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Source: Mountain Research and Development, 39(2)

Published By: International Mountain Society

URL: https://doi.org/10.1659/MRD-JOURNAL-D-18-00090.1

Mountain Research and Development (MRD)
An international, peer-reviewed open access journal
published by the International Mountain Society (IMS)
www.mrd-journal.org

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Participatory Planning Under Scenarios of Glacier Retreat and Tourism Growth in Southeast Iceland

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Glacial mountain environments are changing rapidly as a result of climate change and the expansion of nature-based recreation. Anticipatory planning to adapt to such changes is a key management challenge. The aim of this study was to explore how adaptation planning for recreation sites in these areas can be supported using participatory scenario planning (PSP). For this purpose, a study area in southeast Iceland was chosen where management is likely to be heavily impacted in the near future. PSP involves local stakeholder workshops in which participants generate maps reflecting plausible glacial land cover and land use in the near future. This process takes place in stages, including the identification of potential drivers of land-use change, development of multiple land-use scenarios, and examination of the potential consequences of these scenarios and options for adapting to them. The study demonstrates that PSP can be a valuable tool to support recreational land-use planning in glacial landscapes, and to improve anticipatory adaptation to potentially undesirable future changes. PSP also has the potential to provide salient and usable knowledge for local stakeholders, stimulate stakeholders to elaborate on long-term changes and associated uncertainties through scenario construction and visualization, provide insight into the adaptive capacity of current recreational planning systems, and reframe stakeholders' guiding assumptions to encourage a more future-oriented mentality. This approach could be valuable in other glaciated mountain areas and in recreation areas where there are multiple significant future changes in landscape attributes, processes, and uses at play simultaneously.

Keywords: *Participatory scenario planning; glacial land-cover mapping; land-use mapping; outdoor recreation; climate change adaptation; local stakeholders; Vatnajökull National Park; Iceland.*

Peer-reviewed: *March 2019* **Accepted:** *15 May 2019*

Introduction

Glacial mountain environments are changing rapidly as a result of climate change (eg Vaughan et al 2013; Huss et al 2017) and the expansion of nature-based recreation (Welling et al 2015). Numerous studies (Furunes and Mykletun 2012; Ritter et al 2012; Purdie et al 2015) have shown that the overlap of these 2 trends has diverse implications for the visitors and managers of glacier recreation sites—for example, the increased risk of visitor accidents due to landslides and rockfall, scenic landscape changes, and reduced accessibility to and within glacier recreation sites.

Empirical research has been conducted to project future demand for glacier site visits, revealing a considerable reduction in demand as a result of the deterioration of glacier scenery (Stewart et al 2016; Groulx et al 2017) or complete disappearance of glaciers (Yuan et al 2006; Scott et al 2008). Conversely, the disappearance of glaciers is also viewed by some as a reason to visit them in a form of "last chance tourism" (Dawson et al 2011; Stewart et al 2016), which paradoxically can increase glacier shrinkage due to the heat released by large-scale tourism activities at glacier sites (Wang et al 2019). Despite these projected changes in demand, empirical studies on the behavior of glacier tourism entrepreneurs (eg Furunes and Mykletun 2012; Wilson 2012; Espiner and Becken 2014; Wilson et al 2014) reveal that a majority do not consider the potential further recession of the glaciers to be a significant challenge to their business success and that most respond reactively rather than proactively to these environmental changes, focused on maintaining the "status quo and waiting to see what happens" (Wilson et al 2014: 35).

Many of the most popular glacier recreation sites are located in protected mountain areas (Wang and Jiao 2012; Lemieux et al 2018). Although such areas have management plans, management of protected areas is often hampered by the lack of proactive climate change adaptation planning and implementation by conservation and recreation practitioners (West et al 2009; Lemieux and Scott 2011). Proactive, adaptive land-use planning for glacier recreation sites is critical to address current and future challenges in a sustainable and cost-effective manner.

Lemieux and Scott (2011) argue that an important reason for the current lack of anticipatory adaptation is the high degree of uncertainty about the effects of climate change. This uncertainty is especially relevant in glacial landscapes, which undergo continuous and unpredictable change, such as the erratic retreat of glacier margins, the emergence of glacier lakes and streams, and the continuous and often large-scale course alterations of glacier rivers (Benn and Evans 2010; Björnsson 2017). Other researchers (eg Shaw et al 2009; Hagerman et al 2010; Mastrandrea et al 2010) assert that scientific research for adaptation planning often falls short of providing information that can be directly useful in practical decision-making.

New approaches are therefore needed to more effectively support recreational land-use planning and management for climate change adaptation in glacial mountain environments (McDowell et al 2014; Rannow et al 2014). Such approaches need to address the high uncertainty inherent in glacier recreation sites and to produce information that can be used in practical decision-making.

Participatory scenario planning (PSP) can support decision-making in unpredictable environments by (1) describing plausible future conditions with a range of potential implications (Peterson et al 2003; Mott Lacroix et al 2015) and (2) engaging stakeholders in the development and application of scenarios, thus cocreating understanding and knowledge and enhancing the relevance, credibility, and legitimacy of the resulting information (Bizikova et al 2015). PSP has been applied to different issues in glacial and nonglacial mountain environments, including tourism planning (Malek and Boerboom 2015), management of natural parks (Daconto and Sherpa 2010), risk management (Nussbaumer et al 2014), and development of collective local adaptive capacity (Christmann and Aw-Hassan 2015).

