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Glacier Tourism Research-

Summary of Literature Scoping

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Cover picture: “the Crystal Cave” in the western part of Breiðamerkurjökull.
Photo: Þorvarður Árnason ©.

Glacier tourism research - summary of literature scoping

Johannes T. Welling

ICELANDIC TOURISM RESEARCH CENTRE
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1. Preamble

This is the second annual report of the PhD project *Tourism, landscapes and climate change in Iceland* partly funded by the Icelandic Tourism Research Centre (is. *Rannsóknamiðstöð ferðamála*, RMF). This PhD project explores the current and future implications of climate change on glacier based tourism in Iceland and aims to develop effective adaptation and/or mitigation strategies for this tourism sector.

This report consists of the second sub-study of the PhD project that reviews systematically academic literature on glacier tourism. This study aims to summarize the state-of-the-art knowledge on the relationship between tourism, glacier landscapes and regional climate changes, and identify the main knowledge gaps on this topic. The content of this report will be distilled for an article that will be submitted in February 2015 to a peer-reviewed journal.

This report is organized into six chapters. This first chapter introduces the research followed by a description of the historical development of glacier visitation in the second chapter. In the third chapter the methodology of this study is described as well as the conducted review procedure. Chapter four consists of the results of the review both in quantitative and qualitative terms. This report ends with a discussion which includes the identified knowledge gaps and a final conclusion.

2. Background

Research on tourism in glaciated landscapes is a fairly recent phenomenon. Many glaciers around the world have during the past decades grown to become popular tourist destinations. These majestic, intimidating and fairly uncommon landscapes now form the basis for a broad array of tourism activities, services and products in many different countries. Glaciers are found on all continents (with the exception of Australia) and currently cover 0.5 % of the Earth's terrestrial surface (Arendt *et.al.*, 2012). Due to global climate change, glaciers all over the world have been retreating rapidly over the past decades, resulting in more attention being focused on the remaining glaciers and their perceived value grows. Glaciers are the foundation of many spectacular landscape types, such as glacial valleys, moraines, eskers, and drumlins. Such areas are often characterized by highly dynamic landscapes which in turn attract tourists. Several glaciers and glacial environments furthermore form the centrepiece of World Heritage sites (Wang and Jiao, 2012) or national parks attracting millions of tourists each year (Table 1).

Table 1: Examples of popular glacial tourism destinations

Source: UNWTO, UNEP and WMO, 2008; Purdie, 2013; Guðmundsson, 2013; IUCN and UNEP-WCMC, 2014.

Park name and location	Glacier attraction(s)	Visitor number/ year	Provided tourism activities
Banff NP, Canada	Columbia Ice Fields, Athabasca Glacier	600,000	Glacier coach tours, glacier hiking, exhibitions
Los Glacier NP, Argentina	Perito Moreno glacier, Lake Argentino	167,000	Glacier hiking, ice-climbing, ice cave tours, glacier boat tours
Huascarán NP, Peru	Pastoruri Glacier	109,000	Site seeing, hiking
Te Wahipounamu, New Zealand	Franz Jozef glacier	346,000	Glacier walking, ice-climbing, heli-hiking
Ilulissat Icefjord, Greenland	Sermeq Kujalleq Glacier	12,000	Cross-country skiing, dogsled tours, cruise ships, heli-hiking
Jostedal glacier NP, Norway	Brikdals glacier	40,000	Glacier hiking, glacier lake kayak/ boat, skiing, cross-country skiing, exhibition
Vatnajökull NP, Iceland	Vatnajökull glacier	343,000	Glacier hiking, ice-climbing, ice cave tours, glacier boat tours, snowmobiling, superjeep tours

Today, glaciers such as the Fox and Franz Jozef glaciers in New Zealand, the Aletsch glacier in Switzerland and the Petito Moreno glacier in Argentina form a natural foundation on which densely distributed regional tourism networks of activities, accommodation, infrastructure

and marketing are resting. As an example, the direct economic contribution from glacier-related tourism at the Fox and Franz Jozef glaciers in New Zealand is estimated to exceed US$ 81 million per year (Purdie, 2013). In Iceland, glacial landscapes are among the most popular tourism attractions for hiking and sightseeing, e.g. in the Vatnajökull and Snæfellsjökull National Parks and at Jökulsárlón glacier lagoon (Icelandic Tourist Board, 2014).

Prompted by a growing body of research on nature-based tourism more generally (Newsome, Moor and Dowling, 2002; Hall and Boyd, 2005), glaciers have recently attracted greater attention from tourism researchers (Furunes and Mykletun, 2012; Wang and Jiao, 2012). Initially, tourism in glaciated areas was primarily viewed as a sub-set of mountain tourism and/or nature-based tourism, rather than a tourism niche in itself (Wang and Jiao, 2012). In addition, the relationship between tourism and glacial landscapes has also received increased attention in the context of research on the human dimensions of climate change (e.g. McDowell, Stephenson and Ford, 2014). Glacial environments are extremely dynamic and sensitive to climate change and variability (e.g. UNEP and WGMS, 2008) and thus they are considered to be among the most visible and high confidence level indicators of global warming (IPCC, 2013). Climate-induced environmental change has been documented in several mountain regions of the world that are also key tourism destinations, such as sites in the European Alps, the Rockies, the Andes, and the Himalayas. During the past 40 years an estimated 7,000 km^2 of ice cover has been lost from glaciers in these mountain regions (WGMS, 2012). Although climate research has long been the domain of natural science, recently social scientists and humanistic scholars have entered the fray, focusing on the human dimensions of climate change, and attempting, for example, to describe and analyse perceptions of climate change, public understanding of risk, and construction of climate change policies (Brace and Geoghegan, 2010).

This present study attempts to contribute to both the literature on nature-based tourism and on the human dimensions of climate change by systematically reviewing academic literature on the relation between glaciers and tourism. Hereinafter this relation will be referred to as glacier tourism. This study aims to provide a state of the art overview of knowledge on glacier tourism, as well as to critically define knowledge gaps in the existing

literature on this topic. Therefore this study will assess the scope and nature of the research literature on glacier tourism, and identify and synthesize central concepts, topics and central themes within this literature.

3. Evolution of glacier visitation

Through the history of glacier-human interactions there has been an accumulation of the types of travellers who have explored, observed and researched glaciated landscapes. Each of these types has specific travel goals and different cultural perceptions of glaciers, embedded in the prevailing socio-cultural worldviews of each given period (e.g. Carey, 2007; Orlove, Wiegandt and Luckman, 2008; Brugger *et.al*., 2013). According to Orlove *et.al*., (2008) the earliest frequent glacier visitations documented, undertaken by pilgrims and indigenous communities, can be traced back to the 16th century. In the Andes, for example, researchers have documented an ancient annual pilgrimage of thousands of locals heading to the glacier peaks of mount Sinakara during a regional celebration. In earlier times, glaciers in this region were perceived with a combination of worship, curiosity and fear (Orlove *et.al*., 2008) and culturally framed as spiritual phenomena with a certain degree of agency (Carey, 2007). Medieval archives in Europe describe attempts by local inhabitants to stop glacial advance, which was causing the destruction of their villages during the Little Ice Age, by entering glacier caves with drawn swords (Cruikshank, 2005).

The Cartesian-Newtonian worldview dominant at the end of the 17th century prompted the introduction of a new type of glacier visitors; the natural scientists. Knight (2004) points out that that as early as the eighteenth century; individual observers in the Swiss Alps recognized important characteristics of glacier behaviour, such as glacier dynamics under the influence of gravity, but that it was not until the middle of the following century that the foundations of modern glaciological science were established. Systematic observations and glaciological research took root in Norway, New Zealand and Iceland around 1800 (Andreassen et al., 2008; Purdie, 2013; Sigurðsson *et. al*., 2014.

