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Alpine Ski Resorts in the Pyrenees: Tourist Areas Approaching the Tipping Point

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Introduction

The call for tourism transition [\[1\]](#) began several years ago, particularly in mountain and coastal tourism resorts, which are more exposed to natural risks and hazards and where 85% of the carbon footprint is induced by the transport of people and the energy consumption of buildings (57% and 27% of greenhouse gas emissions, ADEME, 2014) [\[2\]](#). Tourist resorts and tourist areas have been at the crossroads for over a decade already; the factors that structure their change are today well defined around questions of protection of natural environments, putting an end to the artificialisation of natural soils by urban spread, control of land, coordination of the scales of management of these areas, change in tourism practices. The ecological approach confronts these questions and brings new constraints to bear on them. The forms taken by tourism growth are henceforward subjected to environmental changes, and the aptitude of the areas involved to take these into account in their projects reveals considerable resistance to change (Sorbé, 2010, Bonnemains, 2015, Clarimont, 2015, Fablet, 2015, Spandre & al., 2018, Vlès, 2012, 2014, 2017, 2019).

For very strong productivist pressures remain among managers, whose short-term concern is the operating accounts of equipment and activities sometimes marked by chronic deficits. Such a context makes tourist areas even more vulnerable to changes in mobility and energy. The leisure production system is further disrupted by the new behaviour appearing in the clientèle, who want to stay in an environment that is more aesthetic and more respectful of societies and of nature, by the strong emergence of local tourism that now involves the space of daily life, of experiential tourism (looking for sensations, emotion, participation) and of a tourism that seeks to be seen as more “responsible” (ecotourism, educational tourism, “slow” tourism”, etc.). Visitors’ perceptions have changed considerably in the last few years and priority is clearly given to the protection of nature in tourism development projects (Vlès, 2017b). The diversity and the disparate, even independent nature of these factors of change in relation to each other create complex systems made up of numerous entities whose interactions produce an overall behaviour of the “ski and mountaineering resorts” system that cannot easily be explained solely by the individual characteristics of each of these factors. The interactions are temporal, but also multiscale; that is, they operate on the resort system on different levels, with knock-on effects and feedback mechanisms, evolutive cascade phenomena and unpredictable bifurcations that make foresight and planning difficult.

Nevertheless, all these dynamics have to be analysed, understood and evaluated with the usual methods that we still employ today, and are essentially based on principles of causality and linearity. What are the emerging phenomena that enter into the modelling of the complex system that is a ski resort, and what could be the results of simulation? Description and understanding of the mechanisms that profoundly transform productive factors are much more than a tool for foreseeing or predicting the “ski resort” system; they enable us to identify the essential dynamics at work.

In this chapter, we firstly review the disruptions that affect the Fordist heritage^[3] of mountain and coastal tourist areas, the main resistance to efforts to control residential and tourism growth, the major issues of reconversion or of economic and ecological development of tourist resorts. We then model the trajectories of the tourist areas by taking into account, in the long term, the new constraints, risk management and the strong impact of climate change.

1. Ecological transformations of the coastlines and mountains

The ecological issue marks our present and could do so increasingly in the future. Because of it, all tourism projects are subject to an increasing multitude of injunctions: energy transition, clean mobility, protection of biodiversity. Anticipation of the future has served as a basis for the intense production of new laws in recent years (UTN^[4], NOTRe^[5], PCET^[6], ALUR^[7], LEMA^[8]...). It is beginning to be reflected in all the territorial planning documents to which tourist areas are subjected (PLUI^[9], PDU^[10], ScoT^[11], SRADDET^[12]...). But following the injunction made to local tourism authorities to produce plans and schemes on various scales, there has been an accumulation of planning documents that is not a guarantee of efficacy. The first approaches to the relationship between climate and winter sports resorts or the receding coastline followed the winters of the late 1980s and the great storms of the early 2000s. The reports of the intergovernmental panel on climate change (IPCC, 2014) and of environmental scientists (Kœnig, Abegg, 1997) predict an upward retreat of viable snow cover and a decreased thickness of the snow layer. Gradually, for tourism, the risks related to climate change affect the conditions of the summer offer (towns and inland areas become less attractive than the mountains and the coast), the water resources needed to meet demand in all seasons (Paccard, 2010, OECD, 2011), the tourist attractiveness of the mountains in winter because of lack of snow (Sorbé, 2010, Bonnemains, 2015), the loss of biodiversity and change in the landscape (Hatt *et al.*, 2018), the resurgence of natural risks (fires, floods, storms...) for the safety of inhabitants and visitors (Ceron, Dubois, 2005, Bouisset, Degrémont, 2014).

