Abstract

Tourism generates substantial carbon footprint with its air transport sector holding the largest share. Biofuel technology has been repeatedly trialled in aviation to minimise this carbon footprint. While biofuels can become mainstream aviation fuels in the near future, little is known about public knowledge on and perception of its use within the air transport sector. This signifies considerable knowledge gap as the level of public awareness of a new technology determines the speed of its societal acceptance and may affect its market success. This study explores the attitudes of UK tourists to the use of biofuels in aviation. It finds that while the public are generally aware of biofuel technology, public knowledge of its specific application in aviation alongside the carbon benefits this brings is limited. Future policy-making and managerial measures should aim at enhancing public understanding of the biofuel technology use in aviation in the UK.

Keywords: biofuels, tourism, civil aviation, public attitudes, new technology, carbon footprint

Highlights

- Biofuel can reduce carbon intensity of flying
- UK tourists' knowledge on and attitudes to biofuel use in aviation are explored
- General public knowledge of biofuel technology is solid
- Specific use of biofuel technology in aviation is not well understood
- Public knowledge of the benefits of biofuel use in aviation should be reinforced

1. Introduction

Tourism is an important contributor to anthropogenic climate change (Djerba Declaration 2003). It is estimated that about 5% of human-made greenhouse gas (GHG) emissions are attributed to travel with leisure purposes (United Nations World Tourism Organisation–UNWTO 2007). This figure is expected to grow given the continued increase in the number of international tourist arrivals (UNWTO 2016).

Among the different sectors of the tourism industry, transportation holds the largest share of its carbon footprint (Davos Declaration 2007). Aviation generates more than 50% of the industry's GHG emissions (UNWTO 2007). Air travel remains the key means of tourist transport from origin to destination and its steady growth is anticipated in the near future due to the continued rise in international tourism (Dubois and Ceron 2006; Gössling and Peeters 2007; Scott *et al.* 2010).

The importance of reducing carbon intensity of tourism has been repeatedly emphasised (Gössling *et al.* 2005). Air travel should be a primary target of the industry's GHG mitigation efforts given the profound role it plays in the generation of its carbon footprint (Gössling and Peeters 2007). Mitigation can be achieved via voluntary changes in consumer behaviour (McKercher *et al.* 2010); market-based and regulatory instruments can be applied to facilitate these changes (Tol 2007); lastly, technological advancements are expected to contribute to carbon abatement within the sector (Peeters *et al.* 2016). The combination of all these approaches represents the most effective pathway towards the mitigation of GHG emissions in tourism (Capstick *et al.* 2014; Gössling *et al.* 2012; Higham *et al.* 2016b).

There is limited evidence to suggest that tourists will voluntarily change their behaviour towards more climate-benign holidaying practices (Truong and Hall 2016). This is due to limited public understanding of the inter-linkages between tourism and climate change (Dilimono and Dickinson 2015; Hares *et al.* 2010; Higham *et al.* 2014). Tourists fail to associate the carbon footprint generation with their holidaying choices as a result (Cohen and Higham 2011; Dickinson *et al.* 2013; Higham *et al.* 2016a). Lastly, although there are tourists who claim to be prepared to change their holidaying behaviour (for instance, by taking fewer flights or holidaying closer to home), they do not necessarily do so in reality (Gössling *et al.* 2012). The latter phenomenon is known as the 'attitude-behaviour' gap in consumer behaviour research which represents a key obstacle for voluntary behavioural change to serve as a facilitator of the GHG emissions mitigation in tourism (Hibbert *et al.* 2013). The 'attitude-behaviour' gap underlines the important role of technology as a means of advancing the tourism industry towards the goal of environmental sustainability.

Technology can play a many-fold role in reducing the carbon footprint of flying. This can be achieved through the improvements in aircraft design and operational efficiency (Grote *et al.* 2014), or via the adoption of more climate-benign aviation fuels (Gegg *et al.* 2014; Hari *et al.* 2015; Krammer *et al.* 2013). Biofuels are considered a viable alternative to aviation fuels (Kivits *et al.* 2010) and their potential to reduce carbon intensity of flying has been estimated as significant (Marsh 2008). To-date, biofuels have been repeatedly trialled in the air travel sector with a view to make it mainstream aviation fuels in the foreseeable future (Appleyard 2014).

While the potential of biofuels to mitigate the carbon footprint of air travel is recognised, public awareness of the use of biofuel technology in aviation alongside the carbon benefits this technology brings remains unexplored. Better understanding of the public perceptions of a new technology is important as these can often determine success of its societal acceptance and market rollout (Wegener and Kelly 2008). Public awareness of a new technology represents a particularly interesting research object in the air transport context where public safety considerations can hamper the adoption of innovations (Greiner and Franza 2003).

This paper contributes to knowledge by exploring tourist attitudes to the use of biofuel in aviation. The goal of the paper is three-fold. First, it contributes to the scientific discourse on the public perception of tourism as an industry associated with significant environmental pressures, including carbon footprint generation. Second, it explores public knowledge on the application of biofuel technology in civil aviation, including its perceived carbon benefits. Lastly, the paper investigates if tourists consider biofuels as a safe alternative to conventional aviation fuels.

While biofuels have potential to reduce the carbon footprint of flying, there are a number of challenges attributed to the application of biofuel technology in aviation (Marsh 2008). Increased demand for biofuels may lead to the significant, negative changes in global land use (Grote *et al.* 2014). This, in turn, is expected to intensify global food shortages, especially in countries of the Global South (Berndes *et al.* 2003). Furthermore, there is growing evidence to suggest that the level of carbon mitigation achieved through the application of biofuel technology can be lower than commonly anticipated when the indirect, life-cycle related GHG emissions attributed to biofuel production, transportation and distribution are brought into the picture (Repo *et al.* 2011). The increased biofuel production can further generate significant amounts of nitrous oxide (N_2O) which is a GHG and can therefore negate any carbon savings achieved (Lee *et al.* 2010). Lastly, there are a number of institutional and managerial barriers to the production scale and broader use of biofuels, including in the sector of air travel (McCormick and Kåberger 2007). While these issues are acknowledged as being significant, they are beyond the scope of this study whose focus is on tourist knowledge of and tourist attitudes to biofuel use in aviation.

2. Biofuels in the air transport sector

Biofuel technology is not a new invention in transportation as the Henry Ford's original automobile constructed in the 1920s was initially designed to run on bio-ethanol (New York Times 1925). This notwithstanding, it was not until the energy crisis in the 1970s that the use of alternative fuels would become of interest to the transportation industry and its aviation sector (Lee and Mo 2011). Since then, the demand for biofuels in the air travel sector has grown manifold, being driven by such factors as the fluctuations in crude oil prices, political instability in crude oil producing regions, increased environmental concerns among the public and regulators, and the emergence of 'greener' business models (Armstrong 2008; Chiaramonti *et al.* 2014; Nair and Paulose 2014).

2.1. Transportation biofuels

Biofuels are produced from biomass substrates (Giampietro and Ulgiati 1997). In the sector of transportation, biofuels can be used as full or partial substitutes for conventional fossil fuels (Kousoulidou and Lonza 2016). There are three main types of biofuels, i.e. biogas, ethanol and biodiesel (Naik *et al.* 2010). Biogas is a product of anaerobic digestion of energy crops, their residues and waste (Weiland 2010). While it can be used as an energy source for gas-operated and electric vehicles, its application in the aviation sector is limited (Saynor *et al.* 2003). Furthermore, the use of biogas as transportation fuel has only been a major breakthrough in Scandinavia, while the adoption of this technology in the rest of the world has been lagging behind (Jönsson and Person 2003). Ethanol is produced from the plants rich in carbohydrates, such as corn and sugarcane (Balat and Balat 2009). It is the most commonly used liquid biofuel in the transportation sector, mainly due to the vast production volumes in Americas (Energy Information Administration-EIA 2007). This notwithstanding, similar to biogas, ethanol is not considered a suitable alternative to conventional aviation fuels due to its limited chemical and physical qualities (Saynor *et al.* 2003). Lastly, biodiesel is produced from soybeans or other crops containing oil (Moser 2009). Its chemical qualities are close to those demonstrated by kerosene, a conventional aviation fuel (Wardle 2002) which determines why biodiesel holds the largest potential for application in aviation (Saynor *et al.* 2003).

