those that pertain to road traffic emissions since the transportation sector is an integral tourism sector component (see Table 3). However, issues of measurability pertain to all.

In this paper an estimate of the share of road traffic emissions by rental cars most of which are used by tourists in Iceland was calculated. The estimate is limited by data availability and does not include other tourism-specific vehicles, such as coaches, trailers, snowmobiles etc. The assumptions for this estimation were the same as in the *energy intensity of economic activity* indicator above but the time period is further limited by data availability in the air pollution emissions data.

Man-made sulphur oxide (SOx) emissions are primarily related to reported emissions from geothermal energy production in Iceland, or nearly 85% (EEA [European Environment Agency], 2014b). Geothermal energy is Iceland is mostly used for space heating (45%) and electricity generation (40%) (NEA [National Energy Authority], 2021). This indicator is relevant to the tourism industry especially as regards the non-transport-related components, e.g. accommodation, food and beverage. However, there is no data available on SOx emissions of tourism-specific components which means that the indicator does not fulfil the measurability criterion.

Total greenhouse gas emissions and the *carbon intensity of economic activity* are important indicators in assessing the environmental sustainability of a country, as well as a sector. However, measurability is a hindrance since there is no time-series data of tourism sector-specific greenhouse gas emissions. Here the contribution of rental cars to the overall emissions from the Icelandic transportation sector was estimated leading to a partial measurement of greenhouse gas emissions from the tourism sector.

5.4. Water quality and pollution

Both indicators in this thematic category were deemed relevant but there are issues of measurability with both (see Table 4). *Water abstraction* serves as an indication of whether water resources are being depleted faster than their rate of renewal. It is not possible to isolate the tourism sector's contribution to water abstraction. Iceland has ample water resources on a per capita basis (IoES [The Institute of Economic Studies], 2011), however, due to the increase in visitor numbers it is an important issue to monitor.

Wastewater treatment is relevant in the tourism context largely due to the possible dual effects from seasonality and distribution of tourists. Despite the relatively high assimilative capacity of land and sea in Iceland it is important to monitor sewage treatment since the accumulation of impacts in vulnerable areas can cause significant damage (OECD [Organization for Economic Cooperation and Development], 2014). However, there are issues with measurability with this indicator since it is measures only what share of the resident population is connected to urban wastewater treatment facilities and does not take into account the infrastructural pressures from visitors.

5.5. Land use, agriculture and fisheries

The first two indicators in this category can only partially account for tourism impacts on the environment in Iceland (see Table 5). The indicator on *fisheries* is not relevant to the Icelandic tourism context because the Icelandic Fisheries Management System (FMS) with its Total Allowable Catch (TAC) rule precludes overfishing based on biophysical limits regardless of market demand (Matthíasson, 2012).

Pesticide use and *fertilizer consumption* are relevant to the tourism sector, in so far as these indicators can be linked to local food consumption by tourists in Iceland. In this paper the food consumption of local residents versus tourists was estimated based on the size their respective populations and their length of stay, assuming similar diets. These figures were then used to estimate tourists' share of the use of pesticides and consumption of fertilizers as compared to the resident population.

5.6. Biodiversity, forests and soils

Three of the four indicators in this thematic category were deemed relevant to the tourism context but none met the criterion of measurability (see Table 6). *Forest increment and fellings* is not relevant to the Icelandic tourism context as there is no connection of tourism to deforestation in Iceland and no deforestation has occurred in the last few decades (IFS [Iceland Forest Service], 2017).

Due to the seasonality and concentration of tourists in areas of high conservation value, impacts on local flora and fauna can be considerable (Buckley, 2011). In addition, tourists can inadvertently carry with them invasive pathogens, plants and animals (Pickering and Mount, 2010; Wasowicz, 2016). As such, *endangered species* are a relevant issue, but it is very difficult to disaggregate which impacts are directly attributable to tourists.

The *protection of areas* is important for tourism as it is a means of guaranteeing the natural resource base upon which much of tourism depends. However, an indicator which only measures the total land or marine area under protection without taking into account whether these areas are adequately protected fails the criterion of measurability and provides a misleading picture of the state of the environment.

Relating to conservation issues is the matter of *soil conservation*. Soil erosion is a long-standing environmental issue in Iceland and one that is also very relevant in the tourism context (OECD [Organization for Economic Cooperation and Development], 2014). Increased tourism is not the only cause of soil erosion in Iceland (Arnalds and Thorsson, 2012) so an indicator would have to address soil erosion issues more specific to tourism impacts, such as off-road driving, trampling and track erosion.

To sum up, of the total of 23 indicators from the national indicator set under review here (Cook et al., 2017), 21 of the indicators were deemed relevant and out of those 12 were partially measurable, 10 did not meet the criterion of measurability and two were deemed not relevant. In applying these indicators to the tourism sector, data availability often precluded entirely accurate estimations and various assumptions had to be made in order to calculate the relevant indicators. In the next section, the indicators which met both the relevance and measurability criteria were calculated for illustrative purposes.

6. Application of indicator set with respect to tourism impacts

In this section 12 of the indicators (for which it was possible to

provide a partial measurement) were calculated and graphically presented for illustrative purposes. Only partial measurement was possible due to lack of data. Finally, a summary evaluation is presented at the end of this section using a traffic-light system. This constitutes a preliminary assessment; fuller evaluation represents future research for the authors.

6.1. Energy performance

The estimated share of greenhouse gas emissions (GHG) from heat and electricity production attributed to foreign visitors rose from 8.23 Gg in 2011 to about 14 Gg in 2014 (see Fig. 1). Total GHG emissions from heat and electricity in 2014 were 207.49 Gg and most of them (nearly 90%) were due to geothermal energy production.

The estimated energy intensity of car rentals has decreased somewhat since 2011 from 0.31 to 0.25 units in 2016 (see Fig. 2) though it is difficult to confidently discern trends for such a short time period.

6.2. Waste management

Fig. 3 shows the amount of waste predicted by the direct contribution of tourism to GDP. The volume of municipal waste rises with increased GDP as would be expected from about 28 thousand tonnes in 2009 to about 47 thousand tonnes in 2016. However, this is likely underestimating the volume of municipal waste generated as it only accounts for the direct contribution of tourism to GDP. Total municipal waste generation was 132 thousand tonnes in 2009 and rose to 193 thousand tonnes in 2016 (Johnson, 2010). In other words, the proportion of municipal waste generated as predicted by tourism direct GDP has risen from 21% in 2009 to 24% in 2016.

6.3. Air quality and pollution

The results represented in Figs. 4–10 are based on estimated figures on the share of road traffic emissions by rental cars for those years where data is available.

The estimated share of NOx road transport emissions from rental cars in Iceland rose from 0.35 thousand tonnes in 2011 to 0.67 thousand tonnes in 2015 (see Fig. 4). Approximately 19% of the total NOx emissions in 2015 (most recent available data) originated from road traffic emissions (OECD, 2017).

The estimated share of PM 10 road transport emissions from rental cars in Iceland rose from 0.01 thousand tonnes in 2011 to 0.02 thousand tonnes in 2013 (see Fig. 5). Approximately 5% of the total PM 10 emissions in 2015 (most recent available data) originated from road traffic emissions (OECD, 2017).

The estimated share of PM 2.5 road transport emissions from rental cars in Iceland was around 0.01 throughout 2011–2013 (see Fig. 6). Approximately 4% of the total PM 2.5 emissions in 2013 (most recent available data) originated from road traffic emissions (OECD, 2017).