The mountain economy will have to renew itself to face the +3 °C increase expected before the end of the century

All studies now reach the conclusion that environmental and energy conditions put tourist areas and resorts in a highly vulnerable position. Regarding climate change, trends over the last 30 years show that warming is a reality and that accumulated falls of fresh snow, from the foot of the resort to halfway up the ski area, are decreasing (because of their very high altitude at over 2000 m, only about ten French ski resorts – out of 300 – would not be affected by the phenomenon^[13]). The clear trend to warming in the 21st century is seen in all scenarios and all models used in 2018 for meteorological research. Total rainfall will be affected by very high interannual variability, particularly in the scenario of the highest rise in greenhouse gas emission (Piazza-Morel *et al.*, 2018, Le Treut *et al.*, 2018). Consequently, the tourism

offseason will become longer and the winter season will become shorter. The resorts will become less attractive to tourists in winter, conflicts will arise over the use of smaller and smaller snow-covered areas, the clientèle, who will no longer necessarily find snow at the time when they have booked their stay, will be dissatisfied, the economy of ski resorts will be weakened.

In this context, recourse to artificial snow is proposed to make tourist resorts less vulnerable at the most strategic periods. Set up 20 years ago, initially to prepare the slopes to receive natural snow and then to complete it, the production of artificial snow has become a palliative measure to climate change. It is a provisional, short-term adaptation: the prospective works of Sorbé, Bonnemains, or Fablet have proved from 2010 onward that these adaptive measures are a frightening headlong rush forward. They do nothing to halt the ineluctable end of snow cover at a medium altitude (up to 2200 m). The studies and research carried out by Météo France show that the phenomenon will also affect artificial snow below 2200 m, or 80% of ski resorts in France. Even with the scenario of a 2° temperature increase (which will be exceeded, as today the Alps have already reached +1.9 °C)[\[14\]](#), due to the reduction of the window of cold periods that allow the production of artificial snow the resorts of the French mountain ranges will soon descend below the threshold of profitability (Scott *et al.*, 2003). This phenomenon already affects all mountain ranges: at 1800 m, the Pyrénées Orientales have seen the average depth of natural snow decrease from 39 cm in 1960 to 20 cm in 2010. In 2030, the average temperature increase will be 1.1 to 2.1°C and in 2080, 2 to 4°C. The -2°C isotherm is already above 2000 m. In 2030, this line will lie between 2000 and 2500 m. Everywhere, more recently in the Caucasus (since 2015) as well as in the Far East (Winter Olympics of 2022), European companies in this sector have invested in hundreds of small resorts that hardly lie higher than 2000 m, and here artificial snow reigns over an energy-consuming system which is not a model of ecological virtue.

Equipment for artificial snow consumes on average 4000 m³/day of water per hectare, or the annual consumption of a city of more than 200,000 inhabitants. It requires considerable energy consumption of about 25,000 kWh annually per hectare of ski slope, at a cost of 16 million euros/year for the whole of the French ski area. In other words, the electricity consumption needed to produce artificial snow in France is equivalent to that of 50,000 homes, or a city of 110,000 inhabitants. This equipment also produces noise pollution (60 to 100 db for a snow cannon) and landscape pollution (rows of snow cannon along the slopes, hillside catchment reservoirs – more than 1000 in France – that locally change the soil conditions of the catchment areas (Paccard, 2010), over and above the impact of laying underground networks, upkeep of the slopes and the creation of high-altitude lakes. These energy costs will increase considerably in the coming decade, making alpine skiing a very expensive product, reserved for an affluent clientèle. The democratisation of winter sports will have lasted only half a century: without new resources, resorts, some of which are already moribund, will be unable either to balance their operating accounts or to reimburse their debts, which are already considerable (Cour des comptes, 2015). All research thus concludes that the number of viable resorts will drastically decrease (OCDE, 2007, Spandre & al., 2018).

On the ground, providers and stakeholders take climate change issues into account to justify demands for permits for artificial snow equipment, but not to imagine a way out of “100% ski” (Bonnemains, 2015). In fact the question of tourism transition cannot adequately be managed

on the scale of the resort or of the ski area, as gradual specialisation of the resorts leads to that of the valleys, around a fragile single activity centred on snow. Their excessive specialisation makes them more dependent on climate uncertainties, and the resulting artificialisation of the soil is detrimental to the maintenance of biodiversity.

