

Impacts of Climate Warming on Alpine Glacier Tourism and Adaptive Measures: A Case Study of Baishui Glacier No. 1 in Yulong Snow Mountain, Southwestern China

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ABSTRACT: Alpine glaciers usually feature with best hydrothermal condition in mountain climate, and present beautiful glacier scenery, various glacier landforms, rich biodiversity, and easier accessibility, compared with continental glaciers or ice sheets. Nevertheless, Alpine glaciers are more sensitive to climate warming, and climate warming has seriously affected Alpine glaciers and surrounding

environment. The quality and attractiveness of Alpine glaciers to tourism has been and will continue to be diminished with tourists' visitation and local economic development. At present, it has become a primary problem that Alpine glacier tourism adapts to climate warming. Based on this reason, the purpose of this article is to take Baishui (白水) Glacier No. 1 as an example to outline the possible impacts of climate warming on Alpine glacier tourism and put forward some adaptive measures and strategies aligned with climate warming. Specific measures are as follows: (1) optimize the space layout of glacier tourism area; (2) improve glacier tourism and environmental protection planning; (3) adopt multidimensional protective measures; (4) strengthen scientific research of glacier and

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environment protection; (5) develop glacier tourism products by multi-directions; (6) integrate regional tourism resources; (7) reinforce public environmental education.

KEY WORDS: Alpine glacier, global warming, Baishui Glacier No. 1, impact and adaptation.

INTRODUCTION

Glaciers, sensitive indicators of many climate and environmental changes, are important natural resource of the cryosphere and inherent component of the ecosystem and social system. They have the most beautiful and fascinating geological landscapes and extraordinary scenic and aesthetic attractions in the Alpine belt (Labhart, 2007; Meier et al., 2007; Wu and Shen, 2007; Thompson et al., 2006, 1997; Carey, 2005; Global Climate Observing System, 1995). Scientific studies on glaciers began in Switzerland and Norway in the 18th century (Zumbühl and Iken, 1981), while glacier tourism originated from literature and painting in the early 1800's, was developed in the 1900's, and prevailed in the 1980's. Today, there is extensive literature on glacier geology and geography (Vaske et al., 2000; Ormiston and Gilbert, 1998) but relatively little involving glacier tourism. What exists is limited to mountain tourism and the United Nations Educational, Scientific and Cultural Organization (UNESCO) sites. However, today's glacier tourism has been consciously developed and run all over the world as a strong industry. Alpine glaciers are located between the Arctic Circle and the Antarctic Circle. Glacier types include valley glaciers and even smaller ice caps or ice fields, which are usually located in higher mountainous regions. Alpine glacier tourism, generally belonging to mountain tourism, is the tourism activities or events that is carried out by glaciers and ancient glacier relics as main attractions in mountain areas, such as glacier sightseeing, mountaineering, skiing, hiking, trekking, flying, driving, cruising, photographing, exploring, surveying with scientific research, environmental education, etc.. Alpine glaciers provide excellent natural landscapes, various glacier landforms, moderate hydrothermal conditions, and many extend into forested valleys. In addition, Alpine glaciers have rich biodiversity and easier accessibility. Therefore, they have a priority of geographical advantages and market conditions (near tourist market) to develop glacier tourism when compared with continental glaciers or ice sheets (higher latitude, colder temperature).

Due to the economic importance of glaciers being heavily dependent on tourism (Jurt, 2007), all over the world, there are over 50 well-known tourist destinations of Alpine glaciers, among them, some have been listed by UNESCO as World Natural Heritage List because of unique spectacular glacial landforms, such as Aletsch Glacier in the Alps, Perito Moreno Glacier in Argentina, Franz Josef and Fox Glacier in New Zealand, Khumbu Glacier in Nepal, etc..

Nevertheless, the global retreat of mountain glaciers during the 20th century is striking (Berthier, 2007; Molnia, 2007; Haeberli, 2005). The average annual rate of thinning (glaciological mass balance) since 1970 for the 173 glaciers that have been measured reduced at least five times between 1970 and 2004 (Dyurgerov and Meier, 2005). Today, most Alpine glacier retreats are more obvious and serious; material loss is more intense than high-latitude and polar glaciers (Li et al., 2009, 2008; Zemp et al., 2006; Cecil et al., 2004; Kaser et al., 2004; Kaser, 2001). Climate warming is becoming an indisputable, visible, and pivotal issue affecting a wide range of environmental resources and conditions that are critical attractions for vulnerable nature-based tourism, especially, Alpine glacier tourism (Gössling and Hall, 2006; Scott, 2006a, 2003; UNWTO, 2003; Elsasser and Burki, 2002; Mayer and Avis, 1998; Simith, 1993; Perry, 1972). The changes in climate variability have led to a rapid retreat of Alpine glacier systems. Glacier tourism has been seriously affected by this retreat, since in some glaciated regions (especially in Alps, Scandinavia, western North America, Andes, Himalayas, Kilimanjaro, and New Zealand), most tourists visit glaciers for sightseeing, climbing, and hiking. The current accelerated melting and retreat of glacier tourism resources has not only led to the unprecedented decline and loss of mountain aesthetic climbing route and environment, but also caused a reduction of economic benefits in many tourist destinations with glacial features.