Scenarios can be descriptive, exploring what could happen, or normative, exploring what ideally should happen (Borjeson et al 2006). Descriptive scenarios are more suitable for projecting future trends through the exploration of diverse drivers of change based on existing trends or stakeholders' estimations, while normative scenarios are more suitable for developing strategies to reach a desirable future condition (Houet et al 2010). Several PSP approaches use visualization techniques to increase a topic's understandability and relevance to local stakeholders (eg Hoyer and Chang 2014; Malek and Boerboom 2015; Brewington et al 2017). For example, maps have been used effectively to visualize climate change impacts across time and space, and to enhance understanding of complex environmental issues, increase stakeholder engagement, and promote behavioral change and learning (Sheppard 2005; Becken et al 2015). However, other studies (eg Reed et al 2013; Newell and Canessa 2018) point out that visualization techniques pose the risk of visual bias—by which aspects of scenarios that, for example, are easily represented visually or evoke a sense of place receive more attention from focus group participants than other aspects.

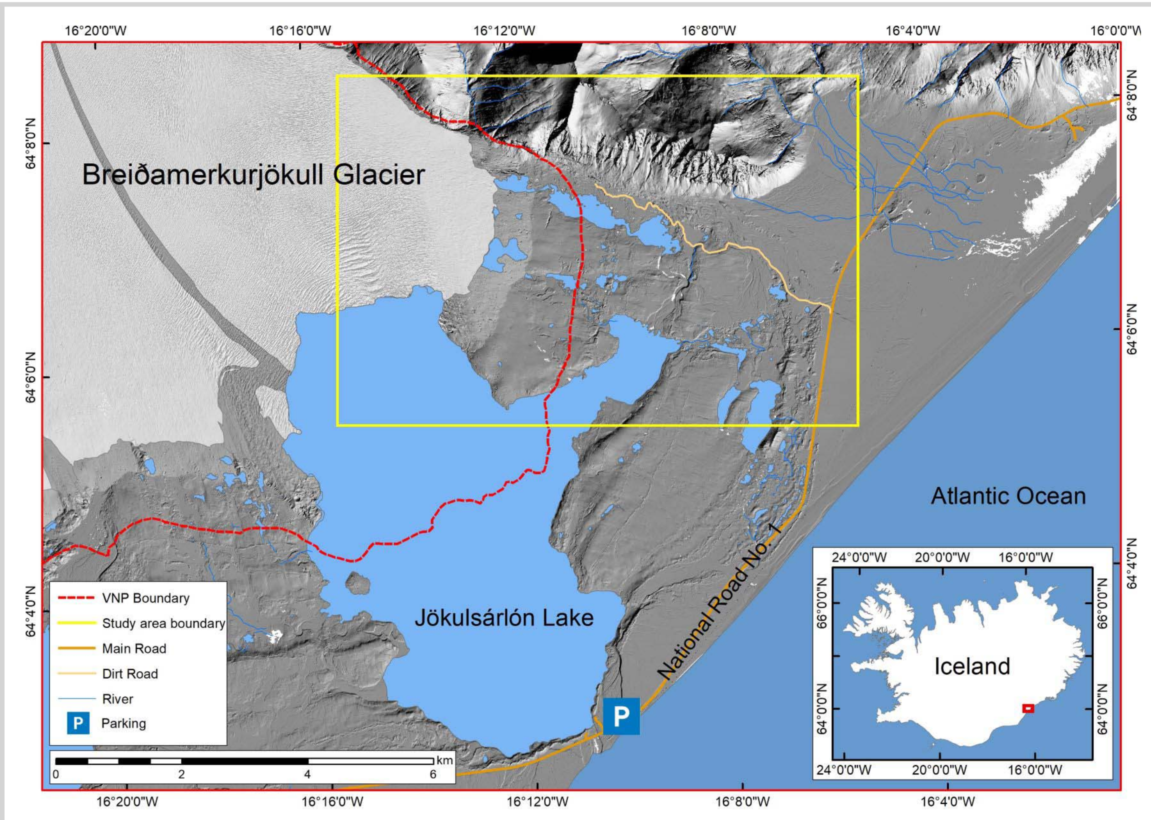
This study explored ways that PSP can support recreational land-use planning and decision-making in glacial landscapes and how it can improve anticipatory adaptation to potential undesirable future changes. To this end, a PSP process was developed, grounded on a combination of scientific expertise and local stakeholders' engagement, and a popular glacier recreation site in southeast Iceland was chosen as a case study.

Study area

Europe's largest glaciers are in Iceland, where they cover about 10% of the landmass (Björnsson 2017). Since the 1990s, glaciers in Iceland have been the setting of increasing outdoor recreation and adventure activities, which have created a substantial niche tourist market, on which some regions of Iceland have become economically dependent (Welling and Árnason 2016). The case study area, called Þröng, is on the southern edge of the Vatnajökull ice cap and has become a glacier recreation site over the past decade (Figure 1). It is approximately 16.5 km^2 in area and includes the eastern snout (terminus) of the outlet glacier Breiðamerkurjökull, where glacier recreation has been gradually increasing during the past 5 years. The study area borders the west side of the proglacial lake (a moraine-dammed lake that emerges adjacent to the frontal margin of a glacier) Jökulsárlón, one of the most popular tourist destinations in Iceland, which received around 800,000 visitors in 2017 (Þórhallsdóttir and Ólafsson 2019). In July 2017, the area became a part of Vatnajökull National Park, but the management plan for this area remains to be developed.

Currently, the Þröng site has no visitor infrastructure or facilities, and it can only be accessed by an unmarked and unmaintained track, only passable by a four-wheel-drive vehicle. Recreation activities include guided glacier hikes during the summer and ice-cave tours during the winter (Árnason and Welling 2019). Around 27,000 people visited the Þröng site in 2018 (Þórhallsdóttir and Ólafsson 2019), most of them on guided tours. Nonguided visitors are currently rare due to the site's limited accessibility. A recent economic impact study of Vatnajökull National Park (Siltanen 2018) stressed the importance of park visitation to the regional economy, showing that the park's direct economic impacts are US$88.3 million, with

FIGURE 1 Location of Þröng recreation site, showing the glacier margin as of 2010. (Map by S. Guðmundsson)



an economic impact-to-cost ratio of 15:1 and the creation of 71 full-time jobs.

