The Impact of Climate Change on Alpine Leisure Tourism in Germany and Austria

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Abstract

This paper presents an interacting multi-agent model as a new method of examining the impact of climate change on Alpine leisure tourism and ski areas in a complex interacting model network. Since tourism varies at a small scale concerning natural resources as well as offered market segments, a regional differentiated analyse of the effects of climate change on both the tourism supply side and demand side is essential. Therefore, we have developed a high-resolution simulation model to rate the tourism development under different climate and societal scenarios in the German and Austrian Upper Danube catchment. As a result, we evaluate implications on the tourism industry for the next fifty years. As the model analyses tourism development on a high level of individualisation, it fosters the finding of economically reasonable investment strategies and supports the policy makers' outward reasoning by making the decisions more objective and transparent. The effects on climate change are very different on a small spatial scale: Some larger and higher located ski resorts will operate very successful in the next decades. They will profit from the shift of guest caused by the problems that smaller and no more snow-reliable ski areas are facing.

Introduction

During the past years, the relevance of climate change for a broad range of human activity sectors has become an obvious fact. Climate change and its impact on the tourism sector have now turned into much-discussed issues in both the science community and in public. Several studies have been carried out on different spatial and temporal scales, most of them on the country level. For example, the model of Hamilton, Maddison, and Tol (2005) as well as the transnational comparative study of Ehmer and Heymann (2008) calculate the change of tourism destination attractiveness on a global scope. As the results are spatially highly generalised, they give a broad overview of tourism development under climate change conditions, but do not distinguish between different tourism market segments or regions being affected to various degrees.

Regarding winter sports tourism, the majority of society has become convinced that the number of snow-reliable ski areas will decrease in future in the whole Alpine region, but particularly in the Bavarian and Austrian Alps (Abegg 1996; Harrison, Winterbottom, & Shephard, 1999; Scott et al., 2001; Elsasser & Bürki, 2002; Scott et al., 2006).

Due to the importance of winter tourism for Bavaria (winter season 2008/2009 30 million bed nights; almost 40 percent of tourist arrivals recorded during the winter season; Bavarian State Ministry of Economic Affairs, Infrastructure, Commerce and Technology, 2009) and also for Austria (winter season 2008/2009 62 million bed nights, and almost 50 percent of tourist arrivals recorded during the winter season; Statistic Austria, 2010), the future development of tourism has a significant impact on the regional economy.

With regard to the operating efficiency of ski areas, snow-reliability and the duration of the season are the vital parameters (König, 1997). In order to remain competitive in the light of a changing climate, many ski areas presently face different options for action concerning their strategic direction. Several ski areas, particularly the smaller and lower located ones, might cease ski operations and switch instead to snow-independent forms of winter tourism or to summer tourism. Alternatively, resort operators are partly confronted with investment considerations in regard to modern ski lifts and snow making facilities (Zimmerl, 2001). The latter are expensive to purchase and have high energy and water requirements, so that the additional construction of water reservoirs is often necessary. Furthermore, even contemporary snow cannons need a certain air temperature (currently artificial snow can be produced at up to -3 °C) and are ineffective if it is warmer, as it might be more frequently the case in the future (IPCC, 2007). Devices that can produce snow at higher temperatures are still under development, but they imply much higher operative costs. It has to be investigated as detailed as possible, which of these options will be the most suitable for the single ski area. Thus, for a profound analysis, methods apart from classic cost-benefit calculations should be deployed. In the course of this, it is essential to not use aggregated data, such as average values on the state level, but to work with preferably individual data. For these requirements, the use of a multi-agent simulation approach is appropriate.

Currently, most ski area operators have to revise their investment strategies. As the depreciation period of snow making machines is indicated with ten to fifteen years, and the one of cable cars and lifts with twenty to thirty years, the consideration of external framework conditions' development such as climate change can yield a decisive advantage. The majority of the studies focussing on winter sport tourism considers only a few variables and fades out the involvement of tourism development in the interdependency of natural and societal components (Abegg, 2006). Recognizing this research gap, we have been implementing and applying a multi-agent system for simulating the impact of climate change on winter tourism in a complex interacting model network. In this sense, the presented model offers decision support to resort operators in order to render their strategic planning more reliable for themselves and to make the line of argumentation more transparent towards their co-decision makers, like politicians, investors, or representatives of a tourism association.

The paper is structured as follows: At first, we describe the main points of the integrated model. Then, we expand to the tourism model's functionality with a focus on ski areas. Selected results are presented subsequently. In a final section, we discuss the findings and draw conclusions in terms of guidance for ski area operators.