Until recently, regional strategic policy on winter sports took little account of this headlong flight forward (Fablet, 2015)[\[15\]](#). In documents on territorial planning (territorial coherence schemes (ScoT), Plan for the mountains in the Alps or Occitania, etc.), instead of dealing with the whole as an interconnected system, issues have been dealt with by separate themes (ski resorts/forest/mixed farming, etc.) and this has produced a veil of ignorance, in the sense understood by Rawls (1971). As yet, few providers and stakeholders imagine, for ski resorts and coastal resorts, a model of development different from that of the Taylorist-Fordist-Keynesian-Corbusian period[\[16\]](#). Innovation seems to be a difficult change of direction. At best, it goes no further than marginal actions of “diversification”, “four-season tourism”, of enlarging scales and redeploying activities into the hinterland, all of which remain only homeopathic measures. Although the territorial coherence schemes (ScoT) promote “soft transition”, “reorganisation of ski areas”, a “collective project for mountain resorts”, “optimisation of ski lifts”, actions and plans still limit public intervention to “ensuring snow on the slopes”. In reality, alternative solutions are little sought for and little wanted. Programmes for the future (new ecotourism activities, infrastructures for soft mobility, positive-energy rental accommodation constructed with biomaterials) receive financial commitments that are largely inadequate to produce credible change in terms of activity and jobs (François, 2007, Hatt, 2011, Vlès, 2012, Achin, 2015).

This blind self-deception is accompanied by systematic recourse to leisure accommodation to “produce development”. It takes two main forms: frenetic pursuit (though in vain for the last decade in economically fragile sites) of building permits for new accommodation in response to the problem of resort profitability, and investment in more and more facilities to adapt the sites to tourist demand and increase their attractiveness.

In the Tarentaise valley, Fablet has very clearly demonstrated the mechanisms at work in property growth in the resorts, quantified the change in their development sites, and described regulation of tourism urbanisation by the public authorities. Briefly, it depends on the “power momentum” of the ski lifts[\[17\]](#). In order to recoup the enormous cost of constructing and operating a mountain ski lift, or major amenities on the coast (marina, casino, etc.), the regions must be able to extract a margin from an operating account surplus, and so keep the amenities running at maximum capacity and maximise the number of paid admissions. In order to do so, stays must be booked and clientèles must be retained, they must stay and come back. New building to meet demand generally takes place on the periphery of the built-up nuclei. Measurement of the urban footprint, a term used in urbanism to evaluate the land consumption of urbanisation, showed that in Haute-Savoie ski resorts today account for 50% of urbanised surfaces, and artificialisation of land in the lower reaches of the valley is characterised by considerable spread. Recourse to new building pushes accommodation with older standards of comfort out of the rental market. This process of renewal by extension rather than by renovation of the older centre of the village or resort leads to a headlong rush onward in real estate, a “spiral system” (Marcelpoil, 2008). The underused properties are more difficult to rent out, the resorts rapidly become unsuited to

their purpose and enter into a rationale of “exhaustion of the accommodation supply”, the tourist wasteland gains ground (Vlès, Bouneau, 2016).

Declining systemic spirals

Transformation of these living spaces under residential pressure from outside again puts into question the urban or local (village) hierarchies and their relationships with traditional activities (notably mixed farming), in the same way as it transforms the relationship of the visitor to discovery and to travel (Bourdeau, 2007, Berthelot, 2012). Another declining spiral appears: abandonment of farming and pastoral activities that leads to loss of character and closure of the landscape, and decreases its attractiveness. Conversely, “diversification of activities” implies a wide range of varied elements, open landscapes, highly complementary activities, a preserved cultural, agricultural and pastoral heritage, creative wayfaring that allows a glimpse of a space that is wider, diffuse, living and less enclosed. Artificialisation of land by continuing urbanisation and specialisation of the economy in the production of artificial snow, because they absorb all the funding, do not help in transition.

Resorts are very highly dependent on the “initial conditions” that determined their economic and social equilibrium when they were built from the 1960s to the 1980s (energy, land and property, and cheap mobility). Climate change, which transforms the system through the abandon of fossil energy, is a highly disruptive external element for this now obsolete system of production. The decrease in the number of ski resorts over the last 20 years bears witness, in Europe as in France, to the first disruptions encountered (Figure 1).

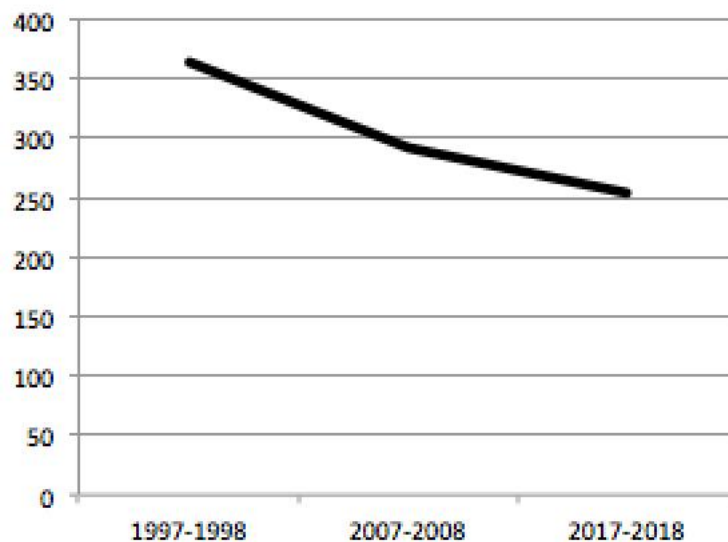


Figure 1. Decrease in the number of ski centres and ski areas in France

(sources: Observatoire national du Tourisme, 1997 and 2007, Domaines skiabiles de France, 2017)