With the onset of the age of Enlightenment the terrifying and potentially lethal glaciers starting to transform into sublime and alluring landscapes that attracted adventurous travellers who wanted to explore the last pure and untouched wilderness areas of Europe (Carey, 2007). Under the influence of the prevailing ideas of Romanticism at the beginning of the 19th century the view of glaciers as “wild and indestructible” nature appealed to the curiosity and enthusiasm of many writers, painters and adventurers (Haeberli, 2008). For example, affected by the sublime powers of the glacier, Jules Verne featured the

Snæfellsjökull glacier in west Iceland as the entrance to the earth's interior in his classic novel *Journey to the Centre of the Earth* (Lund, 2013). In Iceland, glaciers and icecaps were mainly explored by British alpinists such as William L. Watts who in 1884-1885 climbed several glacier peaks and also traversed the Vatnajökull icecap, Europe's largest glacier (Sæþórsdóttir, Hall and Saarinen, 2011; Guðmundsson, 1995). With the establishment of the first mountaineering clubs in the second half of the 19th century and the first decades of 20th century, glaciers became the sources of mountaineering recreation (Carey, 2007) and the first attempts to exploit glaciers for skiing were made (Haimayer, 1989). The growth of global tourism after WWII drove the establishment of a myriad of different commercial tourism activities on or in the direct vicinity of glaciers, combining glacier sightseeing, mountaineering and exploration, the latter both for scientific and educational purposes (Liu, Yang and Xie, 2006). All these different perceptions and utilizations of glaciers have evolved through time and still remain with us to a certain extent, manifesting into today's tourism practices. The current commercial tour activities on the glaciers such as glacier walks or glacier traversing often consist of blend of various experiences grounded on adventure, recreation, education and aesthetics (Pralong and Reynard, 2005; Mykletun and Furunes, 2012). After having in older times variously been perceived as a threat, a sacred place, a source of knowledge, aesthetic scenery or a backdrop for leisure and adventure activities, glaciers are presently being rediscovered as a source for generating income through tourism.

4. Methodology

4.1 Scoping review

In this study a scoping review was used in an attempt to explore the conceptualizations and characteristics of glacier tourism within the academic literature. Scoping in this kind of literature review involves a synthesis and analysis of a wide range of both research and non-research generated material to provide greater conceptual clarity about a specific topic or field of evidence (Davis, Drey and Gould, 2009, p. 1386). Scoping reviews are used in a number of ways, such as examining the range and nature of a particular research area, summarizing findings of research and identifying research gaps (Arksey and O'Malley, 2005), and are especially suitable for use in rather unexplored research fields or where prior synthesis are unavailable (Mays, Roberts and Popay, 2001; McKinstry, Brown and Gustafsson, 2014). Scoping literature can be performed using systematic or non-systematic approaches (Davis *et.al*., 2009).

This study employs a systematic scoping review using a structured and explicit pre-determined methodology to ensure consistency and replicability (McKinstry *et.al*., 2014). A scoping review differs from other review forms, such as systematic reviews, narrative or literature reviews, through its use of broad research questions. The synthesis is qualitative, the author does not typically assess the quality of the included studies and the scoping process requires analytical reinterpretation of literature (Levac, Colquhoun and O'Brien, 2010; Armstrong *et.al*., 2011). Currently only a few scoping reviews appear to have been conducted in the field of tourism research (e.g. Crooks *et.al*., 2010, Snyder *et.al*., 2011; Tremblay, 2006).

4.2 Selection criteria

This study employs the methodological framework presented by Arksey and O´Malley (2005) which consists of the following 5 steps:

(i) Identifying the research question

(ii) Identifying relevant studies,

(iii) study selection,

(iv) charting the data,

(v) collating, summarizing and reporting the results.

The first step was to formulate a research question that guided the structure of the review strategy. The general question used was: 'what knowledge is present in the existing academic literature concerning the nature and scope of glacier tourism?' In the second step eleven on-line academic databases[1] were searched (ISI Web of Knowledge, Bielefeld Academic Search Engine (BASE), BioOne, Directory of Open Access Journals (DOAJ), EconBiz, CABI leisure-tourism, DirectScience, Taylor and Francis online, JSTOR, SAGE and the Library Catalogue of the authors' university) until no new sources could be identified. The database search took place in April 2014. The terms "glacier tourism", "glacier tourist", "glacier recreation", and "tourism" AND "glacier" were used to search each database. The search terms were applied across fields concerning title, abstract, subject heading and key words.

For the selection of relevant studies a set of inclusion criteria was employed. Because the focus of this report is to provide an overview of the knowledge on glacier tourism in the academic literature, only peer reviewed articles, chapters from scientific book, proceedings from science conferences and reports from academic institutions were included. Other criteria used were that the literature: a) was published after 1980, as research prior to this date was deemed unlikely to reflect current research developments, b) was written in English, c) did not constitute the main content of another publication (some identified book chapters and reports formed the basis of articles subsequently published) and d) had a significant focus on the relation between tourism and glaciers. The significance of literature for this review was defined with regard to the method develop by Smith (2004) to prioritize papers in a literature review on the basis on their appropriateness as high, medium or low priority articles (Table 2).

Table 2: Prioritization criteria.
Source: Adapted from Smith, 2004.

	Glacier site specific	**Not glacier site specific**
Focus on tourism / recreation	*high*	*medium*
Non focus on tourism / recreation	*medium*	*low*

[1] The author considered this broad collection of data-basis sufficient to cover all relevant literature regarding the relation between glacier and tourism.

High priority was given to papers and other documents which focused jointly on tourism/recreation *and* glacier sites. Medium priority was given to papers concerned with tourism/recreation in a non-specific glacier region *or* papers that dealt with glacier sites but did not focus exclusively on tourism or the recreational use of those sites. Papers given low priority lacked both a focus on tourism/recreation *and* were not glacier site specific. Only the high and medium priority documents were considered to provide a substantial focus on glacier tourism and were therefore included in the final synthesis of this research.

4.3 Selection procedure

The initial database search resulted in the identification of 213 potentially relevant studies (Figure 1). After removing duplicate records, the remaining 143 publication titles and abstracts were screened on basis of the inclusion criteria to guarantee the suitability for a full text review. The initial search provided 63 publications for full review. Reference lists from reviewed papers were used to identify further studies of interest, based on the inclusion criteria, and this process was then repeated until no new relevant publications were discovered.

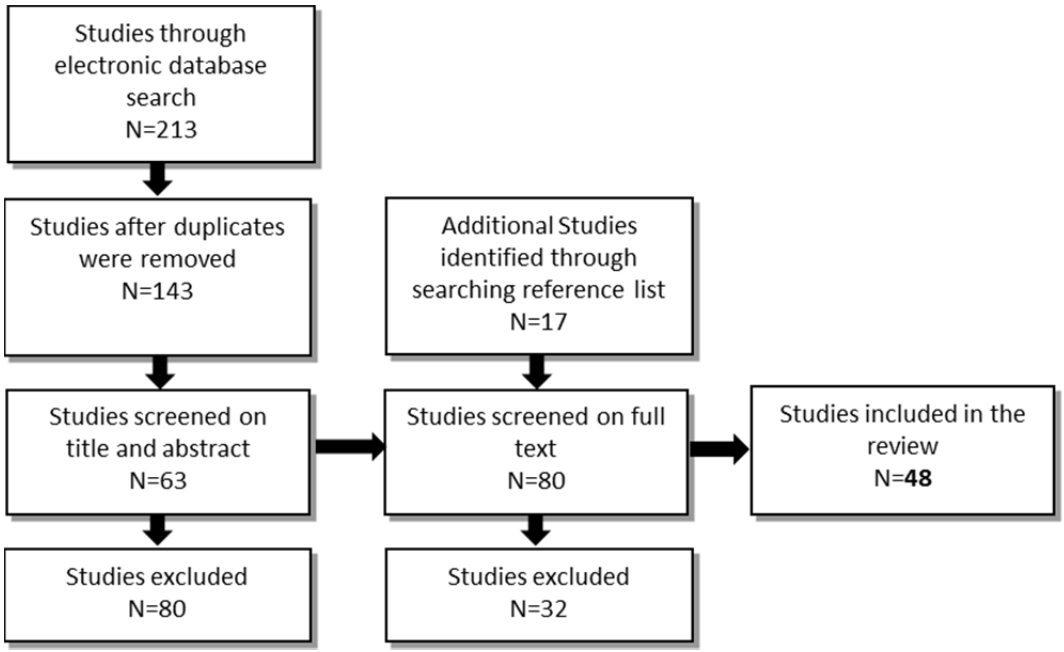

Figure 1: Study selection process.

This process resulted in 17 publications in addition for full review. Altogether, a set of 80 were thus identified for full text review. After further screening of this set on basis of the inclusion procedure, a final set of 48 studies was yielded which form the subject matter of this scoping review (a list of all publications included into the review is provided in table 13 (Appendix 1).

The selected papers were subsequently categorized and charted (fourth step) into a spreadsheet on the basis of information regarding the study, i.e. authors, year of publication, aims of study, methodology, data sources, results, themes, and study location. In the final step, a content analysis was performed to identify recurrent research themes as well as gaps in the literature.