The estimated share of CO road transport emissions from rental cars in Iceland rose from 1.25 thousand tonnes in 2011 to 2,07 thousand tonnes in 2015 (see Fig. 7). Approximately 12% of CO emissions in 2015 (most recent available data) originated from road traffic emissions (OECD, 2017).

The estimated share of NMVOC road transport emissions from rental cars in Iceland rose from 0.23 thousand tonnes in 2011 to 0.43 thousand

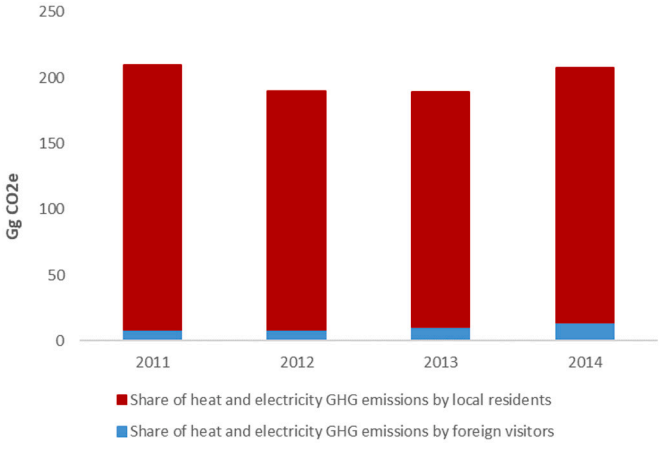

Fig. 1. Estimated share of GHG emissions from combined heat and electricity by foreign visitors and local residents (Data sources: 71, 77).

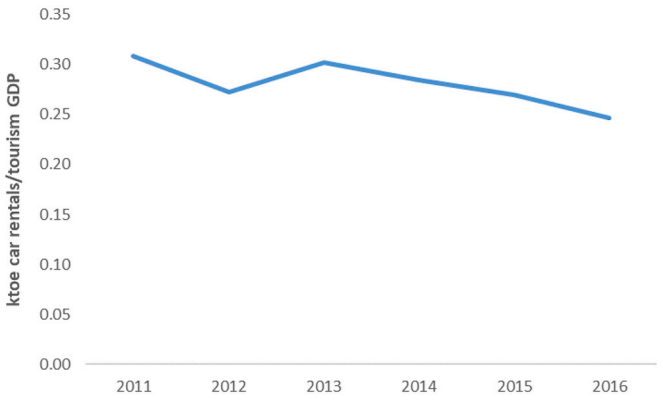

Fig. 2. Estimated total primary energy supply from car rentals (ktoe) per unit of tourism direct GDP (million ISK) [Data sources: (Statistics Iceland, 2021a; Íslandsbanki Research, 2016; Statistics Iceland, 2021c)].

Fig. 3. Predicted municipal waste generation from tourism direct GDP as part of total municipal waste generation [Data sources: (Statistics Iceland, 2021a; Eurostat, 2017)].

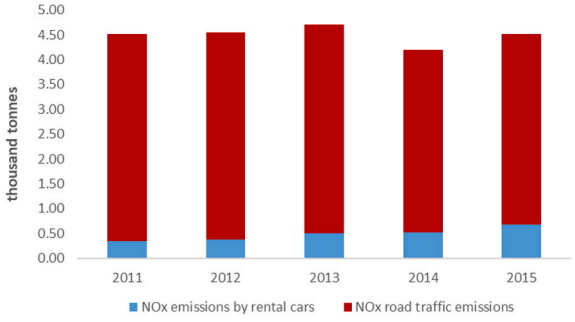

Fig. 4. Estimated share of NOx road transport emissions by rental cars [Data sources: (Íslandsbanki Research, 2016; Statistics Iceland, 2021c; OECD, 2017)].

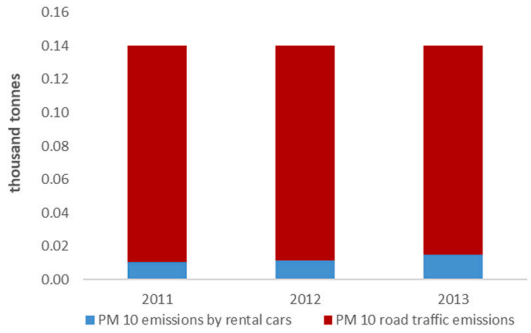

Fig. 5. Estimated share of PM 10 road transport emissions by rental cars [Data sources: (Íslandsbanki Research, 2016; Statistics Iceland, 2021c; OECD, 2017)].

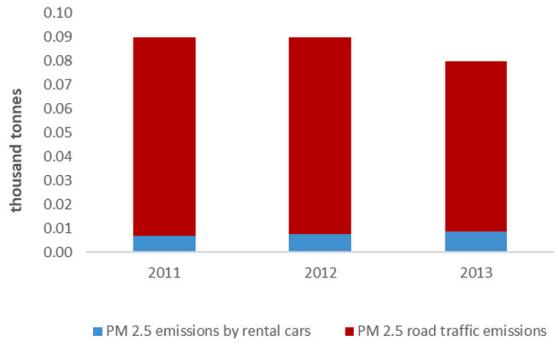

Fig. 6. Estimated share of PM 2.5 road transport emissions by rental cars [Data sources: (Íslandsbanki Research, 2016; Statistics Iceland, 2021c; OECD, 2017)].

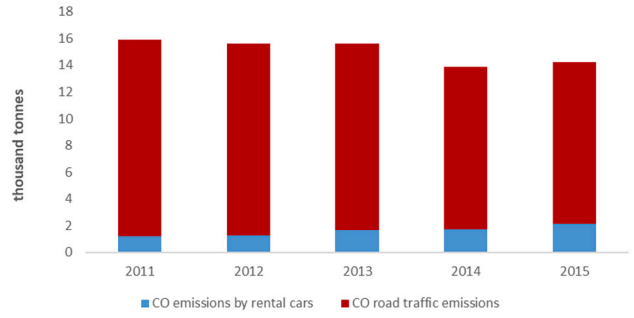

Fig. 7. Estimated share of CO road transport emissions by rental cars [Data sources: (Íslandsbanki Research, 2016; Statistics Iceland, 2021c; OECD, 2017)].

tonnes in 2015 (see Fig. 8). Approximately 50% of NMVOC emissions in 2015 (most recent available data) originated from road traffic emissions (OECD, 2017).

The estimated share of greenhouse gas (GHG) emissions from rental cars has risen from approximately 62 Gg CO2e in 2011 to around 101 Gg CO2e in 2014 (see Fig. 9). Total road transport emissions in 2014 were approximately 800 Gg (UNFCCC [United Nations Framework Convention on Climate Change], 2016).

The estimated carbon intensity of rental cars seems to have decreased somewhat from 0.97 in 2011 to 0.85 in 2015 (see Fig. 10) though it is difficult to conclude anything from such a short time scale.

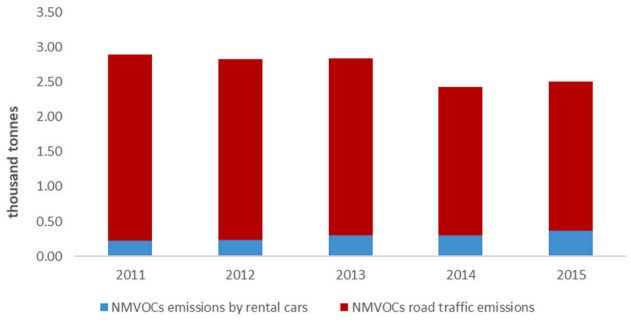

Fig. 8. Estimated share of NMVOCs road transport emissions by rental cars [Data sources: (Íslandsbanki Research, 2016; Statistics Iceland, 2021c; OECD, 2017)].

