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A review of tourism and climate change as an evolving knowledge domain

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ABSTRACT

The academic debate on tourism and climate change has expanded considerably in the last few years. This paper's narrative and systematic review of 459 English-language academic publications (1986 to 2012) synthesises the research on tourism and climate change, identifies key trends and social networks, and provides a critique for further discussion in this evolving knowledge domain. The analysis shows that the size of the field has grown, that research includes multiple dimensions (e.g., climate impacts, adaptation, mitigation, and policy), and that studies have become more integrative and critical. The co-authorship network is characterised by a core, which is disconnected from a more fragmented periphery, whereby the "centre of gravity" comprises a relatively small number of researchers who tend to co-author a large number of publications. The paper concludes that, overall, research on tourism and climate change has developed into a knowledge domain in its own right.

1. Introduction

Climate change and its potentially substantial impacts on tourism worldwide is a pressing issue. The last few years have seen considerable development in the academic debate on tourism and climate change, warranting a review article that examines the current state of knowledge, and provides a platform for further discussion (Atanassov, 2008). Researchers are now engaging in research critiques (Scott & Becken, 2010), and publicise dialogue that moves the field into a new phase of maturity and criticality in a sense of skilful, responsible and reflective thinking (Lai, 2011). The first published debate between researchers in the field focused on the validity of macroeconomic analyses of global tourist flows between Gössling and Hall (2006), and Bigano, Hamilton, Maddison, and Tol (2006). The exchange highlighted disciplinary differences and associated levels of pragmatism when attempting to model complex decision-making in a deterministic way. A second exchange, involving Hall, Buckley, Becken, and Scott (2008), was published in the form of a research probe in Tourism Recreation Research. This probe was partly initiated in response to substantial media coverage of tourism and climate change, and specifically emissions associated with air travel. In her section, Becken (2008, p. 352) pointed out that "the challenge of climate change is also an opportunity for tourism to become more systematic, smart, strategic and sustainable".

Weaver (2011) opened another constructive debate by proposing that the disproportional focus on climate change in the sustainable tourism literature is counterproductive to achieving tourism sustainability. Weaver put forward seven theses in support of this argument, concluding that "failure of the international community to arrive at a consensus for concerted action [on climate change] is therefore unsurprising" and hindered by the "rudimentary state of knowledge about the relationships between tourism and climate change, an apathetic and fickle travelling public and a reciprocally uncommitted tourism industry" (p. 13). Scott (2011) replied to Weaver's (2011) opinion piece by systematically providing information and views to counter the arguments and arrive at the conclusion that sustainable tourism research cannot afford to retrench from climate change research, especially when a longer term and global view of sustainability is taken. Recently reported climate assessments would strengthen Scott's appeal for perseverance in addressing climate change in sustainable tourism research. Research has shown that the Intergovernmental Panel on Climate Change (IPCC, 2007) findings are conservative, and that many components of the climate are already changing near or even beyond the upper ranges of the IPCC projections (Allison et al., 2009).

A fourth academic exchange is noteworthy as it illustrates increasing reflectivity, but also shows how authors' positions on the 'sustainability' spectrum shape their views on the sustainability of tourism and the role of climate change within it. In his article on pathways to sustainable mass tourism, Weaver (2012a) articulates that recent contextual factors (including the global financial crisis) provide a fertile environment in which the growth paths of tourist destinations will converge towards a state of sustainable mass tourism. Peeters (2012) criticised Weaver's interpretation as one that reinforces a (unsustainable) growth paradigm, ignores the transit route as part of tourist systems, and misinterprets the role of aviation in global climate change. Weaver's (2012b) rejoinder indicates that these differing viewpoints are partly informed by varying levels of 'hope versus gloom' in relation to sustainable development of society more broadly, and specifically to the demonstrated urgency of the climate change issue.

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These debates suggest that engagement with tourism and climate change has reached a new level, in which researchers are increasingly interacting with each other's research. The development of communities of practice builds on the common ground of a knowledge domain, which relates to the content of a particular field of knowledge, key issues and the shared value of the knowledge to its members (Hu & Racherla, 2008; Wenger, McDermott, & Snyder, 2002).

The development of a knowledge domain with its evolving structure of social processes encourages further expansion of knowledge in this field, as researchers begin to identify with the domain and put their research into a broader context. Social networks are therefore "inextricably linked" (Hu & Racherla, 2008, p. 303) with knowledge creation. As in other fields, knowledge on tourism and climate change is the result of collecting data and information, organising and processing it, and providing analysis and synthesis for different purposes. Often the motivation for research is to achieve technical improvements (e.g. in relation to management or improvement of skills), but research can also be driven by generating (intrinsic) insight and understanding, or facilitate emancipation (Habermas, 1978, in Xiao & Smith, 2007). Different research paradigms underpin these three types of research pursuit: positivism, constructivism, and critical theory.

This review has several aims and is structured into three main components. First, a quasi-systematic review on the state of knowledge is provided. Second, a systematic analysis of key trends and social networks relevant to the field of tourism and climate change is undertaken. And, third, a critique of the evolving knowledge domain is presented. The review is guided by the underlying proposition that tourism and climate change is an evolving knowledge domain.

2. Methodology

The comprehensive review of tourism and climate change involved several steps. First, an inventory of all published English-language articles in the field was created. This resulted in a database, which was used for the quasi-systematic and the systematic review, and for the critique.

2.1. Compiling the database

The database includes academic publications but excludes reports or other non-peer-reviewed outputs. Book chapters and books were included since they are typically peer-reviewed, and play an important role in the dissemination of academic knowledge. It is possible that chapters that were published in books with a much broader focus than tourism and climate change remain undetected. For pragmatic reasons, only papers published in the English language are part of this review. As a starting point, the inventory built on Scott, Jones, and McBoyle's (2006) bibliography on climate, tourism and recreation, and Becken and Hay's (2012) reference list (as the most recent book covering tourism and climate change comprehensively). The resulting database was then expanded by a keyword search using the extensive online databases of Science direct, Scopus and Google Scholar, as well as examining the reference lists of key papers in the field. Finally, the database was verified (and slightly enhanced) using Zeppel's (2011) research compendium on climate change and global tourism.