The study area is characterized by a dynamic landscape. The southeast glaciers of Vatnajökull are located in the warmest and wettest area of Iceland (Hannesdóttir et al 2010) and therefore respond quickly to changes in temperature and precipitation. The terminus of Breiðamerkurjökull has retreated >5 km, losing 11.2% (114 km^2) of its volume from the late 19th century to 2010 (Guðmundsson et al 2017). Since the start of this millennium, the southeast outlet glaciers of Vatnajökull have retreated rapidly; according to Hannesdóttir and Baldursson (2017), their mass loss per unit area is among the highest in the world. In line with global climate change trends (IPCC 2013), climate projections for southeast Iceland show an increase in annual temperature of 2–2.4°C under Representation Concentration Pathway 4.5 and 3.4–4°C under Representation Concentration Pathway 8.5 by 2081–2100 (Icelandic Meteorological Office 2017). Glacier models (based on Intergovernmental Panel on Climate Change Special Report on Emission Scenarios A2 and B2; IPCC 2000) indicate that southern Vatnajökull could lose around 25% of its current volume within the next 50 years (Björnsson and Pálsson 2008).

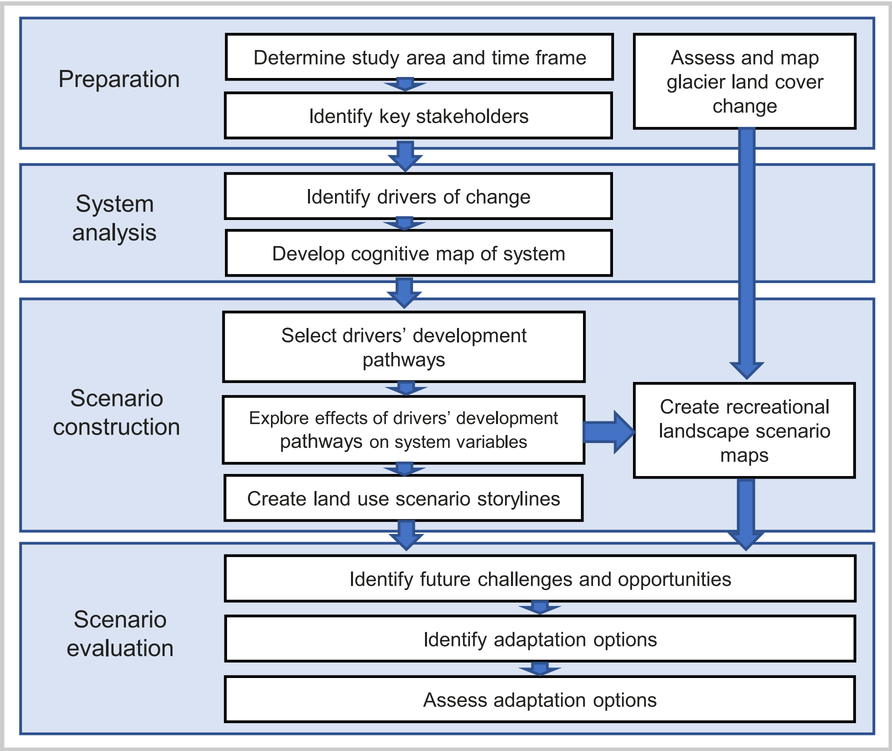
Applying PSP to the study area

We used PSP to explore future scenarios, their potential social and environmental consequences, and potential solutions to these consequences (Carlsen et al 2013). Our initial approach was primarily based on studies by Carlsen et al (2013), who created tailor-made scenarios engaging local stakeholders in their design and application, and Houet et al (2010), who combined landscape modeling and scenario-based approaches to map future land-use changes. These 2 studies provided a foundation for the PSP process used in this study, which consisted of 4 basic stages (the first carried out primarily by researchers and the others in cooperation with local stakeholders): preparation, system analysis, scenario construction, and scenario evaluation. Each stage contained multiple sequential steps, as shown in Figure 2.

Preparation

The first stage in the PSP process involved defining the study area, selecting a time frame, and identifying and selecting representative stakeholders. As a time frame for this study, we chose 2016–2026. According to Purdie (2013), this time span is short enough to encompass a foreseeable future, which entrepreneurs and tourism

FIGURE 2 Participatory scenario planning process used in this study.



planning and management actors ideally want to understand insofar as it pertains to changes in the accessibility of glacier sites and risk regimes. Moreover, management plans for recreation destinations typically cover no more than 10 years (Thomas and Middleton 2003).

Local stakeholders were the key data source in the development of the PSP process. However, power inequalities within stakeholder groups and differing levels of knowledge, worldviews, interests, and semantics can constrain meaningful engagement (Rounsevell and Metzger 2010; Reed et al 2013). Therefore, an important step was to convene a local stakeholder group in which the key interest groups concerned with recreational land use in the case study area were represented proportionally. It has been pointed out (eg Bizikova et al 2015) that connecting PSP with an existing stakeholder network can assist in identifying key stakeholders and can help to establish trust and mutual recognition among workshop participants. We therefore decided to connect the research approach of this study to an existing local stakeholder's network, a closed regional social media group that promotes nature-based tourism education. This was an important aspect of the study because it increased participants' willingness to share information and to speak freely during the workshops. Trust in the participatory process was further enhanced by appointing local workshop facilitators who were perceived by the stakeholders as neutral actors in recreational land-use planning.

