PhD Dissertation of Engineering

Impact of Climate Change on Weather-based Tourism:

Focusing on the demand for outdoor water activities and the operation of ski slopes in South Korea

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Impact of Climate Change on Weather-based Tourism:

Focusing on the demand for outdoor water activities and the operation of ski slopes in South Korea

by

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ABSTRACT

The impact of climate change on the tourism industry is expected to be significant. This is especially true in the case of tourism that requires specific weather conditions to function. It is possible that such forms of tourism will experience radical changes to meet demand and operational difficulties resulting from climate change. Despite this, the academic field of tourism has shown climate change only lukewarm interest. One reason for this attitude might be the fact that the impact of climate change is invisible and long-term, and so at odds with the interests of the tourism industry, which focuses primarily on visible and short-term aspects of business. However, as the seriousness of climate change and its impact becomes more apparent, it is important for researchers to investigate the ways in which it will affect the tourism industry and plan effective countermeasures.

The purpose of this study is to predict changes in weather-based tourism due to climate change and offer meaningful implications that the tourism industry can refer to when preparing to address climate change. This study employs two practical analyses. The first analysis focuses on tourism demand; it analyzes the impact of climate change on the demand for outdoor water activities. The second analysis is focused on tourism supply; it analyzes the impact of climate change on the operation of ski slopes.

For the impact analysis on outdoor water activities, 9 public outdoor swimming pools in 3 megacities, Seoul, Daegu, and Busan, were selected as study sites. To determine the preferred weather conditions for outdoor water activities, the best-fit lines of scatterplots of the Z-score of the number of visitors to each swimming pool and the corresponding temperatures were found. The ranges of the temperature, when the best-fit lines increase, are set as preferred weather conditions for outdoor water activities. To predict changes in the preferred season for outdoor water activities, future weather data for the 2030s, 2060s, and 2090s from RCP (Representative Concentration Pathways) scenarios are adapted to the range of temperature for preferred weather conditions.

In terms of the analysis of the impact of climate change on the operation of ski slopes, all 17 ski resorts in South Korea were selected as study sites. To determine the weather and managerial conditions for the operation of ski slopes, interviews with operators and a review of past weather and operational conditions were conducted. By doing this, the conditions for artificial snowmaking, slope open, and slope close were found. To project future changes in the season of operation for ski slopes, future weather data for the 2030s, 2060s, and 2090s from RCP scenarios were adapted to the conditions of snowmaking, slope open, and slope close. In addition, the sustainability of ski slopes is also examined using the “100-days rule,” which is the minimum required duration of the operation of ski resorts.

The study found that, when it comes to the demand for outdoor water activities, the preferred weather conditions are found at: 24.27 °C to 35.91°C in Seoul, 25.79 °C to 35.30 °C in Daegu, and 26.91 °C to

34.08 °C in Busan. By applying the future weather data to these conditions, it is estimated that the preferred season for outdoor water activity will gradually shift from June to September to May to June and September to October due to extremely hot weather of July and August. The number of days of preferred weather for outdoor water activities will increase from: 126 days at present to 135 days in the 2090s based on RCP 2.6, 149 days based on RCP 4.5, 145 days based on RCP 6.0, and 138 days based on RCP 8.5 in Seoul; 136 days at present to 136 days in the 2090s based on RCP 2.6, 147 days based on RCPs 4.5 and 6.0, and 143 days based on RCP 8.5 in Daegu; 94 days at present to 109 days in the 2090s based on RCP 2.6, 123 days based on RCP 4.5, 127 days based on RCP 6.0, and 136 days based on RCP 8.5 in Busan. If the duration of the non-preferred weather season during July and August due to extreme hot weather is included, the number of days of the preferred season for outdoor water activities is estimated to reach six months in the 2090s.

In terms of the operation of ski slopes, the preferred conditions for operation were found. Artificial snowmaking begins when the temperature reaches -2 °C, the slope is opened 9 days after artificial snowmaking starts, and the slope is closed when the temperature reaches 0 °C. By applying future weather data to these conditions, it is estimated that the ski season will decrease in the future as follows: from around 130 days at present to around 120 days based on RCP 2.0 and RCP 6.0, around 130 days based on RCP 4.5, and 90 days based on RCP 8.5 in the areas where the average temperature of the ski season is below -2 °C; from around 120 days at present to around 120 days based on RCP 2.0 and 4.5, around 100-days based on RCP 6.0, and 60 days based on RCP 8.5 in the areas where the average temperature of the ski season is below 0 °C; from around 90 days at present to around 80 days based on RCP 2.0, around 90 days based on RCP 4.5, around 50 days based on RCP 6.0, and 10 days based on RCP 8.5 in the areas where the average temperature of the ski season is above 0 °C. In addition, it is also estimated that in the 2090s, 16 of 17 ski resorts can survive based on RCP 2.6 and RCP 4.5, 13 ski resorts can survive based on RCP 6.0, and none of the resorts can survive based on RCP 8.5, according to the 100-days rule.

The results of this study show that there will be major changes in weather-based tourism due to climate change. These changes include the expansion of season for summer weather-based tourism activities, including outdoor water activities, and a reduction of season for winter weather-based tourism, including activities such as skiing. In terms of tourism demand, tourists can easily adapt to changing environments due to climate change though the substitution of activities, seasons, and destinations. However, when it comes to tourism operation, operators, who already invested massive budgets into the development of tourist destinations, will experience difficulties in management due to the deterioration of destinations and the loss of tourists due to climate change. Thus, managerial strategies that helps operators flexibly respond to climate change are required.

This study is meaningful in that it suggests landscapes which will be impacted by climate change within the tourism industry, and

takes into consideration future weather-related changes, which have not been studied before in South Korea. To predict more detailed changes and suggest more meaningful countermeasures, future studies that focus on a specific type of tourism industry and a more specific location are required.

Keywords: Climate Change, Tourism Industry, Weather-based Tourism, Outdoor Water Activity, Ski Resort

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I. INTRODUCTION

1. Purpose of the study

Climate is a critical factor impacting the natural and environmental attraction tourists feel for tourist destinations; climate helps determine the natural characteristics of destinations, which include the biosphere, hydrosphere, and geosphere. At the same time, climate itself can be attractive to tourists looking for destinations with specific weather conditions (Gómez Martín, 2005; Kim, Park, & Lee, 2015).

Because of the vital role climate plays for tourist destinations, climate change is naturally of significance to the tourism field at large. The surface temperature of the earth increased approximately 0.85 °C (minimum 0.65 °C to maximum 1.06 °C) from 1880 to 2012, and the rate of global warming has gradually accelerated. Furthermore, it is expected that without efforts to mitigate the effects of climate change, the average surface temperature of the earth will be 4.8 °C higher from 2080 to 2100 than it was from 1986 to 2005 (IPCC 2013).

The changing temperature can have unexpected consequences for tourist destinations (Becken & Wilson, 2013). For example, certain direct changes, such as the geographical and seasonal redistribution of weather-based tourism can occur. As for indirect changes, many tourist destinations could experience biodiversity loss, a reduction in the aesthetic appeal of landscapes, coastal erosion, and more as a result of the socioeconomic and environmental impact of climate change (UNWTO, 2009).

Unfortunately, some of these changes have already come to pass in several areas throughout the world. For example, the number of ski areas in the United States has decreased almost 20 percent in the last two decades (Bagley, 2015). The Great Barrier Reef in Australia has experienced coral bleaching due to a rise in sea temperature; this bleaching has affected 93 percent of the reef (Baird et al, 2016; Ainsworth et al., 2016). In addition, several areas along the Florida, US coast have seen a rise in sea level, and many beaches have suffered from erosion, with some having been lost entirely (The Florida Oceans and Coastal Council, 2010). Furthermore, many natural (e.g. Kilimanjaro in Tanzania, Ilulissat Ice fjord in Denmark) and cultural (e.g. Djenné mosque in Mali, rice terraces in the Philippines) world heritages sites have been threatened by climate change (UNESCO & UNEP, 2016)

As these changes have been recorded and their alarming implications more clearly understood, many tourism organizations, such as UNWTO, UNESCO and UNEP, have reported expected future changes resulting from climate change and provided countermeasures to mitigate the damage it causes (UNWTO, 2009; UNESCO & UNEP, 2016). A number of scholars in a wide range of countries have studied possible future changes to the tourism industry due to climate change (Scott, 2003; Harrison et al., 1999), damages (Nyaupane & Chhetri, 2009; Elsasser & Bürki, 2002), and alternative approaches (Adler et al., , 2012; Scott & McBoyle, 2007; Wong et al., 2012) which may help to alleviate these damages.

In contrast to the international landscape, South Korea has not been very interested in climate change (An, 2012). There are many possible reasons for this lukewarm attitude toward the issue, and one of the main reasons may be the lack of severe damage to South Korea from climate change at present. In addition, the lack of urgency and visibility associated with the threat of climate change may make people uncertain that this is a problem that will come to be fully realized.

However, there have been many signs warning that South Korea is not exempt from the effects of climate change. For example, in the summer of 2015, 1,056 cases of heat-related diseases were recorded, 11 of which resulted in death (Korea Centers for Disease Control and Prevention, 2015), and during the winter of 2015-2016, 483 cases of cold-related diseases were recorded, resulting in 26 deaths (Korea Centers for Disease Control and Prevention, 2016). Beyond that, there has been an increase in a diverse range of abnormal climatic weather conditions, such as heavy snow, heavy rain, and drought, and the damage caused by these conditions has also intensified (Korea meteorological administration, 2016). These show that the society of Korea will see physical and environmental changes in the near future as a result of climate change.

The tourism industry in South Korea is not exempt from the impact of climate change and the damage it causes. As the tourism industry largely depends on weather conditions for its operation, the damage from climate change in this area would be significant (Kim, 2008; Kim, 2009). This is the why studies on the effects climate change has and will have on the tourism industry are necessary.

The purpose of this study is to determine possible changes in the tourism field due to climate change and to offer meaningful implications to the tourism industry in South Korea. In particular, this study focuses on the direct effects of climate change on weather-based tourism, which is the type of tourism most vulnerable to climate change.

It is expected that the results of this study could act as a valuable message to the tourism industry and can contribute to the development of procedures that will improve the sustainability of related businesses.

2. Scope of the study

The scope of this study is the direct impact of climate change on tourism. To clearly investigate the impact of climate change on tourism, this study concentrates on tourism activities wherein the main attractions are very closely related to and dependent on specific weather conditions, such as sun, sand, sea, and snow tourism, meaning they are the most vulnerable form of tourism to climate change (Schott, 2010). This type of tourism, wherein the main attraction is heavily dependent on certain weather conditions, is referred to as *weather-based tourism* in this study.

This study will employ two practical analyses that estimate the impact of climate change on weather-based tourism. The first analysis focuses on the demand side of tourism. To investigate the geographical and seasonal demand changes within tourism resulting from climate change, this study analyzes the changes in the demand for outdoor water activities, which are highly dependent on comfortable weather conditions (Kim, Park, & Lee, 2015).

The second analysis focuses on the supply side of tourism. To research the operational changes of tourist destinations due to climate change, this study analyzes changes in the operation of ski slopes, which are also fundamentally dependent on weather conditions for the creation and maintenance of natural and/or artificial snow (Kim et al., 2015).

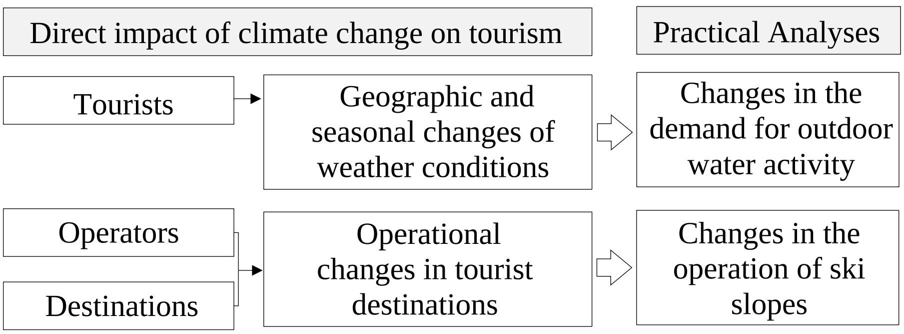


Figure 1. Scope of the study

The spatial scope of this study is South Korea. Practical analyses will be conducted on specific sites that can observe the changes in the demand for outdoor water activities and the operation of ski slopes. The temporal scope of this study is from the present to 2100.

3. Research questions and outline

This dissertation is based on two research questions: 1) what are the weather conditions that lead to a demand for outdoor water activities and operation of ski slopes; and 2) what changes in the demand for outdoor water activities and the operation of ski slopes will occur in accordance with changes in weather conditions due to climate change.

To provide answers to these questions, first, related literature is reviewed. The relationships between tourism, weather, and climate, as well as climate change trends and its projected trends are reviewed. Previous studies that estimated the effects of climate change on the demand for outdoor water activities and the operation of ski slopes are also reviewed.

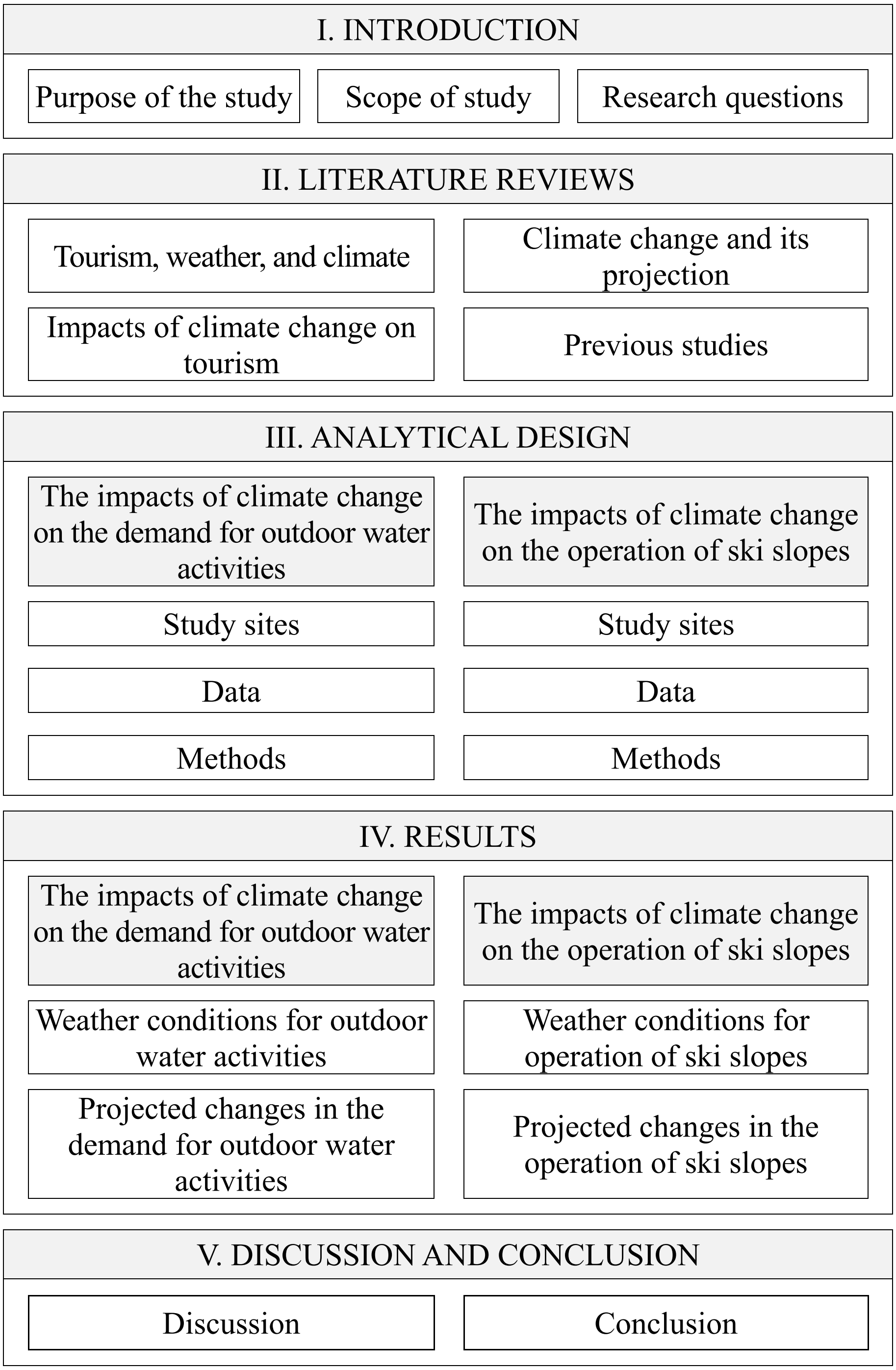


Figure 2. Outline of the dissertation

Secondly, analytical design for practical analyses is conducted. This includes the scope, data, and methods of the analyses of the impact of climate change on the demand for outdoor water activities and the operation of ski slopes.