The erosion of operating margins related to losses of activity, the difficulty the resorts experience in reimbursing the debt encourage the financial regulatory authorities to abandon activities in order to protect the balance of the public accounts (Cour des comptes, 2015). This contributes to a decrease in the number of ski resorts of nearly 30% in 20 years. This

phenomenon will become more marked, as more than two-thirds of the 666 ski and mountaineering resorts of the European alpine region will no longer be profitable with a temperature increase predicted to be in the upper range of COP21, and which we know will doubtless be reached in mountain areas (OCDE, 2007, OECD, 2011).

The tourist coast struggles to face the risks

Other questions related to climate change arise on the coasts, questions which underline the need for transition. Recent research has examined the issues at stake in reconciling tourism development and the protection of sensitive areas in seven French coastal areas [\[18\]](#). Questions of habitat and accommodation, mobility and accessibility, environmental and heritage values are urgently posed. Everywhere, the coasts are marked by the influx on a massive scale of new occupants and of activities related to sun worship. The direct consequence is that the proportion of artificialised coastline has increased from 39% in 1960 to 61% in the 1990s, and from 2000 to 2006 the progression of artificialisation has been 2.7 times greater in coastal communities than in the rest of the territory (MEDDE, 2012) in spite of protective legislation (Calderaro, 2010, Tafani, 2010).

Today, all these coastal areas are subjected to three major risks: erosion of the coastline, flooding, and submersion by the sea. In France, the winter storms of 2014 drew attention to the sudden and spectacular changes in the features that are the foundation of the coast's attractiveness [\[19\]](#). The rest of the world is not spared catastrophes with dramatic consequences (Hurricane Katrina in New Orleans, Irma in the island of Saint Martin, etc.).

Such tourist areas are henceforward clearly subjected to strong planning injunctions: to reconcile the conservation of sensitive natural areas with development of their attractiveness (DGUIHC, 2006, CETE Méditerranée, 2007) in a context where natural hazards and foreseeable evolution related to climate change are taken into account. These devastating phenomena affect areas that are increasingly densely urbanised [\[20\]](#), and have led public-sector actors to set up protective and risk management measures. The quest for "controlled compactness" with a positive energy balance is structured around development and protection. These "adaptive" policies lead to forms of local resilience that do not yet reflect a total change of model (which scientific researchers in ecological transition call the "tipping point") but which bear witness to the beginning of an adaptive curve of the existing model. This is particularly visible in the coastal territorial coherence schemes (ScoT) and local intercommunal urbanism plans (PLUI) of the Côte d'Argent and the Côte d'Azur. Here, as in mountain areas, requests for building permits do not as yet make choices that are truly new. A number of considerations incite communities to protect their natural heritage, but not yet to make a radical change of model. The strategic tools for energy management and control of greenhouse gases and protection of biodiversity still have the status of recommendations, but are the poor relations when it comes to controlling the effects of tourism on a local level.

Quality and ecocitizenship at the heart of the tourism demand

Although the spirit of the offer changes little in the resorts, that of visitors' demand is on the other hand very different from that which was prevalent even twenty years ago. Tourists – who often consider themselves as "users" – and citizens demand a new place in decision-making (Vlès, 2017) ; little by little, resorts and places of stay are managed on a shared basis,

as one manages a “common territorial asset”. For the majority of visitors, these places belong henceforward to the common heritage of the nation, and they want them to be protected rather than exploited. New practices are developing, borne by increasing concerns that are environmental as much as social. In the relationship of these practices with space and with otherness (the encounter with the other, but also with the here and the elsewhere), in the relationship between leisure and the work environment, in the way daily life and technological progress is perceived, the tourist transition is accompanied by reshaping of the landmarks of inhabitants, users, and visitors. Although they are still in the minority, significant practices are developing and introducing new codes in protected natural spaces and adjacent areas (Bourdeau, 2007). The visitor’s conception of the resort in its relationships with nature has changed: it is nature that is seen as carrying positive ideas (beauty, durability, heritage) and no longer the design and layout of the resort itself, as used to be the case. Today, urbanisation is really considered as consuming space and public investment.

