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ORIGINAL ARTICLE

How can winter tourism adapt to climate change in Saxony's mountains?

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Abstract This study deals with regional climate change in five low mountain areas in Eastern Germany and assesses the awareness of tourism professionals towards climate change, its impact on winter tourism and adaptation options. Favourable conditions for winter tourism decreased over the last decades in the Saxon low mountain ranges. A change from predominantly snow-based to a wider variety of winter tourism options appears indispensible as climate models project continuing warming. Diversifying touristic options provides opportunities to develop new business fields and to attract new target groups. This paper reveals obstacles and opportunities to adapt and develop winter tourism in the central European low mountain ranges and to increase the competitiveness of regional tourism. A survey explored the current awareness of representatives of most of the Saxon downhill skiing areas and of selected winter tourism municipalities towards climate change and its implications on their business. Awareness is essential to successfully implement adaptation measures. About half of the interviewees were not aware of the regional changes in natural snow conditions projected for the next 15–20 years. Nevertheless, the majority recognized climate change as a serious issue. Yet, stakeholders repeatedly emphasized their uncertainty about related scientific facts. They attributed their perception to mass media reports that suggest a lack of scientific consensus on climate change issues. Adaptation options for slope-based and general winter tourism are developed and presented, involving ideas of the interviewees. To successfully move towards adaptation, supply and marketing of alternative offers need to be strengthened. A survey of tourist expectations is planned to ensure a successful implementation of new (winter) touristic offers in the Saxon mountains.

Keywords Low mountain range · Climate change awareness · Climate change impacts · Adaptation strategies

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Introduction

Snow dependency makes winter tourism highly vulnerable to climate warming (e.g., IPCC 2007b; OECD 2007). Analysing adaptation needs and developing options to adapt to warmer winters with poor snow conditions are essential, as global average temperature has risen in the 20th century and further increases are projected for the 21st century (IPCC 2007a, b). Global climate change may manifest itself quite differently in various regions and modify local adaptation needs. This study deals with regional climate change in five low mountain areas in Eastern Germany and assesses the awareness of tourism professionals towards climate change, its impact on winter tourism and adaptation options.

First studies connecting climate change with (winter) tourism appeared for Canada (Wall 1985; McBoyle and Wall 1992) and Australia (Galloway 1988). A first comprehensive study of the impact of changing environmental conditions (including climate change) on winter tourism in Germany was published by Harrer (1996). Generally, the high alpine mountain areas dominate in terms of user numbers and economic revenues in European winter tourism. The winter season in those regions is more profitable than its summer counterpart (Jülg 1999). Increasing

awareness of climate change impacts on winter tourism was noticed in the late 1980s in the Alps, when snow-poor winters led to high losses for the regional tourism industry. Resulting studies pointed out the necessity to reduce snow and skiing dependency of alpine winter tourism and suggested alternative, less snow-dependent strategies (e.g., Abegg 1996 and Bürki 2000 for Switzerland; Breiling and Charamza 1999 for Austria). Lacking awareness, understanding and thus acceptance by tourism supply often challenged the implementation of alternative offers (e.g., König 1998 for Australia; Bürki 2000 for Switzerland).

Most recent European studies on the vulnerability of winter tourism and related adaptation strategies still focus on alpine regions (e.g., CIPRA 2006; OECD 2007; WTO 2003). As only the northern alpine region of southern Bavaria reaches altitudes above 1,500 m a.s.l., German winter tourism is mainly based on low mountain ranges. There, only a few downhill skiing areas reach the often used criteria for profitable downhill skiing as defined by Abegg (1996) for the Swiss Alps: "downhill skiing areas allow skiing (snow depths of at least 30 cm) for 100 or more days per season in at least 7 out of 10 years to be called snow-reliable and economically profitable". This criterion does not apply to skiing areas in Central European low mountain ranges, since climatic characteristics and economic structure of winter tourism are not comparable. Some studies defined other threshold values for snow reliability in German low mountain ranges, such as 80 days for new skiing areas in the Sauerland (Roth et al. 2001) or 50–60 days for the Fichtelgebirge (Seifert 2004). Comparable investigations and numbers do not exist for the Saxon low mountain areas.

Winter tourism is not the dominating economic factor in German low mountain ranges (e.g., Black Forest, Bavarian Forest and Harz) as in alpine areas, yet it forms an integral and important part of the regional economy. This economic significance is challenged by increasing temperatures and may be more at risk than in high mountain areas. Available research dealing with the impacts of climate change on German low mountain ranges is increasing, but still limited. Schneider and Schönbein (2006) studied the impacts of climate change on snow conditions and options for artificial snow production. They predicted a distinct decline of suitable conditions for snow tourism in all German low mountain ranges until 2025. The ongoing project GIS-KliSchee (2010) aims at revealing detailed conclusions about the current and future potential for snow tourism and adaptation strategies, using a geographic information system. Studies on individual mountainous areas mostly focus on regions in the southern and western parts of Germany, e.g., Baden-Württemberg (Roth et al. 2005) with the Black Forest (ongoing research project KUNTIKUM 2010), the Sauerland in North Rhine Westphalia (Roth et al. 2001) and the Bavarian Fichtelgebirge (Seifert 2004). The impacts of climate change on winter tourism in Saxon low mountain ranges were first discussed by Hoy (2008).

Saxony has an annual market share of 11% in low mountain range tourism in Germany (Grimm and Winkler 2006). The annual touristic revenues generated by day trips and overnight stays in 2007 added up to 883 Mio. € gross turnover and a touristic per capita income of 560 € in the Erzgebirge. More than half of the gross turnover is generated by day tourism, about 25% by commercial accommodation and the rest by private accommodation and visits of family and friends (IHK Südwestsachsen 2007). Of all overnight stays in 1993, 44% occurred in the winter half year, placing the Erzgebirge on position #1, when comparing the importance of the winter season between German low mountain ranges (Harrer 1996). Day tourism dominates all Saxon low mountain ranges (pers. comment Kis 2010—Saxon State Tourism Agency), basing winter tourism mainly on local tourists. The economic relevance of winter tourism in the Erzgebirge demands detailed information on impacts of rising temperatures on winter tourism and a discussion of possible adaptation options.

