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Review Article

A Review of the Impacts of Climate Change on Tourism in the Arid Areas: A Case Study of Xinjiang Uygur Autonomous Region in China

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Tourism is more sensitive and susceptible in global arid regions to climate change than other sectors, and climate change mainly affects the behavior of tourists, selection of tourist destinations, tourism resources, and tourism safety. China's Xinjiang Uygur Autonomous Region (XUAR) is a representative area of the global arid region. To review its comprehensive impacts of climate change on tourism has indicative significance for the global arid region tourism industry to cope with climate change impacts. On the whole, the impacts of climate change on tourism in the XUAR will coexist with opportunities and challenges both at present and in the future. The XUAR is experiencing or will experience climatic process of warming and wetting. For the tourism climate comfort and extension of suitable travel period, the opportunities far outweigh the risks (high reliability). However, future climate change is expected to have great negative effects on cultural heritages, glacier and snow resources, and agricultural landscapes in arid areas of northwest China (high reliability). The above impacts are potential and long-term, and the measures should be taken as soon as possible to mitigate and adapt to climate change challenges to tourism.

1. Introduction

Tourism is a climate-dependent sector [1], which must not be "immune" to climate change like other sectors. Climate change not only endangers the activities and health of human beings, but also affects tourism activities on global scale [2]. It is unequivocal that human activities have warmed the atmosphere, ocean, and land, which has already affected many weather and climate extremes in every region across the globe [3, 4]. Tourism activities require certain climatic conditions and environmental foundations, which makes it more sensitive and susceptible to climate change than other sectors [5]. Therefore, climate change is also one of main challenges for future tourism development. The research studies on impact assessment of climate change on tourism and put forward adaptive strategies of sustainable tourism development are important [6].

Climate change, with an increasing intensity, has led to frequent occurrences of extreme weather events such as droughts, heat waves, heavy rains, and storms, especially with every additional increment of global warming [4]. IPCC [7] pointed out that the inadequate adaptation response to the emerging impacts of climate change eroded the foundation of sustainable development, including the foundation of sustainable tourism development. Global climate change affects the quantity and quality of tourism resources, space, and time movement of tourist flow. Intensified climate warming, sea level rise, extreme weather, and climate events have severely affected tourism industry, which not only directly influences spatiotemporal distribution of tourism climate resources, tourist flow, and tourist behavior, but also indirectly affects tourism industry through the environment, society, and economy impacts.

The arid area of northwest China has four distinct seasons, with cold winter and spring, and warm summer and autumn. Seasonal tourism is strongly restricted by meteorological and climatic conditions. Tourism seasonality is closely related to the cyclical change of climatic conditions throughout the year. With the improvement of social economy and information networks, tourists' demand for meteorology and climate service is increasing, which is a very important factor selected by tourists and for their destinations because climate elements such as sunshine, precipitation, wind speed, temperature, and humidity are mainly related to ecological environment and tourism system [8]. The tourism system consists of three aspects of the main body, object, and support system, in which main body is tourist source market, the object is tourist destination, and the support system includes tourism traffic, tourism facilities, tourism services, etc.

Xinjiang Uygur Autonomous Region (XUAR) is a typical representative of arid regions in the world [9], and its climate impact has indicative significance in global arid areas. The diverse terrain and complex climate types cause various climatic features and comforts in different regions. Generally, XUAR climate is characterized by drought, cold winters and hot summers, large differences of diurnal temperature, and abundant sunshine, with comfortable summer climate especially in the mountains and valley areas. Accordingly, most of tourist destinations in the XUAR are selected in mountainous area (i.e., Tianshan, Altai Mountains, and Yili River Valley) with mild climates. In recent years, the XUAR has become an increasingly popular holiday destination for tourists [10] as the diverse and plentiful tourism resources are formed by the unique climatic condition there.

The contents of this study are systematically to introduce tourism climate resources in the XUAR, evaluate the comprehensive impacts of climate change on tourism sector, and put forward the adaptive management strategies on this basis as a reference both for the sustainable tourism development in arid areas of northwest China and the world.

2. Study Area

The XUAR locates in the center of European Continent, surrounded by Altai Mountains, Tianshan Mountains, and Karakoram, affected by the atmospheric circulation systems of the westerly. The topography of the XUAR can be summarized as the geographical feature of "Three mountains with two basins," with the Altai Mountains in the north and the Kunlun Mountains in the south, and the Tianshan Mountains running through the central part.

