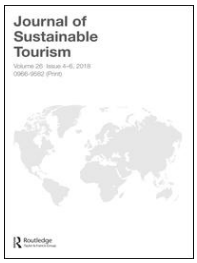
Article C

Toivonen, A. (2020). Sustainability dimensions in space tourism – the case of Finland. *Journal of Sustainable Tourism*, DOI: 10.1080/09669582.2020.1783276



Journal of Sustainable Tourism

ISSN: 0966-9582 (Print) 1747-7646 (Online) Journal homepage: https://www.tandfonline.com/loi/rsus20

Sustainability dimensions in space tourism: the case of Finland

Annette Toivonen

To cite this article: Annette Toivonen (2020): Sustainability dimensions in space tourism: the case of Finland, Journal of Sustainable Tourism, DOI: 10.1080/09669582.2020.1783276

To link to this article: https://doi.org/10.1080/09669582.2020.1783276

JOURNAL OF SUSTAINABLE TOURISM
https://doi.org/10.1080/09669582.2020.1783276

Sustainability dimensions in space tourism: the case of Finland

Annette Toivonen

Multidimensional Tourism Institute/University of Lapland, Finland

ABSTRACT

The current emergence of a new space economy is leading to the exploration of outer space towards unforeseen futures. Space tourism is a new addition to the tourism industry, prompted in large part by adventure-seeking individualism and potentially lucrative private business prospects. However, in light of the current megatrend of environmentalism, different space tourism activities are facing climate change-related challenges to convince the greater public of their necessity, especially as the high cost involved for suborbital space travel limits it to a niche adventure activity for the wealthy. This article explores the views held by the Finnish populace in relation to space tourism and sustainability through an empirical study. The data are derived from two surveys: the first gathering Finnish public opinion on space tourism's sustainability with the use of principal component analysis; the second utilising a professional Delphi panel for qualitative explanations. The findings, analysed using grounded theory, can be compressed into four dimensions – "virtual travel", "comparative fairness", "technological innovations" and "ecopolitics" – through which actions towards sustainability in space tourism might be enhanced in different national planning strategies.

ARTICLE HISTORY
Received 16 March 2020
Accepted 11 June 2020

KEYWORDS
Space tourism; new space economy; sustainable tourism development; virtual travel; Delphi method

Introduction

By their nature, humans are exploratory creatures; for some experienced tourists, the Earth may no longer be a sufficiently adventurous place (Cole, 2015; Harvey, 1989). Expanding tourism into outer space could even prove to be a hugely significant endeavour for humanity, as some astronauts have described viewing the Earth from space as a life-changing experience, enhancing people's respect for the Earth (Cohen & Spector, 2019). Space tourism is defined as "the temporary movement of people for non-military reasons beyond the Earth's atmosphere" (Duval & Hall, 2015, p. 450). It takes various forms, which can be broken down into: terrestrial space tourism such as Earth-based activities and cyberspace tourism; atmospheric and low Earth orbit tourism; astrotourism referring to experiences beyond the Earth's orbit such as lunar and Mars experiences (Cater, 2019; Carter et al., 2015). Space tourism could be promoted as a "next generation" luxury experience offering affluent travellers unique adventures that are difficult to replicate on Earth (Wittig et al., 2017). Indeed, there is currently an ongoing pioneering, status-related space race among several commercial space tourism companies such as Virgin Galactic, Blue Origin, and SpaceX. Furthermore, the National Aeronautics Space Administration (NASA) is opening the

CONTACT Annette Toivonen annette.toivonen@gmail.com Multidimensional Tourism Institute/University of Lapland, Yliopistonkatu 8, 96300 Rovaniemi, Finland.

International Space Station (ISS) to tourists in order to obtain more funding for other space exploration projects, accounting for its recent collaboration with Hollywood for the first movie to be filmed in space (Astronauts and National Space Administration [NASA], 2019a).

Following the release of the Intergovernmental Panel on Climate Change report (IPCC, 2018) addressing the future impacts of climate change, different nations across the world have been urged to adopt new sustainable actions. Relatedly, the development of commercial space tourism in a climate change-conscious world could be interpreted as contrary to new environmentally conscious tourism megatrends. There are obvious environmental concerns arising from the start of commercial space tourism, including greater emissions and other orbital detritus from launch vehicles (Duval & Hall, 2015; Peeters, 2017). For example, Ross et al. (2010) projected that 1,000 new suborbital launches using hybrid rocket engines will cause significant changes in the global atmospheric circulation and distributions of ozone and temperature. Nevertheless, research by Ross and Sheaffer (2014) concluded that there is a lack of understanding regarding the effects, with some calculations even indicating that rocket emissions and particles could cause a cooling of the Earth in the short term.

After NASA ceased its Space Shuttle programme in the 2010s, it began to cooperate with the private sector. New space companies are now rapidly developing new technology for space rocket reuse and satellite miniaturisation, enabling less costly access to space (Praaks, 2018). This has resulted in space becoming increasingly important both economically and politically for many formerly non-active countries, especially as the entire commercial space sector is projected to be worth $2.7 trillion by 2045 (Saigol, 2019). Indeed, "new space" activities, involving governmental and private sector collaborations, are currently dictated by for-profit businesses owned by powerful and enthusiastic entrepreneurs engaging in various commercial space activities (Spector & Higham, 2019b). There is a risk that in the future, the private sector will be primarily concerned with attaining its share of the benefits of space activities, possibly creating an issue around "free-riding" when it comes to environmentally sustainable activities, assuming that other actors (i.e. governments) will make sufficient effort to increase environmental safety and protection, from which they too can benefit, without shouldering any extra costs (Viikari, 2007).

Finland becomes a space nation in 2017 upon the launch of the Aalto 1 research satellite (originally scheduled to be launched on the SpaceX Falcon 9 rocket in 2015). Prompted by the satellite launch, the government of Finland issued its first national space law, entering into force on 23 January 2018 (Ministry of Economic Affairs & Employment in Finland, 2020). In line with the country promoting the global Agenda 2030 for Sustainable Development (Ministry of Foreign Affairs in Finland, 2020), the new space legislation encompassed a progressive, positive approach to environment and space sustainability by highlighting the importance of environmental issues both in outer space and on Earth (Tapio, 2018). For example, in accordance with the desired sustainability approach, Article 5 of the Space Act includes specific references to space debris mitigation, involving the disposal of satellites and possibilities for use on a second mission.

Despite Finland not having any operational spaceports, the country has for decades been involved in space technology research and has been a member of the European Space Agency since 1995. Today an increasing number of new space technology companies are being supported through Business Finland's NewSpace Economy Programme, for example in developing space weather services, artificial intelligence and space robotics (Space Finland, 2020). The government's sustainable focus to future space practices, as additionally highlighted in the hosting of the European Space Week in Helsinki in 2019, has also inspired the author to launch the first national university course on sustainable space tourism, with a futures framework tool used for planning sustainable tourism (Toivonen, 2017). Indeed, establishing sustainability-oriented space tourism education for students follows the general sustainable development emphasis of the government, such as the Ministry of Education's sustainable development strategy for higher education (2007) as well as Finland's tourism strategy for supporting sustainable growth development and foresight (Ministry of Economic Affairs & Employment in Finland, 2020).