Several regional climate change studies showed ongoing modifications of Saxon mountain climate (e.g., Franke et al. 2004; Hänsel et al. 2008; SMUL 2008; Bernhofer et al. 2009). Mild winters with poor snow conditions increased over the past decades; altitudes below 800 m being particularly affected. Higher elevations experienced a strong reduction in snow cover from November to April in recent decades (Freydank 2001; SMUL 2008). Even at Saxony's highest mountain Fichtelberg (1,215 m), the average snow depth decreased considerably. A mean temperature increase of 0.7 K (from −2.6°C to −1.9°C) between the two sub-periods 1950/51—1979/80 and 1980/81–2009/10 was accompanied by a 25% decline in snow depth (77 cm versus 58 cm; DWD 2010). Climate models project an intensification of these tendencies over the 21st century in Europe (e.g., IPCC 2007a) and in Saxony (Kreienkamp and Spekat 2008). Schneider and Schönbein (2006) compared the extrapolated linear temperature trend of 1960–2002 and the IPCC scenarios for the lowest and highest warming trends up to 2025. In conclusion, only individual downhill skiing areas below 900 m a.s.l. will remain suitable for ski tourism in German low mountain ranges in the coming decades.

Awareness of tourism professionals in Saxon low mountain ranges in respect to climate change issues and adaptation strategies in winter tourism is a key for successful and timely adaptation. While first and individual attempts to adapt winter tourism to the changing conditions are made, it is necessary to know whether and to which extent professionals are aware of those changes—as a prerequisite for any successful adaptation. The study was

based on questionnaires addressed to professional representatives with intensive contacts to winter tourists. The survey, a literature review, and several field trips to visit examples of already practiced solutions are the base for adaptation alternatives presented here.

Data and methods

Characterization of the study area

The Free State of Saxony is located in Central Europe, extending between 50° 10′ and 51° 41′ northern latitude and 11° 52′ and 15° 03′ eastern latitude. The state lies at the interface of dominantly oceanic versus continental climate regimes. The climate of the low mountain ranges is therefore characterized by increasing continentality from west to east. Winters in the east are colder and the snow cover persists longer at the same altitude than in the west, while general precipitation amounts are lower. Average winter (December to February) temperatures are below 0°C, with averages below −3°C on the Erzgebirge and Vogtland ridges. The Saxon low mountain ranges consist of five sub-areas extending along the southern border of Saxony with the Czech Republic (Fig. 1). From east to west, these are (area, highest elevation):

(1) Zittau Mountains (Lausche, 793 m),
(2) Upper Lusatia (Valtenberg, 587 m),
(3) Saxon Switzerland (Großer Zschirnstein, 562 m),
(4) Erzgebirge (Fichtelberg, 1,215 m) and
(5) Vogtland (Schneehübel, 974 m).

Skiing slopes extend from 250 to 600 m a.s.l. in the lower mountainous areas of eastern Saxony (Zittau Mountains, Upper Lusatia and Saxon Switzerland) and altitudes above 600 m a.s.l. in the Erzgebirge and Vogtland areas (Fig. 2). Summer tourism (May–October) is much more important than winter tourism in the three lower areas, due to limited snow reliability. Winter tourism (November–April) clearly dominates in the two higher areas with more reliable snow conditions. In lower altitudes, the snow cover that frequently occurs from November to March melts down occasionally due to warm spells, while it mainly accumulates until March in higher elevations and only rarely melts down completely in between. A deterioration of snow conditions, starting in the late 1980s was noticed—similar to the Alps.

Survey approach

Tourism supply includes regional and local touristic planning to secure the best possible development for the region as well as for local suppliers of touristic services. Surveys on climate change impacts on winter tourism and related adaptation strategies may target either tourism demand or supply. Harrer (1996), Pröbstl and Unbehaun (2006) interviewed tourists, while surveys on tourism supply were done, e.g., by Abegg (1996). König (1998) and Bürki (2000) included both target groups in their surveys. König (1998) concluded that tourist managers in Australian skiing areas had a low awareness of climate change impacts, but heavily invested in technical measures to secure skiing. Interviews of tourist officers in the canton of Graubünden/Switzerland showed a highly variable attitude to climate change and tourism (Abegg 1996), while the survey by Bürki (2000) in Central Switzerland revealed the strong distrust of tourism representatives in climate change information. While they use climate change to legitimate forward strategies, its potential influences are played down.

This survey focused on the supply of winter touristic services in Saxony. The touristic marketing for the entire region is organized by tourist associations. Public and private suppliers of touristic services are members of those associations and act as the interface to the customer—the

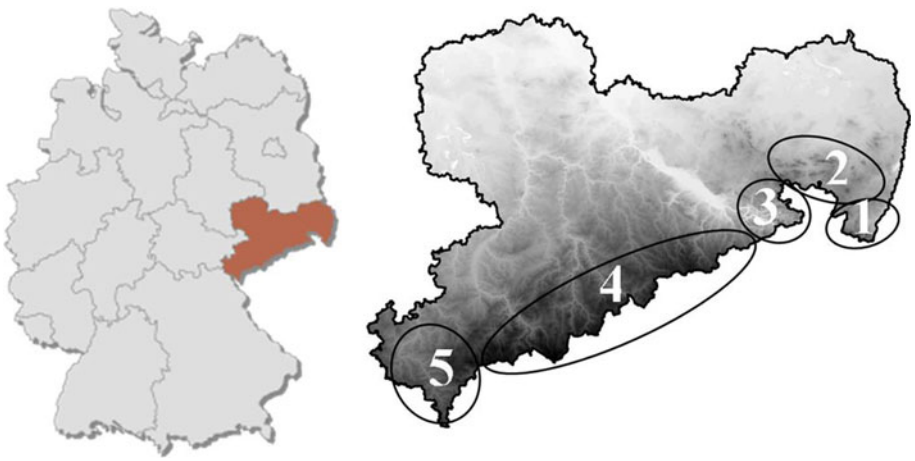

Fig. 1 Location of Saxony within Germany (*left*) and a digital terrain model of Saxony (*right*) with the five Saxon low mountain regions (highlighted; details in text). *Darker* colors depict higher terrain (total elevation from 90 to 1215 m a.s.l.)

