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SUMMER GLACIER SKIING AMID CLIMATE CHANGE: WHAT DOES PRODUCTION TRANSFORMATION MEAN FOR SUSTAINABILITY?

Abstract: This paper examines the impact of climate change on the sustainability of summer glacier skiing (SGS) in Saas-Fee, Switzerland. Summer glacier skiing (SGS) is a niche tourism activity that is particularly vulnerable to climate change. This is evidenced by the notable reductions in snowpack and glacier retreat, which are affecting the viability of SGS. By applying the valuation system framework, the study examines the relationship between the production and consumption systems of SGS and how climate-induced transformations influence sustainability. Methodologically, the research employs a qualitative approach, integrating fieldwork, direct observations, and semi-structured interviews with key stakeholders, including tourism operators, local authorities, and ski athletes. The findings demonstrate that climate change intensifies the scarcity of resources, necessitating augmented investments in infrastructure and modifying consumer behaviour, which in turn affects the economic and environmental sustainability of the activity. Notwithstanding these challenges, the existence of institutional cooperation within Saas-Fee offers the region the opportunity to transition towards more sustainable practices. The paper emphasises the necessity for a comprehensive approach to comprehend and oversee the sustainability of SGS in the context of ongoing climate change.

Keywords: climate change, qualitative research, summer glacier skiing, sustainability, tourism adaptation

LETNIA JAZDA NA NARTACH NA LODOWCU W OBLICZU ZMIAN KLIMATYCZNYCH: CO OZNACZA TRANSFORMACJA PRODUKCJI DLA ZRÓWNOWAŻONEGO ROZWOJU?

Streszczenie (abstrakt): Niniejszy artykuł analizuje wpływ zmian klimatu na zrównoważony rozwój letniej turystyki narciarskiej na lodowcu (SGS) w Saas-Fee w Szwajcarii. Letnia jazda na nartach na lodowcu (SGS) to niszowa działalność turystyczna, która jest szczególnie podatna na zmiany klimatu. Dowodem na to jest znaczne zmniejszenie pokrywy śnieżnej i cofanie się lodowca, które wpływają na rentowność SGS. Stosując ramy systemu wyceny, badanie analizuje związek między systemami produkcji i konsumpcji SGS oraz wpływ transformacji spowodowanych zmianami klimatu na zrównoważony rozwój. Metodologicznie, badanie wykorzystuje podejście jakościowe, integrując badania terenowe, bezpośrednie obserwacje i częściowo ustrukturyzowane wywiady z kluczowymi interesariuszami, w tym operatorami turystycznymi, władzami lokalnymi i sportowcami narciarskimi. Wyniki pokazują, że zmiany klimatyczne nasilają niedobór zasobów, wymagając zwiększonych inwestycji w infrastrukturę i modyfikując zachowania konsumentów, co z kolei wpływa na zrównoważony rozwój gospodarczy i środowiskowy tej działalności. Niezależnie od tych wyzwań, istnienie współpracy instytucjonalnej w Saas-Fee oferuje regionowi możliwość przejścia na bardziej zrównoważone praktyki. Dokument podkreśla konieczność kompleksowego podejścia do zrozumienia i nadzorowania zrównoważonego rozwoju SGS w kontekście zachodzących zmian klimatycznych.

Słowa kluczowe: zmiany klimatyczne, badania jakościowe, letnie narciarstwo na lodowcu, zrównoważony rozwój, adaptacja turystyki

Introduction

Climate change is causing profound transformations in the environment that directly or indirectly affect the tourism sector (Mora et al., 2018). In Europe, impacts include an increase in the intensity and frequency of extreme events, heat waves, sea level rise, and the general retreat of the cryosphere, including permafrost, snow and ice (Steiger et al., 2023). This last element is particularly important for the tourism industry in the Alps, including glacier tourism activities and businesses (Salim, Gauchon, et al., 2021), and the ski industry (Steiger et al., 2019).