5. Results

The main results of the scoping review were twofold. The first part concerns an overview of the characteristics of the reviewed literature, while the second part synthesizes the main outcomes (used concepts and overarching themes) extracted from this literature.

5.1 Characteristics of reviewed literature

Eight out of ten of the 48 reviewed studies were fairly recent. Only two articles were published before 1995 whilst 38 papers were published after 2005 (fig 2).

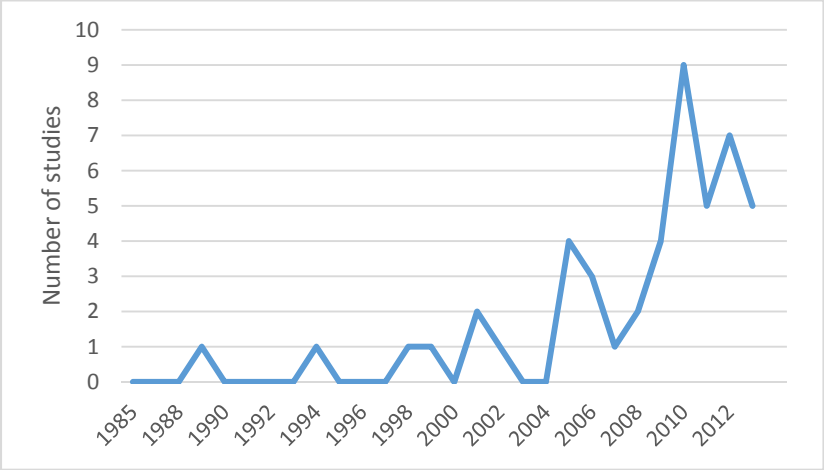

Figure 2: Number of reviewed publications per year (1985-2013).[2]

This clearly indicates that glacier tourism is a relatively new academic topic which is furthermore receiving increasing attention, even if the total number of studies is still quite small. The final literature set consisted of 40 peer-reviewed articles, 4 book chapters and 4 scientific reports. The articles were published in 31 different journals, of these only six journals published more than one article about glacier tourism (Table 3).

[2] The year 2014 (1 publication) is not included into the graph because the literature search terminated in Aril 2014.

Table 3: Distribution of articles per journal.

Journal name	Number	Percentage
Mountain Research and Development	4	10,0%
Géomorphologie: relief, processus, environnement	3	7,5%
Cold Regions Science and Technology	2	5,0%
Environmental Management	2	5,0%
Journal of Earth Science	2	5,0%
Tourist Studies	2	5,0%
Other journals publishing only one paper each	25	62,5%
Total	40	100,0%

The disciplinary focus of the journals in question is multi-disciplinary mountain/arctic research (9), geology (9), tourism (9), environmental/climate science (6), and geography (3) (Table 4). Both the broad range and divers disciplinary background of these journals underlines the multi-disciplinary scope of glacier tourism in the academic literature.

Table 4: Number and percentage of articles per discipline.

Discipline of journal	Number	Percentage
Mountain/Arctic research	9	22,5%
Geology	9	22,5%
Tourism	9	22,5%
Environment/Climate	6	15,0%
Geography	3	7,5%
Ecology	2	5,0%
Glaciology	1	2,5%
Medicine	1	2,5%
Total	40	100,0%

The 48 reviewed studies were produced by 116 authors, of which 30 papers were written by a single or two authors. Ten authors appeared on more than one paper from which just four were first authors. This indicates that glacier tourism constitutes a research subject for a quite limited number of scholars. The geographical distribution of institutions of the first authors (table 5) reveals a broad range of different countries, primarily in areas where glacier tourism has been developed.

Table 5: Geographical location of first authors.

Location	Number of authors	Percentage	Location	Number of authors	Percentage
New Zealand	8	16,7%	France	3	6,2%
Italy	7	14,6%	India	2	4,2%
China	5	10,4%	Switzerland	2	4,2%
Austria	3	6,2%	Australia	1	2,1%
Canada	3	6,2%	Germany	1	2,1%
Iceland	3	6,2%	Luxembourg	1	2,1%
Norway	3	6,2%	Nepal	1	2,1%
USA	3	6,2%	Tanzania	1	2,1%
Total	**48**		**Percentage**		**100%**

The review identified a broad scope of focal research objects (table 6). The majority of studies focused on tourists (17), glacier areas or sites (13), area management (10) and tour operators or other tourism entrepreneurs (8). This indicates that research on glacier tourism goes beyond the demand and supply dichotomy and involves different socio-economic and natural actors and entities at multiple scales. Glacier tourism can be considered as a human-environment system that consists of a network of relationships between physical elements such as glacial landforms and morphologies, as well as tourism actors such as tourists, entrepreneurs and area managers (Pralong and Reynard, 2005).

Table 6: Central research topics of reviewed studies.

Items of research focus	Number*	Percentage of total reviewed studies (N=48)
Tourists	17	35,4%
Area/Landscape	13	27,1%
Area Management	10	20,8%
Operators	8	16,7%
Local communities	4	8,3%
Biodiversity	2	4,2%
Other	2	4,2%

*Some reviewed studies focussed on multiple research topics.

Furthermore, a diverse and broad array of glacier tourism activities was addressed in the reviewed studies (Table 7) with only six studies that did not address any tourism activities specifically. Glacier skiing and hiking/site-seeing are the most prominent amongst these

activities, which is not surprising given their popularity and economic significance for many local communities in mountain areas (Haimayer, 1989; Bury *et.al.*, 2011).

Table 7: Types of glacier tourism activity addressed in reviewed studies.

Tourism activity	**Number***	**Percentage of total amount of reviewed studies (N=48)**
Hiking/site-seeing	19	39,6%
Glacier skiing	8	16,7%
Mountaineering	7	14,6%
Ice walking/ climbing	7	14,6%
Trekking	5	10,4%
Scenic flight (helicopter/plane)	5	10,4%
Geo-tourism	4	8,3%
Boat/ kayak	3	6,2%
Pilgrimage	1	2,1%
Glacier museum	1	2,1%

*Some reviewed studies addressed multiple glacier tourism activities.

The review found that there is a broad range of different geographical regions where glacier tourism was researched. There are no studies in the review that discussed glacier tourism on a global scale. Only two studies were conducted on a regional scale and five studies on a national scale respectively whilst the remainder – the large majority – addressed glacier tourism on a local scale (31). Most reviewed studies consisted of single case-studies that were site specific within 13 different countries around the world (Table 8), mostly in developed countries (e.g. New Zealand, Italy and Canada) but also in some developing countries (e.g. Tanzania, Peru and Nepal). For a complete list all case-study sites see Table 13 (Appendix I).

Table 8: Geographical location of site specific case-studies in the reviewed papers

Location of case studies	N° of papers	Location of case studies	N° of papers	Location of case study	N° of papers
New Zealand	8	Norway	3	USA	2
Italy	7	Canada	3	Peru	1
China	5	France	3	India	1
Iceland	4	Tanzania	2		
Austria	4	Nepal	2		

The methodological approaches of the reviewed studies are summarized below (Table 9 and Table 10). Most of the reviewed documents followed a descriptive research design (34 studies) or an explanatory design (9), while only three studies employed a predictive approach and two an exploratory research design.

Table 9: Research design of reviewed studies.

Research design	Number	Percentage
Descriptive	34	70,8%
Explanatory	9	18,7%
Predictive	3	6,3%
Exploratory	2	4,2%
Total	48	100,0%

The majority of the studies (36) furthermore used an empirical approach, presenting primary research data either through quantitative methods (22), qualitative methods (12) or mixed methods (2). Just 12 papers presented secondary data or a combination of primary and secondary data. The empirical research data originates from a variety of sources including field observation (13), tourists (12), entrepreneurs (8), local community members, and area managers (3) (Table 11).

Table 10: Data collection of reviewed studies

Collected data	Number	Percentage	Data collection method*	Number	Percentage
Primary/ second.	1	2,1%			
Secondary	11	22,9%			
Primary	36	75,0%	Quantitative	22	61,1%
			Qualitative	12	33,3%
			Mixed	2	5,6%
Total	48	100,0%	Total	36	100,0%

* Used methods of data collection in primary studies

Table 11: Types of sources used in reviewed studies.