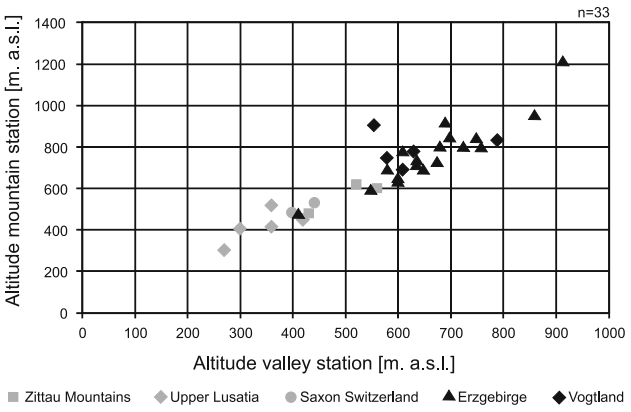

Fig. 2 Altitude of Saxon skiing areas in this study

tourist. Suppliers were chosen as interview partners, since they are capable of implementing necessary adaptation options, and positive or negative evaluation by visitors is highly based on the quality and quantity of on-site services.

Two groups of tourism professionals were interviewed: downhill skiing representatives (31 agents) and those of municipalities that include a downhill skiing area (28 agents). Downhill skiing areas were selected since they generate the highest income from winter tourism. Despite its general relevance, cross-country skiing activities were not analysed separately as no comparable infrastructure with related representatives as for downhill skiing exists. Municipalities were involved in the study to cover the entire spectrum of winter tourism options. Their representatives aim at increasing (a) touristic income and (b) public perception of their offers. A total of 59 extensive telephone interviews were made between January 10 and 18, 2008. The number of interview partners was too small for a robust statistical analysis. However, the interviews cover a representative part of winter tourism supply in Saxony and allow recognizing relations between awareness and adaptation.

All contacts participated in the survey (100%), possibly due to the fact that climate change was not explicitly stated as the main interest. Instead, people were asked about their opinion on (economic) development potential in winter tourism, in particular the relevance of winter versus summer tourism, winter touristic highlights and related marketing activities. This part delivered a comprehensive picture of the current status of winter tourism and its marketing. Climate change issues were addressed in the second part of the questionnaire. Here, the interviewees' awareness on climate change and its connection to development opportunities in winter tourism was explored. The evaluation of existing and new touristic offers in winter tourism helped to further characterize existing and to specify prospective ways of coping with probable impacts of climate change.

Interview partners were chosen to represent the relative touristic relevance of their region. The number of representatives of downhill skiing areas versus those of municipalities from each region was: 18/14 in Erzgebirge, 5/5 in Vogtland, 5/4 in Upper Lusatia, 3/3 in Zittau Mountains and 2/2 in Saxon Switzerland. The high number of interviewees in the Erzgebirge is justified by its touristic relevance. Half of the overnight stays of all Saxon low mountain ranges in 2005 occurred in the Erzgebirge (Grimm and Winkler 2006).

Two questionnaires were used for the groups with eleven questions addressing the same issues for both, plus five more specific questions for skiing area representatives and three for municipality agents. The standardized questionnaires had predominantly closed questions. All additional information provided by the representatives was recorded and assigned to the related questions. This helped to further generate helpful background information for most of the questions, facilitated the interpretation of the survey results and the resulting development of adaptation strategies. In the following, only questions relevant to the context of this paper are discussed in detail (Table 1).

Results

Awareness of tourism professionals

This section analyses to which extent tourism economy, vulnerable to climate change, is aware of expected future changes and their economic consequences. The relation between awareness of regional climate change and the priority given to climate change issues in daily business was additionally assessed. Discrepancies between the level of awareness and (a) the interest in the topic and (b) the extent to which people feel well informed about climate change issues were highlighted.

Question 1: To explore vulnerabilities and future adaptation potentials, municipality agents were asked to assess the relative importance of selected winter tourism activities. While cross-country skiing is generally more important with respect to user numbers (Dietz 1992), downhill skiing creates a higher financial benefit (Jülg 2007). Both winter sports were seen as the top tourist attractions by 90% of the municipality representatives in all regions (Fig. 3). Thus, snow availability is the key parameter for a successful winter season in current Saxon winter tourism.

Question 2: Interviewees were asked to share their opinion about possible climate change impacts in Saxony until 2025 to analyse their awareness of reasons for declining natural snow conditions. Technical solutions that might improve snow conditions, e.g., artificial snow production, were not part of the question. The period to 2025

Table 1 Questions to representatives of Saxon tourism supply

Question 1 (Fig. 3)	Which type of current winter tourism is most attractive for tourists in your region? (only aimed at municipality agents; four given answers to choose)
Question 2 (Fig. 4)	Keyword climate change: What is your opinion on possible impacts until 2025? (three given answers to choose)
Question 3 (Fig. 5)	Which priority does "climate change" have for you? (five given answers to choose)
Question 4 (Fig. 6)	Do you feel informed well enough about a) the scientific background of climate change and b) the consequences for winter tourism in your region? (three given answers to choose, each)
Question 5 (Fig. 7)	What is your opinion on artificial snow production in skiing areas? (only aimed at agents of downhill skiing areas; three given answers to choose)
Question 6 (Fig. 8)	How would you react if natural snow conditions decline further in your area? (only aimed at agents of downhill skiing areas; three given answers to choose)
Question 7 (Fig. 9)	How do you judge the touristic attractiveness of the following (alternative) winter tourism options? (12 options, three given answers to choose)

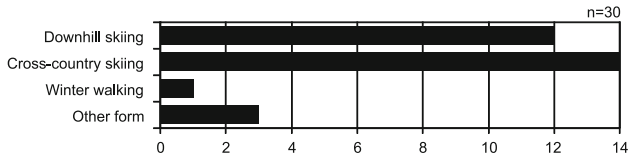

Fig. 3 Main touristic attractions during winter (November–April) as stated by municipality representatives (number of nominations, $n = 30$ as two agents nominated two attractions)