Although climate warming is the main reason, we should not neglect the influences of human activities

to cause glacier ablation and acceleration. Examples of this include burning fossil fuels, greenhouse gases emission, air pollution (Kuniyal, 2002), blindly mining, unreasonable activities of villagers' production, land reclamation, overdeforestation (for fuel wood), trampling plants, overgrazing, illegal hunting (for meat and medicine), leaving behind wastes (e.g., oxygen bottles, water bottles, food packaging, plastic bags, one-shot products, toxic batteries, sullage, garbage, left-over supplies and some building materials etc.). Also significant are large-scale buildings of tourist facilities in Alpine glacier areas that impact the stability of Alpine glacier ecosystem and sustainable development of glacier tourism (Owen et al., 2009; Montgomery et al., 2004). However, facing global warming, knowledge of the capacity of current climate adaptations utilized by the tourism sector to cope successfully with future climate change is currently very limited; numerous studies were concerned about mountain tourism impact on climate change, especially natural settings (Alpine meadows, forest, tree line shift, biodiversity, environment, etc.) and socio-economic changes, in which glacier tourism was infrequently involved, and mostly focused on cultural framing of glaciers, tourists' perceptions and attitudes of glaciers, the ski industry, snowmaking, potential biophysical impacts, and geological hazards in a number of nation's Alpine destinations (Nesje et al., 2008; Amelung et al., 2007; Bardsley and Edwards-Jones, 2007; Bera and Basumatary, 2006; Norgaard, 2006; Scott, 2006b; Becken, 2005; Karl et al., 2004; Gössling, 2002; O'Connor and Costa, 1993). In contrast, the adaptation and mitigation strategies of Alpine glacier tourism based on climate warming have been underresearched thus far.

Based on the above factors, the article takes the Baishui Glacier No. 1 in southwestern China as an example, reveals its retreat trend, and puts forward the corresponding adaptive measures. The Baishui Glacier No. 1 is the nearest glacier from the equator in Eurasia and is China's largest glacier travel resort. As a temperate (maritime) glacier, it is more sensitive to global climate warming. Therefore, it has the obvious representative for studying Alpine glacier tourism and global climate change. In addition, to strengthen adaptive strategy research of Alpine glacier tourism based

on climate warming, not only can it provide a theoretical basis for the sustainable development of glacier tourism, but also it has great significance for ecological environmental protection, glacier disaster prevention, harmonious development of population, resources, environment, economy, and society in Alpine areas.

STUDY AREA

Yulong Snow Mountain, with the summit at 5 596 m a.s.l. (Ren et al., 1957), at present, is the southernmost glacierized region (27°10'–27°40'N, 100°9'–100°20'E) in China (Rai, 2005). Baishui Glacier No. 1, China's typical monsoonal glacier (Shi, 2008; He et al., 2000), is the largest glacier in Yulong Snow Mountain, with an area of 1.52 km² and length of 2.7 km (Pu, 1994), wherein it concentrated almost all the essence in the world's mountain glaciers in the mid and low latitudes, known as a "natural glacier museum" (Li, 1999; Zheng et al., 1999). Yulong Snow Mountain tourism is suitable all year round. Because of the beautiful landscape of the Baishui Glacier No. 1 and its subtropical snow mountain spectacles (e.g., high mountain, deep valley, meadow, shrubs, forest, and glacier), it is opened up as a glacier park in 1997. In 2009, Baishui Glacier No. 1 and surrounding areas were classified as National Glacier Geological Park (NGGP) by the Ministry of Land and Resources. Baishui Glacier No. 1, located 25 km north of Lijiang Old Town (World Culture Heritage), which is less than 200 km from Three Parallel River Area (World Nature Heritage), has a natural location advantage and stronger accessibility (Fig. 1).

NGGP has a 2.9-km mountain cableway leading. This allows the convenient traffic conditions and perfect service facilities to make it easy for tourists to enjoy and experience close-up the scenery of Yulong Snow Mountain and Baishui Glacier No. 1 without disturbing the fragile ecological environment. According to the survey, a travel motivation of 80% of Yulong Snow Mountain tourists is to enjoy and see the Baishui Glacier No. 1. Since 1996, Baishui Glacier No. 1 has gradually developed into the largest glacier resort for visitors in China and has promoted the regional economic and social fast development in an all-round way in the glacier area. The number of