Biogas, ethanol and biodiesel are referred to as the 'first generation' biofuels that have all been an object of significant scientific scrutiny (Naik *et al.* 2010). Such issues as land use changes, competition for food, freshwater and land, deforestation and cost of production have been raised (Anable and Bristow 2007; Bailis and Baka 2010; Marsh 2008). In response to the criticism, the 'next generation' or advanced biofuels have been developed (Table 1). These have been seen more favourably by the scientific community as they can address some, but not all, of the issues attributed to the production of the 'first generation' biofuels (Fairley 2011). Escobar *et al.* (2009) argue that these advanced biofuels have potential to become a commercially feasible technology in transportation within the next 15 years; however, in the short-term perspective, the first and second generation biofuels are likely to remain mainstream in the transportation industry, including its sector of aviation (Doornbosh and Steenblik 2007; Upham *et al.* 2009).

Table 1. Four generations of transportation biofuels and their key characteristics. Source: Adapted from: Demirbas (2011); Kivits *et al.* (2010); Naik *et al.* (2010).

Generation	**Feedstock**	**Examples of feedstock**
First	Traditional food and non-food crop biomass; animal fat	Sugarcane, corn, soybeans, sunflower
Second	Alternative, non-food crop biomass i.e. waste biomass; agricultural and forestry residues; dedicated, high energy yield biofuel crops and plants	Corn stalks and leaves, jatropha, switchgrass, palm oil, rapeseed
Third	Improved, non-food crop biomass i.e. oilier and fast growing crops and plants, algae	Genetically modified types of corn and poplar, microalgae
Fourth	Improved, non-food crop biomass + microbes	Genetically modified types of corn and poplar, microalgae whose growth is facilitated by microbial metabolism

2.2. *The carbon benefits of biofuels*

The carbon abatement potential of biofuels is significant, but varies depending on the production method, production scale, type of feedstock and the country of feedstock origin (Marsh 2008). The sugarcane and palm oil from tropical and sub-tropical countries are recognised as the most energy rich biofuel feedstock due to long growing seasons, warm climate and fertile soils (Doornbosch and Steenblik 2007; Steenblik 2007). IEA (2006 cited in Doornbosch and Steenblik 2007) suggests that biofuels produced from the Brazilian sugarcane can reduce the GHG emissions from road transportation by about 90%. Likewise, IPC and REIL (2006) posit that the ethanol from cellulosic feedstock can mitigate carbon footprint by 70-90%. Lastly, the World Bank (2008) refers to biodiesel as a carbon efficient fuel which can reduce the GHG emissions from transportation by 50-60%.

While indicating the significant carbon abatement potential attached to biofuel technology, the precision of the figures presented above calls for improvement. Existing estimates of the carbon mitigation potential of transportation biofuels come primarily from the small-scale, experimental studies and only a minority originates from the large-scale biofuel production projects (IPC and REIL 2006). Furthermore, some numbers are not based on the 'net' carbon footprint assessments. The 'net' carbon footprint assessments look at the whole lifecycle of biofuel production, distribution and use, and not just at the biofuel usage stage (Bailis and Baka 2010). To produce biofuels, considerable amounts of energy are required (Repo *et al.* 2011). This results in GHG emissions that should be taken into account when assessing the 'net' carbon abatement potential of biofuel technology. To this end, the method of Life Cycle Assessment (LCA) provides the most accurate estimates of the GHG emissions mitigation potential of biofuels and the application of this method in the transportation sector is growing (Repo *et al.* 2011; Steenblik 2007; Warshay *et al.* 2016).

2.3. *Aviation biofuels*

To address the challenge of the low-carbon future, the Biofuels Directive was adapted by the European Union in 2003 (European Union 2003). The directive stipulates that biofuels should shortly replace at least 10% of fossil fuel consumption in the EU transportation sector (European Commission 2008). The directive represents an important driver for the aviation industry to reduce its carbon footprint by applying biofuel technology more broadly (Gegg *et al.* 2014). As a result, biofuels have become an important trial object for many airlines (Kousoulidou and Lonza 2016).

The Virgin Atlantic was the first airline to test biofuels when flying a Boeing 747 from London to Amsterdam driven by a ‘20-80’ blend of biofuels and conventional fuels on 24th February 2008 (Brisbane Times 2008). In subsequent months, other airlines have trialled the biofuel-driven flights using the different blends and the various types of biofuels. In December 2008, the Air New Zealand tested a Boeing 747 driven by a ‘50-50’ mix of traditional jet fuel and oil from jatropha. The airline was the first in the world to use the second-generation biofuel technology (Travel Agent 2009). The carbon savings achieved by the company on that flight were reported as equal to 40-50% compared to conventional aviation fuel (Kjelgaard 2008a). In January 2009, the Continental Airlines flew a Boeing 737 driven by a blend of kerosene, algae and jatropha (Travel Agent 2009). The Japan Airlines became the fourth airline in the world to test biofuels on a Boeing 787 flight driven by a ‘50-50’ mixture of algae-camelina grass-jatropha and conventional fuel (Daily Mail 2009). All airlines reported good performance of the different biofuel blends. The Continental Airlines estimated that the biofuel blend brought about a 60 to 80 % reduction in GHG emissions from the trial flights (Giles 2009).

To-date, about 20 airlines have trialled biofuels in commercial flights (see Enviro Aero 2016 for details) and all have reported positive results. There is a general consensus in the business circles that, given the on-going trials, biofuels will become a commercially viable technology for the aviation industry in the near future (Ayre 2014). Despite the efforts applied by the airlines to advance biofuel use in civil aviation, the public seems to remain generally unaware of the progress achieved (Kjelgaard 2008b). More research is necessary to better understand the reasons for this and the implications of poor consumer awareness (Fung *et al.* 2014).

2.4. Public attitudes to transportation biofuels

Biofuels are considered a safe alternative to conventional fuels in aviation and the stringent safety requirements are imposed by aviation regulators on biofuel manufacturers (Esch *et al.* 2010). Despite the regulatory and business reassurance, consumers often demonstrate a general fear and anxiety over the adoption of a new technology (Meuter *et al.* 2003). In the business context, it has long been established that the public fear of the new and unknown may deter consumers from using a specific type of product or service (Dabholkar 1996). This has important implications for aviation, where safety perceptions play a vital role in the preparedness of people to fly and where a new technology should therefore be introduced with care (Greiner and Franza 2003). Public perception of a new technology should be carefully examined as it shapes public opinion about whether a new technology is acceptable and safe (Siegrist and Cvetkovich 2000). The degree of trust that the public have in technology drives the speed and determines the overall success of its adaption (Schulte *et al.* 2004).

Despite a significant increase in the production and application of biofuels in the past decade and the extensive media coverage of this topic, research on public attitudes towards biofuels, particularly in the context of its use in transportation, is still in its infancy (Fung *et al.* 2014). The literature review has identified no studies looking into this topic specifically in the context of aviation. This is surprising given that the potential technological interventions within this sector may become unsuccessful if the public are not ready to use them (Wegener and Kelly 2008).

Existing literature demonstrates varied public knowledge and attitudes to biofuels and their use in transportation. For example, in the UK and Ireland, while there is good public knowledge on the renewable sources of energy in general, public awareness of biofuel technology and the benefits of its implementation in the transportation industry is relatively low (Cacciatore *et al.* 2012; Rohracher *et al.* 2003). Research from Belgium shows increased levels of public awareness on biofuel technology alongside its environmental benefits (van de Velde *et al.* 2009). In New Zealand and USA, public awareness of biofuels and their use in transportation is higher; this notwithstanding, there is limited public understanding of the carbon benefits associated with biofuel technology (Delshad *et al.* 2010; Energy Efficiency and Conservation Authority-EECA 2009; Ulmer *et al.* 2003). It is acknowledged that further research is required to shape a more comprehensive picture on the subject of public knowledge and public attitudes to transportation biofuels (Fung *et al.* 2014), particularly in the context of the application of this technology in aviation.

In summary, the literature review suggests that public attitudes to biofuels and itheir use in aviation should be better understood. While public perception of biofuel technology is generally positive, public awareness of the associated carbon benefits should be improved. Previous research shows that people often express neutral attitudes to biofuels which implies that the public either do not have a clear opinion on this technology or remain largely unaware of the climate advantages it brings. The lack of public knowledge on biofuels, their safety and their carbon benefits can hamper broader adaption of this technology in the field of transportation, including aviation. This study contributes to knowledge by looking into public attitudes to biofuels among UK tourists, testing public knowledge of biofuel use in aviation and exploring public understanding of the implications of biofuel use, both for the environment and consumer decision-making.