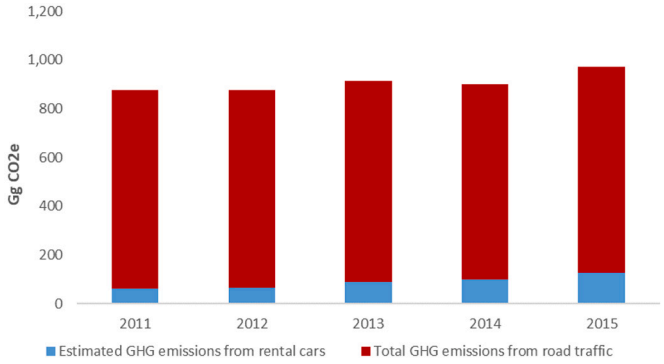

Fig. 9. Estimated share of GHG emissions from rental cars of total road traffic GHG emissions (Gg CO2e) [Data sources: (UNFCCC [United Nations Framework Convention on Climate Change], 2016; Íslandsbanki Research, 2016; Statistics Iceland, 2021c)].

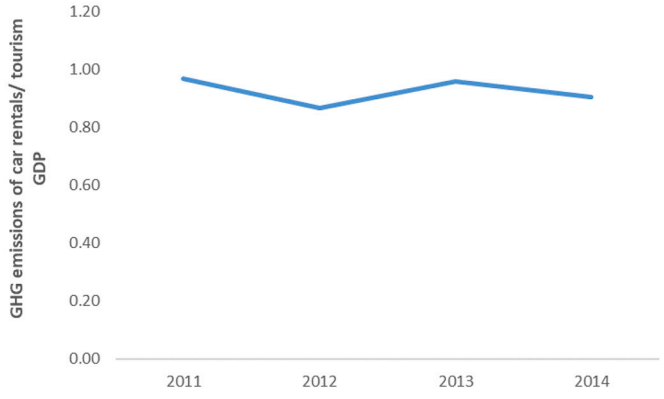

Fig. 10. Total estimated GHG emissions from rental cars (Gg CO2e) per unit of tourism direct GDP (million ISK) [Data sources: (Statistics Iceland, 2021a; UNFCCC [United Nations Framework Convention on Climate Change], 2016; Íslandsbanki Research, 2016; Statistics Iceland, 2021c)].

6.4. *Land use, agriculture and fisheries*[1]

The fertilizers here are composed of three different fertilizers: nitrogen (N), phosphorous (P) and potash (K). In general fertilizer use –

[1] Fertilizers and pesticides are in tonnes of active ingredients due to data availability. In the original indicator set these were in tonnes per thousand hectares of agricultural land.

and especially nitrogen – increased somewhat in 2014 compared to 2011 but not as much as in 2008 when fertilizer use peaked when compared to 1990 levels (Statistics Iceland, 2021d). The estimated share of fertilizer use attributed to foreign visitors' consumption raised from approximately 549 t to 1611 t (see Fig. 11).

In general, the highest consumption of pesticides since 1999 was 6 t in 2004. Since then it has fluctuated between 2 and 5 t per year with no clear trends (Faostat, 2017). The estimated consumption of pesticides attributed to tourists has risen from 0.14 to 0.25 t (see Fig. 12).

7. Summary evaluation

The aim of this paper was to assess whether national-level indicators of sustainability could capture sectoral effects. Using the approach of Cook et al. (Cook et al., 2017) Table 7 summarizes the above results in a traffic light system in order to show trend-based progress towards environmental sustainability outcomes. A trend-based approach was chosen due to the lack of clear targets. It was only possible to calculate rolling averages for nine out of the 12 partially measured indicators and as can be seen from the grey traffic lights, data availability is a frequent hindrance. The table provides an overview of all the indicators that were partially measured and/or estimated followed by the national summary evaluation adapted from Cook et al. (Cook et al., 2017) for comparison's sake and for illustrative purposes.

Table 8 presents the trend-based summary for these same indicators but at the national level for the sake of comparison. Municipal waste generation has been increasing in the last few years and tourism is a factor in this increase. Energy intensity in tourism (as partially measured here) has been decreasing and so is the case also at the national level. It is not clear how tourism may be impacting fertilizer use as there seems to be no general trend at the national level. A negative trend in the context of tourism does not always translate to a negative trend in the national context which would imply that tourism's impact on the national performance of Iceland is not pronounced. This assessment is, however, very limited due to data availability issues in the estimations which often lead to the under measurement of key indicators e.g. GHG emissions only from rental cars rather than all tourism-specific vehicles. The various shortcomings of the indicator set as well as issues to do with data availability are addressed in the discussion.

8. Discussion

Iceland's tourism sector expanded considerably between the years 2012–2018 raising concerns about associated environmental impacts. An indicator set that aims to determine environmental performance at the national level should be able to capture the impact of large-scale changes in the structure of the economy. This preliminary analysis

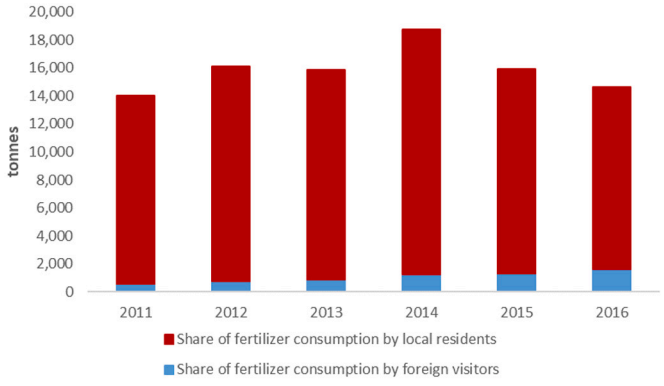

Fig. 11. Estimated share of fertilizer consumption attributed to local residents and foreign visitors [Data sources: (ITB [Icelandic Tourist Board], 2021; Statistics Iceland, 2021d)].

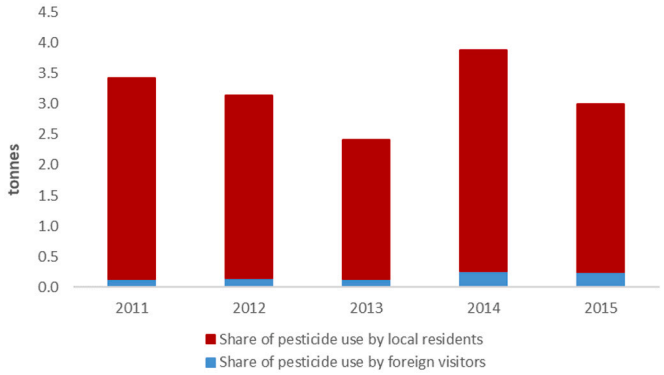

Fig. 12. Estimated share of pesticide use attributed to local residents and foreign visitors [Data sources: (Faostat, 2017; ITB [Icelandic Tourist Board], 2021)].

showed that the indicator set under review here was only partly suitable for capturing the impact of a growing economic sector (in this case tourism) on the overall environmental sustainability performance of Iceland. Out of the total of six thematic categories in the indicator set under evaluation (Cook et al., 2017) (see also Appendix A), partial measurement was mostly possible for three of these i.e. energy performance; air quality and pollution; and land use, agriculture and fisheries. One of the indicators within these themes did not meet the relevance criterion. In the thematic categories of waste management; water quality and pollution; and biodiversity, forests and soils; most indicators (seven) were of limited measurability and two were deemed irrelevant.