Project background

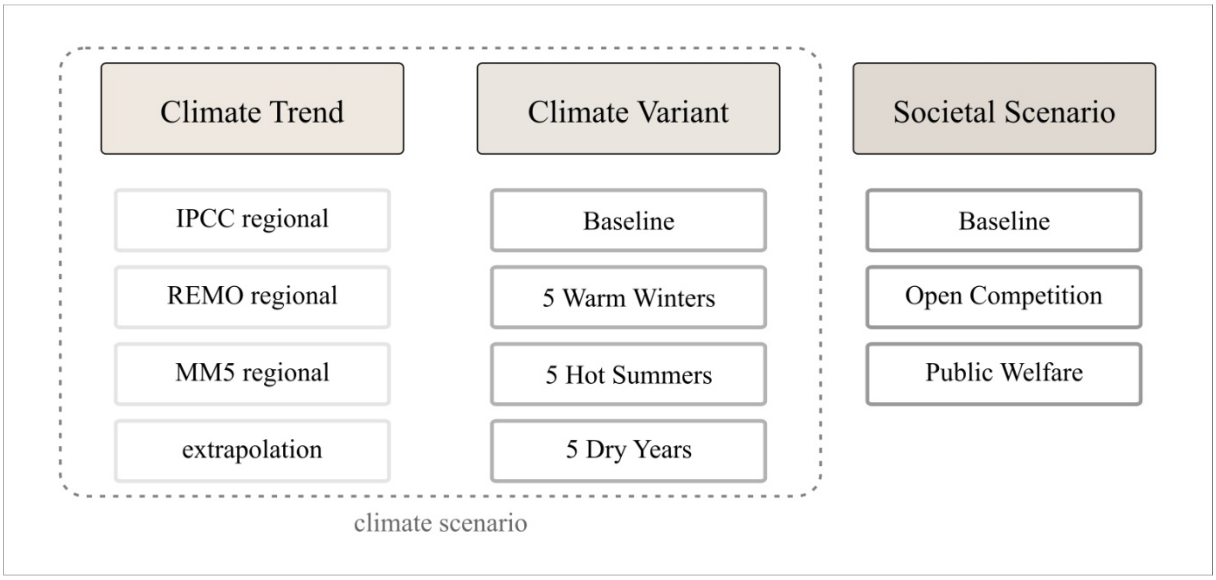
The presented tourism model is part of the GLOWA-Danube (GLObal Change of the WAter cycle) research and development project, which intensively analyses the development of the Upper Danube water balance and the effects of climate change on a broad range of sectors, such as tourism, households and water supply in the next fifty years (2011 to 2060) with a high spatial and temporal resolution. The investigation area has a size of 77,000 km² and is one of the largest and most important Alpine drainages in Europe. It contains parts of the German states of Bavaria and Baden-Wuerttemberg, of the Austrian states of Vorarlberg, Tyrol, Salzburger Land and Upper Austria, and of the Swiss canton of Grisons (Figure 1). Researchers from different natural and socio-economic scientific disciplines work closely together in an interdisciplinary knowledge network. By use of different scenarios, it aims at developing and evaluating sustainable regional adaptation strategies. The results of the GLOWA-Danube project offer decision support to policy makers by helping to pre-estimate the consequences of strategic investment decisions.

Figure 1: GLOWA-Danube investigation area

Therefore, different simulation models have been implemented following the multi-actor approach (‘actor’ is used synonymously for ‘agent’ in the project). This approach allows modelling individual actors with varying attributes, so that aggregating singular results generates spatial patterns. Socio-economic processes are described as the sum of individual behaviour. Thus, it is no longer necessary to use mean values and the outcomes can be analysed on each required level of aggregation. Therefore, an actor may represent any kind of social entity, such as a ski area or a household (Klügl, Oechslein, & Puppe, 2002).

To enable small-scaled simulations, a grid was superimposed on the investigation area. The cells of this grid are called proxels (an acronym of process pixels) and have an edge length of 1 km. A proxel locates all simulated elements, such as settlements, ski areas or rivers, and is fitted with attributes like its individual altitude or the number of inhabitants (Janisch, 2005). Within the GLOWA-Danube project, all models are joined together in an object-oriented framework, which has been developed by the GLOWA-Danube computer science group. All integrated models exchange data during run time. As besides the generation of scientific knowledge another project target is to offer decision support to related stakeholders, the created model system has to cater for the needs of both scientific and practical application. Therefore, different climate and societal scenarios were defined, which can be combined modularly (Figure 2). Thus, a scenario funnel is spanned, which represents different possible development paths and includes the ‘real future’ to all probability.