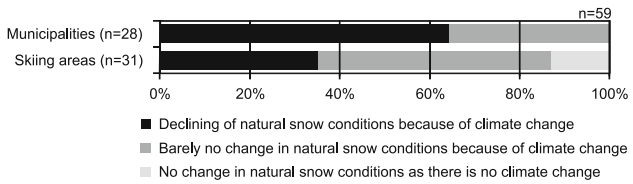

Fig. 4 Opinion on possible impacts of climate change on winter tourism to the year 2025 in the Saxon low mountain ranges

was chosen as economic planning is typically short term. Even at such time scales, Schneider and Schönbein (2006) projected a distinct decline of natural snow conditions. Representatives could select from three specific assumptions (Fig. 4). Two of these accept the reality of climate change, while one denies its existence. A climate impact on snow conditions is implied in one of the assumptions only.

Almost two-thirds of the municipality representatives anticipated a decline of natural snow conditions due to climate change. By contrast, only one-third of the downhill skiing area agents agreed to that statement, although their business would be strongly affected by declining snow availability. Four representatives (13%) denied the reality of climate change. The topic obviously was highly controversial, since answers were extensively justified (unsolicited) by many interviewees. Numerous interview partners argued with personal experience of recent cold (as in 2005/06) or mild winters (as in 2006/07), not with reference to scientific observations or analyses. Many

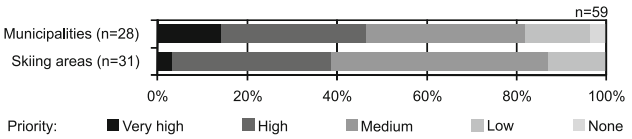

Fig. 5 Personal priority of the phenomenon "climate change"

interviewees expressed their hope that it might not get as bad as expected by climate change experts. Such uncertainty may compromise the implementation of adaptation options.

Question 3: Representatives were asked to rank their personal priority of the issue "climate change" on a scale from "very high priority" to "no priority", independent of their judgement regarding the existence and impact of climate change (Fig. 5). More than 80% of the interviewees consider the topic to be of medium to very high priority. Results for the municipality and the skiing area representatives were quite similar in contrast to question 2. The hypothesis that individuals, who give a low priority to the topic climate change, are more frequently not aware of its impacts could not be verified. While recognizing the relevance of climate change, the interviewees were often not aware of probable impacts on their own business. This could be due to inadequate, inaccurate or not well-targeted communication on climate change impacts.

Question 4: Representatives were asked how well informed they feel about the scientific background of climate change and its probable impact on winter tourism, since reliable information is important for successful adaptation measures (Fig. 6). While the interviewees were not asked where they derived their information from, the replies suggest public media rather than scientific ones as main information sources.

The number of representatives that "feel well informed" about background issues and the probable impact of climate change almost equals that of interviewees who miss information (slightly above 20%). The majority of both

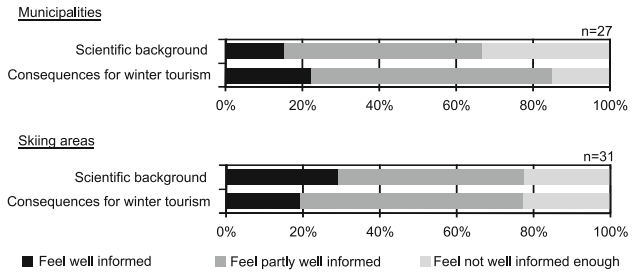

Fig. 6 Perception of the personal information level on the scientific background of climate change and related consequences for winter tourism

groups stated to be "partly well informed". Considerably more skiing area than municipality representatives (29% versus 15%) "feel well informed" regarding the scientific background of climate change. It is thus not surprising that slightly less members of the first group compared to the second group believed to be "not informed well enough" (about one-fourth versus one-third). The information level differed between questions related to the scientific background of climate change or its consequences for winter tourism. Municipality representatives felt better informed about impacts of climate change than about its scientific background, while the situation was inversed for the skiing area agents. The number of representatives feeling well informed remained low in both groups, however. Relating the answers to those of question 2 revealed that agents, who question a future decrease of natural snow conditions or climate change, tend to feel better informed than those, who accept a decline in snow conditions as true.

Communicating climate change to affected economic areas is an important but challenging task. Filho (2009) names factors that influence attitudes towards climate change, reveals common misperceptions related to the communication of climate change, and addresses resulting problems. "*A substantial number of people see climate change as an abstract issue, not connected to day-to-day reality*" (Filho 2009). Specific information needs of relevant stakeholders (here representatives of winter tourism) deserve more attention to help increasing awareness and to motivate them for more engagement (Filho 2009).

Many interviewees accused the media to be confusing, as they deliver highly contrasting views on the topic. They complained repeatedly about missing scientific consensus and stated their uncertainty in respect to the most trustworthy view. This shows that the representatives were in fact not well informed about the scientific background of climate change, since a broad scientific agreement reflects current reality. With mass media as the main source on climate change issues, information deficits almost inevitably emerge. Mass media present opposing views to safeguard the high diversity of the media landscape and the attention of recipients. Dissolving the stakeholder's dilemma is basically impossible (Matschullat 2010).

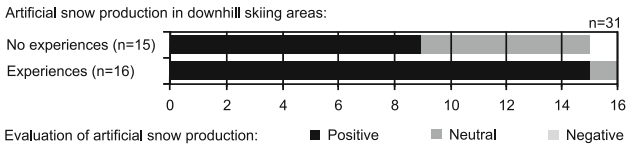

Fig. 7 Downhill skiing area representatives' evaluation of the technical snow production potential

Adaptation strategies in winter tourism

The existing and projected challenges in Saxon winter tourism require the development and implementation of adaptation strategies. Three sources were used to assess adaptation options: (1) a literature review sampled existing best practice examples, (2) field trips revealed onsite adaptation solutions, and (3) tourism professionals were asked about planned adaptation options. The results were merged to deliver one comprehensive picture.