There are a few reasons why the national-level set under evaluation here was not entirely able to capture the impacts of a growing sector. First, many of the indicators do not disaggregate the different sources of impacts by economic sector. This is especially true about the tourism sector, which is also a more diverse and fragmented sector than other traditional sectors of the Icelandic economy such as fisheries or heavy industry. In some cases, such differentiation is in principle possible but has not been carried out by the relevant institutions at the data collection stage. For example, data on fuel emissions by tourism-specific vehicles is available at the company level but has not been compiled by a relevant institution e.g. Statistics Iceland. Similarly, collection of waste data can be improved by changing how the data is statistically categorized. In general, Iceland's statistical information would greatly benefit from the implementation of a green accounting system such as, the European environmental economic accounts.

In other cases, data differentiation is practically complex as the causal link between certain environmental issues and tourism is not clearly established. For the tourism sector in particular, there is the further complication of several different components which need to be taken into account. In some cases, these components are not entirely specific to tourism (e.g. the food and beverage sector), necessitating further disaggregation within specific component sectors.

Second, some issues are likely to be more pronounced in areas that are both fragile and highly popular with visitors. Some national-level indicators are too broad to adequately capture the impacts to specific locations which would require more fine-grained information. A prominent example is the issue of soil erosion related to increased numbers of visitors to protected areas and/or popular destinations in Iceland. It should be noted though that data is lacking on soil erosion also at the national level.

Despite the indicator set's inclusion of a protected areas indicator, it, nonetheless, fails to capture impacts to protected areas which are under strain in Iceland due to increased tourism. This is a shortcoming that is relevant not only in attempting to capture impacts from an economic sector from an indicator set designed to measure national-level effects, but also when assessing environmental sustainability in general. As a

Table 7
Trend-based environmental sustainability performance of the Icelandic tourism sector; adapted from (Cook et al., 2017).

Theme	Indicator	2012	2013	2014	2015	2016
Energy performance	Estimated energy intensity (rental cars)					
Waste management	Municipal waste generation from tourism (predicted values)					
Air quality and pollution	Estimated NOx emissions (rental cars)					
	Estimated CO emissions (rental cars)					
	Estimated NMVOCs emissions (rental cars)					
	Estimated GHG emissions excl. LULUCF (rental cars)					
	Estimated carbon intensity (rental cars)					
Land use, agriculture and fisheries	Estimated fertilizer use					
	Estimated pesticide use					

recent study has shown, one-third of protected areas globally are under intense human pressure (Jones et al., 2018), which highlights the importance of developing indicators which measure not only the number of areas protected but also the state of the environment in these areas. A useful amendment to the set would be to complement the protected areas indicator with a current status indicator based on the Icelandic Environment Agency's reports described above (EAI [Environment Agency of Iceland], 2017).

Third, the national approach places artificial boundaries on sectoral impacts which tends to underestimate the sector's contribution to international environmental issues. This is particularly pertinent as regards greenhouse gas emissions from international aviation which Icelandic tourism largely depends upon. It is not clear how to account for these emissions and whether they should be attributed to the visitor's destination or country of origin, or if they should be shared somehow among different countries (Gössling, 2013). Nor is it clear how stopover flights in Iceland's main international airport should be accounted for. Nonetheless, considering the proportionally high amount of emissions from aviation, an indicator would have to be included to capture these in order to better inform national policy on emission trends and reductions.

Finally, there are also sectoral effects which are omitted in the indicator set under evaluation: a) issues specific to environmentally sensitive areas such as trampling, off-road driving, trail erosion and so on; b) impacts from cruise ships such as air pollution, sewage treatment, and flora and fauna disturbance by passengers visiting the coast line with boats; c) impacts from construction of tourism-specific facilities and accommodation such as waste, material transport and associated greenhouse gas emissions, energy and water consumption and so on; d)

Table 8
Trend-based environmental sustainability performance of Iceland; adapted from (Cook et al., 2017).

Theme	Indicator	2012	2013	2014	2015	2016
Energy performance	Energy intensity					
Waste management	Total municipal waste generation					
Air quality and pollution	Total NOx emissions					
	Total CO emissions					
	Total NMVOCs emissions					
	Total GHG emissions (excl. LULUCF)					
	Carbon intensity					
Land use, agriculture and fisheries	Fertilizer use					
	Pesticide use					

effects from tourism development especially with regard to sensitive and wilderness areas and, e) noise disturbances to wildlife. In order to address these omissions, the national level indicators would have to be complemented with sector-specific satellite indicators representing future research for the authors.

Notwithstanding these limitations, a national level indicator set (as opposed to a global or regional indicator set) is more likely to capture impacts that are highly relevant to the country in question when it has already identified those indicators that are pertinent to its environmental sustainability (Olafsson et al., 2014). This applies especially in cases where the economy is small but highly specialized (Jóhannesson et al., 2018) and where individual sectors have proportionally large impacts. National-level assessments of tourism are not common in part because they can be challenging due to the fragmented nature of the tourism sector comprised by component sectors (Dubois, 2005). Despite the challenges, national assessments are an important tool in guiding national policies on sustainable tourism and in ensuring that sectoral approaches to environmental management are comprehensive.

Various national policies are important in the context of the Icelandic tourism industry's environmental performance. Although there is no sectoral policy for decarbonisation, Iceland's Climate Action Plan for 2018–2030 stipulates the transition to electric vehicles as one of the main avenues towards decarbonisation in the coming years (MENR [Ministry for the Environment and Natural Resources], 2018). Transportation has also been singled out as an important area for reducing carbon emissions within the tourism industry (Sutherland and Stacey, 2017; Cook et al., 2019) and, is therefore, an important category to quantify. The car rental industry, for example, also supplies the general market with used cars which underlies their importance to the Icelandic transportation sector in general and not just in the context of tourism. There has been growing awareness of the national and international implications of climate change by Icelandic tourism operators and accommodation providers and especially larger companies have increasingly been measuring their carbon emissions as part of their environmental management systems [e.g. (Mountaineers of Iceland, 2021)]. The effects of these initiatives are difficult to quantify, however, in part because the data is not collected at the industry level or made publicly available on most companies' reports.

Although national policy with regards to the tourism sector has been lagging there are positive developments such as a draft for Iceland's first national policy on aviation including the importance of addressing carbon emissions (MRLG [Ministry of Transport and Local Government], 2019), the development of multi-dimensional indicators for the sector (EFLA, 2018), and, data collection in connection to the SDGs (Statistics Iceland, 2021e). How effective these policies will be in managing environmental impacts from Iceland's tourism sector will depend on their implementation. Stricter regulations have also been proposed to effectively ban the use of Heavy Fuel Oil (HFO; used by various vessels including cruise ships) within Iceland's territorial waters by 2020 which would address some of the concerns in relation to cruise ship pollution at Icelandic ports (Benediktsdóttir, 2019). Ultimately the challenge for tourism (as with other sectors of the economy) is how it can be accommodated within resource limits and planetary boundaries (Higham and Miller, 2018). In Iceland, as elsewhere, this process can only begin with accurate and comprehensive measurement, and environmental sustainability indicators are well-suited for this purpose.

9. Conclusion

Using a previously developed indicator set specific to Iceland, this paper attempted to evaluate whether an indicator set focused on the national scale could capture the environmental sustainability impacts of the rapidly growing tourism sector in Iceland and how that may be affecting Iceland's overall environmental performance.

The collection of integral economic data for the tourism sector in Iceland has outpaced the collection of environmental data which is arguably equally integral to the continuing prosperity of the sector in Iceland (Sutherland and Stacey, 2017). Given improved data collection, many of the indicators would be useful in the assessment of tourism impacts in Iceland, particularly in connection to tourism's contribution to water and air pollution, waste generation and carbon intensity. Others would have to be re-considered and improved with a sectoral approach in mind representing future analysis for the researchers.