In the European Alps, the ski industry is a highly developed, multi-million euros, industry that is clearly important to the local economy, employment and culture. The ski industry relies on the availability of snow and it is now generally accepted that to be economically viable, most of the ski resorts must be able to operate seven seasons out of ten, for at least 100 days, between 1 December and 15 April (Abegg et al., 2020). However, due to the retreat of the cryosphere, the reliability of snow is decreasing, resulting in a reduction of the season length and the quantity of snow accumulated during the winter (Gilaberte-Búrdalo et al., 2014; Spandre et al., 2019). Accordingly, cryosphere depletion is a very serious threat to the European ski industry, as it reduces the substrate for its activities (François et al., 2023).

The ski tourism industry is developing adaptation strategies to face climate risks. These adaptations are mainly based on and aimed at reducing the vulnerability of ski lift

operators to inter-annual variability of snow cover, in particular by rationalising the snow grooming system and, above all, by developing artificial snowmaking (Steiger & Scott, 2020). Although snowmaking as an adaptation strategy can effectively reduce the vulnerability of operators, it can also lead to path-dependency due to the large investment required (Berard-Chenu et al., 2022). Snowmaking also relies on water and energy resources, which can be difficult to access in some areas (Scott et al., 2022). As a result, snowmaking as an adaptation strategy can be considered a maladaptation because of the increased vulnerability it can lead to (Schipper, 2020).

Questions have been raised about the sustainability of the ski industry. Firstly, even with snowmaking, skiing is still vulnerable to climate risks and at the same time increases water and energy demands that can harm the environment (François et al., 2023; Gerbaux et al., 2020). Second, as a development model, ski tourism is based on high-income tourist visits, which means it relies on travel that is often highly carbon-intensive (Salim et al., 2024). The question of how ski tourism-based areas can transform themselves in a sustainable way, for example by diversifying, is therefore an ongoing one. Answering this question requires a holistic approach to the territory and given the economic nature of the activity, an understanding of the production system on which it is based. The effects of climate change being numerous and multifactorial, special attention is required. As a result, it may be necessary to study specific cases of high vulnerability to climate change in order to inform stakeholders about sustainability.

In this context, summer glacier skiing (SGS) is a niche activity of glacier and ski tourism that is highly vulnerable to climate change. SGS consists of skiing on glaciers outside the winter season, from May to November (Mayer & Abegg, 2022). The activity developed around the 1970s, but many SGS areas (three-quarters in Switzerland) had to close before 2000 because of snow conditions (Koenig & Abegg, 1997). In 2023, only seven summer glacier ski areas are still operating in July and August in the Alps. In Switzerland, Saas-Fee and Zermatt are the two remaining SGS resort that are still operating in July and August.

In comparison to traditional winter skiing, SGS is notably vulnerable to climate change elements, such as reduced snowpack and glacier retreat (Graf, 1995; Huss et al., 2021). This can even lead to the closure of the resort during the summer, as happened in 2022 in the Alps (Abegg & Mayer, 2023). But climate change is not the only threat to SGS, as Mayer & Abegg (2022) has shown. Demand is very volatile, related to meteorological factors like thermal comfort (Mayer et al., 2018). As a result, understanding the functioning of SGS's production system is critical to assessing its sustainability, especially as it is threatened and transformed by climate change.

Rooted in regional economics, the production system is an element of a valuation system that allows to understand the relational process between an object, the production and consumption system, and how the process creates value (Jeannerat & Kebir, 2016). As shown in Figure 1, the object (which can be an artefact, knowledge or, in the present case, a glacier) is identified by a set of actors and their means of production. Through this identification process, the actors change their representation of the object set into

a production system in order to create value based on it (Kebir & Crevoisier, 2007). For example, in the context of SGS, the actors create cable cars and ski lifts, and prepare the snow on the glacier in order to create value from it. Conceptually, this means that a production intention is required for an object to become a resource (Kebir, 2016). The third circle in Figure 1 represents the market and how it interacts with the production system to create value. It incorporates the consumer's perspective and logic as it influences the valuation process. The model has been applied mainly in the industrial context (Jeannerat, 2021), but has recently been extended to tourism and the impact of climate change on it (Salim & Kebir, 2024). As it allows to follow the valuation chain from object to consumer from a territorial perspective, the model is relevant to understand the impact of climate change on SGS and its implications for sustainability.

