ANALYSIS OF THE RELATIONSHIP AMONG PERSONAL FACTORS, RISK PERCEPTION, AND BEHAVIORAL RESPONSES RELATED TO CLIMATE CHANGE IN SOUTH KOREA

by

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Analysis of the Relationship among Personal Factors, Risk Perception, and Behavioral Responses related to Climate Change in South Korea

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ABSTRACT

Despite global collaboration, climate change is getting worse. Fortunately, individuals’ daily actions, along with governments’ policies, can be alternatives for mitigating Greenhouse Gas (GHG) emissions and alleviating the negative impacts of climate change. However, empirical evidence about the process of individuals’ behavioral responses to address climate change, particularly the behavioral responses of the general public, is still insufficient.

According to previous studies, climate change risk perception is deeply associated with individuals’ behavioral responses against climate change. To strengthen empirical evidence of how behavioral responses to cope with climate change within the general public are shaped, this dissertation investigates the causal relationships among personal factors, risk perception, and behavioral responses related to climate change. It hypothesizes that personal factors associated with climate change (i.e., experiences, knowledge, and policy assessment) affect climate change risk perception. Subsequently, higher risk perception is likely to intensify individuals’ behavioral responses to climate change. In addition, some personal factor variables (e.g., extreme weather event experiences and policy-related knowledge) may have a direct impact on individuals’ behavioral responses. To assess these hypotheses, both quantitative analyses at the national and local levels and qualitative analyses at the expert level are conducted in the South Korean context. South Korea is contributing to increasing GHG emissions as a result of economic growth over the past decades.
First, for the national-level analysis, the measure of behavioral responses focuses on individuals’ GHG mitigation behaviors (e.g., saving energy and utilizing renewable energy). Data are collected from a web-based survey implemented in South Korea (2016, N = 1,500). The results of regression analysis, specifically Structural Equation Modeling (SEM), are largely consistent with this study’s expectations. Most personal factors, such as long-term climate change experiences, awareness of climate change, and the assessment of drought policy, significantly influence climate change risk perception. Subsequently, higher climate change risk perception, along with higher familiarity with a government GHG reduction plan, enhances behavioral responses to mitigate climate change. Meanwhile, extreme weather event experiences (e.g., flood and drought) do not have an impact on either risk perception or behavioral responses.

Second, the local-level analysis focuses on individuals’ adaptation behaviors against drought as the measure of behavioral responses. Based on survey data derived from South Chungcheong Province, South Korea (2015, N = 515), the SEM regression analysis presents mixed results. Several personal factors, such as exposure to water saving information and the assessment of water infrastructure policy, are significantly correlated with drought risk perception. However, higher drought risk perception, unlike higher familiarity with a subsidy policy associated with water saving, fails to intensify behavioral responses to adapt to drought. Also, water problem experiences (e.g., limited water supply) have no relationship with both risk perception and behavioral responses.

Third, the last empirical analysis utilizes expert knowledge from face-to-face interviews (2018, N = 13) and an online survey (2018, N = 98) with climate change experts. Their insights offer support for most of the study’s hypotheses. Regarding the gaps between this study’s hypotheses and the results of the quantitative analyses, the experts recognize that the significant
relationship between experiences and risk perception requires several conditions, such as experiences with direct and significant damage, recent experiences, and instances with no possible solution for minimizing damage. Also, many of them are suspicious about the relationship between drought risk perception and behavioral responses against drought. This is because prioritized residential water supply policy and well-established response infrastructure generally ensure that individuals are not exposed to direct and severe damage triggered by drought, which makes individuals reluctant to take action. Given the context of South Korea, such as a high level of climate change adaptation capacity, the recent downward trend of damage brought by floods, and government’s top priority on residential water during drought, the identified gaps between the study’s findings and the hypotheses seem understandable.

Overall, while risk perception plays an important role in enhancing behavioral responses to mitigate climate change, the precise role of risk perception in climate change adaptation may depend on the context of each country (e.g., the capacity of climate change adaptation and recent trends in extreme weather events). Despite some limitations, this study successfully offers empirical evidence of the theorized relationships among personal factors, risk perception, and behavioral responses associated with climate change, which can be important to understand when addressing climate change. The findings of this dissertation and mixed methods research not only contribute to advancing knowledge and the research methodology of the process of individuals’ behavioral responses to cope with climate change, but they also inform policymakers of critical clues as to how the general public voluntarily takes action to address climate change.

The form and content of this abstract are approved. I recommend its publication.

Approved: Tanya Heikkila
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LIST OF ABBREVIATIONS

ADF: Asymptotically Distribution-Free
CAT: Climate Action Tracker
CFI: Comparative Fit Index
COP: Conference of the Parties
GHG: Green House Gas
GSEM: Generalized Structural Equation Modeling
ICT: Information and Communication Technologies
INDCs: Intended Nationally Determined Contributions
IPCC: Intergovernmental Panel on Climate Change
K-water: Korea Water Resources Corporation
KWRA: Korea Water Resources Association
MOLIT: Ministry of Infrastructure and Transport
NASA: National Aeronautics and Space Administration
OECD: Organization for Economic Cooperation and Development
PMT: Protection Motivation Theory
RCP: Representative Concentration Pathway
RMSEA: Root Mean Square Error of Approximation
SEM: Structural Equation Modeling
SRMR: Standardized Root Mean Squared Residual
TLI: Tucker-Lewis Index
UN: United Nations
UNFCCC: United Nations Framework Convention on Climate Change
CHAPTER I
INTRODUCTION

Climate change is not a new issue. As early as 1896, the Swedish chemist Svante Arrhenius explored the relationship between atmospheric carbon dioxide and air temperature to explain the existence of ice ages (Arrhenius, 1896). In 1964, social ecologist Murray Bookchin warned of the probability of anthropogenic climate change appearing and its potential adverse impacts (Bookchin, 1964). However, this issue failed to bring heightened attention from the general public and the international community for a long time. Over two decades later, the Intergovernmental Panel on Climate Change (IPCC), which is the international organization for providing a scientific basis related to climate change to governments at all levels, was set up in 1988 (IPCC, 2017). Since then, the IPCC has continually warned of the risks of climate change through the IPCC Assessment Reports (IPCC, 2014a). As a result, it has been highlighted as a major issue around the world.

Global collaboration to address climate change has remained sluggish due to complicated political (e.g., numerous stakeholders and the absence of legitimate and coercive global organizations), economic (e.g., enormous costs to mitigate and adapt to climate change), and social (e.g., each nation’s different level of public concern and vulnerability to climate change) circumstances. (Bodansky, 2012; Hagen, 2015; Klein, Schipper, & Dessai, 2005; Nyong, 2009; Stern, 2006). Also, technical advancements linked to the reduction of Greenhouse Gas (GHG) emissions and the use of renewable energy are still insufficient and have not provided momentum to global collaboration. In 2015, the international community seemed to bear fruitful results by establishing the first global action plan to curb climate change. This Paris Climate Agreement was endorsed by one hundred and ninety-five countries (European Commission,
2017), and the United States (U.S.) and China were viewed as leaders pushing this agreement’s fulfillment (Bodansky, 2016). A recent challenge to the agreement came early in 2017 when President Donald Trump declared that the U.S. would withdraw from the agreement (Ellis, 2017). The prospect of international climate policy was dampened by this event (Shear, 2017).

Even though climate change is regarded as a global level risk by both the scientific and non-scientific worlds, the national, local, and individual levels typically bear the costs of most impacts (Altschuler & Brownlee, 2016; Mendelsohn, Dinar, & Williams, 2006). To effectively alleviate the adverse effects of climate change, the world needs not only efforts at the global level, but also those at the national, local, and individual levels. However, it is very difficult for both national and local policymakers to design and carry out effective and efficient climate change policies due to several challenges, such as the uncertainty around its predicted trajectories and impacts (Stern, 2006; Tompkins & Adger, 2005), juggling mitigation and adaptation strategies (Biesbroek, Swart, & Van der Knaap, 2009; Kane & Yohe, 2000), and the relatively low priority of climate change among national issues (Dunlap & Saad, 2001; Leiserowitz, 2005). In particular, policymakers in countries that suffer from a lack of resources (e.g., funds, experts, and technologies) are facing much more serious conditions. Fortunately, many existing studies (e.g., Clayton et al., 2015; Semenza et al., 2008; Shove, 2010) advise that not only governments’ policies, but also individuals’ behavioral responses can be alternatives for alleviating the adverse impacts of climate change. Further, the more behavioral responses to address climate change that individuals take, the less of a burden policymakers will feel in shaping and implementing climate policies. Thus, revealing how to inspire individuals to more actively participate in coping actions against climate change might be no simple task, but be very meaningful. This dissertation investigates the process of individuals’ behavioral responses to address climate change.
Recently, many researchers have paid attention to the question, what motivates individuals to take behavioral responses to curb climate change? Most of them focus on personal factors (e.g., experience and knowledge) and climate change risk perception. It is true that public risk perception has been spotlighted by scholars in that it can inform policymakers of public concerns related to particular risks and the public’s preference for public policies (Pidgeon, 1998; Pidgeon & Gregory, 2004). At the same time, however, some previous studies (e.g., Battaglini et al., 2009; O’Connor, Bard, & Fisher, 1999; Spence et al., 2011) have noticed a different role of public risk perception, which is as a trigger of individuals’ behavioral responses to address risks. They note that higher levels of perceived climate change risk can lead to changes in personal actions. Also, personal factors are expected to influence behavioral responses to cope with climate change via risk perception or directly.