For a publication to be included in the database it needed to specifically address topics related to tourism and climate change, for example the reduction of energy use and greenhouse gas emissions, climate change impact modelling, tourism adaptation to climate change, and climate change policy. While the majority of papers in the database constitute unambiguously core papers (e.g. those with tourism and climate change in the title), there are a number of publications at the periphery of the field that required further assessment for inclusion. Some of these make an important contribution even though they may not have been written specifically for tourism and climate change. A prominent example is research on aviation and climate change. A simple keyword search on 'aviation and climate change' in Science direct, however, yielded 4043 articles. To narrow the focus, the procedure involved selecting articles that either directly mention tourism or have been repeatedly used as inputs into tourism–climate change articles, such as Lee et al.'s (2009) paper on aviation's contribution to global climate change. Similar situations occurred in other areas that are relevant but not necessarily core to tourism and climate change, for example sustainable tourism, ecotourism, auditing and certification.

Information collected in the database included authors, year of publication, title, outlet (e.g. name of journal), geographic focus, and a high-level categorisation into the sub domains of Adaptation, Mitigation, Policy, or an integrative approach to these. Only up to four authors were recorded for reasons of database management and with the argument that authors listed in fifth or later order are likely to have made a minor contribution to the publication. The final database contained 459 publications with 539 unique authors. The full content of the papers was considered in the quasi-systematic review and the critique. It is acknowledged that the process of selecting publications (especially non-core ones) involved some subjectivity, and it is possible that there remain relevant publications that were not included in the database. Overall, however, it is unlikely that the potential omission of a small number of English publications would change the nature and results of this review. The omission of non-English literature is potentially a larger issue and deserves more attention in future research.

2.2. Analysis

The articles compiled in the database were first analysed with a view to producing a subjective narrative (Cooper 1989, in Bontekoning, Macharis, & Trip, 2004) of the key themes explored in tourism and climate change research. Such a quasi-systematic review provides a description, summary and synthesis of the publications to date, with the aim of initiating a discussion about the findings and methodologies employed (Atanassov, 2008). This part of the review is subjective in nature. In addition, excel in combination with SPSS 20.0, was used to undertake a systematic and objective review, by analysing trends and generating statistics that describe the field (e.g. publications per year or country).

The systematic review was enhanced by a social network analysis, using UCINET software (Borgatti, Everett, & Freeman, 2002). The network analysis focused on describing and understanding the role of individual researchers (egocentric analysis) and the links between them (socio-centric analysis) (Racherla & Hu, 2010). For the purpose of assessing how the domain evolved in terms of how 'knowledge stakeholders' (Xiao & Smith, 2007) collaborate and produce new knowledge, a co-authorship analysis generates useful insights. Thus, based on the complete database of 459 publications, a separate file was created that compiled all individual relationships between pairs of authors. For example, a publication with 3 authors would yield 3 separate links (A with B, A with C, and B with C). For this particular part of the analysis, the links were categorised as undirected, which means that there is no difference in the order of authorship. UCINET then allowed for calculation of network metrics and visualisation of relationships between authors in the form of a network map. Finally, a critique is provided to assess progress in the evolving knowledge domain of tourism and climate change, to point out gaps, and to identify further research needs.

3. Main themes in tourism and climate change research

Most publications on tourism and climate change relate to climate change impacts and adaptation (50%). Mitigation papers make up 34%, and publications with a focus on policy or integrative papers (e.g. across mitigation and adaptation) each contribute 8%. The two latter types of papers are relatively more prominent in the last decade. The main topics of research on climate change adaptation, mitigation and policy are synthesised below, but quantifications are avoided, as it is often difficult to assign a study to a single theme (Table 1). Not all publications

Table 1
Main themes and methods applied in research on climate change adaptation, mitigation, and policy.

	Key themes	Methods
Impacts and adaptation	— Winter/snow tourism — Coastal tourism — Special interest tourism (e.g. golf) — Protected Areas and tourism — Last chance tourism — Biometeorology — Tourist behaviour and flows — Disaster risk reduction — Specific adaptation options (e.g. derivatives)	— Quantitative and qualitative vulnerability assessments — Climate impact modelling — Economic modelling — Quantitative and qualitative behaviour analysis (surveys, interview, and focus groups) — Delphi survey — Tourism Climate Index — Stakeholder workshops — Indicator development
Mitigation	— Carbon inventories/footprints — Energy efficiency and renewable energy — Low-carbon mobility — Aviation — Accommodation energy use — Tourist perceptions/attitudes — Stakeholder perceptions/attitudes — Corporate social responsibility	— Environmental (footprint) accounting — Carbon accounting — Energy audits — Scenario analysis/backcasting — Feasibility study — Quantitative and qualitative behaviour analysis — Quasi-experiments
Policy	— Carbon tax — Emissions trading scheme — Carbon offsetting — Public policy — Policy perceptions — Geopolitical impacts	— Econometric modelling — Computational General Equilibrium modelling — Quantitative and qualitative behaviour analysis — Policy analysis (e.g. content analysis) — Scenario analysis

captured in the inventory are cited in the text below; instead representative examples are used to illustrate key points.