In the results, the weather conditions determining the demand for outdoor water activities and the operation of ski slopes are found. In addition, the future changes in demand and operation due to climate change are predicted.

Lastly, the results and implications of the study are discussed, and the importance and limitations of this dissertation are detailed in the conclusion.

II. LITERATURE REVIEW

1. Tourism, climate, and weather

People desire to escape from their daily routine and seek new experiences. Tourism is one of the activities that allows humans to fulfill this desire (Dann, 1996). As the purpose of tourism is the experience of an unfamiliar environment, this naturally involves geographic movement from one’s origin (usual area) to a destination (unusual area). This human movement and the activities associated with tourism generate business, leading to attractions and accommodations for tourists. Thus, tourism is perceived as an industry that is structured by the demand of tourists and the supply of their destinations (Leiper, 1990; Gunn, 1994).

Meanwhile, weather is a state of the atmosphere in a given place at a given time, which includes temperature, humidity, precipitation, wind speed, etc., and climate is the dominant condition of the atmosphere over a long-term period, typically at least 30 years (Kwon, 2012).

The influence of weather on tourism is more short-term and more direct. de Freitas (2003) described three facets of the impact of weather on tourism: thermal, physical, and aesthetic. The thermal facet is tourists' perceived thermal sensations and comfort based on the atmospheric environment, which includes temperature, humidity, and wind speed. The physical facet is the existence of specific meteorological elements, such as rain, snow, and high wind, which directly affects or limits tourists' activities. The aesthetic facet is scenic comfort based on visibility, sunshine, and cloudiness with prevailing synoptic conditions.

The impact of climate on tourism is more long-term and macro compare to the impact of weather on tourism. Specifically, climate implies comfortable weather conditions at specific tourist destinations which intrigues and allows tourists to introduce the tourism industry to these destinations. In addition, long-term climate impacts the natural and socioeconomic environment of regions and leads to the formation of tourist attractions that generate tourism industry (Scott, Hall & Gössling, 2012).

Because of the close relationship between tourism, weather, and climate, tourism is often called a climate-dependent industry (Amelung & Viner, 2007). The dependency on climate and weather is much more significant in types of tourism where the main attraction at a given location is weather conditions, such as sun, sea, sand, and snow tourism (Schott, 2010). This study concentrates on this type of weather-based tourism to examine the impact of climate change on tourism more clearly.

2. Climate change trend and its projection

Due to the emergence of human beings and their extraction of resources from the planet and use of fossil fuels, the earth has experienced significant changes. Climate change is one of the most concerning changes that the planet has experienced. By removing the natural resources that purify environmental contaminants and by generating carbon dioxide from the use of fossil fuels, humans have caused an imbalance on Earth. This imbalance directly affects the climate and is responsible for climate change (Kwon, 2012).

The temperature of Earth's surface has increased, and the frequency of extreme events, such as heat waves, heavy rain, and storms, has increased as well (IPCC, 2013). According to a report from the IPCC (Intergovernmental Panel on Climate Change) in 2013, the temperature of the Earth's surface has increased an average of 0.85 °C in the last 100 years. In some areas, the temperature has increased as much as 1.06°C. Because of the rapid changes resulting from climate change, there have been numerous efforts to counteract these changes. One of these involves predicting future effects of climate change to help prevent and prepare for them.

To predict these future changes, many climate projection models have been developed since the 1970s. The first stage models only focused on the levels of carbon dioxide in the atmosphere (AGCMs: Atmospheric General Circulation Models). Next generation models added considerations for ocean circulation (AOGCMs: Atmosphere-Ocean Global Circulation Models), and the most recent models include considerations for physical and chemical dynamics and interactions in the atmosphere (ESMs: Earth System Models) (Kwon, 2012). The model utilized by the National Meteorological Center of South Korea is HadGEM2-AO, which considers atmosphere, ocean, sea ice, water, and aerosol. The future climate data used by this study were obtained from the HadGEM2-AO model.

In addition, for the estimation of climate change, scenarios that project the level of greenhouse gasses and aerosols have also been developed. In 1992, IPCC developed IS92 scenarios that predicted socioeconomic and environmental changes, and in 2000, they developed SRES (Special Report on Emissions Scenarios) scenarios, which were updated with the latest information (IPCC, 2000). In 2009, IPCC developed the RCPs (Representative Concentration Pathway [of Carbon Dioxide]), which consider efforts to mitigate climate change, and announced the AR5, which suggested four climate change-related scenarios in 2013 (Kwon, 2012).

The four scenarios provided by the RCPs are 2.6, 4.5, 6.0, and 8.5. The 2.6 scenario is the most positive of these and assumes that climate change will be halted by mitigation efforts. The 4.5 scenario assumes the maintenance of the current climate change trend, the 6.0 scenario assumes the trend will continue in spite of mitigation efforts, and the 8.5 scenario is the most negative scenario, which assumes climate change will continue at its current rate without any effort made to curtail it.

Based on the RCP 2.6 scenario, the temperature of the Earth's surface will increase 1.0 °C (minimum 0.3 °C, maximum 1.7 °C) until 2081 to 2100, and according to the RCP 4.5 scenario, it is expected that the temperature will increase 1.8°C (minimum 1.1°C, maximum 2.6 °C). The RCP 6.0 scenario estimates that the temperature in 2081 to 2100 will be 2.2°C (minimum 1.4 °C, maximum 3.1 °C) higher than it is at present, and the RCP 8.5 scenario predicts that the temperature will be 3.7°C (minimum 2.6°C, maximum 4.8°C) higher than at present (IPCC, 2013). In addition, it is also believed that extreme events, such as heavy rain, heavy snow, heat waves, storms, and so on, will become more frequent in the future (IPCC, 2013) (Table1).

Table 1. Projected future temperature changes by the RCP Scenarios.

Scenarios	Radiative forcing (W/m2)	Concentration of CO2(ppm)	Temperature (°C)					
			2046 to 2065			2081 to 2100		
			Min	Mean	Max	Min	Mean	Max
RCP 2.6	2.6	420	0.4	1.0	1.6	0.3	1.0	1.7
RCP 4.5	4.5	540	0.9	1.4	2.0	1.1	1.8	2.6
RCP 6.0	6.0	670	0.8	1.3	1.8	1.4	2.2	3.1
RCP 8.5	8.5	940	1.4	2.0	2.6	2.6	3.7	4.8

Source: IPCC (2013)

3. Impact of climate change on Tourism

As mentioned previously, tourism depends heavily on climate and the socioeconomic and environmental conditions that are influenced by climate conditions. Thus, a change in climate influences tourism directly and indirectly through changes in environmental and socioeconomic systems (Figure 3).

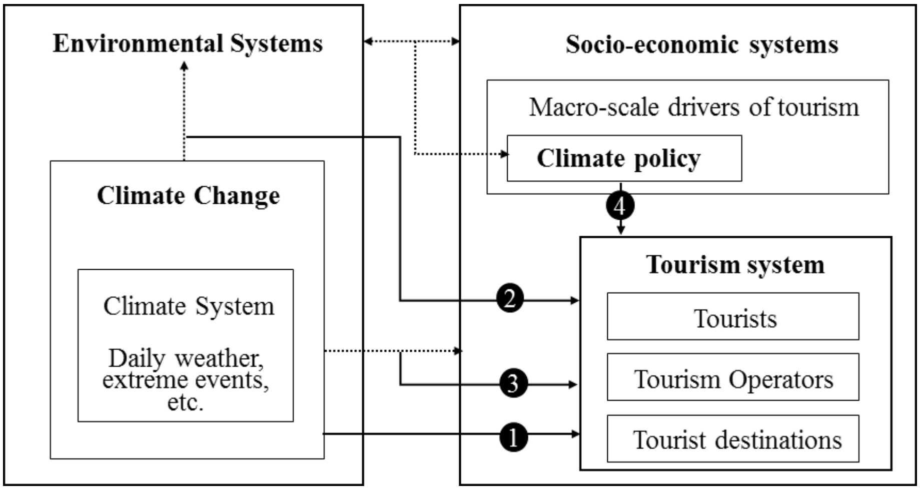


Figure 3. Pathways of climate change impacts on tourism. Adapted from Tourism and climate change (p.190), by Scott, Hall & Gössling, 2012, NewYork, NY: Routledge. Copyright 2012 by Daniel Scott, C. Michael Hall and Stefan Gössling.
(1: direct climatic impacts, 2. Indirect environmental change impacts, 3. Indirect societal change impacts, 4. Indirect mitigation policies impacts)

The direct impact of climate change on tourism results from changes in weather conditions and extreme weather events that occur in tourist destinations. These changes and events cause the geographic and seasonal redistribution of climate resources for tourism and generate additional operating costs for heating-cooling degree-days, insurance premiums, etc.

Table 2. The impact of climate change on tourism

Type	Impacts on Tourism
Direct climatic impacts	Geographic and seasonal redistribution of climate resources for tourism, changes in operating costs (heating-cooling degree days, insurance premiums), etc.
Indirect environmental change impacts	Climate induced-environmental changes such as water shortages, biodiversity loss, decline of landscape aesthetic, increase in vector-borne disease, damage to infrastructure, etc.
Indirect societal change impacts	Consequences of the broader impact of climate change on societies, such as changes in economic growth, development patterns, social-political stability and personal safety in some regions.
Indirect mitigation policies impacts	Changes in tourist flow due to increased prices, alterations to aviation routes, changes in the proportions of short-haul and long-haul flights, etc.

Source: UNWTO & UNEP (2008)

The indirect impact of climate change concerns changes in environmental and socioeconomic conditions due to climate change, as well as the implementation of policies to deal with climate change. The indirect impact of environmental changes includes water shortages, biodiversity loss, a decline in landscape aesthetics, an increase in vector-borne disease, damage to infrastructure, etc. The indirect impacts from societal changes include changes that are caused by economic growth, developmental patterns, sociopolitical stability and personal safety in some regions. The indirect impacts from policies include changes in tourist flow due to increased prices of tourism and flight tickets, alterations to aviation routes, changes in the proportions of short-haul and long-haul flights, etc. (Scott, Hall & Gössling, 2012; UNWTO & UNEP, 2008) (Table 2).

Not all effects of climate change have a negative impact on tourism. For example, in some areas located at high altitudes and latitudes it is possible to experience expansions of the tourism season because of the warmer weather. However, the positive impacts of climate change is considerably outweighed by its negative effects (Kim, 2008). Thus, the field of tourism should first focus on the negative effects of climate change, especially those that have a direct impact, which are more urgent.

This study focuses on the direct impact of climate change on weather-based tourism, which is most vulnerable to climate change. This study involves two practical analyses to investigate this impact. The first analysis concerns the impact of climate change on the demand for outdoor water activities, and the second analysis is climate change's impact on the operation of ski resorts.

4. Previous studies estimating the impact of climate change on tourism

4.1. The impact on the demand for outdoor water activities

As people naturally prefer comfortable weather conditions, tourists prefer to travel to places with more comfortable weather (Gómez Martín, 2005). Thus, weather functions as a major component of all tourists' choice of destination (Um & Crompton, 1990; Gössling, Scott, Hall, Ceron, & Dubois, 2012). Weather plays an even more vital role in tourism destinations where weather conditions are the main attraction (Hu & Ritchie, 1993; Schott, 2010). This is one of the reasons why tourist resorts are concentrated in specific regions, which offer comfortable weather conditions throughout the year (Gómez Martín, 2005).

Many researchers have claimed that there are specific weather conditions that are preferred by tourists and have investigated what these weather conditions are. The very first study about this issue was performed by Mieczkowski (1985). He determined comfortable climate conditions for tourism, which include specific temperatures, humidity and wind conditions and named it TCI (Tourism Climate Index). It was meaningful in that this study attempted to find adequate climate conditions for tourism activities for the first time. However, it was criticized, not only because the climate conditions were identified through literature review and expert surveys without supplemental practical data, but also because this study did not consider different types of tourism.

Since this study, many scholars have tried to develop more accurate climate conditions for specific tourism activities. de Freitas et al. (2007) conducted a survey with potential tourists on their preferred climate conditions for 3S (sun, sea, and sand) tourism activities, articulated optimal climate conditions, and called it the CIT (Climate Index for Tourism). Becker (1998) developed the BCI (Beach Comfort Index) by analyzing thermal perception and human body stress and applied it to the beaches of South Africa. Morgan et al. (2000) surveyed tourists on the beaches of the Mediterranean about adequateness of current climate for their beach tourism and developed the User Based BCI. Scott, Gössling, & de Freitas (2008) surveyed students in Canada, New Zealand and Sweden about their preferred climate conditions for tourism in beaches, urban areas, and mountains within each country and determined comfortable climate conditions for each. Hewer, Scott,

& Gough (2015) figured out the preferred climate for camping activities by surveying visitors to campgrounds in Ontario, Canada.

These studies commonly mentioned that tourists are more interested in going to locations as their temperature increases, but that this preference declines after the temperature reaches a specific threshold (Figure 4).

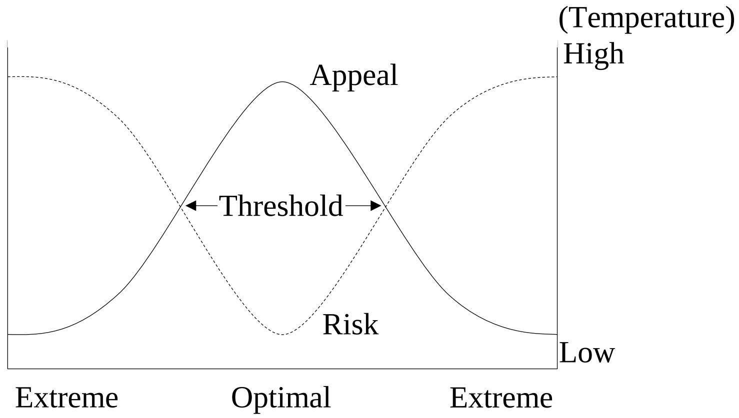


Figure 4. The thermal preference of tourists. Adapted from Tourism and climate change(p.64), by Scott, Hall & Gössling, 2012, NewYork, NY: Routledge. Copyright 2012 by Daniel Scott, C. Michael Hall and Stefan Gössling.

The threshold for the increase of tourists' interest in traveling to a particular area in the previous studies was around 20°C to 27 °C for general tourism, and 25°C to 35.5 °C for beach tourism in these studies (Table 3).