Figure 2: GLOWA-Danube scenario kit



According to the modular principle, the user can choose a climate scenario and a societal scenario for each simulation run. A climate scenario contains a Climate Trend and a modifying Climate Variant, where four different Climate Trends (IPCC regional, REMO, MM5, and an extrapolation model) and four climate variants (Baseline, Five Warm Winters, Five Hot Summers, Five Dry Years) are available for selection (Jacob et al., 2001; IPCC, 2007; Jacob et al., 2008; Mauser et al., 2009). The Climate Trends vary in the degree of temperature and precipitation alteration and thus offer a broad range of possible climatic futures. Depending on the respective question, a Climate Variant can be chosen additionally. If for instance a farmer wants to know whether his planned substitutions of crops are economically reasonable, even in the extreme case if five consecutive dry years are expectable in the near future, an adapted simulation can be run.

As climate change and societal development are interacting parts of a complex system, the scenario kit contains an additional Societal Scenario choice, which describes different possible trajectories of the demographic, economic and political development. Beyond a Baseline scenario, the two contrary scenarios Open Competition and Public Welfare are distinguished. Thereby, the Open Competition scenario describes a hedonistic, market-oriented and materialist orientation with a focus on profit maximisation. In contrast, the Public Welfare scenario envisages a concentration on societal responsibility with a focus on non-economic dimensions, including balance and faith becoming more important (Kuhn & Ernst, 2009). The concrete realisation of the Societal Scenarios is specifically implemented in each of the actors models (tourism, household, industrial enterprises, farmers, water suppliers) corresponding to the particular requirements. For instance, households react on (temporal) water shortages by installing water saving lavatory flushes, whereas ski areas are prohibited or sponsored to invest in artificial snow-making facilities.