3. Method

Due to the exploratory nature of this project, primary data were collected via a qualitative study. This is because of the limited, inconclusive and even contradictory nature of the outcome demonstrated by previous research on the topic of public attitudes to biofuels and their carbon benefits. This is also because no evidence of such research held specifically in the context of civil aviation has been identified by the literature review. The qualitative research paradigm is therefore appropriate given that it enables an in-depth analysis and better conceptualisation of public opinions, which can subsequently be tested in large-scale, quantitative studies (Veal 2006).

Semi-structured interviews are considered a reliable method in qualitative research to obtain rich data for analysis; they are also seen as a suitable instrument for exploratory research on complex social phenomena where previous knowledge on the topic of interest is limited (Silverman 2000); hence, their suitability for this project. Semi-structured interviews were further selected because of the contacts established by researchers with a local travel agent. These contacts enabled direct access to tourists as researchers were invited to undertake the project on business premises. The professional contacts also provided researchers with an opportunity to gain spontaneous and more informal responses from consumers that guarantee a more natural and honest expression of public opinions (Shi 2008).

Interviewing consumers in a busy commercial environment can be difficult. To minimise this difficulty, multiple mini interviews (MMIs) can be employed instead of traditional interviews (Pau *et al.* 2013). While resembling semi-structured interviews in a way how these are designed and undertaken, MMIs enable quicker collection of robust and reliable qualitative data in the contexts where consumer preferences or willingness to partake in a research project can change at short notice (Kumar *et al.* 2009), such as commercial premises of a busy travel agent. The MMI format was therefore adopted for the purpose of this study.

MMIs were conducted within the period of four weeks in June–July 2015. The convenience sampling approach was utilised as a high street travel agent located in Poole, Dorset, UK had agreed to provide researchers with access to their clients. In total, 150 tourists were approached and 102 interviews were conducted which demonstrates a response rate of circa 60%. The exact number of MMIs was determined by the 'saturation effect' (Srivastava and Hopwood 2009) and primary data collection was drawn to a close once no new themes were found to be emerging from the material collated. In the case of family clients, only one family member was interviewed. On average, each MMI lasted between 10 and 25 minutes.

An interview schedule was devised based on the themes identified in the literature review whose list was continuously updated through iterative analysis applied to the interim data collected (Srivastava and Hopwood 2009). The original interview schedule was built around the themes comprising of public knowledge on, perceptions of, and attitudes to biofuel technology in general, and its specific use in the sector of aviation with the purpose of carbon mitigation. To enable exploratory quantitative analysis (see next paragraph), some questions were developed using the attitudinal Likert scale (ranging from 1=Strongly disagree to 5=Strongly agree). An example of such question would be ‘to what extent do you agree with N statement’. No incentives were offered to interview participants. All interviews were digitally recorded and transcribed.

Importantly, due to the considerable number of interviews held, an element of quantitative analysis was added to the study to enhance its analytical power and scientific rigour. To this end, a small number of carefully selected multivariate analyses were run on the data collected with the help of SPSS. These were predominantly employed to examine the significance of the relationship between the key socio-demographic profiles of participants (most notably, age, gender, levels of income and education) and their attitudes to aviation biofuels. Table 3 presents the outcome of these analyses for those questions where significant differences between the samples were recorded.

Thematic analysis was applied to the qualitative data collected whose write-up was supported with verbatim quotations (Braun and Clarke 2006). These quotations were primarily used to provide empirical evidence for the data interpretation conducted in this study and enhance credibility of its findings. This is in line with the traditional approach to data analysis in qualitative research (Corden and Sainsbury 2006; Ritchie *et al.* 2003).

The study has a number of limitations. First, given the qualitative, exploratory nature of research, its outcome is indicative, rather than conclusive, and a larger sample size would have strengthened the quality of data collected in terms of their generalisability and representativeness. This limitation outlines a prospective avenue for another research project in the area of interest which would utilise a large-scale quantitative survey to gain a more statistically significant sample of responses. Second, the data obtained were skewed in terms of some key socio-demographic parameters. The reasons for this are explained in detail in Section 4. Third, all respondents represent the category of leisure travellers. It is possible that other categories of tourists (for example, business travellers) may have different opinions on the study subject. Lastly, the absolute majority of participants were British. The cultural and national backgrounds may play a role in shaping public perceptions of technological innovations (Wegener and Kelly 2008) and should therefore be examined in more detail in the future.

4. Findings and discussion

4. 1. Demographical profile of respondents

The sample comprised of 62% females and 38% males (Table 2). This may be partially attributed to some empirical evidence that females are more inclined to partake in research projects (Curtin *et al.* 2000). The age of participants ranged from 18 to 84 (46 years on average), with approximately half (49%) falling into the category of 50+ years. Elderly tourists represent the key clientele of high street travel agents in the UK (ABTA–Association of British Travel Agents 2014; Travel Trade Gazette-TTG Digital 2013) and this was confirmed in private communication held by researchers with a representative from the high street travel agent on whose premises the project was run. Better familiarity of younger travellers with technology which results in online holiday booking may serve as another explanation of the high average age of the study participants. Only 29% of respondents were educated to a University degree. This closely relates to the fact that the sample was skewed towards the elderly demographics.

Over 50% of participants can be classed as ‘frequent air travellers’ as they flew internationally for leisure at least three times within the last 12 months. This is considerably above the nation’s annual average of 1.2 flights (ABTA 2014). This indicates that flying for leisure has become an integral part of everyday life for people in the UK, regardless of their demographical profile. Only 9% of participants claimed that they did not fly in the last year. Among these, 6 or 60% of respondents were at the age of 70 and over which implies that they did not travel due to health constraints. These participants were nevertheless included into analysis as the primary aim of the project was to explore general public understanding of the inter-linkages between tourism, climate change and aviation biofuels.

Table 2. Respondents' demographic characteristics

Variable	**Category**	**Total number of respondents**	
		N=102	**%**
Gender	Male	39	38
	Female	63	62
Age	18-29	11	11
	30-49	41	40
	50 and over	50	49
Highest level of education achieved	High school or less	61	60
	Diploma/college or professional degree	11	11
	Undergraduate	24	23
	Postgraduate or higher degree	6	6
Employment	Employed	37	36
	Unemployed	8	8
	Retired	55	54
	Student	2	2
Annual income	Under nation’s average (<£27,000)	38	37
	Over nations’ average (>£27,000)	52	51
	No answer given	12	12
Frequency of flying (per year)	No flights	9	9
	1 flight	16	16
	2 flights	21	20
	3 flights	14	14
	4+ flights	42	41

4.2. Tourism and its environmental impacts

Although the interview schedule was pre-tested prior to the project commenced and some questions were subsequently re-worded to account for the comments made at the testing stage, the questions designed to better understand tourist knowledge of and attitudes to the inter-linkages between the problem of climate change and tourism confused some participants. About a third did not initially understand the questions about the environmental/climate change impacts of tourism and asked for clarification. After gaining clarity, about 65% of respondents agreed that tourism contributes to various environmental issues. Importantly, within this category, circa 11% participants stated that they 'were not worried' about this contribution:

'It does not contribute enough to stop me' (Female, 23)

'[Tourism] could do [contribute], but I am not worried, it's life' (Female, 40)

Concurrently, 17% of participants did not see tourism as a contributor to global environmental impacts while the remaining 18% were undecided. The multivariate analysis was run to establish the relationship between tourist knowledge and their socio-demographic characteristics. Education level was found to strongly affect tourist knowledge, but no further relationship was recorded (Table 3). This finding is in agreement with the literature which posits that the majority of tourists acknowledge the negative environmental significance of the industry (Cohen *et al.* 2011; Gössling *et al.* 2006; Hillery *et al.* 2001). However, the interviews also indicate that while many tourists have some good understanding of the inter-linkages between the tourism industry and its environmental pressures, there are a large number of those who do not pay attention to these impacts.

Table 3. Relationship between gender and attitudes to biofuel use in aviation.

Attitudinal questions (Likert scale from 1=Strongly disagree to 5=Strongly agree)	Educated to a degree level		No formal University education		Sig.
	Mean	SD	Mean	SD	
Tourism generates substantial environmental impacts	4.2	0.7	3.9	0.8	0.016
Flying contributes to climate change	3.6	0.9	3.4	0.9	0.022
The negative environmental effects of flying are negligible	1.7	1	2.3	1.1	0.002
I am familiar with the concept of biofuels	4	0.7	3.6	0.8	0.011

The next set of questions asked participants to provide examples of the environmental issues they associated with tourism (Figure 2). Climate change was mentioned by a third of participants. This finding contradicts some of the previous research (Becken 2004; Becken 2007; Gössling *et al.* 2006) which established that only a small portion of tourists consider the tourism industry as an important contributor to global climatic changes. This may indicate the increased role of mass media and national governments in shaping public knowledge on the issue of climate change and its relationship with mobilities. Importantly, water consumption was not mentioned as an environmental consequence of tourism operations despite this problem being significant (Gössling *et al.* 2012). This indicates that national governments should design dedicated public awareness raising campaigns on the growing contribution of tourism to global water use.