Table 3. Preferred weather conditions for tourism activities according to the survey-based studies

Type	Study	Methods	Preferred Weather Conditions
General	Mieczkowski (1985)	Survey of experts and literature review	20~27 °C; Up to 15mm rain; Up to 10hour sunshine; Up to 5 km/h wind speed
Beach	de Freitas et al. (2007)	Survey of potential tourists	Slightly warm or warm with clear skies or scattered clouds
	Morgan et al. (2000)	Survey of on-site tourists	32.5~35.5 °C
	Scott, Gössling, & de Freitas (2008)	Survey of potential tourists	24.9~ 28.5 °C
Mountain	Scott, Gössling, & de Freitas (2008)	Survey of potential tourists	20.5 °C
Camping	Hewer et al., (2015)	Survey of on-site tourists	24~31 °C

These studies are meaningful in that they have attempted to discover weather conditions that tourists prefer. However, these studies have their limitations. First, because these studies are based on tourists' surveys, which are based on opinions rather than actual behavior, it is unclear whether stated preferential weather conditions are actual preferred conditions (Scott et al., 2008). In addition, there is a possibility that the concept of preferred weather differs between tourists

(Moreno & Amelung, 2009). Thus, Falk (2014) and (Lise & Tol, 2002) analyzed the relationship between the number of tourists and weather conditions to determine preferred weather conditions in a data-driven and objective manner. However, these studies are also limited in that they were conducted considering demand on an international level, where many non-weather factors might affect the demand of tourists, including currency and other international situations.

Secondly, because these studies were conducted on very popular tourist destinations, especially when researching outdoor water activities, the sites were world-class beaches, which had other noteworthy attractions, such as the landscape and nearby facilities. Because these diverse attractions (e.g. beach itself, accommodations, and landscapes) may overwhelm the dissatisfaction from weather conditions (Alegre & Garau, 2011), weather satisfaction is difficult to separate from the satisfaction provided by other nearby attractions (Kim, Park, & Lee, 2015).

In order to overcome these limitations, this study employs several strategies. This study specified the type of tourism being examined as tourism related to outdoor water activities and conducted data-based analysis using the data of number of visitors and weather conditions. Here, in order to focus on the effect weather has on tourism and control other attributes of the tourist destination, this study selected public urban outdoor swimming pools as study sites. Because the public pools offer limited attractions and services, unlike beaches or pools managed by private companies that offer diverse attractions like rides, non-weather-related influences are minimized. The selected pools are located in urban areas, which offer good accessibility so visitors can decide to visit the pools on the morning of visitation with consideration for contemporary weather conditions (Kim, Park, & Lee, 2015).

Meanwhile, studies of the projected changes over time in the demand for tourism, especially tourism related to outdoor water activities, have been conducted. Research in this regard has focused on how preferred tourism seasons and destinations will be affected by climate change. Amelung & Viner (2006) and Scott, McBoyle, & Schwartzentruber (2004) analyzed the TCI of popular tourist destinations, such as the Mediterranean and Miami, and estimated the change of the tourism seasons for these cities resulting from climate change in the future. Moreno & Amelung (2009) analyzed the BCI of European beaches and predicted changes in climate comfort provided by the beaches when the long-term effects of climate change are accounted for.

These studies commonly claimed that comfortable weather areas will move north due to global temperature increases, and the preferred season at present, normally July to August, will be less preferred in the future because of hot weather, while seasons that are less preferred now will become more popular because of their warmer weather.

4.2. The impact on the operation of ski slopes

Skiing is only available at specific weather conditions that meet the requirement of cold temperatures for either natural snowfall or snowmaking. Thus, the operation of ski slopes is a good way to study the impact of climate change on tourism.

Studies related to ski slopes started in the 1990s, when climate change began to be recognized as a global issue. The first studies analyzed the trends of snowfall based on observed climate data and suggested expected managerial difficulties due to the lack of snow in the future (Division & Vic, 1996; Koenig & Abegg, 1997; Elsasser & Bürki, 2002; Fukushima et al., 2002).

In the 2000s, following a development and expansion of artificial means of snowmaking, studies that focused on weather conditions for making artificial snow began to appear. Researchers have developed ski season simulation models that suggest the threshold temperature for snowmaking, slopes' opening and closing dates, and projected future operational changes for ski slopes due to climate change (Kim et al., 2015).

One of the most representative models was the SkiSim developed by Scott et al. (2003). It employed interviews with ski slope managers and investigated past data concerning snow conditions and operations based on the ski slopes in southern Ontario, Canada. The conditions for the operation of ski slopes in SkiSim are found below. Artificial snowmaking is available from <-5°C (with improved technology this becomes <-2°C), and ski slopes are open when snow depth is greater than 30cm and closed when it is less than 30cm. The ski season was calculated as the number of days the slopes are open (Table 4). In 2010, Steiger added a natural snowfall module to the SkiSim and named it SkiSim 2.0. Steiger (2010) also added altitude difference to the model.

Table 4. The conditions for the operation of ski slopes

	SkiSim (Scott et al, 2003)
Snowmaking threshold	<-5°C (in the condition on improved technology <-2°C)
Open	snow depth > 30cm
Close	snow depth<30cm; maximum temperature 10℃ for 2 consecutive days accompanied by liquid precipitation; or 2d of liquid precipitation totaling>20mm
Ski Season	Number of open days

Scott et al. (2003) applied the SkiSim to the ski slopes in Ontario, Canada and projected future operational days based on the data from the SRES future climate scenario. Steiger (2010) applied SkiSim 2.0 to the ski slopes in Tyrol, Austria and projected future operational periods using the SRES scenarios. The results showed that the operational season of ski slopes would decrease from its present 123 days to a maximum of 73 days in the 2090s in Ontario, and would decrease from 136 days to a maximum of 2 days in the 2090s in Tyrol (Table 5).

Furthermore, there have been many studies that projected future changes in ski slope operations due to climate change (Table 6). Each study predicted that ski seasons will decrease in duration in the future. Depending on regions and future climate, some ski slopes were expected to experience around a 90% decrease in operational days while others were expected to experience only a slight decrease.

Table5. Projected future changes in the operational season (days) of ski resorts by SkiSim

Regions	Ontario, Canada (Scott, 2003)						Tyrol, Austria (Steiger, 2010) A resort		B resort		C resort	
Climate change scenario	HadCM3-B2	CGCM2-B2	CSIRO-A2	CCSR-IS92a	HadCM3-IS92a	CGCM1-IS92a	B1	A1B	B1	A1B	B1	A1B
Present	123	123	123	123	123	123	136	136	136	136	166	166
2030s	123	118	114	112	114	107	136	125	131	134	164	161
2060s	116	114	104	102	104	91	124	103	122	97	158	161
2090s	112	104	73	78	86	75	92	12	54	2	153	130

Table 6. Projected future changes in the operational season of ski resorts in previous studies

Region	Ski season (days) change	Period	Future climate scenarios	Source
Sälen, Sweden	- 40.0 %	2070s-2100s	SRES B2	Moen & Fredman (2007)
Sälen, Sweden	- 59.0 %	2070s-2100s	SRES A2	Moen & Fredman (2007)
Tylor, Austria	- 93.7 %	2080s	SRES A1B	Steiger (2010)
Tylor, Austria	- 32.4 %	2080s	SRES B1	Steiger (2010)
Northeast area, U.S.	-3.4 %	2040s-2060s	SRES B1	Dawson, Scott & Mcboyle (2009)
Northeast area, U.S.	-10.9 %	2040s-2060s	SRES A1B	Dawson, Scott & Mcboyle (2009)
Quebec, Canada	-34.0 %	2050s	SRES A1	Scott, McBoyle, & Minogue (2007)
Quebec, Canada	- 5.0 %	2050s	SRES B2	Scott, McBoyle, & Minogue (2007)
Ontario, Canada	-50.0 %	2080s	SRES A2	Scott et al. (2003)
Ontario, Canada	-11.0 %	2080s	SRES B2	Scott et al. (2003)

Meanwhile, according to previous studies, the minimum operational days necessary to maintain the business of ski resorts was found to be 100 days (Scott, McBoyle, & Minogue, 2007; Steiger & Stötter, 2013; Koenig & Abegg, 1997). According to the 100-days rule, it was expected that many of the current ski slopes will close in the future because of the shortening of the season for the ski slopes' operation.

These studies have played an important role in offering information about the uncertain future of ski resorts and suggesting practical implications. However, most of these studies were performed at large scale ski slopes in Austria and Canada, and results of the studies are somewhat difficult to apply at small-scale ski slopes. The ski slopes with smaller sizes have very different environmental conditions compared to larger ones. For example, small ski resorts are located at lower altitudes, have smaller and narrower ski slopes, and largely depend on artificial snow due to a lack of snowfall. Because of these differences, the operational conditions and future changes due to climate change may differ from large ski resorts (Kim et al., 2015).

Thus, this study attempts to analyze the impact of climate change on ski slopes in the context of South Korea, which has small-scale ski slopes. Even though there were several studies that analyzed the impact of climate change on a couple of ski slopes in South Korea (Heo & Lee, 2008; Heo & Lee, 2012), these studies did not include all of the ski slopes in Korea and used SRES scenarios, which is a previous version of the RCP scenarios, that did not consider mitigation efforts regarding climate change. Therefore, in this study, all of the ski slopes in Korea were included. In addition, this study will use RCP scenarios, which are an updated version of the SRES scenarios. The basic analysis unit will be set at 1km x 1km to increase the accuracy of the analysis (Kim et al., 2015).

III. ANALYTICAL DESIGN

1. The analysis of the impact of climate change on the demand for outdoor water activities

The analysis of the impact of climate change on outdoor water activities is conducted in two stages. The first stage is focused on figuring out the preferred weather conditions for outdoor water activities, and the second stage involves applying future climate data to the preferred weather conditions to predict future changes in the demand for outdoor water activities.

As mentioned in the chapter concerning literature reviews, there are three types of study utilized to investigate tourists' weather preferences: expert survey-based, tourist survey-based, and data on number of visitors-based (Mieczkowski, 1985; de Freitas et al., 2007; Becker, 1998; Morgan et al. 2000; Rutty & Scott, 2014). Because the data-based analysis is relatively objective as it is based on tourists' actual behavior (visitation) rather than opinion (stated preference) (Scott et al., 2008), this study employs the analysis of the number of visitors to ascertain the preferred weather conditions for outdoor water activities.

1.1. Study sites

Many recreational sites for outdoor water activities have numerous attractions aside from the weather, which can overshadow the role of weather conditions in the appeal of the sites (Alegre & Garau, 2011). Thus, to minimize the non-weather impacts on the tourist demand in a particular setting, this study selected public outdoor swimming pools as study sites, which offer limited attractions and services. In addition, in order to select the sites, which visitors can decide to visit the morning of their visitation, this study chose to focus on pools in megacities, which are easily accessible.

Seoul, Daegu, and Busan were selected from the 7 megacities in South Korea, all of which have a population greater than 1 million, with consideration for geographical characteristics. Seoul is the capital of South Korea located in the northwestern portion of the country, Daegu is basin-like, and so one of the hottest cities of South Korea, and Busan is a coastal city that is located at the far southeastern portion of South Korea.

According to the climatic data of the Korea Meteorological Administrator, maximum temperatures during summer (July and August) in 2014 were 29.18 °C in Seoul, 31.30°C in Daegu, and

28.53°C in Busan. Average temperatures during the summer were 25.57 °C in Seoul, 26.76 °C in Daegu, and 25.40 °C in Busan. Precipitation during summer was recorded as 20.93 mm in Seoul, 14.53 mm in Deagu, and 19.03 mm in Busan. Number of tropical nights were 8.8 days in Seoul, 16.7 days in Daegu, and 14.2 days in Busan (Table 7).

Table 7. Climatic characteristics during summer for Seoul, Daegu, and Busan

	Temperature-mean (°C)	Temperature-max (°C)	Discomfort index-mean	Discomfort index-max	Precipitation (mm)	Number of tropical nights
Seoul	25.57	29.18	75.11	80.62	20.93	8.8
Daegu	26.76	31.30	76.47	83.26	14.53	16.7
Busan	25.40	28.53	75.29	80.22	19.03	14.2

(Averages of June to August of 2014)

From these cities, all public outdoor swimming pools that collected data on the number of visitors were selected as study sites. Thus, six pools (e.g. Yeouido, Thukseom, Mangwon, Gwangnaru, Ttukseom and Jamsil) in Seoul, one pool (e.g. Dooryu) in Daegu, and two pools (e.g. Hwamyung and Onchenoncheno) in Busan were selected (Figure 5).

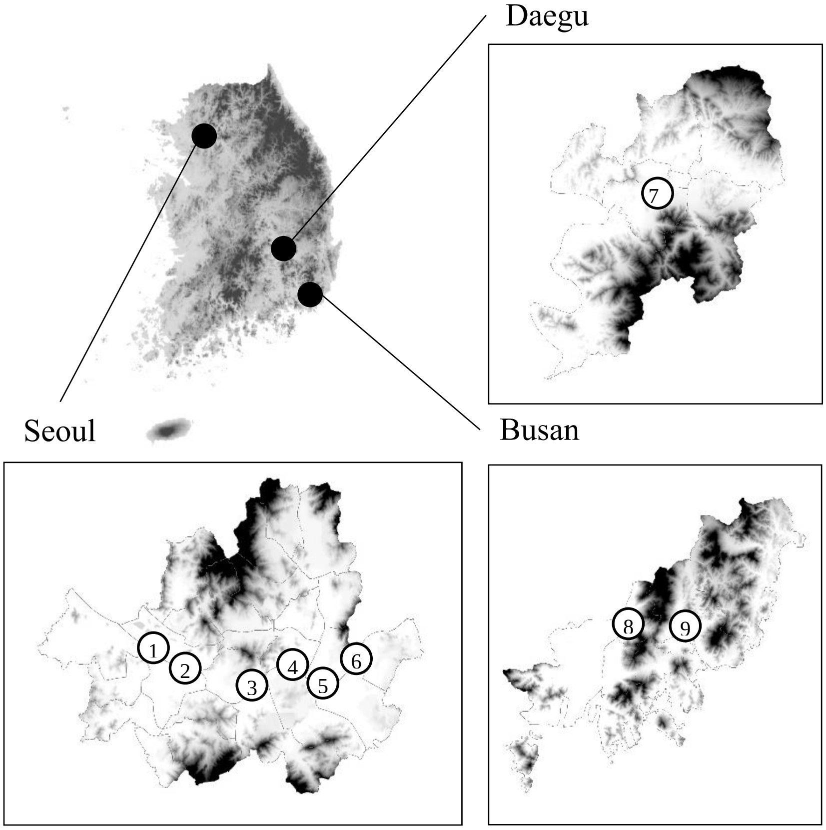


Figure 5. Study sites for the analysis of the impact of climate change on demand for outdoor water activities
(Names of outdoor swimming pools: 1=Mangwon, 2=Yeouido, 3=Jamwon, 4= Ttukseom, 5=Jamsil, 6=Gwangnaru, 7=Dooryu, 8=Hwamyung, 9=Onchenonchen)

The size of outdoor swimming pools in Seoul are 20,000 m^2 to 28,000 m^2 and their capacity averages 3,000 to 3,600 persons with the exception of the Gwangnaru swimming pool (Size: 1,200 m^2, Capacity: 1,200 persons). The size of the outdoor swimming pool in

Daegu is 3,625 m^2 and its capacity is 5,500 persons. The sizes of the two pools in Busan are 9,966 m^2 and 210 m^2, and their capacities are 5,000 persons and 200 persons (Table 8).

From 2009 to 2013, the average number of visitors per day to the six pools in Seoul was between 500 to 2,500 persons. During the period of 2008 to 2014, the average number of visitors per day to the pool in Daegu was around 900 persons. From 2012 to 2014, the average number of visitors per day for the two pools in Busan was around 450 to 1,500 persons (Table 8).