A stakeholder group of 14 participants (of whom 8 were men), all local residents, was established. Three workshops were held, each with 8–10 participants drawn from this group, representing the main stakeholders in the area (Table 1). The workshops were held in Höfn, the only village in the municipality, in November 2016, June 2017, and October 2017. In each workshop, different nominal group techniques (ie structured face-to-face group session methods; Delbecq et al 1975) were employed—such as brainstorming, problem identification, group discussions, and solution generation—to obtain the necessary data.

To design future land-cover maps representing responses to future climate change in the case study area, a 2-step glacial land-cover modeling technique was applied, based on the work of Guðmundsson et al (2017). In the first step, 2 digital land-cover maps of the study area, for the years 2010 and 2016, were created using light detection and ranging (LiDAR) digital elevation models (DEMs) of the Vatnajökull ice cap (Jóhannesson et al 2011, 2013), Landsat 8 images, and the geographical database of the National Land Survey of Iceland. The 2016 ice-surface geometry was further constructed by studying the elevation changes between 2010 and 2016 near the terminus and its lateral margins and by using differential

TABLE 1 Focus group participants.

Stakeholder group	Details	Number
Entrepreneurs	Local glacier tour operators	5
National park	Manager and staff of Vatnajökull National Park	3
Municipality	Officials from planning and tourism departments	3
Nongovernmental organization	Nature conservation organization	1
Destination marketing organization	Regional tourism promotion and strategy development organization	1
Scientists	Experts in natural history	1

global positioning system elevation data collected on the glacier in 2016, also with the LiDAR DEM.

In the second step, a predictive land-cover map of the study area in 2026 was created by adding an extrapolation of the terminus position and the outlet's ice surface. The assumption was based on a continuation of the annual average retreat (about 96 ± 9 m) and surface lowering (3.5–6 m) of Breiðamerkurjökull during 2010–2016. The elevation contours of the assumed exposed foreland within the 2016 boundary were based on glacier subfloor uplift development derived from a radio-echometric survey of Breiðamerkurjökull in 1991 (Björnsson et al 1992).

System analysis

The second stage involved analyzing the recreational land uses of the study area as a socioecological system and exploring how drivers of change may influence this system through a collective cognitive mapping exercise. Cognitive mapping is a technique that captures a stakeholder's view of a particular issue in a graphical representation (Tegarden and Sheetz 2003). Through cognitive mapping, the qualitative knowledge of expert participants and local stakeholders is summarized to construct a simple systems model in which nodes represent concepts or ideas and arrows denote the interactions or linkages between these ideas (Mendoza and Prabhu 2006). This format gives participants the opportunity to investigate the complex interconnections between the elements of the system and to gain insights into the consequential relationships and feedbacks among different system issues, exogenous drivers, local variables, and outcomes (Goodier and Soetanto 2013).

During the first workshop, participants were asked to identify drivers of land-use change within the study area. After discussions, the stakeholders selected the drivers they considered most important and listed key local system variables that were directly connected to them. Based on these drivers and variables, the stakeholders developed a cognitive map of the recreation system in the study area.

Scenario construction

In the third stage of the first workshop, participants designed alternative future scenarios in the form of narratives and recreational landscape maps of the study area. Participants were asked to imagine 2 to 3 contrasting but plausible pathways along which each identified driver of land-use change might develop by 2026 (their development pathways). Then, a simple scenario matrix (Carlsen et al 2013) was used to put together a relevant, important, and challenging combination of different driver development pathways and to construct and label significantly different plausible future scenarios based on "scenario logic," a simple method to structure potentially divergent issues and statements that underpin a story line to allow comparison and establish internal consistency (Rounsevell and Metzger 2010). Subsequently, based on the cognitive system map, the influence of the different combinations of potential development pathways on key system variables in the study area were explored, and the development of the system variables for each scenario was translated into 1-page descriptive story lines.

During the last step in this stage, future land-use changes were assessed by comparing the development of the land-use variables described in the story lines with the spatial distribution of current land uses of the study area. The development pathways were translated into simple spatial rules to modify current land-use attributes based on Carter et al (2017) to convert the scenario narratives into spatial representations. Together with the outcomes of the 2026 land-cover mapping, the land-use attributes were processed using GIS (geographic information system technology) into landscape maps that consisted of a set of accumulated (overlaid) land-use and land-cover feature layers.

In general, it is problematic to validate exploratory scenario assumptions because they are derived from worlds that might happen in the future and have never happened in the past, which makes it impossible to test them against empirical data (Rounsevell and Metzger 2010). We validated all scenario story lines and maps through discussion in the stakeholder workshops. To evaluate the plausibility of the recreational land-use scenarios and land-