2. Chaotic tourist trajectories

All these points clearly show that tourism is still an uncontrolled phenomenon. Until now, there has been much concern about the economic and social implications of tourism; nature was taken into consideration only in its relationship to an environment that was “useful” to man and to development seen as consumption, essentially constructed around a standardised and rather conventional culture, in a relationship where the ecosystem only existed to be exploited. Nature was considered only for the purposes of marketing or even greenwashing of resorts and tourist areas.

The direct consequences of climate change imply a more profound change in the relationship with nature in the world of tourism. The idea of transition takes its strength from this context of tensions and crises which is that of contemporary societies: climate crisis, energy crisis, economic crisis – known by the Anglo-Saxons as the “triple crunch” – against a background of cultural change and increasing awareness that we are in a post-growth period (Gordon, 2016). This new conception calls into question the capacity of humanity to invent a model other than that of tourism based on growth marketing. The first impacts of this representation by the clientèles are henceforward very present in the resorts (Vlès, 2017b).

A generalised dynamic of adaptation

In spite of their apparent immutability, tourist resorts are perpetually changing. The effects of technical progress, changes in consumer habits or leisure practices constantly affect them. Subjected to these changes, the enterprises by which they live ceaselessly die and are born. In spite of this intense internal activity, the dynamic balance of tourist territories does not generally vary suddenly, but rather over a prolonged period, as has clearly been shown by historians studying the long term (Hagimont, 2017). However, in this incessant, self-perpetuating cycle where one operator replaces another and one client succeeds another, a disruption from outside, sudden or gradual, climate change or human action, upsets the dynamic balance and stability of tourist areas. Their life curve obeys processes of construction, destruction or replacement that appear less as cycles (Butler, 1980) than as successive adaptations (in the ecosystemic sense of the term, Ramade, 2009). Some of these successions of providers, stakeholders and tourism activities are autogenic and arise from internal processes of adaptation to a production system disrupted by natural, political, economic and

social factors that are peculiar to the sites: for example, the closure and then the reopening of the resort of Artouste (Pyrénées-Atlantiques), the transformation of Mas de la Barque (Lozère), the evolution of Sotchi (Caucasus) were due to internal decisions that were political in nature.

But the changes are also due to allogeneic successions that result from the influence of disruptive factors originating outside the tourist area, the majority of which arise from climate and energy transition [21]. In certain cases, these successive tourism specialisations are regressive in nature, the number of activities, operators and clients decreases, and profitability is lost. At this transitional moment, their life is at the edge of the precipice, at a tipping point, a moment that oscillates between catastrophe (in the sense of the theory of catastrophes, Thom, 1972) and a radical transformation of public investments and individual practices [22].

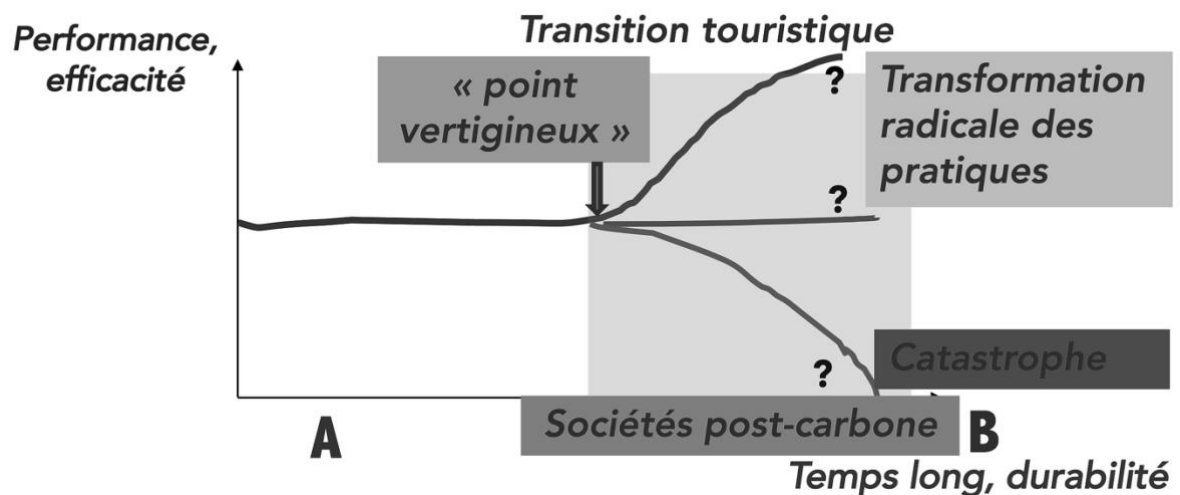


Figure 2. The edge of the precipice, or “tipping point” in the life curve of coastal or mountain tourist resorts — © VLès