Source type	Number*	Percentage of total amount of reviewed studies (N=48)
Field observation/ survey	13	27,1%
Tourists/visitors	12	25,0%
Literature	10	20,8%
Entrepreneurs	8	16,7%
Local community members	4	8,3%
Records/ statistics	3	6,2%
Area managers	3	6,2%
Author's own experience	1	2,1%
Newspapers	1	2,1%

*Some reviewed studies used multiple information sources

5.2 Definitions and conceptualizations of glacier tourism

It is noteworthy that only four reviewed studies attempted to define the concept of glacier tourism as such and also that the definitions presented differed considerably between authors. Liu, Yang and Xie (2006, p. 365) describe glacier tourism simply as "tourism activities in glacier areas", but also point out that this form of tourism differs from conventional tourism in several ways; the resources used (glaciers and icecaps) are scarce and fragile, the activities are heavily localized, its connotation is scientific, and it is

multifunctional with a high recreation, aesthetic and scientific value. Wang and Jiao (2012, p. 401) extend the definition of Liu et.al. (2006) by referring to glacier tourism as an "…activity or event whereby glaciers and ancient glacier relics serve as main attractions…". Finally, Furunes and Mykletun (2012, p. 324) in contrast present a more confined concept of glacier tourism in their study on glacier adventure tourism in Norway. According to their definition, glacier tourism consists mainly of "walking and climbing on glaciated areas for the unique experience". All of these descriptions apply a geographical perspective to typify glacier tourism, i.e. one where the glacier area functions as the main attraction or setting for various leisure activities. In this regard, they resonate with some of the general descriptions of nature based tourism such as those of Hall and Boyd (2010, p. 3) who describe nature based tourism as forms of tourism that take place in natural setting, tourism that focuses on specific elements of the natural environment, and tourism that is developed in order to conserve or protect natural areas. While it may thus seem logical to classify glacier tourism as a sub-category of nature based tourism there are several critical issues which need to be further addressed before this step can be taken, e.g. regarding what kinds of activities should be included as part of glacier tourism and how to demarcate glacier areas in spatial and morphological terms, as stressed by Mehmetoglu (2007) and Fredman and Tyrväinen (2010).

Concerning the latter point, this review finds that glacier tourism does not solely consist of activities that take place on the glacier itself but also in adjacent areas. In her research on glacier tourism in New Zealand, Purdie (2013) thus includes both activities that take place on the glacier and activities in pro-glacial areas, such as boat tours on glacier lakes. Pro-glacial areas are the dynamic forefields immediately in front of or just beyond the outer limits of a glacier, icecap or ice sheet that are formed by or derived from glacier ice. These areas often contain spectacular landforms and features such giant boulders named erratics, dead ice, kettle holes, moraines and pro-glacial lakes with icebergs that often reflect a magnificent blue colour (Fig 3). Wang, He and Song (2010) and Wang and Jiao (2012) consider ancient glacier relics such as cirques, hanging valleys and horns as a source of attraction for glacier tourism. Also glacier lakes in New Zealand and the Italian Alps attract tourists for different reasons, such as watching the calving process of glacier ice into the lakes (Smiraglia *et.al*., 2008; Purdie, 2012). The pro-glacial zones furthermore form attractive areas for hiking

(Brandolini and Pelfini, 2010) and are the sites from which most of the tourists view the different glacier features and processes. More importantly, as landforms formed by glacier advance and recession, the pro-glacial zones illustrate the dynamics and power of glaciers. Pro-glacial zones areas contain high educational value providing geological and climatological information (Bollati, Smiraglia and Pelfini, 2013; Moreau, 2010).

Figure 3: The magnificent blue colour of the ice (*photograph*: Þorvarður Árnason).

The pro-glacial zones are also places where tangible evidence of global warming can actually be perceived. Various interpretative glacier trails have been laid out in different parts of the Alps countries, leading visitors through glacial landscapes, providing geological and climatological information to them *en route* (Cayla, 2009; Bollati, Smiraglia and Pelfini, 2013). The studies mentioned above consider tourism activities implicit to pro-glacial zone as glacier tourism. However, none of them defined the extent of the pro-glacial area or zone, either in quantitative or qualitative terms.

The reviewed literature shows that glacier areas offer a suitable arena for various nature- and actor related activities based on three specific elements; adventure, recreation (based on specific geomorphology) and education. Furunes and Mykletun (2012, p. 329) for example describe glacier tourism as form of nature adventure tourism where “glaciers can be considered playground for tourists seeking different levels of challenges in strange and

potentially hazardous environments". They further emphasize that in order to reduce the risk of accidents and increase access to glaciers for tourists most tourism activities are performed under guided supervision where clients rely on guides' expertise to find their way through the glacial landscape. This is in line with the general description of adventure tourism by Buckley (2007, p. 1428) who considers glacier adventure tourism to encompass mostly guided commercial tours, where the principal attraction is an outdoor activity that relies on features of the natural terrain (e.g. glacier ice wall to climb or a glacier tongue to traverse), generally requires specialized equipment (e.g. crampons and ice axes), and is exciting for the tour clients. Typical activities in glacier adventure tours include glacier hiking, ice climbing, glacier-traverse on skies, snowmobiling and glacier lake kayaking. Nevertheless, a considerable part of the tourists that visit the glacier sites come there just to view or observe glacier attributes and adjacent landforms, often without setting foot on the glaciers themselves (Wilson, 2012). In contrast with adventure tourism, these sightseeing activities are often conducted in an unorganized manner (Wilson, 2012). Finally, many glacier sites are at the present time becoming the object of educational trips because of the educational values related to spectacular landscapes, their geodiversity and their status as representatives of the environmental response to global climate change (Feuillet and Sourp, 2011; Bollati *et.al*., 2013).

Pralong and Reynard (2005) in contrast propose a framework that presents multiple forms of relationships between geomorphology and tourism (e.g. natural and social-cultural land features, services, infrastructure, impacts, vulnerabilities, risks and exploitations) which frame glacier tourism as a form of geomorphological tourism. The glacier geomorphology sites are highly representative for the study of climate history (Reynard & Panizza, 2005). They are the tangible evidence that our planet's climate is changing and the accelerated pace of worldwide glacier retreat makes visitors more aware of the consequences of this. This educational idea has already been put into practice at the renowned Norwegian Glacier Museum, one of the three glacier visitor centres around the Jostedalen glacier (Aal and Hoye, 2005), as well as in various interpretive trails in glacier areas in the Alps (Cayla, 2007; Martin, 2010; Bolatti *et.al*., 2013).

5.3 Identified themes

Although the research focus in the reviewed literature is diverse, three recurrent themes can be identified (Table 12):

i. Climate change and variability,
ii. the effects of glacier tourism on its social and ecological environment, and
iii. Perceptions and values values glacier tourism actors.

These three themes represent the most discussed issues concerning the relationship between glaciers and tourism in the English-language academic sources (for an overview of reviewed studies per theme and issue, see Appendix II).

Table 12: Identified themes in reviewed studies.

Theme	**Number of studies***	**Percentage of total amount of reviewed studies (N=48)**
Climate change and variability	23	48%
The effects of glacier tourism	14	29%
Perceptions and values	12	25%

*Some reviewed studies addressed multiple glacier tourism activities

5.3.1 Climate change and variability

The worldwide retreat of icecaps and glaciers is often considered to be one of the most tangible and high confidence level indicators of global climate change. It is therefore not surprising that the impacts of climate variations and conditions on glacier tourism should prove to be the central issue in 23 studies of the reviewed literature. Three issues were most discussed with regard to climate change and variability: (a) impacts of climate change and variability; (b) responses to climate change; and (c) perceptions of climate change.

5.3.1.1 Impacts of climate change and variability

According to studies focusing on impacts of climate change and variability, the impacts of local climate on glacier tourism both concern changes in weather conditions, mostly on a daily or multi-day basis, and changes in weather patterns which include gradual average change of weather conditions over a period of years or decades (Figure 4). In general, climate influences tourism directly by determining weather conditions at a specific tourist

destination and at the tourists´ place of residence (UNWTO, UNEP and WMO, 2008). Weather also directly affects key aspects of tourism operations, including activity programming and infrastructure (Scott, Jones and Konopek, 2007). Cloudiness and fog, for example, reduce the visibility and accessibility of glacier sites and thus affect various glacier based tours such as sight-seeing flights and heli-hikes (Becken, 2012; Espiner and Becken, 2014). Furthermore, weather conditions such as heavy rain can indirectly effect tourism by triggering unexpectedly large ice block calving (Tinti, Maramai and Cerutti, 1999), destabilizing ground moraine areas, or enhancing glacier river run-off, which increases the risk of hazardous events, hampers terrain accessibility and can even lead to the closure of entire sites (Wilson, 2012).