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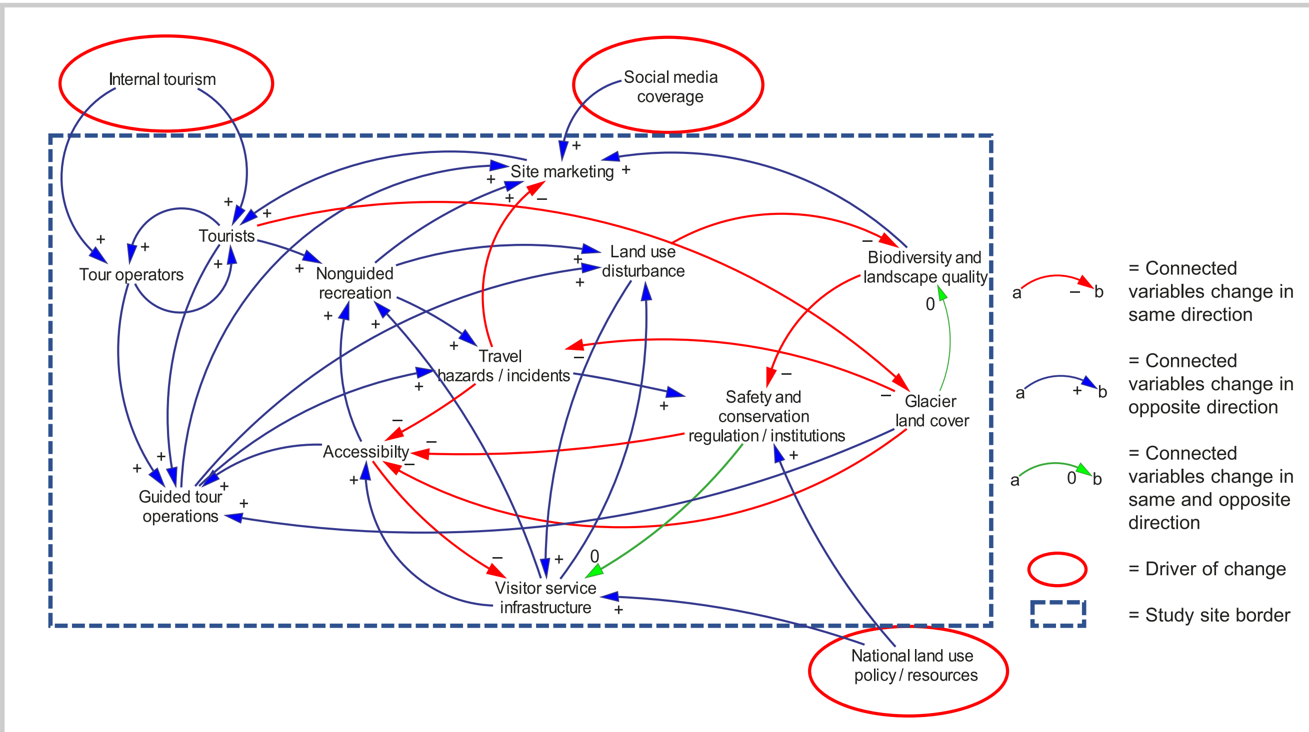
FIGURE 3 Cognitive map of the recreational system in the study area.



cover changes, we compared them to other scenarios of future tourism development in Iceland (eg KPMG 2015; Ministry of Industries and Innovation 2015) and simulations of the retreat of Breiðamerkurjökull glacier (Björnsson et al 2001; Nick et al 2007).

Scenario evaluation

The final stage of the process took place in subsequent workshops. In the second workshop, the scenario story lines and maps were presented and discussed with the local stakeholder group to identify the most important opportunities and threats for each scenario. In the third and last workshop, the stakeholders identified a set of options to adapt to the main threats and opportunities identified earlier, and they assessed the practicality of implementing the main options, including the availability and sufficiency of land-use governance and management products and services.

Results

Cognitive map of drivers of land-use change

During the first stakeholder workshop, the participants identified several drivers of change, that is, external variables of the Þröng site for the study period. Participants discussed these drivers and selected 3 for further discussion: (1) internal tourism development, (2) national land-use policies and resources, and (3) social media coverage. Next, they projected these drivers' likely development pathways (eg increase or decrease). During the second part of the workshop, participants identified, discussed, and selected 11 internal system variables on the basis of the 3 selected drivers of change. They then determined the connections between the variables and whether the connected variables changed in the same and/or opposite directions. Based on these findings, they developed a cognitive map of the recreation system in the study area (Figure 3).

Scenario matrix, story lines, and maps

The scenario matrix construction resulted in 3 plausible and challenging scenarios of recreational land use in the study area in 2026: business as usual, hot spot, and green tourism (Table 2). These scenarios differed in terms of development direction and the intensity of the local system variables, such as number of tourists and tour operators, demand for nonguided recreation, marketing, visitor regulation, and infrastructure development. The scenario maps are shown in Figure 4, and a summary of the corresponding story lines is given in Table 3. The comparison between the land-cover maps of 2016 and 2026 suggested glacier retreat of almost 1 km and surface lowering near the 2016 terminus of approximately 33–58 m. The estimated shrinkage of the Breiðamerkurjökull snout by 2026 also was expected to lead to the emergence of approximately 2.6 km^2 of deglaciated moraine,

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TABLE 2 Scenario matrix.

Driver of change	Scenario		
	Business as usual	Hot spot	Green tourism
National land management policy	No change—limited regulation of recreation in protected areas	Slow extension	Fast extension
Tourism	Slow increase	Fast increase	Slow increase
Social media coverage	No change—low coverage	Fast increase	Fast increase

including 2 rivers, and to a shift of the glacier margin to an elevation 20 m higher.

Scenario evaluation

The story lines and maps of the 3 scenarios were validated through discussion with the local stakeholder group during the second workshop. Workshop participants identified 14 threats and 12 opportunities (Table 4). One opportunity and 2 threats were selected from each scenario to address in a third stakeholder workshop, where participants identified, discussed, and defined adaptation options to address the selected opportunities

FIGURE 4 Three scenarios for recreational land use in the study area in 2026.