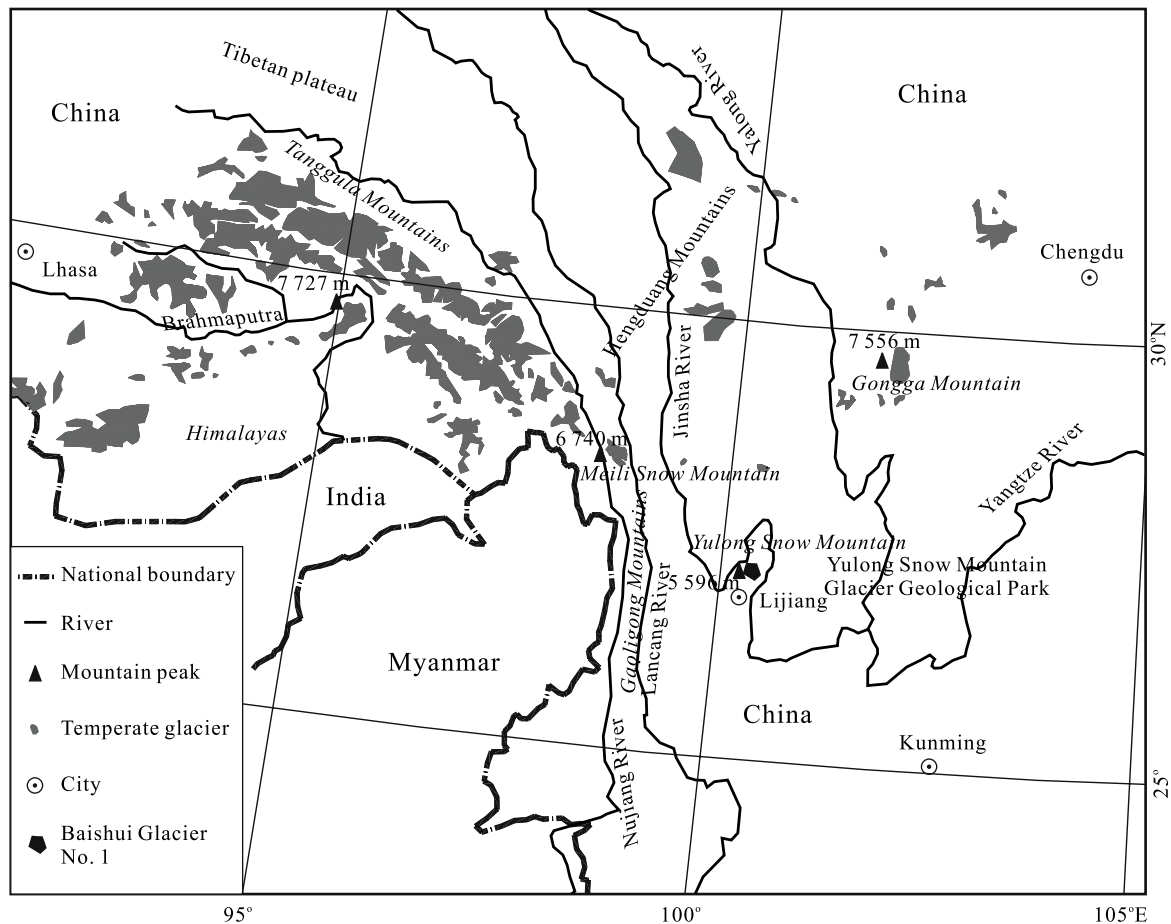


Figure 1. Location and spatial distribution of temperate glaciers and Yulong Snow Mountain NGGP.

tourists arriving at Yulong Snow Mountain has risen from 0.64 million in 1995 to 1.90 million in 2008, increasing to about 169.88%. Today, Baishui Glacier No. 1 tourists now have greatly exceeded their host populations in a year. At the same time, in 2008, glacier tourism generated over 5×10^8 RMB direct business revenues, increasing 2 168 times, compared with 1994 (Fig. 2).

BAISHUI GLACIER No. 1 MELTING TREND

From 1978 to 2008, the annual average temperature in Lijiang City showed an upward trend. Compared with 1979–1988, the mean temperature rose by 1.71°C between 1999 and 2008 (Fig. 3). Under global climate warming and the large increase in tourism, Yulong Snow Mountain glaciers have been observed to be in rapid retreat. As of now, Yulong Snow Mountain has only 15 glaciers with a total area of 8.5 km^2 . Four glaciers melted away, and the total area was reduced up to 26.78% (3.11 km^2), compared with 1957. Among them, Baishui Glacier No. 1's accumulation

area is very limited. Because of the fragile nature of this glacier, it would not be able to withstand any warming caused by either climate or man-made reasons. From 1982 to 2008, Baishui Glacier No. 1 observation data and Fig. 4 showed that altitude of its front raised 210 m, annual average elevation 7.78 m/a, while the glacier retreated nearly 840 m, annual average retreat 31.11 m/a, and the retreat speed obviously speeds up in recent years (Figs. 3, 4). Similarly, the average snowline elevation moved upward to about 50 m, and the tree line advanced approximately 40 m during this period. Also, during this time, the snowline moved upward, the glacier ablation period advanced, the glacier surface was seriously broken and roughened, the glacier's crevasse extended to accumulation zones, the streams on the glacier expanded significantly year to year, and the glacier side and tongue frequently collapsed. In addition, the south edge of glacier retreated to 20 m, and the thickness of the end reduced 15 m from 2000 to 2004 (Li et al., 2009, 2008; He et al., 2008). When visiting Baishui Glacier No. 1,