The realisation that the the edge of the precipice, or “tipping point” is near for these tourist areas in the decade 2020-2030 can be clearly read in the documents relating to their territorial planification or urbanism. These envisage, in their desirable prospective scenarios, that vulnerabilities and natural risks should be examined before any urban extension or tourist development. Anticipating the wished-for future, tourism transition reveals the mobilisations of a civil society that sees the problems of a given place in terms of the tourist model that gave it birth. It responds by quite different adaptive strategies, either by adopting mechanisms of resilience (such as the acquisition of equipment for producing artificial snow or for rock fill on the coasts, which yield only short-term results in the majority of cases), or by modifying the structure and composition of the products throughout the successional process, characterised by the appearance of new providers offering ecotourism products or products that are sustainable in terms of mobility and energy, or by restricting themselves to a well-heeled clientèle who have the means to enjoy products that have become costly and therefore rare (high altitude resorts). Resorts evolve as a result of the sum of individual adaptations of the providers and the stakeholders involved, assisted in this by regulatory requirements that help

them make their decision. Successive changes appear to prioritise quality over quantity (Hatt *et al.*, 2018). The regulatory measures show that tourist areas are now entering into a phase of their territorial management where everything may be jeopardised. They call into question the relevance of the old model.

Towards a radical change in tourism development

This transformation reveals a change in the relationship between nature, culture and society in our contemporary society. Turbulence affects entire sectors of coastal and mountain productive tourist areas and forces them to adapt in ways they had not foreseen. The tensions that have appeared in recent years (Vlès, Bouneau, 2016) have revealed a questioning of the traditional process of tourism development: it is no longer a matter of adapting the initial model, but rather of envisioning a make-over according to a radical change of plan. The old idea that tourist development was entirely determined by a tourism “base” (scientists speak of tourism “potential”, “resources”, “capital”) seems in fact to be giving place to the idea of “differentiation”, of “territorial scenes” that are contrasted according to the resorts. The “sensitive values of the territory” (perceptions and representations that inhabitants and visitors have of it) also appear to be factors that accompany this transition (Clarimont, 2015, Vlès, 2018). The snow front or the beach front is the place where everyone meets, the place where one loses one’s way, hires a pair of skis, strolls, has a drink and meets up with others.

Renewal of their relationship with nature henceforward weighs heavily on visitors’ values, with sometimes a complete reversal of the professionals’ vision of the tourist’s relationship with the world (Hatt, 2011). This spatial component, the fight against the impermeabilisation of the soil, the reconquest of mineralised spaces, the reintroduction of nature in the tourist public spaces in the resort, the renovation of refuges in the mountains or of accommodation on the coast, control of land and property in the long term with building up of reserves, reconciliation of the preservation of green and blue corridors with the practice of sports and activities in the great outdoors, an end to urban spread on the coast and in the mountains, remodelling of ski runs and creation of hillside catchment reservoirs, the creation of pedestrian areas and the systematic availability of electric vehicles for hire, all appear as so many factors that condition the future of tourist places. If these changes are not anticipated, tourist areas will enter a turbulent phase of their life and their dynamic system.