Finnish Lapland has for years been an internationally renowned and popular tourism destination for witnessing the Aurora Borealis (Northern Lights), a type of terrestrial space tourism that allows tourists to explore the universe using the naked eye from the Earth, not necessitating physically leaving the planet (Visit Finland, 2020). Furthermore, during the 2010s, a Finnish start-up company pioneered the establishment of a virtual game environment for authentic astronaut training and adventure space travel experiences (Space Nation, 2020). Such activities already serve as good examples of sustainable practice in space tourism (Cater, 2019). As early as the 2000s, Virgin Galactic and Spaceport Sweden in Kiruna, located less than 200 km from the Finnish border, mutually discussed an option to start offering space tourism, promoting the option to witness the Northern Lights from the "inside" (Finnish News Agency, 2007); crucially, polar spaceports are efficient locations to reach orbit as all of the spacecraft's energy can be used for north–south velocity, while the 90-degree inclination provides more complex coverage of the Earth's surface (Anderson, 2005).

Should such suborbital space tourism cooperation be realised in the future, it is likely that it (as well as all its positive and negative impacts) will be based in an approximate location to Finland. Therefore, it is necessary to elicit Finnish people's perceptions of space tourism. The key question answered in this paper is: What sustainability aspects do Finns regard as most significant in relation to future space tourism? As Finland currently has neither tourism nor other governmental strategies for space tourism, by gaining the views of the populace, some sustainability dimensions for space tourism can be identified. These may assist in developing a future space tourism strategy for Finland and aid in governmental foresight and funding initiatives for the new space industry in the country.

Literature review

For decades, academic space research focused on space technology, whereas discourses of space tourism remained in science fiction-styled future forecasting. Fawkes (2007) was one of the first academics to link space tourism and sustainable development by defining different levels of sustainability in space tourism, including "operational" (infrastructural sustainability), "cultural" (increased awareness and education), "economic" (cost efficiency by reusing), "resource" (alternative resources to explore) and "survival" (saving the human species). The significance of outer space and sustainability was made highly visible to the public through Apollo 17's photograph of the Earth beyond the biosphere in 1972, this becoming a symbol of environmentalism, presenting the Earth as a fragile object significantly influenced by human actions (Spector et al., 2017).

Early space tourism research included Collins' (1994) pioneering analysis of space economics and reusable launch vehicles, Marsh's (2006) exploration of the ethical and medical dilemmas of space tourism and Viikari's (2007) emphasis on the environmental elements of space law. Collins and Autino (2010) connected the development of space tourism to reducing the danger of human extinction on Earth as a result of disaster, a view similarly emphasised by the cosmologist Steven Hawking (2010). Cole (2015) explored future prospects for space tourism planning, such as the limitations of tourism planning methods, while Duval and Hall (2015) analysed the policy implementations associated with the challenges faced when forming a new space tourism destination. Furthermore, Cohen (2017) investigated the paradoxes of space tourism; Peeters (2017) critiqued the concept of space tourism sustainability, including addressing various climate-related reasons why space tourism will not be part of sustainable tourism; and Toivonen (2017) introduced a sustainable future planning framework for space tourism to be used as a tool in future tourism research. In between 2017 and 2019, Spector et al. analysed conceptualisations of sustainability and anthropogenic relations to space tourism, highlighting outer space's

immense resources, with the potential to develop colonies that can help ensure humans' long-term survival.

Human activity such as motorised transportation has contributed to modern-day environmental changes in the current era of the Anthropocene (Moore, 2015; Spector & Higham, 2019; Young, 2019). However, the core concept of the tourism industry is paradoxically based on moving between places, naturally creating a major challenge from an environmental perspective (Peeters, 2017; Tervo-Kankare, 2017). During the past decades, sustainable tourism has been researched from various angles and, in the most critical approaches, demands have been made for the concept of sustainable tourism to be completely abandoned (Weaver, 2011). It has been noted that the concept of sustainable tourism is nearly impossible to implement as it essentially implies a form of tourism that does not emit any greenhouse gas emissions, yet the relationship between tourism and environmental change can be classified as a vicious circle (Patterson et al., 2006). Indeed, there have been environmental considerations with respect to the practice of sustainable tourism, especially in relation to aviation (as an important form of transportation for tourism purposes and representing an increased use of fossil fuels for energy consumption; Fletcher, 2008). Nevertheless, sustainability today means more than just the environment. As tourism is part of the capitalist system, there is little excuse for such luxurious enterprises to neglect the need for sustainable activity, even if the individual operator may not initially view the implementation of sustainable tourism as meaningful for their own activities (Saarinen, 2013; Wittig et al., 2017).

The anthropocentric slant in the space industry was previously related to the historical phenomenon of industrial development, as all human activities in outer space have been made possible by technological achievements (Viikari, 2007). However, contemporary films and video games alike have also utilised technological advancements, with various virtual reality gadgets enhancing people's familiarity with the concept of space (Ceuterick & Johnson, 2019). Virtual travel enables one to gain an experience of the outer space environment without leaving the Earth, thereby democratising participation, altering the practice of space tourism (Damjanov & Crouch, 2019) and allowing a person to access such a tourism experience from anywhere, including the home, rendering safety, security, financial and personal medical concerns practically nonexistent (Beck, 2016). After all, the travel experience is very personal in nature (indeed, it exists in the mind of the traveller) and involves a desire to design one's experience individually (Tung & Ritchie, 2011). However, virtual travel has also been criticised for depressing demand for real-life encounters, as tourists tend to seek physical engagements, filled with emotionally laden experiences and strong, novel sensations (Cooper et al., 2008; Räikkönen, 2017).

According to Mojic and Susic (2014), sensible sustainable planning should always be undertaken prior to any development of tourism activities. The global Agenda 2030 for Sustainable Development (United Nations, UN, 2015) includes 17 different sustainable development goals, with Finland's main goals including enhancing equality (Ministry of Foreign Affairs in Finland, 2020). The 1990 United Nations Environmental Program (UNEP) extended the sustainability concept used by the Brundtland Commission in *Our Common Future* (1987) to intra-generational and economic equity by stating that sustainable development requires the use of natural resources in a way that underpins ecological resilience and economic growth as well as helps achieve international equity (Birnie & Boyle, 1992). On the eve of the new space tourism industry, responsibility for the consequences of the growth of new space economy businesses and what this means for different societies on the planet must be considered carefully (Spector et al., 2017).

Space tourism may be considered the ultimate luxury tourism experience, as the current cost (250,000 United States dollars) of a "space jump" makes it affordable only for the elite (Cater, 2019; Webber, 2019). However the current aviation industry still resembles a similar division between travellers from the developed world and their counterparts from developing countries: approximately 80% of the world's population have never flown on an aeroplane (Anderson & Bows, 2011). This also instantly indicates that 20% are "higher emitters", responsible for

substantial anthropogenic emissions, raising another equality aspect of the environmental impacts caused by an affluent minority at the expense of the rest of the world (Ormond & Dickens, 2019; Spector et al., 2017). According to Cohen and Taylor (1992), daydreaming and space tourism represent forms of escape in which people either participate non-physically or actually escape from social monotony and from themselves. However, for the foreseeable future, physical escapism is only likely to be adopted by those already in the most powerful economic, social, cultural and political positions, enhancing issues related to responsibilities and fairness (Höckert, 2015; Ormond & Dickens, 2019).