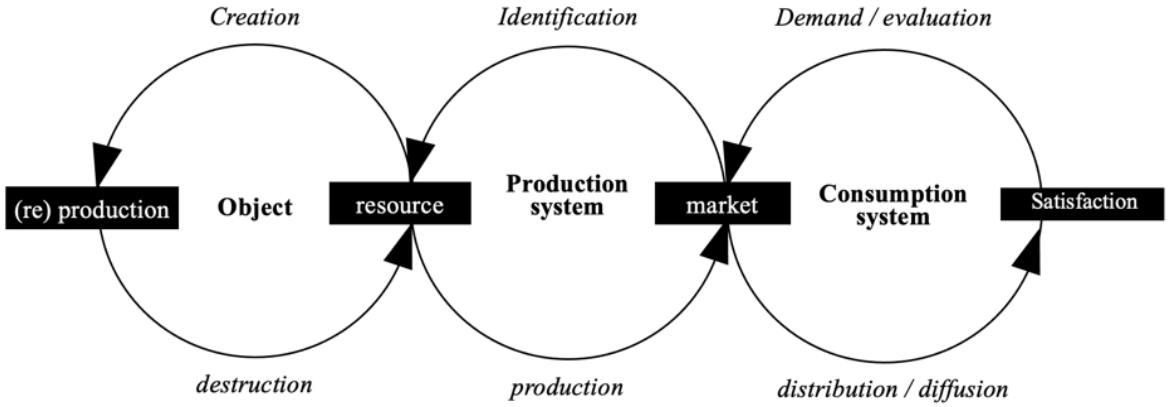

Figure 1. Conceptualisation of the valuation system (modified from Jeannerat & Kebir, 2016)

The aim of this paper is to assess the role of climate change in the transformation of the SGS production system, the way it interacts with the object and consumer system, and the implications it has for sustainability. Accordingly, the research question guiding this work is: how is climate change transforming the SGS production system, and what are the implications for sustainability? Because of the importance of summer glacier skiing for Saas-Fee and its clear vulnerability to climate change, the research was carried out in this destination.

The following sections of the paper present the methodology used to conceptualise summer glacier skiing within the framework of the valuation system (Jeannerat & Kebir, 2016). The paper then describes the production and consumption system of glacier skiing and the impact of climate change on it. It then discusses the implications of the impact of climate change on the sustainability of it using the economic, socio-cultural, institutional and environmental dimensions of sustainability proposed by Asmelash & Kumar (2019).

Methodology

Selection of the study site

In 2023, Saas-Fee and Zermatt were the only remaining glacier summer ski resorts operating in July and August in Switzerland. Saas-Fee is located in the canton of Valais in Switzerland. The resort operates in winter and summer, with approximately 60% of tourist arrivals during the winter season (November to April; data from the Swiss Federal Office of Statistic). Part of the Saas-Fee ski area is located on the Fee glacier. The activities of the SGS require the use of the cable car and the Alpine metro to reach the Mittelallalin. At this point, ski lifts are operated to allow skiing on the glacier during the summer season (Figure 1). The Fee Glacier, like the other glaciers in Switzerland, is receding rapidly. From 1883 to 2019, Fee glacier lost about 1100 meters in length (GLAMOS-Glacier Monitoring Switzerland, 2019; Figure 1).