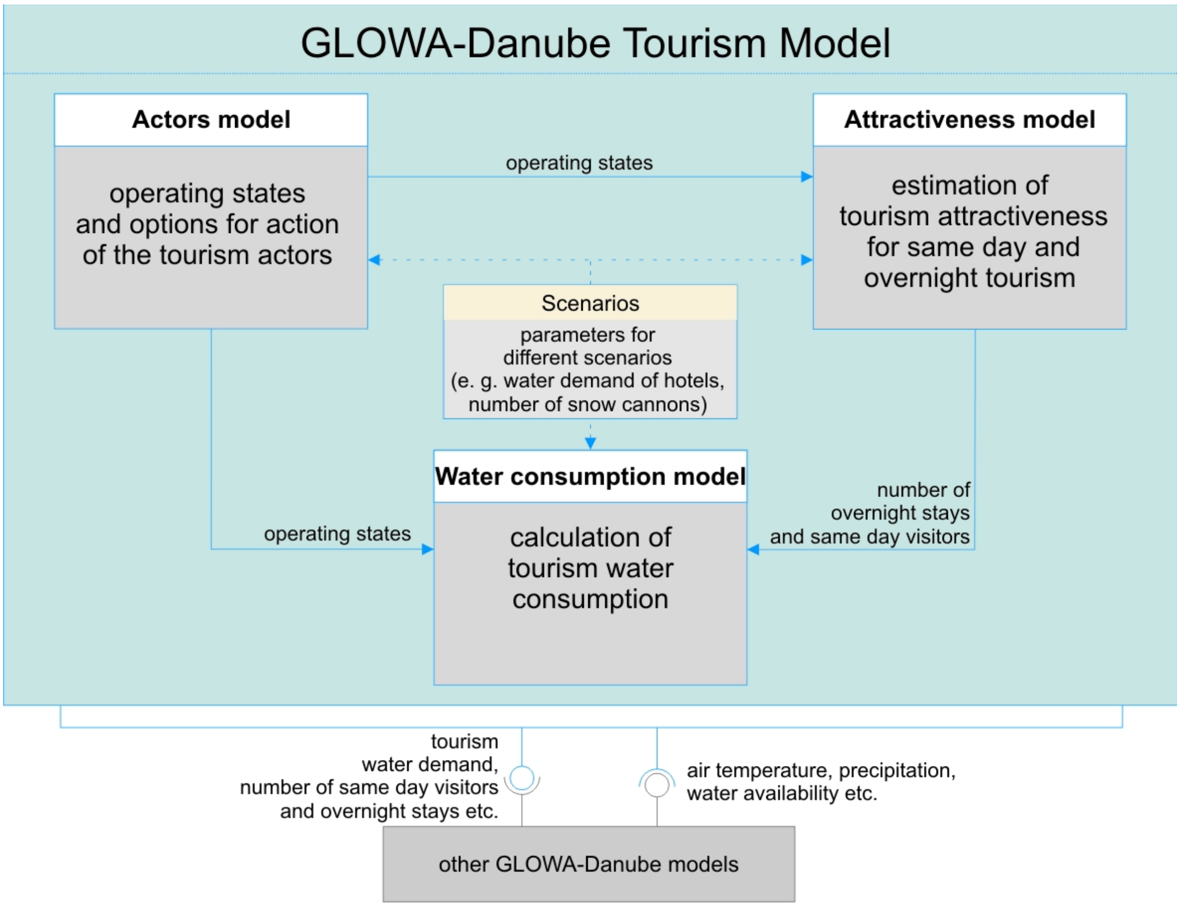
Tourism Model Description

After having presented some general aspects of the overall project, we now focus on the Tourism Model. This model quantifies the tourism water consumption, which is an important innovation as this data is up to now recorded neither in official nor in non-official statistics. In addition, the model simulates the operating ability of different tourism infrastructure facilities and the resulting trend of bed nights under climate change conditions on different spatial scales.

The state of tourism specific infrastructure influences the tourism demand and may cause demand-side shifts. The advance of this is the consideration of different interacting aspects affecting the quality of an entrepreneurial or political decision. Since natural resources of the tourism supply, such as the slopes of a ski area, are directly affected by climate change, the Tourism Model investigates the correlation of tourism supply with the regional impacts of climate change. As the data is generated on the individual level, it can be aggregated on different spatial and temporal levels. By this means, a highly detailed examination of the tourism supply is possible, allowing for example development studies for single communities as well as for different levels of aggregation, including districts or states.

The Tourism Model is basically supply-side oriented and structured in three sub-models: the Actors Model, the Attractiveness Model and the Water Consumption Model (Figure 3).

Figure 3: Tourism Model structure



The Actors Model contains different classes of tourism supply facilities, including ski areas, golf courses, swimming pools, hotels, and restaurants. Each of these classes has singular attributes, like the number of snow cannons for ski areas or the area size for golf courses, and own options for action, like artificial snow-making for ski areas or greens irrigation for golf courses. Within each actor's class, every existing facility is an individual instance of an actor class, so that the model simulates for example the development of 253 different ski areas. To link the modelled area with the real investigation area, extensive sets of data, among them the spatial location of the facility and several attributes, have been collected within own surveys (Dingeldey, 2008; Sax, 2008). The data is assigned to the respective actor depicting the real facility, which can be identified by a specific identification number.

As for example a ski area can open only if the snow depth is deep enough for skiing, the Tourism Model needs information, such as about air temperature, precipitation, and water availability from other GLOWA-Danube models, like the climate model, or the water supply model. By importing these data during simulation runtime, the operating state of each single actor is calculated on a daily basis. Based on its current environmental conditions, each actor decides anew every day for one action from several options. To remain with the example of ski areas, a ski area has the choice between opening, closing, and artificial-snow making plus the exit-option to close down finally. According to the input data received from other GLOWA-Danube models, each ski area goes through a decision process, decides for the momentary best action, executes it, and thus influences in turn its environment, for example by using water for artificial snow-making.

The infrastructure facilities serve as tourism attractions in a region. If for example a ski area has to close temporary or goes bankrupt due to the climatic conditions, this has an adverse effect on the attractiveness of the related communities or the region. Potential tourists might switch to more snow-reliable ski resorts situated at higher altitudes. These demand-side reactions, such as temporal or spatial shifts, are factored in the Attractiveness Model. This sub-model reflects the attractiveness of each of the more than 2,100 communities in the investigation area for the tourism demand side. The more attractive tourists perceive a specific community, the more bed nights and same-day visits are generated. The number of bed nights is calculated for each populated proxel, taking into account the community-specific annual number of bed nights and its average seasonal distribution during the course of the year. As same-day visitors account for a considerable quota of the overall tourism, the relative number of same-day visitors is estimated based on the number of bed nights (Maschke, 2005; Sax, 2008).

The model distinguishes furthermore between summer and winter tourism. The operating state of ski areas is affecting the attractiveness of a region. During the winter season, the model verifies for each tourism community, whether there is any ski area within a radius of 20 km. This is the maximum distance between the hotel and the ski area that a tourist is willing to cover, according to expert interviews with tourism professionals (hotel managers, ski resort operators, CEO of tourism associations and tour operators) conducted by Dingeldey (2008). Depending on the share of winter sport guests a closed ski area can cause losses in the number of bed nights from up to 50 percent. It is assumed that the number of guests in communities with no ski area within a 20 km-distance is not influenced by winter sport tourism. The share of winter sport guests has been estimated with a cluster analysis (Dingeldey, 2008). The same applies to golf courses during the summer season and to swimming pools. In addition to the operating state of the tourism infrastructure, the general economic conditions, the availability of (drinking) water and climate data, like the monthly mean temperature are considered in the tourism demand calculation. Communities with a high proportion of leisure guests will gain attractiveness with higher temperatures in the summer (Dingeldey, 2008).