Table 8. The information on study sites (swimming pools)

	Outdoor Swimming Pools	Area[a] (m^2)	Capacity [a] (persons)	Number of Visitors [b] (persons)		
				Max	Mean	Min
Seoul	Yeouido	20,000	3,600	8,795	1,429	14
	Ttukseom	21,000	3,500	10,534	2,571	13
	Mangwon	23,493	3,300	7,412	1,215	11
	Gwangnaru	9,630	1,200	2,519	530	11
	Jamsil	27,945	3,400	2,353	536	13
	Jamwon	23,325	3,000	1,946	485	12
Daegu	Dooryu	3,625*	5,500	2,773	894	18
Busan	Hwamyung	9,966	5,000	4,980	1,448	40
	Onchenonchen	210*	200	1,300	451	50

[a] Ministry of culture, sports, and tourism (2012), Current state of public sports facilities in South Korea
[b] Management organization of each swimming pool (Soul: 2009 to 2013, Daegu: 2008 to 2014, Busan: 2012 to 2014)
* The area of pool with water only

1.2. Data

There have been a couple of studies that found preferred weather conditions for tourism using the data on the number of visitors to a site (Falk, 2014; Lise & Tol, 2002). Even though these studies focused on general tourism rather than outdoor water activity and were conducted on an international level, there has been no specific study that focused on outdoor water activity in urban areas. Thus, if we consider the variables of this study, these studies include number of visitors, area, distance, and year in study models.

This study used the variable of number of visitors and controlled the differences within swimming pools (e.g. area and distance) and years by using the Z-score of number of visitors to each swimming pool each year. Additionally, this study also controlled the differences between weekday and weekend visitation by only using weekday data.

The number of daily visitors were gathered from management organizations for each swimming pool. The data was used accounting for: 896 days for the six pools in Seoul from 2009 to 2013, 181 days for the one pool in Daegu from 2008 to 2014, and 117 days for the two pools in Busan from 2012 to 2014.

The calculation formula of the Z-score is below.

$$\text{Zscore} = \frac{x - u}{\sigma}$$

(x: score, μ:mean, σ: standard deviation)

Meanwhile, in terms of weather data, in previous studies, precipitation and wind speed (physical factors), temperature and humidity (physiological factors), and cloudiness and duration of sunshine (psychological factors) were used (Gómez Martín, 2005; Scott et al., 2008; Morgan et al., 2000; Moreno et al., 2008; Rutty & Scott, 2014). However, wind speed, cloudiness and sunshine duration influence satisfaction at the on-site stage, rather than when making the decision to visit in the planning stage (Yu & Walsh, 2009). Thus, these three factors were excluded from the variables. In addition, humidity was replaced with a discomfort index (the impact of heat stress on the individual through the status of temperature and humidity). This is because what humans practically feel is a complex discomfort status rather than isolated humidity (Kim, Park, & Lee, 2015).

Thus, the data for maximum temperature, precipitation, and humidity were gathered from regional meteorological stations, which are located near each outdoor swimming pool, and the discomfort index were calculated. The calculation of the discomfort index also adapted the formula that was used by the Korean Metrological Administration.

$$\text{THI} = \frac{9}{5}T - 0.55(1 - RH)\left(\frac{9}{5}T - 26\right) + 32$$

(T: temperature (°C), RH: relative humidity (%))

The projected climate data for estimation of changes in the demand for outdoor swimming pools were extracted from the RCP (Representative Concentration Pathway) 2.6, 4.5, 6.0, and 8.5 scenarios. The scenarios, which are based on the HadGEM2-AO climate change projection model, were provided by the Korean Metrological Administration and Climate Change Information Center. The data resolution was set on a 1km x 1km scale.

1.3. Methods

The first step of the analysis is determining the preferred weather conditions for outdoor water activities. To accomplish this, the correlation between number of visitors and weather conditions was verified through the correlation analyses of the number of visitors and each weather element including temperature, discomfort index, and precipitation. In terms of the analysis of the correlation between number of visitors and precipitation, only the data of rainy days were included.

After the confirmation of the correlation between number of visitors and weather conditions, the preferred weather conditions for outdoor water activities were analyzed by finding the best-fitting line from scatterplots of the number of visitors for each weather element using OLS (ordinary least squares). To find the most reasonable lines, the adequacy of linear, quadratic, and log lines were tested.

The preferred weather conditions for outdoor water activities were found from the inflection points of the best-fitting lines. To verify if weather conditions from this analysis were reasonable, the graphs for actual number of visitors and weather conditions were visually compared.

Based on the preferred weather conditions for outdoor water activities, future changes in the preferred season for the use of outdoor swimming pools were predicted by applying future climate data for the 2030s (2031 to 2040), 2060s (2061 to 2070), and 2090s (2091 to 2100) to the weather conditions.

2. The analysis of the impact of climate change on the operation of ski slopes

In this study, the analysis of the impact of climate change on ski slopes is conducted in two stages. The first stage was centered on specifying the weather conditions for the operation of ski slopes in South Korea. Secondly, to these weather conditions, future climate data were applied to predict changes in the operation of ski slopes. In order to figure out the overall environment for the operation of ski slopes, this study includes every ski slope in South Korea.

2.1. Study sites

The analysis of the impact of climate change on ski slopes was conducted on all 17 ski resorts in South Korea. In order to consider the different climate conditions by regions where ski resorts are located, this study categorized the ski resorts by average winter (November to February) temperature. Based on climate data gathered from *The Climate Atlas of Korea 1981-2010* (Korean Metrological Administration, 2012), the regions were divided into the area below -2°C, between -2°C to 0°C, and above 0°C.

The area below -2°C is usually located in the Gangwon province, which is adjacent to the Taebaek Mountain Range that is the backbone of South Korea. 10 of the country’s 17 ski slopes are located in this area (e.g. Bears Town, Elysian, Vivaldi Park, Oak Valley, Alpensia, Yong Pyong, O2, High One, Phoenix Park, and Wellihilli Park). The elevations of ski slopes in this area range from 800 to 1,000 m. The -2°C to 0°C region is located primarily within the Gyeonggi, Chungcheong, and Jeolla provinces. There are six ski slopes located in this area (e.g. Star Hill, Konjiam, Pine, Jisan, Sajo, and Muju). The elevations of ski slopes in this area range from 300 to 800m. The Gyeongsang province is the region above 0°C. One slope (e.g. Eden Valley) is located in this area, the elevation of which is approximately 600m (Figure 6).

In the region below -2 °C, the number of visitors to ski resorts is between 64,000 to 850,000 persons per season, the size of the slopes range from 178,000 to 1,100,000 m^2, and the average minimum temperatures during winter seasons (November to February) are -8.14 to -5.77 °C. In the area between -2 to 0°C, the number of visitors to ski resorts is between 21,000 to 474,000 persons per season, the size of the slopes range from 102,000 to 1,291,000 m^2, and the average minimum temperatures are -6.44 to -4.11 °C. In the area above 0°C, the number of visitors to the studied ski resort is 281,000 persons per season, the size of the slope is 226,000 m^2, and the average minimum temperature is -2.18 °C (Kim et al., 2015) (Table 9)

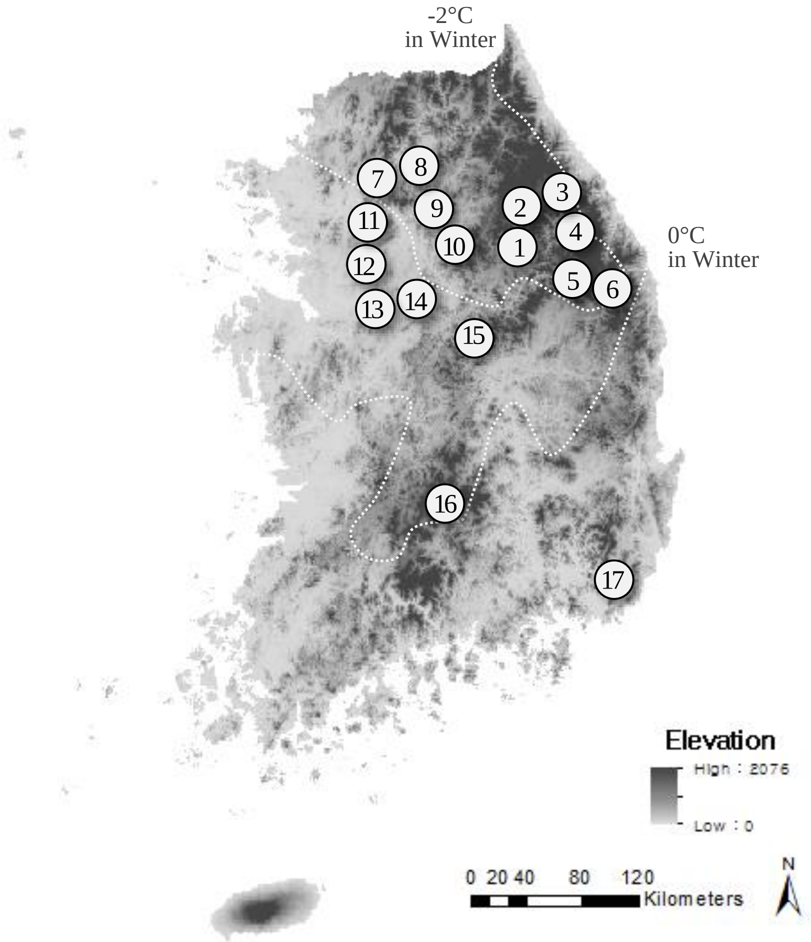


Figure 6. Study sites for the analysis of impacts of climate change on operation of ski slopes
(1: Wellihilli Park, 2: Phoenix Park, 3:Alpensia 4: Yong Pyong, 5:High One, 6: O2, 7: Bears Town, 8: Elysian, 9:Vivaldi Park, 10: Oak Valley, 11: Star Hill, 12: Konjiam, 13: Pine, 14: Jisan, 15: Sajo, 16: Muju, 17: Eden Valley)

Table 9. The information on study sites (ski resorts)

Region	Ski Resorts	Number of visitors per season	Size of slopes (m^2)	Average minimum temperature (Nov to Feb)
Below -2 °C	Phoenix Park	597,688	729,549	-8.14
	Yong Pyong	533,342	1,103,449	-8.14
	Alpensia	116,493	177,648	-8.14
	Wellihilli Park	367,615	526,046	-8.14
	High One	791,564	880,838	-5.68
	O2	63,742	611,473	-5.68
	Vivaldi	845,371	435,794	-5.77
	Oak Valley	466,416	281,168	-5.77
	Elysian	328,947	203,740	-5.77
	Bears Town	256,765	245,920	-5.77
Between -2 °C to 0°C	Jisan	473,692	298,400	-4.11
	Pine	239,726	178,652	-4.11
	Konjiam	414,642	367,687	-4.11
	Star Hill	57,910	102,026	-4.11
	Sajo	20,592	201,452	-6.44
	Muju	458,739	1,291,015	-4.42
Over 0 °C.	Eden Valley	281,073	226,420	-2.18

Source: Ski Resort Business Association of Korea (2013) and Korean Metrological Administration (2003 to 2012)

2.2. Data

In previous studies (Steiger & Mayer, 2008; Scott et al., 2003; Scott et al., 2007), the operation of ski slopes was analyzed based on weather and operational conditions for snowfall, artificial snowmaking, and the opening and closing conditions for slopes. To determine these conditions in the operation of South Korean ski resorts, interviews with ski slope operators were conducted. Interview requests were sent to all 17 ski resorts, and operators from seven of the ski slopes (e.g. Phoenix Park, High One, Vivaldi Park, Pine, Sajo, Muju, and Eden Valley) responded. The interviews were conducted for half an hour with each operator, using one-to-one base telephone methods from March 23 to 27, 2013. To verify the reasonability of weather and operational conditions from interview results, the conditions were applied to actual data concerning weather and operations from 2003 to 2012.

In previous studies, minimum temperature, humidity and precipitation were considered as weather elements that influence snowmaking and the operation of ski slopes (Steiger & Mayer, 2008; Scott et al., 2003; Scott et al., 2007). Thus, data on these were gathered from the regional meteorological stations: the data for Alpensia, Yong Pyong, Phoenix Park, and Wellihilli Park are from the Daegwallyeong station; the data for O2 and High One are from the Taebaek meteorological station; the data for Bears Town, Elysian, Vivaldi Park, and Oak ValleyWest are from the Hongcheon meteorological station; the data for Star Hill, Konjiam, Pine, and Jisan are from the Yangpyeong station; the data for Sajo is from the Jecheon station; the data for Muju is from the Muju station; and the data for Eden Valley is from the Milyang station.

The projected future climate data were extracted from the RCP (Representative Concentration Pathway) 2.6, 4.5, 6.0. and 8.5 scenarios. The scenarios, which are based on the HadGEM2-AO climate change projection model, were provided by the Korea Meterological Administration and Climate Change Information Center. The data resolution was set as 1km x 1km scale.

2.3. Methods

Based on the results of the interviews with the ski slope operators, the weather conditions for the ski slopes' operation, including conditions for artificial snowmaking and the open and close periods for the ski slopes, were determined.

To test if these conditions are actually applicable to the projections for the ski slopes' operation season, the average length of the operation season from 2003 to 2012 was estimated using these conditions and compared with the actual season length. Here, observed open dates were adapted from the real open dates of each slope each year. However, because there was little information on close dates, the close dates were set based on the operators' interviews, with a date of

March 11 for the region below -2°C, March 21 for the region below 0°C, and March 31 for the region above 0 °C.

To predict future changes resulting from climate change in the duration of the ski slopes' operational season, future climate data for the 2030s (2031 to 2040), 2060s (2061 to 2070), and 2090s (2091 to 2100) were applied to the ski slopes' operation conditions. In addition, observed climate data from 2003 to 2012 were used as baseline data. To project the potential for the ski slopes' continued operation into the future, the 100-days rule was applied. The 100-days rule served as a threshold for the minimum necessary business days for the ski slopes' operation (Scott et al., 2007; Steiger & Stötter, 2013; Koenig & Abegg, 1997).

IV. RESULTS

1. The impact of climate change on the demand for outdoor water activities

1.1. Weather conditions for the demand for outdoor water activities

To determine if there are significant correlations between the number of visitors to outdoor swimming pools and weather conditions, correlation analyses between the number of visitors and temperature, discomfort index, and precipitation were conducted. As a result, it was found that the number of visitors has significant correlations with all climate elements with a 0.001 significant level (Table 10). In particular, the correlation between the number of visitors and temperature was the highest of the correlations examined (Seoul: .517, Daegu: .332, and Busan: .371).

Table 10. Results of correlation analysis with number of visitors and weather elements

Climate factors	Seoul	Daegu	Busan
Temperature	.517***	.332***	.371***
Discomfort index	.472***	.325***	.337***
Precipitation	-.226***	-.276***	-.317***

*** Correlation is significant at the 0.001 level (2-tailed)

To examine the relationship in detail, scatterplots for the relationship between the number of visitors and each weather element were drawn, and the lines that best represent the data of the scatterplots were found using OLS (ordinary least squares). To select the most fitted shape of line, the linear, quadratic, and cubic models were tested. When it comes to precipitation, because considerably fewer people visit pools when precipitation occurs, a log model was added to the test.

As a result, it was determined that the cubic model, which had two inflection points in the graph, had the best fit in temperature (R^2: Seoul= .28, Daegu= .20, and Busan= .26), and in discomfort index (R^2: Seoul= .22, Daegu= .18, and Busan= .15). However, there was no model that accurately represents the relationship between precipitation and number of visitors (Table 11).

Because the cubic model that is applied to temperature showed the highest R^2 in both Seoul, Daegu, and Busan, the preferred weather conditions were found using the inflection points of the cubic model for temperature (Table 12).