Unfortunately, previous empirical research projects do not provide enough evidence about the process of individuals’ behavioral responses with respect to mitigating climate change and adapting to different types of climate change impacts (e.g., drought and flood risks). Most existing studies focus on the simple relationship between personal factors and climate change risk perception (e.g., Brody et al., 2008; Lowe et al., 2006; Slovic et al., 2004) or between climate change risk perception and behavioral responses to address climate change (e.g., Battaglini et al., 2009; Joshi et al., 2013; Roco et al., 2015). Although a few research projects have investigated the relationship among personal factors, climate change risk perception, and behavioral responses against climate change, they are usually based on specific industry contexts, such as agriculture (Niles, Lubell, & Haden, 2013), or local level data (e.g., flood and

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1 Public (risk) perception has been studied in diverse fields (e.g., health, technology, and environment) because policy-making is affected by what the public perceives (Bostrom et al., 1994; Leiserowitz, 2006; Ruddell et al., 2012). In the climate change field, public risk perception can play a significant role in both shaping climate policies (Brody et al., 2008; Liu, Smith, & Safi, 2014) and generating public support for those policies (Leiserowitz, 2005).
drought-prone areas) (Whitmarsh, 2008). The findings of these studies are not necessarily applicable to behavioral responses of the general public at the national level. Also, while a number of studies (e.g., Lindell & Hwang, 2008; Takao et al., 2004) explored risk perception and self-protective behaviors by individuals against flood, research projects investigating personal risk perception and behavioral responses against drought are very rare (e.g., Deng, Wang, & Yousefpour, 2017). To fill the gap in the literature and support policymakers’ decision-making linked to climate policy, this dissertation tries to answer the following research question:

*How do personal factors (experiences, knowledge, and policy assessment) and risk perception related to climate change influence behavioral responses to address climate change?* Obviously, the aim of this study is not to explain all of the potential factors that drive individuals’ behavioral responses to cope with climate change, but to shed light on this theoretical relationship and in doing so better articulate the role of risk perception in mediating the influence of individuals’ experience, knowledge, and policy assessments of climate change.

This question is answered based on the case of South Korea, which is experiencing the rapid increase in GHG emissions in return for economic growth over the past decades. More specifically, the answer is derived from three different contexts: a) climate change risk perception and personal behaviors to mitigate climate change among individuals at the national level; b) drought risk perception and personal behaviors to adapt to drought among individuals at the local level; and c) significant issues affecting the relationship among personal factors, risk perception, and behavioral responses related to climate change as perceived by experts. Prior to empirical analyses, five hypotheses, including the positive correlation between risk perception and behavioral responses related to climate change, are proposed based on literature reviews. The works of Kates (1971), Rogers (1983), and Grothmann and Patt (2005) provide a theoretical
foundation for developing the hypotheses. Two data sets, provided by the Korea Water Resources Corporation (K-water), are utilized to conduct quantitative analyses at the national and local levels. K-water collected national level data by a Web-based survey (2016, N = 1,500) in South Korea, and collected local level data from a face-to-face survey (2015, N = 515) in north-west area of South Chungcheong Province, South Korea. Regression analysis, specifically structural equation modeling, is employed to evaluate the data. To reinforce the findings of the two cross-sectional analyses, this study conducts qualitative analyses based on an expert survey (2018, N = 98) and interviews (2018, N = 13) collected from the members of the Korea Water Resource Association, the K-water institute, and other academic organizations.

By providing empirical evidence about the relationship among personal factors, risk perception, and behavioral responses to address climate change at the national and local levels along with expert knowledge, academically, this study contributes to improving knowledge of behavioral responses against climate change as well as advancing the methodology of unveiling that relationship by using mixed-methods research. In addition, it is meaningful in that this study will be an initial step toward revealing how climate change risk perception serves as a link between personal factors and behavioral responses related to climate change in South Korea. Practically, this dissertation informs policymakers of critical clues as to how the general public voluntarily takes action to address climate change. Policymakers both in South Korea and in countries with similar socio-economic conditions can benefit the most from this study’s findings.

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2 Two survey companies, the opensurvey (‘www.opensurvey.co.kr’) and the Gallup Korea (‘www.gallup.co.kr’), conducted the Web-based survey in 2016 and the face-to-face survey in 2015 respectively, by signing survey contracts with K-water.

3 Those data include expert knowledge not only about the causal relationship among personal factors, risk perception, and behavioral responses to address climate change, but also about significant issues surrounding the relationship among them (e.g., obstacles which hinder the relationship and governmental policies to encourage individuals’ behavioral responses) within the general public.
This dissertation consists of seven chapters, including this introduction chapter.

**Two literature reviews.** The second chapter covers the background literature explaining the fundamentals of climate change and climate policy and individuals’ behavioral responses against climate change risk. It helps understand the obstacles of global collaboration to address climate change, policymakers’ difficulties in managing climate policy, and the features of individuals’ responses to cope with climate change. The third chapter presents existing theories and empirical studies dealing with the relationship among personal factors, risk perception, and behavioral responses related to climate change. A research question and hypotheses are provided in this chapter. Also, a research model based on the hypotheses is set up here.

**Three empirical analyses.** The fourth and fifth chapters quantitatively test the hypotheses at the national and local levels, respectively. While the former focuses on climate change risk perception and behavioral responses to mitigate climate change, the latter pays attention to drought risk perception and behavioral responses to adapt to drought. Both chapters provide information of research context, research methods, and the results of descriptive and regression analyses. These are followed by several policy implications and future research directions, along with potential limitations with methodology. The sixth chapter qualitatively approaches the research question from an expert’s perspective. The key point here is to fill the gaps between the hypotheses and the findings of the two quantitative analyses. The components of this chapter are similar to those of the previous two chapters.

**Synthesis and conclusion.** The seventh chapter briefly summarizes the content of the main chapters (from II to VI), including the results of the three empirical analyses, and evaluates the attainment of study objectives. Finally, it presents useful lessons for policymakers and researchers respectively, and ends with a short epilogue.
CHAPTER II

BACKGROUND

Fundamentals of Climate Change

Despite the efforts of the Intergovernmental Panel on Climate Change and the international community, the outlook of future international climate policy remains bleak.

Beginning of Anthropogenic Climate Change

Since the existence of humankind, the interaction between human and environment has ensued in direct or indirect ways. During this interaction process, human activities often caused a disturbance of natural cycles that resulted in human misery (Dankelman, 2010). Severe floods and desertification caused by deforestation of mountains (i.e., the overuse of natural resources) in human history might be good cases in point (Dankelman, 2010). Climate change brought by global warming is somewhat similar to these disasters in that human activities, called Greenhouse Gas (GHG) emissions, are responsible for it. However, climate change should not be treated equally as national or local disasters (e.g., earthquakes, wildfires, and hurricanes). This is because it can trigger social, economic, and environmental damages (e.g., extreme weather events, food shortage, biodiversity loss, and sea level rise) not only on a national or local level, but also on a global level (Bellard et al., 2012; Fischer et al., 2005; Pearce et al., 1996).

More than a century ago, before the use of the term, ‘climate change,’ the Swedish chemist Svante Arrhenius investigated how atmospheric carbon dioxide is connected with air temperature to account for the existence of ice ages (Arrhenius, 1896). In 1964, the possibility of catastrophic climate change generated by human activities was cast by social ecologist Murray

4 The earth’s cooling efficiency to space is reduced by increases in the concentration of the greenhouse gas (e.g., carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons). Global warming triggered by this phenomenon leads to unpredictable climate change (Houghton, Callander, & Varney, 1992; Nordhaus, 1991).
However, this issue raised sporadically by scholars did not receive much attention from the general public and the international community for a long time.

**Emergence of a Global Climate Change Organization**

In 1987, the word, ‘sustainable development,’ which refers to the “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987, p. 8), was introduced by the Brundtland Commission’s report (Giddens, 2011). The next year, a significant global effort for combating climate change first appeared. The Intergovernmental Panel on Climate Change (IPCC) was established jointly by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) (IPCC, 2014a). The purposes of this intergovernmental organization are both to assess the causes and impacts of climate change and to come up with more effective measures for addressing this challenge. The findings of the IPCC’s studies have been announced in a 5–6 year cycle, called *an IPCC Assessment Report* (IPCC, 2014a). Some researchers have identified problems with IPCC studies, such as a lack of systematic empirical research (Vasileiadou, Heimeriks, & Petersen, 2011), the increased mediatization and politicization (Berkhout, 2010), and a monopoly on the provision of international climate policy recommendations (Tol, 2011). Despite such criticisms, the IPCC’s papers have been rated as the most scientifically authoritative reports on climate change and have provided a framework for international negotiations related to climate change (Bolin, 2007; Choi, 2016; IPCC, 2014b; Zillman, 2007).

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5 Bookchin (1964) writes, “The burning of fossil fuels (coal and oil) add 600 million tons of carbon dioxide to the air annually…. Since the Industrial Revolution, the overall atmospheric mass of carbon dioxide has increased by 25 percent over earlier, more stable levels…. This is growing blanket of carbon dioxide, by intercepting heat radiated from the earth, will lead to more destructive storm patterns and eventually to melting of the polar ice caps, rising sea levels, and inundation of vast land areas” (p. 22).
Recently, the fifth assessment report points out that the main cause of global warming is GHG emissions from human activities, and human and natural systems are facing the greatest crisis due to climate change (IPCC, 2014b). According to the findings of the report, the average global temperature has risen by 0.89 degrees Celsius (0.69–1.08 degrees Celsius) for the past 112 years (1901–2012) due to global warming. Melting glaciers and sea level rise have been evident. Arctic glaciers will continue to recede and Antarctic glaciers have also declined in recent years (2002–2011). As a result, the mean sea level in the 20th century rose 1.7 (1.5–1.9) millimeters per year. Since 1993, it is estimated that sea level rise is accelerating by 3.2 (2.8–3.6) millimeters per year. In other words, climate change is getting faster.