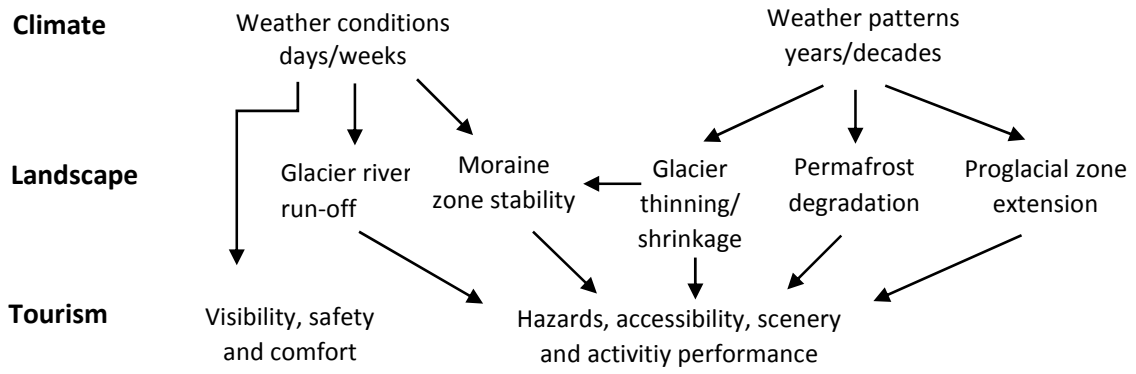

Figure 4: Climate change impacts on glacial landscapes and tourism.

The impacts of climate change in terms of gradually changing weather patterns on glacier landscapes can be divided into three main phenomena: a) glacier thinning and shrinkage, b) permafrost degradation and c) pro-glacial area extension (Haeberli and Beniston, 1998; Kääb, Reynolds and Haeberli, 2005). Some reviewed studies which focused on the impacts of glacier recession on tourism provided a general descriptive analysis of the existing or potential impacts on non-specific glacier tourism in certain regions caused by the recently accelerated thinning and recession of glaciers worldwide, as well as a description of optional adaptation strategies and measures (e.g. Liu, Yang and Xie, 2006; Wang, He and Song, 2010; Wang and Jiao, 2012; and Purdie, 2013). The majority of studies, however, analysing the risks and hazard associated with glacier recession dealt with specific tourism activities in glacier areas, such as mountaineering (Ritter, Fiebig and Muhar, 2012), summer skiing

(Diolaiuti *et.al.*, 2006 Smiraglia *et.al*., 2008; Fisher, Olefs and Abermann, 2011), pro-glacial lake tourist activities (Tinti *et.al*., 1999; Smiraglia *et.al*., 2008;) or geo-tourism (Brandolini and Pelfini, 2010). Based on expert and stakeholder opinions, Ritter *et.al*. (2012) classified the different impacts of glacier recession and permafrost thawing on high Alpine trails and routes. They distinguished two types of impacts on glacier mountain tourism due to glacier recession and permafrost degradation. Firstly, changes in the occurrence (intensity, frequency and spatial distribution) of natural hazards and secondly, changes in terrain accessibility. Glacier shrinking and permafrost degradation cause debris slope and rock wall instability, and accumulation and uncovering of debris, which can lead to increased rock fall, landslides and debris flows, all substantial threats for tourists and recreationists that visit a glacier or its foreland (Blair, 1994; Ritter *et.al*., 2012). Furthermore, the calving of icebergs and ice blocks into pro-glacial lakes or waters adjacent to tidewater glaciers can cause huge waves which are able to flood sight-seeing tourists on the lake shore and destabilize tour boats (Tinti, 1999; Smiraglia *et.al*., 2008; Purdie, 2013). In addition, two studies support the ideas that glacier tourism includes risky and hazardous outdoor recreation activities without referring directly to effects of climate change and variability. Schindera et.al., 2010 examined the types and frequency of injuries associated with glacial-crevasse or ice-field fall which range from range from common extremity injuries with fracture or joint instability and peripheral frostbite to potentially life-threatening no orthopedic trauma. In addition, Espiner (2001) identified a modest level of hazard awareness and risk-taken behavior among tourists that visit glacier sites in New Zealand.

Glacier retreat can reduce the accessibility to glaciers or within glacier sites by increasing supraglacial debris cover, changing the access routes to the glacier and increasing steepness of ice slopes at the glacier terminus (Ritter *et.al*., 2012; Furunes and Mykletun, 2013). This can result in increased costs for entrepreneurs who need different transportation modes such as helicopters and or fast motor boats to ensure that tourists will go on the glacier or venture close to the glacier terminus (Purdie, 2013; Espiner and Becken, 2014). On the other hand, inaccessibility contributes to the appeal of some glacier activities such as glacier mountaineering and trekking and generates employment and other economic opportunities, e.g. through the rent of special equipment or need for local guides (Nyaupane and Chhetri, 2009; Wilson, 2012). In addition, glacier recession can lead to the formation of sub-glacial

caves and pro-glacial lakes, both phenomena provide opportunities for new forms of site-seeing tourism activities (Smiraglia *et.al*., 2008; Diolaiuti and Smiraglia, 2010; Purdie, 2013). However, climate change is not the only driver of glacier hazards to tourism. Both sub glacial volcanic and seismic activities cause a diversity of glacier hazards which can affect tourism activities and management (Bird, Gisladottir and Dominey-Howes, 2010).

Another important potential impact of glacier retreat pointed out by the reviewed studies is the change of scenery that this entails (Diolaiuti and Smiraglia, 2010; Garavaglia *et.al*., 2012). Despite repeated warnings about the potential negative effects of environmental change on the attractiveness of mountain landscapes (UNWTO, UNEP and WTO, 2008), the question of how the changes of glacial landscapes will affect tourism demand is a central issue in just two studies (Yuan *et.al*., 2006; Scott, Jones and Konopek, 2007). Both studies examined tourists´ stated future behaviour preferences under hypothetical scenarios of natural areas impacted by climate change. The results of both studies showed a decrease of tourism numbers with the partial or total disappearance of glaciers in the visited area.

The dissemination of information about worldwide glacier recession and disappearance may increase the number of glacier visits as a form of last chance tourism (Purdie, 2013) or climate change tourism (Aal and Hoye, 2006). To what extent climate induced changes of the natural environment such as glacier recession, permafrost thawing and changing pro-glacier area are actually going to impact tourism actors depends also on geological and geomorphological factors such type of bedrock, sloop steepness or landform elements (Ritter *et.al*., 2012) and the ability of tourism actors (tourists and operators) to adapt to the changing environment, as well as their different perceptions on environmental and climate induced changes (Brouder and Lundmark, 2011; Gössling et.al., 2012; Espiner and Becken, 2014).

5.3.1.2 Responses to climate change

Responses to climate change in the form of adaptation or mitigation measures were addressed in 18 articles. The responses studied varied widely depending on the climate induced impact type (e.g. glacier hazards or destination accessibility), impacted glacier tourism activities (e.g. skiing or hiking) and geographical area, or the actors or institutions

that carry out these adaptation or mitigation arrangements (e.g. entrepreneurs or area managers). Adaptation measures towards glacier hazards included the increase of scientific knowledge on monitoring moraine relief (Blair, 1994), the calculation of safe distances (Kohler, 2009), distribution and location of hazard signs or panels (Espiner, 2001), development of specific map symbols (Brandolini and Pelfini, 2010), putting on special safety gear (Schindera *et.al*., 2005; Furunes and Mykletun, 2012) or implementing safety zones and closing specific areas (Bury *et.al*., 2011; Wilson, 2012). The adaptation initiatives proposed to address climate induced impacts on glacier sites´ accessibility included reducing ice ablation through the employment of chemicals additives or physical protection covers (Fisher *et.al*., 2011) and the use of new transportation means such as helicopters (Purdie, 2013) or new trail routes or infrastructure (Ritter *et.al*., 2012)

In more general terms, Aal and Hoye (2005) discern three dimensions of climate change adaptation responses concerning tourism. These are adaptation to climate change in itself (e.g., the emergence of "climate change tourism"), adaptation to changes in natural conditions due to climatic changes (e.g. artificial snowmaking for ski resorts), and adaptation to greenhouse gas mitigation policies. Wang *et.al*., (2010) have developed a taxonomy of adaptation for Baishui Glacier No. 1 in China that consists of seven adaptation and mitigation strategies to deal with global climate change: (1) optimize the space layout of the glacier tourism area; (2) improve glacier tourism and environmental protection planning; (3) adopt multidimensional protective measures; (4) strengthen scientific research of glaciers and environment protection; (5) diversify glacier tourism products; (6) integrate regional tourism resources; (7) reinforce public environmental education.