Questions 5: Artificial snow production and slope management help dealing with limited snow availability in downhill skiing areas in the short run. Sixteen out of 31 skiing areas use artificial snow, but only some of them consider those devices an adaptation to climate change (Fig. 7). Most interviewees showed a very positive opinion about artificial snow production; the most positive replies coming from those that already apply it in their own business (Fig. 7). Weeks without snow cover ("green weeks") within the core season were seen as endangering a successful winter. Representatives complained that it takes several days or even weeks until skiers return after the formation of a fresh snow cover. The interviewees stated several times that a profitable operation of a downhill skiing area in low mountain ranges already is barely feasible. The recent warmer winters and the increasing amount of downhill skiers were seen as main reasons for that conclusion. One representative claimed that "*these days there are too many people and too little snow*".

Question 6: Degrees of freedom for Saxon tourism suppliers to satisfy the touristic demand for skiing activities decrease with declining snow cover. Downhill skiing areas are particularly affected, as they require considerably higher snow depth when compared, e.g., to cross-country skiing.

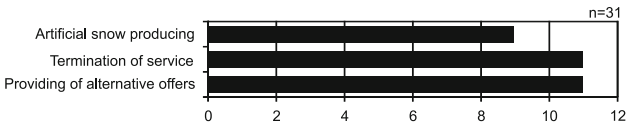

Fig. 8 Downhill skiing area representatives' strategies in case of worsening natural snow conditions

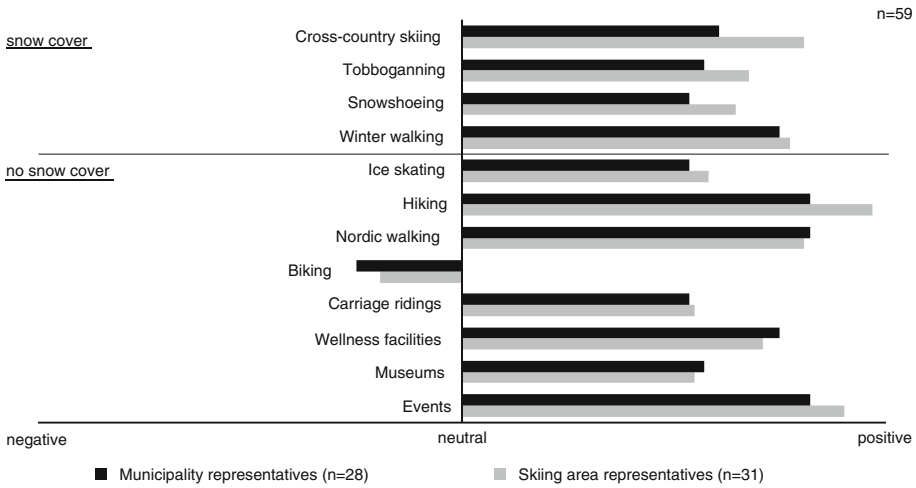

Fig. 9 Evaluation of the touristic attractiveness of alternative winter tourism options, demanding no or less snow than downhill skiing

Representatives of downhill skiing areas were asked about their potential adaptation behaviour under a continuing decline of natural snow conditions—three predetermined reaction options were given (Fig. 8). The answers did not provide any specific pattern related to location or altitude of the skiing areas. Nine out of the 31 representatives would introduce or expand artificial snow production with decreasing natural snow. This strategy fails, however, with increasing winter temperatures, additionally requiring an updated feasibility study of local climate conditions. Eleven agents would give up their business if snow conditions would further decrease, while the same number would try to provide alternative offers that do not demand snow cover. Some suggested solutions for snow-independent touristic offers.

Question 7: The representatives of skiing areas and municipalities were asked to assess the touristic attractiveness of twelve pre-selected options for less snow demanding winter tourism. They could evaluate the attractiveness of those options as negative, neutral or positive. Figure 9 illustrates the results and facilitates a comparison of the individual offers. The interviewees were additionally asked to brainstorm new suitable ideas for winter tourism in low mountain ranges.

The first four options—cross-country skiing, tobogganing, snowshoeing and winter walking—were included into the questionnaire, although they require a certain amount of snow. Studies from the European Alps state that on average, only half of the snow cover depth is needed to prepare cross-country tracks when compared to downhill track preparation (15 versus 30 cm; Abegg 1996; Elsasser and Bürki 2007). Conventional tobogganing just requires a thin snow cover. Winter walking means hiking across a snow or even white frost-covered landscape. Snowshoeing is also possible with just a small or even partial snow cover. Most agents considered these four snow-related offers to be attractive for winter tourists. Generally, the representatives of skiing areas evaluated them more positive than municipality agents. This may be connected to the higher relatedness of their business to snow activities.

Cross-country ski tracks are maintained by the municipalities. Related costs cannot be covered easily through fees as with cable cars or similar infrastructure in downhill skiing areas. Thus, ways to add value to this offer are required. Guided cross-country tours as well as guided snowshoe or winter walking tours could be new attractions for tourists. Interesting routing and additional information on culture, nature, history and other interesting information could add even more value. Tobogganing, snowshoeing and winter walking do not need any major infrastructural effort. These are straightforward options to attract tourists seeking a "true" winter experience.

Some municipalities already have experiences with guided snow shoe and winter walking tours. Nevertheless, winter walking was still considered to be "boring" or not attractive enough for the younger generation. However, offensive marketing may increase the performance of existing options. A German tourism manager aroused interest in using the English-language slogan "deep temperature trekking" in a German speaking setting, particularly among youngsters (Baumgartner 2006). This shows that touristic offers have to be advertised with confidence to not evoke an "emergency" or "backup" character.

Attractive alternatives, independent of weather and climate conditions, are in demand for low mountain range winter tourism, according to the interviewees. Snow-independent hiking in winter was positively evaluated by the vast majority of skiing area representatives and by most of the municipality agents. Nordic walking also received very positive ratings. Both alternatives are increasingly in demand even in Saxony's most popular skiing resort Oberwiesenthal/Fichtelberg that is characterized by the most reliable snow conditions. Events may be organized

throughout the year and should be focused on the demands of specific touristic target groups. The variability of events makes them attractive for tourists.

