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## EDITOR'S NOTE

Issue coordinator: Dominique Baud (co-director of JAR-RGA. Researcher and lecturer at the Institute of Urban Planning and Alpine Geography, PACTE Laboratory. University of Grenoble Alpes).

- 1 Mountain tourism is mainly based on two particular territorial resources: landscape (Reichler, 2002) and snow (Gumuchian, 1983). In the European mountains, after a phase of development of summer tourism since the end of the 18<sup>th</sup> century, winter sports appeared at the beginning of the 20<sup>th</sup> century in Saint-Moritz (Engadine, Switzerland), and then spread to almost all mountain ranges (Alps, Pyrenees, Carpathians, etc.), as early as the inter-war period and especially after the Second World War. Some countries, such as France, have implemented proper policies for the planned development of the “snow” resource. The *Plan Neige* thus aimed to compensate in a systematic and planned manner for the decline of the agricultural and pastoral economy and to position France on the European ski market (Granet-Abisset, 2016), giving rise to the model of integrated resorts (Knafou, 1978). In many regions, a real snow economy has taken place, a model that is now moving towards new markets, such as the Caucasus. In North America, snow tourism has also emerged in some Rocky Mountain resorts, complementing the “wilderness” tourism developed in the late 19<sup>th</sup> century and the creation of the first national parks.
- 2 In the Alps and the Pyrenees, the development of ski resorts has had the beneficial effect of partially slowing down the rural depopulation and maintaining jobs in the valleys, especially seasonal jobs which, at least initially, were complementary to

agricultural activity. However, where tourism mono-activity was most exacerbated, winter tourism induced a very strong economic dependence on this economic sector. The development of snow tourism has also often been accompanied by strong impacts on the other major resource at the base of mountain tourism: landscape. Whether through the “export” of the mountain urban construction model in certain integrated resorts (Delorme, 2014) or the landscape sprawl by chalets and other second homes, it is clear that winter tourism has literally “consumed” large portions of landscape (Krippendorf, 1977). The development of ski lifts to very high altitudes (Chamonix, Zermatt, Sölden) has allowed easy access to the high mountains (peaks, glaciers), an area hitherto reserved for mountaineers, causing an almost complete “colonisation” of mountain spaces.

- 3 In mountains of developing countries, in the Himalayas and to a lesser extent in the Andes and African mountains, it is the development of commercial mountaineering and trekking that has been the main tourist development over the last fifty years (Sacareau, 1999). Although the phenomenon of second homes is not on the same scale as in European and North American mountains, tourism has greatly modified local socio-economic systems, which until then had been based mainly on agriculture and livestock. It has also led to the improvement of public (roads, communication or supply networks) and private (improved comfort) infrastructure.
- 4 Due to natural characteristics (increase in precipitation with altitude, barrier effect), mountains are often rich in water and thus constitute water towers for the surrounding areas (Viviroli and Weingartner, 2004). Areas with rain-shadow effect have dry conditions and are poor in water resources, leading to the development of highly sophisticated irrigation and agricultural water management systems, both technically and socially. Mountain regions are particularly sensitive to the effects of global climate change (Elsasser and Bürki, 2002; Beniston, 2003, 2012; Gobiet *et al.*, 2014). Moreover, the steep slopes, the reduced vegetation cover – for both natural and anthropogenic reasons – and sometimes the particular geological context (clayey rocks), make certain sectors prone to slope processes (landslides, debris flows) and river processes (torrential floods), which constitute a major challenge for the development and maintenance of infrastructures, particularly communication infrastructure. At high altitudes, the cryosphere and its evolution under the effect of current climate change also is a challenge for water management (glaciers can constitute an essential part of the resource) and risks (slope instabilities, ice breakup). These particular natural conditions, as well as their current transformations because of climate change, constitute important constraints to land use and economic development. They can also be seen as opportunities for certain economic activities. This is the case of hydropower generation, which has taken advantage of natural characteristics (water richness at high altitudes, storage of water in the form of snow and ice, steep gradients) to intensively exploit water resources.
- 5 Snow and water are both constraints and opportunities for mountain tourism. In the majority of European and North American mountain resorts, snow became, after the Second World War, the primary tourist resource, before landscape. This led to a strong dependence on this resource and the development of a business model based essentially on the winter season at a time, between the 1960s and 1980s, when this resource was particularly abundant compared to the 20<sup>th</sup> century as a whole. Since the end of the 1980s, rising temperatures and the interannual variability of winter

precipitation have undermined this mono-tourism activity and resorts have had to adapt, first by developing artificial snow production facilities (Scott, 2006) and increasingly by seeking alternatives to skiing and other snow sports.