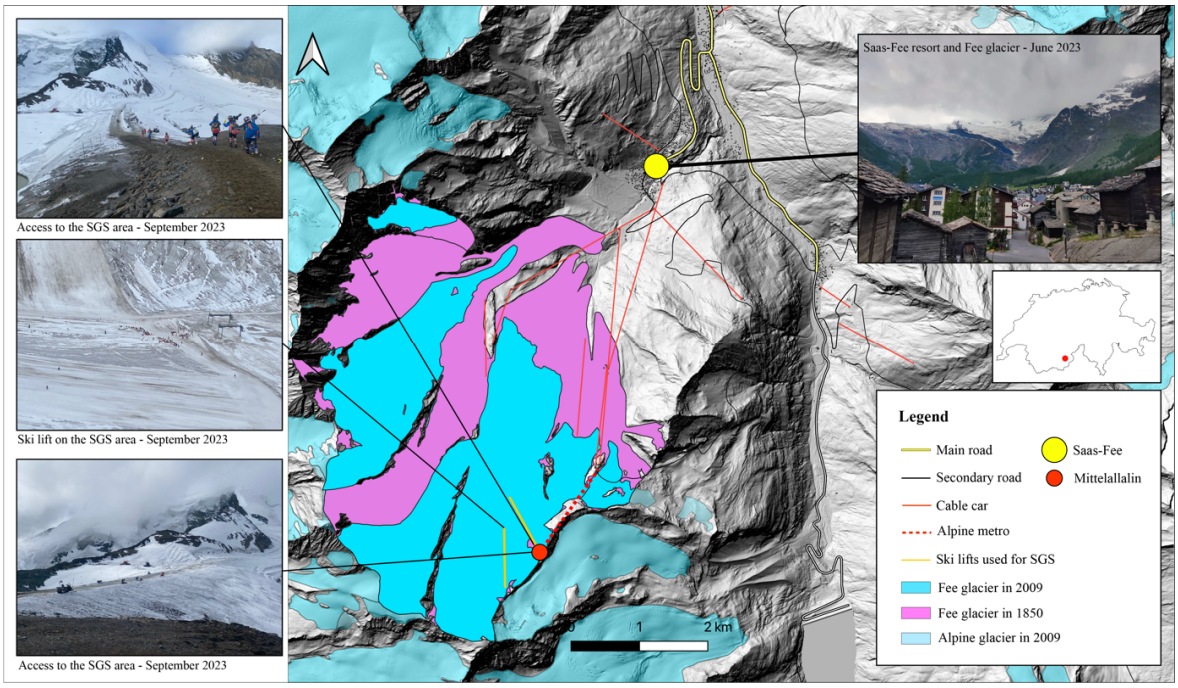

Figure 2. Situation map of Saas-Fee and the SGS area. Glacier extentions are from GLAMOS (2019). Taken photography are from the authors.

Saas-Fee stands out as one of the top SGS destinations in the Alpine region. It is particularly esteemed among various categories of ski athletes, the main customer base. These athletes can be skicross, downhill skiing, and freestyle skiing practitioners. Saas-Fee has become a singular location for ski training activities during the summer months for a number of reasons. Primarily, its glacier is oriented in a northerly direction and situated at a relatively high altitude (the summit elevation of the ski area is approximately 3,500 m a.s.l.). Furthermore, Saas-Fee is able to draw on a diverse range of expertise and infrastructure to cater to the needs of skiers. This is partly due to the destination's dual identity, which primarily positions it as a winter ski resort, and allows for the development of the necessary infrastructure to serve as a summer training base for ski athletes. In

comparison to regular winter skiing, SGS clientele is mostly composed of ski athletes (more than 90%, according to the destination manager). The presence of the later for the training purposes, the potential vulnerability of SGS activities to warming climatic conditions carries significant ramifications for the destination's summer-related viability. The local hospitality and tourism infrastructure have been meticulously tailored to accommodate the needs of SGS athletes, featuring dedicated off-snow training facilities and ski workshops. Moreover, the incorporation of SGS into a four-season strategy offers local stakeholders a reliable source of income. However, alternative tourist and recreational activities during the summer months are relatively scarce, which highlights the reliance of the destination's economic vitality on the continuity of SGS activities. In this context, Saas-Fee has been selected as a case study to examine the vulnerability and adaptation of SGS to climate change.

Methodological approach

This research adopted a qualitative approach. The qualitative data acquisition process included three modes of collection: (1) exploratory phase, characterised by direct observations and informal interviews with stakeholders, (2) semi-structured interviews (N=20), conducted with stakeholders from the tourism sector and embedded in the valuation of the SGS activity (N=6), ski athletes representing the main customers of the SGS in Saas-Fee (N=14), and (3) a workshop bringing together researchers and stakeholders (N=7) to present and validate the first results. The local stakeholders comprised two representatives of the cable car company, two hoteliers hosting SGS athletes, a former president of the community, and a representative of the tourism office. On the consumption side, our focus was directed towards ski athletes, which encompassed both snowboarders and skiers, while recreational skiers were excluded from the interview pool due to their limited presence within the study context. The interviews were conducted during summer and autumn 2023. All interviews with the local stakeholders took place within the destination; and the interviews comprising ski athletes were conducted in Valais, Haute-Savoie and through video conferencing. All these interviews were recorded with the participants' agreement and were transcribed for analysis using NVivo. The interviews lasted between 1 and 2 hours.