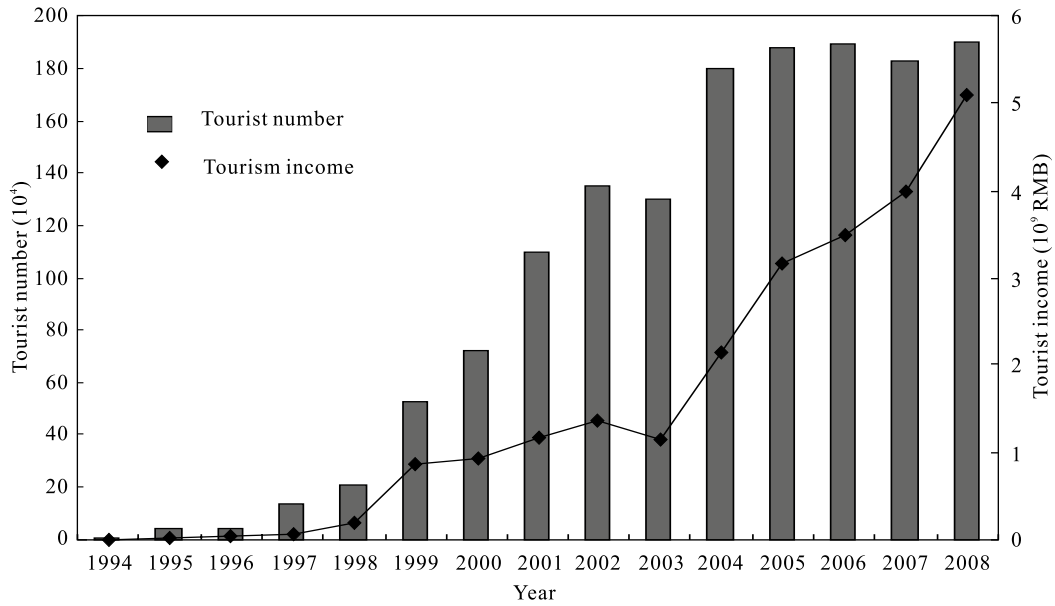


Figure 2. Change trend on tourist numbers and incomes of Yulong Snow Mountain Glacier Geological Park. Sources: Statistical Yearbook of Lijiang in 2003, National Economic and Social Development Statistical Communique in Lijiang City in 2004–2008.

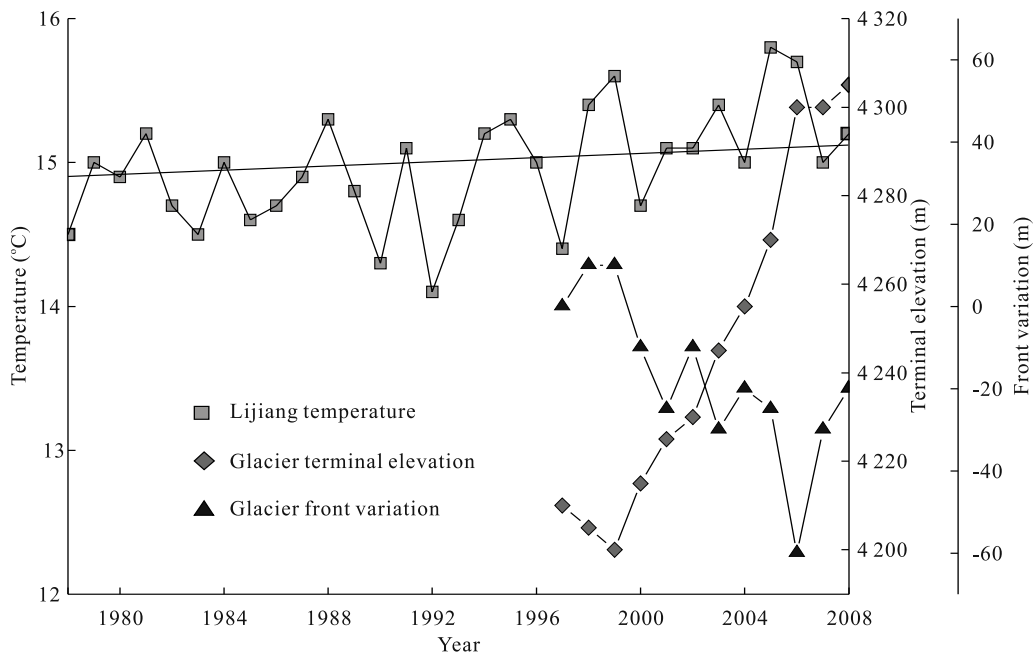


Figure 3. Front variation trend of Baishui Glacier No. 1 and the mean annual temperature in Lijiang.

one notes that most of the ice bodies are surrounded and covered by roche moutonnee and fresh moraines, suggesting rapid retreat of Baishui Glacier No. 1.

With global climate warming increasing (an unavoidable reality) in recent years, Baishui Glacier No. 1 will continue to retreat and thin down, which will damage the scenic landscape and even make some glacier tourism resources disappear. This will cause

glacier aesthetic damage as well as a number of natural disasters. At the same time, the retreat of Baishui Glacier No. 1 also will bring serious consequences to the ecological environment and tourism sustainable development in the glacier area. Therefore, it became particularly important to strengthen Baishui Glacier No. 1 and the surrounding environment protection. Based on these reasons, tourism managers and local