Human-caused GHG emissions are affected by several factors such as an economic activity, energy use, population size, technology, and climate policy. The fifth assessment report provides the standard set of future climate change scenarios, called the Representative Concentration Pathways (RCPs) (IPCC, 2014b). Simply, the RCPs refer to “time-dependent projections of atmospheric greenhouse gas (GHG) concentrations” (Moss et al., 2008, p. 5). The four RCPs described in the fifth assessment report consist of one stringent mitigation (RCP2.6), two intermediate (RCP4.5 and 6.0), and one high GHG emission (RCP8.5) scenarios. According to IPCC (2014b), if the international community does not make additional efforts to control GHG emissions, the pathway will be located between the RCP6.0 and RCP8.5. Given the RCP8.5, the global average temperature and sea level at the end of this century (2081–2100) are expected to rise 3.7 degrees Celsius and 63 centimeters, respectively. However, if substantial net

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6 Each RCP presents a quantitative description of climate change pollutant (e.g., CO₂ and CH₄) emissions and concentrations as well as radiative forcing in 2100 (IPCC, 2014b). Radiative forcing, measured in watts per square metre (W/m²), refers to “the additional energy taken up by the Earth system due to the enhanced greenhouse effect” (Bjørnæs, 2013, p. 2). The numbers of RCPs mean their radiative forcings by 2100 (see Bjørnæs (2013), Moss et al. (2008), or Wayne (2013) for more information).
negative GHG emissions that follow the RCP2.6 are realized by the international community, the rise of the global average temperature and sea level at the end of this century can be constrained by 1.0 degrees Celsius and 40 centimeters, respectively. Finally, the report warns that if GHG emissions continue (i.e., the efforts of GHG reduction fail), and the global mean temperature exceeds 2 degrees Celsius above pre-industrial temperatures, damages due to climate change, such as the increase of food shortage, the intensification of terrestrial species’ extinction, and the rise of the death toll in extreme weather events, will most likely spread across the planet during and beyond the 21st century (IPCC, 2014b).

The IPCC has highlighted climate change as a universal issue, and its assessment reports have presented the major risks of climate change, which can have an irreversible impact on humankind (Ford et al., 2016; Zillman, 2007). Also, the IPCC has contributed to creating robust consensus that not only can effective global actions significantly reduce the levels of climate change risks, but they also lead to sustainable development (Choi, 2016). It is true that the IPCC has shown science-based leadership in the climate change field. However, the IPCC is not a real actor on the climate change stage, but an assistant. It cannot solely combat climate change without active players, such as national and local governments and the general public.

**Global Efforts for Addressing Climate Change**

Since the 1990s, the international community has made efforts and attempts to combat climate change. However, the world is in a precarious situation and needs more efforts. In 1992, the efforts of the international community to address climate change began in earnest as the United Nations Conference on Environment and Development (UNCED) adopted the United Nations Framework Convention on Climate Change (UNFCCC) in Rio, Brazil (Aldy & Stavins, 2012). This convention was based on the scientific results of climate change risk coming from
the IPCC and aimed at stabilizing the concentration of GHG in the atmosphere. The principles of the UNFCCC were “common but differentiated responsibilities and respective capabilities (CBDRC),” and these served as the core guideline of climate change negotiations (Brunnée & Streck, 2013, p. 589).

With the UNFCCC as a beginning, the efforts of the international community to prevent severe damages triggered by climate change gradually have expanded. Since 1995, parties to the UNFCCC have held the Conference of the Parties (COP) once a year for an international agreement on GHG emission control (Bodansky, 2001). In 1997, the third conference (COP–3) adopted the Kyoto Protocol, which specified global actions for responding to climate change. The Kyoto Protocol prescribes binding GHG reduction goals for thirty-eight advanced countries (e.g., France, Germany, and Japan) which is to cut GHG emissions by 5.2 percent compared to the 1990 level during the first commitment period (2008–2012) (Meyerson, 1998). However, doubts about the effectiveness of the Kyoto Protocol arise among the targeted nations. This is because although some countries, such as China, South Korea, and India, have increased GHG emissions along with the economic growth, they are not obliged to cut GHG emissions (Choi, 2016; Helm, 2008). The commitment of the Kyoto Protocol weakens further as the U. S., one of the most powerful countries and the world’ second-largest GHG emitter, refuses to ratify the Kyoto Protocol (Freedman & Jaggi, 2011).

To prepare for the post 2012 climate system after the Kyoto Protocol, in 2007, the COP–13, held in Bali, Indonesia, adopted the Bali Roadmap. Based on this roadmap, the COP–15, held in Copenhagen, Denmark, attempted to draw up a new agreement, which forces both advanced and the rest of countries to participate in the post 2012 climate system, but this conference ended without big progress (Parker et al., 2012). In 2010, the efforts of the international community to
address climate change came to first fruition at the Cancun conference (COP‒16). Countries participating in the conference agreed to put joint efforts into realizing a long-term goal (i.e., limiting the average temperature rise to within 2 degrees Celsius above pre-industrial levels) through adopting a new agreement (Liu, 2011). Namely, the necessity of a paradigm shift to a low-carbon society was recognized by the international community throughout the COP‒16 (Hourcade & Shukla, 2015). In 2013, the COP‒19, held in Warsaw, Poland, produced an agreement that each country submits a GHG reduction plan for 2020 and beyond under the slogan “Intended Nationally Determined Contributions (INDCs)” (UNFCCC, 2017).

In 2015, the COP‒21, held in Paris, France, adopted the Paris Agreement. It stressed the principle of equality and common but differential responsibilities and acknowledged different national circumstances (Choi, 2016). Through this agreement, the GHG emission reduction system, which was centered on some advanced countries at the Kyoto Protocol, was expanded to all countries. This agreement endorsed by one hundred and ninety-five countries initiated a global action plan to prevent drastic climate change through curbing global warming (European Commission, 2017). From a long-term perspective, it aimed to limit the increase in global average temperature to well below 2 degrees Celsius above pre-industrial levels (Rogelj et al., 2016). To this end, each country should establish its GHG reduction plan along with adaptation plan, and its implementation performance will be checked by the United Nations (UN) (Savaresi, 2016). As of 2016, one hundred and eight-nine countries submitted INDC reports related to the GHG reduction plan to the UN, which account for more than ninety-seven percent of global GHG emissions (Kitous et al., 2016).

Despite the international community’s efforts, the future prospect of climate change at the global level does not seem bright. According to the Climate Action Tracker (CAT), global
temperatures will likely increase 3.2 degrees Celsius above pre-industrial levels in 2100 even if major countries abide by their INDC reports (CAT, 2017a). Additionally, the U.S.’s intention to withdraw from the Paris Agreement significantly deteriorates that figure compared to 2.8 degrees Celsius estimated in 2016 (CAT, 2017a). Given that many states and cities in the U.S. have vowed to continue upholding the agreement (Plumer, 2017; Regan, 2017), the real impact of the U.S.’s exit from the deal is likely to be smaller than CAT’s outlook. Nevertheless, it might be true that the withdrawal intention of the U.S. from the Paris Agreement has cast a dark cloud over global collaboration to address climate change (Shear, 2017).

**Conditions Surrounding Global Collaboration**

**Complex characteristics of climate change.** Regarding climate change, the Earth, more specifically the atmosphere, seems to have the features of public goods (i.e., non-excludable and non-rivalrous). These goods (e.g., national security and fresh air) are usually accompanied by free rider problems and insufficient provision (Bodansky, 2012). A free rider refers to a person who gains a benefit without paying all or part of its cost (Gauthier, 1986). Also, negative

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7 The Climate Action Tracker, a scientific analysis, is provided jointly by three research organizations such as the Climate Analytics (http://climateanalytics.org/), the Ecofys (https://www.ecofys.com/), and the NewClimate Institute (https://newclimate.org/). It evaluates the efforts of thirty-two nations (e.g., the E.U., China, and South Korea), which cover around eighty percent of global emissions, based on their INDC reports and provides expected global warming consequences over the 21st century (CAT, 2017b).

8 Public goods have two characteristics: Non-excludable and non-rivalrous (Bodansky, 2012; Bueno de Mesquita, 2016; Kaul, Grunberg, & Stern, 1999). The former refers to “my having access to it means you have access to it as well,” and the latter refers to “my using the good does not reduce your access to the good” (Bueno de Mesquita, 2016, p. 105). Recently, the extended concept of public goods, called *global public goods*, has been studied by many researchers (e.g., Barrett, 2007; Kaul et al., 2003; Kaul, Grunberg, & Stern, 1999). This concept is simply defined as goods that have “non-excludable, non-rival benefits that cut across borders, generations and populations” (Kaul, Grunberg, & Stern, 1999, p. 452).