The equation of the model is below.

$$y = \alpha + \beta x + \gamma x^2 + \delta x^3$$

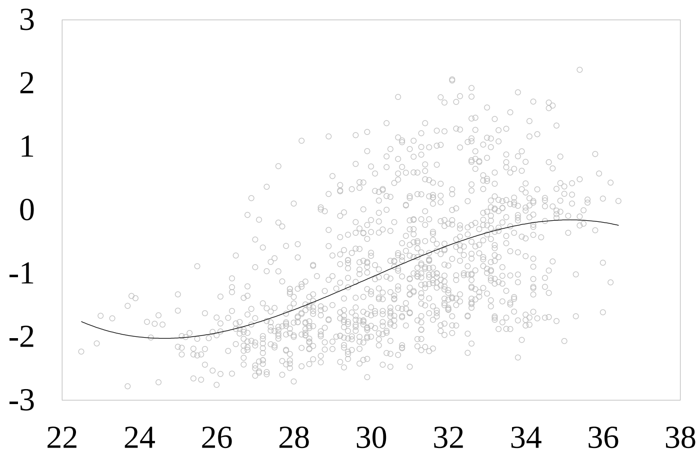
Here, y is Z-score of number of visitors and x is temperature.

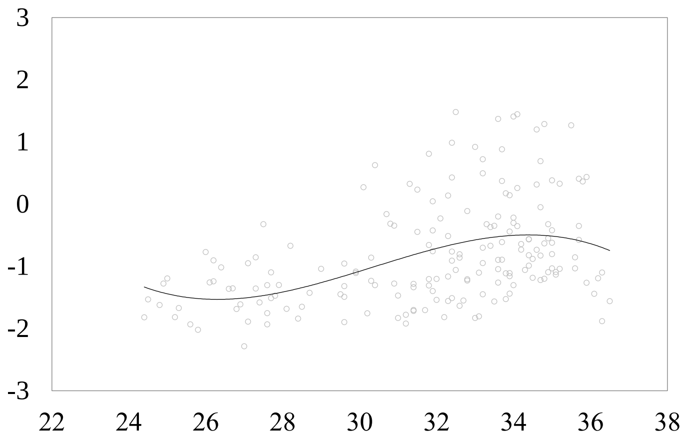
Table 11. R^2 of the best fit-lines of scatterplots of Z-score of number of visitors and weather elements

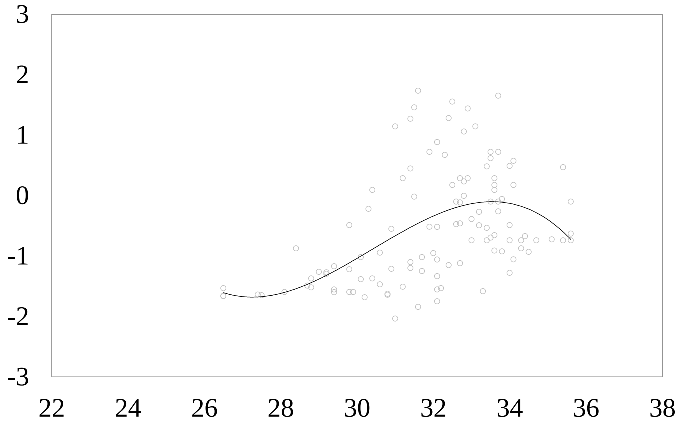
Climate factors	Model	Seoul	Daegu	Busan
Temperature	Linear	.27	.18	.17
	Quadratic	.27	.18	.19
	Cubic	.28	.20	.26
Discomfort index	Linear	.22	.18	.15
	Quadratic	.22	.19	.17
	Cubic	.24	.20	.22
Precipitation	Linear	.11	.11	.15
	Quadratic	.14	.11	.15
	Cubic	.14	.11	.18
	Log	.10	.13	.06

(Seoul: n=896, Deagu: n=181, Busan: n=117)

Table 12. Scatterplots and best-fit lines for Z-score of number of visitors (y) and temperature (x)

Region	Scattor plots and best-fit lines
Seoul (n=896)	 $y = -0.0032x^3 + 0.2889x^2 - 8.3689x + 76.986$ (R^2 = .27) Inflection points: Low = 24.27 °C, High = 35.91 °C

<table>
<tr><th>Region</th><th>Scattor plots and best-fit lines</th></tr>
<tr><td>Daegu
(n=181)</td><td>

$y = -0.0039x^3 + 0.3574x^2 - 10.653x + 102.85$ ($R^2 = .20$)
Inflection points: Low= 25.79 °C, High= 35.30 °C</td></tr>
<tr><td>Busan
(n=117)</td><td>

$y = -0.0127x^3 + 1.1618x^2 - 34.938x + 345.46$ ($R^2 = 0.26$)
Inflection points: Low=26.91 °C High=34.08 °C</td></tr>
</table>

The inflection points of each of the lines were found at 24.27 °C and 35.91°C in Seoul (R^2=0.28), 25.79 °C and 35. 30°C in Daegu (R^2=0.20), and 26.91°C and 34.08 °C in Busan (R^2=0.26).

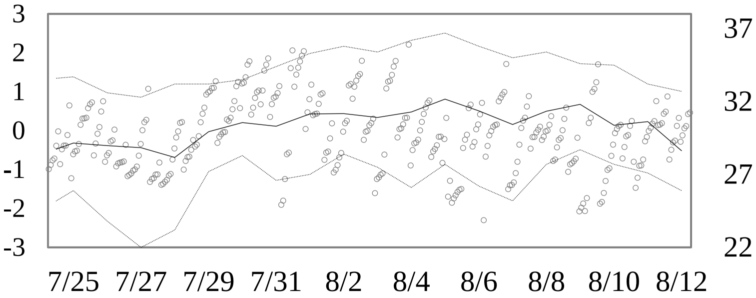
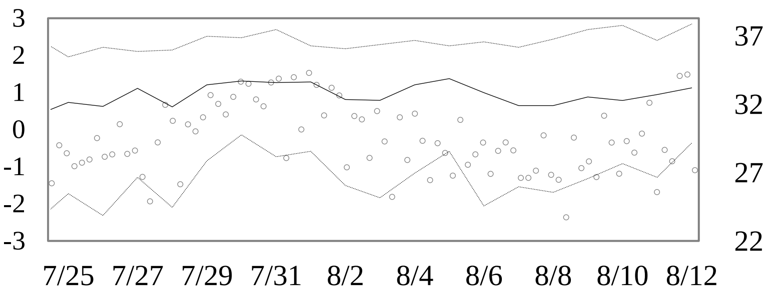
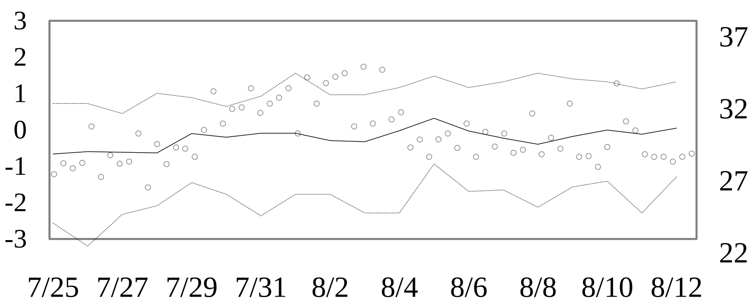
The number of samples and average Z-score for number of visitors by each degree of temperature is described in Table 13.

Table 13. Average Z-score of number of visitors and number of samples by temperature

	°C	23	24	25	26	27	28	29
Seoul	Z-visitor	-1.93	-1.80	-2.06	-1.95	-1.77	-1.65	-1.32
	N (896)	4	7	14	25	61	81	81
Daegu	Z-visitor			-1.56	-1.31	-1.49	-1.35	-1.37
	N (181)			7	7	10	11	3
Busan	Z-visitor					-1.62	-1.37	-1.39
	N (117)					4	3	9
	°C	30	31	32	33	34	35	36
Seoul	Z-visitor	-1.04	-0.78	-0.60	-0.35	-0.37	-0.06	-0.13
	N (896)	112	134	117	123	79	41	13
Daegu	Z-visitor	-1.04	-1.04	-0.61	-0.87	-0.43	-0.43	-0.63
	N (181)	13	13	24	21	33	24	14
Busan	Z-visitor	-1.05	-0.72	-0.41	-0.02	-0.16	-0.53	-0.58
	N (117)					4	3	9

To verify the study results that the number of visitors decreases when temperature exceeds a specific temperature (Seoul: 35.91°C, Daegu: 35.30°C, and Busan 34.08°C) is practical, the relationship between number of visitors and actual temperature was analyzed through graph comparison.

Table 14. Temporal distribution of the Z-score of number of visitors and temperature

<table>
<tr><th>Region</th><th>Scatterplots of number of visitors / Line graphs of temperature</th></tr>
<tr><td>Seoul
(n=544)</td><td>
</td></tr>
<tr><td>Daegu
(n=122)</td><td>
</td></tr>
<tr><td>Busan
(n=94)</td><td>
</td></tr>
</table>

(y=Z score of number of visitors(left/dispersion), average of daily maximum/mean/minimum temperature during 2005 to 2014(right/line), x=date)

The scatterplot for the number of visitors showed that the number of visitors decreased temporally at the first of August, when the temperature (the line graph) is the highest. This means that number of visitors increases according to an increase in temperature, but decreases when the temperature exceeds a specific threshold due to extremely hot weather (Table 14).

Thus, the threshold for preferred temperature for outdoor water activities is set as 23.51 to 37.56°C in Seoul, 25.58 to 34.68°C in Daegu, and 26.01 to 33.91°C in Busan (Table 15).

Table 15. Preferred temperature for outdoor water activities

	Seoul	Daegu	Busan
Preferred temperature (°C)	24.27 to 35.91	25.79 to 35.30	26.91 to 34.08

1.2. Projected changes in the demand for outdoor water activities

To predict the future preferred seasons for outdoor water activities, the future climate data from the RCP scenarios was applied to the preferred temperature for outdoor water activities.

The results showed that if the mitigation efforts to halt climate change are successful in the future (RCP 2.6), the preferred season for outdoor water activities is expected to slightly increase from 126 days at present to 135 days (7 %) in the 2090s in Seoul, from 136 days to 136 days (0%) in Daegu, and from 94 days to 109 days (16%) in Busan. In addition, reluctant days within the whole season due to heat waves were estimated to increase from 1 day at present to 4 days in the 2090s in Seoul, 8 days at present to 10 days in Daegu, and 1 day at present to 10 days in the 2090s in Busan.

If the mitigation efforts related to climate change are realized (RCP 4.5), the preferred season for outdoor water activities was projected to increase to 149 days (18%) in Seoul, 147 days (8%) in Daegu, and 123 days (31%) in Busan in the 2090s. In addition, reluctant days throughout the entire season due to heat waves were estimated to increase to 12 days in Seoul, 17 days in Daegu, and 10 days in Busan in the 2090s.

If the trend of climate change continues with mitigation efforts (RCP 6.0), the preferred season for outdoor water activities was projected to increase to 145 days (18%) in Seoul, 147 days in Daegu (8%), and 127 days in Busan in the 2090s (35%). In addition, reluctant days due to heat waves were estimated to increase to 17 days in Seoul, 23 days in Daegu, and 17 days in Busan in the 2090s.

If there is no effort to mitigate climate change (RCP 8.5), the preferred season for outdoor water activities was predicted to increase to 138 days (10%) in Seoul, 143 days (5%) in Daegu, and 136 (31%) days in Busan in the 2090s. Reluctant days due to heat waves were estimated to increase to 35 days in Seoul, 44 days in Daegu, and 33 days in Busan in the 2090s (Table 16 and 17).

Table 16. Projected changes in preferred season (days) for outdoor water activities

		Seoul			Daegu			Busan		
		Whole Season (a)	Too Hot (b)	Preferred season (a-b)	Whole Season (a)	Too Hot (b)	Preferred season (a-b)	Whole Season (a)	Too Hot (b)	Preferred season (a-b)
RCP 2.6	Recent	127	1	126	144	8	136	95	1	94
	30s	136	1	135	142	7	135	110	6	104
	60s	138	1	137	142	7	135	111	6	105
	90s	139	4	135	146	10	136	119	10	109
RCP 4.5	Recent	127	1	126	144	8	136	95	1	94
	30s	141	9	132	149	13	136	110	10	100
	60s	154	2	152	158	12	146	125	9	116
	90s	161	12	149	164	17	147	133	10	123
RCP 6.0	Recent	127	1	126	144	8	136	95	1	94
	30s	135	2	133	138	3	135	105	1	104
	60s	149	6	143	160	14	146	134	9	125
	90s	162	17	145	170	23	147	144	17	127
RCP 8.5	Recent	127	1	126	144	8	136	95	1	94
	30s	140	3	137	155	8	147	120	6	114
	60s	148	13	135	168	21	147	150	16	134
	90s	173	35	138	187	44	143	169	33	136

Table 17. Projected rate (%) of change in preferred season (days) for outdoor water activities

		Seoul			Daegu			Busan		
		Whole Season (a)	Too Hot (b)	Preferred season (a-b)	Whole Season (a)	Too Hot (b)	Preferred season (a-b)	Whole Season (a)	Too Hot (b)	Preferred season (a-b)
	Recent									
RCP 2.6	30s	7.09	0	7.14	-1.39	-13	-0.74	15.79	500	10.64
	60s	8.66	0	8.73	-1.39	-13	-0.74	16.84	500	11.70
	90s	9.45	300	7.14	1.39	25	0.00	25.26	900	15.96
	Recent									
RCP 4.5	30s	11.02	800	4.76	3.47	63	0.00	15.79	900	6.38
	60s	21.26	100	20.63	9.72	50	7.35	31.58	800	23.40
	90s	26.77	1100	18.25	13.89	113	8.09	40.00	900	30.85
	Recent									
RCP 6.0	30s	6.30	100	5.56	-4.17	-63	-0.74	10.53	0	10.64
	60s	17.32	500	13.49	11.11	75	7.35	41.05	800	32.98
	90s	27.56	1600	15.08	18.06	188	8.09	51.58	1600	35.11
	Recent									
RCP 8.5	30s	10.24	200	8.73	7.64	0	8.09	26.32	500	21.28
	60s	16.54	1200	7.14	16.67	163	8.09	57.89	1500	42.55
	90s	36.22	3400	9.52	29.86	450	5.15	77.89	3200	44.68