Once these semi-structured interviews were conducted and analysed, a first draft with results was presented and discussed with local stakeholders from Saas-Fee in December 2023. A hotelier along with both a former and a current representative of the cable car company were invited to discuss the results with the research team during the workshop. This workshop functioned as a crucial step in the validation process of the accrued data. Through active engagement with these stakeholders, potential ambiguities were mitigated, and findings underwent further elucidation and refinement.

Results

Summer glacier ski valuation system

Compared to other tourist destinations in the Alps, Saas-Fee was relatively late in developing tourism structures, especially summer-related recreational activities. The first ski-lift company was founded in 1948, and this can be viewed as an inaugural phase of an ongoing ski-tourism oriented development. Hotels were built, services developed (ski rental, accommodation, restaurants and snacks in the resort and on the ski slopes, ski schools, etc.) constituting the production system that gave value to the snow as an object. Nowadays in Saas-Fee, there are strong interconnections between the main stakeholders in local tourism. For example, Saastal Bergbahnen AG, which operates the ski lifts, holds shares in Saastal Tourismus, the tourist office in Saas-Fee. The public authorities of Saas-Fee also hold shares in both entities. Cooperation between these actors is guided by a destination strategy (Destinations Strategy 2020-2025), which outlines strategic directions, key areas of activity and the overall strategy. Seven stakeholders are driving the development of this strategy: Saastal Bergbahnen AG, Bergbahnen Hohsaas AG, the four Saas Valley municipalities (Saas-Fee, Saas-Grund, Saas-Almagell and Saas-Balen) and Saas Valley Tourism, which also represents the hotel and accommodation sector.

The glacier as an object was considered valuable by the cableway company in the eighties. In 1984, in order to allow access to the glacier, the cableway company built the "Alpine Metro", which allowed the glacier to be used for summer skiing. The analysis of the production system shows that two objects are valued by it: the glacier and the snow.

The valuation of glaciers has changed from the 1980 to the present day. In the first place, the glacier and summer glacier skiing as an activity was promoted as a leisure and touristic activity. Its promotion has gradually transformed from leisure-oriented public to sport- and training-oriented public. Nowadays, the consumption system is mainly composed of Swiss and international sports teams that come to the glacier during the summer to train for competitions. As a result, the Fee Glacier has become a training ground for many Worlds Cup, European Cup, and junior teams. Different facilities have been built to accommodate different disciplines, including alpine skiing, ski cross and freestyle. For freestyle, a company specialising in snowpark construction came to Saas-Fee to set up, in 2006, the first ever "pre-season" training facility for freestyle athletes.

Climate change impact on the valuation system

The dynamics of glacier and snowpack are profoundly impacted by the consequences of climate change, and these two cryospheric components are the basic object put into resource for SGS. According to the interviews, the retreat of glaciers causes both a reduction in height and an increase in the number of crevasses. The reduction in height provokes instability in the infrastructures, which undermines the production system. As an illustration, some ski lift pylons are built directly into the ice. Changes in the glacier morphology lead to the destabilisation of these pylons, which requires more maintenance, increased operating costs. Sometimes this destabilisation can lead to the closure of the ski

facilities. The reduction in height also makes access to the slopes more difficult, meaning that skiers have to walk further to reach the slopes. At the same time, the proliferation of crevasses rises safety concerns and escalates maintenance costs for ski lift operators. In a broader context, glacier retreat reduces the space allocated for skiing. Furthermore, climate change is also increasing snow anomalies, with two main consequences: a diminution in snow reliability and a drop in snow quality. Reduced snowfall and more frequent rainy days during the summer mean that less space is available for skiing due to insufficient snow conditions. Changes in snowfall patterns also lower the quality of snow for skiing, leading to poor conditions for competition, training or, more generally, an increased risk of injury during practice.