On the whole, according to the Köppen-Geiger climate classification, XUAR's climate types mainly include cold arid desert climate, cold arid steppe climate, and polar tundra climate [11]. Less precipitation, strong evaporation, and large temperature difference are the main climatic characteristics of the XUAR. Northern XUAR has a climate of relatively humid with abundant grassland and forest vegetation, whereas Southern XUAR has a dry climate but with many cultural heritage sites around the oasis cities [12]. Over the past 60 years, XUAR has experienced a process of warming and wetting [9, 13–17] (Figure 1). To the south of the Tianshan Mountains is known as the Southern XUAR, and the north of it is the Northern XUAR. Because the Tianshan Mountains extend from east to west across the vast study area, the climate difference between North and South XUAR is obvious.

Generally, diverse topographic and climatic conditions create diverse landscape features in the whole XUAR, such as ice and snow, grassland and forest, Gobi and deserts, farmland, and oasis resources. Among these tourism resources, sandy deserts and gobi deserts are widely distributed. There are strong wind days in the desert area during spring, and strong wind erosion results in plenty source of dust and salt dust. The fragile ecosystem of Xinjiang is extremely sensitive to climate change [18–20]. There are two World Heritage Sites in the XUAR, of which the XUAR-Tianshan has four subareas of Tuomuer Peak, Kalajun-Kurdening, Bayinbulak, and Bogda and the Silk Road has Chang'an-Tianshan Corridor with fiverelics of Gaochang, Jiaohe, Beiting Ancient City and Kizil Gaha Beacon, Kizil Grottoes, and Subashi Buddhist Temple. In all tourism sites, there are 16 national tourist attractions with 5A level (Sailimu Lake Scenic Area, Taklimakan 359 th Army Cultural Tourist Area, Tianshan Tianchi, Grape Valley, Kanas, Nalati, Koktokay, Jinhuyang, Tianshan Canyon, Bosten Lake, Kashgar Old City, Kalajun, Bayinbulak, Pamir, Devil City, and Baisha Lake) and 97 national tourist attractions with 4 A level (Figure 1).

Diverse and plentiful climate tourism resources are a key foundation for rapid tourism development. Relying on these advantageous conditions, the XUAR received a historic breakthrough of 200 million tourists and achieved tourism revenue of more than 340 billion CNY in 2019. Both figures have increased by more than 40% year-on-year. In recent years, XUAR has also been presenting the "blowout" growth in the country. In the past two years, tourism has been severely affected by the COVID-19 pandemic.

3. Study Method

The effects of climate change on tourism can be either negative or positive, depending mainly on the degree of dependence on climate. However, the negative effects generally outweigh the positive benefit. Tourism climate comfort, ice and snow tourism, and its industry are very sensitive to climate change, while tourism and cultural landscape are more sensitive to extreme weather events. In this study, the impact of tourism climate change is mainly evaluated from four aspects: tourist's behavior, tourist routes and destinations, and tourism climate comfort. Tourism impact assessment is mainly based on published literature studies. Among them, qualitative evaluation data mainly come from mainstream newspapers, network news websites, central and local government websites, and other channels. Weather and climate data of daily precipitation and temperature were provided by the National Climate Center, China Meteorological Administration (CMA) (https://www.nmic.gov.cn/). Other quantitative indexes are mainly based on literature evaluation results. In literature selection, we systematically searched for studies through SCOPUS and Web of Knowledge, as they contain the biggest data base of articles in social and environmental sciences [21]. This study selected 77 literature studies related to climate change and