Each operating part of the tourism infrastructure exhibits a specific water demand, for example ski areas need water to run their snow cannons, and guests consume water, for instance when they stay in a hotel or a restaurant. Therefore, both the Actors Model and the Attractiveness Model deliver data to the third model, the Water Consumption Model, in which the total tourism water demand is calculated (Sax, 2008).

The Actors Model reacts on the above mentioned Societal Scenarios. In detail, the Tourism Model assumptions for the implementation of the three Societal Scenarios have been realised as follows:

Public Welfare: The Public Welfare scenario focuses on sustainability including environmental protection. Within this scenario, the extension of existing facilities for artificial snow-making is excessively restrained. Operators of tourism infrastructure have to invest in savings of drinking water. If there are environmental problems (like drinking water shortages), harsh regulations are set very fast into place. The general tourism development is slowed down by regulations (such as environmental protection, cost of transport, energy taxes).

Open Competition: In contrast, the Open Competition scenario allows the expansion of artificial snow-making to extend the ski season. Tourism will grow, because of lower restrictions and higher investments into the infrastructure. When environmental problems occur, operators have more time to react. Because of the higher level of investment, the large ski areas need more operating days to be profitable.

Baseline: The Baseline scenario is just in between the both extreme scenarios. It assumes a moderate tourism development and a moderate expansion of the infrastructure.

Furthermore, it is possible to set completely individual values of the setscrews to the particular questioning. For example, the minimum snow depth for skiing is fixed at a specific level for the Bavarian Forrest and the Alps. If a single ski resort operator knows that the minimum snow depth for skiing in his ski area varies from this value in reality, or wants to calculate the effect of an expansion of the snow-making infrastructure, the specific value can be set in the model.

Tourism Model Results

For the simulation runs described in this paper, we chose the climate trend REMO combined with a Baseline climate variant. REMO is an intermediate climate scenario presuming a temperature increase of +5.2 °C, an increase of winter precipitation of +9.1 percent and a reduction of summer precipitation of -31.4 percent until 2100 (Jacob et al., 2008). So both the selected climate trend and the added climate variant are conductive to a moderate simulated climate development. For the second scenario component, the societal scenario, we compare a Baseline to an Open

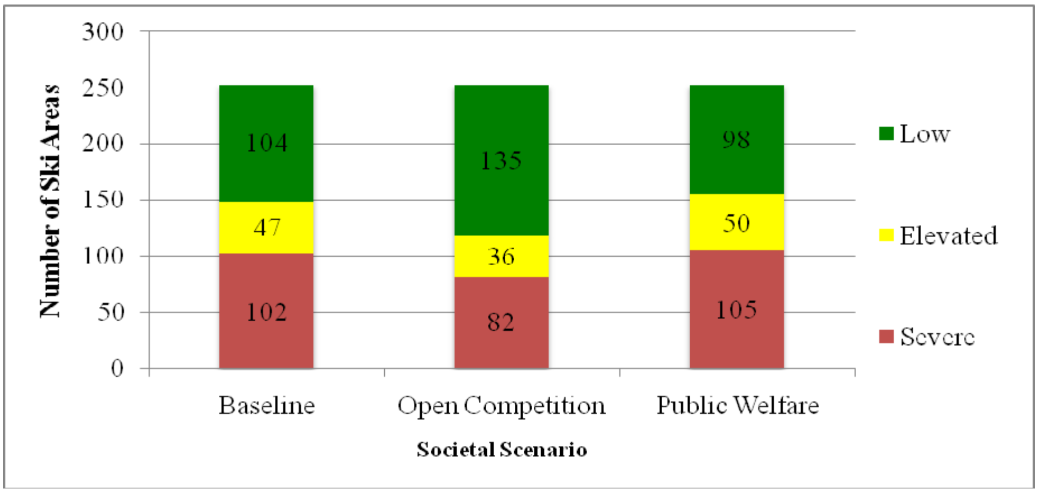
Competition and a Public Welfare scenario, as the latter two scenarios mark the extremes of the potential societal developments and the first represents a business-as-usual trend.

To assess the vulnerability of the ski areas against the climate change they were classified based on the average opening days per season. The potential operating days can be used as a measure for profitability – each ski area needs a certain number of operation days to stay profitable on the long run (Sax, 2008). The average number of operating days of the last simulation-decade – the seasons 2051/51 to 2059/60 was used to compare the ski areas. As a result the threat level of the ski areas is classified in three groups:

- Low: These ski areas will operate in the future with very few problems.
- Elevated: These ski areas can keep a certain level of opening days, but might face problems with the profitability.
- Severe: These ski areas cannot be considered as snow-reliable in the future. They have to face seasons without snow.

