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General Commission for Sustainable Development

Water in ski resorts:
a resource under pressure

MARCH 2019

In the mountains, water demand sporadically spikes in winter in ski resorts due to increased tourist activity. Meeting the demands related to these seasonal influxes (accommodation, catering, etc.) combines with the daily needs of local inhabitants. Faced with a trend decrease of natural snow due to the effects of climate change, resorts are more and more using artificial snow. But in winter, watercourses are at their lowest levels. These pressures on water can lead to stress on this resource and cause use conflicts. Wastewater treatment can also be complex in mountain areas, as population fluctuations result in a seasonal increase in the volume of wastewater requiring treatment.

Mountains are often described as Earth's "water towers", and the water available in these areas is perceived as being unlimited. However, human activities, alongside the effects of climate change, have lead to water becoming an increasingly vulnerable resource. Changes in rainfall patterns and increased temperatures linked to decreased natural snow cover have a direct impact on the availability of water, particularly in winter.

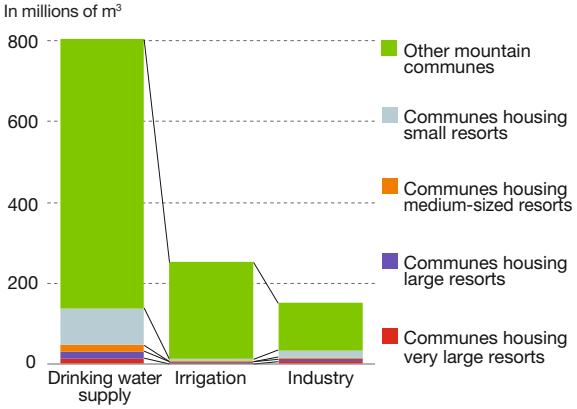
In municipalities that "house" ski resorts (municipalities with at least one ski lift or Nordic ski area), water management must take into account the increased demand caused by both an influx of population during the tourist period and by the requirements of snow guns, which ski areas are using increasingly often. The increased demand can lead to use conflicts between tourist services, holidaymakers, and the resident population, particularly as concerns water withdrawals for the drinking water supply.

HIGH DEMAND FOR DRINKING WATER IN MUNICIPALITIES HOUSING SKI RESORTS

In mountain municipalities, excluding hydroelectricity production, the demand for drinking water is purpose of freshwater withdrawal (*figure 1*).

In 2015, municipalities housing ski resorts accounted for 17% of mountain freshwater withdrawals for drinking water supplies, while only 10% of the population living in mountain areas actually reside in these specific areas. The size of the ski resorts (*see methodology*) has an impact on the variations observed. In municipalities that have large or very large ski resorts, the share of the volume of water withdrawal for drinking water supplies is twice that of the resident population. Variations are less pronounced in municipalities that house small and medium-sized ski resorts.

Figure 1: distribution of the volumes of water withdrawal in mountain municipalities in 2015, by use



Sources: *CGET; STRMTG, Cairn; Ministry of Sport, RES; Onema, BNPE. Processing: SDES*

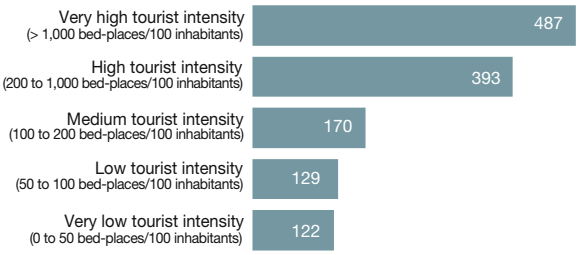
In relation to the number of permanent inhabitants, the volume withdrawn for drinking water supplies in municipalities housing ski resorts is much higher than in other mountain municipalities (278m³ versus 150m³ per inhabitant on average). In municipalities with large resorts, the annual volume withdrawn per inhabitant averages at 381m³, which is 2.5 times more than the average volumes in mountain municipalities that do not have ski resorts.

A MARKED EFFECT CAUSED BY SEASONAL POPULATION INCREASE RELATED TO TOURISM

The theoretical increase in population numbers linked to tourism can be estimated using the tourism function rate, a tourism intensity indicator that compares the number of tourist-intended bed-places to permanent population numbers. In municipalities housing resorts where the population can, on average, increase almost sixfold (472 beds per 100 inhabitants), the largest volumes of water withdrawal for drinking water supplies per inhabitant can be found in municipalities with very high tourist intensity (*figure 2*). The volume withdrawn in these areas is four times higher than in municipalities housing resorts with very low tourist intensity.