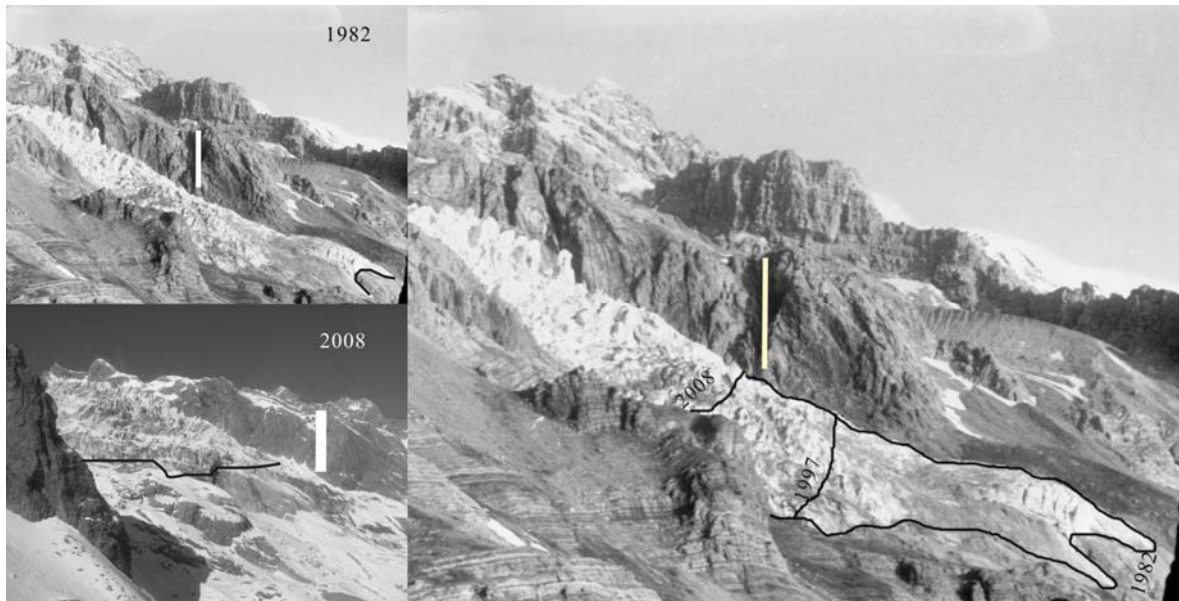


Figure 4. Front variation of Baishui Glacier No. 1, China, between 1982 and 2008. Note: the foreground rocks (white beeline) provide an excellent reference point; photos from Zhu Guocai in June 1982; data of 1997 based on the investigation report on Yulong Snow Mountain glacier resources.

government officials have given Baishui Glacier No. 1 priority to protect it from adapting climate warming and to put protective countermeasures into effect.

ADAPTATION STRATEGIES OF BAISHUI GLACIER No. 1 TOURISM

Baishui Glacier No. 1 enjoys abundant glacier tourism resources, pleasant mountain climate, gorgeous natural scenery, and large numbers of domestic and foreign visitors. However, climate represents an important long-term challenge to the glacier tourism industry. Considering the frangibility and sensitivity of Baishui Glacier No. 1 to global climate warming, operators and managers have taken many steps since the Baishui Glacier No. 1's opening up. They have increased successively research and development investment, taken strong environmental protection measures, increased the glacier's sightseeing quality, exploited gradually tourism resources of glacial vestige, expanded the type and scope of Alpine tourism projects, stressed the great importance of environmental harnessing and pollution control, and improved environmental protection requirements for companies that entered the scenic area so as to effectively avoid glacier and environmental degradation. At present, Baishui Glacier No. 1 tourist attraction has formed

seven adaptation and mitigation strategies to deal with global climate warming, as follows (Fig. 5).

Optimize the Space Layout of Glacier Tourism Area and Highlight Glacier's Ecological Protection

The sensitive character of the Baishui Glacier No. 1 to climate change makes it imperative for tourism operators and managers to rationally define glacier protection and tourism functional zone and to optimize planning and layout. Taken this into consideration, Baishui Glacier No. 1 area should be divided into three major categories: first, the glacier accumulation (upper glacier) area should be designated as a prohibited zone (sensitive area), where tourist access is restricted except for scientific personnel. Also, the operators need to put an end to all tourism facilities, strictly prohibit any human activities, and avoid impacting the ecological and aesthetic value of glacier. Second, the top part of glacier ablation zone should be designated as a restrictive area, and only glaciers sightseeing can be carried out here, and any other activity should be prohibited. According to environmental capacities, tourist numbers should be limited to the right scope for avoiding damage to glacier environment and ensuring glacier sightseeing quality. Certainly, managers should maximize the existing glacier

quality and function as far as possible and avoid developing further glacier resources. Third, managers and operators should also take glacial reliques and Alpine valley area as key development zones. In these areas, large-scale man-made landscapes should be prohibited, and mining, quarrying, deforesting, overgrazing, and other illegal behaviors should be also

forbidden. Tourism service centers should be concentrated (Liu et al., 2006) away from the three areas. The private cars and other vehicles entering tourism service centers must transfer to environment-friendly vehicles to reach various tourism spots so as to reduce vehicle exhaust pollution.