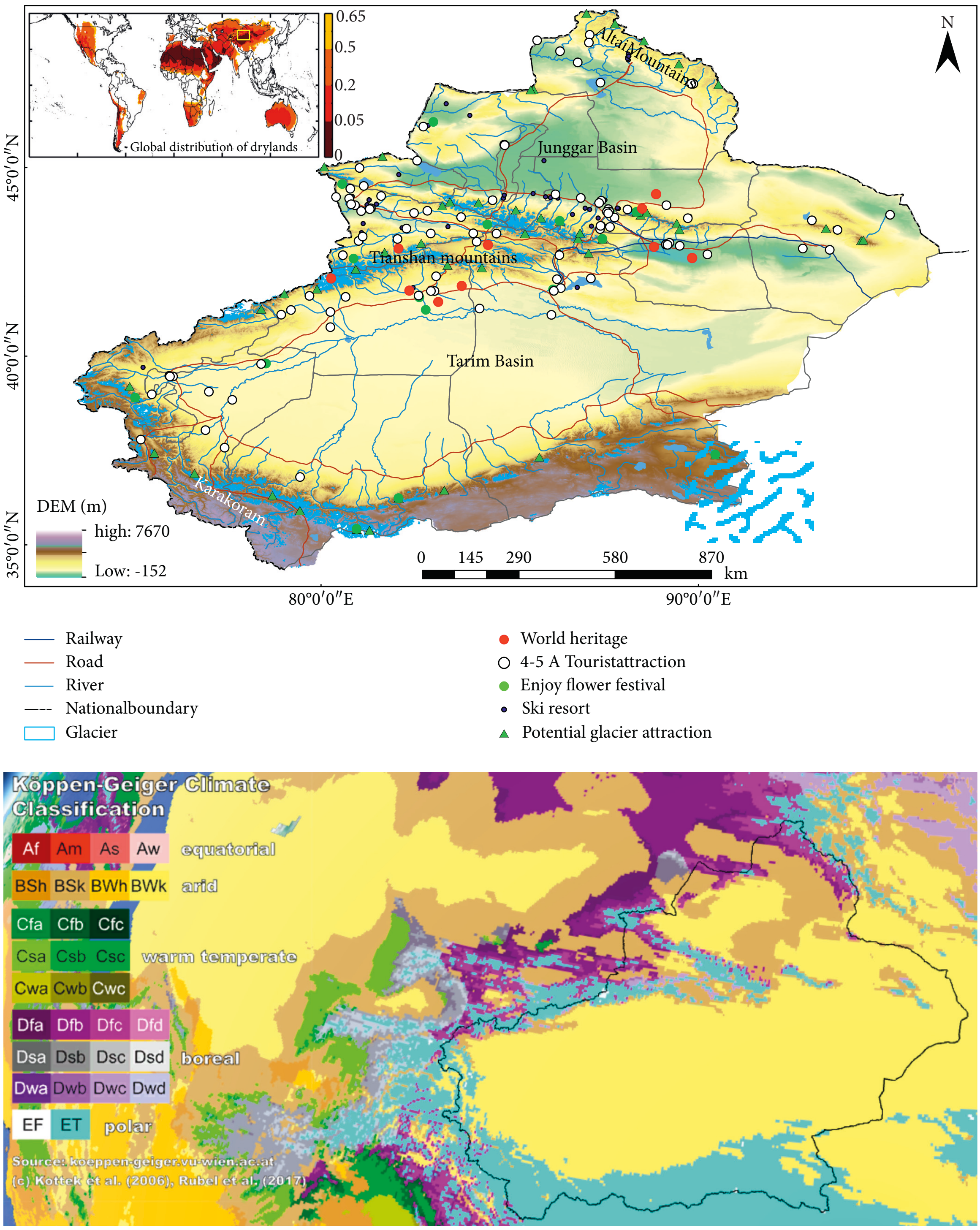

Figure 1: Geomorphic features (above) and climate classification (blow) of the XUAR.

tourism in Xinjiang as the basic data. Among them, 32 were in English and 45 were in Chinese. When the results of multiple literatures were consistent, we considered this conclusion to have high reliability.

4. Characteristics of Tourism Climate

Spatial layout of XUAR's tourism resources is significantly affected by climate factors. In winter, the combination of snow and forest landscape is like an ink painting [22]. In spring, mountain flowers accompany with melting snow and ice. In summer, there is a murmuring water and verdant vegetation. In autumn, ring upon ring of woods tinted with deep red constitute a beautiful scenery beyond words. Tourism resources in different seasons have different attractions for tourists [23]. In winter and spring, glacier sightseeing, skiing, and enjoying flowers are the main ways of tourism. In summer, vacation and grassland tourism are mainly enjoyed. In autumn, rural, forest, and agricultural tourism are major modes of travel (Figure 2).

(https://www.travelxj.cn/TravelXJ/zh-cn/; https://www.xj.xinhuanet.com/) From March to May, XUAR is in the flower appreciation tourism season and the spring flower tour products are rich-colorful during this period, such as apricot flower, peach blossom, rose, and snow chrysanthemum. For example, Wushi County in Aksu prefecture has successfully held the "Apricot Blossom Festival" cultural tourism activity for five consecutive years. In 2018, the two-week apricot blossom period received 65, 000 tourists. China Fushou Mountain Scenic area of Huocheng County holds a mountain flower festival in April every year. There are nearly 400, 000 wild raspberry, wild hawthorn, and wild apple flowers in the scenic area. From March to May 2018, XUAR launched 342 spring cultural tourism activities, and nearly 100 products of flower appreciation tours and spring tour routes are presented (Figures 1 and 2).

The peak season of summer tourism occurs between June and August each year and grassland, lavender flower sea, and other tourism resources normally attract many tourists during this period. Yili Prefecture, with the same latitude zone as Provence, France, become the world's one of the world's three best major lavender bases with Japan's Hokkaido Furano and France's Provence in recent years [24], due to suitable climate and planting conditions such as proper temperature difference between day and night, long effective illumination and inversion with the air humidity, and summer without the extreme heat [25–27] (Figures 1 and 2).