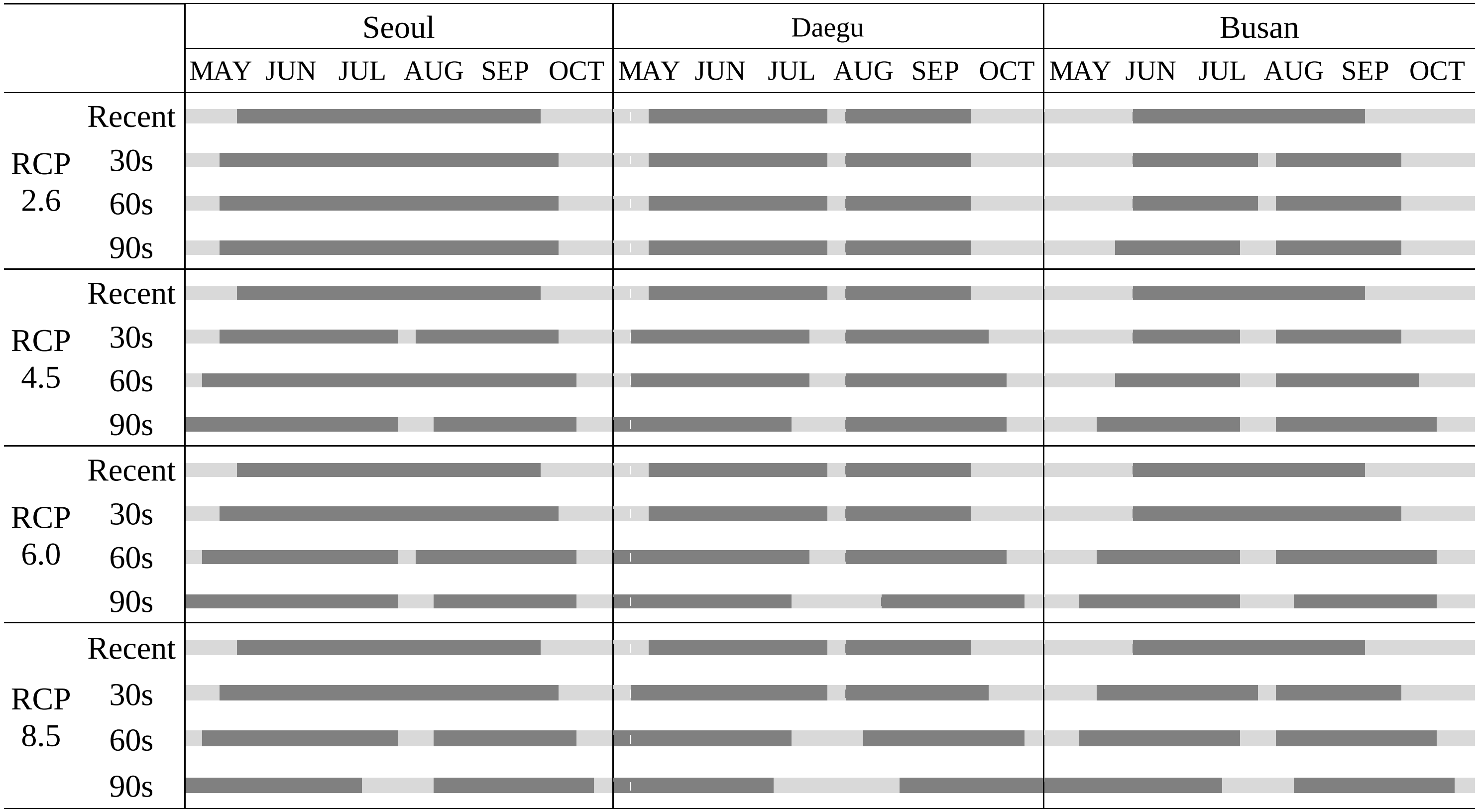
When it comes to duration of season, if mitigation efforts regarding climate change are realized successfully (RCP 2.6), it was determined that the preferred season for outdoor water activities would expadn from the end of May to the end of September at present to the middle of May to the first of October in the 2090s in Seoul; from the middle of May to the end of September at present to the middle of May to the end of September in the 2090s in Daegu; and from the first of June to the middle of September at present to the first of June to the end of September in 2090 in Busan. In addition, it was also estimated that the end of July to the first of August in Daegu and Busan would not be favored from the 2030s on. If the mitigation efforts regarding climate change are realized (RCP 4.5), it was expected that the preferred season for outdoor water activities would expand to: the first of May to the middle of October in Seoul; the first of May to the middle of October in Daegu; and the first of June to the first of October in Busan in the 2090s. In addition, it was also predicted that the first of August would not be favored in Seoul in the 2090s and that the last of July to the first of August in Daegu and the first of August in Busan would not be favored from the 2030s on.

If the trend of climate change continues on (RCP 6.0), it was predicted that the preferred season for outdoor water activities would expand to: the first of May to the middle of October in Seoul; the first of May to the middle of October in Daegu; and the last of May to the first of October in Busan in the 2090s. In addition, it was also predicted that the end of July to the first of August would not be favored in Seoul and Busan during the 2090s. In addition, the middle of July to the middle of August would not be favored in Daegu in the 2090s.

In the scenario in which there are no efforts to mitigate climate change (RCP 8.5), it was decided that the preferred season for outdoor water activities would expand to: the first of May to the middle of October in Seoul; the end of April to the end of October in Daegu; and the first of May to the middle of October in Busan in the 2090s. In addition, it was also estimated that the middle of July to the middle of August in Seoul and Busan would not be favored in the 2090s. In addition, the first of July to the end of August would not be favored in Daegu in the 2090s (Table 18).

In sum, the general preferred season at present, July and August, will be less favorable, and the less preferred season currently, May, June, September and October, will be more favorable for outdoor water activities in the future. However, if people adapt to increased temperature and enjoy outdoor water activities during July and August, the season for outdoor water activities will be six months, lasting from May to October.

Table 18. Projected changes in preferred season (period) for outdoor water activities (gray: less, dark gray: more preferred)



2. The impact of climate change on the operation of ski slopes

2.1. Weather conditions for the operation of ski slopes

According to the results of the conducted interviews, the weather conditions for the operation of ski slopes were found. First, most of the operators explained that because of a lack of natural snowfall, they largely depend on artificial snow as they do not consider natural snowfall in terms of the operation of slopes. The operators also explained the weather conditions for artificial snowmaking. According to them, ski slopes located in regions below -2°C start to make artificial snow at -3°C, and other slopes start at -2°C. The operators said that they do not consider humidity and precipitation, because these have almost no influence on artificial snowmaking. (Indeed, a previous study that was conducted in South Korea (Heo & Lee, 2012) explained that precipitation is lacking in the South Korean winter, so it is not important to the operation of ski slopes.) (Kim et al., 2015).

When it comes to the ski slopes' opening, operators said that they open the slopes when the snow reaches a depth greater than 30 cm. However, they added that it is hard to determine the depth of snow by the amount of artificial snow, because it varies according to daily weather conditions, snow storing skills, and snow piling machines. They recommended that it would be better to use the time-frame covering the number of days from initial snowmaking date to slopes' open date, rather than calculating the depth of snow (Kim et al., 2015). Thus, the number of days from the date when daily minimum temperature went below - 2°C, the minimum temperature required for snowmaking, to the date when the slopes opened from 2003 to 2012 was determined. As a result, it was determined that it generally took an average of 9.4 days after snowmaking began for the slopes to open (Table 19). Thus, this study set the ski slopes' opening conditions as being met 9 days after the date when the temperature goes below -2°C (Kim et al., 2015).

In addition, the operators answered that they had closed the ski slopes in March because the number of visitors started to decline around that time due to the start of the school semester and the deterioration of snow quality. Thus, this study set the condition for the slopes' closure at the point of snow melting, when the temperature goes over 0°C (Kim et al., 2015).

Table 19. Number of days from initial artificial snow making to slopes' opening

	Below -2°C										Below 0°C						Over 0°C	Mean
	Phoenix Park	Yong Pyong	Alpensia	Wellihilli Park	High One	O2	Vivaldi	Oak Valley	Elysian	Bears Town	Jisan	Pine	Konjiam	Star Hill	Sajo	Muju	Eden Valley	
2003	6						5		13	5	7	5		7	5	14		7.6
2004	8	7								13	11	14		4		20		12.4
2005	6	3		13			12		19	13	8	12		11		20		12.5
2006	3	12		7			16	13	18	6	5	7		8	16	8		10.8
2007	15	14		17	6		7	14	7	6	7	6		8		9		7.8
2008	8	8		10	7			15	6	4	4	12		12		5	6	7.9
2009	7	4	14	14	4	13	3	13	9	6	6	6	7	7		5	4	6.9
2010	13	5	11	5	11	17	4	12	17	14	5	6	12	16		13	12	11.6
2011	12	3	5	9	4	6	5	12	4	7	17	9	6	6	9	6		7.6
2012	11		11	5	3		8	14	9	15	16	17	17	15		11	11	12.4
Mean	8.9	7.0	10.3	10.0	5.8	12.0	7.5	13.3	11.3	8.9	8.6	9.4	10.5	9.4	10.0	11.1	8.3	9.4

Lastly, the operators explained that once they opened the slopes, they continued operation without closure, even if weather conditions were not adequate to open the slopes. Thus, the season was regarded as consecutive days from the slopes' opening date to closing date (Kim et al., 2015).

For the verification of the ski slopes' operation conditions, the estimated season based on these conditions was compared with the actual seasonal data from 2003 to 2012. The results of the comparison showed that there was a difference on average of 4.2 days between the estimated seasons and the observed season. With the exception of two slopes (Sajo and Muju), which showed relatively significant differences, the average difference was 2.1 days (Table 20).

The reason why the season for Sajo and Muju was overestimated could be explained as being because both slopes were located in relatively southern areas, where the ski market is less active than it is further north. They may open later and close earlier than necessary because of market demand, rather than as a result of weather conditions.

Table 20. The comparison of the estimated and actual season length of ski slopes' operation (number of days)

Ski Slopes		Estimated Season (a)	Actual Season (b)	Difference ([a-b])
Below -2°C	Phoenix Park	133	132	1
	Yong Pyong	133	137	4
	Alpensia	133	131	2
	Wellihilli Park	133	131	2
	High One	129	131	2
	O2	129	126	3
	Vivaldi	127	128	1
	Oak Valley	127	125	2
	Elysian	127	126	1
	Bears Town	127	124	3
Below 0°C	Jisan	113	115	2
	Pine	113	116	3
	Konjiam	113	115	2
	Star Hill	113	112	1
	Sajo	129	102	27
	Muju	127	114	13
Over 0°C	Eden Valley	94	96	2
Average				4.2
Average with exception of Sajo and Muju				2.1

In conclusion, the opening condition for slopes in this study is set as 9 days after the date when the temperature goes below -2°C, which is the minimum temperature required for snowmaking. The closing condition is set as the date when the temperature goes over 0°C. The duration of the season was set as the consecutive days between the open and close dates (Table 21).

Table 21. The conditions for ski slope operation

Operations	Conditions
Open	9 days after the date when temperature goes below -2°C
Close	The date when temperature goes over 0°C
Season	Consecutive days from open date to close date

2.2. Projected changes in the operation of ski slopes

Regarding the conditions for the operation of ski slopes, future climate data based on RCP scenarios were adapted. As a result, if the mitigation efforts regarding climate change are realized successively (RCP 2.6), it was determined that the operation season for ski resorts would be slightly shortened in the future. The ski slopes in the region below -2°C would experience a decrease from about 130 days at present to between 101 and 127 days (-1 to -21 %) in the 2090s. The slopes located in the area below 0°C would experience a shortening of around 127 days at present to between 100 and 121 days (-2 to -9 %) in the 2090s. The slope in the area over 0°C would experience a shortening from 94 days at present to 81 days (-14%) in the 2090s.

Table 22. Projected changes in season (days) for operation of ski resorts

		Below -2°C										Below 0°C						Over 0°C
		Phoenix Park	Yong Pyong	Alpensia	Wellihilli Park	High One	O2	Vivaldi	Oak Valley	Elysian	Bears Town	Jisan	Pine	Konjiam	Star Hill	Sajo	Muju	Eden Valley
	Recent	133	133	133	133	129	129	127	127	127	127	113	113	113	113	129	127	94
RCP 2.6	30s	134	128	126	123	133	128	122	126	121	109	118	127	122	111	122	114	95
	60s	131	126	128	128	129	127	122	127	111	100	119	121	123	103	118	114	92
	90s	127	123	128	124	128	119	117	131	111	101	115	115	121	100	120	115	81
	Recent	133	133	133	133	129	129	127	127	127	127	113	113	113	113	129	127	94
RCP 4.5	30s	135	134	135	135	135	136	121	121	122	135	118	116	109	115	117	126	91
	60s	136	127	135	136	126	126	114	114	114	134	113	113	112	112	112	126	94
	90s	134	133	133	134	133	133	115	132	120	134	114	117	110	117	118	133	90
	Recent	133	133	133	133	129	129	127	127	127	127	113	113	113	113	129	127	94
RCP 6.0	30s	136	121	126	125	129	115	120	128	110	90	116	116	118	85	116	114	77
	60s	135	124	127	127	127	108	119	126	108	87	114	114	118	82	111	110	69
	90s	126	110	118	117	120	104	103	117	96	84	102	100	103	71	105	103	54
	Recent	133	133	133	133	129	129	127	127	127	127	113	113	113	113	129	127	94
RCP 8.5	30s	131	120	133	133	131	126	120	119	120	131	110	108	92	93	116	131	84
	60s	97	93	121	114	97	96	91	93	93	97	72	70	60	69	92	95	52
	90s	93	85	95	96	93	93	73	73	73	74	73	43	45	46	55	56	11

Table 23. Projected rate (%) of change in season (days) for operation of ski resorts

		Below -2°C										Below 0°C						Over 0°C
		Phoenix Park	Yong Pyong	Alpensia	Wellihili Park	High One	O2	Vivaldi	Oak Valley	Elysian	Bears Town	Jisan	Pine	Konjiam	Star Hill	Sajo	Muju	Eden Valley
RCP 2.6	Recent																	
	30s	0.8	-3.8	-5.3	-7.5	3.1	-0.8	-3.9	-0.8	-4.7	-14.2	4.4	12.4	8.0	-1.8	-5.4	-10.2	1.1
	60s	-1.5	-5.3	-3.8	-3.8	0.0	-1.6	-3.9	0.0	-12.6	-21.3	5.3	7.1	8.8	-8.8	-8.5	-10.2	-2.1
	90s	-4.5	-7.5	-3.8	-6.8	-0.8	-7.8	-7.9	3.1	-12.6	-20.5	1.8	1.8	7.1	-11.5	-7.0	-9.4	-13.8
RCP 4.5	Recent																	
	30s	1.5	0.8	1.5	1.5	4.7	5.4	-4.7	-4.7	-3.9	6.3	4.4	2.7	-3.5	1.8	-9.3	-0.8	-3.2
	60s	2.3	-4.5	1.5	2.3	-2.3	-2.3	-10.2	-10.2	-10.2	5.5	0.0	0.0	-0.9	-0.9	-13.2	-0.8	0.0
	90s	0.8	0.0	0.0	0.8	3.1	3.1	-9.4	3.9	-5.5	5.5	0.9	3.5	-2.7	3.5	-8.5	4.7	-4.3
RCP 6.0	Recent																	
	30s	2.3	-9.0	-5.3	-6.0	0.0	-10.9	-5.5	0.8	-13.4	-29.1	2.7	2.7	4.4	-24.8	-10.1	-10.2	-18.1
	60s	1.5	-6.8	-4.5	-4.5	-1.6	-16.3	-6.3	-0.8	-15.0	-31.5	0.9	0.9	4.4	-27.4	-14.0	-13.4	-26.6
	90s	-5.3	-17.3	-11.3	-12.0	-7.0	-19.4	-18.9	-7.9	-24.4	-33.9	-9.7	-11.5	-8.8	-37.2	-18.6	-18.9	-42.6
RCP 8.5	Recent																	
	30s	-1.5	-9.8	0.0	0.0	1.6	-2.3	-5.5	-6.3	-5.5	3.1	-2.7	-4.4	-18.6	-17.7	-10.1	3.1	-10.6
	60s	-27.1	-30.1	-9.0	-14.3	-24.8	-25.6	-28.3	-26.8	-26.8	-23.6	-36.3	-38.1	-46.9	-38.9	-28.7	-25.2	-44.7
	90s	-30.1	-36.1	-28.6	-27.8	-27.9	-27.9	-42.5	-42.5	-42.5	-41.7	-35.4	-61.9	-60.2	-59.3	-57.4	-55.9	-88.3

If the mitigation efforts regarding climate change are realized (RCP 4.5), it was determined that the ski slopes' seasons would be decreased slightly in the future. In 2090, the seasons for the ski slopes in the region below -2°C would be shortened to between 120 and 134 days (-6 to -10%). The season of the ski slopes in the region below 0 °C would shorten to between 110 and 133 days (-5 to -9%), and the season of the ski slope in the region above 0°C would be shortened to 90 days (-4%).

If the trend of climate change continues on with mitigation efforts (RCP 6.0), it was determined that ski slopes' operational seasons would become shorter in the future. In 2090, the seasons of the ski slopes in the region below -2°C would be shortened to between 84 and 126 days (-5 to -34%). The season of the ski slopes in the region below 0°C would shorten to between 71 and 105 days (-9 to -37%), and the season of the ski slope in the region above 0 °C would be shortened to 54 days (-43%).