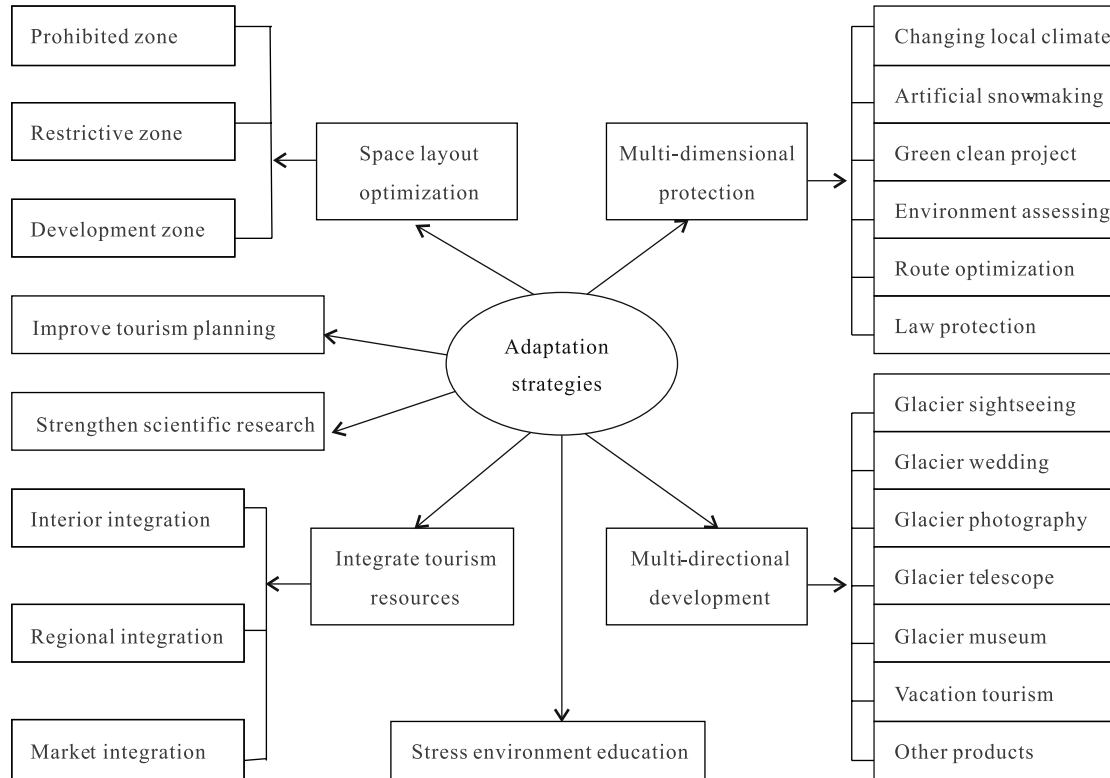


Figure 5. Seven adaptation strategies of Baishui Glacier No. 1 tourism based on climate warming.

Improve Glacier Tourism Planning and Formulate Environmental Protection Planning

Tourism planning is a blueprint, a macroguide-line, and the basis of strategic promotion of tourism scientific development. Alpine glacier tourism development must adhere to the principle of “protection goes before development, building follows planning”, regulate scientifically and implement effectively tourism planning, determine the scope and order of tourism development, and strictly limit frequent human activities and pollution industries. When millions of tourists, employees, workers, and scientific research personnel visited Baishui Glacier No. 1, they will leave inevitably huge amounts of waste material behind them every year. At the same time, tourists overcrowding, treading vegetation, fire hazards, extraction

of valuable resources, etc., will certainly affect the ecological environment in glacier regions (Naithani et al., 2001), and the degenerate environment will also conversely impact Baishui Glacier No. 1. Tourists should be more concerned about the sensitivities of the environment and the resultant problems if they leave behind the refuse. Thus, a proper glacier tourism planning for glacier conservation, tourism environment treatment, waste management, pollution control, etc., will play a key role in minimizing eco-impacts on nature environment around Baishui Glacier No. 1. Glacier tourism should be characterized by a participatory planning process, efficiency, environmental friendliness, authenticity, slow development, high quality, and a humanistic (i.e., people-centered) philosophy and management (Sanjay, 2002).

In addition, environmental impact assessment systems (following “first planning then developing and evaluating when exploiting” principles) in tourism projects that have been constructed or will be reconstructed should be extended to other contents, such as natural scenic resources, fragile eco-environment, economic conditions, the appreciation of landscape aesthetics, the influence in social environment and cultural levels, especially in sensitive environment areas, whether direct or indirect, are to be evaluated (Wu, 2001). Based on these reasons, since 1997, the management committee of scenic area have drawn up and adopted a variety of tourism and environment planings one after another, such as “Yulong Snow Mountain scenic area overall planning”, “a feasibility study report on development zone of Yulong Snow Mountain”, etc.. At the same time, they also issued successively a series of environmental protection rules, such as “provisional rules on environmental protection and management of Yulong Snow Mountain Tourism Zone”, etc.. In addition, tourism managers should also make tourism participants follow environmental rules and regulations at their own level (if not up to the set norms, they should be strictly fined, debarring them from further activities) (Kuniyal, 2002).

Adopt Multidimensional Protective Measures and Reduce Retreat Tread of Baishui Glacier No. 1

Tourism managers and operators must abide by the development principles of “strict protection, rational exploitation”, adopt three dimensional protective measures to develop scientifically Baishui Glacier No. 1 and the surrounding resources and maintain their ecological balance. In recent years, the Yulong Snow Mountain scenic area adhered unswervingly to multidimensional protective measures by “the protection first and development second” to protect glacier area environment. Their specific measures are as follows. The first was to strive to conserve biodiversity, natural ecosystems and landscapes, strengthen forestation, vegetation restoration, soil and water conservation and beautification projects in the exposed areas, strictly control forests area, build “man-made lakes” and reservoirs to maintain the balance of humidity and temperature and increase precipitation, impact significantly on regional and local climate (Pitman et al.,