3.1. Impacts and adaptation

The focus of publications addressing climate change impacts on tourism and adaptation options has been, and remains, on winter tourism (48 publications specifically dealing with this topic). The geographic focus is the European Alps (Abegg, König, Bürki, & Elsasser, 1998; Elsasser & Messerli, 2001) and North America (e.g. Lipski & McBoyle, 1991). In recent years, there has been a broader geographic diversity of winter sport and climate change studies (Hennessy et al., 2008; Landauer, Pröbstl, & Haider, 2011; Tervo, 2008). Methods and models to assess vulnerabilities (Falk, 2009; Uhlmann, Goyette, & Beniston, 2009) and adaptation options (Bank & Wiesner, 2011; Hoffmann, Sprengel, Ziegler, Kolb, & Abegg, 2009) have become increasingly sophisticated. Research on the biophysical impacts of climate change on winter sport and its adaptation is complemented by studies on tourist behaviour and changes in demand (Pickering, Castley, & Burtt, 2009; Shih, Nicholls, & Holecek, 2009).

Relatively less attention in terms of numbers of studies (14 studies explicitly examine coastal tourism) has been paid to coastal tourism (e.g. Lohmann, 2001; Moreno, 2010), although there has been a recent focus on 'disappearing destinations' (or last chance tourism) and island tourism in relation to climate change (Becken, Hay, & Espiner, 2011; Jones & Phillips, 2011; Lemelin, Dawson, Stewart, Maher, & Lueck, 2010). Vulnerability assessments of coastal tourism (e.g. Moreno & Becken, 2009) have been undertaken at the global level (Perch-Nielsen, 2009) and for specific coastal destinations (Coombers, Jones, & Sutherland, 2008; Perry, 2005) or activities (Lambert, Hunter, Pierce, & MacLeod, 2010). Climate change impact research also covered how other tourist activities might be influenced by changes in climate parameters, for example golfing (Nicholls, Holecek, & JeongHee, 2008), visitation of national parks (Hadwen, Arthington, Boon, & Taylor, 2011; Richardson & Loomis, 2005; Scott, Jones, & Konopek, 2007), and cruise ship expeditions in polar regions (e.g. Stewart, Tivy, Howell, Dawson, & Draper, 2010).

The tourism and climate change literature has been occupied for a long time with understanding how climate change might impact on tourism demand and tourist flows. This research builds on related studies in the field of biometeorology, which seek to identify 'comfortable' conditions for tourists, for example via climate indices (Braun et al., 1999; Matzarakis & Amelung, 2008). The body of literature on climate as a resource for tourism has continued to grow with more details on potential shifts in visitation patterns (Endler, Oehler, & Matzarakis, 2009; Hein, Metzger, & Moreno, 2009; Rossello-Nadal, Riera-Font, & Cardenas, 2011), as well as critiques of simplistic analyses (Rutty & Scott, 2011). Some studies have also analysed the potential changes in environmental resources due to climate change and implications for tourism demand (Nyaupane & Chhetri, 2009; Prideaux, Coghlan, & McNamara, 2010; Uyarra et al., 2005).

Recently, adaptation research has begun to investigate how to engage tourism businesses and other stakeholders in climate change adaptation (Nicholls & Holecek, 2008; Turton et al., 2010). Bicknell and McManus (2006) noted that tourism stakeholders involved in the ski industry did not see an urgency to address climate change, as investment cycles for that industry are typically less than 10 years. Implementation costs and low returns on investment were also identified as barriers in relation to water use efficiency measures (Charara, Cashman, Bonnell, & Gehr, 2011). Turton et al. (2010) found that the tourism sector is not yet ready to invest in climate change adaptation because of the perceived uncertainties in the magnitude of climate change and related environmental impacts, and responsibility was seen to rest with the public sector and not with the industry. A number of extreme events that impacted on tourism in recent years have sparked more interest in climate change adaptation and disaster reduction (Becken & Hughey, submitted for publication; d'Mello, McKeown, & Minninger, 2009).

3.2. Mitigation

In response to pressure on tourism to address its greenhouse gas emissions, an increasing number of carbon measurement exercises have been published. Popular methodologies include energy audits and 'carbon footprinting', ecological footprinting, and life-cycle analysis (Filimonau, Dickinson, Robbins, & Reddy, 2011; Gössling, Borgström Hansson, Hörstmeier, & Saggel, 2002). A consistent approach and scope, for example the inclusion of indirect emissions such as those related to supply chains or construction of tourism assets (Rossello-Batle, Moia, Cladera, & Martinez, 2010) is still lacking. The greenhouse gas inventories have focused on the country-level (e.g. Dwyer, Forsyth, Spurr, & Hoque, 2010; Wu & Shi, 2011), tourist destinations (Lin, 2010; Walz et al., 2008), sub-sectors (Nepal, 2008) and events (Otto & Heath, 2009).

Mitigation responses by the tourism industry have been of growing interest to researchers, especially in relation to aviation (e.g. Bows, Anderson, & Peeters, 2009; Sgouridis, Bonnefoy, & Hansman, 2010). Research on tourism transport more broadly has investigated its contribution to global mitigation (Peeters & Dubois, 2010), tourist travel and itineraries (Becken, 2005; Becken & Schiff, 2011; Peeters, Szimba, & Duijnisveld, 2007), specific subsectors (e.g. cruise ships, e.g. Howitt, Revol, Smith, & Rodger, 2010) and 'slow travel' (e.g. Dickinson & Lumsdon, 2010). Sixteen studies on energy use or climate change have been published for the accommodation sector (Bohdanowicz & Martinac, 2007; Priyadarsini, Xuchao, & Eang, 2009). Research on emissions associated with different types of accommodation has been complemented with studies on operators' perceptions of energy use (Bohdanowicz, 2006), and the potential for greater use of renewable energy sources in tourism (Bode, Hapke, & Zisler, 2003; Dalton, Lockington, & Baldock, 2008). The tourist activity and attraction sectors have received limited attention in relation to energy use or greenhouse gas emissions (Aall, 2011; Becken & Simmons, 2002).