The period between September and November in autumn is also a peak season for agricultural tourism. Different plants and fruits, such as Turpan grape ditch, Hami cantaloupe, Hetian jujube, Shihezi flat peach, Qinghe County Seabuckthorn, and Ye City Walnut, have a great attraction for many tourists to enjoy their experience. In addition, tourists are also interested to see the large-scale Tarim *Populus euphratica* forest, Aksu cotton, and Colorful Beach Yadan landform at the same period. In 2010, the Ecological Tourism Planning of *Populus euphratica* and the Detailed Control Planning of Main Nodes in Shaya County, Xinjiang, were approved by the National Tourism Administration, and the development of ecological tourism of *Populus euphratica* in Shaya County had a new guidance and implementation plan. Based on above plans, local government established ecological protection policy and investigated the distribution patterns along Tarim river bank in iminqak Shaya County by a scientific research team, and developed a series of sightseeing, leisure, and experience tourist attractions (Figures 1 and 2).

From October to March of the next year, the winter tourism resources in the north of Tianshan Mountains are very rich. The average annual temperature is 6.4°C, and the snow period reaches more than 160 days. The potential and huge ice and snow sport and tourism are developed in this season [28]. "China Ice and Snow Tourism Development Report" [29] was released, and Urumqi and Altay were awarded the title of "2018 Top Ten Ice and Snow Tourism Cities" [29]. Xinjiang Silk Road International Resort, Western China Snow and Ice Tourism Festival, and China XUAR Winter Tourism Industry Trade Expo were selected as one of the top ten-ski tourism areas and festivals in 2017-2018, respectively (Figures 1 and 2).

5. Extreme Weather and Climate Events

The unique climate background is the basis for the formation and development of tourism resources in Xinjiang. From 1961 to 2018, the annual average temperature and annual precipitation in the XUAR were 7.4°C and 237 mm, and the average temperature and precipitation have significantly increased by about 0.3°C/10a and by 10.4 mm/10a in pasted 60 years (Figure 3). On the spatial scale, the annual mean temperature in the south is higher than that of north, higher in the east than that of west, and higher in the basin than that in mountains. The spatial distribution of precipitation is asymmetrical, with the higher values in the north and west than that of the south and east, and it in mountainous area is higher than that in the basin. The annual precipitation in most regions is less than 200 mm, indicating it is a typical arid area.

However, occurrence of extreme weather and climate events has huge impacts on tourism sectors [30]. In the periods of 1961 to 2018, the average extreme minimum temperature warming (0.63°C/10a) in the XUAR was much higher than the average extreme maximum temperature (0.13°C/10a). The warm night days increased significantly, which was 1.9 times of the warm days. Snowfall intensity has also significantly increased, in which the change rates of heavy snowfall in the XUAR and Altay reached to 1.99 mm/10a and 2.09 mm/10a, respectively, in recent 50 years [31]. On the contrary, cold events significantly decreased (e.g., hail, freezing rain, and frost), in which cold night days decreased 2.8 times than cold days. Overall, there are various types of climatic extremes with high frequency, strong seasonal, and regional differences, and a wide range of effects (high confidence). During the past 60 years, climate extremes have changed significantly, with increased events of high temperature, extreme precipitation, and rainstorm days on contrary with the decreased number of high wind days, sandstorm, and cold wave weather. Otherwise, it shows a strengthened tendency of aridiffication (high confidence) and upward trend of flood disaster under the background of the climatic change in recent decades [32], with increasing affected areas and continuous disaster loss [33].

6. Impacts of Climate Change on Tourism

By contrast, tourism is more dependent and more susceptible sector on the climate change, in the aspects of tourists, tourism destinations, tourism resources, travel lines, tourism experience, and accessibility of tourism destinations, tourist safety, and tourism infrastructure [34–37]. Especially, long-term climate warming also influences ice and snow tourism resources, cultural heritages, and agricultural tourism resources.

Figure 2: Seasonal tourism landscapes in four seasons.

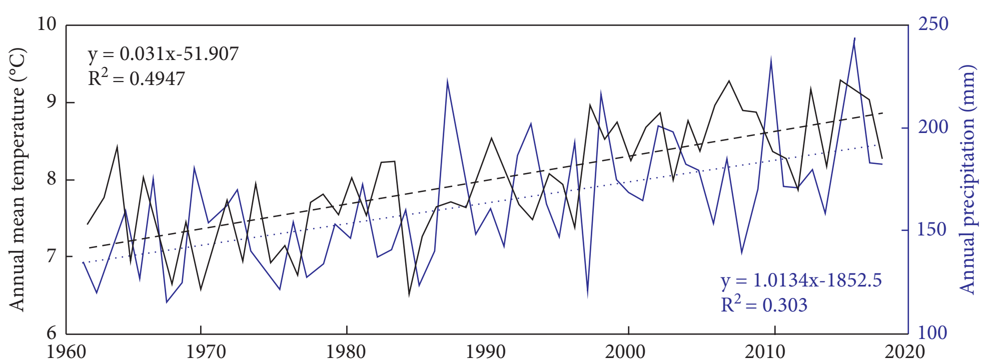

Figure 3: Variation trends of temperature and precipitation in the XUAR during 1961–2018.