Measuring sector-specific impacts provides indispensable information in developing national and sectoral policies to improve the environmental performance of nations. As this investigation has shown, taking the national context into account constitutes only a starting point and capturing sectoral impacts on national performance presents new challenges (MENR [Ministry for the Environment and Natural Resources], 2018). Nonetheless, the collection of important environmental impact data from a nation's largest sectors provides essential information for policy makers and managers attempting to reduce environmental impacts. For example, the collection of waste flow and fuel emission data can be substantially improved so that major economic sectors and their impacts can be accurately represented in the national statistics registry. This investigation highlighted data gaps and provided a preliminary assessment of indicators relevant to measuring impacts from tourism. Future research would also have to examine accountability in terms of how accurate the collected data is.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Table A1
Indicators of environmental sustainability at the national level [source: (Cook et al., 2017)].

Theme	Indicator	Measure
Energy performance	Carbon intensity of heat and electricity generation	Total GHG emissions (tCO_{2e}) per GWh_e of combined heat and electricity generation
	Energy intensity of economic activity	Total primary energy supply (ktoe) per unit of national GDP
	Renewable energy generation	Percentage of renewable energy (including waste recovery) as a share of primary energy supply
Waste management	Total volume of municipal waste generation	Total generation of municipal waste (thousand tonnes)
	Recycling of municipal waste	Percentage of municipal waste that is recycled
	Waste sent to landfill	Percentage of municipal waste that is sent to landfill
Air quality and pollution	Total emissions of sulphur oxide (SOx)	Total measured in thousands of tonnes of SOx, only from man-made sources
	Total emissions of nitrogen oxide (NOx)	Total measured in thousands of tonnes of NOx, only from man-made sources
	Total emissions of PM 2.5	Total measured in thousands of tonnes of PM 2.5, only from man-made sources
	Total emissions of PM 10	Total measured in thousands of tonnes of PM 10, only from man-made sources
	Total emissions of carbon monoxide (CO)	Total measured in thousands of tonnes of CO, only from man-made sources
	Total emissions of non-methane volatile organic compounds (NMVOC)	Total measured in thousands of tonnes of NMVOC, only from man-made sources
	Total greenhouse gas emissions	Total measured in million tonnes of CO_2 equivalent ($MtCO_2e$) including and excluding land use, land use change and forestry (LULUCF)
	Carbon intensity of economic activity	Total GHG emissions (tCO_{2e}) per unit of national GDP
Water quality and pollution	Fresh and groundwater abstraction	Percentages of fresh and groundwater abstraction as proportion of long term average available water
	Wastewater treatment	Percentage of population connected to urban wastewater receiving at least secondary treatment
Land use, agriculture and fisheries	Pesticide use	Total pesticides applied to crops and seeds expressed in tonnes per thousand hectares of agricultural land
	Fertilizer consumption	Total fertilizer consumption (nitrogen and phosphates) expressed in tonnes per thousand hectares of agricultural land
	Sustainability of fish stocks	Average ratio of aggregated stock landings to abundance measured by scientific stock assessments
Biodiversity, forests and soils	Endangered species	Total number of threatened species on the red list
	Forest increment and fellings	Fellings as percentage share of net natural increment
	Protection of areas	Total land and marine area of the International Union for the Conservation of Nature (IUCN) protected areas (km^2)
	Soil erosion rates	Soil erosion by water and air (tonnes per hectare per year)

Table A2
Tourism classification [source: (UNFCCC [United Nations Framework Convention on Climate Change], 2016)].

UNWTO categories	Icelandic categories
Tourism industry components	Description
A1. Tourism characteristic products/industries (for international comparability)	
1. Accommodation for visitors	Hotels and similar accommodation, without restaurants
	Hotels and similar accommodation, with restaurants
	Holiday and other short-stay accommodation
	Camping grounds, recreational vehicle parks and trailer parks
	Other accommodation
2. Food and beverage serving activities	Restaurants and mobile food service activities
	Other food service activities
	Beverage serving activities
3. Road passenger transport	Taxi operation
	Other passenger land transport not elsewhere classified
4. Water passenger transport	Sea and coastal passenger water transport
	Inland passenger water transport
5. Air passenger transport	Scheduled air transport
	Non-scheduled air transport
6. Transport equipment rental	Renting and leasing of cars and light motor vehicles
	Renting and leasing of trucks
7. Travel agencies and other reservation service activities	Travel agency activities
	Tour operator activities
	Other reservation service and related activities
8. Cultural activities	Performing arts
	Supporting activities to performing arts
	Artistic creation
	Operation of arts facilities
	Museums activities
	Operation of historical sites and buildings and similar visitor attractions
	Botanical and zoological gardens and nature reserves activities
9. Sports and recreational activities	Renting and leasing of recreational and sports goods
	Gambling and betting activities
	Operation of sports facilities
	Fitness facilities
	Other sports activities
	Activities of amusement parks and theme parks
	Other amusement and recreation activities
A2. Other consumption patterns	
Goods purchased from trade activities	Wholesale trade
	Retail sale
10. Other services	All the rest of industries providing services to tourists

References

Agyeiwaah, E., McKercher, B., Suntikul, W., 2017. Identifying core indicators of sustainable tourism: a path forward? Tour. Manag. Perspect. 24, 26–33. https://doi.org/10.1016/j.tmp.2017.07.005.

AIP [Associated Icelandic Ports], 2018. Cruise Statistics. Available online. https://www.faxafloahafnir.is/en/cruisestatistics.

Arbulú, I., Lozano, J., Rey-Maquieira, J., 2015. Tourism and solid waste generation in Europe: a panel data assessment of the Environmental Kuznets Curve. Waste Manag. 46, 628–636. https://doi.org/10.1016/j.wasman.2015.04.014.

Arnalds, Ó., Thorsson, J., 2012. Soil Erosion and Land Care in Iceland. European Society for Soil Conservation, Newsletter, 2/2012. Retrieved from: http://www.soilconservation.eu/assets/newsletter_2_2012.pdf.

Bauler, T., Douglas, I., Daniels, P., Demkine, V., Eisenmenger, N., Grosskurth, J., Van Woerden, J., 2007. Identifying methodological challenges. In: Hák, Tomás, Moldan, Bedrich, Dahl, Arthur Lyon (Eds.), Sustainability Indicators: A Scientific Assessment, SCOPE Publication Series. Island Press, pp. 49–64.

Benediktsdóttir, E.B., 2019, May, 24. Heavy Fuel Oil Ban in Icelandic Territorial Waters in 2020 (in Icelandic). Accessed November 2019. https://www.ruv.is/frett/svartoliubann-i-islenskri-landhelgi-2020.

Blackstock, K.L., White, V., McCrum, G., Scott, A., Hunter, C., 2008. Measuring responsibility: an appraisal of a Scottish national park's sustainable tourism indicators. J. Sustain. Tour. 16 (3), 276–297.

Blancas, F.J., Gonzalez, M., Lozano-Oyola, M., Perez, F., 2010. The assessment of sustainable tourism: application to Spanish coastal destinations. Ecol. Indic. 10, 484–492. https://doi.org/10.1016/j.ecolind.2009.08.001.

Boluk, K., Cavaliere, C.T., Higgins-Desbiolles, F., 2017. Critical thinking to realize sustainability in tourism systems: reflecting on the 2030 sustainable development goals. J. Sustain. Tour. 25 (9) https://doi.org/10.1080/09669582.2017.1333263.