Major growth in the literature (with 23 dedicated papers to date) has occurred in relation to tourist behaviour and climate change mitigation. A key question seems to be whether tourists change their travels to reduce their impacts on the global climate or not (e.g. Dickinson & Lumsdon, 2010; Lassen, 2010; Weaver, 2011). Results are ambiguous, although there is some indication that the environmentally aware and educated tourists are amongst the most frequent travellers (McKercher, Prideaux, Cheung, & Law, 2010). Moreover, research indicates that when on holiday people's propensity to engage in climate mitigation is reduced, compared with every-day life (Barr, Shaw, Coles, & Prillwitz, 2010). Higham and Cohen (2011), on the other hand, found first indications of a 'social tipping' point that might result in a decreasing popularity of long-haul travel due to its climate impact. The question whether there are certain tourist segments that might be particularly amenable to climate change mitigation has been explored (Mair, 2011), but the small numbers of those who do actually carbon offset reduce the reliability of such segmentation analyses. The role of carbon offsetting as a means to avoid further growth emissions from tourist travel has received some attention (Brouwer, Brander, & Beukering, 2008) and criticism (Gössling et al., 2007).

3.3. Policy for climate change and tourism

While tourism stakeholders are becoming more involved in planning for, and responding to, climate change, academic research on tourism policy related to climate change is still sparse. The majority of policy-related publications address the tourism impact of carbon taxes or emissions trading schemes, especially in the context of aviation (Hihara, 2010, Mayor & Tol, 2007). A small number of studies have specifically investigated the effect of aviation policies on developing countries (Gössling, Peeters, & Scott, 2008; Pentelow & Scott, 2011), but impacts appear to be minimal. Concerns have also been raised that increasing travel demands of a growing world population are not reconcilable with the climate policy targets of the international community (Gössling, Hall, Peeters, & Scott, 2010).

In a Delphi study involving 70 tourism experts from Europe, companies and state authorities were perceived to be the key agents responsible for dealing with climate change. The top two actions for companies were to 'prioritise the use of renewable energies' and 'prioritise energy savings'. Public authorities were seen to be responsible for adopting 'integral destination management' and to 'promote greater environmental awareness' (Valls & Sardá, 2009). However, analysis of existing policies reveals major gaps. National climate change strategies, for example, may be at odds with tourism growth strategies, poorly integrated with tourism (Becken & Clapcott, 2010), or ill-enforced (Yaw, 2005). There is also evidence that some tourism stakeholders do not consider climate change to be a major problem and that communication amongst different government departments is insufficient (Dodds & Kelman, 2008). Countries with strong climate change policy frameworks are also more likely to show interest in tourism-specific policies to address climate change (Becken & Hay, 2012). Corporate policies on climate change (Cowper-Smith & de Grosbois, 2011) and sustainability motivations (Lynes & Andrachuk, 2008) have been examined as well, but their existence is limited, especially in the area of climate change adaptation.

4. Main trends

The number of publications on tourism and climate change has increased substantially since the first papers were published in 1986. The first 14 years saw less than five publications per year (Fig. 1). This increased to an intermediate peak of 11 publications in 2001 (with the first papers specifically addressing tourism's emissions), followed by a rapid increase in publications from 2005 (34 publications) to a maximum of 83 publications in 2011. 2012 already counts 25 publications.

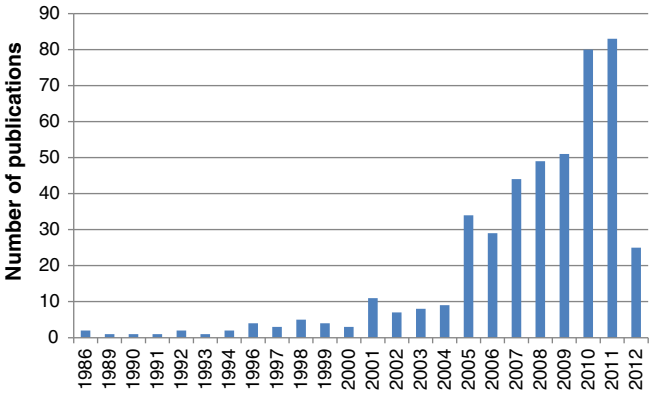

Fig. 1. Number of publications per year between 1986 and 2012.

Book chapters (108) were the most frequent outlet for publications on tourism and climate change. Most are part of the eight edited books on this topic. Seven books were authored books (three of which were published doctorates). The single most important journal publishing tourism and climate change articles was the Journal of Sustainable Tourism with 49 papers, contributing 14% of all journal publications. Out of the other top ranking tourism journals, Tourism Management (21 papers) was the only one that attracted a large number of papers in this field. Much of the remaining research has been published in climate (e.g. 14 papers in Climatic Change), transport (e.g. 9 in Journal of Transport Geography) or environmental journals (e.g. 6 in Ecological Economics). In total, research on tourism and climate change has been published in 109 different journals. Of these, 77 are non-tourism (or leisure) journals, indicating the diversity of disciplines involved in the field.

Geographically, research on tourism and climate change is clearly centred on a small number of Western world tourist destinations, namely Canada (40 studies), Australia (38), USA (33), UK (30), and New Zealand (24). If research on Switzerland (14) and Austria (14) was combined into a group called 'Alps', it would rank higher than studies focusing on Europe more broadly (21), indicating the significant attention that this geographic area has received. Eleven specific studies addressed the Mediterranean, the world's largest tourist destination, mostly from an impacts and adaptation perspective. A considerable number of studies (N = 53) took a global focus, either by specifically analysing global issues (e.g. global tourist flows, Amelung, Nicholls, & Viner, 2007) or by integrating research across a larger number of case studies from around the world (Gössling et al., 2005). In more recent years, interest in how climate change might affect developing countries has increased (e.g. Peeters, 2009), but research that broadly deals with developing countries is still very limited (8 publications). Several individual developing countries have attracted some research, for example Nepal and Fiji with each three publications. The increase of research focusing on China is notable, with the first paper published in 2008 and all other six publications being from 2011.