Figure 2: volumes of water withdrawal for drinking water supplies in municipalities housing ski resorts in 2015, according to their tourism function rate

In m³ per inhabitant



Note: volumes withdrawn in municipalities housing resorts compared to the resident population of these municipalities. The withdrawal location is not necessarily the consumption location. Some withdrawals are used to supply neighbouring areas and therefore require more substantial volumes of water.
Sources: *CGET; STRMTG, Cairn; Ministry of Sport, RES; Onema, BNPE. Processing: SDES*

In terms of the different mountain ranges, withdrawals in municipalities housing resorts are especially significant in the Alps, where most ski resorts are located, as well as in the Vosges. They account for about a quarter of the withdrawals in each of these mountain areas (89 million m³ and 7.5 million m³ respectively). They also represent a significant portion of withdrawals in the Jura Mountains and the Pyrenees (18% and 15%). Conversely, this portion is much lower for the Massif Central and Corsica (9% and 2%).

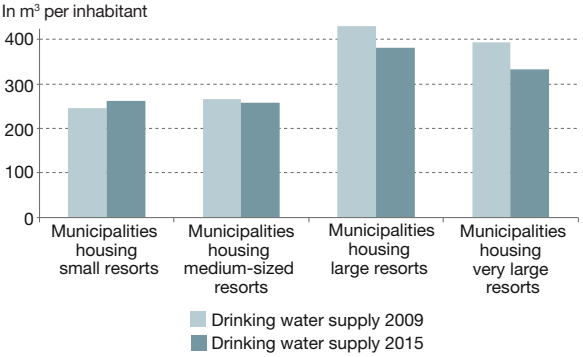
WITHDRAWALS DROPPING SLIGHTLY, EXCEPT IN SMALL RESORTS

Since 2008, following the national trend, volumes withdrawn in municipalities housing resorts have tended towards stagnation or even decline. However, this situation is largely dependent on the size of the ski resorts (*figure 3*). The volumes are increasing at small resorts (up 7% over the observed period), whereas they are decreasing at other resorts.

The withdrawal figures, in relation to the number of inhabitants, show a major contrast between municipalities housing small and medium-sized resorts (262m³/ inhabitant on average in 2015), and those with large and very large resorts (381 m³ and 333m³/inhabitant respectively in 2015).

Figure 3: changes in the volumes of water withdrawn for drinking water supplies in municipalities housing ski resorts

In m³ per inhabitant



Sources: *CGET; STRMTG, Cairn; Ministry of Sport, RES; Onema, BNPE. Processing: SDES*

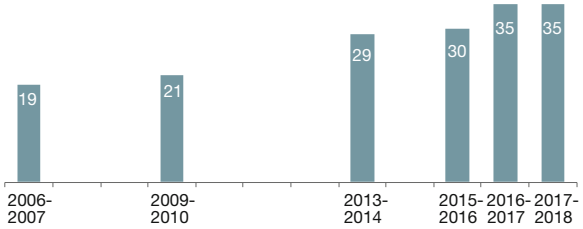
ARTIFICIAL SNOW: A STRAIN ON WATER RESOURCES

With melting glaciers and thawing permafrost, a decreased amount of natural snowfall is one of the visible consequences of climate change in mountains. Between 1880 and 2012, average temperatures in the Alps increased by more than 2°C, while snow stocks have declined in all high mountain ranges (according to Météo-France, the spring snow stock has fallen by 20kg/m² per decade on average). The decreased snowpack at the Col de Porte pass in the Chartreuse massif (according to Météo-France, -39cm average snow depth during winter between the 1960-1990 and 1990-2017 periods) is also indicative of such changes in medium-altitude mountain ranges.

Faced with increasingly common snowless winters, mountain resorts have had to adapt in order to maintain tourist activity: historically, the first and primary method has been the use of snow guns, which consume both water and energy resources.