Space tourism represents an idealised experiment for future international and domestic policy implementation, as it helps determine whether private and public valuations of an environment can coexist (Webber, 2013). Collaborations between governments and the private sector have previously tended to be economy-based, with environmental issues regarded as somewhat voluntary (Duval & Hall, 2015). The opening up of space for activities such as space tourism instead of just political and military purposes (as in the past) has necessitated the specification of new types of legal regulations not covered by the Outer Space Treaty (1967). Indeed, beyond this, space is equivalent to the historic "Wild West", characterised by a "first come first served" attitude and approach to rights and actions (Cofield, 2017; Vereshchetin et al., 1987; Viikari, 2007; Von der Dunk & Tronchetti, 2015). At present, global discussions are underway concerning which laws and regulations should apply to private suborbital space flight and space tourism and which should be further developed to fit the future variety of space flights in any existing category, either within space activities and space law or within aviation and air law (Von der Dunk, 2019).

Methods

To ascertain the views of the Finnish population towards space tourism, this article's data were collected using methodological triangulation, involving more than one method to gather data and increase the credibility and the validity of the empirical research (Altrichter, Feldman, Posch, & Somekh, 2008; Denzin, 2006). The data were derived from two surveys, the first gathering knowledge about the public's views regarding space tourism using principal component analysis, the second targeted at professionals related to space tourism who could provide new insights and enrich the data with qualitative explanations.

The quantitative data were collected using the Webropol online survey tool. The survey was operated by providing a web link to people willing to participate. The link was available in libraries and university campuses in the Uusimaa region in order to reach respondents representing different demographic groups. Data collection took place between February and March 2019. The survey sample consisted of 132 respondents, who were 18–75 years old and living in urban Southern Finland. There were, however, limitations in the data collection process, as many people over 50 years old considered the topic too imaginary. Indeed, it should be admitted that the space tourism industry is not yet active or publicly recognised, resulting in poor participation among that age group.

The respondents were asked to share their views on space tourism by endorsing (or not) 29 statements on a Likert scale from 1 ("strongly disagree") to 5 ("strongly agree"). The questions related to the environment and to space tourism, highlighting current concerns and actions in climate change presented in the Finnish media, with one open-ended question on sustainable space tourism. The quantitative data were analysed using principle component analysis to compress the information of the original variables (Hair et al., 1998) to gain a better understanding of the results. Kaiser-Meyer-Olkin (KMO) and Bartlett's test for sphericity (Child, 2006) was first used to test the components, generally indicating the proportion of variance in the variables that might be caused by underlying components; moreover, direct oblimin rotation was used to

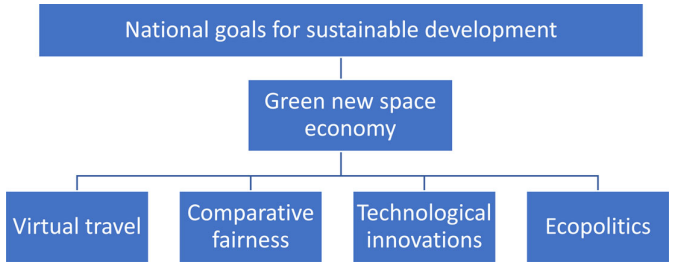


Figure 1. Sustainable new space model for Finland.

allow the components to be dependent on each other. The analysis yielded five components: *ethical*, *environmental*, *technical*, *political* and *social*. These themes were adapted from the social, technological, economical, environmental and political (STEEP) futures model of tourism (Nordin, 2005). With the use of reliability analysis, Cronbach's alpha was calculated for each component; all the alphas were over 0.6, indicating that the content of the components was sufficiently informative. The sum variables were calculated as the mean values of the variables belonging to the components (Hair et al., 1998).

The qualitative data were collected in April 2019 using an argument Delphi survey, a method that aims to develop relevant arguments and expose underlying reasons for different opinions on a specific issue (Hasson & Keeney, 2011; Kuusi, 2017). Ten Finnish professionals were invited to participate on the panel, these figures being identified as professionals on the basis of their context-related appearances in the media or their backgrounds as governmental executives and academics in sustainable tourism and future research, space legislation, meteorology and space technology; one participant was employed at a space tourism company. The two Delphi rounds were modified innovatively, as in the first round, the quantitative estimates were sought from the Webpropol survey, whereas in the second, the component-based results were presented to the professional panel to allow them to make judgments and arguments based on the first round estimates.

The members of the panel were presented with future claims involving quantitative findings on the environmental, social, ethical, political and technological prospects of space tourism; for example, the environmental claim consisted of concerns regarding the amount of emissions caused, hence claiming that space tourism would be abandoned by 2040. Before commenting on each question, the panellists were asked to determine the probability and the desirability of the future claims, similarly to those on a Likert scale (i.e. from "least likely" to "most likely") and their responses were placed on median and quartiles. The future claims were: 1) space tourism will be completely abandoned by 2040; 2) by 2040, space tourism will have enabled humankind to establish new colonies in space; 3) space tourism is only an activity for the elite up to the year 2040; 4) the future law of space tourism will emphasise in particular sustainable development extending to 2040; and 5) virtual travel represents the most likely means of visiting space by the year 2040. The year 2040 was selected as a reasonable point in the future, being regarded as sufficiently soon for contemporary events to be forecast but not so long that forecasting would become utopic. The panellists were grouped into three categories with the assistance of the Delphi analysis programme – a *tourism* group, a *future* group and a *space technology* group – to clarify the background context for the presented in-depth citations. All the panellists were able to respond to each other's comments, which nevertheless remained anonymous.

Using the method of grounded theory (Glaser & Strauss, 1967), the data was first sorted conceptually. This was followed by selective coding to identify linkages between the in-depth responses for the future claims (for example, to identify similar sustainability themes in relation to space tourism). Finally, the responses were grouped into categories to create sustainable dimensions for space tourism, visually modelled in Figure 1 and termed a "sustainable new space

model". The sustainability dimensions of space tourism emerging from the qualitative data were conceptually termed "virtual travel", "comparative fairness", "technological innovations" and "ecopolitics". A sub-category termed "green new space economy" emerged from both the qualitative and quantitative data, combining environmental and economy aspects. A main core category, termed "national goals for sustainable development", was formed based on the concepts developed from the initial analysis.

Results

Principal component analysis

Through analysing the quantitative data, nine components were derived, although the last four were not contextually relevant (Hair et al., 1998). The number of components was thus set as five and named *environmental*, *social*, *ethical*, *political* and *technological*. The findings supported similar themes in the STEEP future model of tourism (Nordin, 2005), which consists of social, technological, economic, environmental and political prospects and assists in comprehending the environment within which tourism operates. The STEEP model's "economic" component was replaced by "ethics" to better reflect the context of the findings as the sub-category of "green new space economy" already combined the economy aspects having an impact on all dimensions.

The strength of Cronbach's alpha was determined for each component; the highest loadings for the first component with the highest alpha (.836) was named *environmental* and consisted of variables like "my values are similar to the principles of sustainable development" (.737) and "I regard recycling as important" (.718). The findings indicated positive individual values attached to sustainability and the practice of environmental actions, although the practice of environmentalism was also considered challenging: indeed, "I feel it is hard work to act in an environmentally conscious fashion" (.-329) resulted in a negative component (Table 1).

The highest loadings for the second component (.807), *social*, consisted of variables like "Finland should aim to be a space tourism nation" (.808) and "Finland should invest in people and resources with technological expertise in space travel" (.752), indicating a popular perception in Finland that the country should become more deeply involved in future space tourism and space technology development. However, concerns were presented regarding the public funding of space activities: "the development money used for space tourism should preferably be used to solve the problems of humankind" (-.458), especially if it means increasing space debris ("humankind has no right to litter in the space environment"; −.364). The respondents were quite supportive of the emergence of the space tourism industry, being "willing to experience it if economically possible" (.707) and accepted the future vision of space colonisation: "space tourism ensures the creation of new living places in space if the Earth becomes non-viable" (.658).