Buckley, R., 1999. An ecological perspective on carrying capacity. Ann. Tour. Res. 26 (3), 705–708. https://doi.org/10.1016/S0160-7383(99)00013-4.

Buckley, R., 2011. Tourism and the environment. Annu. Rev. Environ. Resour. 36, 397–416. https://doi.org/10.1146/annurev-environ-041210-132637.

Buckley, R., 2012. Sustainable tourism: research and reality. Ann. Tour. Res. 39 (2), 528–546. https://doi.org/10.1016/j.annals.2012.02.003.

Budenau, A., Miller, G., Moscardo, G., Ooi, C.S., 2016. Sustainable tourism, progress, challenges and opportunities: an introduction. J. Clean. Prod. 111, 285–294. https://doi.org/10.1016/j.jclepro.2015.10.027.

Burger, J., 2006. Bioindicators: a review of their use in the environmental literature 1970–2005. Environ. Bioindic. 1 (2), 136–144. https://doi.org/10.1080/15555270600701540.

CBI [The Central Bank of Iceland], 2016. Economy of Iceland. Retrieved from: https://www.cb.is/library/Skraarsafn—EN/Economy-of-Iceland/2016/Economy_of_Iceland_2016.pdf.

Choi, H.C., Sikaraya, E., 2006. Sustainability indicators for managing community tourism. Tour. Manag. 27 (1), 1274–1289. https://doi.org/10.1016/j.tourman.2005.05.018.

Coccossis, H., Mexa, A., 2004. Tourism carrying capacity methodological considerations. In: Coccossis, H., Mexa, A. (Eds.), The Challenge of Tourism Carrying Capacity Assessment: Theory and Practice, Kindle edition. Ashgate, Aldershot, pp. 55–90.

COM, 2017. The European Tourism Indicator System: ETIS Toolkit for Sustainable Destination Management. Retrieved from: http://ec.europa.eu/growth/sectors/tourism/offer/sustainable/indicators/index_en.htm.

Cook, D., Saviolidis, N.M., Davíðsdóttir, B., Jóhannsdóttir, L., Ólafsson, S., 2017. Measuring countries' environmental sustainability performance – the development of a nation-specific indicator set. Ecol. Indic. 74, 463–478. https://doi.org/10.1016/j.ecolind.2016.12.009.

Cook, D., Saviolidis, N., Davíðsdóttir, B., Jóhannsdóttir, L., Ólafsson, S., 2019. Synergies and trade-offs in the sustainable development goals—the implications of the Icelandic tourism sector. Sustainability 11 (15), 4223. https://doi.org/10.3390/su11154223.

Csagoly, Z., Sæþórsdóttir, A.D., Ólafsdóttir, R., 2017. Tourism changing the edge of the wild. J. Outdoor Recreat. Tour. 17, 1–8. https://doi.org/10.1016/j.jort.2016.10.004.