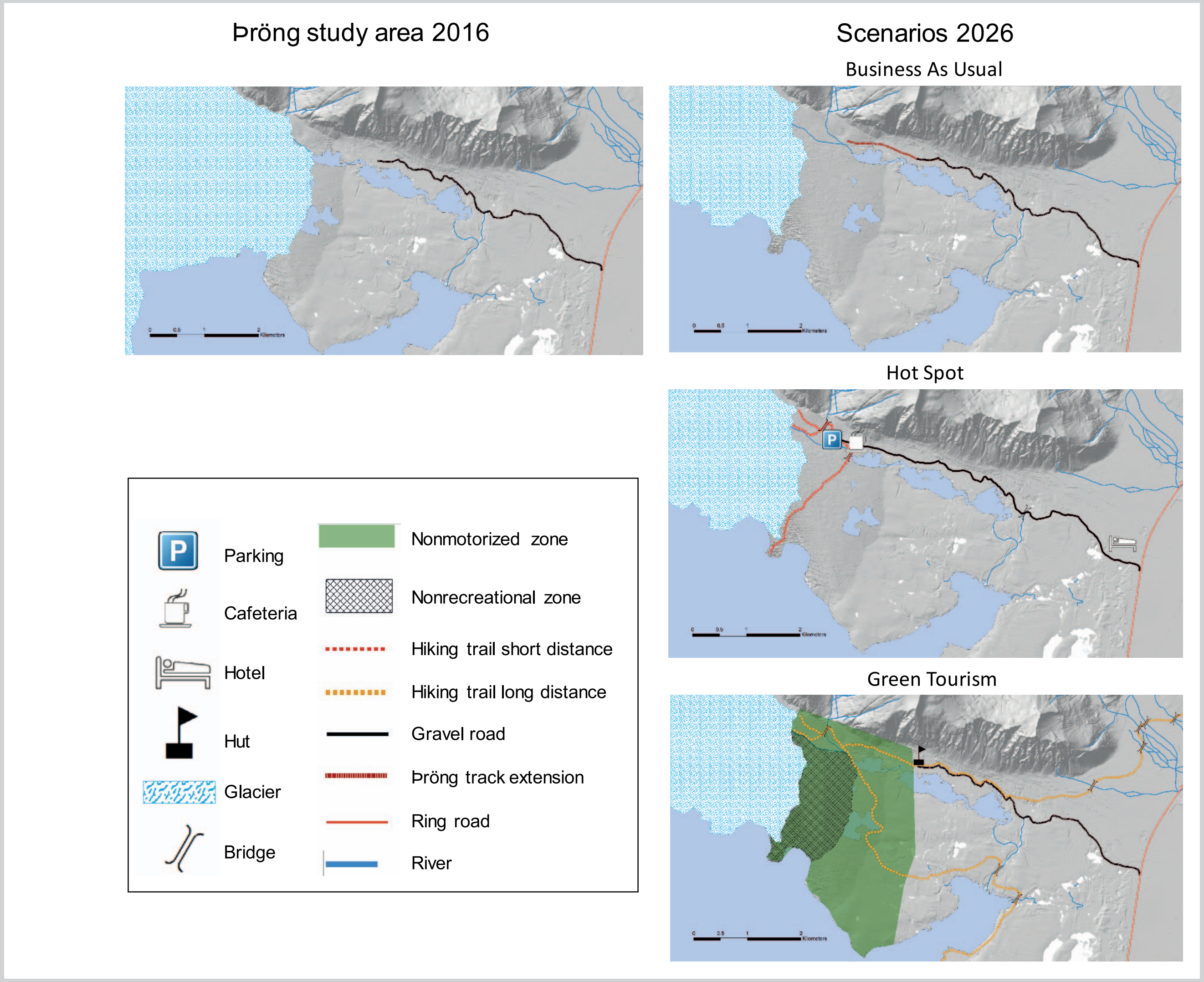

TABLE 3 Story lines for the 3 scenarios.

Variables	Scenario		
	Business as usual	Hot spot	Green tourism
Visitors per year	Around 50,000	Around 250,000	Around 50,000
Number of tour operators	Only a few companies offer guided hiking tours	About 25 companies offer transport to the area for sightseeing, and 10 companies offer special hiking or ice-climbing tours	No more than 5 companies receive a license to operate tours each year
Visitors pursuing nonguided recreation	Very few	Most	About half
Marketing	The site is not promoted as a tourist destination	The site is promoted as a tourist destination	The site is promoted as an ecotourism destination
Land-use restrictions	None for visitors or tour operators	None for tour operators	Nonrecreational and nonmotorized zones; ban on fossil-fuel-driven vehicles; restrictions on type and number of tour operators
Infrastructure	A single dirt road; no visitor facilities	Gravel road suitable for regular cars, parking area, toilet facilities, food shop, picnic tables, marked sight-seeing paths, hotel at the entrance	Small mountain hut and small campground with minimal services, marked geo-heritage educational walking trails, and connection to southern Iceland's network of hiking and biking routes

and threats. The options identified by workshop participants can be summarized as improving regulation/enforcement and planning/maintenance processes, stimulating research and education, promoting tourism, communication, and cooperation.

Due to the limited amount of time that was available during the workshop and maximum amount of time participants can be asked to devote to a focus group session, the workshop participants were asked to select 1–2 of the main adaptation options for addressing each threat selected in the previous workshop. After selecting adaptation options, participants assessed how each could be implemented in practice under current management

TABLE 4 Threats and opportunities identified for each scenario.

Scenario					
Business as usual		Hot spot		Green tourism	
Threats[a)]	Opportunities [a)]	Threats [a)]	Opportunities [a)]	Threats [a)]	Opportunities [a)]
Conflict and chaos	Research	**Increased pressure on nature and society**	Economic growth; increased income	Wishful thinking	Holistic planning
Poor access	**Passive nature conservation**	Diminished wilderness experience	Increased business opportunities	Conflicts due to changes	**Ecotourism**
Lack of planning	Tour diversity and availability	Risk of accidents	Increased accessibility	**Excessive management**	Wilderness experience
Risk of accidents	Experiencing untouched nature	**Increase in conflicts**	**Educating the public**	**Limited market**	Research
Lack of visitor planning or policy		Short-lived situation followed by a rapid socioeconomic and environmental downfall			

[a)] The threats and opportunities in bold were selected to be addressed in the third workshop.

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TABLE 5 Assessment of adaptation options.