9 Ostrom *et al.* (1999) describe climate change as a new challenge of global commons. According to Ostrom, Gardner, and Walker (1994), goods are categorized into four types (i.e., public goods, common-pool resources, toll goods, and private goods), based on the degrees of exclusion—“the difficulty of excluding individuals from benefiting from a good”—and subtractability—“the subtractability of the benefits consumed by one individual from those available to others” (p. 6). While public goods have difficult exclusion and low subtractability, common-pool resources have difficult exclusion and high subtractability (Ostrom, Gardner, & Walker, 1994). Given the quality of the atmosphere which can be depleted, the perspective of Ostrom *et al.* (1999) is also right.
externalities can be triggered by the excessive use of public goods.\textsuperscript{10} However, climate change caused by GHG emissions is actually more perplexing and insurmountable than it seems. While some countries emit a greater amount of GHG with economic activities into the atmosphere and it triggers other countries’ social, economic, and environmental losses via global warming, the larger GHG emitters do not compensate them for the losses. Moreover, GHG emissions are likely to be over-supplied. If no one pays the costs (i.e., the reduction of GHG emissions), all countries in one ecosystem, the Earth, will bear immense expenses (i.e., damages from climate change). Those negative impacts can even affect future generations. Looking closer, climate change accompanied by negative impacts across the world and generations should be categorized as a “global public bad” (Kaul, Grunberg, & Stern, 1999, p. 456).\textsuperscript{11} Unfortunately, negotiations between the party triggering global warming and the party influenced by global warming are hindered by significant challenges such as difficulties in measuring damages and transaction costs (Gruber, 2013; Weimer & Vining, 2011). There is no global organization (or nation) which has legitimacy or coercion related to GHG emissions.\textsuperscript{12} Further, poor countries are much more vulnerable to damages of climate change than rich countries (Nyong, 2009). The more climate change becomes serious, the more citizens of poor countries will be under the triple torture of

\textsuperscript{10} Externalities occur “whenever the actions of one party make another party worse or better off, yet the first party neither bears the costs nor receives the benefits of doing so” (Gruber, 2013, p. 122). Negative externalities (e.g., air and noise pollutions) are more problematic.

\textsuperscript{11} Barrett (1999) also regards Ozone depletion and climate change as global public bads. Similar to public goods, public bads are non-excludable and non-rivalrous (Kolstad, 2000). However, while public goods provide positive utility to consumers and are typically under-supplied, public bads bring disutility to them and are over-supplied (Kaul, Grunberg, & Stern, 1999).

\textsuperscript{12} Legitimacy means that its members are predisposed to accept the actions of the organization, whether they agree with those actions or not (Bickers & Williams, 2001). Coercion refers to the method of persuading its members to do actions by using force such as imposing fines, taking property, and arresting (Bickers & Williams, 2001). Even though there are several global organizations associated with GHG emissions, such as the IPCC and UNEP, all of them solely depend on agreements ratified by countries. Some of the most powerful countries militarily and economically (e.g., the U.S. and China) are the main emitters of GHG, and global agreements are vulnerable to powerful nations’ withdrawal.
abnormal weather conditions, the lack of food and quality water, and social disturbances and economic instability. Overall, these characteristics, along with the following unsettled leadership and insufficient technological advancement, are retarding global collaboration for responding to climate change.

**Unsettled climate change leadership.** Many scholars consider leadership as a core determinant of success or failure in coping with transnational issues (Young, 1991). As mentioned above, poor countries, in which a majority of the population derives their livelihood from agriculture or fishery, are likely to bear a larger proportion of climate change’s adverse effects (Nyong, 2009). Also, if the international community does not reduce GHG emissions due to national self-interest, damages of climate change are passed on to future generations in the forms of natural disasters, conflicts of generations, and a larger split between the haves and have-nots. Climate change is not just a political or economic problem. It is deeply connected to ethics and requires the leadership of global leading countries. Both the U.S. and China are two of the most powerful countries in various fields as well as the second and first-largest emitters of GHG in the world, respectively (Christoff, 2016). In 2001, Paul G. Harris wrote, “Because the U.S. economy is so large, its diplomatic influence so great and its contributions to environmental

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13 The economies of poor countries can easily crash because their industries based on agriculture and fishery are deeply influenced by weather conditions (Fischer et al., 2005). Even though poor countries have contributed little to the intensification of GHG emissions in the atmosphere, they will go through more serious torment than rich countries due to weather disaster-prone industries and the lack of capacity and funding (Fischer et al., 2005; Mendelsohn, Dinar, & Williams, 2006; Nyong, 2009).

14 Considering the work of Northouse (2016), leadership consists of four components (i.e., a process, influence, groups, and common goals) and can be defined as “a process whereby an individual influences a group of individuals to achieve a common goal” (p. 6). In light of Northouse’s definition, climate change leadership might be defined as a process whereby a country (or countries) affects a group of countries to reduce global GHG emissions and minimize the impact of climate change.

15 Previous studies state that ethical leadership can positively affect organizations through reducing counterproductive and unethical behaviors (Mayer et al., 2009), enhancing followers’ moral awareness and judgement (Trevino et al., 1999), and fostering dedication, altruism, and better work willingness of followers (Brown, Trevino, & Harrison, 2005).
problems so extensive ... the United States must be part of international solutions to
environmental change” (Harris, 2001, p. 34). However, in the same year, the Bush administration
refused to ratify the Kyoto Protocol (Oberthür & Roche Kelly, 2008). This event triggered the
schism within the international community. About sixteen years later, the Trump administration
once again shocks many countries across the world by announcing the U.S. intention to withdraw
from the Paris Agreement (Ellis, 2017; Shear, 2017). In the case of China, even though it has
been recognized as one of the leaders in the climate change field by many countries (Parker et
al., 2012), China has taken a passive stance and seems unwilling to show strong leadership
toward climate change (Harris, 2017; Heggelund, 2007; Lewis, 2008).

In 1999, David A. Heenan and Warren Bennis introduced co-leadership to the climate
change field. From their perspective, climate change is a real global issue involved with many
tasks and stakeholders, unstable circumstances, and severe damages, and one leader cannot be
responsible for this huge and complicated issue. Heenan and Bennis (1999) stress that co-
leadership should not only permeate all institutions associated with climate change (from the
global to local levels), but it also shares values and aspiration to curtail the negative impacts of
global warming. Based on their work, Nhamo (2009) provides a co-leadership model for climate
change governance (i.e., the leadership vehicle). This model consists of seven leadership zones:
“mitigation, adaptation, policy and legal frameworks, technology, financing, social dynamics,
and research and development” leaders’ zones (Nhamo, 2009, p. 477). While the co-leadership
model can be utilized at various levels ranging from the local to global levels, there is no clear
guideline for who mitigation leaders should be, who technology leaders should be, etc. It
requires leaders to find their zones by themselves, and this process seems very obscure and
subjective. In sum, while leadership can play a pivotal role in enhancing global collaboration to
combat climate change, it is still immature. Global leading countries still do not show an example of pursuing the ethical norms for the world in the climate change field. Co-leadership does not seem practical due to the absence of an explicit guideline. Karlsson et al. (2011) write, “It is no easy task to provide effective leadership on such a multifaceted issue which involves high stakes for all parties involved” (p. 104).

**Insufficient technological advancement.** Increasing efforts to prevent GHG emissions generate increasing economic costs. These huge economic costs have made many countries reluctant to actively participate in global efforts on climate change (Osberghaus et al., 2010). To address this cost problem, the world should make ceaseless efforts to develop long-term and sustainable technologies, instead of depending on short-term and end-of-pipe measures which trigger marginal cost surges (Jaeger et al., 1997). Such a technological breakthrough cannot be realized immediately, and the longer the international community waits in inventing sustainable technologies, the higher the cost barrier will be (Jaeger et al., 1997). In 1997, Jaeger and colleagues advised that the European Union (E.U.) had better “break through the cost barrier” based on “procedural leadership” rather than “posture as an environmental leader by declaring ambitious targets for short-run emissions reduction” (p. 199). This advice may not be only for the E.U., but be for all developed nations. Actually, many countries have made constant efforts to enhance technologies and experiences related to climate change. For instance, in 2007, the E.U. set the target of 20% renewable energy by 2020, and many of its member states, such as

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16 Long-term and sustainable technologies to curb GHG emissions cannot be predicted in detail. But, considering the work of Jaeger et al. (1997), technologies which can improve energy efficiency, increase the production of renewable energy, produce environmentally benign goods, change people’s consumption patterns, or accelerate ecological innovation might be part of them.

17 End-of-pipe solutions refer to the inhibition of pollution emissions by utilizing additional measures without curtailing resource use (Frondel, Horbach, & Rennings, 2007) or the treatment of the impact on the environment triggered by human activities without adjusting the production process itself (Hammar & Löfgren, 2010).
Denmark, Germany, and the Netherlands, have been speeding up the development of clean
energy technologies (Lewis & Wiser, 2007; Jacobsson & Lauber, 2006; Lund & Mathiesen,
2009). Yet despite many nations’ active efforts, fossil fuel-based industries are still prevalent
in the world, and high-level technologies and huge costs linked to climate change mitigation and
adaptation strategies are a burden to many technically and economically weak countries.
Consequently, the development of inexpensive and easy-to-apply technologies related to climate
change can strengthen global collaboration and provides the bedrock of transformation to a low
carbon society. But, like leadership, technological advancement is still insufficient to make a
breakthrough in enhancing global struggle with climate change.