These changes in the object (the glacier) which affect directly ski lift operators, have not only cascading effects on the entire production system, but influence the consumption system too. These direct effects of climate change on the glacier increase the risk of closure, as happened in the summer of 2022. Hence customers, predominantly ski athletes interested in on-snow training, are confronted with increased uncertainty. According to interviews with professional skiers and coaches who used to train in Saas-Fee, this uncertainty about skiing conditions and the access to skiing facilities has led them to plan their training more flexible or to change their training venue altogether; sometimes opting for more remote ski resorts in the southern hemisphere or indoor skiing facilities.

Consequently, the hospitality sector has to deal with the increased flexibility of ski teams who plan their trip closer to the date of arrival and sometimes cancel at the last minute due to poor skiing conditions. On the other hand, the uncertainty of snow and glacier conditions affect the destination image as well, whereby the destination management adopts and promotes more diverse touristic activities.

As a result, changes in the glacier and snow conditions due to climate change have a direct impact on the infrastructure on the glacier, mainly affecting one stakeholder in the production system, namely the cable car company. Changes felt by this stakeholder directly determine the consumption system, thereby changing the demand of SGS. At one level, changes in the production system transform the consumption system. At another level, changes in the consumption system affect the other stakeholders within the production system, as shown by shifted demand behaviour related to hospitality.

Discussion

With reference to the aforementioned valuation system, the primary finding of our research reveals that environmental changes cause profound transformations in one part of the production system (the local cable car company); these changes, then, directly alter the consumption system (skiers); thereby exerting effects on the rest of the production system (the local hospitality industry). These dynamics prompt inquiries into sustainability of the activity and the way it is managed by destination stakeholders.

The impact of changes of the valuation system on the sustainability of the destination in terms of economic, social and environmental dimensions needs to be examined (WTO, 2024). In their paper, Asmelash & Kumar (2019) set out indicators to measure progress on

sustainability. Rather than the three traditional dimensions of sustainability, Asmelash & Kumar's (2019) assessment is divided into four dimensions: economic sustainability, socio-cultural sustainability, institutional sustainability and environmental sustainability.

Economic sustainability

The effects of climate change on mountain areas are challenging the economic sustainability of SGS in Saas-Fee. Even if summer skiing represent 40 to 50 per cent of the incomes of the cable car company during summer[1], the economic viability of the system is challenged by several aspects: firstly, the increased maintenance requirements for the cable car operators increase their costs, leading them to increase the price of the ski ticket and, during the high season, to restrict access to the ski facilities for sports club and professional skiers, increasing prices and restrictions. Coupled with the uncertainty of the availability of the glacier for training, this has an impact on the decision of sports teams to choose Saas-Fee for training. Nowadays and according to the interview, top athletes (national teams) often choose to move to the southern hemisphere in order to find better training conditions than in Saas-Fee. This means that clients with more financial means are going elsewhere, while predominately regional teams with less means are staying in Saas-Fee at a time when prices are rising.

This situation is different from other glacier tourism sites. In the Alps, for example, Salim, Ravanel, et al. (2021) show that environmental changes also lead tourism stakeholders to increase maintenance and labour, thereby increasing their costs. In these cases, however, projects are developed with a logic of upgrading in order to attract more international tourists (Salim, Girault, et al., 2023). In terms of value production, the glacier as an object leads the production system in a dynamic of scarcity (Kebir, 2006) that is not yet compensated by the operators.

Socio-cultural sustainability

Socio-cultural sustainability can be seen at the visitor satisfaction levels (Asmelash & Kumar, 2019). According to our results, the customers of the SGS activity in Saas-Fee are mainly professional or sport team members. On the one hand, due to glacier retreat and reduced snowfall, the spring and summer activity does not meet their requirements in terms of slope quality, availability and safety. The main challenge is related to the uncertainty of the opening of the slopes in summer. As professional skiers have to train before the first competition in October, this situation leads them to substitute Saas-Fee as a training facility for indoor slopes or destinations in the southern hemisphere.

In this sense, the socio-cultural sustainability of SGS in Saas-Fee is questionable, as it does not fully meet visitor expectations in terms of slope conditions and availability for training. However, the glacier landscape is also a vehicle for cultural and environmental learning (Weber et al., 2019). In other words, based on our findings, training on a glacier that is clearly affected by climate change is also a way for skiers to reflect on the

[1] Data provide by Saastal Bergbahnen, 2023.

consequences of climate change. A reflection that is discussed in order to promote pro-environmental, low-carbon, as well as sustainable behaviours (Lv et al., 2023; Salim, Ravanel, et al., 2023).