5. Authors and their networks

The researchers are an essential part of a knowledge domain and it is therefore of great interest to identify key authors, their relationships, and the network as a whole (Ye, Song, & Li, 2012). Table 2 identifies Prof. Scott as the most prolific researcher in terms of overall publications (and third based on first or sole authorship), and most connected to other authors (degree of 25, reflecting co-authorship with 25 unique authors). Some authors contribute to the field typically in the lead authorship role (e.g. Dr. Dodds and Prof. Becken) whereas others publish more often as second (or more) co-author (e.g. Professors Tol and McBoyle). A large number of co-publications with reoccurring partners as indicated in Table 2 poses a risk of inflating the field without necessarily adding 'fresh thinking'. A substantial number of 44 unique authors published

Table 2
Number of publications and measures of centrality and power for key authors.

	Publications	First/sole author	Degree	Bonacich power[a]	Betweenness	Collaboration partners
Scott	44	17	25	4697	4232	Gössling (11×), McBoyle (9×), Jones B. (8×), Dawson (6×), Hall M. (5×)
Gössling	31	23	25	4302	2014	Scott (11×), Peeters (9×), Hall M. (8×), Ceron (5×)
Becken	28	24	12	2064	1478	Simmons (6×), Hay (3×)
Peeters	20	10	16	3062	1309	Gössling (9×), Ceron (3×)
Hall M.	19	12	6	1994	571	Gössling (8×), Scott (5×)
Amelung	13	6	10	1183	1624	Moreno (3×), Nicholls (2×) Viner (2×)
Dawson	12	5	15	2056	958	Scott (6×), Stewart (4×)
Tol	12	1	8	16	16	Bigano (4×), Mayor (3×), Hamilton (3×)
Wall	11	7	4	1018	326	Scott (2×)
Ceron	11	3	8	2476	129	Dubois (8×), Gössling (5×), Peeters (3×)
McBoyle	10	1	8	1752	396	Scott (9×), Wall (3×)
Moreno	10	6	6	1140	398	Amelung (3×)
Dickinson	9	5	6	11	18	Robbins (5×), Lumsdon (3×)
Nicholls	8	6	6	209	460	Holecek (3×), Amelung (2×)
Jones B.	8	3	5	1336	15	Scott (8×)
Simmons	8	1	4	333	565	Becken (6×)
Matzarakis	7	2	7	1041	468	Endler (3×)
Dodds	7	6	5	8	17	Graci (3×)
Buckley	6	5	2	3	3	No repetition

[a] There is an alternative theory of power, which suggests that the more links a person has to people that are not well connected, the greater that person's power is, as these others depend on him/her. This metric could be calculated by choosing a negative beta value.

solely on their own, and are therefore not connected to the network via co-authorship.

The 'centrality' of an individual in the network can be analysed by a number of measures in addition to the degree to which they are linked with others. Two commonly used measures are power (in this case Bonacich power with a beta of 0.13) and betweenness (Table 2). Power takes into account not only the author's own links, but also the degree to which the author he or she relates to is linked into the network. In other words, the more connections one has with well-connected researchers, the greater the power. Prof. Ceron is a good example of a researcher who is linked to a number of authors that are well connected, giving him a higher value of power (2476). Betweenness measures the amount of research activity flowing through a particular node (i.e. author) to other nodes in the network. This means that authors with a high betweenness are important in providing links between other members of the network (Ye et al., 2012). The high value of 4232 for betweenness of Prof. Scott confirms the connector role he plays in the field of tourism and climate change. The most common co-authorships are summarised in the last column of Table 2. As indicated above, a high degree of interconnection is noteworthy.

Visualisation of the network is first presented for the network's publications between 1986 and 2006 (N = 98) (Fig. 2). Clearly, the first 20 years of research into tourism and climate change highlight a disconnected and insular network. While subgroups have begun to form (e.g. one around Gössling, Peeters and Becken, one with Bürki, Elsasser, König and Abegg, and another one around Wall, Scott and McBoyle), they are not connected with each other. To investigate how the network has evolved, co-authorships for all years have been visualised (Fig. 3). The network has become more complex, diverse and inter-connected. Importantly, the network shows a relatively large and dense core, and a periphery that is not connected to the core. The early sub-groups of Professors Gössling, Scott, Becken and Peeters have all merged into one, and new smaller groups emerged outside it, for example those including Prof. Buckley and Dr. Pickering, Prof. Tol, and another one including Professors Lumsdon, Dickinson and Robbins. The group of Swiss researchers around Prof. Elsasser has remained independent from the core group, as in the earlier network (Fig. 2). An interesting 'satellite' including Professors Dwyer and Forsyth is linked to the core (through Prof. Simmons) but remains at the margin.

As a whole, the network has grown in size. Before 2006, there were 102 authors and 138 links in the network (sole authors do not collaborate and are not considered in this analysis). This compares to 495 authors and 679 unique links for all years until today. The average number of authors for each publication was 2.1 before 2006 and 2.2 for all years, indicating greater number of authors per paper over time. The overall density of the network, i.e. the ratio of the number of links to the number of possible links has decreased somewhat over time (from 0.013 to 0.003). This means that while both the number of network participants and authors per publication have increased, the total connectivity amongst different research groupings has decreased. This is also evident in the component ratio, which indicates the proportion of groups that are isolated. The closer the ratio is to 1, the more groups are isolated. The values are 0.386 for the years before 2006, and 0.482 for all years, indicating greater isolation.