**Necessity of more comprehensive efforts.** According to Meijerink and Stiller (2013),
“Climate change is undoubtedly one of the most urgent policy issues of our times” (p. 240). The
evidence is clear that climate change is occurring and affecting all nations (Brecher, 2015).
Abnormal weather conditions (e.g., extremely high temperatures, floods, and droughts), glaciers
melting, and sea level rise are evident today. More seriously, it is getting worse (IPCC, 2014b).
This is because past and current global efforts, especially the reduction of GHG emissions, are
not sufficient to address perilous climate change (Osberghaus *et al.*, 2010). IPCC (2014c) warns
that if the rise of the global average temperature exceeds 2 degrees Celsius above pre-industrial
temperatures, it will fall into a vicious cycle of raising the temperature, and any human efforts to
suppress that will become meaningless. No further fence-sitting can be allowed, and genuine
accountability and swift countermeasures are needed. Paradoxically, the characteristics of
climate change as a global public bad inform the international community of both the necessities

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18 Even though many advanced countries (e.g., the U.S., China, Canada, and Japan) turned away from the Kyoto
Protocol (Odeku, Maveneka, & Konanani, 2013), the E.U. remained faithful to its roles as a global leader and has
played a significant role in saving it (Oberthür & Roche Kelly, 2008).
and the difficulties of global collaboration to address climate change. Leadership and technological advancement do not still create favorable conditions for global efforts to cope with climate change. Under this tough circumstance, to address climate change at the global level, both developed and developing countries should make more efforts to enhance global collaboration and to raise their reduction target of GHG emissions. In addition, considering the fragile global collaboration and the above-mentioned unstable conditions that surround it, this dissertation argues that efforts not only at the national and sub-national levels, but also at the non-governmental level (especially individual level) are indispensable.

**Government and Individual’s Responses to Climate Change**

*To cope with climate change, policymakers must try not only to design and implement effective climate policies, but also to activate individuals’ voluntary behavioral responses.*

**Anthropogenic–Natural Hybrid Disaster**

The identification of climate-related disasters by policymakers, whether they are natural origin or anthropogenic, is one of the key points in shaping response policies. Baum, Fleming, and Davidson (1983) compare the characteristics of natural disasters (e.g., floods, hurricanes, and earthquakes) and those of technological catastrophes (e.g., the collapse of dams and the leakage of toxic waste dumps and radiation). They state that while both of them are sudden, powerful, destructive, and hard to predict, there are two significant differences between them. First, natural disasters are uncontrollable and bring short-lived impacts, while technological catastrophes are more controllable (just a “temporary loss of control in the system”) and pose long-lasting threats (Baum, Fleming, & Davidson, 1983, p. 346). Second, recognizing the guilty party of natural disasters is difficult, whereas the guilty party of technological catastrophes can be more easily identified. This study assumes that while man-made disaster is a broader concept
than technological catastrophes, their characteristics are almost identical. In the cases of natural disasters which are uncontrollable, have short-lived impacts, and responsible agents are difficult to identify, policymakers may aim to minimize the adverse consequences of these disasters. In terms of man-made disasters which are controllable, have long-lasting threats, and have responsible agents that are more easily identified, policymakers may try to reduce the cause and probability of those disasters through controlling the responsible parties.

The complex identity of climate change does not allow policymakers to simply select one of these dichotomous strategies. The scientific community overwhelmingly has agreed that anthropogenic global climate change is occurring (Oreskes, 2004). The IPCC’s report also indicates that GHG emissions from human activities are the main cause of global warming (IPCC, 2014b). When considering only the cause of climate change, it can be categorized as a man-made disaster and seems controllable. However, climate change is accompanied by natural disasters, commonly called extreme weather events such as floods, droughts, and heat waves. The pattern of extreme weather and natural hazard events are regarded as a key signature of climate change by scientists (Mirza, 2003; Scheraga & Grambsch, 1998). Swim et al. (2009) also regard these events as “the most salient aspects of global climate change” (p. 78). Further, even climate change is controllable, it takes a great deal of time. In short, climate change has the features of both a man-made disaster and a natural disaster. Climate change policies must deal with both the causes and consequences of this anthropogenic–natural hybrid disaster.

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19 Park (2011) views man-made disasters as catastrophic accidents triggered by “human factors such as poor judgment, poor working condition, poor maintenance of equipment and/or the negligence of the operators” (p. 466). Also, Wiegman and Gutteling (1995) which compare natural disasters with man-made risks echo the conclusion of Baum, Fleming, and Davidson (1983).

20 Since the early 20th century, natural disasters triggered by human activities have been investigated by researcher projects (e.g., Bellegarde-Smith, 2011; Simpson, 1986; Ulrich, 1935). These studies mostly focus on earthquakes.
Difficulties in Government Responses to Climate Change

Unfortunately, establishing and implementing effective policies to address climate change is no simple matter for policymakers due to the following three problems.

**Uncertainty.** The great uncertainty surrounds climate change policy. Kane and Shogren (2000) characterize climate change policy as complex and contentious. This is because the relative merits of response policies are liable to alteration in accordance with “one’s view of the path of future technology, estimates of net damages, and adaptability of social and economic systems” (Kane & Shogren, 2000, p. 92). Tompkins and Adger (2005) also note that long time frames, unsure climate change impacts, and unpredictable social and economic futures make it challenging to create climate policies. Policymakers have to design policies, allocate resources wisely to serve the policies, and convince the public to support their decisions under uncertainty.

**Balancing responses.** Keeping a balance between two response options confuse policymakers. Climate change policies consist of mitigation and adaptation (Füssel, & Klein, 2006; Osberghaus, et al., 2010; Pielke, 1998; Stern, 2006). Simply, mitigation refers to “actions taken to reduce greenhouse gas emissions and hence to tackle the causes of climate change,” and adaptation refers to “actions taken to deal with the consequences of climate change, both before and after impacts are felt” (Tompkins & Adger, 2005. p. 563). Typically, mitigation brings benefits to all climate-sensitive systems at the global levels and its lead time is decades, whereas adaptation provides benefits to selected systems at the local or regional levels and its lead time is from immediate to decades (Füssel & Klein, 2006). The formulation of mitigation and adaptation policies has been largely independent (Füssel & Klein, 2006). Regarding the structure of the

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21 Regarding uncertainty, Stern (2006) describes it as “a key element of most aspects of climate change” (p. 9). Deser et al. (2012) also view it as a main challenge in planning climate policies.
IPCC, Working Group II and Working Group III deals with adaptation and mitigation, respectively (IPCC, 2017). According to Wilbanks et al. (2003), the perception that the reinforcement of adaptation policies can weaken the requirement for mitigation policies causes an adaptation and mitigation dichotomy. They state that this dichotomy is particularly prevalent where the interests toward mitigation are not strong and the costs of adaptation are considered affordable. Tompkins and Adger (2005) also note that governments make decisions about climate change mitigation and adaptation in different policy domains (e.g., energy sector / non-energy sector). However, many studies (e.g., Biesbroek, Swart, & Van der Knaap, 2009; Bosello, Carraro, & De Cian, 2010; Jones et al., 2007; Kane & Shogren, 2000; Laukkonen et al., 2009) highlight that the apparent separation of mitigation and adaptation (or trade-offs between them) might result in ineffective climate policies. Namely, the optimal mix of the two options leads to more risk reduction with less costs. Kane and Yohe (2000) write, “Each pursued in a vacuum can easily lead to increased costs of policies and programs with no attendant reduction in climate risk” (p. 2). Overall, policymakers must effectively and efficiently react to climate change, but the difficulty lies in seeking a good balance between mitigation and adaptation.

**Prioritization.** Climate change is likely to be low on the list of national policy priorities. Leiserowitz (2005) reports that while the environment and climate change have gained a high level of both awareness and concern from the American public, it has not been perceived as an imminent or a high-priority danger by them. In a 2000 Gallup poll, the environment came in 16th place on Americans’ list of the most significant problems confronting the nation today. Among thirteen environmental issues, global warming ranked 12th (Dunlap & Saad, 2001). This phenomenon that the public does not regard climate change as a priority concern is not only confined to the U.S. In 2001, the English public viewed many environmental issues, such as
hazardous waste disposal and water and air pollution, as more concerning problems than climate change (Department for Environment, Food and Rural Affairs, 2002). In 2009, global warming and climate change were ranked 13th among sixteen issues for the government (e.g., economy, unemployment, and crime) by the English public (Department for Environment, Food and Rural Affairs, 2009). Bord, O’Connor, and Fisher (2000) note that any environmental issues are less pressing concerns for the public than economic and social issues. Low priority of climate change may cause policymakers’ lack of attention to climate policy and finally lead to belated responses.

From a policymaker’s perspective, uncertainty, standing at the crossroad of mitigation and adaptation, and low policy priority associated with climate change act as barriers to set up optimal climate policies. In reality, it might be challenging for policymakers, especially in technically and economically weak countries, to perfectly overcome these obstacles by themselves. Thus, along with efforts to solve those issues, additional efforts to promote public participation in addressing climate change are necessary. The role of individuals in the climate should not be underestimated. Actually, individual and households, along with particular industries or large organizations, are major sources of climate change. For instance, in the U.S., the amount of energy consumed by individual and households at homes and in nonbusiness travel accounts for around thirty-eight percent of total energy (Gardner & Stern, 2008).

**Difficulties in Individual Responses to Climate Change**

Thankfully, individuals’ behavioral responses to address climate change can have positive effects on climate policies. Previous studies (e.g., Kane & Shogren, 2000; Kane & Yohe, 2000) report that personal adaptive responses should be considered during decision-making related to public investment in mitigation. This dissertation further asserts that individuals’ behavioral responses to cope with climate change are influential factors on both mitigation and
adaptation policies, especially where the costs of national-scale mitigation and adaptation are considered insurmountable. The more behavioral responses to cope with climate change individuals take, the less of a burden policymakers will feel in shaping climate policies and allocating limited resources to the policies. However, when focusing just on personal benefits and costs brought by behavioral responses, they are less likely to occur automatically. Recall, governments generally have two options in addressing climate change (i.e., mitigation and adaptation) and implement both mitigation and adaptation policies. Meanwhile, individuals can have the third option: No response. They can overlook climate change and depend on efforts to address climate change brought by global organizations or governments. This third option is associated with the features of individuals’ mitigation and adaptation responses.