Threat	Adaptation option	Products and services needed	Available?	Sufficient?[a]	Easy to acquire or change?[a]	Possible to implement?
Poor access	Track repair and extension	Financing for infrastructure by tour operators	Yes	No	Yes	Yes
		Permits for commercial use	Yes	Yes	n/a	
		Visitor management plan	No	n/a	Yes	
Risk of accidents	Requirement to travel with guide	Specific regulation	No	n/a	No	No
		Enforcement of regulation	Yes	No	n/a	
Pressure on nature	Network of walking paths	Infrastructure fund financed by users (tour companies)	No	n/a	Yes	Yes
		Expert knowledge (eg concerning hiking trails)	Yes	No	Yes	
Stakeholder conflict	Proactive master planning and local planning	Holistic vision	No	n/a	No	No
		Stakeholders willing to cooperate	Yes	No	Yes	
Restrictive management	Cooperation platform between companies and park	Facilitation and maintenance of cooperation platform	Yes	No	Yes	Yes
	Promotion of changed attitudes to nature	Education, training, knowledge	Yes	No	No	No
Limited market	Promotion of tourism products	Marketing to increase awareness of the value of the area	Yes	No	Yes	No
		Grants for environmentally friendly tourism innovation and development	No	n/a	No	

[a] n/a, not applicable.

and governance conditions, guided by the following questions:

- What kind of governance or management products and services are required to implement the particular adaptation option?
- Are those required products and services currently available?
- If the required products and services exist, are they available in sufficient quantity and quality?
- If the required products and services do not exist or are insufficient, are they easy to acquire, increase, or improve to allow implementation of the particular adaptation option?

Of the 7 selected adaptation options, 4 were considered difficult or impossible to implement under current decision-making and governance conditions, because at least 1 of the products and services required to implement the option was absent or insufficient (Table 5). Not one of the selected adaptation options was considered sufficiently available by the stakeholders. However, the options—repair and extend the current track, extend a network of walking paths in Þröng, and establish a cooperation platform between companies and park—required actions or products that were not all currently available but would be, according to workshop participants, relatively easy to acquire or increase or improve.

Discussion

The value of PSP in glacial recreation sites

Outdoor recreation is an interconnected activity that depends on the interplay of natural and socioeconomic services and goods. Glacier mountain environments have complex dynamics in which biological, geophysical, and socioeconomic trends and actors interact and are affected by climate change. An important strength of the process developed in this study is the successful integration of socioeconomic and natural environmental changes into future scenarios. This is supported by Bonzanigo et al (2016), who concluded that such integration is a much more effective and realistic way to analyze the impacts of climate change on and responses to recreational land uses than examining these in isolation. The process furthermore enables the cocreation of future land-use scenarios by combining science-based knowledge in the form of land-cover dynamic modeling with local knowledge of land-use practices. Such approaches have been shown to provide effective ways to produce usable knowledge in support of adaptation-related decision-making (Dilling and Lemos 2011; Meadow et al 2015).

For the effective implementation of PSP, it is important that the process stimulates understanding and trust among stakeholders by using an existing regional network as the basis for stakeholder workshops, selecting workshop participants who represent a balanced mixture of local interest groups, and appointing as workshop mediators local residents who are perceived as neutral (in this study, the headmaster of a secondary school and director of a research center). Furthermore, the effectiveness of the stakeholder workshops is enhanced by developing tailor-made scenarios on the basis of the stakeholders' concerns and perceptions (ie their identification and prioritization of drivers of change of recreational land uses and their development pathways), developing and addressing cocreated knowledge at relevant spatial and temporal scales, and visualizing this knowledge in the form of maps to add a spatial dimension to the process. These last 2 aspects are supported by Purdie (2013), who stressed that the mismatch between glacier-based science and practitioners of glacier tourism can partly be addressed by focusing on short-term processes and site-specific studies.

In addition, the use of GIS techniques makes it possible to integrate plausible future recreational land-use attributes—such as roads, hiking trails, and restriction zones—into the land-cover maps, thus making the scenarios more in tune with stakeholders' immediate concerns and interests. Maps can also provide practical insights regarding the accessibility of a glacier site, such as in our case the nonemergence of a previously anticipated proglacial lake in front of the glacier terminus and the elevation of exposed moraine in the future, both of which were mentioned by entrepreneurs as important obstacles to business operations. Moreover, the maps' spatial and temporal scales make the derived information easier to integrate into the existing planning process.

To assess the future recession of the Breiðamerkurjökull glacier located at the Þröng site, this study used recession rate data from previous years to produce a map of projected future land cover. This approach provided accurate and robust results for the study area but did not generate varying plausible future outlooks other than the continuation of the current rate of glacier retreat. Regarding biophysical changes, the scenarios presented only limited changes from the current land-cover situation, resulting in the entrepreneurs' identification and selection of adaptation measures that did not differ from current practices. In addition, the glacier land-cover map may have confirmed many stakeholders' perception that the glacier is receding in an erratic but gradual way, without taking into consideration the crossing of possible natural thresholds that would force major transformations of business operations and site management. Therefore, an important future improvement of landscape maps for the PSP process would be to undertake more exploratory land-cover scenario development with varying landscape attributes.

Workshop participants were empowered by their contributions to the creation and application of the different scenarios. First, the cocreation of the scenarios ensured that all participants had a stake in the final outcome; they all contributed their own knowledge and expertise to the development of the scenarios, and they reached a consensus. According to Reed (2008), such an increase of participants' ownership of the scenario-planning process strengthens their sense of responsibility to act on what they have learned. During the scenario development process, greater mutual understanding is further attained within a diverse group, whose members would otherwise be less likely to have the opportunity to meet and discuss these issues. Individually, the participants tended to be caught up in their own immediate concerns, but when given a task to solve together, these private concerns faded into the background. Second, the future-oriented aspect of the exercise reduced latent tensions within the stakeholder group, as the problems and solutions did not affect the present-day situation, with its immediate conflicts and competition.