If the trend of climate change continues without any effort (RCP 8.5), it was determined that the ski slopes' seasons would also grow shorter in the future. In 2090, the seasons of the ski slopes in the region below -2°C would be shortened to between 73 and 96 days in the 2090s (-28 to -43%). The seasons of the ski slopes in the region below 0°C would decrease to between 43 and 73 days in the 2090s (-35 to -62%), and the season of the ski slope in the region above 0°C would be shortened to 11 days (-88%) (Table 22 and 23).

There are some cases wherein ski seasons are slightly expanded, especially in the RCP 2.6 and RCP 4.5 scenarios. This is because the trend of temperature does not gradually increase in these scenarios but fluctuates, as it is assumed in these scenarios that the efforts to mitigate climate change will be successful.

To predict the likelihood of the continuation of business, the 100-days rule was applied to the projected season of the ski slopes. The results showed that if the mitigation efforts regarding climate change are realized (RCP 2.6 and RCP 4.5), 16 of the 17 ski slopes will be able to continue their business until the 2030s, 2060s and 2090s.

However, if climate change continues (RCP 6.0), only 14 slopes in the 2030s and in the 2060s, and 13 slopes in the 2090s will be able to continue their business. Moreover, if there are no mitigation efforts (RCP 8.5), while 14 slopes will be able to run their business in the 2030s, only 2 slopes will be operational in the 2060s, and there will be no more manageable ski slopes in the 2090s (Table 24).

Table 24. Projected operation possibility of ski slopes under the 100-days rule

	Baseline	30s	60s	90s
RCP 2.6				
	17	16	16	16
RCP 4.5				
	17	16	16	16

	Baseline	30s	60s	90s
RCP 6.0				
	17	14	14	13
RCP 8.5				
	17	14	2	0

3. Comparison of the results with previous studies

3.1. The impact of climate change on the demand for outdoor water activities

The weather conditions influencing the demand for outdoor water activities within this study are slightly different from those of previous studies. In the case of the conditions for outdoor water activities, this study suggested relatively broader and lower temperatures: 24.27°C to 35.91°C in Seoul, 25.79°C to 35.30°C in Daegu, and 26.91°C to 34.08 °C in Busan. In previous studies, Morgan et al. (2000) suggested 32.5°C to 35.5°C based on beaches in Wales, Malta, and Turkey; Ibarra (2011) proposed 35°C to 41°C based on the Alicante coast in Spain.

The reason for the relatively extensive range of this study could be explained as being due to the fact that previous studies were conducted based on world class beaches, with tourists expecting a specific type of weather, and so visiting the beaches meeting those specific weather conditions. In addition, there is also a possibility that the ranges of temperatures at the beaches were originally narrower than at outdoor pools in South Korea (Kim, Park, & Lee, 2015). The reason for the relatively lower temperatures of this study could be explained as being due to the demand for outdoor water activities shifting to beaches or out of urban areas when temperature increases over a certain threshold. The fact that the season for summer vacation in Korea is concentrated around the first of August, when the temperature is highest and the number of visitors to outdoor swimming pools is temporally decreased, supports this assumption (Korea Employers Federation 2013-2016).

The predicted changes in the preferred season for outdoor water activities in this study showed a similar tendency to that of previous studies. Many previous studies, which were conducted in North America and the Mediterranean, predicted that the available seasons for leisure activities will expand and that the demand will shift from July and August to May to June and September to October (Scott et al., 2004; Amelung & Viner, 2006). These predictions are very similar to the results of this study, which predicted a shift in preference from June and September to May to June and September to October.

3.2. The impact of climate change on the operation of ski slopes

Regarding the conditions for the operation of ski slopes in South Korea, the artificial snowmaking threshold was set at a higher temperature, -2°C, than in previous studies, which used -5°C (Scott et al., 2003; Steiger, 2010). This may be due to the fact that South Korean ski slopes have already tried to develop snowmaking skills in higher temperatures. The operators who participated in the interviews frequently mentioned that they have made efforts to improve their snowmaking skills, as they have already experienced a lack of snow (Kim et al., 2015). Furthermore, the fact that ski slopes in South Korea are relatively small also makes it more feasible for them to make snow in higher temperatures, because it takes less time to cover the whole ski slope, meaning less of the produced snow melts during the process.

In addition, this study set the open and close conditions of ski slopes in more managerial terms. While previous studies set the standard of the open and close of the slopes as a snow depth of greater than 30 cm (Scott et al., 2003; Steiger, 2010), this study set the open date as 9 days after the start of snowmaking and the close date as the date when the temperature goes over 0°C. In addition, while the previous studies counted the duration of the ski season as the sum of a day unit (the sum of days when slopes are able to open), this study counted it as one continuous unit that covers the consecutive days from open date to the close date. The fact that this study did not consider humidity and precipitation, because these weather elements are not regularly considered in the operation of ski slopes in South Korea, is also a difference between this study and others. These differences, resulting from modifications intended to help the study more accurately incorporate and examine conditions in South Korea contributed to more accurate predictions of future changes in ski slope operations in the context of South Korea (Kim et al., 2015).

The results of the projection of changes in the operation of ski resorts were similar to those of previous studies. The duration of the operational season for ski slopes in European and American countries was estimated to decrease a minimum of 3% in positive scenarios, and a maximum of 94% in negative scenarios in the 2090s (Moen & Fredman, 2007; Dawson, Scott & Mcboyle, 2009; Steiger, 2010). The operational season of ski slopes in South Korea is expected to remain constant in positive scenarios and decrease a maximum of 88% in negative scenarios.

In sum, the weather conditions for the demand for outdoor water activities and the operation of ski slopes in this study are different from previous studies because of the differences between South Korea and other countries. However, the expected changes in the demand for outdoor water activities and the operation of ski slopes due to climate change were still comparable to the results of other studies, including the seasonal shift and expansion of outdoor water activities and a seasonal shortage in the operation of ski slopes into the future. This means that even though the environments for weather-based tourism in South Korea are different from other countries, weather-based tourism in South Korea will also experience an impact from climate change.

V. DISCUSSION AND CONCLUSION

1. Discussion

Climate plays an important role in the tourism industry. It contributes to the formation of natural environments and landscapes used for tourist destinations, and weather itself functions as a crucial attraction that attracts potential tourists. Because of the importance of climate in the tourism industry, climate change is a very critical issue that can directly influence the tourism industry. Thus, many researchers throughout the world have studied how climate change will influence the tourism industry in the future and how the tourism industry can respond to the effects of climate change.

In contrast to this international interest and efforts, the field of tourism in South Korea has shown relatively little interest in climate change. Lack of damage to South Korea from climate change, and a lack of urgency and visibility of the threat of climate change might explain part of the reason for this lukewarm attitude toward the topic. However, an increase in unusual weather events, including extreme hot weather and heavy rainfall, showed that South Korea is not exempt from the effects of climate change.

The purpose of this study was to predict future changes in weather-based tourism due to climate change in the context of South Korea and to suggest valuable implications for the tourism industry to respond to climate change. In order to form a clearer picture of the direct impact of climate change, this study focused on weather-based tourism, which is tourism that depends on a specific weather condition for operation.

To consider the impacts on both the demand and supply sides of the tourism industry, this study analyzed changes in demand due to the seasonal redistribution of weather conditions, as well as changes in the operations of tourist destinations due to changes in environmental conditions. The analysis of the demand side was conducted on outdoor water activities, which is dependent on a specific weather condition desired by visitors, and the analysis of the supply side was conducted on ski slopes, which also depend on a specific weather condition for operation.

So it could accurately predict changes, this study determined the preferred weather conditions for outdoor water activities by finding the best-fit line of scatterplots of the number of visitors and weather conditions. This study also discovered the weather conditions for the operation of ski slopes through interviews with ski slope operators and reviewed the data of past weather conditions and operations. Then, this study applied future weather data from four RCP scenarios (e.g. 2.6, 4.5, 6.0, and 8.5) to the weather conditions determining the demand for outdoor water activities and the operation of ski slopes.

The results of this study explained that if climate change continues into the future, the demand for and operation of weather-based tourism will experience crucial changes. This is especially true when climate change becomes worse (RCP 8.5). It was estimated that the preferred season for outdoor water activities will slightly expand and shift from June to September to May, June, September, and October in the 2090s, and the current peak season of July and August will be less preferred due to extremely hot weather. In terms of the operation of ski slopes, it was expected that the available season for the operation of ski slopes will decrease from the middle of November to the middle of March to the beginning of December to the middle of February in the 2090s. The ski slopes in the region, wherein average temperature during winter season is over 0 °C, were estimated to be able to maintain their business only two months in the 2090s.

This means that the season for summer weather-based tourism activities including outdoor water activities, will shift and its duration will increase slightly, while the season for winter weather-based tourism activities, including skiing, will be decrease significantly due to increased temperature. Additionally, if we consider the possibility that people will adapt to increased temperatures and enjoy outdoor water activities during July and August, it is expected that the season for summer weather-based tourism will be expand to over 6 months, lasting from May to October.

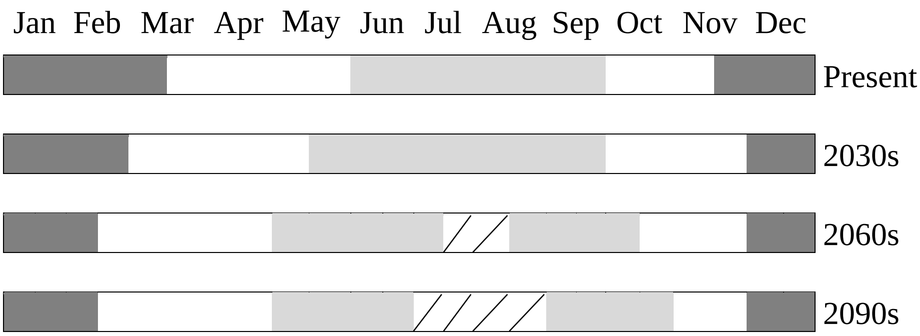


Figure 7. Projected changes in season for weather-based tourism by RCP 8.5 scenario
(Gray: season for outdoor water activity in Seoul, Dark gray: season for ski slopes' operation in the area below -2 °C in winter temperature, Diagonal Line: Less preferred season for outdoor water activity due to extreme hot weather, but potentially available season in the condition that people adopt to increased temperature)

These results suggest many implications for weather-based tourism. When it comes to the demand for weather-based tourism, in terms of leisure activities, when a person is no longer able to perform leisure activities they originally wanted to do, the person replaces that desire with other leisure activities (Iso-ahola, 1986) or with activities in other places. In other words, people substitute their leisure activities or destinations when they can be satisfied by other expected activities and destinations.

A study that analyzed how tourists deal with extremely hot weather during outdoor water activities showed that they changed their activities to avoid unpleasant weather conditions to maintain their satisfaction (Becken & Wilson, 2013; Rutty & Scott, 2014). The studies that analyze how skiers deal with no longer being able to ski at their preferred slopes because of a lack of snow or poor snow conditions also showed comparable results. The results showed that most of the skiers were willing to visit other ski slopes with better snow conditions (Pickering, Castley, & Burtt, 2009; Rutty et al., 2015a; Rutty et al., 2015b; Dawson & Scott, 2013).

Therefore, altered weather conditions of tourist destinations due to climate change may not be a very serious problem for tourists (demand), because they can simply alter their planned activities or destinations to achieve their desired leisure activity.

On the contrary, climate change would be a critical issue in terms of tourism operators (supply), as locations have already invested massive amounts of capital into the development of tourist attractions and/or destinations. The flexibility of tourism demand can cause difficulties for tourism operators, because they would experience not only damage to attractions from climate change (e.g. lack of snow in ski resorts) but also a decrease in visitors due to the deterioration of their attractions.

Thus, many researchers mentioned that because tourism operators have little capacity to respond to climate change, managerial and technical efforts by operators to respond to climate change are required (Njoroge, 2015; Scott, Hall, and Gössling, 2012).

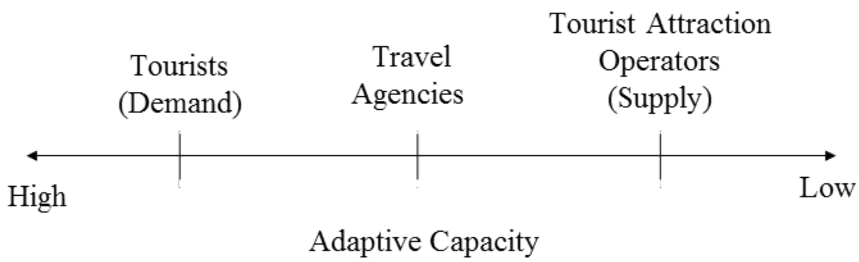


Figure 8. Adaptive Capacity of tourism to climate change. Adapted from Tourism and climate change(p.271), by Scott, Hall & Gössling, 2012, NewYork, NY: Routledge. Copyright 2012 by Daniel Scott, C. Michael Hall and Stefan Gössling.

It may be possible to offer a couple of suggestions based on the results of this study. When it comes to summer weather-based tourism including outdoor water activities, it is predicted that the preferred season will shift to May, June, and September, and July and August will be less desirable due to extremely hot weather. Thus, in order to expand the season for summer weather based-tourism so that it includes July and August, an effort to appeal to visitors even during hot weather conditions is required. For example, operators can implement diverse indoor facilities such as pools, rides, or rest areas, which allow tourists to avoid heat-waves. In addition, operators can also prepare safety facilities to deal with heat-related accidents, such as heat strokes.

If operators can successfully intrigue tourists even in July and August, and if people can adapt to the increased temperatures and enjoy summer weather-based tourism during July and August, operators can manage their businesses over a period of six months from May to October. Thus, tourism operators may need to promote destinations as attractive daily leisure areas rather than specialty areas for the summer season. In order to do this, operators may need to offer diverse facilities, such as shops and spas, and better services, such as healthcare programs, to visitors.

In addition, as it is also believed that an increase in temperature causes more tourists to visit beaches or simply to leave urban areas for their vacations, beach areas also need to prepare for an expanded operational season and the increased demand of tourists. For example, implementing additional accommodations and facilities for summer weather-based tourism, such as water sports and sunbaths, may be a potential area for increased investment going forward.

In the case of winter weather-based tourism including skiing, because the operational season of this type of tourism is expected to decrease in the future, it is important to consider how to effectively manage these businesses as the impact of climate change becomes more dramatic.

For example, there have been several studies that suggested managerial strategies for the ski industry to address climate change. Factors that motivate visitors to attend certain ski slopes are the number of slopes, snow quality, and overall cost (Cocolas, Walters, & Ruhanen, 2016). Because of this, ski slopes should first make efforts to develop snowmaking skills that are increasingly effective at higher temperatures. If ski resorts can't open entire slopes due to a lack of snow or have to offer lower-quality snow, they will need to offer other attractions that can compensate for the dissatisfaction of the slopes. For example, businesses can diversify their products and marketing by implementing expanded options for shopping, water parks, and so on (Scott & McBoyle, 2007; Kim et al., 2015).

However, these efforts require an expanded budget, which is directly connected to an increase in ticket prices. As mentioned previously, ticket price is an important factor in the demand of skiers. Thus, if this investment increases ticket prices, these efforts may not be practical for business. The operators should also consider the fact that the demand skiing is flexible, so skiers can easily move to other resorts in nearby countries. Indeed, it was estimated that the ski slopes in Hokkaido will hardly be influenced by climate change (Fukushima et al, 2002). In addition, at present, the ticket price for ski slopes in Hokkaido is already lower than that of the ski slopes in South Korea (Table 26). This means that the demand of skiers in South Korea can shift to Japan with ease when snow quality decreases and price increases. Because of this, operators will need to consider many aspects, including region, market, benefits-costs, and so on, when they apply any adaptation strategies to their business.