6.1. Tourist's Behavior. Tourists' willingness and decision is subject to the significant impact of climate comfort [2]. There is a close relation between passenger flow and climate comfort. In other words, the direct manifestation of tourists' willingness influenced by climate comfort is the corresponding change of passenger flow [38]. Studies have shown that a one-unit increase in the comprehensive climate comfort index will increase the inbound passenger flow by 18, 200 and the domestic passenger flow by 352, 630. For example, climate comfort of Urumqi continued to increase, corresponding to significantly increased number of inbound tourists, especially of the number of domestic tourists with an increased mean annual number of about 1.366 million from 1977 to 2017 [39].

Climate change may lead to impairment of tourists' physical and mental health, such as limited activities, visual obstruction, and other problems, thus bringing negative emotions to tourists. Bad climate mainly refers to unsuitable climatic conditions such as temperature, wind speed, air humidity, and sunshine, or frequent climatic anomalies such as hail and drought. Some impairments of physical and mental health caused by the weather and climate factors manifest as sunburn, dry and cracked skin, altitude sickness, cough and fever, fear and anxiety, and other physical discomfort. Visual obstruction mainly refers to tourists' aversion to fog, rain, and other factors that destroy visual appreciation experience. All of these climate impacts can limit outdoor activities, inconvenience in carrying goods, leading to changes in tourism plans, and reduced travel experiences [40]. As a result of snowstorm with a thickness of eight centimeters during the Golden Week in October 2016, XUAR, roads were closed and tourists were not allowed to enter the mountains, the number of tourists was greatly reduced, and the length of tourists' tour was shortened. The bad climate is the internal driving factor, which directly determines the low state of tourists' emotion, their physical and mental health, resulting in damage to scenic sites, travel restrictions, traffic jams, and differences in expectations moderated the direct climate-emotional connection [41]. Overall, these weather conditions also affect tourist behaviors.

6.2. Tourist Routes and Destinations. The selection of tourism lines, tourist destination, and travel time are largely dependent on climatic conditions [2, 42, 43]. Under the situation of changing climate, tourists may momentarily change their travel destination, tourist line, and travel period. Accordingly, travel flow may transfer between the different spaces of same destination, leading to a gradually varied time and space pattern of tourist flow. In recent years, a series of extreme snowfall events have affected Xinjiang airport and railway traffic nets.

Normally, there is relatively concentrated traffic flow of tourists in spring and summer, because tourists tend to choose the most comfortable season (spring and summer) to travel, when tourism comfort is generally higher than that in autumn and winter [44]. Although the passenger flow is significantly reduced in winter due to low comfort levels, many tourists still like to choose Altay, Urumqi, and other northern XUAR regions to carry out ice and snow tourism activities in this season. At the spatial scale, tourists prefer the climate-comfortable tourist destination [39]. Therefore, tourist may avoid to choose some areas, such as Turpan, for their destination where are too hot in summer to reduce comfort, and the tourist flow clearly shows a trend of migrating to places with high climate comfort.

The general increase in climate comfort has a positive impact on tourists' experience during various types of tourism activities. For Turpan and other areas, high temperature in summer may reduce the tourism comfort, causing heat stroke, dizziness, and change of tourists' travel routes or destination choices.

6.3. Tourism Climate Comfort. Temperature, relative humidity, and wind speed are the main climatic elements affecting tourism climate comfort. The warm and humid climate has slightly slowed down the severe cold in winter and spring to a certain extent, which is more suitable for tourists' physical comfort [44, 45], especially in the northern XUAR cities, such as Karamay, Altay region. The most suitable tourism months in most parts of the XUAR are from July to September. The average numbers of inbound tourist receptions from July to September were 334, 705.33 people/day in 2017, 376, 573 people/day in 2018, and 369, 755.5 people/day in 2019. In the past 60 years, the average annual temperature and precipitation in the XUAR have increased in all four seasons [46]. Temperature rises in spring from February to April, and coldness gets slowly down in early spring, when everything gradually recovers, accompanying with coming of suitable travel time and comfortable climate. There is the most comfortable climate for tourists in summer from May to July, when increased precipitation can slow down the extreme heat. Increased temperature and precipitation in autumn from August to October are more comfortable for tourism climate and more suitable for tourists' body feeling. Warming in cold winter (from November to January next year) can reduce the severity of winter tourism and the risk of frostbite and increase the sustainable time of the tourism period. Therefore, improvements of tourism climate comfort can promote the development of tourism there and the moderate changes in climate comfort have an important impact on tourism entry. Studies show that the comprehensive climate comfort index will increase each unit, and domestic and immigration tourists will increase or decreased by 18, 500 people and 3, 526 million [47].