The highest loadings for the third component (.746), *political*, consisted of variables such as "businesses should take responsibility for helping reduce climate change" (.781) and "politicians should take responsibility for helping reduce climate change" (.650). These findings highlight the importance that companies create their own sustainable operational strategies, as consumers ultimately expect them to carry the final responsibility for the climate, indicating that further political regulations should concentrate on businesses rather than on penalising individuals and that space tourism companies, similar to the current aviation industry, should participate in compensation schemes on behalf of their customers.

The highest loadings for the fourth component (.706), *ethical*, consisted of variables such as "I am worried about the impact of emissions caused by space tourism" (.559) and "space tourism will increase inequality between people" (.478). These findings highlight the global equality discourse of the rich versus the poor as well as the consequences of individual elites' actions for the rest of the world. The emphasis placed on "sustainable development in space law creation"

Table 1. Loadings of the components in the public survey on space tourism.

	Component				
	Environmental	Social	Ethical	Political	Technological
I am concerned about global warming	.432				
I am concerned about my own ecological footprint	.535				
I feel I can influence the slowing down of climate change by my own choices			.315		
Businesses should take responsibility for helping reduce climate change				.781	
Politicians should take responsibility for helping reduce climate change				.650	
Consumers should take responsibility for helping reduce climate change				.552	
I feel that nature conservation is important	.521				
Preventing the loss of nature caused by tourism is important	.560				
I am worried about the negative impacts of tourism on the environment	.519				
In my daily life I emphasise sustainable choices	.628				
I regard recycling as important	.718				
Sustainable development should primarily be promoted through legislation	.310				
My own values are similar to the principles of sustainable development	.737				
I feel it is hard work to act in an environmentally conscious fashion	-.329				
I think the sharing economy (like Airbnb and Uber) is a good thing					.493
It is important to change the way tourists operate in a more environmentally friendly way	.430				
I would like to know more about the sustainability of the tourist services offered				.446	
The nature of a tourist area should be kept as original and natural as possible				.548	
I think it would be good to start space tourism in the next few years		.697			
I find the idea of space tourism interesting		.643			
I would like to go on a space trip if it were economically possible for me		.707			
I would like to go on a space trip only if it does not pollute the environment			.436		
I would like to try out space tourism in the future but I do not feel it is safe					.340
I would like to take part in a non-physical space trip					.451
Space tourism will increase inequality between people			.478		
The developmental money used for space tourism should preferably be used to solve the problems of humankind		-.458			
Space-based technology also produces new inventions to be used on the Earth		.353			
Space tourism ensures the creation of new living places in space if the Earth becomes non-viable		.658			
I am worried about the impacts of emissions caused by space tourism			.559		
Humankind has no right to litter in the space environment		-.364			
Space tourism should be regulated by international agreements					
The law of space travel should emphasise in particular sustainable development			.440		

(*continued*)

Table 1. Continued.

	Component				
	Environmental	Social	Ethical	Political	Technological
I believe that space travel will be a normal travel option in the future		.645			
Finland should invest in people and resources with technological expertise in space travel		.752			
Finland should aim to be a space tourism nation		.808			
Finland should play an internationally active role in promoting sustainable development in legislation related to space tourism		.393			
% of variance	21.7	11.6	4.1	3.2	2.7
Cronbach's alpha	.836	.807	.706	.746	.520

(.440) implies that sustainable development has become part of society's values and needs to be included in the planning of future operations. The highest loadings for the fifth component (.520), named *technological*, consisted of variables such as "I think the sharing economy is a good thing" (.493) and "I would like to take part in a space trip other than physically" (.451). People's general familiarisation with and acceptance of the usage of virtual sharing platforms implies that such technologies could be utilised in space tourism, for instance, companies could provide social media tools for space tourists to share their photos from space. There was also general acceptance of forms of space travel beyond physical activity, implying interest in virtual space tourism experiences.

For the optional open question, which received 71 responses ("What kind of space tourism is sustainable?"), over half of the respondents under 30 years of age leaned towards advancing reusable space technology and minimising new space debris. Some of the respondents also questioned why people should enter space in the first place, as the most likely result will be the destruction of its environment. Such answers reflected the younger generation's anxiety about climate change and fears for the future of the Earth. One third of those aged 30 to 40 years old expressed ethical concerns about starting space tourism under the current climate crisis. Some suggested that space travel (specifically its emissions) could only be justified if it takes places for longer than mere space jumps. Two thirds of those aged 41 to 50 years of age pointed out alternative fuels and virtual travel experiences. Concerns about emissions and impacts on the environment were also highlighted within this age group. Some solutions were suggested to justify space travel, such as spreading cultural awareness to larger audiences. The majority over 50 years old leaned towards creating global sustainable space legislative frameworks and, similarly to the 41–50 group, emphasised educating people to understand planet Earth's fragility within the universe. It was generally emphasised within all age groups that the nature of space tourism should be exploratory and research-based, rather than for mere personal amusement, in order to qualify as environmentally acceptable (Table 2).

Argument delphi

The professional Delhi panel's future claims reflected the themes of the quantitative findings, first rating the desirability and the profitability of the claims akin to a Likert scale. The environmental claim reflected the concerns of the impact of climate change and suggested that space tourism will be completely abandoned by 2040. Most panellists agreed that sustainable space tourism is desirable; they also agreed that the probability of it occurring soon is quite low. The social claim reflected changes in Western society, also considering the impact of climate change on habitable areas (stating that by 2040 space tourism will have enabled humankind to establish new colonies in space). The panellists neither agreed nor disagreed on both the desirability and the probability

Table 2. What kind of space tourism is sustainable?.

Under 30 years old (n = 55)
'Minimising space debris is paramount. The durability and reuse of used equipment must also be a priority. Significant resources must be invested in the selection and development of potential propulsion' (Male, Bachelor's Degree, Employee)
30-40 years old (n=28)
'In my opinion, as long as humankind is mentally so low, we have no reason to go into space. This planet must first be balanced and humanity must become much wiser before space travel makes any sense' (Male, Master's Degree, Unemployed)
41–50 years old (n = 36)
'No fossil fuels, virtual travelling from the couch at home' (Male, Master's Degree, Professional)
Over 50 years old (n = 13)
'Organised by international communities following the mutually agreed legislative framework and regulations' (Male, Master's Degree, Manager)

of the social claim of the development of space colonies, as some considered them highly likely while others were more sceptical.

The desirability and the profitability of the ethical claim of equality were both strongly endorsed; however, in more extensive comments it was noted that some people always desire to willingly pay and practise extreme adventure-oriented travel, hence this claim could not be directly linked to inequality among people. For the political claim, the panellists strongly agreed on both the desirability and the probability of global sustainably oriented space law to emerge, to guide both the commercial sector and national operators in future space-related activities. However, in-depth comments on the timescale speculation of such globally binding laws taking place caused major variations. For the technological claim, the majority of the panellists agreed that the desirability of virtual reality space travel was high; however, the probability of it occurring yielded varied responses. The in-depth comments also presented some doubts as to whether a virtual space experience would even prove satisfactory to all travellers, especially given that existing technological products remain limited.