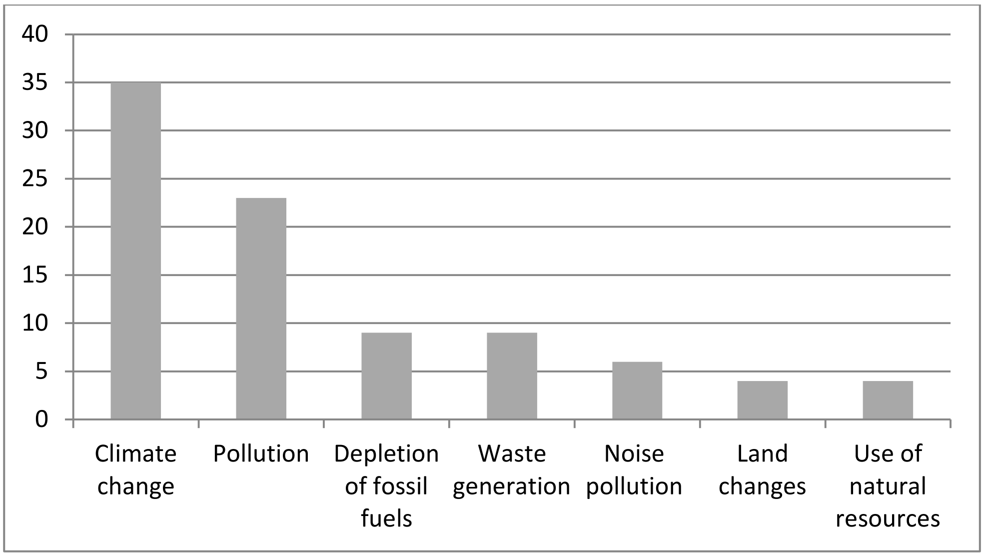

Figure 2. Environmental problems associated with tourism

The next set of questions focused specifically on the environmental impacts associated with flying (Figure 3). They revealed that tourist awareness of the aviation's contribution to anthropogenic climate change is fairly high (about 45%) which is in line with Gössling *et al.* (2009), but contradicts Becken *et al.* (2007). The multivariate analysis established the important role of the educational level of respondents (Table 3) and their income (p=0.018) in tourist awareness of the carbon implications of flying. The difference in the outcome demonstrated by this project and the study by Becken *et al.* (2007) may be in part attributed to the positive effect of the measures applied by UK government to raise public knowledge on the climate implications of flying. The recorded discrepancy in public attitudes may also be due to the studies being conducted in different geographies. Importantly, it was found that while some participants mentioned the problem of climate change in the context of flying, they were not entirely confident about its causes and consequences:

'The carbon footprint thing, I know it is important when flying but I do not really understand it' (Female, 33)

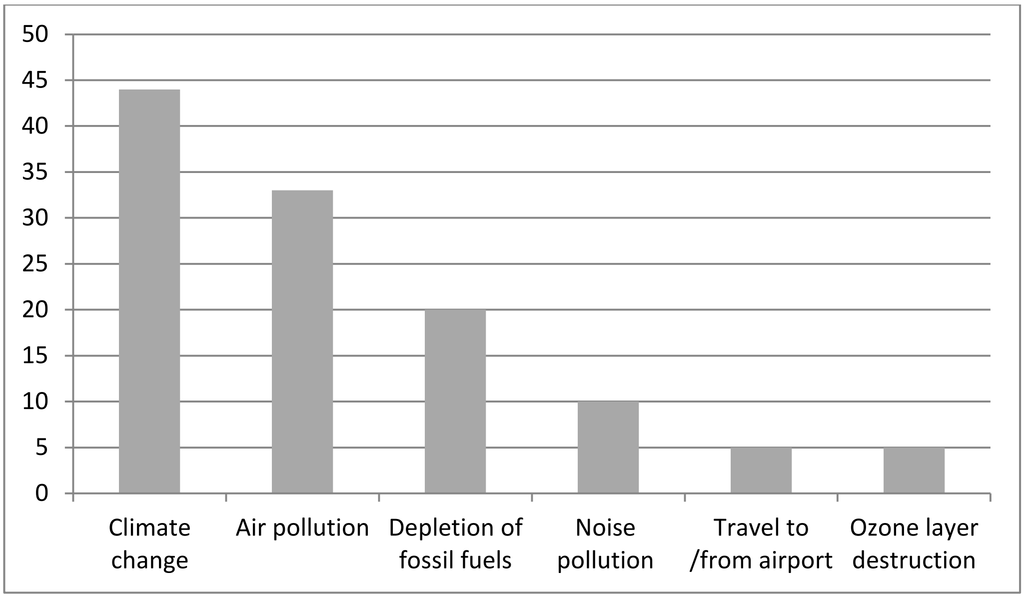

Figure 3. Environmental problems associated with flying

This is partially confirmed by the fact that a small number of participants referred to airport travel as an important contributor to the environmental impact of flying (Figure 3). When clarification was sought, it appeared that vehicle fuel combustion and the associated GHG emissions was the primary impact associated by tourists with this category of responses. The carbon footprint of airport travel is negligible compared to the carbon implications of flying (Filimonau *et al.* 2014), which signifies limited public understanding of the inter-relationships between aviation and the problem of climate change.

The outcome of this study may underline the profound role played by governmental institutions and mass media in enhancing public knowledge on the importance of the issue of climate change; however, it also shows that while the UK public take a note of such intervention 'messages', they hold limited knowledge on the scientific underpinning of the problem broadcast. This suggests that a better explanation of the inter-linkages between aviation, carbon footprint and climate change is necessary to enhance public understanding of this issue.

While a significant number of participants were aware about the contribution of aviation to global climatic changes, all of them claimed that this knowledge would not affect their decision to fly for leisure purposes. Speed, convenience and price were put forward as the primary factors to take into account when deciding on how to get to an international holiday destination. Air travel was perceived as the most viable transportation option as it would meet all the above criteria. This is reflected in UK travel statistics indicating that air travel accounts for circa 80% of all tourism related visits of Britons abroad (Office for National Statistics 2014):

'[Flying contributes to] CO2 and all the other environmental problems, but there is no other way to travel. It's so cheap, it's so affordable!' (Female, 52)

'*For domestic tourism I will use coaches but for international travel it's more convenient to fly*' (Female, 26)

'I'd be happy to fly less, but only if it was cheaper to use alternative transport, such as train or bus, but flying is the most effective way to travel these days' (Female, 19)

Importantly, a small number of participants did not see any environmental problems associated with flying. The multivariate analysis revealed that this was pronounced for those respondents with low levels of education (Table 3). This may indicate that a large number of tourists do not attach any environmental significance to their leisure travel:

'I do not know, I've never thought about this kind of stuff, really. Flying is flying, full stop' (Male, 27)

The last set of questions in this category was designed to explore if tourists would be prepared to reduce the number of flights undertaken with leisure purposes in order to minimise the impact of personal leisure travel on the environment and climate change. Three quarters of participants stated they would not be prepared to change and the multivariate analyses established no significant effect of demographics. This is in line with Shaw and Thomas (2006) who found that air travel brings substantial benefits to tourists and these benefits appear to outweigh any harm to the society or the environment. Importantly, the range of opinions given in this study varied from total climate change denial to general unwillingness to change the routine leisure habits:

'No, I couldn't imagine flying less as a man has to do what a man has to do' (Female, 54)

'We don't believe that there are aviation problems. We don't believe in that kind of global warming stuff. We don't need to fly less' (Male, 58)

'Tourists need to take the plane! If I travel, I like to enjoy it and don't think about the environment. I don't think you can change people's behaviour, it's just necessary for people to fly' (Female, 25)

Importantly, when discussing this set of questions, some participants asked the interviewers about how they had themselves first arrived to the UK seeking to hear a 'by plane' answer. According to Festinger (1962), this exemplifies the defence mechanism to the sudden internal dissonance and an effort to defend someone's own, often societally- and environmentally-damaging, actions. These findings correlate with Gössling *et al.* (2009) who revealed a similar pattern. Importantly, most respondents believed that they were already doing a lot to contribute to the goal of environmental sustainability in other areas, such as recycling and using energy-saving bulbs at home. Reducing the number of leisure flights was seen as an overly laborious and even unnecessary action to undertake:

‘We’re already recycling at home and couldn’t do really much more’ (Female, 52)

According to Festinger (1962), people tend to ‘compensate’ the ‘poor’ behaviour’ shown in one area (for instance, when traveling with leisure purposes) by demonstrating some ‘good’ behaviour in another area (for example, when staying at home). This compensation behaviour theory may partially explain why people do not consistently stick to their behaviour, thus contributing to the scientific discourse on the ‘attitude–behaviour’ gap:

‘I could not fly less but I could compensate in other ways. I recycle at home, for example’ (Male, 65)

The respondents saw price as the most decisive factor which could make them reduce the number of leisure flights undertaken. This may suggest that the national governments should provide more subsidies to operators of overland modes of public transport to make it a more financially appealing travel option. Imposing a carbon tax on flying could also facilitate behavioural changes:

‘The government should put caps on emissions and encourage the use of alternative transport. Trains could lower their prices, because now it’s often cheaper to use the plane’ (Female, 28)

‘Flying should be made more expensive. I could imagine changing my lifestyle and choosing other transport alternatives’ (Female, 32)

This is in line with other studies (Becken 2007; Shaw and Thomas 2006) concluding that effective carbon footprint mitigation requires the national governments to apply more stringent efforts in terms of consumer demand regulation and transportation capacity management. According to Gössling *et al.* (2009), it is a common expectation among the public that the national governments and transportation providers should be in the forefront of dealing with environmental issues, thus putting their own responsibility last.

4.3. Aviation biofuels

More than half of participants were familiar with the concept of biofuel. Here, the level of education had a strong effect on tourist knowledge (Table 3). Further 15% claimed that they heard about biofuels but could not provide any further explanation as to what these stood for. This finding correlates with the outcome of other studies demonstrating that public awareness of biomass as a renewable energy source should be improved (Rohracher *et al.* 2003). This is supported by further analysis conducted in this project: when respondents who claimed to have knowledge on biofuels were asked to explain and provide examples, only half were capable of doing this. This indicates a rather diffused notion of biofuel technology among the UK tourists:

‘Biofuels is something good, is not it? Must be good for the environment as it’s bio’ (Male, 48)

‘Biofuels are made of coal. They can be used to fuel cars’ (Female, 36)

When asked about the use of biofuels in aviation, only a quarter of participants stated they knew about the application of biofuel technology in the sector of air travel. There was no effect of demographics on the level of tourist knowledge. Furthermore, none were able to provide examples of specific flights and airlines which had trialled biofuels. This demonstrates very limited public knowledge about the use of biofuels in aviation and outlines prospective avenues for policy-making interventions. These should be designed to enhance public understanding of the advantages associated with biofuel technology and its application in transportation, including the sector of air travel.

Among those participants who knew about biofuels, the key advantage of biofuel use was seen in reducing the impacts on the environment. This correlates well with other studies that have found that the public perceive biofuel technology largely positively (Fung *et al.* 2014). However, the mitigation of carbon impacts was not specifically mentioned by participants; this may indicate limited public understanding of the rationale behind the implementation of biofuel technology in transportation. This also underlines the necessity for the national governments and mass media to design awareness raising campaigns emphasising the climate benefits of biofuel use to the public:

'[Biofuel is] Better for the planet. It can be more expensive for the companies but it's better for the world' (Female, 44)

'We could be using less fossil fuel. Carbon footprint? Yeah, they [biofuels] may do some good to it as well' (Male, 51)

The next set of questions aimed to understand if tourists saw any issues associated with the use of biofuel technology in general, and with its implementation in aviation in particular (Figure 4).

The outcome of interviews demonstrated that the three quarters of participants could either not comment on this question due to limited knowledge, or could not think of any issues. The multivariate analysis revealed no inter-linkages between the socio-demographic profiles of respondents and attitudes. The cost constraints and the 'food versus fuel' dilemma were each mentioned by about 10% of participants. A very small number considered safety to be an issue, which may show that the public have a good degree of trust in the industry and the national governments that oversee the safety of the biofuel technology implementation in aviation:

'Biofuels... they must be safe as they are regulated by governments, aren't they? (Male, 53)

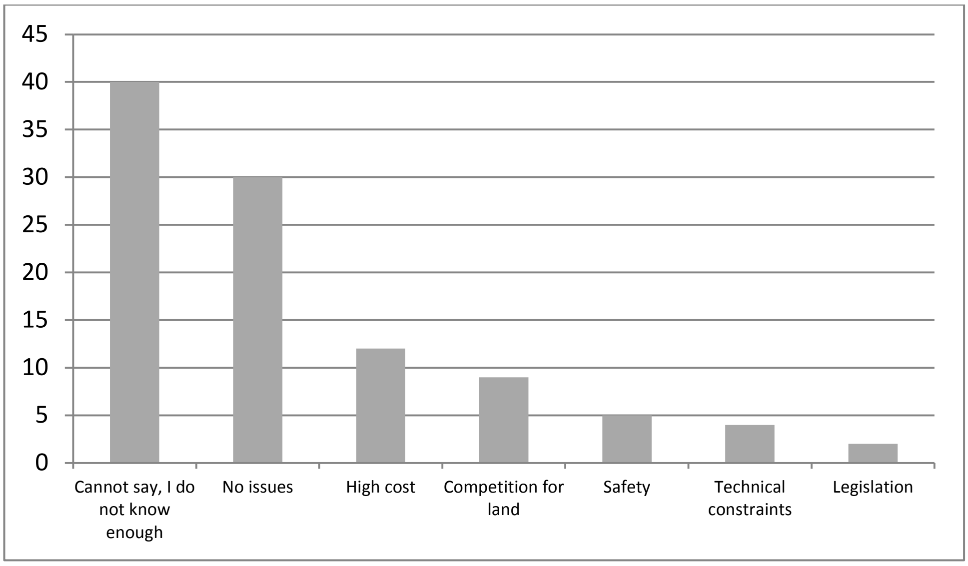

Figure 4. Limitations of biofuel use in aviation

In further analysis, participants were asked to share their feelings, particularly any concerns, about being on an aircraft which would be entirely driven by biofuels (Figure 5). The majority claimed they would not think about this at all. About a quarter of participants stated that they would feel happier knowing their impact on the environment was reduced:

'If I were going on a holiday and could do it more environmentally friendly, I'd be glad' (Male, 50)

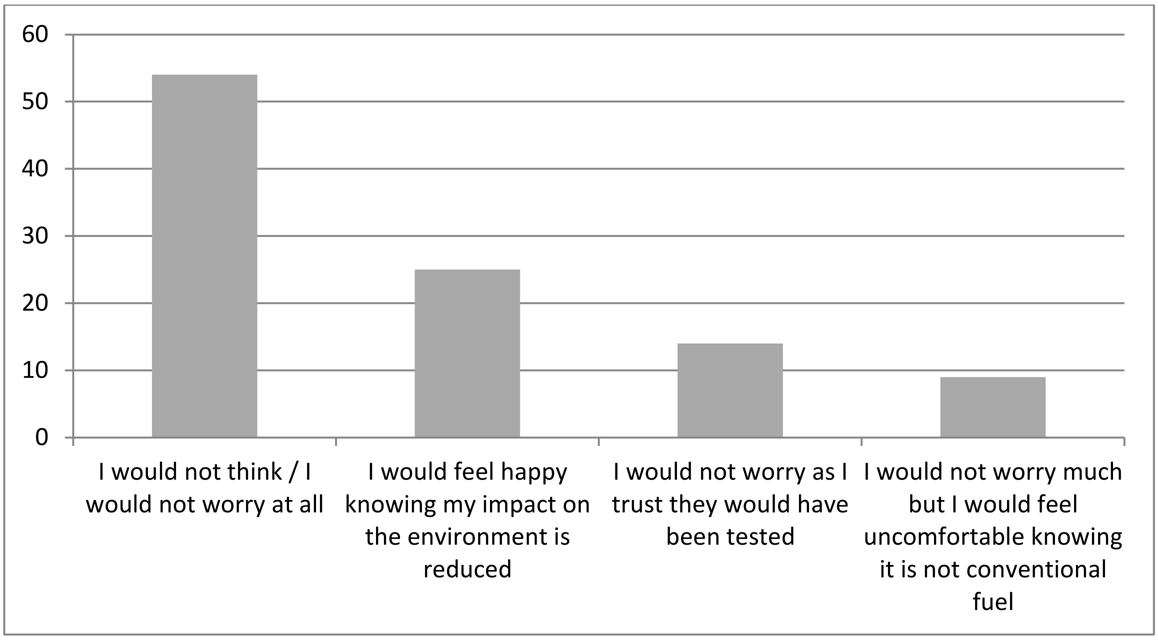

Figure 5. Public attitudes to being flown on an aircraft driven by biofuels

A small number of participants stated that they would not worry as they trusted the national government and the airline industry to have made the aircraft safe to fly:

'It must have been tested by someone, so it wouldn't bother me, I'd trust and I'd fly' (Female, 59)

Lastly, a similarly small portion of respondents revealed they would not feel comfortable knowing that the aircraft used a non-conventional fuel technology:

'A bit nervous, shall I say. This is something new, what if it breaks?' (Female, 44)

This shows that the issue of safety attached to the use of biofuel in aviation is not considered by tourists as significant. This is possibly due to the high level of public trust in the national government and the aviation industry. Given that the degree of trust that people have in a technology determines its adoption rate (Schulte *et al.* 2004), it is fair to suggest that British tourists are generally ready for the broader implementation of biofuel technology in aviation. As biofuels are considered by some participants a more environment-benign fuel type compared to conventional aviation fuel, UK policy-makers should therefore consider accelerating the rollout of this technology in aviation. This can be achieved via incentivising the industry and investing more actively into research and development of biofuel technology in the air travel sector.

5. Conclusions

Tourism is an important contributor to global climatic changes. To facilitate progress of the industry towards the goal of environmental sustainability, effective carbon mitigation measures should be developed and implemented in practice. Biofuel technology represents a mitigation measure which has potential to considerably reduce the carbon intensity of flying, the sector of the tourism industry characterised by the largest GHG emissions. For a technology to succeed, it is crucial to ensure its benefits are understood and accepted by consumers. Little is known about public attitudes to biofuel use in the sector of air travel, particularly from the standpoint of its carbon benefits and safety. This study contributed to the scientific discourse on tourist attitudes to flying as being an important contributor to global climatic changes and analysed public opinion on the role, benefits and limitations of biofuel use in aviation.

The study showed that while British tourists possess some knowledge on the environmental issues attributed to tourism and aviation, they do not associate these with their own leisure travel behaviour. The relationship between tourism and climate change is seen as loose and therefore needs to be reinforced. The national governments should play a more active role to address this task. This is because voluntary behavioral changes are unlikely to become an effective solution to the problem of carbon footprint in the tourism industry alone. To succeed, they need to be better facilitated by the national governments.

The study demonstrated limited public understanding of the environmental benefits attached to the use of biofuels in general, and their application in aviation in particular. This highlights areas for potential policy-making interventions as public awareness of biofuel technology should be raised, especially with a view to provide better knowledge on the carbon benefits of its implementation. Better public knowledge can accelerate consumer acceptance of biofuel technology in the air travel sector.

Biofuels are generally seen by British tourists as a safe alternative to conventional aviation fuels. This demonstrates a high level of public trust in the national governments and the aviation industry. The dominant perception of safety attributed to biofuel use in aviation indicates that consumers are generally prepared for the broader rollout of this technology in the sector of interest. This emphasises the necessity for the national governments to incentivise more rapid adaption of aviation biofuels.

The study outlined a number of promising areas for future research. First, the issue of the rebound effect (Druckman *et al.* 2011) can be of particular importance to the topic concerned. The broader use of biofuels in aviation, with the enhanced image of the sector as being more carbon efficient, may bring about more flights, thus not mitigating, but rather intensifying, the GHG emissions from tourism. Second, public perception of biofuels may vary depending on the social, economic and political environment within which people choose to adopt or refrain from using biofuel (Wegener and Kelly 2008). This underlines the necessity for more research on public attitudes to the use of biofuels in aviation conducted in the different geographical and political contexts. Lastly, the impact of mass media on public perception of the environmental/climate change impacts from tourism and the role played by biofuel technology in the mitigation of these impacts calls for better understanding. The media, especially the social media, represent a powerful tool to shape public opinion. The role of media in enhancing public awareness of the negative carbon implications of holidays alongside the behavioural, financial and technological opportunities for the mitigation of these implications should be better examined.

References

ABTA–Association of British Travel Agents, 2014. *The consumer holiday trends report. ABTA consumer survey 2014.* ABTA. Available from: https://c0e31a7ad92e875f8eaa-5facf23e658215b1771a91c2df41e9fe.ssl.cf3.rackcdn.com/publications/1420_ABTA_Consumer_Survey_2014_WEB.pdf [Accessed 10 January 2017].

Anable, J., and Bristow, A.L., 2007. Transport and climate change: supporting document to the CfIT report. Report prepared for the Climate Change Working Group of the Commission for Integrated Transport. Available from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.113.8032&rep=rep1&type=pdf [Accessed 08 January 2017].

Appleyard, D., 2014. Green replacement fuels taking flight. *Renewable Energy Focus, 15*(1), 38-39.

Armstrong, D., 2008. Alternative Jet Fuels: The Reality Comes Closer. *Aviation,* 1 April. Available from: http://www.aviation.com/technology/080401-alternative-jet-fuels.html [Accessed 14 March 2017].

Ayre, J., 2014. *Biofuel flights within five years, says Head of Etihad Airways.* Clean Technica. Available from: http://cleantechnica.com/2014/01/27/biofuel-flights-within-five-years-says-head-etihad-airways/ [Accessed 08 March 2017].

Bailis, R.E., and Baka, J.E., 2010. Greenhouse Gas Emissions and Land Use Change from *Jatropha Curcas*-Based Jet Fuel in Brazil. *Environmental Science & Technology,* 44(22), 8684–8691.

Balat, M., and Balat, H., 2009. Recent trends in global production and utilization of bio-ethanol fuel. *Applied Energy, 86*, 2273–2282.

Becken, S., 2004. How tourists and tourism experts perceive climate change and carbon-offsetting schemes. *Journal of Sustainable Tourism, 12*(4), 332-345.

Becken, S., 2007. Tourists' perception of international air travel's impact on the global climate and potential climate change policies. *Journal of Sustainable Tourism,* 15(4), 351-368.

Berndes G., Hoogwijk M. and van den Broek R., 2003. The contribution of biomass in the future global energy supply: a review of 17 studies. *Biomass and Bioenergy*, 25(1), 1-28.

Braun, V., and Clarke, V., 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101.

Brisbane Times, 2008. *Coconut jet fuel? You gotta be nuts*. Available from: http://www.brisbanetimes.com.au/news/travel/coconut-jet-fuel-thats-nuts/2008/02/25/1203788223183.html [Accessed 8 April 2016].

Cacciatore, M.A., Binder, A.R., Scheufele, D.A., and Shaw, B.R., 2012. Public attitudes toward biofuels. Effects of knowledge, political partisanship, and media use. *Politics and the Life Sciences,* 31(1-2), 36-51.

Capstick, S., Lorenzoni, I., Corner, A., and Whitmarsh, L., 2014. Prospects for radical emissions reduction through behavior and lifestyle change. *Carbon Management*, 5(4), 429-445.

Chiaramonti, D., Prussi, M., Buffi, M., and Tacconi, D., 2014. Sustainable bio kerosene: Process routes and industrial demonstration activities in aviation biofuels. *Applied Energy,* 136, 767-774.

Cohen, S.A., and Higham, J.E.S., 2011. Eyes wide shut? UK consumer perceptions on aviation climate impacts and travel decisions to New Zealand. *Current Issues in Tourism, 14*(4), 323-335.

Cohen, S.A., and Higham, J.E.S., Cavalieri, C.T., 2011. Binge flying: Behavioural addiction and climate change. *Annals of Tourism Research*, 38(3), 1070-1089.

Corden, A., and Sainsbury, R. 2006. *Using Verbatim Quotations in Reporting Qualitative Social Research: Researcher's Views*. Social Policy Research Unit, University of York: York, 2006.

Curtin, R., Presser, S., & Singer, E., 2000. The effects of response rate changes on the index of consumer sentiment. *Public Opinion Quarterly*, 64, 413–428.

Dabholkar, P.A., 1996. Consumer evaluations of new technology-based self-service options: An investigation of alternative models of service quality. *International Journal of Research in Marketing*, 13(1), 29-51.

Daily Mail, 2009. *Japanese airline prepares to test biofuel blend made from flowers and algae.* Available from: http://www.dailymail.co.uk/sciencetech/article-1131409/Japanese-airline-prepares-test-biofuel-blend-flowers-algae.html [Accessed 8 January 2017].