Table 25. The prices of lift tickets of ski slopes in Hokkaido, Japan and in Gangwon-province, South Korea

Hokkaido, Japan		Gangwon-province, South Korea	
Slopes	Lift ticket Prices (Yen)	Slopes	Lift ticket Price (Won)
Niseko United	7,400	Yong Pyong	76,000
Furano	5,600	Alpensia	69,000
Tomamu	5,600	Phoenix Park	78,000
Kiroro	5,500	Wellihilli	75,000
Teine	4,900	High One	62,000
Kokusai	4,200	O2	73,000

Source: Japan-the website of Ilbonski (www.ilbonski.com), South Korea-websites of each ski slopes

These managerial issues will not be restricted to the operation of ski slopes; other types of winter weather-based tourism, including snow festivals, outdoor skating, and outdoor sledding will need to consider them to remain viable in the future.

In sum, it is expected that climate change will impact tourism destinations, tourism operators, and tourists directly and indirectly. If its effect is positive, the environment of a tourism destination will improve and the demand of tourists to visit that location will also increase, leading to new and enhanced opportunities for tourism operators. However, if the impact of climate change on a given destination is negative, the environment of said destination will deteriorate, and demand will shift to other places or activities which offer more favorable conditions. This is because tourists can easily substitute their activities or destinations when met with unsatisfactory environments at tourism destinations.

Following the deterioration of tourist destinations and the corresponding loss of tourists, tourism operators who have invested in inflexible facilities at tourism destinations will experience significant managerial difficulties. If operators make efforts to adapt to the changing environment and are able to successfully respond to climate change, they will be able to improve the attributes of tourist destinations and increase the demand of tourists. However, such adaptation efforts are often expensive, which can lead to an increase in the ticket price for an attraction and a decrease in further investments for a location. Ultimately, this can decrease the demand of tourists for and attractiveness of a given location. Because of this, it is important to carefully consider large-scale changes at a given tourist destination before implementing them (Figure 9).

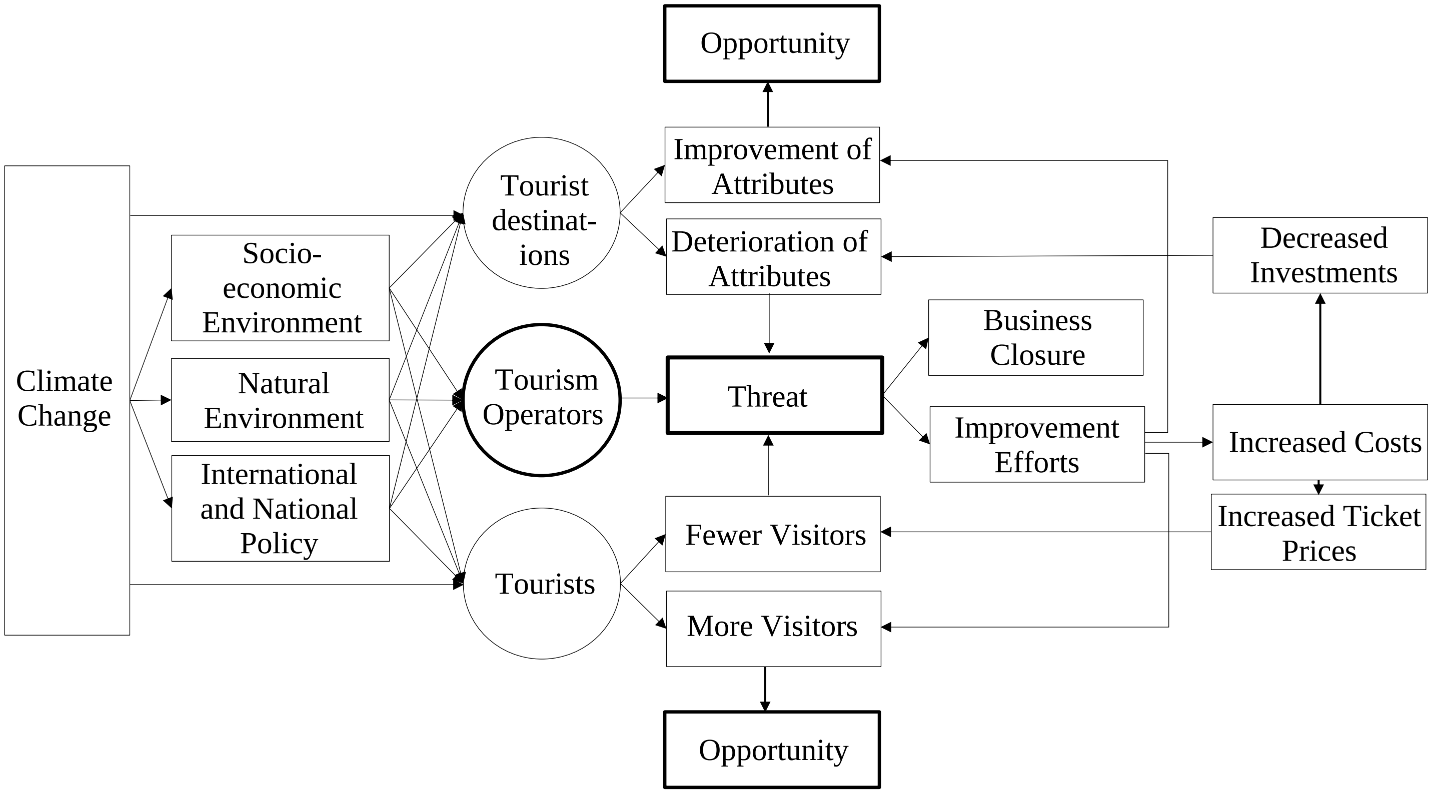


Figure 9. Impact of climate change on weather-based tourism and response

2. Conclusion

The purpose of this study was to project changes in weather-based tourism due to climate change and offer meaningful implications that the tourism industry can refer to when operators prepare to deal with climate change.

The results of this study showed that there will be major changes in the demand and operation of weather-based tourism due to climate change. In terms of demand, it is expected that seasonal and regional redistribution will occur, and in terms of operation, it is expected that the operational season of tourism destinations will change as a result of climate change. When it comes to summer weather-based tourism including outdoor water activities, it is expected that the available season will expand and demand will increase. Thus, this study suggests strategies that can intrigue potential tourists and satisfy their needs. When it comes to winter weather-based tourism including skiing, it is expected that the available season for operation will shorten. Thus, this study suggests managerial strategies that can improve the efficiency of these businesses.

This study is meaningful in that it attempted to predict future changes to the tourism industry as a result of climate change in South

Korea. As there have been few studies on this issue, it is expected that the results of this study can offer meaningful implications to the field of tourism as a whole.

However, as this study was almost the first of its kind, it has some limitations. First, in the analysis of the relationship between temperature and the number of visitors for outdoor water activities, this study controlled the differences within swimming pools (e.g. area and distance) and within years by using the Z-score of number of visitors to each swimming pool each year, and by selecting urban public pools located in megacities as study sites. This study also controlled the differences between weekday and weekend visitation to pools by only using weekday data. However, this study could not control the vacation season of South Korea, which is an important factor that can influence the demand for swimming pools. This remains a limitation of this study.

Second, in the analysis of the duration of ski slope seasons, this study could not consider individual situations for each ski slope, such as more or less developed snowmaking skills and management strategies, because the focus was on overall changes affecting all South Korean ski slopes.

Third, because this study did not conduct a survey of tourists, it is not clear if the visitors of outdoor swimming pools and ski slopes will continue to perform their leisure activities in the future. There exists the possibility that the effects of climate change will alter the way visitors feel about certain destinations and activities, but that they will continue to enjoy them regardless.

Lastly, there is an insurmountable limitation of this study: the uncertainty of the future. It is possible that the trend of climate change might not follow the RCP scenarios, people might adapt to changed climatic conditions better than expected, rather than become concerned with the changes, and tourism may take on an entirely new landscape in comparison to the present.

However, this uncertainty merely highlights the necessity for further studies on the future of the tourism industry going forward. Because nobody knows what the future holds, the efforts to prepare for the uncertainty of tomorrow is necessary to minimize the damage from possible changes.

This study is basic and one of the first studies to investigate the impact of climate change on weather-based tourism in South Korea. Because of this, in order to build more practical strategies for the tourism industry to deal with climate change, follow-up studies based on more specific types of tourism and regions will be required. If more detailed studies can overcome the limitations of this study, they will not only contribute to the academic field of tourism, but also to the sustainability of the tourism industry as a whole in the era of climate change.

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초 록

기후변화가 관광산업에 미치는 영향은 매우 클 것으로 예상되고 있다. 특히 특정 기후조건에서만 가능한 날씨기반형 관광의 경우 기후변화로 인해 관광 수요 또는 공급이 어려워지거나 불가능해질 수 있을 것으로 전망된다. 그러나 기후변화의 관광산업 영향에 대한 학계의 관심은 미온적인 편이다. 기후변화 현상이 장기적, 비가시적인 것에 반해 관광산업의 초점은 단기적, 가시적 수익 창출에 맞춰져 있다는 점이 그 이유 중 하나일 것이다. 그러나 기후변화와 이로 인한 영향이 점차 현실화 되고 있는 만큼 기후변화가 관광산업에 미칠 수 있는 영향을 검토하고 이에 대한 대응방안을 마련하는 것은 매우 중요한 일이다.

이에 본 논문에서는 기후변화의 영향이 가장 클 것으로 예상되는 날씨기반형 관광을 대상으로 미래 영향을 검토함으로써, 관광산업의 기후변화 적응 및 대응 방안 마련에 활용할 수 있는 기초자료를 제시하고자 한다. 이를 위해 본 논문에서는 두가지의 실행 분석을 진행하였다. 첫번째 분석은 관광수요차원의 분석으로 기후변화가 여름철 야외물놀이 활동 수요에 미치는 영향을 분석하였으며, 두번째 분석은 관광공급차원의 분석으로 기후변화가 겨울철 스키장 운영에 미치는 영향을 분석하였다.

야외물놀이 활동 수요 영향 분석의 경우, 서울의 7 개, 대구의 1 개, 부산의 2 개 수영장을 대상으로 분석을 진행하였다. Z-score 로 변환된 각 지역별 수영장의 일별 방문객 데이터와 기온과의 관계를 산포도로 작성하고 최적선을 도출하여, 최적선이 증가하는 기온부터 감소하는 기온까지를 야외물놀이 활동 선호 구간으로 도출하였다. 이후 해당

구간에 RCP 미래 기후 시나리오를 적용하여 2030 년대, 2060 년대, 2090 년대의 방문 선호 기간과 시기를 예측하였다.

스키장 운영 영향 분석의 경우, 전국 17 개 스키장을 대상으로 관리자 인터뷰 및 기존 운영 자료 분석을 통해 스키장의 개장, 운영, 폐장 조건을 도출하고, 도출된 조건에 RCP 미래 기후 시나리오를 적용하여 2030 년대, 2060 년대, 2090 년대의 운영기간 변화를 예측하였다. 또한 스키장 운영의 최소 일수로 여겨지는 100 일을 기준으로 향후 스키장의 지속적 운영가능성을 검토하였다.

분석 결과, 야외물놀이 활동에 선호되는 기온은 서울의 경우 24.27 °C 에서 35.91°C, 대구의 경우 25.79 °C 에서 35.30 °C, 부산의 경우 26.91 °C 에서 34.08 °C 로 나타났다. 위 기온 구간에 미래 기후 시나리오를 적용하여 야외물놀이활동에 선호되는 시기를 분석한 결과, 현재는 6 월에서 9 월이 선호되지만, 점차 5 월에서 6 월, 9 월이 더 선호되고 7 월과 8 월은 무더위로 인해 상대적으로 덜 선호될 것으로 전망되었다. 야외물놀이활동 선호 기간은 서울의 경우 현재 126 일에서 2090 년대에는 135 일까지 증가될 것으로 RCP 2.6 시나리오에서 전망되었으며, RCP 4.5 에서는 149 일, RCP 6.0 에서는 145 일, RCP 8.5 에서는 138 일까지 증가될 것으로 전망되었다. 대구는 현재 136 일에서 RCP 2.6 의 경우 136 일, RCP 4.5 의 경우 147 일, RCP 6.0 의 경우 147 일, RCP 8.0 의 경우 143 일까지 증가될 것으로 전망되었다. 부산은 현재 94 일에서 RCP 2.6 의 경우 109 일, RCP 4.5 의 경우 123 일, RCP 6.0 의 경우 127 일, RCP 8.5 의 경우 136 일까지 증가될 것으로 전망되었다. 7 월과 8 월에 무더위로 인해 덜 선호되는 기간 까지를 포함하면

2090 년대의 여름철 야외물놀이 활동 가능기간은 6 개월에 달할 것으로 전망되었다.

스키장 운영의 경우 일 최저 기온이 영하 2℃ 이하로 떨어진 날부터 제설을 시작하여 약 9 일후에 스키장을 개장하여, 일 최저 기온이 0℃ 이상으로 증가되는 날 폐장하는 것으로 나타났다. 위 운영 조건에 미래 기후 시나리오를 적용하여 개장일부터 폐장일까지의 운영일수를 분석한 결과, 스키 시즌 동안 평균 최저 기온이 영하 2 도 이하인 지역의 경우, 현재 약 130 일에서 2090 년대에는 120 일 정도로 감소될 것으로 RCP 2.6 시나리오에서 전망되었으며, RCP 4.5 에서는 130 일, RCP 6.0 에서는 120 일, RCP 8.5 에서는 90 일까지 감소될 것으로 전망되었다. 스키 시즌 동안 평균 최저기온이 영하 2 도에서 0 도 사이인 지역의 경우, 현재 약 120 일에서 RCP 2.6 과 RCP 4.5 의 경우 120 일, RCP 6.0 의 경우 100 일, RCP 8.5 의 경우 60 일까지 감소될 것으로 전망되었다. 스키 시즌 동안 평균 최저기온이 0 도 이상인 지역의 경우 현재 약 90 일에서 RCP 2.6 의 경우 80 일, RCP 4.5 의 경우 90 일, RCP 6.0 의 경우 50 일, RCP 8.0 의 경우 10 일까지 감소될 것으로 전망되었다. 이에 따라 2090 년대에는 RCP 2.6 과 RCP 4.5 시나리오의 경우 17 개 스키장 중 16 개 스키장, RCP 6.5 시나리오의 경우 13 개 스키장이 100 일 이상 운영 가능할 것으로 전망되었으며, 8.5 시나리오의 경우 100 일 이상 운영 가능한 스키장이 없을 것으로 전망되었다.

본 연구의 결과는 향후 기후변화가 지속될 경우, 야외물놀이 활동을 비롯한 여름철 날씨기반형 관광의 시즌은 증가하고 스키를 비롯한 겨울철 날씨기반형 관광의 시즌은 감소하는 등 관광산업의 수요 및 공급에 큰 변화가 발생할 수 있음을 시사한다. 관광 수요의 경우

관광활동, 관광시기, 관광목적지 등을 변경 또는 대체함으로써 기후변화에 용이하게 대응할 수 있을 것이나, 기 고정자산을 투자한 관광 공급의 경우 관광목적지 여건 변화로 인한 운영 어려움과 더불어 관광 수요 유출로 인한 경영 어려움 등을 동시에 겪을 수 있을 것으로 전망된다. 따라서 기후변화에 유연하게 대응할 수 있는 관광공급차원의 구체적인 운영방안 마련이 필요할 것이다.

본 논문은 우리나라에서 미진하게 연구되어온 거시적 차원의 관광산업 기후변화 영향을 분석하고 이에 대한 미래 변화를 전망했다는 점에 의의가 있다. 보다 실질적이고 구체적인 대응방안 마련을 위해서는 관광산업 유형별 특성과 지역적 특성을 고려한 후속 연구가 지속될 필요가 있다.

주요어: 기후변화, 관광산업, 날씨기반형 관광, 야외물놀이 활동, 스키장

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