Dubois, G., 2005. Indicators for an environmental assessment of tourism at national level. Curr. Issue Tour. 8 (2–3), 140–154. https://doi.org/10.1080/13683500508668210.
Dymond, S.J., 1997. Indicators of sustainable tourism in New Zealand: a local government perspective. J. Sustain. Tour. 5 (4), 279–293. https://doi.org/10.1080/09669589708667292.
EAI [Environment Agency of Iceland], 2017. State of Protected Areas (in Icelandic). Retrieved from: https://www.ust.is/library/Skrar/utgefid-efni/astand-fridlystra-svaeda/Astandsskyrsla%202016%20febr%C3%BAar_final.pdf.
EAI [Environment Agency of Iceland], 2021. Driving in Uninhabited Areas Off-Road Driving Damages the Land. Accessed, April, 2017 at: https://www.ust.is/the-environment-agency-of-iceland/tourist-information/driving-in-uninhabited-areas/.
EEA [European Environment Agency], 2014a. Digest of EEA Indicators 2014. Retrieved from: https://www.eea.europa.eu/publications/digest-of-eea-indicators-2014.
EEA [European Environment Agency], 2014b. Air Pollution Fact Sheet: Iceland. Retrieved from: https://www.eea.europa.eu/themes/air/air-pollution-country-fact-sheets-2014/iceland-air-pollutant-emissions-country-factsheet/view.
EFLA, 2017. Source of Particulate Matter in Reykjavík (in Icelandic). Retrieved from: http://www.vegagerdin.is/vefur2.nsf/Files/uppruni_svifryks_i_reykjavik/$file/Uppruni%20svifryks%20%C3%AD%20Reykjav%C3%ADk.pdf.
EFLA, 2018. Assessment of Pressures on the Environment, Infrastructure and Society Regarding the Number of Tourists in Iceland Phase 1: Development of Indicators for Assessment of Pressures (in Icelandic). Available online. https://www.efla.is/media/utgefid-efni/6732-001-sky-v01-tholmarkarverkefni-lokaeintak_web.pdf.
Eurostat, 2017. Municipal Waste by Waste Operations. Retrieved from: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_wasmun&lang=en.
Faostat, 2017. Pesticides Use: Iceland. Retrieved from: http://www.fao.org/faostat/en/#data/RP.
Feleki, E., Vlachokostas, C., Moussiopoulos, N., 2020. Holistic methodological framework for the characterization of urban sustainability and strategic planning. J. Clean. Prod. 243, 118432. https://doi.org/10.1016/j.jclepro.2019.118432.
Frent, C., 2015. The New Compilation of the Tourism Satellite Account in Iceland for 2009–2013: Data Sources, Methodology and Results. Icelandic Tourism Research Centre. Retrieved from: https://hagstofa.is/media/49503/prent_rmf-cfrent-tourism-satellitepdf.pdf.
Goodland, R., 1995. The concept of environmental sustainability. Annu. Rev. Ecol. Syst. 26, 1–24. Retrieved from. http://www.jstor.org/stable/2097196.
Goodland, R., Daly, H., 1996. Environmental sustainability: universal and non-negotiable. Ecol. Appl. 6 (4), 1002–1017. https://doi.org/10.2307/2269583.
Gössling, S., 2013. National emissions from tourism: an overlooked policy challenge? Energy Policy 59, 433–442. https://doi.org/10.1016/j.enpol.2013.03.058.
Gössling, S., Hall, C.M., 2006. Wake up…this is serious. In: Gössling, Stefan, Hall, Michael C. (Eds.), Tourism and Global Environmental Change: Ecological, Social, Economic and Political Interrelationships. Routledge, New York, pp. 305–320.
Gössling, S., Peeters, P., 2015. Assessing tourism's global environmental impact 1900–2050. J. Sustain. Tour. 23 (5), 639–659. https://doi.org/10.1080/09669582.2015.1008500.
Gren, M., Huijbens, E.H., 2014. Tourism and the Anthropocene. Scand. J. Hosp. Tour. 14 (1), 6–22. https://doi.org/10.1080/15022250.2014.886100.
Hall, C.M., Gossling, S., Scott, D., 2015. The Routledge Handbook of Tourism and Sustainability. Routledge, London, UK.
Higham, J., Miller, J., 2018. Transforming societies and transforming tourism: sustainable tourism in times of change. J. Sustain. Tour. 26 (1), 1–8. https://doi.org/10.1080/09669582.2018.1407519.
Horng, J., Hu, M., Teng, C., Lin, L., 2012. Energy saving and carbon reduction management indicators for natural attractions: a case study in Taiwan. J. Sustain. Tour. 20 (8), 1125–1149. https://doi.org/10.1080/09669582.2012.663380.
Hughes, G., 2002. Environmental indicators. Ann. Tour. Res. 29 (2), 457–477. https://doi.org/10.1016/S0160-7383(01)00071-8.
Huijbens, E.H., Jóhannesson, H., Jóhannesson, G.T., 2014. Clusters without content? Icelandic national and regional tourism policy. Scand. J. Public Adm. 18 (1), 63–85.
IFS [Iceland Forest Service], 2017. Forestry in a Treeless Land 2017. Retrieved from: http://www.skogur.is/media/2017/Forestry_in_treeless_land_BKL_210x260mm.pdf.
IoES [The Institute of Economic Studies], 2011. Economic Analysis on the Utilization of Water (in Icelandic). Retrieved from: http://hhi.hi.is/sites/hhi.hi.is/files/C-Series/C11_04_Vatnatilskipun.pdf.
IPCC, 2018. National Inventory Submissions 2018: Iceland. Retrieved from: https://unfccc.int/process/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2018.
Íslandsbanki Research, 2016. Icelandic Tourism (in Icelandic). Retrieved from: https://www.islandsbanki.is/fyrirtaeki/serthekking/ferdathjonusta/islensk-ferdathjonusta-2016/.
Íslandsbanki Research, 2017. Icelandic Tourism (in Icelandic). Retrieved from: https://www.islandsbanki.is/library/Skrar/Fyrirtaeki/Islensk-ferdathjonustaskyrsla2017-LQ.PDF.
ITB [Icelandic Tourist Board], 2017. Tourism in Iceland in Figures. Retrieved from: https://www.ferdamalastofa.is/static/files/ferdamalastofa/Frettamyndir/2017/juli/tourism-in-iceland-2017-9.pdf.
ITB [Icelandic Tourist Board], 2021. Foreign Visitors in Iceland: Results from Icelandic Tourist Board Surveys. Accessed at: http://maskina.is/maelabord/fms/.
ITSO [Icelandic Transmission System Operator], 2021. Energy Transmission Now. Accessed December 1st, 2017 at: https://www.landsnet.is/flutningskerfid/kerfisstjornun/aflflutningur-nuna/.
Janoušková, S., Hák, T., Moldan, B., 2015. Relevance – a neglected feature of sustainability indicators. In: Bell, Simon, Morse, Stephen (Eds.), The Routledge Handbook of Sustainability Indicators, Kindle edition. Taylor & Francis, New York, NY.
Jóhannesson, S.E., Davíðsdóttir, B., Heinonen, J.T., 2018. Standard Ecological Footprint method for small, highly specialized economies. Ecol. Econ. 146, 370–380. https://doi.org/10.1016/j.ecolecon.2017.11.034.
Johnson, D., 2010. Environmentally sustainable cruise tourism: a reality check. Mar. Policy 26, 261–270. https://doi.org/10.1016/S0308-597X(02)00008-8.
Kolbeinsson, J.B., 2017, January 29. Hotel rooms increase by half (in Icelandic). In: The Icelandic National Broadcasting Service RÚV. Retrieved from: http://www.ruv.is/frett/hotelherbergjum-fjolgar-um-helming.
Kristjánsdóttir, K.R., Ólafsdóttir, R., Ragnarsdóttir, K.V., 2018. Reviewing integrated sustainability indicators for tourism. J. Sustain. Tour. 26 (4), 583–599. https://doi.org/10.1080/09669582.2017.1364741.
Ling, R., 2015. A review of tourism supply chain based on the perspective of sustainable development. J. Econ. Sustain. Dev. 6 (22) (ISSN 2222-2855).
Matthíasson, T., 2012. Rights based fisheries management in Iceland and economic and financial crisis. In: European Parliament Directorate General for Internal Policies. Retrieved from: http://www.europarl.europa.eu/RegData/etudes/note/join/2012/474531/IPOL-PECH_NT(2012)474531_EN.pdf.
Mazzanti, M., Zoboli, R., 2009. Municipal Waste Kuznets Curves: evidence on socio-economic drivers and policy effectiveness from the EU. Environ. Resour. Econ. 44, 203. https://doi.org/10.1007/s10640-009-9280-x.
MENR [Ministry for the Environment and Natural Resources], 2018. Iceland's Climate Action Plan for 2018–2030—Summary. Available online. https://www.government.is/library/Files/Icelands%20new%20Climate%20Action%20Plan%20for%202018%202030.pdf.
Michailidou, A.V., Vlachokostas, C., Moussiopoulos, N., Maleka, D., 2016. Life Cycle Thinking used for assessing the environmental impacts of tourism activity for a Greek tourism destination. J. Clean. Prod. 111, 499–510. https://doi.org/10.1016/j.jclepro.2015.09.099.
MII [Ministries of Industry and Innovation], 2018. Report by the Minister of Tourism, Industry and Innovation on the Capacity Limits of Tourism (in Icelandic). Retrieved from: https://www.althingi.is/altext/148/s/0717.html.
Mikulic, J., Kožic, I., Krešic, D., 2015. Weighting indicators of tourism sustainability: a critical note. Ecol. Indic. 48, 312–314. https://doi.org/10.1016/j.ecolind.2014.08.026.
Miller, G., Twinning-Ward, L., 2005. Monitoring for a Sustainable Tourism Transition: The Challenge of Developing and Using Indicators. Cabi Publishing, Wallingford.
Mitchell, G., 1996. Problems and fundamentals of sustainable development indicators. Sustain. Dev. 4, 1–11. https://doi.org/10.1002/(SICI)1099-1719(199603)4:1<1::AID-SD24>3.0.CO;2-N.
Mountaineers of Iceland, 2021. Environmental Policy. Accessed, November, 2019: https://mountaineers.is/about/environmental-policy/.
MRLG [Ministry of Transport and Local Government], 2019. Green Paper on Government Policy on Air and Flight Operations in Iceland (in Icelandic). Available online. https://samradsgatt.island.is/oll-mal/$Cases/Details/?id=1456.
Muscardo, G., Murphy, L., 2014. There is no such thing as sustainable tourism: re-conceptualizing tourism as a tool for sustainability. Sustainability 6, 2538–2561. https://doi.org/10.3390/su6052538.
NEA [National Energy Authority], 2021. Fuels. Accessed November 29th 2017 at. http://www.nea.is/fuels/.
OECD, 2017. Emissions of Air Pollutants. Retrieved from: http://stats.oecd.org/. Accessed 2 March 2018.
OECD & IEA [International Energy Agency], 2017. Iceland: Electricity and Heat for 2015. Accessed December 1st, 2017 at: http://www.iea.org/statistics/statisticssearch/report/?country=ICELAND&product=ElectricityandHeat&year=2015.
OECD [Organization for Economic Cooperation and Development], 2014. Environmental Performance Reviews: Iceland 2014. Retrieved from: http://www.oecd.org/environment/iceland2014.htm.
Ólafsdóttir, R., Haraldsson, H., 2015. A Systemic Approach to Assessing the Environmental Impacts of Tourism and the Attractiveness of Tourism Destinations. University of Iceland and Icelandic Tourist Board. Retrieved from: http://www.ferdamalastofa.is/static/research/files/1464605608-environmental-impacts-tourism-sd_medislagripi_heild-pdf.
Ólafsdóttir, R., Runnström, M.C., 2013. Assessing hiking trails condition in two popular tourist destinations in the Icelandic highlands. J. Outdoor Recreat. Tour. 3, 57–67. https://doi.org/10.1016/j.jort.2013.09.004.
Ólafsdóttir, R., Runnström, M.C., 2015. Impact of Recreational Trampling in Iceland: A Pilot Study Based on Experimental Plots from Þingvellir National Park and Fjallabak Nature Reserve. Icelandic Tourist Board and University of Iceland.
Olafsson, S., Cook, D., Davidsdottir, B., Johannsdottir, L., 2014. Measuring countries' environmental sustainability performance – a review and case study of Iceland. Renew. Sust. Energ. Rev. 39, 934–948. https://doi.org/10.1016/j.rser.2014.07.101.
Perez, V.E., Santoyo, A.H., Guerrero, F., León, M.A., da Silva, C.L., Caballero, R., 2017. Measuring the sustainability of Cuban tourism destinations considering stakeholders' perceptions. Int. J. Tour. Res. 19, 318–328. https://doi.org/10.1002/jtr.2114.
Pickering, C.M., Mount, A., 2010. Do tourists disperse weed seed? A global review of unintentional human mediated terrestrial seed dispersal on clothing, vehicles and horses. J. Sustain. Tour. 18, 239–256.
Pridham, G., 1999. Towards sustainable tourism in the Mediterranean? Policy and practice in Italy, Spain and Greece. Environ. Polit. 8 (2), 97–116. https://doi.org/10.1080/09644019908414463.