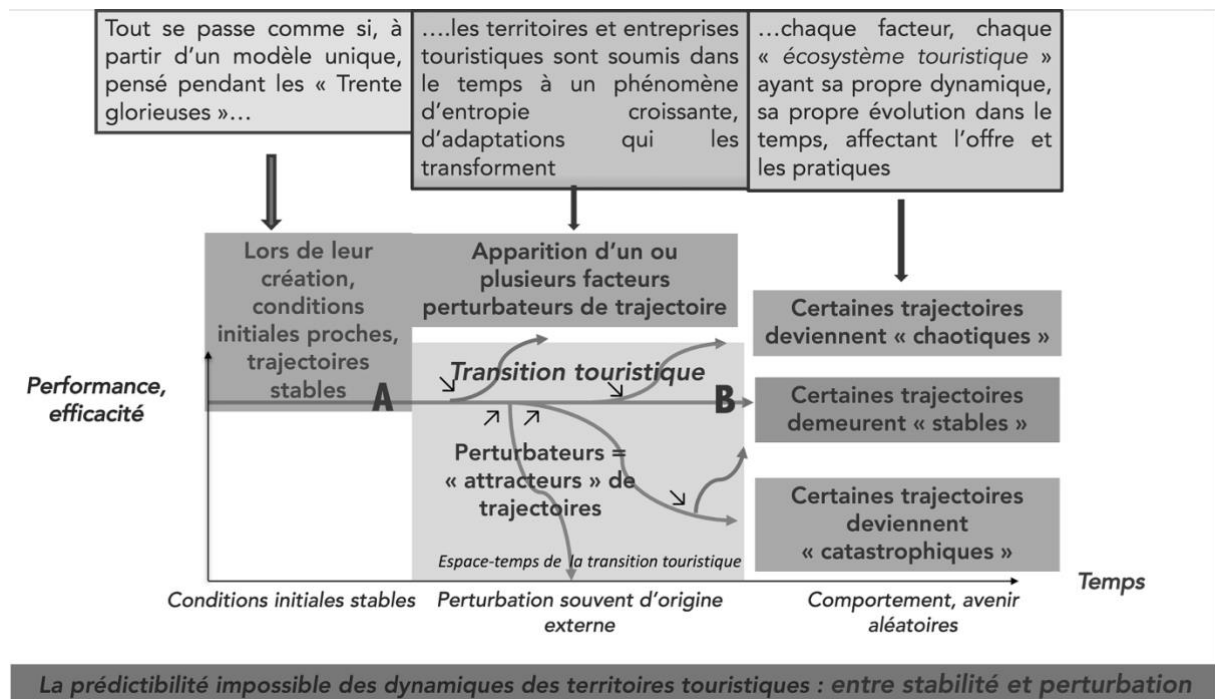


Figure 3. Evolution of tourist resorts and areas according to their adaptive strategies — © Vlès

Already, this chaotic phase is appearing in the most fragile places, amplified by the emergence of natural risks as economic factors of destabilisation. On all sides, initial trajectories can be seen to bifurcate, revealing the weight of the chronic operating deficits of equipment and activities that were designed in past decades. By focussing financial efforts on the necessary cyclical recovery, they prevent strategic investment to prepare the future. Emergency decisions may need to be taken even more rapidly. Certain trajectories will remain stable (the high altitude resorts of Savoie or Haute-Savoie, the historic seaside resorts which have a considerable reputation and which have known how to anticipate), other trajectories will be disrupted (medium-altitude resorts, seaside resorts at high risk of erosion and submersion), and yet others will be very disrupted (30% of alpine ski areas have closed during the last 20 years, and the sites have gradually disappeared). While, for the moment, we see no marked renewal of local production systems, in order to survive the resorts will change their development model. If they do not, the majority will be laid up [23].

Conclusion

Because the interconnexions between the factors of production are complex, unpredictability is still the major characteristic of the changes taking place. They are difficult to foresee, making it difficult to plan ahead. Civil society needs to undertake anticipatory initiatives to stabilise the tourist system and also needs to propose alternative solutions well in advance. In order to adopt a stable strategy, we need to come out of our state of denial and integrate ecological transition as a structuring factor and no longer as a marginal one. Tourist sites can optimise the land that is already urbanised so that development is economic on space and the need for

new constructions is limited through rehabilitation of building stock and policies of renewal, by developing more compact urban forms that take up limited space (small apartment buildings, intermediary housing, houses grouped around a central garden space), integrating the area in a principle of circular economy for a model that makes less demand on carbon, energy and natural resources. Anticipating, no longer acting only in an emergency, looking further ahead than immediate adjustments limited to a particular sector, all these can help to make regulation more stable, more foreseeable and more easily accepted by society.

Extremely demanding of capital, the mutation of modes of production and consumption of leisure redirects investment towards a green model. Through a pricing policy it decreases use of all production factors that involve carbon, starting with the forms of mobility that are available to visitors. If we are to succeed in bringing tourism out of the economy of predation, planned obsolescence, speed, factors that lead to depletion, then behaviour transformation should be accompanied by training, by information, by increasing awareness, and by actions involving providers and stakeholders, visitors and inhabitants. Tourist areas that are under threat and do not take this path run the risk of early maturity, of a short life.

The ski and mountaineering resort, which is today at the crossroads between two complex systems (the city and the climate), combines all the external constraints of natural and man-made origin whose chaotic behaviour limits the foreseeability of change, the trajectories and, above all, the predictability. Reducing their vulnerability to risks through interdisciplinary research – in social and human sciences in particular – by testing prospective scenarios is perhaps an effective way to help them to prepare themselves for what looks like being a radical transformation of their future.

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NOTES

[1] The concept of tourism transition may be understood as the slow transformation of the social sphere of worldwide production and consumption of tourism under the impact of measures taken to ensure energy transition, clean mobility, and the protection of biodiversity.

[2] Tourism is one of the sectors of the economy that is the most sensitive to climatic effects. The World Tourism Organization, the United Nations Programme for the Environment and Oxford University published in 2008 an ongoing scenario that predicts an increase of 154% in energy consumption, 131% in greenhouse gas emissions, 152% in water consumption and 251% in solid waste by 2050 if nothing is done.