The analysis of the qualitative data saw the emergence of four dimensions of space tourism sustainability. First, the sustainability dimension, *virtual travel*, was formed of a completely mutual panellist view of such an activity presenting a sustainable way of experiencing space tourism. A space technology group panellist suggested that different types of terrestrial space tourism, enhanced by elements of virtual reality, could be utilised to a greater extent to attract tourists without needing to use the actual space environment:

> I wish especially Lapland would utilise stargazing and virtual space travel opportunities more and not only promote the Northern Lights. Finland has great potential for such a development, as a large number of people already want to watch the sky in Lapland.

However, some doubts were also presented: will tourists be willing to simply opt for a virtual experience, especially if they can economically afford a space trip, for just the sake of being a "sustainable tourist":

> I doubt anybody set on doing an actual space journey and having the means to do it would be satisfied with the virtual experience alone. People are unfortunately too egoistic to just keep that experience as their single option: it is relatively well known how polluting current-day air travel is, and still journeys are sold, and people fly for leisure purposes.

The tourism group panellist quoted above enhanced the current travel behaviourism. Despite the well-acknowledged environmental impacts of the tourism industry and the fact that only a small percentage of the world's population are actually able to fly for a vacation, travelling for leisure purposes has not stopped. On the contrary, travelling is increasing as people from less developed countries have become more active due to increased levels of income. It is thus plausible that space tourism will follow a similar pattern in the future.

A future group panellist suggested educational virtual options in order to offer future generations a greater sense of connection to the universe without needing to travel to space: "I do not

see virtual travel to space to be a new form of travelling, but instead it provides a new method to learn or become a new encyclopaedia". A space technology group panellist considered virtual travel as a good option for "those with medical issues, as the health risks associated with space travel are quite high, or those who cannot afford the ticket", highlighting the importance of creating space tourism experiences for various different groups in society than just the wealthy elite.

The second sustainability dimension, *comparative fairness*, was formed of the concerns addressed regarding the world's equality issues. For example, the panellists considered how ethical it is to launch a niche luxury tourism activity for the pleasure of just a few, "despite the rest of the world suffering from the environmental impacts caused" (Future group panellist). A panellist from the tourism group pointed out that "there are always people who can afford while others cannot" and that "it is difficult to use the word "inequality" in the context of a luxury service", as space tourism will become part of an already existing luxury tourism market, which due to the high costs involved already has a limited clientele. For example, to be permitted to climb Mount Everest, the cost is over tens of thousands of dollars.

> It might be possible for an international body to ban space travel altogether, but I don't think so. Instead, I would hope that more sustainable forms of space travel could be produced and tested, moving away from space travel as a hobby for a small elite. This could also provide climate compensation for space travel, which could try to repair an uncomfortable conscience.

The future group panellist quoted above addressed the need for some sort of compensation for the individual consequences caused by one's travel choices and by doing so setting an example for others to follow to create more sustainable ways of practising space tourism in the future. The third sustainability dimension, *technological innovations*, was formed of the concerns gathered pertaining to climate change, the future of the Earth and humans as a species. Future space technology innovations, such as artificial intelligence and robotics, could provide solutions to exclude the presence of human beings in the first stage of space colony formation as well as help protect the Earth's atmosphere and environment.

> We have one Earth, with tremendous opportunities, but we are gradually eroding this away in our pursuit of the next big thing, the next growth, the next something … whilst simultaneously making the Earth that exists in front of our eyes less and less liveable.

The future group panellist quoted above addressed the concern over the impacts of climate change making the Earth's regions less liveable. The space environment was considered as a possible solution for solving the Earth's environmental problems by colonising and harnessing the resources it offers. The formation of space colonies was viewed as the future developmental path of humans, as expressed in a quotation from a tourism group panellist:

> As social human beings, there will soon be a push towards having companionship in space and being the first human to establish a colony is very attractive to people who can afford it. Getting a colony there would be a major scientific advancement and it is possible that after facing a tremendous catastrophe, it might be the only way to save humankind.

Nevertheless, some fears were expressed that such human colony formations would lead to other problematic issues: "sustainable development is important of course, but at least equally important is making sure that conquering space does not lead to a war between humans and nations" (space technology group panellist), a concern recently enhanced by the formation of the United States Space Force. The fourth sustainability dimension, *ecopolitics*, was formed by gathering mutual concerns over the current lack of space legislation, especially as the only existing space regulation, the Outer Space Treaty, was established over fifty years ago (1967) and fails to reflect the current new space economy and the environmental debris caused by increased activity in space, as expressed in a quotation from a future group panellist:

.Space law is firstly needed to guarantee the constancy of the satellites, which have also produced enormous amounts of space litter, complicating future actions in space. Asteroid mining laws should also be set before regulating actual space tourism.

Additional concerns included whether it would even be possible to build consensus in world politics regarding space, as "current global politics make me doubt the ability of world leaders to agree on common rules for just about anything, and in that perspective, I am afraid that no big breakthroughs will have happened before 2040 in space law" (space technology group panellist). Nevertheless, concerns regarding the growing impacts of climate change were believed to represent a potential catalyst for future agreements, as stated by a future group panellist: "the sustainability issues of the Earth will be above everything by the year 2040, making it absolutely certain for the space tourism industry to be regulated as well under the set sustainable targets".

Discussion

The tourism industry has the potential to contribute either directly or indirectly to different sustainable development goals, as defined in the global 2030 Agenda for Sustainable Development (UN, 2015). The emergence of a new space economy in Finland has brought new opportunities to promote sustainable economic growth (Goal 8), with the support of national strategies and initiatives in favour of sustainable approaches in space legislation, education and tourism (Ministry of Economic Affairs & Employment in Finland, 2020). Space tourism represents part of this new space economy in Finland, as the nation already has terrestrial space tourists, private businesses contributing to space tourism operations as well as higher education for space tourism. However, space tourism has yet to be included within existing national strategies. Based on the empirical findings, four sustainability dimensions can be identified: "virtual travel", "comparative fairness", "technological innovations" and "ecopolitics". All four dimensions are directly linked to a sub-category termed the "green new space economy", comprising the environmental and economic aspects involved in "new space" in Finland, which as a new industry aims to benefit the Finnish economy of the future (Space Finland, 2020). This will prove especially important given the economic growth decline in "traditional" industries caused by the global COVID-19 pandemic.

The findings presented here highlighted the importance of environmental sustainability as the basis of Finnish public support for new space activities, as environmental and climate change concerns were combined with social, ethical, political and technological prospects. Such considerations were also in line, for example, with scientific calculations regarding environmental rocket impacts, as just 1,000 space tourism-related launches might, in a worst-case scenario, produce a global temperature increase of up to 1 °C (Ross et al., 2010). The predicted environmental impacts additionally stimulated questions regarding social fairness, with Peeters (2018) claiming that 1,000 launches per year represents a tiny number for the impacts caused, placing considerable responsibility on those few people benefiting from the launches. Space vehicles will travel through the atmosphere, where the discharge from the rocket motors will damage the ozone layer and diminish the Earth's protection against ultraviolet radiation (Viikari, 2007). Due to the increased activity of new space companies, there will also be more space debris from satellites, posing safety risks to space tourism operations. The findings suggested that emphasis on environmental space regulations is highly desirable, but it was also recognised that despite the environmental impacts of the current aviation industry (Fletcher, 2008), people still choose to fly and, if made economically available to the broad populace, space tourism is not likely to significantly differ from such travel behaviour.