There is quite a significant difference of the number of ski areas in each class depending on the societal scenario: The Open Competition scenario allows the excessive expansion of artificial snowmaking. This improves the snow reliability of some ski areas (Figure 4). But even in the Open Competition scenario, 82 ski areas are still severely threatened. It results that some ski areas can improve their competitive position and reduce the threat of climate change with the expansion of artificial snowmaking. On the other hand there are still a significant number of ski areas that are endangered in all scenarios: With the technology that is currently available, the expansion of artificial snowmaking is not a general solution for every operator and has to be planned quite carefully.

Figure 4: Simulated threat level of climate change 2050/51 to 2059/60 – number of ski areas



The size of each ski area can be very different and is measured with various parameters: The area, the lifts (number, length, capacity) and slopes (area, length, difficulty): There is a range small areas with one or two T-bar lifts to modern and dense ski areas with many contemporary detachable chair lifts and various slopes. The closure of a small area with low capacity has much lower effect on the tourism demand than the closure of a modern and dense ski area. In this model we use the carrying capacity of each ski area – measured in persons per hour – as parameter for the size and density for each ski area. It has been surveyed for all 253 ski areas in the investigation area. The carrying capacity correlates with the most other size parameters of ski areas and is used as a parameter for the market share of each ski area in the Tourism Model (Dingeldey, 2008). Figure 4 shows the threat level of the ski area weighted by the capacity: Smaller ski areas are affected in a higher level by the climate change than larger ones: For example in the Baseline scenario, 40 percent of the ski areas are severely threatened, but only 23 percent of the total capacity.

Figure 5: Simulated threat level of climate change 2050/51 to 2059/60 – carrying capacity of ski areas

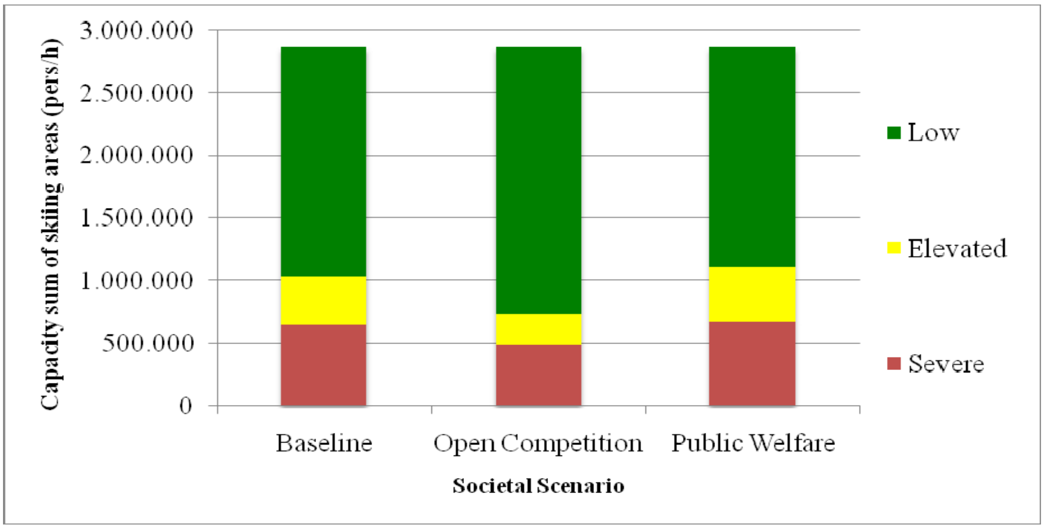


Figure 5 shows the individual threat level of the ski areas in the investigation area for a Baseline scenario. As described in Chapter 2 the projection of the attractiveness of the overnight tourism – in the winter and summer season – takes several other factors into account, such as the regional tourism development, the status of golf courses in the summer season, swimming pools, and drinking-water supply. Figure 4 shows the spatial distribution of the calculated change of the number of bed nights as a result of the Tourism model. This is displayed as the cumulated average growth rate (CAGR) during the simulation (from 2011/12 to 2059/60).

Figure 6 shows that the communities with ski areas with a low threat level – especially in Tyrol – will profit from the climate change. One reason is the per se attractiveness of those communities and their infrastructure (ski areas, accommodation etc.). Additional some guests shift during the winter season from destinations with lower snow reliability. The climate change accelerates the general concentration tendency. Some destinations will lose quite a significant number of guests. Even the better performing summer season cannot compensate the general losses during the winter season.