Figure 4: changes in the artificial snow coverage of ski areas

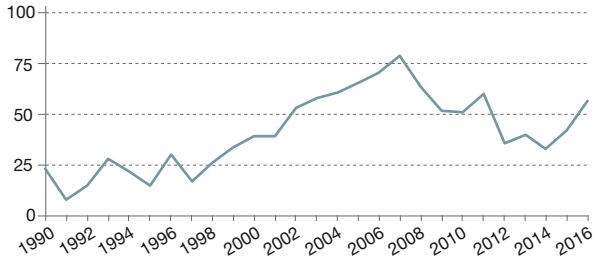
As a percentage of slope surfaces equipped with a snowmaking system



Source: *Domaines skiables de France*

The use of artificial snow appeared in France in the mid-1970s. In 1979-1980, France had 10 resorts capable of producing artificial snow, and 19 snow-covered hectares (*source: Odit France*). In a few decades, these numbers have changed considerably. Over the last ten years, the coverage of ski areas has increased by 16 percentage points, from 19% to 35% (*figure 4*), i.e. almost 9,000 hectares with the potential to be covered with artificial snow during the winter tourist season, depending on weather conditions. These numbers remain lower than those of other European ski areas: 48% in Switzerland, 60% in Austria, 70% in Italy. Initially installed at the bottom of resorts, snow guns are now found at increasingly high altitudes as a result of climate change.

Figure 5: changes in artificial snow investments made by ski areas in France.
In € millions, excl. tax



Source: *Montagne Leaders, investments survey. Processing: SDES*

Currently, artificial snow is the second largest investment for ski areas, ranking after ski lifts (14% and 58% of investments made for the 2010-2015 period respectively). From the mid-1990s up to 2007, as with all investments made by ski areas, they only continued to increase (*figure 5*).

They dropped at the beginning of the 2010s, but began rising again from 2015. In 2016, almost €57 million were invested in artificial snow. However, the size of these investments differs strongly from one resort and from one moutain range to another. Over a third of these investments are concentrated in seven ski areas (Le Grand Bornand, Praz de Lys-Sommand, Le Grand Massif, Courchevel, Chamrousse, Gréolières, and Puy-Saint-Vincent), and more than 90% of the total amount is invested in ski resorts in the Alps.

DIRECT PUMPING, DRINKING WATER, AND RESERVOIRS USED TO SUPPLY SNOW GUNS

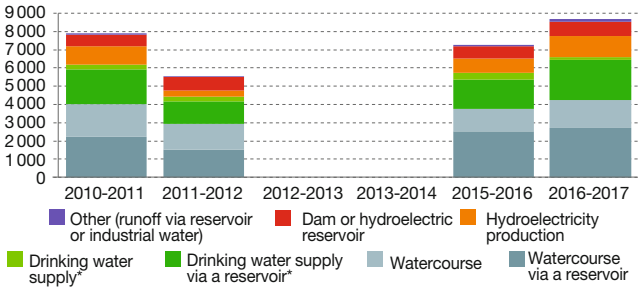
The use of snow guns has an impact on available water resources. 1m³ of water is required to create 2m³ of artificial snow (*source: Observatoire de la Savoie*). Water withdrawals to supply snow guns come from three primary sources: direct pumping of surface or subterranean water stocks, withdrawals from the drinking water supply, and pumping water from reservoirs. The latter can also be supplied by direct withdrawal from drinking water supplies.

The absence of shared data on the number of snow guns, their annual water consumption, and their supply methods makes it difficult to analyse local water withdrawals related to the use of snow guns. In total, *Domaines Skiables de France* estimates that withdrawn volumes equal around 25 million m³ (approximately twice the volume withdrawn in 2015 for irrigation in all mountain municipalities that house resorts), with variations between seasons depending on the climate. Locally, the *Savoie artificial snow observatory* provides a detailed estimate of volumes and uses for the area (*see box below*).

Highlighting: water withdrawals for the production of artificial snow in Savoie

In Savoie, the volumes of water withdrawal for the production of artificial snow vary significantly from one year to another depending on the climate and the amount of natural snowfall (*figure 6*). These withdrawals are primarily used to supply snow guns in the Tarentaise Valley and in Maurienne, where the majority of the department's very large ski areas are located (respectively, 67% and 27% of the withdrawals in Savoie intended for the production of artificial snow last season).