6. Critique

There is no doubt that research on tourism and climate change has developed substantially. The number of publications for the years of 1986 to 2005 compared with the years 2006 to 2012 increased from 98 to 361; an increase of 368%. Already, the years of 2011 and 2012 together count 108 publications. With its total number of 459 publications, the field is comparable with research on hospitality with 331 publications and 441 unique authors between 2001 and 2005 (Hu & Racherla, 2008). However, it is naturally smaller than the broader field of 'human dimensions of global change', which comprised 2266 papers and 3860 authors between 1967 and 2005 (Janssen, Schoon, Ke, & Börner, 2006). Proliferation in output alone is not a sufficient measure to assess how a field is evolving as a knowledge domain. Evidence of debates summarised in the introduction of this review originate from intrinsic research motivations, rather than instrumental ones, and this may be an indication of increasing maturity of the field. The diversity of outlets, representation of disciplines, geographic spread, and breadth of research paradigms and methods are important dimensions of a knowledge domain, and will be discussed below.

While the single largest means of publication is book chapters, the remaining 351 papers are spread across an impressive number of 109 journals, most of which are not tourism journals. Naturally, these include climate change journals, but they also reflect a broader pool of disciplines from which research on tourism and climate change originates. Examples include Ecological Economics, Journal of Cleaner Production and Regional Environmental Change. The earlier

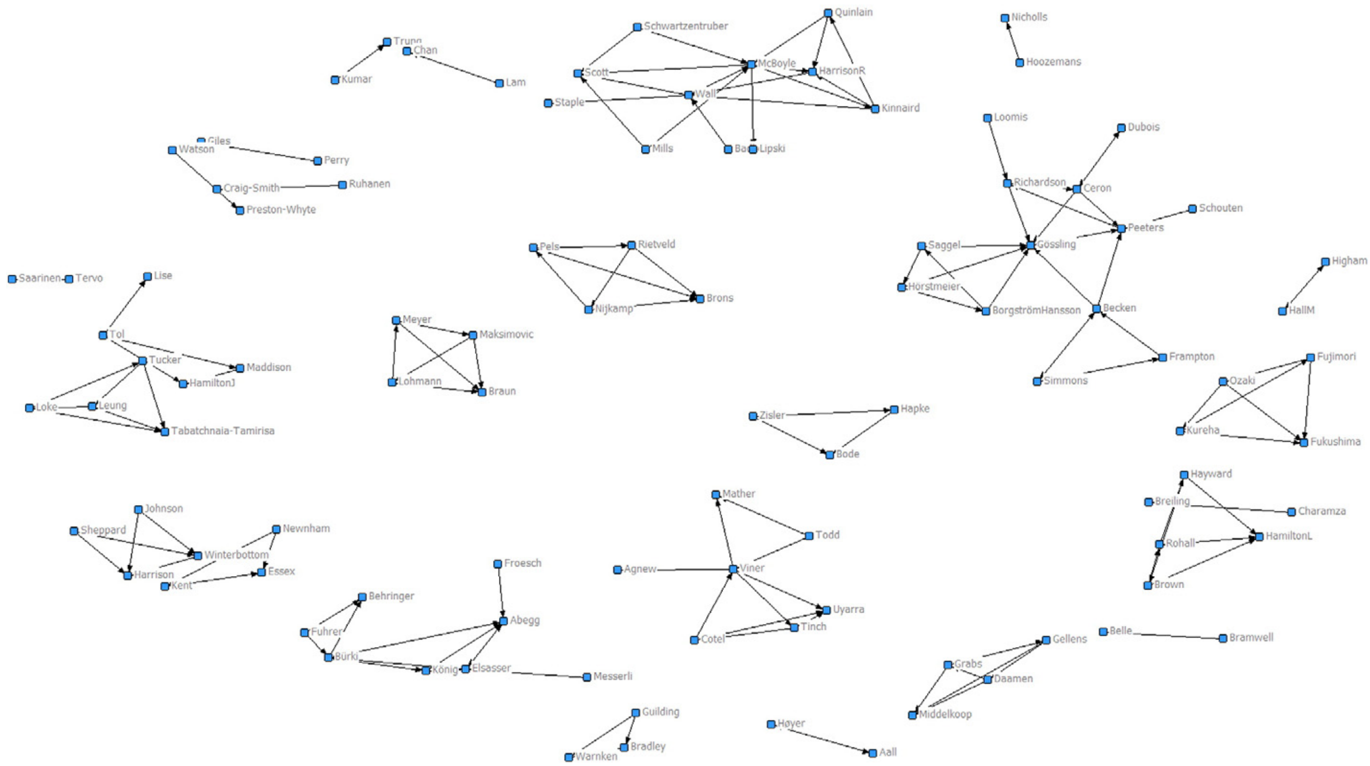

Fig. 2. Visualised network for publications before 2006 (layout spring embedded geodesic distance 5).

publications mostly reflected disciplinary backgrounds of geography or environmental science (e.g. Elsasser & Messerli, 2001), but more recently there is clear evidence of cross-fertilisation from other backgrounds, including the entry of authors into the field with distinct backgrounds in disciplines such as sociology (Urry, 2008), planning (Hof & Schmitt, 2011), and engineering (Rossello-Batle et al., 2010). While integrative studies are still a minority, and research rarely offers solutions instead of problems, recent books, amongst others, are beginning to address