5.3.1.3 Perceptions on climate change

Two studies examined tourists' awareness, perceptions and knowledge of glacier landscape changes (Moreau, 2010; Garavaglia *et.al*., 2012). These studies reveal that the interviewed visitors demonstrated knowledge about the processes involved in glacial recession but that this was often not perceived in the actual landscape. The knowledge of glacier retreat by the visitors depended more on preconceived ideas, expressed by society, most probably from the media, than on direct observations of the glacial landscape (Moreau, 2010). The results of these studies show also that visitors' knowledge of glacier recession strongly differs

between types of glacier recreation. Moreau's (2010) study on glacier tourists' perceptions and behaviours showed that hikers and mountaineers participate in different activities in the mountains and have different lengths of stay, which affects their visual perception of the glacier foreland. Hikers primarily search for the beauty of the site, have poor knowledge of the site's geomorphology, and have some difficulties in seeing the glacial retreat in the landscape. Mountaineers turn out to know geomorphology better, and have a global view of the glacier's retreat. Besides the type of recreation and length of stay, the viewpoint from where visitors can observe and understand the landscape also has a significant influence on the perception of glacial landscape changes (Garavaglia *et.al*., 2012).

Studies on tourism operators on the other hand indicate some indifference to climate change among entrepreneurs, as they consider recent glacier recession more as a product of local precipitation and summer temperatures than global climate change (Furunes and Mykletun, 2012; Espiner and Becken, 2014). Operators connect the issue of climate change to global, high profile examples (e.g., floods in Bangladesh and the melting ice shelf) rather than changes in local weather patterns (Wilson, 2012).

The majority of studies that addressed climate change mitigation or adaptation responses consist of general descriptions of existing measures and policies or a summation of suggested means for the future. Only two studies evaluated the effectiveness of climate change responses (Olefs and Fisher, 200; Fisher, Olefs and Abermann, 2011). Both studies evaluated technical mitigation measures to reduce snow and ice ablation in Alpine glacier ski resorts.

5.3.2 Perceptions and values of glacier tourism actors

Different studies attempted to assess the values of glacier areas in the context of tourism utilization. These landscape quality studies can be divided into expert design approaches, which involve the evaluation of landscape quality by trained experts or scientists and public perception based approaches which involve the subjective assessment of a landscape based participants' individual perceptions (Daniel, 2001). Several studies in this review employed a landscape quality assessments involving the evaluation of landscape qualities by experts

using numerical assessment frameworks that assign scores to landscape on the basis of quantitative criteria in order to assess the values of a particular site (Pralong, 2005; Pralong and Reynard, 2005; Feuillet and Sourp, 2011; Bollati, Smiraglia and Pelfini, 2013). The frameworks in these studies include criteria to assess glacier areas in terms of scenic/aesthetic, scientific, cultural/historical, social/economic values, and use and management potential. Other studies employ subjectivist approaches using qualitative methods, such as participant observation to explore the values that tourist attach to glacier landscape (Jóhannesdóttir, 2010, Lund, 2013; Ólafssdóttir, 2013). A study by Beza (2010) examined the aesthetic value which foreign tourists and local porters place on glacier/mountain environments. Beza (2010) found that the aesthetic value of landscapes found along the Mt. Everest trek consists of a specific phenomenological structure that contained bio-physical features (e.g. mountains, trees) but also included concepts (e.g. wilderness) and emotions (e.g. excitement). Similar observations were collected on a study of organized glacier tours in Iceland by Jóhannesdóttir (2010). She noticed that the glacial landscape created an atmosphere of wonder and awe through the perception and experience of the physical qualities of the glacier: colours, forms, texture and sounds. Corbett (2001) and Garavaglia *et.al*. (2012) investigated the specific interests behind visits to a glacier site and found that scenery and encounters with glaciers were the two most mentioned motives. Touching a glacier can be such a high priority that tourists book glacier tours despite bad weather or low visibility (Espiner and Becken, 2014). On the other hand, glaciers also invoke a sense of unpredictability, exoticism, uncertainty or even hostility towards visitors, which can make the idea of visiting them feel like a challenge and thus participating in a glacier tour becomes an exciting adventure (Ólafssdóttir, 2013). According to Furunes and Mykletun (2012, p.327) glaciers can been seen as an "accelerated sublime" attraction, a destination that offers the opportunity to have a close encounter with a rare and sublime natural phenomena and at the same time fuel adventurous motivations such as opportunities for play, tension, insight, increased self-understanding, identity formation, and risk-taking.

Four studies investigated factors that cause differences in perceptions or values attached to glaciers among tourist actors. Identified factors in these studies are: the social-cultural background of tourism actors (Beza, 2010), the extent of experience with the visited area

(Moreau, 2010), the viewpoint from where glacial landscapes were perceived (Garavaglia *et.al*., 2012) and underlying local – global power relations (Frömming, 2009). Frömming (2009) argued that the current prevailing perceptions and valuations of the Kilimanjaro glacier as a beautiful or sublime site are grounded in Western based hegemony of aesthetic modernity, which oppresses ancient cultural values of native tribes that lived for centuries in the vicinity of the glacier.

5.3.3 The effects of glacier tourism on its social and ecological environment

A considerable number of studies (14) in this review focused on the effects of glacier tourism on its social-economic and ecological environment. Three issues regarding these effects can be discerned: 1) glacier tourism impacts on local communities, 2) impacts on the natural environment, and 3) the impacts of tourist activities on other tourists at glacier sites.

According to four studies, glacier tourism constitutes an import source of income and employment for local communities adjacent to glacier tourist sites (i.e. Haimayer, 1989; Frömming, 2009; Bury *et. al.*,2011; Espiner and Becken, 2014). The utilization of glaciers as ski slopes in Austria was considered to have positive economic impacts at the regional level from the increase of tourism demand due to the extension of the ski season throughout the year (Haimayer, 1998). A household survey among the residents of Catac region, a gateway community for visiting the Pastoruri glacier in Peru, indicates that a quarter of the surveyed households were engaged in some form of tourism-based activity, which includes the production of arts and crafts, animal rentals, guiding services, and food and refreshment preparation for trips to the Pastoruri glacier site (Bury *et.al*., 2011). Also indirect economic gains in the form of required services for the construction of glacier tourism related infrastructure (such as glacier railways) can have positive effects on local community's economic situation (Haimayer, 1989). However, a study by Aspinall, Cukier and Doberstein (2011), evaluating the social impacts of a hypothetical glacier ski resort in the Canadian Rocky Mountains on neighbouring local community, found that the respondent's perceived that quality of life would be negatively influenced by growing tourism development.

Six studies investigated the environmental impacts of glacier tourism (i.e. Kuniyal, 2002; Kaseva and Moraina, 2009; Zhang et al., 2010; Dhaulakhand, Rajwar and Kumar, 2010;

Goodwin, Loso and Braun, 2012 and Hoover-Miller *et.al*., 2013. The study of Hoover-Miller *et.al*. (2013) assesses vessel and kayak visitation to tidewater glaciers and the resulting impacts on harbour seals in the Kenai Fjords National Park in Alaska. The study revealed that boat and kayak tourism have a significant disturbance effect on seal populations and that voluntary changes in operations can lead to a significant reduction of these disturbances. Other studies analysed the effect of glacier tourism on the air quality around the Baishui Glacier in China (Ningning and Yuanqing, 2010) or the pastures beneath Gangotri glacier in India (Dhaulakhand, Rajwar and Kumar, 2010). The effects of waste produced by tourists in glacier areas was the subject of three studies (Kuniyal, 2002; Kaseva and Moraina, 2009; Goodwin, Loso and Braun, 2012). These studies highlighted the negative effects of waste produced by tourism on the natural environment and human health, and argued that with the projected growth of tourism in the examined regions pollution levels can increase significantly without effective waste management Furthermore, the growing discussion around the extension of tourism activities into often fragile environments, both in natural and cultural terms, was analysed by two studies (Stoddard, 2011; Stoddard and MacDonald, 2012). The studies mentioned above underline the sometimes detrimental effects of different forms of glacier tourism on biodiversity, as well as ancient cultural customs and perceptions of local stakeholders and indigenous communities. Frömming (2009) e.g. describes how Kilimanjaro's melting glacier has shifted from being a sacred heritage surrounding native communities to becoming the property of today's postcolonial Tanzanian state and international tour operators, whose joint aim is to gather revenue by collecting entrance fees and selling hiking tours to the glacier.