Figure 6: changes in water withdrawals for the production of artificial snow in Savoie based on the water's origin
In thousands of m³



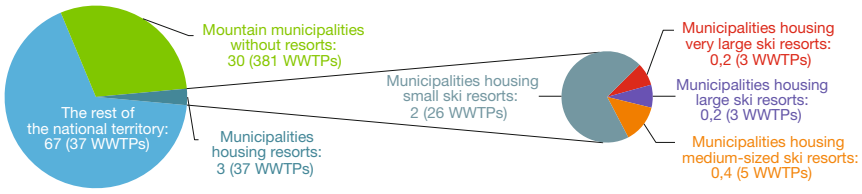
*Note: no data for the 2012-2013 and 2013-2014 seasons; * including overflow.*
Source: *Observatoire de l'eau et de la neige de culture en Savoie/Savoie water and artificial snow observatory Processing: SDES*

For the 2016-2017 season, reservoirs were the primary source for water withdrawals (65%). Nearly a third of this reservoir water is sourced from watercourses, and over a quarter from drinking water supplies. One third of the water volume is primarily pumped directly from watercourses (18%) or comes from hydroelectricity production (13%). This distribution has been stable overall since 2010, but with gradual changes in withdrawal methods from watercourses: a decrease in direct pumping (-5 percentage points between the 2010-2011 and 2016-2017 seasons), and a slight increase in withdrawals from high altitude reservoirs (+3 percentage points).

Tourism and altitude: complex wastewater management

In mountainous regions, the climate and topography can make the implementation of wastewater treatment complex (low effluent temperatures, harsh climate, topography, challenges inherent to preserving the natural landscape, etc.). The altitude, alongside climatic hazards, also causes access difficulties.
In municipalities housing ski resorts, these difficulties in sanitation are added to those experienced by small tourist areas, or areas that are sparsely populated throughout the year. Sanitation systems must take into account variations in pollution load caused by seasonal population peaks in order to be able to ensure high quality wastewater treatment. As for municipal sanitation, a treatment plant that is inadequately sized for the volume of water requiring treatment may lead to non-compliance with waste standards and pollution of the natural environment.
In 2016 in France, over a third of wastewater treatment plants (WWTP) that are non-compliant in terms of facilities, of any size, were located in mountain municipalities (*figure 7*). This represents 418 WWTPs. Of these, 37 were located in municipalities housing, primarily small, ski resorts. "Non-compliant facilities" means that the resorts in question have treatment facilities that cannot adequately manage the incoming pollution load in accordance with requirements set by the European Directive of 21st May 1991 concerning urban wastewater treatment.

Figure 7: Non-compliant WWTPs in 2016 according to the type of municipality they are located in
In % of WWTPs



Note: the municipalities taken into account are those in which the WWTP is located.
***Sources:** BDRU; CGET; STRMTG, Cairn; Ministry of Sport, RES. Processing: SDES*

For resorts, 11% of WWTPs in municipalities housing resorts have non-compliant facilities, compared to 8% for WWTPs located in mountain areas, and 6% on a national scale. The majority of non-compliant WWTPs found in municipalities housing ski resorts are located in the Alps (51%), followed by the Pyrenees (19%).

METHODOLOGY

Statistical processing cross-referencing a multitude of data sources (STRMTG, RES, ©OpenStreetMap, BD Topo®, etc.) was performed in order to define the ski resorts and the municipalities housing ski resorts. These were sorted by size and according to the power of their ski lifts. This indicator measures skiers' ability to reach higher altitudes thanks to equipment. A working paper details the methodology employed.

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FIND OUT MORE

- *Environmental atlas of ski resorts and municipalities housing resorts (in preparation)*, CGDD/SDES, *Datalab*.
- *Geolocation of ski resorts and identification of municipalities housing resorts, methodological guide (in preparation)*, SDES, *Working paper*.
- *Observatoire national sur les effets du réchauffement climatique*/National Observatory on the Effects of Global Warming
www.ecologique-solidaire.gouv.fr/impacts-du-changement-climatique-montagne-et-glaciers
- *Observatoire neige de culture en Savoie*/Savoie artificial snow observatory
www.observatoire.savoie.equipement-agriculture.gouv.fr/Atlas/4-hydro.htm
- Information portal for communal sanitation
http://assainissement.developpement-durable.gouv.fr

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