Despite the high cost, the findings revealed that touristic space travel itself created curiosity. Even though competition in the space tourism industry is forecast to reduce the cost of space tourism flights (Ashford, 2009), space tourism is likely to remain an elite activity for the

foreseeable future (Ormond & Dickens, 2019). In the meantime, virtual reality technology could bring a realistic space tourism experience at an affordable price and thus democratise participation in the practices of space tourism (Damjanov & Crouch, 2019). Virtual space tourism was widely regarded as a sustainable choice, as people may not need to even travel from their couch and the travel experience could be enhanced using multi-sensorial technological gadgets. The findings revealed that virtual space education, especially for the younger generation, was supported by respondents as a means of fostering people's sense of protectiveness towards the Earth. Here, experiencing moments of awe were said to inspire people to support the cause of sustainability (Rudd, Vohls, & Aaker 2012). Not everyone, however, would be satisfied with virtuality alone, as such an experience is not equal to physical activity (Cooper et al., 2008) Räikkönen, 2017;. Nonetheless, the findings also indicated some positive reflections regarding non-physical travel experiences, especially timely with the COVID-19 pandemic transforming different virtual forms into a potential new normal (Ateljevic, 2020).

There were various considerations of the social fairness of space tourism: while in the pioneering phase activity will be focused on elites, growing environmental impacts will eventually affect the mutually shared atmosphere (Duval & Hall, 2015; Peeters, 2017). There was a desire for space tourism companies as well as wealthy travellers to assume the responsibility for the environmental impacts caused by the industry, such as by financially compensating for emissions, with funds possibly applied to improving other sustainability-oriented schemes on the Earth, thereby preventing a form of climate apartheid from occurring (Alston, 2019). Such consumers' conscious participation or neglect in influencing ethical standards for the commercialisation of space could shape the character of the commercial space industry in the long term (Marsh, 2006). Nevertheless, the findings revealed subservience towards the entire existence of the luxury tourism market, as inequality is already present in many travel options and linked to onés individual circumstances (Höckert, 2015), rendering space tourism another subtheme to an already existing rich versus poor equality discourse.

The findings highlighted the realisation that humans are "social creatures" in need of companionship, hence there may be a further need for future technological innovations to support the establishment of space colonies. The formation of such communities was also viewed as the ultimate form of insurance to save humans from becoming extinct if planetary-scale disasters serve as the ultimate impacts of climate change (Collins & Autino, 2010; Fawkes, 2007; Spector et al., 2017). The findings also related to current global technological innovations in robotization and artificial intelligence that exclude the presence of human beings, enabling China to experiment with potato-growing on the Moon's surface and the United States to plan to utilize the Moon as a hub base on the way to Mars (hinting that there could be a permanent colony on the Moon even before the year 2040 (NASA, 2019b).

The findings suggested that governmental involvement in and regulation of space tourism is highly desirable to support current climate change-related equality concerns, especially as space tourism implies detrimental impacts on the Earth's atmosphere (Duval & Hall, 2015; Viikari, 2007). To ensure that space will not be commercialised for the powerful and the rich to the exclusion of others (Cole, 2015; Marsh, 2006), the findings indicated there must be actions taken by the governments to control and regulate businesses operating in space. Indeed, as a "no man"s' land, space is similar to older forms of colonisation of remote areas such as the South Pole, first being subject to human values of treatment and handling (Von der Dunk & Tronchetti, 2015). Nevertheless, quite recently better defined national-level space legislation has been established, with space tourism-related regulations introduced in NASA's Authorisation Act (US Congress, 2019) to support the developing commercial space sector in the United States as well as in the United Kingdom's Space Industry Act (Government UK, 2018) to regulate space activities, specifying strict environmental and safety assessments for spaceports (Hutton, 2019; Von der Dunk, 2019). Finland's Space Act (2018) also contains provisions for environmental protection and space debris for the space industry (Ministry of Economic Affairs & Employment in Finland, 2020).

Based on the sustainable new space model, national sustainable goals for space tourism in Finland could involve enhancing the watching of the Northern Lights by introducing other space-related, virtual and multi-sensory experiences and emphasising governmental funding for sustainably focused space technology developments, exemplified by the Finnish invention of the electric solar wind sail (Janhunen, 2004), which collects space debris and hence increases safety for space tourists, too. Despite suborbital space tourism starting as an elite activity, there are visions of space tourism serving as a stepping stone to space colony transportation, even resulting in future generations working and living in space. As Finland is committed to national social equality in education, teaching about space technology and space tourism could be expanded to prepare students for future space tourism-related employment opportunities. As Finland's space legislation involves environmental sustainability in space activities (Ministry of Economic Affairs & Employment in Finland, 2020), a climate change-focused approach should also be promoted for future global space legislation, with Finnish representatives highlighting (for example) obligatory regulations like compulsory compensation schemes for emissions and space debris for an entirely new space industry.

Conclusion

Commercial space tourism, enhanced by new technological innovations and individually oriented adventure seeking, will start operating soon. However, the timing collides with the growing megatrend for intense environmental actions (in the form of tightened policy initiatives forestalling the impacts of climate change and presumed change in tourists' travel behaviour), enhanced by the IPCC (2018) report, with significant negative implications for all future tourism. This paper has sought to ascertain the sustainability aspects that Finns consider as substantial in relation to future space tourism. By conducting a principal component analysis via public survey, the quantitative data produced five components, termed environmental, social, ethical, political and technological. Combining the components with empirical findings from a professional Delphi panel to deepen the analysis with in-depth explanations, four sustainability dimensions were identified: "virtual travel", "comparative fairness", "technological innovations" and "ecopolitics". All four dimensions were directly linked to a sub-category termed "green new space economy" and to the main category termed "national goals for sustainable development".

The findings indicated that the significant influences on space tourism's sustainability include issues related to environmentally focused technology (such as enhancing the multi-sensorial virtual space experience) and tightened national initiatives prompted by global climate change regulations. Ethical concerns were raised in connection with further developments in space tourism, such as growing rich versus poor inequalities, responsibility for compensation and fairness in determining ownership of the space environment (especially relevant with the discourse of space colonisation, hypothetically in the future providing a base for mining minerals to preserve the Earth's natural resources) and ultimately saving the human race in the case of a global catastrophe.

The data collection was limited to the Finnish way of understanding sustainability issues and concerns related to space tourism. However, the findings supported Finland's new space strategy of enhancing research for sustainable space technology, the innovations potentially benefiting the entire space tourism sector and global cooperation advocating future sustainability-focused space regulations. The findings also suggested that already existing terrestrial space tourism, such as witnessing the Northern Lights, could be enhanced with virtual technology. The findings were congruent with previous academic research findings in space tourism, whilst noting that there is still a need for more in-depth future scenario analysis, given that academic research on sustainable space tourism in particular remains very limited. More research is required, for example, to create a better understanding of the future environmental impacts of space tourism

as well as to more thoroughly investigate aspects related to future equality, especially among Western travellers. The sustainable new space model could assist in sustainable space tourism research as well as new space economy activities in other countries to enhance sustainable actions and strategy formation at the global scale.

Acknowledgements

The data that support the findings of this study are available from the corresponding author, AT, upon reasonable request.

Disclosure statement

No potential conflict of interest is reported by the author.