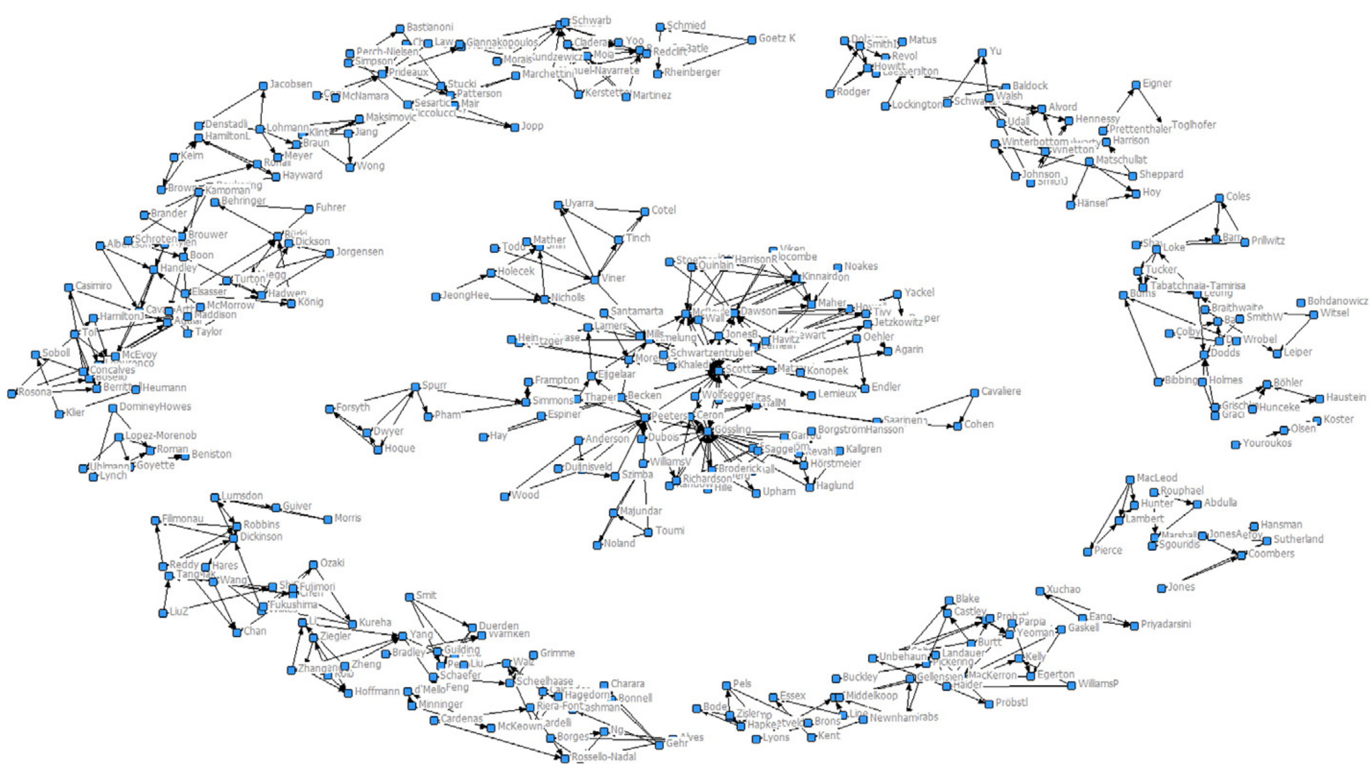

Fig. 3. Visualised network for publications between 1986 and 2012 (layout spring embedded with a geodesic distance of 7; 'pendants', i.e. nodes with degree 1 deleted).

this gap. Examples include Gössling's (2010) book on carbon management and Becken and Hay's (2012) book on policy and practice case studies from around the world.

In their Journal of Sustainable Tourism editorial, Scott and Becken (2010) criticised the geographic concentration of research on tourism and climate change. While these shortcomings still hold true to some extent, there is clear indication that researchers are addressing these gaps. For example, a larger number of publications now pay attention to climate change issues in developing destinations, and even more encouragingly, researchers are emerging from these countries, and are contributing to the growing body of knowledge. Recent publications from China are a good example of this trend, even though Chinese research on tourism and climate change seems to be limited to aspects of energy and greenhouse gas emissions (Yang, Li, Zheng, & Zhang, 2008). Pertinent issues such as the melting of Himalayan glaciers, increasing water constraints and extreme weather events in China, and their impacts on tourism have not yet been published in the English literature. More explicit integration of non-English knowledge is an important next step in the advancement of the field and its network.

The publications analysed for this review paper reflect a wide range of research paradigms, including positivist, constructivist, interpretivist and critical theory. The focus, however, is clearly on positivist research. The most common research methods in this domain, as shown in Table 1, are atmospheric and biophysical modelling (e.g. snow densities), economic modelling (e.g. using econometrics, contingency valuation, input–output analyses, and computable general equilibrium models), and behavioural analyses using quantitative approaches (e.g. factor and cluster analyses). Increasingly, other research methods, such as interviews, focus groups, Delphi surveys, and document and policy analysis, are employed. In addition, meta-analyses (e.g. Filimonau et al., 2011) and debates are now published with the explicit focus of advancing the field as a whole rather than just 'adding another piece in the jigsaw puzzle'. The co-existence, and ideally interaction, of research that originates from different paradigms and employs different methods, strengthens the field. Such an epistemological plurality avoids being locked into one particular paradigm, reducing the risk that research becomes self-referential. Depth of the field is also achieved by increasingly recognising complexities and overcoming some of the more simplistic assumptions made earlier in the field (e.g. the Mediterranean 'becoming too hot', see Rutty & Scott, 2010). There is still ample of room for developing more sophisticated research approaches that address aspects of multi-scale, multi-issues, and multi-actor problems, and that successfully integrate across different types of knowledge (i.e. using a transdisciplinary approach).

The lack of research on tourism and climate change policy is still evident, with a current focus on economic impact analyses of aviation policies. However, more complex questions, for example those related to the north–south social inequities of tourism and climate policy, remain sparsely researched (e.g. Peeters, 2009). The dearth of research on developing countries' dependencies on tourism, the impacts of mass tourism, the political dimensions of carbon offsetting, the effects of increased extreme events in countries with a low adaptive capacity, and the general geopolitics of tourism are closely related to a lack of research on tourism and ethics. Tourism and climate change lends itself as a prime domain for more research into the moral dimensions of tourism and inequality of our societies, but this remains largely untapped. Future research into policy, geopolitics and ethics calls for the use of new research paradigms, including those built on complexity and critical theory. Researchers with experience in political ecology, for example, could make an important contribution to this research domain.