Davos Declaration, 2007. Davos Declaration. Climate Change and Tourism Responding to Global Challenges. In: *Second International Conference on Climate Change and Tourism*, Davos, Switzerland, 3 October 2007. Available from: http://www.unwto.org/pdf/pr071046.pdf [Accessed 19 February 2017].

Delshad, A., Raymond, L., Sawicki, V., Wegener, S., 2010. Public attitudes toward political and technological options for biofuels. *Energy Policy*, *38*, 3414–3425.

Demirbas, M.F., 2011. Biofuels from algae for sustainable development. *Applied Energy*, *88*, 3473-3480.

Dickinson, J., Robbins, D., Filimonau, V., Hares, A., and Mika, M., 2013. Awareness of tourism impacts on climate change and the implications for travel practice: a Polish perspective. *Journal of Travel Research*, 52(4), 506-519.

Dillimono, H.D., and Dickinson, J.E., 2015. Travel, tourism, climate change, and behavioral change: travellers' perspectives from a developing country, Nigeria. *Journal of Sustainable Tourism*, *23*(3), 437-454.

Djerba Declaration, 2003. Djerba *Declaration on Tourism and Climate* Change. In: *First International Conference on Climate Change and Tourism*, Djerba, Tunisia, 9-11 April 2003.

Available from: http://www.world-tourism.org/sustainable/climate/decdjerba-eng.pdf [Accessed 19 February 2017].

Doornbosch, R., and Steenblik, R., 2007. *Biofuels: is the cure worse than the disease*? Paris: OECD. Available from: http://www.oecd.org/sd-roundtable/39411732.pdf [Accessed 8 August 2016].

Druckman, A, Chitnis, M., Sorrell, S., and Jackson, T., 2011. Missing carbon reductions? Exploring rebound and backfire effects in UK households. *Energy Policy, 39*(6), 3572-3581.

Dubois, G., and Ceron, J.P., 2006. Tourism/Leisure Greenhouse Gas Emissions Forecasts for 2050: Factors for Change in France. *Journal of Sustainable Tourism*, 14(2), 172-191.

Energy Efficiency and Conservation Authority-EECA, 2009. *Consumer research into the motivators and barriers to using biofuel blends.* Wellington: EECA. Available from: http://www.eeca.govt.nz/node/1521 [Accessed 7 February 2017].

Energy Information Administration-EIA, 2007. *Biofuels in the U.S. Transportation Sector*. Washington: EIA. Available from: http://www.eia.doe.gov/oiaf/analysispaper/biomass.html [Accessed 7 March 2017].

Enviro Aero, 2016. *Passenger biofuel flights.* Air Transport Action Group, Geneva, Switzerland. Available from: http://aviationbenefits.org/environmental-efficiency/sustainable-fuels/passenger-biofuel-flights/ [Accessed 8 December 2016].

Escobar, J.C., Lora, E.S., Venturini, O.J., et al., 2008. Biofuels: Environment, technology and food security. *Renewable and Sustainable Energy Reviews, 13*(6-7), 1275–1287.

Esch, T., Funke, H., and Roosen, P., 2010. *Safety implication of biofuel in aviation.* EASA Report 2008.C51. Available from: https://easa.europa.eu/essi/egast/wp-content/uploads/2011/03/Final_Report_EASA.2008-6-light1.pdf [Accessed 7 March 2017].

European Commission, 2008. *Proposal for a directive of the European parliament and of the council on the promotion of the use of energy from renewable sources*. Brussels: Commission of the European Communities.

European Union, 2003. *Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport*. Brussels, Belgium.

Fairley, P., 2011. Introduction: Next generation biofuels. *Nature,* 474, S2-S5.

Festinger, L., 1962. *A Theory of Cognitive Dissonance.* London: Tavistock Publications.

Filimonau, V., Dickinson J., and Robbins, D., 2014. The carbon impact of short-haul tourism: a case study of UK travel to Southern France using life cycle analysis. *Journal of Cleaner Production, 64,* 628-638.

Fung, T.K.F., Choi, D.H., Scheufele, D.A., and Shaw, B.R., 2014. Public opinion about biofuels: the interplay between party identification and risk/benefit perception. *Energy Policy, 73,* 344-355.

Gegg, P., Budd, L., and Ison, S., 2014. The market development of aviation biofuel: Drivers and constraints. *Journal of Air Transport Management,* 39, 34-40.

Giampietro, M., and Ulgiati, S., 1997. Feasibility of large-scale biofuel production. *Bioscience, 47*(9), 587-600.

Giles, C., 2009. Positive results from Continental biofuels demo flight. *Biofuel Review.* Available from: http://www.biofuelreview.com/content/view/1928/ [Accessed 3 June 2016].

Gössling, S., and Peeters, P., 2007. "It does not harm the environment!" An analysis of industry discourses on tourism, air travel and the environment. *Journal of Sustainable Tourism,* 15(4), 402-417.

Gössling, S., Bredberg, M., Randow, A. and Sandström, E., 2006. Tourist Perceptions of Climate Change: A Study of International Tourists in Zanzibar. *Current Issues in Tourism,* 9(4&5), 419-435.

Gössling, S., Haglund, L., Kallgren H., Revahl, M., and Hultman, J., 2009. Swedish air travellers and voluntary carbon offsets: towards the co-creation of environmental value? *Current Issues in Tourism*, 12(1), 1-19.

Gössling, S., Peeters, P., Hall, C. M., Ceron, J.-P., Dubois, G., Lehman, L. V., and Scott, D., 2011. Tourism and water use: Supply, demand and security. An international review. *Tourism Management, 33*(1), 16–28.

Gössling, S., Scott, D., Hall, C. M., Ceron, J.-P., & Dubois, G., 2012. Consumer behaviour and demand response of tourists to climate change. *Annals of Tourism Research*, 39(1), 36–58.

Greiner, M.A., and Franza, R.M., 2003. Barriers and bridges for successful environmental technology transfer. *Journal of Technology Transfer, 28*, 167–17.

Grote, M., Williams, I., and Preston, J. 2014. Direct carbon dioxide emissions from civil aircraft. *Atmospheric Environment*, 95, 214-224.

Hares, A., Dickinson, J., and Wilkes, K., 2010. Climate change and the air travel decisions of UK tourists. *Journal of Transport Geography*, 18, 466–473.

Hari, T.K., Yaakob, Z., and Binitha, N.N., 2015. Aviation biofuel from renewable resources: Routes, opportunities and challenges. *Renewable and Sustainable Energy Reviews,* 42, 1234-1244.

Hibbert, J.F., Gössling, S., Dickinson, J.E., & Curtin, S., 2013. Identity and tourism mobility: An exploration of the attitude-behaviour gap. *Journal of Sustainable Tourism*, 21(7), 999-1016.

Higham, J.E.S., Cohen, S.A., and Cavaliere, C.T., 2014. Climate Change, Discretionary Air Travel, and the “Flyers’ Dilemma”. *Journal of Travel Research,* 53(4), 462-475.

Higham, J.E.S., Reis, A., and Cohen, S.A., 2016a. Australian climate concern and the 'attitude-behaviour gap'. *Current Issues in Tourism*, 19(4), 338-354.

Higham, J., Cohen, S.A., Cavaliere, C.T., Reis, A., and Finkler, W., 2016b. Climate change, tourist air travel and radical emissions reduction. *Journal of Cleaner Production, 111(Part B)*, 336-347.

Hillery, M., Nancarrow, B., Griffin, G., and Syme, G., 2001. Tourist perception of environmental impact. *Annals of Tourism Research, 28*(4), 853-867.

International Food and Agricultural Trade Policy Council (IPC) and Renewable Energy and International Law (REIL), 2006. *WTO Disciplines and Biofuels: Opportunities and Constraints in the Creation of a Global Marketplace. IPC Discussion Paper October 2006.* Available from: http://www.agritrade.org/Publications/DiscussionPapers/WTO_Disciplines_Biofuels.pdf [Accessed 8 February 2017].

Jönsson, O., and Person, M., 2003. Biogas as transportation fuel. *Proceedings of Fachtagung Regenerative Kraftstoffe*, 13-14 November 2003, Stuttgart, Germany, 37-43.

Kivits, R., Charles, M.B., and Ryan, N., 2010. A post-carbon aviation future: airports and the transition to a cleaner aviation sector. *Futures, 42*(3), 199-211.

Kjelgaard, C., 2008a. Air Zealand Strives for Eco-Leadership. *Aviation*, 20 June. Available from: http://www.aviation.com/technology/080620-air-new-zealand-environment.html [Accessed 15 February 2017].