Reddy, M.V., Wilkes, K., 2013. Tourism, Climate Change and Sustainability. Routledge, London [Kindle version].
Roberts, S., Tribe, J., 2008. Sustainability indicators for small tourism enterprises – an exploratory perspective. J. Sustain. Tour. 16 (5), 575–594.
Sæþórsdóttir, A.D., 2013. Managing popularity: changes in tourist attitudes in a wilderness destination. Tour. Manag. Perspect. 7, 47–58. https://doi.org/10.1016/j.tmp.2013.04.005.
Schaller, H., 2014. The Footprint of Tourism: Ecological Sensitivity and Hiking Trail Assessment at Selected Protected Areas in Iceland and Hokkaido. Icelandic Tourism Research Centre. Retrieved from: https://rafhladan.is/bitstream/handle/10802/9667/report-hiking-trails-harald-final-for-print.pdf?sequence=1.
Schott, C., 2010. Tourism and the Implications of Climate Change: Issues and Actions. Emerald Group Publishing Limited, London.
Sharp, H., Grundius, J., Heinonen, J., 2016. Carbon footprint of inbound tourism to Iceland: a consumption-based life-cycle assessment including direct and indirect emissions. Sustainability 8, 1147. https://doi.org/10.3390/su8111147.
Skarphéðinsson, K.H., Katrínardóttir, B., Guðmundsson, G.A., Auhage, S.N.V., 2016. Important bird areas in Iceland (in Icelandic). Fjölrit Náttúrufræðistofnunar 121–125. Nr. 55. 295 s. Retrieved from: http://utgafa.ni.is/fjolrit/Fjolrit_55.pdf.
Statistics Iceland, 2021a. Tourism Direct Gross Domestic Product. Accessed: January 2018 at: http://px.hagstofa.is/pxen/pxweb/en/Atvinnuvegir/Atvinnuvegir_ferdathjonusta_ferdaidnadur_ferdaidnadur/SAM08008.px/table/tableViewLayout1/?rxid=397e1430-de95-4998-b9e9-ccb9cf246984.
Statistics Iceland, 2021b. Number of Number of Hotels, Bedrooms and Bedplaces in Regions 2015–2019. Accessed at: https://px.hagstofa.is/pxen/pxweb/en/Atvinnuvegir/Atvinnuvegir_ferdathjonusta_gisting_1_hotelgistiheimili/SAM01202.px.
Statistics Iceland, 2021c. Rental Cars by Registration and Months 2010–2018. Accessed February 2018 at: http://px.hagstofa.is/pxen/pxweb/en/Atvinnuvegir/Atvinnuvegir_ferdathjonusta_ferdaidnadurhagvisar/SAM08049.px/?rxid=397e1430-de95-4998-b9e9-ccb9cf246984.
Statistics Iceland, 2021d. Consumption of Artificial Fertilizers. Accessed: March 2018 at: https://statice.is/statistics/business-sectors/agriculture/fertilzers/.
Statistics Iceland, 2021e. Iceland data for Sustainable Development Goal indicators. Accessed at: https://visar.hagstofa.is/heimsmarkmidin/.
Steger, U., 2000. Environmental Management Systems: empirical evidence and further perspectives. Eur. Manag. J. 18 (1), 23–37. https://doi.org/10.1016/S0263-2373(99)00066-3.
Sutherland, D., Stacey, J., 2017. Sustaining Nature-Based Tourism in Iceland. OECD Economics Department Working Papers, No. 1422. OECD Publishing, Paris. https://doi.org/10.1787/f28250d9-en.
Torres-Delgado, A., Saarinen, J., 2014. Using indicators to assess sustainable tourism development: a review. Tour. Geogr. 16 (1), 31–47. https://doi.org/10.1080/14616688.2013.867530.
UN [United Nations], 2015. Resolution A/C.2/70/L.5/Rev.1. Retrieved from: http://undocs.org/A/C.270/L.5/Rev.1.
UNFCCC [United Nations Framework Convention on Climate Change], 2016. Annual Compilation and Accounting Report for Annex B Parties Under the Kyoto Protocol for 2015. Retrieved from: http://unfccc.int/resource/docs/2015/cmp11/eng/06.pdf.
UNWTO, 2016. SDG Indicators for "Sustainable tourism": A UNWTO Contribution to the IAEG-SDG. Retrieved from: http://cf.cdn.unwto.org/sites/all/files/docpdf/unwtosdgtourismindicators02032016.pdf.
UNWTO, 2017. Tourism Indicators for Monitoring the SDGs. Retrieved from: http://cf.cdn.unwto.org/sites/all/files/pdf/laimer_conf2017manila_central_paper.pdf.
World Tourism Organization, United Nations Development Programme, 2017. Tourism and the Sustainable Development Goals – Journey to 2030, Highlights, UNWTO, Madrid. https://doi.org/10.18111/9789284419340.
Jones, K.R., Venter, O., Fuller, R.A., Allan, J.R., Maxwell, S.L., Negret, P.J., Watson, J.E.M., 2018. One-third of global protected land is under intense human pressure. Science 360 (6390), 788–791. https://doi.org/10.1126/science.aap9565.
Vera Rebollo, J.F., Ivars Baidal, J.A., 2003. Measuring sustainability in a mass tourist destination: pressures, perceptions and policy responses in Torrevieja, Spain. J. Sustain. Tour. 11 (2), 181–203.
Wasowicz, P., 2016. On-native species in the vascular flora of highlands and mountains of Iceland. PeerJ 4. https://doi.org/10.7717/peerj.1559.

Nína M. Saviolidis is a PhD candidate at the School of Business at the University of Iceland. Her research interests include sustainability indicators, pro-environmental behaviour, organizational change and environmental policy-making.

David Cook is a Post-Doctoral Researcher linked to the University of Iceland's interdisciplinary Environment and Natural Resources programme. His research interests include environmental sustainability and sustainable development indicators, ecosystem services valuation, and environmental policy-making.

Brynhildur Davíðsdóttir is a Professor within the Environment and Natural Resources graduate program, the Department of Economics, and the Department of Life-and Environmental Sciences. Her research interests include energy and climate modelling, sustainable energy development, and sustainability indicators.

Lára Jóhannsdóttir is a Professor within the Environment and Natural Resources graduate program, at the School of Business at the University of Iceland. Her research interests include corporate social responsibility, responsible investments, insurance, sustainable economic development in the Arctic and sustainability indicators.

Snjólfur Ólafsson is a Professor at the School of Business at the University of Iceland. His research interests include sustainability indicators, corporate social responsibility, strategy implementation and policy-making.