Two studies in this review examine the impacts of glacier tourism activities on tourists themselves. The studies of Sutton (1998) and Corbett (2001) investigated the issue of crowding by visitors to the Fox and Franz Josef glaciers in New Zealand. Both studies indicate that crowding occurs only during the periods of highest visitation in the main valley or is concentrated at the front of the glacier.

6. Discussion

This review has shown that there is a limited but growing amount of literature that examines the relationship between tourism and glaciers (n=48). However, the majority of the studies provide data from single case-studies that investigate glacier tourism in a particular context. While this has advanced the general knowledge of glacier tourism to some extent, the studies are grounded in specific local or regional contexts and are based on very diverse interpretations of glacier tourism concepts and attributes. As a result there is a lack of consistency in the employed conceptualizations and principles that underpin the research, which in turn leads to a literature set that is quite broad in scope and lacks cohesion. A future and more comprehensive research agenda might aim at the development of a coherent conceptual framework that incorporates the main elements of glacier tourism brought up in this review. Glacier tourism hovers at the interface between the established tourism research fields of mountain tourism, geo-tourism and outdoor adventure tourism. Each of these sub-fields have established different conceptual frameworks, e.g. Nepal and Chipeniuk (2005) on mountain tourism, Pomfret (2006) on mountain adventure tourism or Reynard (2008) on geo-tourism; that collectively can provide valuable input for the conceptual and theoretical grounding of glacier tourism research.

The reviewed literature taken as a whole provides indications of the main social, economic and environmental dimensions of glacier tourism impacts which need to be addressed to find sustainable trajectories for the development of the glacier tourism niche. From a social-cultural perspective, a central issue concerns the emergence of modern tourism in mostly remote rural areas which can lead to a severing of the bond between the glacier and its local communities which in turn can result in deprivation or degradation of the locals' sense of place. From an environmental perspective there are two major issues: first that glacier tourism operates in highly fragile and inaccessible environments that requires specific infrastructure which easily leads to negative effects on the natural environment, as well as on the aesthetic values of glacial landscape and its perception as wild and untamed nature. Secondly, glacier tourism refers to tourism in general as a significant contributing sector of the increasing emission of greenhouse gasses, the primary cause of global climate change (IPCC, 2013).

These limitations in the literature identified in this review are bound to raise questions about the existence and legitimacy of glacier tourism as a *fully fleshed* or *stand-alone* research topic. There are two main reasons to put this tourism niche on the agenda for further scientific research. First a pragmatic reason, as stated in the beginning of the review, glaciers worldwide attract millions of visitors every year, effecting multiple actors in socio-economic, cultural, and/or environmental matters in many different countries around the world. Seen in this light, glacier tourism (however it should be defined) is certainly a very real tourism phenomenon. The activities, interactions, impacts, attitudes and perceptions of tourism actors in this sector need to be guided by scientific research. The other reason is the recent call for more social science and humanistic approaches to climate change research that has until now been dominated by natural science paradigms (Hulme, 2009; Brace and Geoghegan, 2010). According to Brace and Geoghegan (2010) climate change has to be addressed in a relational context which blends physical spaces with human daily practices, values and history. As clearly revealed in the review, glacier tourism encompasses lived, valuable experiences of climate change induced phenomena, such as glacier recession and fragmentation. Research on how such localized lay knowledge and understanding is formed during glacier tour activities provides an important opportunity to study climate change as part and parcel of society.

In addition to the above named limitation and potential research benefits, the results of this review point out a lack of in-depth knowledge about several basic elements of this tourism niche such as:

- Uneven geographical coverage in the literature. There were e.g. no studies retrieved dealing with countries such as Switzerland, Sweden or Argentina where a significant glacier tourism market exists.

- There is lack of data concerning the motives, preferences, experiences and behaviours of glacier tourists, as well as of the motivational push and pull factors of glacier tourism.

- There are no cross area or sub-sector comparative analysis neither on tourists' perceptions and experiences of glacier site visits nor on existing or potential climate induced impacts on glacier tourism or adaptation strategies and measures.

- There is a lack of knowledge about how to develop reliable future scenarios of glacial landscape changes for tourism purposes.

Moreover, the focus on English language academic studies as data source of this review can be considered a limitation as relevant studies may have been overlooked. No doubt there is research on glacier tourism in other languages than English or documented outside the academic literature, it is therefore important that future research on glacier tourism includes non-English language literature and publications from grey literature.

7. Conclusion

This report has provided the first attempt to synthesize the available knowledge on glacier tourism in Anglophone academic literature. The present study investigated concepts, themes, topics and concerns dealing with the nexus of tourism and glaciers. By employing a scoping review method this study was able to specify the state-of-the-art knowledge on glacier tourism and revealed a number of pressing knowledge gaps that can inform the development of a future and more structured research agenda. This review illustrates that literature on glacier tourism deals with a broad scope of topics and addresses glacier tourism in a diversity of ways. Within this diversity of research disciplines, used concepts, methodologies and focal research topics, three relatively distinctive research themes have been discerned. The review, however, revealed also that there is currently a significant lack of comprehensive conceptual and theoretical understandings of glacier tourism which could tie together the diverse research interests, subjects and methodologies found in the reviewed studies and subsequently ground a more coherent and consistent research field. The chosen methodology for this research limits the possibility to explore all facets of the glacier tourism concept in detail. However, this report constitutes a baseline understanding of glacier tourism and provides a first but necessary step to create a foundation to guide the development of glacier tourism research.

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Appendix I

Table 13: List of studies in final review

Author	Document type	Name Journal	Nationality first author	Focal research topic	Research design	Data[3]	Type of tourism	Case-study
Haimayer, 1989	Article	Mountain Research and Development	Austria	Local communities	Descriptive	P	Skiing	Divers glacier in Austria
Blair, 1994	Article	Mountain Research and Development	New Zealand	Glacier area	Explanatory	P	Not specified	Tasman glacier, New Zealand
Sutton, 1998	Report	N.a.	New Zealand	Tourists	Descriptive	P	Hiking, scenic flights	Franz Josef and Fox glacier, New Zealand
Tinti, Maramai and Cerutti, 1999	Article	Phys. Chem. Earth (A)	Italy	Area management	Descriptive	S	Sightseeing	Miage glacier lake, Italy
Corbett, 2001	Report	N.a.	New Zealand	Tourists	Explanatory	P	Hiking, glacier walk, scenic flights	Franz Josef glacier, New Zealand
Espiner, 2001	Article	Pacific Tourism Review	New Zealand	Tourists	Descriptive	P	Hiking, sightseeing	Franz Josef and Fox glacier, New Zealand
Kuniyal, 2002	Article	Environmental impact assessment review	India	Glacier area	Descriptive	S	Not specified	Pindari Valley, India

[3] Data type: P= primary data, S= secondary data

Pralong, 2005	Article	Géomorphologie	Switzerland	Glacier Area	Descriptive	S	Geo-tourism	Not specified
Pralong and Reynard, 2005	Article	Il Quaternario, Italian Journal of Quaternary Science	France	Glacier Area	Exploratory	P	Geo-tourism	Bossons glacier, Mer de Glace glacier, Chamonix-Mont Blanc region, France
Aal and Hoye, 2005	Book Chapter	N.a.	Norway	Operators	Descriptive	S	Glacier museum tourism	Jostedalen glacier, Norway
Schindera et al., 2005	Article	Wilderness and Environmental Medicine	Switzerland and USA	Tourists	Descriptive	P	Not specified	Not specified
Liu, Yang and Xie, 2006	Article	Chinese Geographical Science	China	Area management	Descriptive	S	Not specified	Bogda Glacier Park, China
Diolaiuti et al., 2006	Article	Cold Regions Science and Technology	Italy	Glacier area	Explanatory	P	Skiing	Vedretta Piana glacier, Italy
Yuan et al., 2006	Article	Journal of Mountain Science	China	Tourists	Predictive	P	Sightseeing	Yulong Mountain glacier, China
Scott, Jones and Konopek, 2007	Article	Tourism Management	Canada	Tourists	Predictive	P	Hiking/sightseeing	Waterton Lakes National Park, Canada
Olefs and Fischer, 2008	Article	Cold Regions Science and Technology	Austria	Area management	Explanatory	P	Skiing	Schaufelferner and Gaiβkarferner glaciers, Austria
Smiraglia et al.,2008	Book Chapter	N.a.	Italy	Tourists, glacier area and area management	Descriptive	P	Skiing, sightseeing	Vedretta Piana Glacier and Miage lake, Italian Alps