Institutional sustainability

Analysing institutional sustainability, that is local oriented control policy, political participation, local planning policy and political support (Asmelash & Kumar, 2019), for Saas-Fee, it is essential to differentiate between two different community systems: the municipality and the *Bourgeoisie* (citizen's community). The former administers municipal affairs such as education and infrastructure maintenance, while the latter refers to individuals with deep-seated ties to the community, often inherited through birthright as *Bourgeoisie* citizens[2]. The cable car companies involve stakeholders from the *Bourgeoisie*, who possess shares historically allocated to long-established locals. The same goes for the local tourism office that coordinates the communication and marketing of the operators. Relations with the hotel and catering industry have made it possible to define a joint strategy, which has proven to be more resilient in times of crisis. These dynamics underscore the agency afforded to locally rotted individuals, enabling them to manage rural resources reflecting local oriented control policy.

Nevertheless, such a system is vulnerable to changes in competitive economic dynamics and has let the cable car company to a precarious financial state. Over the past decade, the primary shareholder has undergone multiple changes in ownership. Consequently, the direction of the production system is largely dictated by the agenda of these main shareholders, today a foreign entity. Secondly, the representation of the *Bourgeoisie* only encapsulates a segment of the local population, neglecting individuals in the decision process who have relocated to Saas-Fee. Such a dynamic is incongruent with locally oriented political control.

Environmental sustainability

Even with measures to mitigate glacier retreat (e.g., Clouse, 2022), it is now clear that glaciers will continue to shrink, even years after we reach net-zero targets (Rounce et al., 2023). In this sense, and considering the Fee Glacier, it seems improbable to continue summer glacier skiing in the future. This fact is already acknowledged by the various stakeholders encountered during the interviews, who thought that this specific activity will continue for a maximum of ten years. From a regional economic angle, this situation acknowledges the fact that the production system of summer glacier skiing is facing a situation of scarcity, which should lead to a change in the valuation system.

Environmental sustainability can also be seen within the context of the overall operations carried out by the cableway company on the slopes during the summer and winter seasons. In this case, snowmaking and the maintenance of the ice cave for tourist

[2] The term "*bourgeoisie*" is used to describe a local authority in which the original inhabitants of the commune participate, as opposed to new inhabitants.

visits require the covering of snow with a blanket, which can have adverse effects on the dispersal of microplastics (Ambrosini et al., 2019). The degradation of the permafrost also has an impact on the stability of certain slopes and structures, which will become more important in the future (Schrott et al., 2024).

Conclusion

Summer glacier skiing is an activity that is particularly affected by climate change and cryosphere depletion. From a regional economic perspective, the glacier and the snow can be considered as two objects that are processed into a resource by a production system consisting of the ski lift operator and the other actors of the destination, namely the hospitality sector, the tourist office, etc. This production system allows sports teams and ski professionals, conceptualised as the consumption system, to practice summer skiing in Saas-Fee. In this context, this paper shows that climate change induces a resource scarcity dynamic, which leads the production system to increase the means needed to guarantee the activity. On the one hand, changes in the object affect the production system. On the other hand, changes in the object and in the production system influence the consumption system, which increases substitution behaviour and creates a feedback loop in influencing the production system.

The changes in the valuation system caused by climate change raised concerns about the sustainability of the activity. On the one hand, in terms of environmental sustainability, the projection of glacier retreat in the future led to the hypothesis that summer glacier skiing would not be able to continue in the future. Meanwhile, the current retreat requires investment from the cable car company to increase maintenance, and this investment, together with changes in customer behaviour due to dissatisfaction, reduces economic sustainability. On the other hand, the cultural and ecological value of the glacial landscape increases socio-cultural sustainability. In Saas-Fee, the cooperation between the actors that make up the production system is an aspect that increases institutional sustainability.

Overall, climate change impacts on the production and consumption systems of summer skiing in Saas-Fee reducing the sustainability of the valuation system. However, the institutional organisation of the destination gives the opportunity to the system to transition away from this activity and to develop new resources based on the territory and complying with sustainability.

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