Notes on contributor

Annette Toivonen is a space tourism lecturer at Haaga-Helia University of Applied Sciences, Finland. She is currently finalising her world pioneering PhD thesis in sustainable space tourism at the University of Lapland, Finland. She has also gained both a BA Hons (University of Westminster, UK) and MSc (University of Lapland, Finland) in Tourism Research, holds a teacher's pedagogical qualification and an Extractive Arctic Industries Certificate (The Arctic University of Norway). She will be publishing her own book, *Sustainable Space Tourism – An Introduction* (Channel View Publications) in the United Kingdom in November 2020 and is also one of the co-authors in "Science Fiction, Disruption and Tourism" book to be published in the United Kingdom. Her research interests include space tourism, sustainability, futurology, arctic tourism and service design.

ORCID

Annette Toivonen http://orcid.org/0000-0003-3499-7577

References

Alston, P. (2019). *Climate change and poverty*. UN Human Rights Council. Retrieved from ttps://www.ohchr.org/Documents/Issues/Poverty/A_HRC_41_39.pdf

Altrichter, H., Feldman, A., Posch, P., & Somekh, B. (2008). *Teachers investigate their work: An introduction to action research across the professions.* (2nd ed.). Routledge.

Anderson, E. (2005). *Space tourist's handbook*. Quirk Books.

Anderson, K. L., & Bows, A. (2011). Beyond 'dangerous' climate change: emission scenarios for a new world. *Philosophical Transactions. Series A, Mathematical, Physical, and Engineering Sciences*, *369*(1934), 20–44. https://doi.org/10.1098/rsta.2010.0290

Ashford, D. (2009). An aviation approach to space transportation. *The Aeronautical Journal*, *113*(1146), 499–515. https://doi.org/10.1017/S000192400000316X

Ateljevic, I. (2020). Transforming the (tourism) world for good and (re)generating the potential "new normal. *Tourism Geographies*, 1–9. https://doi.org/10.1080/14616688.2020.1759134

Beck, J. (2016). *Space travel with VR*. Retrieved from http://www.virtual-reality-in-tourism.com/space-travel-with-vr/

Birnie, P. W., & Boyle, A. E. (1992). *International law and the environment*. Clarendon Press.

Carter, C., Garrod, B., & Low, T. (2015). *The encyclopaedia of sustainable tourism*. CAB International.

Cater, C. (2019). History of space tourism. In. E. Cohen & S. Spector (Eds.). *Space tourism: The elusive dream. Tourism Social Science Series*. (Vol. 25, pp. 51–66). Emerald Publishing Limited.

Ceuterick, M., & Johnson, M. (2019). Space tourism in contemporary cinema and video games. In E. Cohen & S. Spector (Eds.). *Space tourism: The elusive dream. Tourism Social Science Series.* (Vol. 25, pp. 93–115). Emerald Publishing Limited.

Child, D. (2006). *The essentials of factor analysis*. (3rd ed.). Continuum International.

Cofield, C. (2017). *President Trump signs NASA authorisation bill*. 21 March 2017. Retrieved from https://www.space.com/36154-president-trump-signs-nasa-authorization-bill.html

Cohen, E. (2017). The paradoxes of space tourism. *Tourism Recreation Research*, *42*(1), 22–31. https://doi.org/10.1080/02508281.2016.1239331

Cohen, E., & Spector, S. (2019). *Space tourism: The elusive dream*. Emerald Publishing Limited.
Cohen, S., & Taylor, L. (1992). *Escape attempts: The theory and practice of resistance to everyday life*. Routledge.
Cole, S. (2015). Space tourism: Prospects, positioning and planning. *Journal of Tourism Futures*, *1*(2), 131–140. https://doi.org/10.1108/JTF-12-2014-0014
Collins, P. (1994). Potential demand for passenger travel to orbit: Construction engineering and operations in space IV. *ASCHE*, *1*, 578–586.
Collins, P., & Autino, A. (2010). What the growth of a space tourism industry could contribute to employment, economic, growth, environmental protection, education, culture and world peace. *Acta Astronautica*, *66*(11/12), 1553–1562. https://doi.org/10.1016/j.actaastro.2009.09.012
Cooper, C., Fletcher, J., Fyall, A., Gilbert, D., & Wanhill, S. (2008). *Tourism: Principles and practice*. (4th ed.). Pearson Education Limited.
Damjanov, K., & Crouch, D. (2019). Virtual reality and space tourism. In. E. Cohen & S. Spector (Eds.). *Space tourism: The elusive dream. Tourism Social Science Series*. (Vol. 25, pp. 117–137). Emerald Publishing Limited.
Denzin, N. (2006). *Sociological methods: A Sourcebook*. (5th ed.). Aldine Transaction.
Duval, D. T., & Hall, C. M. (2015). Sustainable space tourism. New destinations, new challenges. In C.M. Hall, S. Gössling, & D. Scott. (Eds.). *The Routledge handbook of tourism and sustainability*. (pp. 450–459). Routledge.
European Space Week (2019). *European space week*. Retrieved from https://euspaceweek.eu/
Fawkes, S. (2007). Space tourism and sustainable development. *Journal of the British Interplanetary Society*, *60*(11), 401–408.
Finnish News Agency (2007). *Kiirunasta turistilennolle avaruuteen (Space travel from Kiruna)*. Retrieved from https://www.ts.fi/uutiset/maailma/ https://doi.org/1074176438/Kiirunasta+turistilennolle+avaruuteen
Fletcher, J. (2008). Sustainable tourism. In C. Cooper, J. Fletcher, A. Fyall, D. Gilbert & S. Wanhill (Eds.). *Tourism: Principles and Practice*. (4th ed., pp. 214–244). Pearson Education Limited.
Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Aldine de Gruyter.
Government UK. (2018). *Space Industry Act 2018*. Retrieved from http://www.legislation.gov.uk/ukpga/2018/5/contents/enacted
Hair, J. F., Tatham, R. L., Anderson, R. E., & Black, W. (1998). *Multivariate data analysis*. (5th ed.). Prentice Hall.
Harvey, D. (1989). *The urban experience*. The John Hopkins University Press.
Hasson, F., & Keeney, S. (2011). Enhancing rigour in the Delphi technique research. *Technological Forecasting and Social Change*, *78*(9), 1695–1704. https://doi.org/10.1016/j.techfore.2011.04.005
Hawking, S. (2010). *Stephen Hawking's warning: Abandon Earth – or face extinction*. Retrieved from https://www.bigthink.com/dangerous-ideas-ideas/5-stephen-hawkings-warning-abondon-earth-or-face-extinction
Höckert, E. (2015). *Ethics of hospitality: Participatory tourism encounters in the northern highlands of Nicaragua. Acta Universitatis Lapponiensis 312*. University of Lapland.
Hutton, G. (2019). *When will UK spaceports be ready for lift-off*? House of Commons. Retrieved from https://www.commonslibrary.parliament.uk/science/technology/when-will-uk-spaceports-be-ready-for-lift-off/
Intergovernmental Panel on Climate Change (IPCC). (2018). *Summary for policymakers of IPCC special report on global warming of 1.5 Celsius approved by the governments*. Retrieved from https://www.ipcc.ch/2018/10/08/summary-for-policymakers-of-ipcc-special-report-on-global-warming-of-1-5c-approved-by-governments/
Janhunen, P. (2004). Electric sail for spacecraft propulsion. *Journal of Propulsion and Power*, *20*(4), 763–764. https://doi.org/10.2514/1.8580
Kuusi, O. (2017). The Delphi method. In O. Kuusi, S. Heinonen & H. Salminen (Eds.). *How do we explore our futures? Methods of futures research? Acta Futura Fennica 10*. The Finnish Society for Future Studies. [*Mismatch*]
Marsh, M. (2006). Ethical and medical dilemmas of space tourism.*Advances in Space Research,* 37(9), 1823–1827.
Ministry of Economic Affairs and Employment in Finland (2020). *Space offers new opportunities*. Retrieved from https://tem.fi/en/finland-tourism-strategy
Ministry of Education in Finland (2020). *Towards sustainable development in higher education*. Retrieved from https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/79511/opm06.pdf?sequence=1
Ministry of Foreign Affairs in Finland (2020). *Agenda 2030: Sustainable development goals*. Retrieved from https://um.fi/agenda-2030-sustainable-development-goals
Mojic, J., & Susic, V. (2014). *Planning models of sustainable development destination*. Towards Sustainable Growth, University of Nis. 17 October 2014.
Moore, J. W. (2015). *Capitalism in the web of life: Ecology and the accumulation of capital*. Verso Books.
National Space Administration (NASA) (2019a). *NASA opens international space station to new commercial opportunities, private* Astronauts, Retrieved from https://www.nasa.gov/press-release/nasa-opens-international-space-station-to-new-commercial-opportunities-private
National Space Administration (NASA) (2019b). *Humans in space*. Retrieved from https://www.nasa.gov/topics/humans-in-space
Nordin, S. (2005). *Tourism of tomorrow: Travel trends and forces of change*. European Tourism Research Institute.