- 6 Two articles in this volume deal with this issue. Martin Gerbaux and his colleagues have systematically studied the evolution and reliability of snow cover for skiing in 24 ski areas of the Isère department over the recent period (2001-2016) and over the future period up to the middle of the 21<sup>st</sup> century. Future projections took into account, in addition to climate change, snow grooming and artificial snow production. They show that for the resorts in the department, the evolution of the natural snow cover should be identical at equal altitudes, with the major discrimination between areas being essentially linked to altitude. The inclusion of artificial snow in the modelling shows that the median reliability with artificial snow by 2050 would be equivalent to the reliability over the recent period without artificial snow, and that snow production will remain possible in the mid-21<sup>st</sup> century, although the number of cold windows favorable for snowmaking will decrease. The authors also looked at the water demand induced by artificial snowmaking; it is expected to increase by 15% compared to the recent period. They conclude that for Isère ski resorts, given the current situation in terms of rival uses on the scale of local catchment areas and the projected increase in demand for artificial snowmaking, the availability of water resources should not be a major constraint by 2050.
- 7 David Sauri and Joan Carles Llordés propose an analysis of the ten ski areas in the Spanish Pyrenees. They highlight the difficulties of these resorts in terms of natural snow cover, which is more problematic here than in the French Northern Alps. The relatively modest size of the ski areas, the uncertainties caused by the recent economic situation in Spain and the competition with the resorts of the French Pyrenees and Andorra, which are north-facing and therefore more favourable to skiing, have made these resorts particularly vulnerable and raise questions about their future viability. A compilation of data on future snow cover shows that the ski area of Baqueira-Beret, oriented to the North-West (Atlantic) and located at a relatively high altitude, would remain quite favorable for skiing. It is also the largest and best equipped resort to face competition from other resorts in the Pyrenees or other mountain ranges. Elsewhere, the small size of the ski areas and their relatively low altitude, especially in the south-eastern part of the massif, make the future of skiing uncertain. The authors thus argue for diversification strategies: these areas should move from a ski resort model to a new model of mountain resorts offering a diversified range of activities and products.
- 8 The relationship between the availability of water resources and tourism has been the subject of various studies (Gössling, 2006; Gössling *et al.*, 2012, 2015), especially where a high level of tourist activity is superimposed on low water resources; this is the case, for example, in certain highly touristic islands (Hof and Schmitt, 2011). A challenge is the complexity of the demand for water for tourism, both individual and collective (Gössling *et al.*, 2015). Another issue is the high seasonal variability of use: peaks in water demand often coincide with low water levels in rivers and springs (Vanham *et al.*, 2008), and the central issue is the management of peaks in demand and water storage (Reynard *et al.*, 2020). This is the case in mountain during the winter season, a problem exacerbated by water demands specific to tourism (Reynard, 2001). In developing countries, tourist use in rural areas often results in increased specific demand for tourists (especially for personal hygiene), which develops in contexts where

distribution infrastructures are still poorly developed. This can have positive effects, through the improvement of infrastructures, but can also induce rivalries with other existing uses, notably irrigation.