[3] Tourist resorts are the product of a “Taylorist-Fordist-Keynesian-Corbusian” period. The creation of such places is materialised, among other ways, through zoning according to function, the translation into spatial terms of the strict division of labour advocated by Ford and Taylor. Taylorism, understood as a particular organisation of the production process, attaches tourism, like industry, to a rationality that seeks to be perfect and mechanical, while being based at the same time on capitalist concentration of the factors of production. This model was reflected in a regimen of intensive accumulation encouraged by growth in the thirty-year postwar boom (Hatt, 2011).

[4] New tourist units (Unités touristiques nouvelles)

[5] Law on new territorial organisation of the Republic (Loi portant nouvelle organisation territoriale de la République)

[6] Territorial climate energy plan (Plan climat energie territorial)

[7] Law for access to housing and renovated urbanism (Accès au logement et à un urbanisme rénové)

[8] Law on water and aquatic environments (Loi sur l’eau et les milieux aquatiques)

[9] Local intercommunal urbanism plan (Plan local d’urbanisme intercommunal)

[10] Plan for urban mobility (Plan de déplacement urbain)

[11] Scheme for territorial coherence (Schéma de cohérence territoriale)

[12] Regional plan for land use, sustainable development and equality of territories (Schéma régional d’aménagement, de développement durable et d’égalité des territoires)

[13] Climate scenarios are used to feed models of impact relating to natural and managed snow cover, the risk of avalanche and winter viability. As part of the AdaMont research programme (Piazza-Morel *et al.*, 2018), the national Centre for Meteorological Research (Centre d’Etudes pour la Neige (CEN) Grenoble and Toulouse), and Irstea have analysed several dozen CMIP5/EUROCORDEX scenarios using a descending scale approach and quantile/quantile adjustment taking weather conditions into account, and based on the SAFRAN-Nivo reanalysis (1960-2010) used as a basis for hourly surface observations. This research explicitly represents the altitudinal dependence of the meteorological fields needed

to feed models of impact on conditions of climate change, while adhering to the intrinsic dynamics of climate simulations. The NIVOPYR project, financed by the Working Community of the Pyrenees, has developed our knowledge of vulnerability within the Pyrenean mountain range.

[14] The most recent climate records and COP23 have revealed how much the prospective predictions of 10 years ago have been exceeded: climate change is much more rapid than predicted (in mountain areas the +2.5° expected overall at the end of the century for the whole planet will be largely exceeded) and the ensuing deterioration of air and water currently causes 36% of deaths by lung cancer, 34% of stroke deaths and 27% of heart attack deaths (WHO, 2018). These terrible figures bear witness to the current climate problem, not only to the future problem, and they have notorious implications for the future of tourist resorts which place health at the heart of their legitimacy.

[15] This latter point is also apparent in analysis of the territorial coherence schemes (SCoT).

[16] See note 3.

[17] Conventional indicator of ski lift capacity corresponding to the product: theoretical throughput (number of skiers/hour) x height differences.

[18] The coastal areas of the lakes of the Médoc region, the Bassin d'Arcachon, the south of the Landes and the French Basque country (coast of Aquitaine) and the Catalan coast, the coast in the area of Béziers, the Bassin de Thau and the Etang de Berre have been studied in depth (Noailles, 2012, Ballester, 2016, Vlès *et al.* 2019). Another study, requested by the Ministry of Ecology in 2014, examined the way in which seven outstanding natural sites approach this question. It showed the increasing importance of immaterial factors in regulating visitor flow to these sites and the radical paradigm shift of the natural common asset as a resource that is both material and immaterial, which work together, through their recognition and promotion, to define the regulation of tourism in major sites (Vlès, 2018).

[19] Particularly the coast of Aquitaine in France where the retreat of the coastline, in certain resorts, is as much as 30 m/winter at Lacanau (territorial coherence plan (SCoT) of the Lakes of the Médoc), an area with 4000 inhabitants in the winter but 50,000 in summer; or at Soulac, Mimizan or Capbreton, where the retreat of the coastline is 20 m/winter (territorial coherence plan (SCoT) of the southern Landes area).

[20] For example the flooding in the region of Cannes on 3-4 October 2015, the events in the Hérault department in autumn 2014, or in the Var and the Vendée (storm Xynthia) in 2010.

[21] This is shown by the permanent abandonment of Val Pelouse, Ceüse, Puigmal, La Chaud, Saint Honoré, the Monts de Lachen, Ulrichen-Sennturm, Puyvalador, Heul-ri in Korea... the list grows increasingly long.

[22] The mathematical bifurcation theory (late XIXth century, Poincaré, espoused by Lorenz (1963) in his theory of chaos) models certain aspects of the evolution of dynamic systems. Notably, it establishes how a bifurcation occurs when a small change in a physical parameter produces a major change in the organisation of the system.

[\[23\]](#) In development, the terminology applied to tourist resorts is that of the shipping industry : a resort is “laid up” just as a ship is “laid up”, and the equipment is stored.