Ormond, J., & Dickens, P. (2019). Space tourism, capital and identity. In. E. Cohen & S. Spector (Eds.). *Space tourism. The elusive dream. Tourism Social Science Series.* (Vol. 25, pp. 223–244). Emerald Publishing Limited.
Outer (1967). Space, Treaty. *Treaty of Principles (UN).* Retrieved from http://www.unoosa.org/oosa/en/ourwork/space-law/treaties/introouterspacetreaty.html
Patterson, T., Bastianoni, S., & Simpson, M. (2006). Tourism and climate change: Two-way street or vicious/virtuous circle. *Journal of Sustainable Tourism*, *14*(4), 339–348. ? https://doi.org/10.2167/jost605.0
Peeters, P. (2017). *Tourism's impact on climate change and its mitigation challenges: How can tourism become "climatically sustainable?*. Delft.
Peeters, P. (2018). Why space tourism will not be part of sustainable tourism. *Tourism Recreation Research*, *43*(4), 540–543. https://doi.org/10.1080/02508281.2018.1511942
Praaks, J. (2018). *Avaruus avautui myös pienille maille* (*Space opening up for smaller nations*). Retrieved from https://www.yle.fi/uutiset/
Räikkönen, J. (2017). Elämykset. In J. Edelheim & H. Ilola (Eds.). *Matkailun tutkimuksen avainkäsitteet.* [*Key concepts in tourism research*.] (pp.153–157). Lapland University Press.
Ross, M., Mills, M., & Toohey, D. (2010). Potential climate impact of black carbon emitted by rockets. *Geophysical Research Letters*, *37*(24), n/a–n/a. https://doi.org/10.1029/2010GL044548
Ross, M., & Sheaffer, P. M. (2014). Radiative forcing caused by rocket engine emissions. *Earth's* Future, *2*(4), 177–196. https://doi.org/10.1002/2013EF000160
Rudd, M., Vohs, K. D., & Aaker, J. (2012). Awe expands people's perception of time, alters decision making and enhances well-being. *Psychological Science*, *23*(10), 1130–1136. https://doi.org/10.1177/0956797612438731
Saarinen, J. (2013). Critical sustainability: Setting the limits to growth and responsibility in tourism. *Sustainability*, *6*(1), 1–17. https://doi.org/10.3390/su6010001
Saigol, L. (2019). *As Virgin Galactic shares debut, here are the billionaires leading the new space race.* Retrieved from https://www.marketwatch.com/story/as-virgin-galactic-shares-debut-here-are-the-billionaires-leading-the-new-space-race-2019-10-28
Space X. (2019). *SpaceX News*. Retrieved from https://www.spacex.com/news
Space Finland (2020). *Space research*. Retrieved from https://spacefinland.fi/in-english/research/
Space Nation. (2020). *Astronaut expeditions*. Retrieved from https://spacenation.org/
Spector, S., & Higham, J. (2019). Space tourism in the Anthropocene. *Annals of Tourism Research*, *79*, 102772. https://doi.org/10.1016/j.annals.2019.102772
Spector, S., Higham, J., & Doering, A. (2017). Beyond the biosphere: Tourism, outer space and sustainability. *Tourism Recreational Research*, *42*(3), 237–282.
Tapio, J. (2018). The Finnish Space Act: En route to promoting sustainable private activities in outer space. *Air & Space Law*, *43*(4/5), 387–409.
Tervo-Kankare, K. (2017). Kestävä matkailu. In J. Edelheim & H. Ilola (Eds.). *Matkailun tutkimuksen avainkäsitteet* [Key concepts in tourism research] (pp. 235–240). Lapland University Press.
Toivonen, A. (2017). Sustainable planning for space tourism. *Matkailututkimus*, *13*(1-2), 21–34.
Tung, V. W. S., & Ritchie, J. R B. (2011). Exploring the essence of memorable tourism experiences. *Annals of Tourism Research*, *38*(4), 1367–1386. https://doi.org/10.1016/j.annals.2011.03.009
Von der Dunk, F. & Tronchetti, F. (Eds.). (2015). *Handbook of space law: Research handbooks in international law*. Edward Elgar Publishing.
United Nations (UN) (2015). *The agenda for sustainable development*. Retrieved from https://www.sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf
United States (US) Congress. (2019). *NASA Authorization Act*. Retrieved from https://www.congress.gov/bill/116th-congress/senate-bill/2800
Vereshchetin, V., Vasilevskaya, E., & Kamenetskaya, E. (1987). *Outer space: Politics and law*. Progress Publishers.
Viikari, L. (2007). *The environmental element in space law: Assessing the present and charting the future. Acta Universitatis Lapponiensis 120. University of Lapland, Faculty of Law*. University of Lapland Printing Centre.
Visit Finland. (2020). *On the hunt for the Northern Lights*. Retrieved from https://www.visitfinland.com/article/on-the-hunt-for-the-northern-lights/#7a84182c
Von der Dunk, F. (2019). The regulation of space tourism. In. E. Cohen & S. Spector (Eds.). *Space tourism: The elusive dream. Tourism Social Science Series.* (Vol. 25, pp. 177–199). Bingley: Emerald Publishing Limited.
Weaver, D. (2011). Can sustainable tourism survive climate change? *The. Journal of Sustainable Tourism*, *19*(1), 5–15. https://doi.org/10.1080/09669582.2010.536242
Webber, D. (2013). Space tourism: Its history, future and importance. *Acta Astronautica*, *92*(2), 138–143. https://doi.org/10.1016/j.actaastro.2012.04.038
Webber, D. (2019). Current space tourism developments. In. E. Cohen & S. Spector (Eds.). *Space tourism: The elusive dream.* Tourism social science series (Vol. 25, pp. 51–66). Emerald Publishing Limited.
Wittig, M. C., Beil, P., Sommerock, F., & Albers, M. (2017). *Rethinking luxury: How to market exclusive products and services in an ever-changing environment*. LID Publishing.
Young, L. (2019). *Machine landscapes: Architectures of the post-Anthropocene*. John Wiley and Sons.