Figure 6: Threat level of ski areas and simulated development of overnight tourism

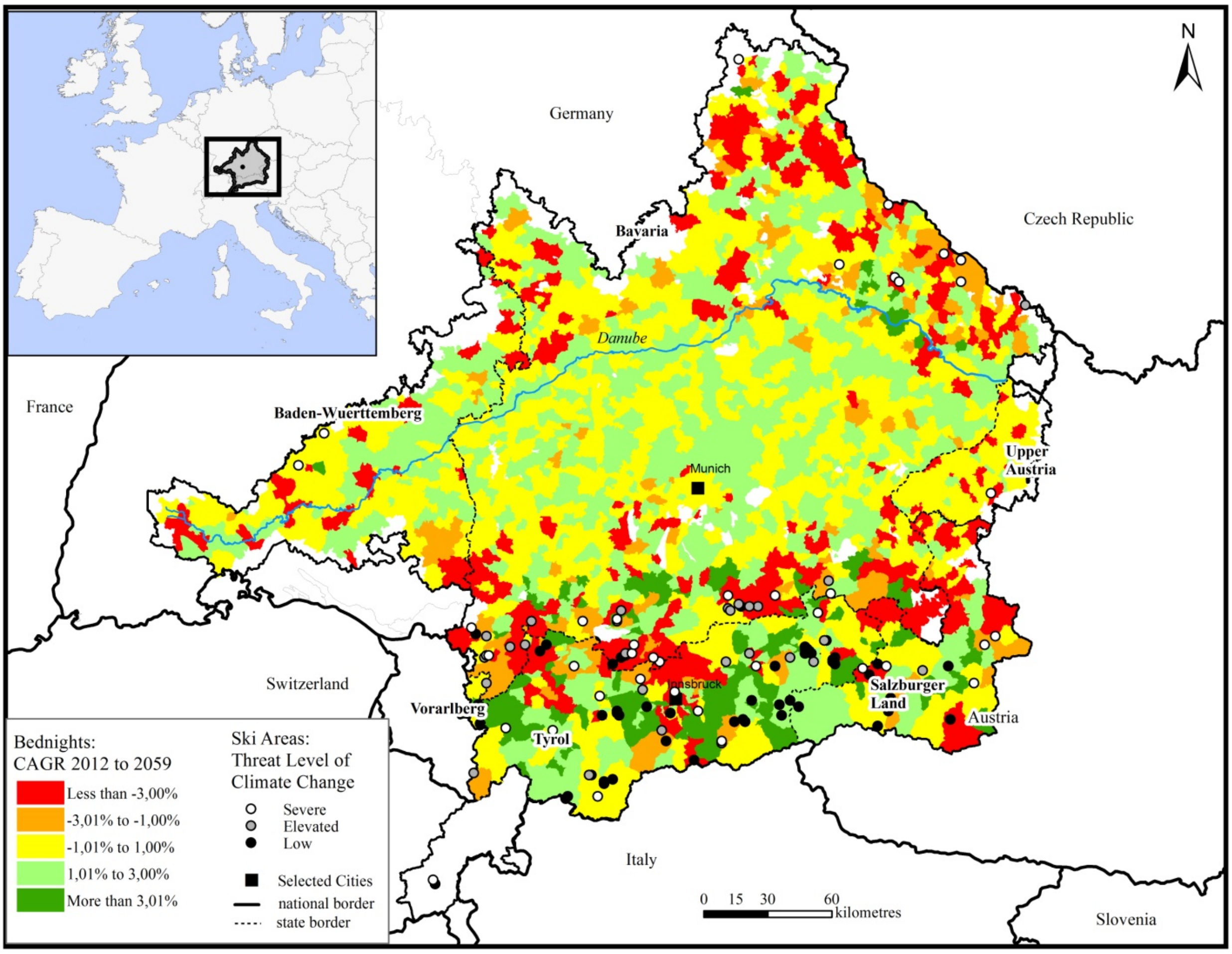
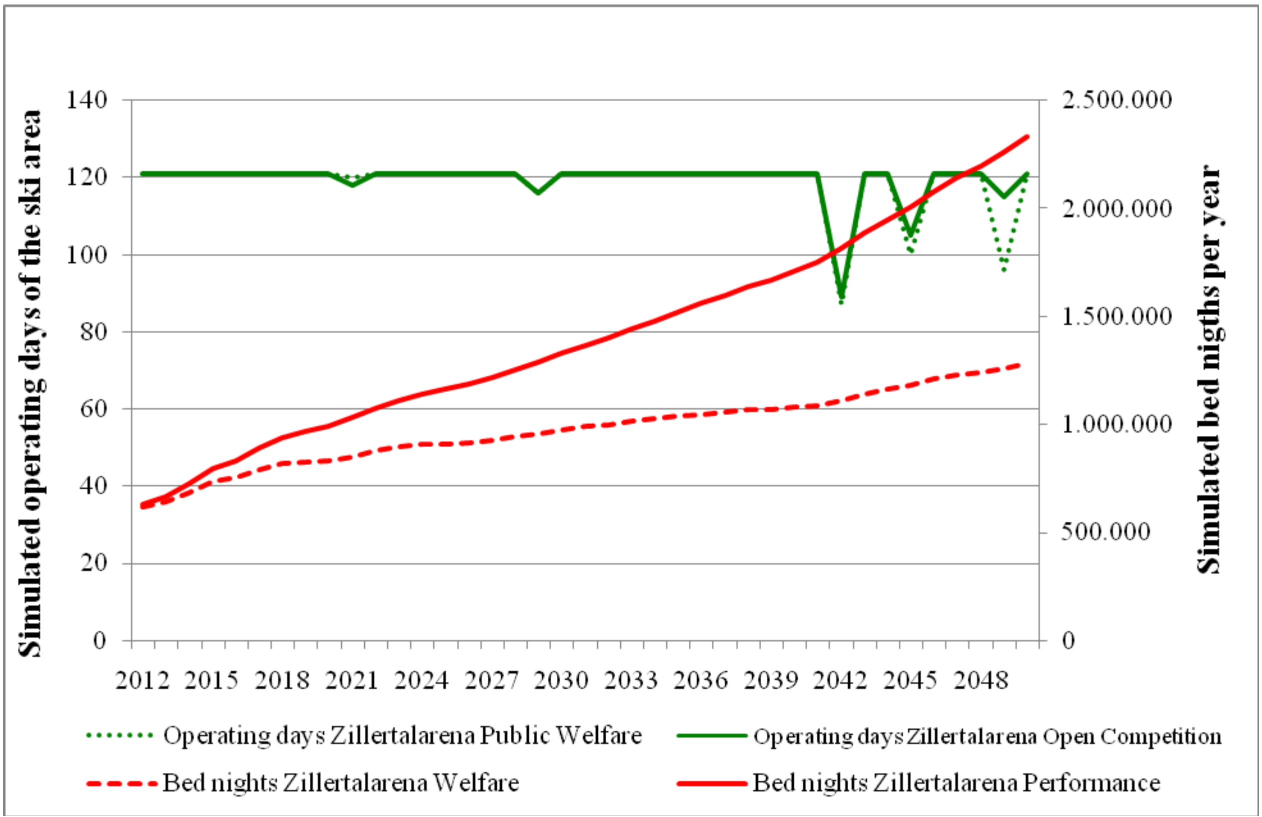