2004), avoid the local climate deterioration trend to dry, soil and water loss, and ensure a long-term sustainable use of the environmental resources. The second is to increase artificial snowfall simulation and snowmaking. Though global warming is the main reason of glacier retreat, we can increase glacier accumulation and decrease ablation by strengthening artificial snow frequency with vertical elevation and the characteristics easy to form snowfall (rainfall) of Yulong Snow Mountain. At the same time, glacier accumulation area also can increase snow supply to offset fast melting by snowmaking. The third is to implement invariably a “green transportation and clean energy” project. Scenic zone transportation was replaced by environment-friendly vehicles (horse, vehicles equipped with electric engine, car with natural gas engine, collective transport, etc.), and part of energy will be replaced next by solar energy and hydropower; all which will reduce greenhouse gas and contaminant emissions. At the same time, tourism managers also emphasized circular economy principles, such as energy saving, consumption reduction, emission reduction, pollution treatment and control, etc.. The fourth is to strictly enforce an environmental impact assessment system, “three principle simultaneity” (namely, the facilities to prevent and control pollution and the main project simultaneously design, construct, and product), and total control and responsibility system for environmental protection goals in order to ensure the ecosystem stability in the glacier area. The fifth is to enhance route functions of glacier tourism areas and coordinate pressure of the hot and cool spots. Tour route layout should be reasonable and avoid duplication. The traveling routes should consider minimizing the impact on Baishui Glacier No. 1 and ecology resources caused by travel activities. They should also pay attention to shunting action and diffusion function of tour route (Wang, 2001). Shunting action is to disperse tourists from the hot spots. Part of the tourists or time will be spread to other non-hot spots. While the diffusion plays a lead role of the radiation, it can drive fast development of other visit spots and neighborhood around hot spots by radiation function, let hot spots bring along cold spots fast development (Huang and Wang, 1999). Finally, managers are extremely checked on behaviors that violated laws and regula-

tions, such as illegal cutting forests or other trees, digging medical herds, collecting specimens of plants and animals, hunting, extensive constructing building and reception facility, etc., so as to avoid destroying and polluting environment such as vegetation, soil, air and water, and other resources in the glacier area.

Strengthen Scientific Research of Environment Protection, Promote Glacier Tourism Sustainable Development

Glacier tourism development must highlight and strengthen protection works of the glaciers and the surrounding environment. In Baishui Glacier No. 1, tourism operators and managers strengthened scientific research of glacial and ecological environment protection. Since 1999, they continuously entrusted glaciologists and geologists of the Chinese Academy of Sciences (CAS) or relevant foreign institutes to investigate and study glacier resources for protecting reasonably and developing efficiently glacier tourism resources. At the same time, they also collected large amounts of comprehensive data and information about climate, glacier change, ecological environment, etc., and focused on studying some general problems (glacier ablation and runoff change, connection of glacier and climate, ecological environment protection and sustainable development of glacier tourism, etc.). Also, these scientists have analyzed some correlative impacts that glacier ablation has had on the surrounding environment (e.g., water resources, vegetation, animal habitat, climate, etc.) and brought forward some advice and measures to protect and develop scientifically Baishui Glacier No. 1 without affecting ecological environment of glacier areas in the future. On the other hand, Management Committee co-operated with tourism planning departments to calculate rationally tourist and environment capacity in glacier park, by which they will control the number of visitors for fear frequent tourist activities affecting glacier ecosystem during the busy traveling season. Moreover, the Management Committee also used the price (raising prices when tourism midseason) to restrict and control tourists numbers based on the carrying environment capacity for protecting effectively precious glacier tourism resources (Wu et al., 2004).

Develop Glacier Tourism Products by Multi-directions, and Cater to the Needs of Glacier Tourists

The diversifications of tourists' consumption patterns are bound to stimulate the multidirectional development of glacier tourism resources. In accordance with Alpine glaciers' characteristics and attractiveness, the Baishui Glacier No. 1 has developed many types of tourism products in order to meet multilevel consumer demand. First, the operators improved the existing cableway facilities, increased the viewing perspective, and improved the quality of glacier sightseeing. Second, they held glacial mass weddings and photography contest around the glacier. Through these activities, managers expanded the glacier tourism image, lengthened glacier tourism industry chain, and presented more of the glacier's beauty and mountain scenery to lovers and tourists of Baishui Glacier No. 1 and Yulong Snow Mountain. Third, they developed telescopic glacier tourism, namely, by telescope, to display the upper Alpine glaciers to tourists (especially, glacier accumulation area landscape). At the same time, visitors could also enjoy different tourism resources of Alpine weather and climate and vegetation change in different seasons. Fourth, they are establishing a glacier museum and popular science education base in the tourist service center. By combining glacier tourism, popular science and geographical practices with glacier, geology, forest vegetation, ecological environment, and tourists could learn more correlative knowledge on formation and features of glaciers and glacier reliques, and the relationship among glacier, climate, rainfall etc.. At the same time, tourists' awareness of ecotourism and glacier protection were also raised by glacier, vegetation, rock sample and three-dimensional virtual scene, multi-media, glacier forum, etc.. Through this, a new paradigm or idea of the sustainable development of glacier tourism was provided. Fifth, operators appropriately developed vacation tourism projects in the summer and autumn, extend tour time of glacier tourism, and increased tourism income in glacier areas. Finally, they increased and expanded the glacier tourism types by combining Alpine mountaineering, trekking, horseback, mountain biking, camping, Alpine azalea enjoying, etc. in order to mitigate the direct impact on Bai-

shui Glacier No. 1.