- 9 Over the last thirty years, in mountain ski resorts, the demand for water for artificial snowmaking has given rise to much controversy and passionate debate, not always well argued. However, several studies have highlighted in some ski areas the current and future sharp reduction in the reliability of the natural snowpack (Vanham *et al.*, 2009) and the substantial contribution of artificial snowmaking to the viability of ski areas (Scott *et al.*, 2012). They show that artificial snowmaking is an effective form of adaptation to climate change in mountain resorts. Other studies highlighted the relatively small impact of water demands for artificial snowmaking on regional water balances (Reynard and Bonriposi, 2012; Reynard *et al.*, 2014). On the other hand, at the local scale, especially in the upper parts of catchment areas, often occupied by ski slopes and rich in wetlands of high ecological value, which are particularly sensitive to anthropogenic impacts, careful management of artificial snowmaking is essential. In some particularly dry regions, such as the Engadine in Switzerland (Lanz, 2016), potential use conflicts between artificial snowmaking and other water demands need to be carefully addressed (Reynard *et al.*, 2020).
- 10 In general, whether in the mountains of the South or the North, the impact of climate change on local water management systems is not yet studied in sufficient detail. Two articles in this volume attempt to partially address this issue. One of the problems related to the modelling of the resource-demand ratio at the scale of regional and local catchments and the identification of possible water stress situations (Milano *et al.*, 2015) is related to the lack of sufficiently precise data on current water demands and their recent evolution (Grouillet *et al.*, 2015). In tourist regions, this gap is further reinforced by the variability of tourist occupation. It is necessary to better understand this variability (Reynard, 2001; Calianno *et al.*, 2018; Calianno and Reynard, 2019) in order to better calibrate models of future evolution. This is the objective of Martin Calianno's paper, which proposes a method for estimating the seasonal variation in the demand for drinking water in tourist resorts with few measurements. Based on the case of Megève resort (Haute-Savoie), the author shows that tourist attendance varies on two frequency scales: weekly (high frequency) and seasonal (low frequency). The analogues method consists in measuring at a fine temporal scale (daily) the water demands at the supply level (see Calianno *et al.*, 2017, for a discussion of the terminology related to the urban water cycle) on a reduced sample of buildings representative of the station's building typology, and then extrapolating to the whole station. The results thus obtained allow an accurate representation of the intra-annual temporal variability of current water demands. This is particularly useful for modelling future demands in places with strong seasonal variations in occupancy. In these resorts the adaptation strategy involves, in particular, the improvement of storage systems (Reynard *et al.*, 2014).
- 11 The last paper is about the Everest Massif in Nepal. Due to the strong attractiveness of the World's highest peak and the development of a significant trekking activity, the local socio-economic systems have changed significantly over the last decades (Sacareau, 1999). Marie Faulon and Isabelle Sacareau analyse local water management at the village level in the Dudh Koshi valley, a major Himalayan trekking destination, using the social water management model (Sabatier and Ruf, 1995). Based on a

systematic survey conducted on a random sample of 366 housing units (including 144 lodges), supplemented by semi-structured interviews and river transects, they show that the evolution of trekking, particularly the shift from camping to accommodation in lodges from the 1980s onwards, has led to an increase in water demand for tourism. The demand is both direct (the average consumption of a tourist being twice that of an inhabitant) and indirect (due to the demand for fresh vegetables, which require irrigation). Water is also involved in the production of electricity by means of micro-power plants, which have developed as a result of tourism. The two researchers highlight very fragmented management systems and strong socio-spatial disparities in access to water within these villages, depending in particular on the degree of household involvement in tourism. They conclude that water is currently a resource for the local tourism system and that the pressure on water, although significant, remains moderate for the moment at the regional level. Disparities and possible conflicts are rather the result of the lack of optimization of technical infrastructures and network fragmentation. The impact of climate change is still unclear, but there is no doubt that the socio-technical fragmentation of local water management is a factor of vulnerability.

- 12 These four papers are the follow-up to the “Water and Tourism” Conference organized by the University of Lausanne and the HES-SO Valais-Wallis in Sion/Sierre (Valais) on 9 and 10 November 2017 (<https://www.unil.ch/igd/fr/home/menuinst/colloques--conferences/colloques/2017/eau-et-tourisme--water-and-tourism.html>). They demonstrate that research on the impact of climate change on water management in mountains cannot be limited to rough analyses of the evolution of some climatic parameters (precipitation, snow). The studies must analyze in detail – on spatial and temporal scales – both the resource and the water demand, their interrelationships and the socio-technical systems involved in their management, as well as territorial specificities. Mountains are multiple, as are their territories and economies; reasoned management of water management systems at the local and regional scales necessarily requires detailed studies of the management systems. This is what the authors of the four papers presented here have focused on.

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