Mitigation response. GHG emissions triggering climate change are derived from fossil fuel energy use, agriculture, and deforestation (Stern, 2006). The first source accounts for around two-thirds of GHG emissions (Stern, 2006). Government policies, such as the transformation from fossil fuel energy to renewable energy and regulation on energy-intensive industries, are indispensable to reduce GHG emissions. However, given that energy is typically used by industries and individuals, individuals’ behavioral adjustments also are needed to mitigate climate change. Semenza et al. (2008) view both government actions and cooperation from consumers as necessary things to mitigate global climate change.

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22 Given the work of Smit et al. (2000), mitigation policy is linked to “reducing or stabilizing greenhouse gas emissions or levels,” and adaptation policy is related to “adjustments in ecological-social-economic systems in responses to actual or expected climatic stimuli, their effects or impacts” (p. 225).

23 Actually, no response is not the exclusive option of individuals. Governments also can use this option against climate change. However, even though governments can make no effort to reduce GHG emissions (e.g., the U.S.’s intention to withdraw from the Paris Agreement), no response to mitigation, they cannot fully avoid the responsibility of adaption related to extreme weather events (i.e., key figures of climate change), such as preventing flood, securing water for drought, and strengthening a response system for heat waves. Overall, no response to climate change is not a realistic option for governments.
Individuals’ energy saving activities can vary such as recycling, reducing the amount of waste, using less electric facilities, driving less and using public transportation, and purchasing energy efficient cars (or electric vehicles) and facilities (Bockarjova & Steg, 2014; Masud et al., 2016; O’Connor, Bard, & Fisher, 1999; Rainear & Christensen, 2017; Whitmarsh, 2009a). But, voluntarily taking these actions to mitigate climate change is not a simple task. From a short-term perspective, benefits and costs are intermingled in human decision making. For instance, in the case of recycling, individuals should prepare spaces for recycling and non-recycling materials separately and invest their time to recycle materials. These actions for recycling are accompanied by tangible costs (e.g., spaces and time) and intangible benefits (e.g., intrinsic satisfactions linked to values).24 In contrast, in terms of using less electric facilities, individuals can obtain tangible financial benefits (e.g., saving money on their electricity bills), whereas they might accept intangible costs (e.g., inconvenience).25 Regarding driving less and using public transportation, while individuals save their money (e.g., gas and parking fees) and keep their health, the trade-off is that they may spend more physical energy (e.g., more walking) and time. Namely, it is uncertain whether individuals’ net utility, individual’s benefits minus direct and indirect costs brought by their behavioral response for responding to climate change, is positive or negative. While those who achieve positive net utility are likely to participate in behavioral responses to mitigate climate change, those who achieve negative net utility are not (i.e., selecting no response option). From a long-term perspective, as the proverb says, “One man sows and another man reaps.” Mitigating climate change has a potential to bring benefits to

24 Many studies report that values (or worldviews), such as altruism and environmentalism, are influential factors on pro-environmental behaviors (Barr, 2007; Clark, Kotchen, & Moore, 2003; Corbett, 2005) or coping actions against climate change (Akerlof et al., 2013; Kahan et al., 2012) (see p. 63 for more information about pro-environmental behaviors and coping actions against climate change).

25 Some of them may get intangible benefits, too (intrinsic satisfaction based on values).
world through reducing impacts of climate change. However, even though mitigation actions are conducted by current generations, potential benefits are expected to be enjoyed by next generations. Recall, the lead time of mitigation is decades. While those who value benefits for next generations are likely to participate in those actions to mitigate climate change, those who do not value that for next generations are not (i.e., choosing no response option).

**Adaptation response.** As mentioned earlier, anthropogenic climate change brings severe extreme weather events, posing a great threat to humankind and ecosystems, such as flood and drought. Extreme weather events themselves are not climate change but natural disasters. However, anthropogenic global warming makes extreme weather events more violent and volatile. Thus, extreme weather and natural hazard events getting more intense are viewed as parts of climate change (Mirza, 2003; Scheraga & Grambsch, 1998). Among them, flood and drought are the most common events across the world, and adaptation efforts against these disasters have been made at the national, local, and individual levels. While both flood and drought are related to water (quantity) management, they are quite different from each other.

**Flood.** According to Berz et al. (2001), “No other event of nature occurs as frequently throughout the world and causes so much damage as flood in all its various forms” (p. 458). Flood, usually led by extreme precipitation, causes extensive damage not only to human life and properties, but also to ecosystems. Briefly, it is a matter of uncontrollably excessive water in certain areas. From an individual’s perspective, their adaptation responses toward flood, such as

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26 The World Meteorological Organization (2016) defines an extreme weather as “the occurrence of a value of a weather variable above (or below) a threshold value near the upper (or lower) ends (‘tails’) of the range of observed values of the variable” (p. 4).

27 Flood refers to “an overflow or inundation that comes from a river or other body of water and causes or threatens damage” and is triggered by “weather phenomena and events that deliver more precipitation to a drainage basin than can be readily absorbed or stored within the basin” (U.S. Geological Survey, 2017). River flood, flash flood, and storm surge are generally considered as the main types of floods (Barredo, 2007; Berz et al., 2001; Jonkman, 2005).
setting up sandbags in front of the house, purchasing flood protection devices (e.g., pumps), and moving expensive furnishings to the second floor (Zaalberg et al., 2009; Grothmann & Reusswig, 2006), can bring direct benefits (e.g., minimization of property losses and loss of life) to themselves. Numerous research projects (e.g., Lindell & Hwang, 2008; Miceli, Sotgiu, & Settanni, 2008; Takao et al., 2004; Thieken et al., 2007; Zaleskiewicz, Piskorz, & Borkowska, 2002) have investigated self-protective behaviors by individuals against flood. Many of them identify that individuals get involved with behavioral responses to address flood based on perceived flood probabilities, perceived risk to life and property, and others (Bubeck, Botzen, & Aerts, 2012). Namely, there is a high possibility that individuals voluntarily take action against flood for obtaining personal benefits, and these activities can help policymakers ease the burdens of climate adaptation policy. Grothmann and Reusswig (2006), which highlight the impacts of individuals’ adaptive behaviors toward flood, note that residents’ self-protective activities at flood-prone urban areas can contribute to the prevention of monetary flood damage by eighty percent and the reduction of the need of public risk management.

*Drought.* Due to the conflicting concepts held by diverse academic fields, drought, regarded as “one of the deadly natural hazards” (Lloyd-Hughes, 2014, p. 607), has no unanimous definition (Dracup, 1991; Dracup, Lee, & Paulson, 1980; Palmer, 1965; Wilhite & Glantz, 1985). Instead, the simple definitions of Palmer (1965) and Sheffield and Wood (2012) are useful for understanding this event. Palmer (1965) defines drought as a “prolonged and abnormal

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28 Drought is usually categorized into three (Dai, 2011; Dracup, Lee, & Paulson, 1980) or four (Thurow & Taylor, 1999; Wilhite & Glantz, 1985) types: a) meteorological drought—a “period of months to years with below-normal precipitation” (Dai, 2011, p. 45); b) agricultural drought—a “period with dry soils that results from below-average precipitation, intense but less frequent rain events, or above-normal evaporation, all of which lead to reduced crop production and plant growth” (Dai, 2011, p. 45); c) hydrological drought—a “period during which streamflows are inadequate to supply established uses under a given water management system” (Linsley, Kohler, & Paulhus, 1975, p. 374); and d) socioeconomic drought—“conditions whereby the water demand outstrips the supply, leading to societal, economic, and environmental impacts” (Mehran, Mazdiyasni, & AghaKouchak, 2015, p. 7520).
moisture deficiency” (p. 2), and Sheffield and Wood (2012) describe it as “a deficit of water relative to normal conditions” (p. 11). In brief, drought can be viewed as a water shortage due to less precipitation than normal. Drought has several characteristics. From a general approach based on the work of Wilhite (2000), first, the existence of drought itself is unclear due to the absence of a precise and objective definition of drought. Second, it is uncertain when drought starts and ends because of gradual accumulation and long term persistence of its effects. Third, a wider range of geographical areas suffers from drought than other natural disasters (e.g., floods and hurricanes), and the quantification of the loss and necessary relief works is challenging. From a policy approach based on the work of Kim (2016), first, governments are likely to miss the timing to have a sense of crisis because of drought’s creeping impacts. They expect a water shortage to be solved through one or two rain events. Second, when people or industries suffer from the restriction or interruption of the water supply for a long time due to governments’ belated responses, great social and economic disruption can happen. Third, despite the adverse effects of drought on local societies, drought is underestimated among natural disasters because it hardly brings infrastructure collapsing and casualties. Fourth, the severity of drought is determined not only by natural factors (e.g., precipitation), but also by social factors (e.g., dam operation, water infrastructure, and water consumption pattern). Therefore, there can be a great deal of conflict regarding who is responsible for drought.