The comfortable period for tourism in the XUAR, about five months, is relatively short. The average annual temperature and precipitation showed an increasing trend between 1958 and 2017. In recent years, the process of warming and humidification has promoted the improvement of tourism climate comfort in entire XUAR. The time suitable for tourism has advanced and the duration of the period suitable for tourism has extended, which has promoted the development of tourism and tourism activities in the entire region.

6.4. Tourism Resources

6.4.1. Cultural Heritage Resources. XUAR has a long history with profound culture and rich heritages including the ancient city of Jiaohe and Gaochang, the Ruins of the Beiting Ancient City, the Kizil Grottoes, Subashi Buddhist Temple, Kizil Gaha Beacon, and the Great Wall (XUAR section) listed in World Cultural Heritages. Other heritages are the ancient city of Loulan, Yuqikat, Qiuzita, and Tongguzibash, the ruins of Damagou Buddhist temple and Rewak Buddhist temple. The 830 sites of the World Heritage List are facing the threats brought by climate change, which may destroy the ancient buildings in historic city. Extreme climate events may result in "irreversible damage" [48] for the world's precious ancient artifacts or cultural sites.

Among XUAR's cultural heritages, many existing sites use soil as the main building material, in which the eroded sites can be divided into surface wind erosion, crack development, base etching, surface water etching, crispine, mud flakes, and biological damage and collapse [49]. Wind erosion is the major reason to damage cultural heritages. Example, wall sites of Gaochang Ancient City and eastern Turpan are constantly suffered from wind erosion and surface weathering. Weathered debris reduces the volume and shape of the wall site and even destroys the existing city wall [50]. Similarly, in the ancient city of Jiaohe, west of Turpan, wind erosion dominates its various diseases. Because buildings and cultural layers of the heritage were eroded by strong winds and sand brush, the Heritage in the River ancient city was destroyed [51]. The damage caused by rain and snow is also a serious impact on the cultural site of the XUAR. For example, rain eclipse is also a disease factor to erode the North Ting Ancient City. Under the role of abnormal development, there are three forms of diseases such as wall-shaped abutment, water in low-lying areas, and rushing [52]. The peeling is mainly caused by comprehensive factors such as cavitation and wind erosion, which may affect the stability of the site and threaten the integrity of site surface. The erosion of wind and rain can make cracks and small pieces on the surface of the site, and the walls facing wind are most serious. North Ting Ancient City welcomes the wind surface—there are different levels of wall-shaped erosion in the northwest [52]. There also are three main diseases of collapse, etching, and pungent in the caves of the Subashvon Temple Site of Kuqiu County [53]. Ancient murals generally have a variety of diseases such as cracks, empty drums, colors, nail, brunette, smoke, and biological erosion [54]. Temperature changes can cause damage to murals. It has been found that the library wood-vomeric cave rock mass is different from the material of the mural, and the thermal expansion is different, and the temperature has changed the murals to produce different degrees of separation [55]. Acid rain can corrode the decorative materials of the building exterior wall and endanger the exposed buildings [56]. Acid rain occurred more frequently in northern XUAR, followed by the eastern but the southern has no. Especially, Urumqi and Yili experienced qualitative changes from no acid rain to acid rain with an increased rate [57]. In addition, drought-high winds have increased the fire risk of ancient buildings. Overall, climate change not only directly acts on the body of cultural heritage, but also affects its carrier (such as rock body/cliffs), forming single or composite diseases both from physical and chemical effects [58].

6.4.2. Glacier and Snow Tourism Resources. Ice and snow tourism resources are most sensitive to climate change. Climate warming will result in the huge reduction of snowfall, shortened tourist season, the glacier/snow tourism projects, and the potential loss [59–61]. The special topography of "Two basins sandwiched between three mountains" in the XUAR has a distinctive characteristic of the glaciers and snow on mountainous areas in Tianshan, Karakoram, Kunlun Mountains, and other large mountain ranges, where there is topographical basis to develop glacier and skiing tourism. There are 20, 695 glaciers in the XUAR, covering an area of 22, 623.82 km^2, accounting for 42.61% and 43.70% of the national total, which are only less than 45.01% and 45.97% of the Tibet Autonomous Region [62]. Since 2000, glacier mass balance of Western Kunlun, Pamir, and Karakoram has been stable or even slightly equilibrium [63], while the loss of glacier mass in Tianshan Mountain gradually intensified. In 2018, the duration of snow cover in the Altai and Tianshan mountains exceeded 100 days, with some areas exceeding 120 days [64]. However, due to climate warming, the total area of glaciers and perennial snow in the XUAR decreased from 24, 137 km^2 to 22, 192 km^2 during the 10 years from 2005 to 2015. The total area has been reduced by 1945 km^2, with an average annual shrinkage rate of 8.06% [65]. In this context, most of the glaciers in XUAR are rapidly retreating, and the stable snow area has been significantly reduced [66, 67].