Ice skating facilities were seen more critical by some of the representatives because of the infrastructural costs. Some sceptical remarks were made for aesthetic reasons about the attractiveness of horse, dog or engine-driven carriage rides in a snow-free winter landscape. The potential of museums in attracting a larger number of tourists in winter was also questioned by some agents, as museums are not specific offers of mountainous areas.

The opinion of downhill skiing area agents regarding alternative uses of existing slopes was explored. Suggested solutions included grass-ski (downhill-skis with wheels on the bottom), grass-cars (sliding down the slope with a cart) and trend sports like mountain biking. Those activities may use the existing ski lifts at downhill slopes. The same is true for summer bob slides, but these need special slide rails that may prevent other uses for the slopes. Several interviewees referred to equipping ski slopes with plastic mats, as it has already been done at one ski areal in the Saxon Switzerland (Rugiswalde). The preparation involves moistening the mats and allows year-round snow-like sliding with ordinary downhill skies. The mats in the Rugiswalde skiing area are used from late August to late April. To prevent erosion by promoting undisturbed growth of grass, the mats are removed from May to August. Except for summer bob sliding, these alternatives are not widespread yet. Thus, they can become economically successful independent of their general touristic attractiveness, as they may catch the attention of curious tourists.

Cycling was the one alternative that was largely evaluated as negative. Interviewees perceived cold weather as inconvenient for biking. Moreover, the corresponding infrastructure is difficult to maintain in winter, as tracks are either blocked by snow and ice or wet and muddy. Nevertheless, it should be checked to which extent cycling offers would be accepted by tourists, particularly in lower and medium altitudes where the ground is mostly snow free. Mountain and cross-cyclists are target groups with specific needs. Conditions perceived as unfavourable by "normal" cyclists may be very attractive for them. One participant of our survey suggested offering "adventure-tours" for mountain cyclists on muddy ways.

Cross-country ski trails may be used for other sport and training activities independent of a snow cover, if individually marked. The success of such offers can be further increased by innovative marketing. Slogans like "active trails" (*Aktivwege*) and "all weather cross-country tracks" (*Allwetterloipen*) promote the new concept of a all-season use. Sealing or gravelling cross-country tracks allows their utilization for hiking, running, Nordic walking, roller skating, inline skating and roller-skiing.

Wellness was another topic in the discussions with experts and is considered an important component of current and future (winter) tourism. The attractiveness of wellness offers was evaluated mainly positive, but it was questioned how those offers stand out from the crowd of regional and national competitors. Nevertheless, "Selfness" (originating from "self-being"), a term used in the German language area to describe an advancement of wellness, could be a chance to reach this goal. It links relaxation with activities and covers four competences: (1) physical, (2) work-life-balance, (3) self-reliance and (4) mental maturation (Zukunftsinstitut 2007). These competences aim at further personal development and the rediscovery of an individuals' potential. "Selfness" is not yet booming, offering an opportunity for service providers to enter a developing market early. Examples of "selfness" such as individual assistance and coaching have the potential to create unique regional selling propositions, independent of season, weather and climate.

An ageing society offers the additional opportunity to provide more touristic options targeting older people. This group is less focussed on snow conditions than younger generations. Older people are more likely to enjoy a beautiful landscape of low mountains independent of snow availability. A target group-oriented marketing of winter tourism alternatives should take their interest in nature activities like hiking and Nordic walking as well as health issues into account.

Nearly all representatives agreed that Saxon mountains will become less attractive for winter tourists with declining snow cover. However, low mountain range tourism can be a "winner" in other seasons. The interviewees believed that with increasing temperatures, low mountain ranges become climatically more attractive in all seasons despite the current main season winter. Many tourists visit the mountains because of hiking opportunities. Thus, the tourism sector may profit from an extension of the hiking season with an earlier start in spring and a later end in autumn. "Summer retreat" is another opportunity to compensate possible losses in winter tourism revenues. Areas like the central European mountain regions may attract visitors at the expense of tourist destinations such as the Mediterranean during the summer season, as they provide a more comfortable climate in hot summers.

The many options to adapt winter tourism to changing climate conditions will have to be verified for any specific local economic, ecological and societal situation to identify and implement the most suitable solution.

Conclusions

Winter tourism is an important economic factor in the tourism sector of Saxony's low mountain areas, especially in Erzgebirge and Vogtland, where skiing activities form the basis of winter tourism. These two regions are characterized by higher elevations than the more easterly located study areas. As snow cover became less reliable over the last decades, efforts are needed to maintain and enhance the touristic competitiveness of Saxon low mountain ranges. A survey amongst public and private suppliers of currently important winter touristic services (downhill and cross-country skiing) in all five areas explored their awareness of climate change issues as well as their evaluation and suggestion of alternative, less snow-dependent offers. Their agents form the basis of tourism supply and represent the interface to the tourists.

The survey showed that the interviewees' awareness of increasing winter temperatures and related declines in snow availability was limited despite the fact that the interviewees ranked climate change issues with a comparatively high priority. Only some of the representatives were aware of the necessity to adapt to already existing and to expected changes in climate conditions. However, representatives fear the risk of decreasing snow covers and warmer temperatures independent of their awareness level. The awareness of municipality agents was generally higher than that of skiing area representatives, explainable by their different perspectives. Municipality agents first consider the overall economic implications, while the representatives of skiing area were more focussed on their local enterprises. The individual level of information on climate change issues explains their awareness, too. While the majority feels at least partly well informed, the objective level of information is rather low. "Artificial confusion", provoked by mass media, was identified as one of the main reasons for the related knowledge deficit. This conclusion corresponds with the findings of Bürki (2000), who discovered that Swiss tourism representatives had the impression that climate change is presented highly exaggerated in the media. Since it is difficult to influence the quality of public mass media, stakeholders should be motivated to preferably use science-based information sources.