Given these characteristics of drought, it seems more difficult for individuals to detect and address drought than flood. Also, unlike flood, individuals’ behavioral responses against

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29 Zamani, Gorgievski-Duijvesteijn, and Zarafshani (2006) categorize drought into “slow-onset disasters” in opposition to “fast-onset disasters” (p. 679). They present slow evolvement, uncertainty and ambiguity, belated perception, and an unclear low point as the features of the slow-onset disasters.

30 However, given the work of Peduzzi et al. (2003), severe drought in highly vulnerable nations (mostly poor countries) can bring numerous casualties.
drought (e.g., saving water) generally bring social benefits rather than personal benefits. While behavioral responses to cope with flood influence personal life and properties (e.g., house and furniture), those against drought affect water resources (e.g., dams, reservoirs, and rivers), regarded as common-pool resources and increase not personal resistance but social resistance to drought. Further, whether or not an individual takes water saving actions, he or she can have an equal opportunity of water consumption with others during the period of drought. Namely, individuals are more likely to be reluctant to take action to address drought compared to flood.

In brief, individuals’ behavioral responses can contribute to helping out government climate policies and addressing climate change. However, the process of individuals’ behavioral responses based merely on personal benefits and costs triggered by the responses is not likely to be seamless and reliable.

Advantages of Individuals’ Behavioral Responses to Climate Change

Although the active role of governments is more imperative due to unstable global collaboration associated with climate change, policymakers are also facing real issues in establishing and implementing climate policies, such as uncertainties, keeping a balance between mitigation and adaptation, low policy priority, and a lack of resources which is the most serious problem in developing countries. Many research projects have suggested policy frameworks or specific strategies related to climate change mitigation (Bosetti, Carraro, & Tavoni, 2009; Lutsey & Sperling, 2008) and adaptation (Biesbroek et al., 2010; Lemieux et al., 2014; Lim et al., 2004) to help policymakers. All of those studies are valuable to policymakers to manage climate policies. Especially, Hallegatte (2009) introduces several significant and practical considerations

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31 Ostrom, Gardner, and Walker (1994) present two key points of common-pool resources: a) “excluding potential appropriators or limiting appropriation rights of existing users is nontrivial;” and b) “the yield of the resource system is subtractable” (p. 4).
to policymakers when handling climate policies: a) the production of benefits, whether or not climate change exists (“no regret strategies”); b) flexibility (“reversible strategies”); c) the reduction of vulnerability with no or low costs (“safety margin strategies”); d) the utilization of institutional or financial tools with technical solutions (“soft strategies”); and others (pp. 243–244). Surprisingly, individuals’ voluntary behavioral responses related to climate change mitigation and adaptation largely meet these options.32

Consequently, curbing the adverse impact of climate change requires not only governments’ policies, but also individuals’ daily actions (Semenza et al., 2008; Shove, 2010). Clayton et al. (2015) stress the importance of individual behaviors: Climate change cannot be effectively addressed without the exploration of its impact on human well-being, public perception, and influential factors on mitigation and adaptation behaviors. Semenza et al. (2008) also write, “Opportunity for immediate action lies in increasing voluntary mitigation by individuals engaging in more sustainable, low-carbon lifestyle choices” (p. 479). Given that individuals’ voluntary behavioral efforts for responding to climate change can support governments’ climate policies and also have the above-mentioned advantages, exploring how to promote individuals’ behavioral responses against climate change (i.e., finding a more robust process of individuals’ behavioral responses instead of depending on the relationship between personal benefits and costs from the responses) and informing policymakers of the findings are significant assignments of the academic world. This study introduces the process of individuals’ behavioral responses to address climate change, mediated by risk perception, in the next chapter.

32 Most individuals’ mitigation or adaptation actions bring themselves benefits such as saving money, improving health, and increasing satisfaction associated with the protection of environment (of course, these actions are accompanied by some costs such as inconvenience and time). Those actions also bring societies benefits, such as saving social resources, regardless of the existence of climate change. Furthermore, their activities are flexible and can be linked to institutional and financial tools.
CHAPTER III
THEORY
Risk Perception Driving Behavioral Responses

Despite the strong potential of risk perception in activating individuals’ behavioral responses to climate change, empirical evidence surrounding this relationship is still insufficient.

Climate Change Risk

In light of previous research projects (e.g., IPCC, 2001; Team, Pachauri, & Reisinger, 2007; Whitmarsh, 2009b), climate change is a change in the typical or average weather caused by (direct and indirect) human activities or natural origin. However, what inspires human responses to climate change is not climate change itself, but the perceived risk triggered by climate change. Climate change risk can be described as the probability of exposure to perilous consequences on the health or living conditions of humans and ecosystems brought by anthropogenic climate change (or conditions led by previous climate change), considering existing studies (e.g., Böhm & Pfister, 2001; Jones, 2001; Pachauri et al., 2014; UN, 1992).

Recall, the IPCC’s Fifth Assessment Report warns that excessive increases in global mean temperature will prompt several risks such as a decrease in food production, an increase in the risk of extinction of land and freshwater species, and land loss due to coastal flooding (IPCC, 2014).

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33 Weather and climate are distinct terms. While weather refers to the short-term conditions (changes) of the atmosphere in terms of temperature, precipitation, wind, etc., climate refers to average weather conditions over a long period of time (i.e., a statistical phenomenon) (Lombardi & Sinatra, 2012; National Aeronautics and Space Administration (NASA), 2011; Rebetez, 1996; Weber, 2010; Whitmarsh, 2008).

34 In the environment field, a response refers to “any action taken by any region, nation, community or individual to tackle or manage environmental change, in anticipation of that change or after change has occurred” (Tompkins & Adger, 2005, p. 564).

35 The definition of risk varies depending on the research fields, such as health, economics, and environment (Sjöberg, Moen, & Rundmo, 2004; Yates & Stone, 1992). Simply, risk refers to “the possibility of loss” and has three essential elements, such as “losses, the significance of those losses, and uncertainty associated with those losses” (Yates & Stone, 1992, p. 23). Risk perception refers to “intuitive risk judgments” (Slovic, 2000, p. 220).
2014b). These risks threatening human life and ecosystem are accompanied by untold economic damage. Estimates of damage range from US$ 140 billion to US$ 1.4 trillion (IPCC, 2014c).

Also, climate change risk has been identified in diverse fields such as human health (Haines et al., 2006; McMichael, Woodruff, & Hales, 2006; Patz et al., 2005), food (Lobell et al., 2008; McMichael et al., 2007; Rosenzweig & Parry, 1994), ecosystems (Millar, Stephenson, & Stephens, 2007; Walther et al., 2002; Winder & Schindler, 2004), and water management (Arnell, 2004; Christensen et al., 2004; Vörösmarty et al., 2000). Much scientific evidence indicates that human-induced climate change could jeopardize the world’s ecosystems and human societies (Klein, Schipper, & Dessai, 2005; Whitmarsh, 2009a).

Given the prevalence of climate change risk, this points to the question, “to what degree is the general public aware of (or familiar with) climate change risk?” According to Brechin and Bhandari (2011), at least sixty-six percent of the respondents in all the twenty-five countries surveyed (e.g., Germany, South Korea, and the U.S.) believe that the problem of global warming is either very serious or somewhat serious. Based on the different cross-national survey data, they note that more than sixty percent of the respondents in all the fifteen countries surveyed (e.g., China, India, and Japan) answer that either people are being substantially affected by climate change now or it will happen within twenty-five years. Hagen (2015) reports that more than half of the respondents in the eight countries surveyed (e.g., Germany, Spain, and the U.S.), except the Netherlands, are either highly concerned or concerned about the possible impacts of

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36 More than fifty percent of the respondents in seventeen out of the twenty-five countries answer that the problem of global warming is very serious. The question has a four point scale: very serious, somewhat serious, not too serious, and not a problem. These survey data are derived from the Pew Global Attitudes Project study released in 2009 (Brechin & Bhandari, 2011).

37 Also, a considerable major of the respondents in all the fifteen countries indicate that climate change will have significant human and ecological impacts. The results are based on the data of the World Bank survey administered in 2009 (Brechin & Bhandari, 2011). The findings of other comparative studies related to climate change perception, such as Kim (2011) and Leiserowitz (2007), are in line with those of the above-mentioned studies.
climate change. Over sixty-five percent of the respondents in all the nine countries believe that if global warming increases substantially over the next twenty years, either serious negative consequences or moderate negative consequences will take place. Over the past three decades, the general public has been exposed to scientific evidence and academic findings crystallizing climate change risk through mass-media, public campaigns, social communities, private communication networks (e.g., family and friends), and others. It is likely to be difficult for the general public to exactly figure out what trajectory climate change follows (will follow) and how much climate change negatively affects (will affect) humanity and ecosystems (in the future) in detail. However, this study asserts that the general public’s grasp of the whole situation has increased. Individuals are increasingly aware that climate change is a serious risk, an on-going risk, and a gradually intensifying risk.

Role of Public Risk Perception

Regarding the fundamental question about what goes on in individuals’ minds and what thought process they usually go through when reacting to climate change, Swim et al. (2009) offer a critical clue. They write, “Human perceptions and judgments about climate change are important because they affect levels of concern and, in turn, the motivation to act” (Swim et al., 2009, p. 37). This dissertation argues that understanding risk perception related to climate change is a prerequisite for revealing the process of individuals’ behavioral responses against climate change. O’Connor, Bard, and Fisher (1999) simply conceptualize climate change risk perception as “perceived likelihood of negative consequences to oneself and society from one specific environmental phenomenon: global warming” (p. 462). Based on existing studies (e.g., Böhm &

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38 The survey questions have a five point scale, where 1 is not at all concerned (not likely at all to happen) and 5 is highly concerned (serious negative consequences). The data of cross-national survey are emanated from the “Global Survey on Public Attitudes towards Climate Change research project” initiated in 2010 (Hagen, 2015, p. 68).
Pfister, 2001; Sjöberg, Moen, & Rundmo, 2004), this study more precisely defines climate change risk perception as a subjective evaluation of the probability of climate change (or conditions produced by previous climate change) happening and the severity of and vulnerability to its adverse consequences. The role of risk perception is presented in the following paragraphs from two perspectives: A policy perspective and an individual’s behavior perspective.