Kjelgaard, C., 2008b. Airlines Intensify environmental efforts. *Aviation*, 19 June. Available from: http://www.aviation.com/technology/080619-airlines-environmental-efforts.html [Accessed 17 June 2016].

Kousoulidou, M., and Lonza, L., 2016. Biofuels in aviation: Fuel demand and CO_2 emissions evolution in Europe toward 2030. *Transportation Research Part D: Transport and Environment*, 46, 166-181.

Krammer, P., Dray, L., and Köhler, M.O., 2013. Climate-neutrality versus carbon-neutrality for aviation biofuel policy. *Transportation Research Part D: Transport and Environment,* 23, 64-72.

Kumar, K., Roberts, C., Rothnie, I., Fresne, C.D., and Walton, M., 2009. Experiences of the multiple mini-interview: a qualitative analysis. *Medical Education,* 43(4), 360-267.

Lee, D.S., Pitari, G., Grewe, V., Gierens, K., Penner, J.E., Petzold, A., Prather, M.J., Scchumann, U., Bais, A., and Bertsen, T., 2010. Transport impacts on atmosphere and climate: aviation. *Atmospheric Environment,* 44(37), 4678-4734.

Lee, J., and Mo, J., 2011. Analysis of technological innovation and environmental performance improvement in aviation sector. *International Journal of Environmental Research and Public Health, 8*(9), 3777–3795.

Marsh, G., 2008. Biofuels: aviation alternative? *Renewable Energy Focus*, 9(4), 48-51.

McKercher, B., Prideaux, B., Cheung, C., and Law, R., 2010. Achieving voluntary reductions in the carbon footprint of tourism and climate change. *Journal of Sustainable Tourism*, 18, 297–318.

McCormick, K., and Kåberger, T., 2007. Key barriers for bioenergy in Europe: economic conditions, know-how and institutional capacity, and supply chain co-ordination. *Biomass and Bioenergy,* 31(7), 443-452.

Meuter, M.L., Ostrom, A.L., Bitner, M.J., Roundtree, A., 2003. The influence of technology anxiety on consumer use and experiences with self-service technologies. *Journal of Business Research, 56,* 899-906.

Moser, B.R., 2009. Biodiesel production, properties and feedstocks. In: *Vitro Cellular and Developmental Biology–Plant, 45*, 229–266.

Naik, S.N., Goud, V.V., Rout, P.K., and Dalai, A.K., 2010. Production of first and second generation biofuels: a comprehensive review. *Renewable and Sustainable Energy Reviews, 14*(2), 578-597.

Nair, S., and Paulose, H., 2014. Emergence of green business models: The case of algae biofuel for aviation. *Energy Policy*, 65, 175-184.

New York Times, 1925. *Ford predicts fuel from vegetation*. September 20th, 1925, p. 24.

Office for National Statistics, 2014. UK residents' visits and spending abroad by purpose and region of visit, 2013. Available from: http://www.ons.gov.uk/ons/rel/ott/travel-trends/2013/rft-travel-trends--section-5-uk-residents-abroad--2013.xls [Accessed 10 March 2017].

Pau, A., Jeevaratnam, K., Chen, Y.S., Fall, A.A., Khoo, C., and Nadarajah, V.D., 2013. The Multiple Mini-Interview (MMI) for student selection in health professions training–A systematic review. *Medical Teacher*, 35(12), 1027-1041.

Peeters, P., Higham, J., Kutzner, D., Cohen, S., and Gössling, S., 2016. Are technology myths stalling aviation climate policy? *Transportation Research Part D: Transport and Environment*, 44, 30-42.

Repo, A., Tuomi, M., and Liski, J., 2011. Indirect carbon dioxide emissions from producing bioenergy from forest harvest residues. *Global Change Biology Bioenergy*, 3(2), 107-115.

Ritchie, J., Spencer, L. and O'Connor, W., 2003. Carrying out qualitative analysis. In: J. Ritchie and J. Lewis (Eds). *Qualitative Research Practice*. London: Sage.

Rohracher, H., Bogner, T., Späth, P., and Faber, F., 2003. *Improving the public perception of bioenergy in the EU. Final Report.* Brussels: EU.

Sanfourche, J-P., 2001. Safety, environment, ATM: Three key issues! *Air & Space Europe*, 3(3-4), 201-202.

Saynor, B., Bauen, A., and Leach, M., 2003. *The Potential for Renewable Energy Sources in Aviation. Imperial College Centre for Energy Policy and Technology*, Imperial College, London.

Schulte, I., Hart, D., and van der Vorst, R., 2004. Issues affecting the acceptance of hydrogen fuel. *Hydrogen Energy*, 29(7), 677-685.

Scott, D., Peeters, P., and Gössling, S., 2010. Can tourism deliver its "aspirational" greenhouse gas emission reduction targets? *Journal of Sustainable Tourism*, 18(3), 393-408.

Shaw, S., and Thomas, C., 2006. Discussion note: Social and cultural dimensions of air travel demand: Hyper-mobility in the UK? *Journal of Sustainable Tourism*, 14(2), 209-215.

Siegrist, M., and Cvetkovich, G., 2000. Perception of hazards: the role of social trust and knowledge. *Risk Analysis*, 20(5), 713-719.

Silverman, D., 2000. *Doing Qualitative Research – A Practical Handbook.* London: SAGE Publications Ltd.

Srivastava and Hopwood, 2009. A Practical Iterative Framework for Qualitative Data Analysis. *International Journal of Qualitative Methods*, 8(1), 76-84.

Steenblik, R., 2007. *Biofuels—At What Cost? Government support for ethanol and biodiesel in selected OECD countries.* Geneva: The Global Subsidies Initiative of the International Institute for Sustainable Development (IISD). September 2007.

Tol, R.S.J., 2007. The impact of a carbon tax on international tourism. *Transportation Research Part D: Transport and Environment*, 12(2), 129-142.

Travel Agent, 2009. Eco-Friendly Air Travel. *Travel Agent*, 13 April 2009, p. 22.

Travel Trade Gazette-TTG Digital, 2013. Opinion: Over 55s is perfect market for agents to tap into. Available from: http://www.ttgdigital.com/news/opinion-over-55s-is-perfect-market-for-agents-to-tap-into/4686712.article [Accessed 06 March 2017].

Truong, V.D., and Hall, C.M., 2016. Corporate social marketing in tourism: to sleep or not to sleep with the enemy? *Journal of Sustainable Tourism,* in press.

Ulmer, J.D., Huhnke, R.L., Bellmer, D.D. and Cartmell, D.D., 2004. Acceptance of ethanol-blended gasoline in Oklahoma. *Biomass and Bioenergy,* 27(5), 437-444.

UNWTO-United Nations World Tourism Organization, 2007. *Climate Change and Tourism: Responding to Global Challenges. Advanced Summary.* Davos, UNWTO, October 2007.

UNWTO, 2016. *Tourism highlights.* UNWTO, 2016.

Upham, P., Tomei, J., and Boucher P., 2009. Biofuels, Aviation and Sustainability: Prospects and Limits. In: Gössling, S., and Upham, P. (Eds). *Climate Change and Aviation. Issues, Challenges and Solutions*. London: Earthscan, 309-328.

Veal, A.J., 2006. *Research methods for leisure and tourism: a practical guide.* Pearson Education Limited 2006.

van de Velde, L., Verbeke, W., Popp, M., Buysse, J., and Van Huylenbroeck, 2009. Perceived importance of fuel characteristics and its match with consumer beliefs about biofuels in Belgium. *Energy Policy,* 37(8), 3183-3193.

Wardle, D.A., 2003. Global sale of green air travel supported using biodiesel. *Renewable & Sustainable Energy Reviews,* 7(1), 1-64.

Warshay, B., Brown, J.J., and Sgouridis, S., 2016. Life cycle assessment of integrated seawater agriculture in the Arabian (Persian) Gulf as a potential food and aviation biofuel resource. *The International Journal of Life Cycle Assessment,* in press.

Weiland, P., 2010. Biogas production: current state and perspectives. *Application of Microbiology and Biotechnology, 85,* 849–60.

Wegener, D. T., and Kelly, J. R., 2008. Social psychological dimension of bioenergy and public acceptance. *Bioenergy research*, *1*(2), 107-117.

World Bank, 2008. *Biofuels: The Promise and the Risks.* Available from: http://siteresources.worldbank.org/INTWDR2008/Resources/2795087-1191440805557/4249101-1191956789635/Brief_BiofuelPrmsRisk_web.pdf [Accessed 8 March 2017].