Four options for winter tourism exist to deal with climate change: (a) avoidance strategies (e.g., reduction of greenhouse gas emissions) demand long-term global commitments and do not work on the short run, (b) to stop offering winter tourism is no viable solution for sustainable tourism development in the investigated region, (c) "business as usual" strategies are no alternatives if snow reliability is decreasing, and (d) adaptation is the only reasonable alternative to meet the challenges of changing mountain climate. Examples of successful adaptation already exist in the region. These are not always regarded as adaptations to climate change, but to changing touristic demands (e.g., increasing number of ski tourists). A higher awareness of climate change and its impact on snow-related business would support the acceptance and implementation of more diverse and less snow-dependent offers in Saxon winter tourism.

As snow demand of downhill skiing is the highest of all snow-dependent tourist activities, poor snow availability was seen as the major threat for downhill skiing areas by nearly all agents. Coping strategies include technical solutions to save snow tourism (e.g., artificial snow and slope management) as well as the implementation of alternatives to classical downhill skiing. Half of the examined downhill skiing areas used artificial snow, and nearly all of their representatives see the related operation facilities as positive for their business. Nevertheless, losses in natural snow would be compensated by enhanced artificial snow production by only one-third; another third would abandon their service, while the remaining third would try to attract tourists by alternative offers. Those include grass-ski, ski on plastic mats or summer bob slides and are feasible all year-round. These offers are not used widely so far, apart from summer bob slides. The natural curiosity of tourists could provide a success even for very rare and unusual offers.

Cross-country skiing, tobogganing, snowshoeing and winter walking have the potential to provide a "true" winter experience even in a warmer winter climate during times with an available snow cover. Hiking and Nordic walking might be attractive alternatives during warm winters. From all presented alternatives, only cycling was evaluated mostly negatively by the interviewees, as recent and future climatic conditions were perceived as unsuitable for related offers. However, the true suitability should be verified especially at lower and medium altitudes. Conditions might be perfect for mountain and cross-country cyclists, since their needs differ from those of "normal" cyclists.

These alternative offers generally do not have a value creation comparable to downhill skiing, which is a challenge to the profitability of mountain tourism in general. Furthermore, they often attract a smaller target group, not being able to fully compensate disappearing skiers. Nevertheless, their value creation is higher compared to a ski slope without snow. Related offers have to be promoted with confidence, and not to be perceived as improvisation for "bad" snow conditions. A gradual diversification with new target groups is recommended instead of an immediate shift from snow tourism to alternative offers. A broader economic foundation based on a larger variety of touristic options is wise as it decreases economic risks coming along

with a focus on just a few numbers of touristic highlights or limited target groups.

This study is a first step in forming a comprehensive picture about threats and opportunities in the future development of Saxon low mountain range winter tourism. Probable reactions of the touristic demand, when confronted with the scenario of a changing structure in winter tourism, need to be explored. In most surveys, snow-independent offers were rated to be less important by tourists (e.g., König 1998; Bürki 2000; Pröbstl and Unbehaun 2006). In contrast, the increasing amount of older people yields the chance to attract a group interested in the beauty of mountainous landscapes regardless of winterly snow conditions. Additionally, Saxony might also have a comparative advantage within Germany as 72% of the East German (former GDR) population, interested in a journey to mountainous areas, would go there regardless of the snow situation (survey in 1993 by Harrer 1996). In West Germany, only 47% would do so. The main reasons to visit were beautiful landscapes and intact nature.

A follow-up survey among winter tourists is planned for the near future. Further questions of that study will be, e.g., How would tourists react to further declining snow conditions? What target groups would be at risk and are there new ones to aim at? Which alternatives to snow tourism are attractive to which target group? With the results of both studies (touristic supply and demand), target group-oriented, attractive alternatives for low mountain range winter tourism can be developed, to secure the position of winter tourism in Saxony.

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References

Abegg B (1996) Klimaänderung und Tourismus. Klimafolgenforschung am Beispiel des Wintertourismus in den Schweizer Alpen. Schlussbericht NFP 31, H. 2, Zürich, p 222

Baumgartner C (2006) Technikglaube oder Fantasielosigkeit—Lokale Anpassungsstrategien der Tourismuswirtschaft an den Klimawandel. In: CIPRA (ed) Klima—Wandel—Alpen—Tourismus und Raumplanung im Wetterstress. Commission Internationale pour la Protection des Alpes, Conference proceedings 18.-20.05.2006 in Bad Hindelang, oekom Verlag, München, pp 116–123

Bernhofer C, Matschullat J, Bobeth A (eds) (2009) Das Klima in der REGKLAM-Modellregion Dresden. Rhombos Verlag, Berlin, p 117

Breiling M, Charamza P (1999) The impact of global warming on winter tourism and skiing: a regionalised model for Austrian snow conditions. Reg Environ Change

Bürki (2000) Klimaänderung und Anpassungsprozesse im Wintertourismus, Ostschweizerische Geographische Gesellschaft NF, H. 6, St. Gallen, p 197

CIPRA (2006) Klima—Wandel—Alpen—Tourismus und Raumplanung im Wetterstress. Commission Internationale pour la Protection des Alpes, Conference proceedings 18.-20.05.2006 in Bad Hindelang, oekom Verlag, München, p 143

Dietz K (1992) Umweltgerechter Skisport/Wintertourismus in den sächsischen Mittelgebirgen. In: Universität Leipzig, Fakultät für Sportwissenschaften, Bereich Wintersport/Umwelt (ed): Umweltgerechter Skisport/Wintertourismus in den sächsischen Mittelgebirgen, report scientific colloquium 01.10.1992, Leipzig, pp 5–24

DWD (2010) Daily climate dataset 1916–July 2010 meteo station Fichtelberg of the German Weather Service (unpublished)

Elsasser H, Bürki R (2007) Auswirkungen von Umweltveränderungen auf den Tourismus—Dargestellt am Beispiel der Klimaänderung im Alpenraum. In: Becker C, Hopfinger H, Steinecke A (eds) Geographie der Freizeit und des Tourismus. Oldenbourg Verlag, München/Wien, pp 865–875

Filho WL (2009) Communicating climate change: challenges ahead and action needed. Int J Clim Change Strateg Manag 1:6–18

Franke J, Goldberg V, Eichelmann U, Freydank E, Bernhofer C (2004) Statistical analysis of regional climate trends in Saxony, Germany. Clim Res 27:145–150