Researchers and their networks are at the heart of a knowledge domain. A co-authorship network analysis highlighted the centrality of a small number of authors, as well as their collaboration style, for example in relation to lead authorship. The egocentric analysis presented in this review also emphasised the existence of so-called 'cliques', which is most evident in the considerable repetition of co-authorship amongst some scholars (Table 2). Considering that these cliques produce a large number of publications there is a risk that the field looks larger than it is and the penetration of new thinking is constrained. Thus, a situation where a small number of academics largely publish for each other (Xiao & Smith, 2007) seriously undermines the evolution of tourism and climate change as a knowledge domain. This becomes even more problematic when a small number of researchers are disproportionally involved in journal peer review, thus potentially acting as gatekeepers to the field. At the same time, however, an increasing number of new researchers enter the field, providing fresh thinking and new approaches. In some cases there may be a risk of researchers 'jumping on the climate change band wagon' by producing research that does not build sufficiently on the existing body of knowledge. Such publications could add to a dilution of the field rather than adding depth to it. Future research could undertake a citation analysis to investigate some of these issues further.

The tight partnerships amongst some authors became also evident in the socio-centric analysis of the network as a whole. The visualisation of research collaborations for two periods of time (1986 to 2005 and 1986 to 2012) has shown that tourism and climate change has grown from a fragmented and insular network to a much more connected and complex one. The earlier network (Fig. 2) is in a pre-paradigmatic phase with a number of small research communities working on their own problems and using their own definitions and concepts (Bontekoning et al., 2004). Over time, however, two developments occurred. One, a number of the earlier groupings merged into one big core of the network, and second, a substantial number of new small groups have emerged at the periphery. These have no links to the core, and are often not connected with other peripheral groups. As a result, despite the overall growth of the network, its density has decreased. It is noteworthy though that the density of the tourism and climate change network is still higher than that of other tourism research networks (Hu & Racherla, 2008; Racherla & Hu, 2010).

Importantly, while there is a clear core-periphery structure to the social network of co-authors involved in tourism and climate change research, it is at the core that most of the integrative (e.g. across the main themes discussed earlier) research occurs. Researchers at the network core have been involved in research across all dimensions of the field, namely climate impacts and adaptation, mitigation, and policy. These researchers have also presented increasingly critical assessments of more complex issues, for example the impact of mitigation policies on developing countries. In contrast, the groupings at the periphery are typically more concerned with a one-dimensional aspect of the field, for example the development of tourism carbon footprints. Overall, it appears that researchers interested in tourism and climate change are now 'fine tuning' (e.g. see opening of this article) their consensus on definitions and problems to be investigated, thus reaching a state of 'normal science' (Bontekoning et al., 2004), or even post-normal science.

Post-normal science is characterised by facts that are uncertain, interpretations of facts that are influenced by values, and high stakes of research and implementation outcomes (Funtowicz & Ravetz, 1991). Further, post-normal science demands the involvement of the tourism industry, government and other public actors in the production and consumption of knowledge. In, Scott (2011, p. 19) argued that the "field is now developing a critical mass of knowledge and research techniques better suited to deliver relevant knowledge for government and the private sector" and Scott and Becken (2010, p. 27) claimed that the field has moved beyond mere "awareness raising". Indeed, one reason for limiting the analysis to the peer-reviewed scope was that there are a large number of non-academic reports, presentations and policy documents, which in themselves would constitute an important future research topic. A prominent example is the UNWTO, UNEP and WMO (2008) report written by eight key researchers (six of whom appear in Table 2) as a background document to the second international conference on climate change and tourism.

There are many other examples of governments, international organisations, tourist destinations, businesses, industry associations or non-governmental organisations that have commissioned research on tourism and climate change. Thus, the existence of a substantial academic body in addition to strong evidence of a stakeholder community that engages with this knowledge supports the proposition that tourism and climate change research has developed into a knowledge domain. An analysis of how authors of the non-peer reviewed studies relate to the academic network studied in this paper would be of great interest to understand better how the generation of academic knowledge translates into sector-relevant knowledge. Finally, for the purpose of examining integration of tourism and climate change research with other domains of interest, for example aviation or sustainable tourism (i.e. Weaver's (2011) concern), an analysis similar to Jannsen et al.'s (2006), where the links between different but conceptually related knowledge domains have been examined, could be undertaken to understand links between multiple scholarly networks.

7. Conclusion

Research on tourism and climate change has grown substantially over the last 26 years, and is published in a wide range of outlets, including books and 109 different journals. While the focus of research is still on how climate change will impact on tourism and how destinations can adapt, considerable attention is also paid to tourism's role as a contributor to greenhouse gas emissions and how these can be mitigated. Increasingly, researchers investigate integrative issues and policy dimensions of tourism and climate change. Geographically, research has widened beyond the focal areas of Europe, North America, and Oceania, and authors are emerging from countries such as China or the Caribbean. There are still substantial gaps that need to be addressed, including geographic and topical ones (e.g. ethical dimensions of tourism and climate change). The network of researchers has grown significantly in size and complexity, however, the core of the network is not linked to the many small groups at its periphery. The 'centre of gravity' remains in the hands of a small number of researchers who also tend to co-author a large amount of publications. This poses a risk to the intellectual diversity that research on tourism and climate change could reach if greater diversity in co-authorship could be achieved. Overall, however, considering the visibility and recognition of the research field, the diversity of paradigms and methods and the increasing connectedness with the tourism industry, this review concludes that tourism and climate change has developed into a knowledge domain in its own right. The next steps in the evolution of this domain would be the integration of English and non-English language knowledge, a better connection of the network's core with its periphery, or, alternatively, the development of new cores by collaborations amongst researchers from the periphery.

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