Integrate Tourism Resources and Reduce Ecological Pressure of Glacier Areas

With rapid melting of Baishui Glacier No. 1, managers and operators need urgently to integrate interior and region tourism resources for reducing its ecological pressure. Glacier sights, snowscape, Alpine grassland all exist at the same time on Yulong Snow Mountain, and visitors will find scenery changes with the season and altitude.

Based on this, operators and managers should make interior integration of Yulong Snow Mountain resources a strategic priority, especially package development of Baishui Glacier No. 1, Alpine grassland, forest, stream, and local culture resource. Moreover, operators and managers need to consider integration of existing glaciers and other natural resources in Northwest Yunnan, as well. Due to intensive geological effects, Northwest Yunnan has formed geomorphologic marvelous spectacle (e.g., World Nature Heritage: Three Parallel River Area), numerous gorges (e.g., Lujiang Gorge and Hutiao Gorge), high snow mountains (Yulong, Meili, Baimang, Haba Snow Mountains), the lower latitude glaciers (Baishui Glacier No. 1 and Mingyong Glacier, etc.), most splendid natural sceneries, and variety biological resources. At the same time, there are several thousand years of history. All ethnic peoples have created a unique traditional culture for themselves and have made the Northwest Yunnan become a coexistence area of multiethnic, multilingual, multilanguage, multireligious and a variety of lifestyles and customs. They have left a rich historical and cultural heritage (e.g., World Culture Heritage-Lijiang Old Town, World Memory Heritage-Ancient Naxi Dongba Literature). For these reasons, it is necessary to integrate glaciers, jokuls, forests, grasslands, rivers, ancient towns, and national cultures. In addition, the local governments also need to unite regional tourism marketing, expand tourist market share, exert concerted development, cooperate reciprocally, promote interregional coordinated development to their own advantages, and avoid the competition from similar glacier tourism projects. Finally, they need to form a united and orderly development pattern with harmonious development and

mutual benefit in glacier areas of Northwest Yunnan. Through tourism resource integration and alliance strategy, it is sure to alleviate the pressure from human activities on Baishui Glacier No. 1 and achieve glacier tourism sustainable development with population, economy, society, resources, and environment all in harmony in glacier tourism areas in northwestern Yunnan.

Reinforce Public Environmental Education and Raise Visitors' Awareness of Environmental Protection

Climate change is a complex issue, often ignored, and minimally understood by glacier tourists. During the busy season of tourism, thousands of people visit glacier park daily, and environment influence is inevitable. Thus, it is very necessary and valuable to establish a public education base for raising visitors' awareness of environmental protection. First, operators and managers should establish some information boards on climate warming and glacier changing to arouse visitors to reduce human-caused threats to the glacier and environment protection. Second, operators and managers should train glacier tourist guides to study correlative knowledge on climate warming and glacier retreat issues in order to improve tourists' understanding and popularize glacier knowledge. Third, operators and managers should provide timely glacier tourists with some comprehensive and interesting information about glacier change, the ecological environment, the tourism situation, landscape change, tourist numbers, tourist area pollution, ecological damage, accessibility degree, hotel accommodation industry, tourist satisfaction degree, as well as tourism honesty services, etc.. Finally, operators and managers should raise awareness among visitors and staff on climate change impacts. They should engage them in response processes and promote glaciers responsible travel that supports "quadruple bottom line" sustainable tourism, incorporating climate, environmental, social, and economic considerations (Lipman and Kester, 2008). In short, by environmental public education, glacier tourist sites can not only let tourists understand glacier change, ecological environment, and human activities, but also can enhance tourists' awareness to protect glacier resources.

CONCLUSIONS AND DISCUSSION

According to UNWTO studies, international arrivals will reach one billion visitors in the next decade, and with global warming, Alpine glacier tourism will become a new trend in the future. Alpine glaciers are in retreat in almost all of the world's mountain belts. Many of the smallest Alpine glacier complexes will likely disappear in the next two decades. If Alpine regions will be affected by climate warming, the well-known glacier landscapes, summer leisure resorts, and classic climbing routes on Alpine glacier will become unattractive or disappear completely. At present, it has become very obvious that global climate warming is the most seriously threat to Alpine glaciers tourism in the 21st Century. The operators and managers of Alpine glacier tourism can not just sit back idly in the face of climate change, but rather, they must react to global climate warming in demand. However, glacier tourism adaptation should not lead to the degradation of the mountain environment and a decrease of glacier tourism quality in the name of climate change. Based on the above factors, adaptive and mitigative strategies of Alpine glaciers not only should concern climate warming but also should improve traditional tourism items (glacier sightseeing, trekking, climbing, hiking, skiing, glacier cruising, glacier flight, etc.).

At the same time, adaptive and mitigative countermeasures should not limit to space layout optimization, tourism planning, environment protection, glacier scientific research, tourism resources integration, etc.. Instead, people should think over environmental and energy adaptive policies facing Alpine glaciers and environmental degeneration or disappearing on the regional and global scale; for instance, environment protection, pollution control and cutting, clean energy utilizing, energy saving, emission reducing of greenhouse gases, etc.. Moreover, there is also a need for further study and discussion on highly effective technologies of glaciers protection, tourism resources development of glacial vestiges, alternative tourism, controlling tourists by rational pricing, local people psychological studies, and regional socio-economic adverse impacts of glacier ongoing retreat in well-known Alpine glacier attractions. In short, a series of adaptive responses through the above studies will make worldwide Alpine glaciers tourism sustainable.

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