Freydank E (2001) Statistische Untersuchungen regionaler Klimatrends in Sachsen (CLISAX). German Weather Service—Regionales Gutachterbüro Dresden (unpublished)

Galloway RW (1988) The potential impact of climate changes on Australian ski fields. In: Pearman GI (ed) Greenhouse: planning for climate change. CSIRO, Melbourne, pp 428–437

GIS-KliSchee (2010) http://www.klimazwei.de/ProjektezumSchutzvorKlimawirkungen/Projekt%C3%BCbersicht/GISKliSchee/tabid/115/Default.aspx. Accessed 08 September 2010

Grimm B, Winkler K (2006) Urlaubstourismus in Sachsen—Studie auf Basis der Reiseanalyse RA 2006. Tourismus Marketing Gesellschaft Sachsen mbH, Kiel, p 96

Hänsel S, Petzold S, Matschullat J (2008) Precipitation trend analysis for Central Eastern Germany—1851–2006. In: Strelcova K, Matyas C, Kleidon A, Lapin M, Matejka F, Blazenec M, Kvarenina J, Holecy J (eds) Bioclimatology and natural hazards. Springer, New York, pp 29–38

Harrer B (1996) Wirtschaftsgeografische Auswirkungen einer veränderten ökologischen Situation—Konsequenzen für den Wintertourismus in Deutschland. In: Schriftenreihe des Deutschen Wirtschaftswissenschaftlichen Institutes für Fremdenverkehr an der Universität München: 47, München, p 238

Hoy A (2008) Wintertourismus in Sachsens Mittelgebirgen—Marketingstrategien zur Anpassung an die Folgen des Klimawandels. Diplomica GmbH, Hamburg, p 165

IHK Südwestsachsen (2007) Wirtschaftsfaktor Tourismus im Erzgebirge study by dwif-consulting for Industrie- und Handelskammer Südwestsachsen Chemnitz—Plauen–Zwickau, Chemnitz, p 20

IPCC (2007a) Climate change 2007: the physical science basis. Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge/New York, p 1008

IPCC (2007b) Climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge/New York, p 992

Jülg F (1999) Faszination Schnee. In: Bensberger Protokolle: 94: Der Winter als Erlebnis—zurück zur Natur oder Fun, Action und Mega-Events? Neue Orientierungen im Schnee-Tourismus. Köln, pp 9–38

Jülg F (2007) Wintersporttourismus. In: Becker C, Hopfinger H, Steinecke A (eds) Geographie der Freizeit und des Tourismus. Oldenbourg Verlag, München/Wien, pp 249–258

König U (1998) Tourism in a warmer world: implications of climate change due to enhanced greenhouse effect for the ski industry in the Australian Alps. Wirtschaftsgeographie und Raumplanung 28, Zürich

Kreienkamp F, Spekat A (2008) Synopse beobachteter und projizierter Klimate für Sachsen auf der Basis deutscher statistischer und dynamischer Regionalmodelle (REGKLIM)—Final report, Potsdam, p 352

KUNTIKUM (2010) http://www.klimatrends.de/, Accessed: 08 September 2010

Matschullat J (2010) Klimawandel—Klimaschwindel? Mitt Deutsch Meteorolog Ges 02: 21–36; Offenbach

McBoyle GR, Wall G (1992) Great lakes skiing and climate change. In: Gill A, Hartmann R (eds) Mountain resort development. Center for Tourism Policy and Research, Simon Fraser University, Burnaby, pp 77–81

OECD (2007) Climate change in the European alps—adapting winter tourism and natural hazards management. In: Agrawala S (ed). OECD publishing Organisation for Economic Co-operation and Development, Paris, p 127

Pröbstl U, Unbehaun W (2006): Climate change in winter sport—a new approach to transdisciplinary research and implementation. OECD-Wengen workshop 2006—adaptation to the impacts of climate change in the European Alps, 04.-06.10.2006, Wengen. http://www.oecd.org/dataoecd/25/40/37909236.pdf. Accessed 08 September 2010

Roth R, Türk S, Armbruster F, Polenz R, Velten A, Schrahe C (2001) Masterplan Wintersport im Sauerland und Siegerland-Wittgenstein, Stufe I: Räumliche Entwicklungskonzeption und Marktanalyse, Projekt- und Forschungsberichte des Instituts für Natursport und Ökologie der Deutschen Sporthochschule Köln. Band 6, p 208

Roth R, Prinz N, Krämer A (2005) Nachhaltige Entwicklung des Wintersporttourismus und des Schneesports in Baden Württemberg. Baden Württemberg Ministry of Economy (ed), Köln, p 105 http://www.klimageo.rwth-aachen.de/fileadmin/klima-data/literatur/ Schneider-Schoenbein_Klimatol_Raumpotenzial-Nachh_Entw_Schneesp_Wintersporttouri s_BaWue_2005_01.pdf, Accessed 08 September 2010

Schneider C, Schönbein J (2006) Klimatologische Analyse der Schneesicherheit und Beschneibarkeit von Wintersportgebieten in deutschen Mittelgebirgen. Deutsche Sporthochschule Köln, Institut für Natursport und Ökologie (ed), Schriftenreihe Natursport und Ökologie 19, p 111

Seifert W (2004) Klimaänderung und (Winter-)Tourismus im Fichtelgebirge—Auswirkungen, Wahrnehmung und Ansatzpunkte zukünftiger touristischer Entwicklung. Unpublished Diploma thesis, University of Bayreuth, Faculty of Biology, Chemistry and Geography, p 206

SMUL (Saxony Ministry for Environment and Agriculture) (2008) Sachsen im Klimawandel. Eine Analyse. Dresden, p 211

Wall G (1985) Climate change and its impact on Ontario—tourism and recreation. Phase 1, Report submitted to Environment Canada, Ontario Region

WTO (2003) Proceedings/final report of the first international conference on climate change and tourism. World Tourism Organisation, Djerba, p 55

Zukunftsinstitut (2007) 100 top trends—Die wichtigsten Driving-Forces für den kommenden Wandel. Kelkheim, p 228