The construction and evaluation of the scenarios also provided insights into stakeholders' values, concerns, and interests. For example, workshop participants focused on short-term issues, such as the current rapid growth of tourism to protected areas in Iceland and the governance of public lands, both of which are debated and have a major impact on local conditions (Petursson et al 2016; Tverijonaite et al 2018). Such issues were prioritized above incremental and long-term changes, such as glacier recession, as important drivers of land-use change. This in line with findings, for example, by Evans et al (2013), which indicated that stakeholders in the Great Barrier Reef in Australia perceived future climate change scenarios that induce biophysical changes to the reef as being relative and only one of many challenges with which reef managers and industries needed to deal. Such

https://doi.org/10.1659/MRD-JOURNAL-D-18-00090.1

findings indicate that climate change implications cannot be understood as isolated factors; rather, they should be viewed as constituting interconnected and cumulative effects on the socioeconomic and natural environments. An improvement of our process would be to bring together experts (eg climate change scientists) with local stakeholders for the evaluation of the scenarios in order to address issues that transcend prevailing regional rationales and perceptions regarding incremental and long-term changes such as climate change.

General perceptions among stakeholders of the risk of glacier retreat also seem to have an impact on their level of concern about the physical changes to glacier landscapes. The framing of climate change as a global phenomenon that manifests itself in local impacts, such as glacier recession, could generate greater interest or action among those that experience such local impacts on a personal level (Shaw et al 2009). However, in cases where such manifestation is perceived as entailing limited risk or being controllable, this may actually lead to reduced concern. This is in line with findings from studies focusing on stakeholder perceptions of natural environments affected by climate change (eg Behringer et al 2000; Trawöger 2014; Lupp et al 2016). These studies show that due to climate change skepticism or due to personal experiences of limited impact severity or successful adaptation, climate change is not regarded as a significant risk. Such perceptions often result in a wait-and-see strategy for coping with future climate-induced changes (Berkhout 2012), and they can easily lead to maladaptation when natural or managerial thresholds (eg the situation when the margin of a glacier becomes impossible to reach on foot or by car) are crossed. In addition, it can be counterproductive to continue a business-as-usual strategy of increasing infrastructure and the number of transport vehicles in order to adapt to reduced accessibility of glacier sites; indeed, many visitors see these measures as a disturbance of wilderness and a degradation of the scenery, which in turn can lead to reduced visitation (Groulx et al 2017).

Anticipatory adaptation to climate-change-related challenges

PSP also provides insight into the capacity of the recreation planning system to adapt to potential future changes, such as glacier recession. The results of the scenario evaluation indicated that different factors can enhance the capacity of recreational land-use management to properly respond to potential future threats. One such factor is the presence of an informal network of major stakeholders, which can be mobilized to meet specific targets or to offer support for adaptation decision-making. Furthermore, the results show that the inclusion of local knowledge of the natural environment and recreational possibilities contributes to an awareness of the implications of climate change, which is an important requirement to increase adaptation action planning (Naess 2013).

However, the results also reveal barriers to implementing adaptive actions that reduce management's adaptive capacity. For example, the institutional planning and policy processes are inadequate and difficult to modify due to their rigidity and lack of transparency, both of which result from insufficient communication between policymakers and the people who are affected by the policies. The results further indicate that lack of funding for infrastructure, education, and maintenance may limit the adaptive capacity of recreational land-use managers. These results are in line with findings of other studies, which showed that limited financial resources and complex and rigid institutional structures significantly hinder anticipatory adaptation planning for protected areas (eg Jantarasami et al 2010; Lonsdale et al 2017).

Another crucial limitation to building adaptive capacity in protected area management in Iceland is the absence of policy for adaptation planning in general, a constraint that has been identified in other studies as well (eg Lemieux et al 2013).

Conclusion

The PSP process developed and applied in this study involves the identification of potential drivers of recreational land-use change in the context of climate change, the development of multiple scenarios for future recreational land use, and the examination of the potential consequences of these scenarios and adaptation measures to lessen or counter these consequences. The study results demonstrate that PSP is a valuable tool to support recreational land-use planning and decision-making in glacial landscapes, as well as to improve anticipatory adaptation to potentially undesirable future changes.

A similar process could be used in glacier regions worldwide and in other recreational areas where multiple simultaneous changes in landscape attributes, processes, and uses are anticipated. Glacier sites in mountain environments will continue to be impacted by climate change in future decades, resulting in multiple dimensions of dynamism (ie the interaction of biophysical, land-use, and governance changes in glacier sites at multiple temporal and spatial scales). Anticipatory management planning will thus need to address a constantly moving target, including the cumulative impacts of both natural and anthropogenic dynamics, and take into account both direct impacts (through tourism development) and indirect impacts (through climate change). Developing such an approach in Iceland is likely to involve a steep learning curve, as there has been only limited dialogue among the fields of outdoor recreation management, nature conservation, and climate change

https://doi.org/10.1659/MRD-JOURNAL-D-18-00090.1

adaptation. The process outlined in this paper could provide a prototype for more anticipatory and climate-conscious management of recreation in glacial mountain environments.

ACKNOWLEDGMENTS

This work is a part of a larger project supported by the European Union Interreg Northern Periphery and Arctic Programme (Interreg-npa.eu), titled BuSK (Building shared knowledge capital to support natural resource governance in the northern periphery). It also received financial support from Kvískerjasjóður research fund. We would further like to thank all workshop participants for their enthusiastic and productive cooperation. Thanks are also to our anonymous reviewers for their valuable comments and suggestions, which led to significant improvement of this paper.

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