Figure 7 shows an example of the model results for the tourism region (Tourismusverband) Zillertalarena in Tyrol, Austria. The ski area is highly snow-reliable and can operate as usual in the next future. Possible problems in the distant future can be solved with an expansion of the artificial snow-making facilities. The number of bed nights is positive in both simulated scenarios. One reason is the solid basis of the tourism in general in the region. Another reason is the quite significant number of guests that shift from other areas with lower snow-reliability. Thus, the Zilleratlarena can be rated as a winner of the future climate change conditions.

Figure 7: The ski area Zillertalarena, Austria as an simulation example - development of operating days and bed nights



Discussion and Conclusions

In order to keep their good competitive position, ski areas classified with a low thread level should continually make further investments, particularly as in the light of climate change snow-reliable ski areas will expect higher demand by spatial shifts of tourist flows.

Ski areas with a severe threat level should deploy a strategy to run the existing ski infrastructure with lowest possible costs and close down if necessary. Investment decisions for ski areas with an intermediate and high threat level should be revised very carefully. The communities around those ski areas are exposed to lose a large number of guests, so only well planned investments can help to get back on a growth path. Especially some ski areas in the Bavarian Alps lose quite some competitive position against modern ski areas in Austria. They should expand carefully their snowmaking infrastructure and renew the lifts in order to regain attractiveness. With the currently existing technology, highly threatened ski areas can hardly probable be made snow-reliable. A use of the lifts in the summer season can help to stay on a profitable path. In view of the exit criteria, additional investments are economically reasonable only if enormous advancements in snowmaking technologies are realised, so that snow can be produced at higher temperatures and much lower costs. Under present-day aspects, these ski areas should be operated as long as possible with further investments only to cut operating costs. For the future, the surrounding communities should focus on snow-independent tourism market segments, such as hiking, wellness or MICE-tourism (Meetings, Incentives, Conventions, Events). Where possible, ski areas should cooperate or merge with more snow-reliable ski areas in order to make them more attractive in whole. Higher average temperatures in the summer make the destinations in the Alps more attractive. But with the current level of infrastructure it is not possible to compensate the losses of guests in the winter-season.

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