Overall, in the context of climate warming, the glacier and snow tourism will face a certain adverse effect. Except for the northern regions and plateau regions, almost all ski resorts in Japan will reduce the number of skiers by 30% when the air temperature rises by 3°C. Similarly, low-altitude ski resorts in Switzerland are greatly affected due to lack of snow resources as a result of global warming [68]. However, because of rich ice and snow resources in the XUAR, climate change has a slighter impact on them than North China and South China. Of course, ice and snow tourist destinations should be assessed in advance, to search the unfavorable factors brought by the retreat of ice and snow, to improve the quality of existing ice and snow tourism and related projects, to find alternative products for ice and snow tourism, and to extend the ice and snow tourism industry chain for coping with the impact of climate change.

6.4.3. Agricultural Tourism Resources. The large-scale agricultural tourism resources in the XUAR include *Populus euphratica* forest, flower viewing, picking, and fruits. Shaya County has developed and brought a certain amount of economic income from a group of tourist attractions such as the Natural Park of *Populus diversifolia* forest, the Leisure Resort of *Populus euphratica* forest, the Art Scientific Research Film of Kokchoele *Populus euphratica* and Television Base (Moon Bay Scenic Area), and Tarim Poplar Forest Park. However, some weather and climate events may directly or indirectly affect these tourism resources. There is a largest area of natural *Populus euphratica* forests in XUAR over the country and more than 90% of *Populus euphratica* in China grows in the Tarim River Basin, which amounts to 950, 000 mu. *Populus diversifolia* is a landmark wooden plant [69] of the ecological environment in arid area. The discharge variations of the main stream and channels changes of Tarim River have a significant impact on formation, development, and decline of desert riparian forests. The uneven change of Tarim River water resources caused by natural and artificial reasons in the past 60 years has led to serious degeneration of the ecological environment in this region, and the desert river bank vegetation represented by *Populus euphratica* forests, as the secondary forest developed after the original forest, is obviously declining. The normal growth of *Populus euphratica* mainly relies on groundwater which is inseparable from floods. When groundwater level is below 8 m and its mineralization is over 10 g/l, *Populus euphratica* forests would start to die [70]. Because of rising temperature and precipitation in mountainous area, the total runoff discharge of Tarim River three-source is gradually increasing from 1960 to 2016, especially after 1990. The upstream runoff reduced slightly, but it got down obviously in downstream, and the runoff reduction of main stream is the result of the large-scale cultivation and diversion of humanity [71]. The gradual shrinking area of *Populus euphratica* forest has been affected by some hydrological factors between 1992 and 2009, especially in 1992. However, by 2009, water in most areas was severely deficient, and some areas with low waterdeficiency were gradually reduced and concentrated near the banks of the river. In addition, a large area of dry land has no water. Climate change has the more obvious influence on the spatial distribution pattern of *Populus euphratica* forests. Landsat TM/OLI long-time series remote sensing data from 1990 to 2015 show that *Populus euphratica* forests distribute along the banks of main stream and source branch of Tarim River. The high density of *Populus euphratica* forests distributes along the upstream of Tarim River and the Yeqiang River Basin, with large distribution area and high vegetation coverage. The distribution density of poplar forests in the Tianhe River Basin is lower, with smaller area, lonelier tree species, and lower coverage rate. The patches of *Populus euphratica* forest landscape have shown a gradual disappear characteristic with the smashing process and the disappearance of landscape features [72].

Overall, the drought, windy and frozen, and other extreme climate events have greatly affected the agricultural tourism landscapes in the Ak Philharmon Abra. From 1980 to 2016, XUAR Production and Construction Corps mainly suffered three types of meteorological disasters, resulting in more than 90% of agricultural area affected. After then, these disasters are becoming more and more serious. Extreme weathers have increased as the volatility of meteorological disasters, in the trends of gradually weakened drought, increased wind disaster, and low temperature freezing. The meteorological disasters with long effect cycle have resulted in the low adaptability for agriculture and insufficient self-relief ability [73].