Nyaupane and Chetri, 2009	Article	Tourism Geographies	Nepal	Glacier area	Descriptive	S	Mountaineering, hiking	Divers glaciers in Nepal
Kohler, 2009	Report	N.a.	Norway	Glacier area	Descriptive	P	Glacier boat tours	Hornsund area of Svalbard
Frömming, 2009	Article	Etnográphic	Germany	Local communities	Descriptive	P	Trekking	Kilimanjaro glaciers, Tanzania
Kaseva and Moraina, 2009	Article	Waste Management and Research	Tanzania	Management	Descriptive	P	Trekking	Kilimanjaro glaciers, Tanzania
Wang, He and Song, 2010	Article	Journal of Earth Science	China	Area management	Descriptive	S	Miscellaneous	Baishui Glacier No. 1, China
Zhang et al., 2010	Article	Journal of Earth Science	China	Atmosphere	Descriptive	P	Not specified	Baishui Glacier No. 1, China
Dhaulakhandi, Rajwar and Kumar, 2010	Article	Journal of Plant Development	India	Biodiversity	Explanatory	P	Pilgrimage, mountaineering, hiking	Gangotri glacier, India
Brandolini and Pelfini, 2010	Book Chapter	N.a.	Italy	Glacier area	Descriptive	P	Hiking	Solda Valley, Stelvio National Park, Italian Alps
Diolaiuti and Smiraglia, 2010	Article	Géomorphologie	Italy	Glacier area	Descriptive	S	Geo-tourism	Forni glacier, Val Viola glacierised basin, Italy
Jóhannesdóttir, 2010	Book Chapter	N.a.	Iceland	Tourists	Discriptive	P	Glacier walking	Sólheimajökull glacier, Iceland
Moreau, 2010	Article	Géomorphologie	France	Tourists	Descriptive	P	Hiking and mountaineering	Évettes glacier Cirque, French Alps, France
Beza, 2010	Article	Landscape and Urban Planning	Australia	Tourists and operators	Descriptive	P	Trekking	Mount Everest region, Nepal

Bird, Gisladottir and Dominey-Howes, 2010	Article	Journal of Volcanology and Geothermal Research	Iceland	Tourists and management and operators	Descriptive	P	Not specified	Myrdalsjökull glacier, Iceland
Fisher, Olefs and Abermann, 2011	Article	Annals of Glaciology	Austria	Area management	Explanatory	P	Skiing	Mittelbergferner, Austria
Feuillet and Sourp, 2011	Article	Geoheritage	France	Glacier areas	Descriptive	P	Geo-tourism	Pyrenees National Park, France
Bury et al., 2011	Article	Climatic Change	USA, Canada, Peru	Local communities, operators and area management	Descriptive	S	Not specified	Pastoruri glacier, Peru
Aspinall, Cukier and Doberstein, 2011	Article	Journal of Environmental Assessment Policy and Management	Canada	Local community	Predictive	P	Skiing	Jumbo glacier, Canada
Stoddart, 2011	Article	Leisure Studies	Canada	Media	Descriptive	P	Skiing	Jumbo glacier, Canada
Wang and Jiao, 2012	Article	Sciences in Cold and Arid Regions	China	Area management	Descriptive	S	Not specified	Mt. Yulong Snow scenic area, China
Ritter, Fiebig and Muhar, 2012	Article	Mountain Research and Development	Austria	Glacier area	Descriptive	S/P	Mountaineering	Glaciated mountain ranges in Austrian Alps
Furunes and Mykletun, 2012	Article	Scandinavian Journal of Hospitality and Tourism	Norway	Operators	Descriptive	P	Ice-climbing, glacier walks	Different glacier sites in Norway
Wilson, 2012	Report	N.a.	New Zealand	Operators	Descriptive	P	Hiking, glacier walks, scenic flights	Frans Jozef and Fox Glacier, New Zealand

Becken, 2012	Article	Journal of Travel Research	New Zealand	Tourists	Explanatory	P	Scenic flights	Franz Josef Glacier, New Zealand
Garavaglia et al.,2012	Article	Environmental Management	Italy	Tourists	Descriptive	P	Mountaineering, hiking	Forni Valley in Stelvio National Park, Italy
Goodwin, Loso and Braun, 2012	Article	Arctic, Antarctic, and Alpine Research	USA	Tourists	Explanatory	P	Mountaineering	Kahiltna Glacier in Denali National Park and Preserve, USA.
Hoover-Miller et al., 2013	Article	The Journal of Wildlife Management	USA	Biodiversity	Explanatory	P	Kayaking, boat tours	Kenai Fjords National Park, USA
Bollati, Smiraglia and Pelfini, 2013	Article	Environmental Management	Italy	Glacier area	Descriptive	P	Hiking	Miage Glacier Area, Italy
Lund, 2013	Article	Tourist Studies	Iceland	Tourists	Descriptive	P	Hiking	Snæfelljökull glacier, Iceland
Ólafsdóttir, 2013	Article	Tourist Studies	Luxembourg	Tourists	Descriptive	P	Trekking	Vatnajökull glacier, Iceland
Purdie, 2013	Article	Mountain Research and Development	New Zealand	Tourists and operators	Descriptive	S	Glacier walking, sightseeing and glacier boat tours	Franz Josef and Fox glaciers, New Zealand
Espiner and Becken, 2014	Article	Journal of Sustainable Tourism	New Zealand	Operators	Exploratory	P	Hiking, glacier walks	Fox and Franz Josef Glaciers, New Zealand

Appendix II

Themes/Issues	**Studies**
Climate change	
Types of climate impacts	Blair, 1994; Tinti et al., 1999; Aal and Hoye, 2005; Diolaiuti et al., 2006; Yuan et al, 2006; Scott et al., 2007; Kohler, 2009; Smiraglia et al., 2008; Nyaupane, 2009; Moreau, 2010; Diolaiuti and Smiraglia, 2010; Brandolini and Pelfini, 2010; Bury et al., 2011; Becken, 2012; Wilson, 2012; Ritter et al., 2012; Purdie, 2013; Espiner and Becken, 2014
Actors perceptions	Moreau, 2010; Wilson, 2012; Garavaglia et al, 2012; Furunes an Mykletun, 2013; Espiner and Becken, 2014
Adaptation and mitigation	Blair, 1994; Tinti et al., 1999; Espiner, 2001; Aal and Hoye, 2005; Schindera et al., 2005; Diolaiuti et al., 2006; Olefs and Fisher, 2008; Smiraglia et al., 2008, Kohler, 2009; Wang et al, 2010; Diolaiuti and Smiraglia, 2010; Brandolini and Pelfini, 2010; Bury et al., 2011; Fisher et al., 2011; Wilson, 2012; Wang and Jiao; Purdie, 2013; Espiner and Becken, 2014
Tourism impacts	
Economic effects	Haimayer, 1989; Frömming, 2009; Bury et al., 2011, Espiner and Becken, 2014
Social-cultural effects	Haimayer, 1989; Sutton, 1998; Corbettt, 2001; Frömming, 2009; Stoddart, 2011; Aspinall et al., 2011; Goodwin et al., 2012
Environmental effects	Kuniyal, 2002; Kaseva and Moraina, 2009; Zhang et al., 2010; Dhaulakhandi et al., 2010; Goodwin et al., 2012;Hoover-Miller et al., 2013
Perception & Values	
Assessment approach	Pralong, 2005; Pralong and Reynard, 2005; Beza, 2010; Jóhannesdóttir, 2010; Feuillet and Sourp, 2012; Ólafsdóttir, 2013, Bollati et al., 2013; Lund, 2013
Type of value	Pralong, 2005; Pralong and Reynard, 2005; Beza, 2010; Jóhannesdóttir, 2010; Feuillet and Sourp, 2012; Wilson, 2012; Furunes and Mykletun, 2012; Ólafsdóttir, 2013, Bollati et al., 2013; Espiner and Becken, 2014
Perception differences	Frömming 2009; Moreau, 2010; Beza, 2010

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