6.4.4. Plant and Bird Watching Tourism Activities. Seasonal tourism activities of plant viewing around the world, such as flowering and leaf discoloration in autumn, have attracted many tourists. The tourism experience of ornamental plants blooming and leaf discoloration has become one of the important tourism resources of tourist destinations. Between 2010 and 2018, the ordinal number of days suitable for peach blossom viewing activities in the XUAR was from the 90th day to the 105th day each year, which is the first ten days of April. As the phenological period of plants such as flowering period is more sensitive to temperature changes, plant viewing and tourism activities, such as flower viewing, are susceptible to climate change. Usually, the temperature of one month before flowering and the temperature of the first three months have the greatest impact on the phenological period of plants. Because most parts of XUAR are located in the southern and the middle temperate zones, the flowering period of peach blossoms in the XUAR has been advanced or delayed to varying degrees from 2010 to 2018. Among them, the flowering period of peach blossoms in Ili Kazak Autonomous Prefecture has been significantly advanced [74]. In addition, the advancement or delay of the flowering period affected by climate change and extreme weather such as low temperatures can cause flowers to fall off, which may also seriously affect the development of flower viewing activities [75]. In addition to peach blossoms, crocus (commonly known as wild lily) and apricot flowers in Xinyuan County, Ili Prefecture, and lavender in Huocheng County are all important plant ornamental tourism resources [25–27].

Bird watching also has certain seasonality. The scale of global bird watching activities has reached tens of millions of people every year, and bird watching tourism has become an important part of the world's wildlife viewing industry. Climate change has resulted in the changes the phenological period of birds and their spatial patterns, thereby affecting the travel cycle of birdwatchers. Through the analysis of 98 phenological sequences of birds in 26 regions of China in the past 20 years, it is found that with the impact of climate change in the past 20 years, the patterns of birds' departure, arrival, residence time, and bird habitat have all changed. The staying time of birds presents an extended trend (the staying time of birds is longer in low latitude areas and western regions), and the pattern of bird habitats shows the characteristics of northward and westward migration [76]. With the warming of the climate, in recent years, the number of winter swans in XUAR has increased. Yining, Korla, Bole, Yanqi, Manas, Bayinbulak, and other places have become tourist destinations for watching swans in winter. From 2007 to 2019, the number of swans in the Peacock River in Korla, XUAR, increased from 19 to 320, from a handful of silver gulls of a single species to the current multiple number of mallard ducks, magpie ducks, merganser ducks, white-eyed porcine gulls, white goosander, red-billed goose, mandarin duck, etc. In 2018, tourists discovered that the first batch of swans that arrived in the Kongque River for wintering was advanced to mid-September. The wintering time of swans has also changed from 51 days to more than 180 days. The number of people who visit Korla to watch swans every year exceeds 100,000, and the peak number even reached hundreds of thousands.

7. Conclusions and Discussion

At present, the impact of climate change on tourism sector in arid areas is omnidirectional. It is expected that these impacts will be long and complex in the future, and tourism needs to be optimized and adjusted in advance. Advantages of tourism climate comfort, such as climate warming and moisture wet, will be more than risks.

Future changes of climate are expected to have continuous impacts on cultural heritage, ice and snow resources, and agricultural landscape (high reliability). The ice and snow landscape resources will continue to subside, which will affect the sustainability of glacier and ski tourism sectors (high reliability). The varied climate may change biological tourism resources and their layouts, and may also change the overall landscape, such as Huyang and other plants (medium reliability). Under the background of climate warming, ice and snow melting runoff will show an increasing trend in a certain period. This may provide positive development opportunities for crop landscapes such as cotton, forest, and fruit, which are highly dependent on water resources in the short term (high reliability) [77]. In addition to the direct impact on tourism, climate change may also be influenced by many negative impacts produced by the tourism support system. Extreme weather events can cause inconvenience of tourism transportation and other tourism activities. After 2000, the frequency of occurrence of persistent high temperature events in northwestern China has been increasing, and the low temperature events were reduced [78]. The increase in high temperature events will mainly affect the development of outdoor tourism activities in summer, and the decrease in extreme cold events will be beneficial to the winter and spring snow tourism.

Overall, the impacts of climate change on tourism will be potential and long-term. As the most potential and vitality industry in the XUAR, some measures should be made, to slow down and adapt to the climatic influence on tourism [79]. Because there are four distinct seasons in Xinjiang, it is necessary to increase the promotion and publicity of tourism climate resources there and advertise the advantages of diverse tourism resources. On the other hand, the tourism destinations and resources in sensitive areas of climate change need to be monitored continuously (including the tourist flows between hot spots). Especially, the cultural heritage is more affected by climate change than other tourism resources, which need further to strengthen climate change and cultural heritage monitoring.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this article.

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