**From a policy perspective.** As alluded to previously, the establishment and implementation of effective climate policies at the national and local levels is no simple task, and depending solely on scientific information might not be a desirable way to soften this situation. This is due to the difficulties of conveying complex scientific information associated with global environmental change (e.g., climate change and stratospheric ozone depletion) to policymakers and of making usable information for decision-making purposes (Pielke, 1994). Also, scientific information cannot clearly answer policymakers’ question, “So, what?” or “What does global change mean in my district?” (Pielke, 1994, p. 317). In other words, it is very hard for policymakers to distill practical significance of scientific information related to global environmental change, to generate policy alternatives, and to secure public support.

Instead of scientific information, government policies related to environmental risks are subject to public debate and risk perception, which attract policymakers’ interests (Fischhoff et al., 1981; Johnson & Tversky, 1983). Public risk perception has widely been regarded as a significant factor in pushing or restricting political, economic, and social actions to cope with particular risks (Leiserowitz, 2005). Many researchers also highlight that public risk perception can drive both technological and scientific risk assessments and relevant policies (Correia et al., 1998; Perry, Lindell, & Tierney, 2001). Moreover, understanding public risk perceptions is critical in developing effective policies to alleviate both human-induced adverse impacts on the
environment and human vulnerability to climate change impacts (Ruddell et al., 2012). In short, public risk perception plays a significant role in producing effective climate policies and inspiring public support.

**From an individual’s behavior perspective.** Both nature and society scholars are fundamentally interested in the question: How do people perceive and respond to climate change? (Diggs, 1991). In the health field, in which investigations related to risks and behavioral responses are prevalent, estimating the seriousness of a risk (risk perception), comparing the benefits and costs of responses (coping appraisal), and choosing the response maximizing expected outcomes (behavioral response) are common steps in the process of addressing the risk (Van der Pligt, 1996). Likewise, understanding how people perceive environmental risks is critical to predicting their responses to environmental issues (Fischhoff, 1985). In the climate change field, previous research projects (e.g., Battaglini et al., 2009; Bockarjova & Steg, 2014; Keshavarz & Karami, 2016; Niles, Lubell, & Haden, 2013; Yu et al., 2013) have investigated the relationship between climate change risk perception and individuals’ behavioral responses. Many of them verify that individuals’ risk perceptions of climate change lead to their behavioral responses to address climate change.39

Overall, public risk perception can play a critical role in addressing climate change both from the perspective of policy and that of individuals’ behavior. This study mentioned that individuals are becoming more aware of climate change risk in the previous section. Nevertheless, it may not be easy for the general public to clearly perceive climate change risk

39 A few different point of views also exist. For instance, Mainieri et al. (1997) warn that public perception related to the environment may not perfectly correspond with behaviors. Based on survey data in the Athens area, Greece, Papoulis et al. (2015) report that while the majority of the respondents are concerned about climate change and agree with public actions, they remain unlikely to take individual action to cope with climate change. This is because the respondents believe that climate change should be solved by the efforts of state and industry, which they view as the main stakeholders, rather than those of individuals.
due to the three major characteristics of global change: a) the long temporal scales, which hinder humans’ direct perception; b) the extensive spatial scales, which have relatively little connection with everyday life; and c) its inherent abstraction (Kearney, 1994). Also, difficulties of transferring scientific information are likely to hinder the general public from perceiving climate change risk (Rebetez, 1996). Therefore, close attention should be paid to the formation of climate change risk perception as well as the process of individuals’ behavioral responses to address climate change, mediated by that risk perception.

**Gaps in Climate Change Risk Perception Literature**

Since the early 1970s, when the first Earth Day and the initial peak of the ecology movement emerged (Erskine, 1972), many research projects have investigated public perception regarding environmental issues. Erskine (1972) describes the “unprecedented speed and urgency with which ecological issues have burst into American consciousness” as a “miracle of public opinion” (p. 120). In 1986, Gillroy and Shapiro state that the issue of environmental protection has gained persistent concern in the U.S. The work of Dunlap and Scarce (1991) also supports the evidence of growing public concern toward environmental issues and public support for government actions to address those issues.

Regarding individual behavioral responses, Baldassare and Katz (1992) unveil that those who perceive a serious environmental threat to their health and well-being have more willingness to engage in eco-friendly practices (e.g., recycling and less driving) based on survey data in the U.S.’s Orange County, California. Since the 1990s, research projects related to climate change risk perception also have been increasing with many scientific warnings. The characteristics of the existing studies are as follows:
First, initial studies, such as Read et al. (1994), Bostrom et al. (1994), and Berk and Schulman (1995), focus on how people think about climate change and how risk perception affects the public’s willingness to pay to prevent climate change (or support tax-related climate policy). Weber (1997) studies whether farmers’ beliefs in global warming influence behavioral responses based on interview data in the U.S. Later, O’Connor, Bard, and Fisher (1999) explore the relationship between climate change risk perception and willingness both to support government actions (e.g., tax and regulation) and to take voluntary actions (e.g., driving less, avoiding the purchase of a gas guzzler, and using less air conditioning and heat). These topics have been consistently explored by many scholars (e.g., Berk & Fovell 1999; Brouwer, Brander, & Van Beukering, 2008; Veronesi et al., 2014; Viscusi & Zeckhauser, 2006; Zahran et al., 2006). Most of them indicate that the majority of people are concerned about climate change, and risk perception has a positive correlation with willingness to pay.

Second, since the 2000s, many studies have paid attention to the relationship between personal factors and climate change risk perception. These personal factors include past experiences (Keller, Siegrist, & Gutscher, 2006; Slovic et al., 2004), physical vulnerability (Brody et al., 2008), knowledge (Shi et al., 2016; van der Linden, 2015), political preferences (Carlton & Jacobson, 2013; McCright & Dunlap, 2011), and diverse socio-demographic characteristics (e.g., gender, age, education, and income). However, this research neglects the linkages between personal factors and behavioral responses addressing climate change.

Third, while research projects about the relationship between risk perception and behavioral responses have been growing recently, most are limited to certain fields, such as farming (Battaglini et al., 2009; Niles, Lubell, & Haden, 2013; Roco et al., 2015), stock-farming (Joshi et al., 2013; Opiyo et al., 2016), fisheries (Musinguzi et al., 2016), and tourism (Saarinen
& Tervo, 2006), which can be directly damaged by climate change. Unfortunately, the findings of these studies which are mostly related to specific adaptation strategies of certain industries are not necessarily applicable to behavioral responses of the general public.

Fourth, even though some studies (e.g., Deng, Wang, & Yousefpour, 2017; Spence et al., 2011; Whitmarsh, 2008) have explored the causal relationship among personal factors, risk perception, and behavioral responses associated with climate change, these empirical research projects typically employ a single personal factor (e.g., experiences of flood, drought, or climate change), focus on specific industry contexts (e.g., agriculture) and adaptive responses, or utilize the data derived from certain cities and flood and drought-prone areas.

Overall, numerous research projects have studied climate change risk perception. However, their findings do not provide enough evidence about the process of personal factors—risk perception—behavioral responses to mitigate climate change which can be generalized in the majority of people at the national level. Additionally, very few studies (e.g., Deng, Wang, & Yousefpour, 2017) have investigated individuals’ risk perceptions and their behavioral responses to cope with drought, whereas a number of studies (e.g., Lindell & Hwang, 2008; Takao et al., 2004; Thieken et al., 2007; Zaleskiewicz, Piskorz, & Borkowska, 2002) have explored risk perception and self-protective behaviors by individuals against flood.

**Filling the Gaps in the Literature: Research Question**

**Research question.** According to Valls and Sarda (2009), “Climate change has already begun, and will go on for decades” (p. 48). For alleviating the adverse effects of global change, human behaviors must be changed (Kearney, 1994). This dissertation also asserts that what national-level policymakers really need is how to encourage people voluntarily participate in behavioral responses to mitigate climate change, and what local level policymakers actually need
is how to facilitate people’s adaptive behaviors against to climate change, especially drought. Therefore, to fill the gaps in the literature and support policymakers’ policy-making related to climate change, this study investigates the following research question: *How do personal factors and risk perception related to climate change influence personal behaviors to address climate change?* This research question is answered in three different contexts: a) climate change risk perception and personal behaviors to mitigate climate change among individuals at the national level; b) drought risk perception and personal behaviors to adapt to drought among individuals at the local level; and c) significant issues influencing the relationship among personal factors, risk perception, and behavioral responses related to climate change as perceived by experts.

**Three personal factors.** Unlike physical scientists who approach risks from empirical climate observations and models, the risk perceptions of the public are being affected both by scientific and technical descriptions of risk and by a broader spectrum of factors such as psychological, social, and personal experiences (Lorenzoni & Pidgeon, 2006; Slovic, 2000). As mentioned above, many personal factors (e.g., experiences and knowledge) have been utilized by previous research projects. This dissertation focuses on three personal factors: *Personal experience, knowledge, and policy assessment.* It is important to note that this study does not aim to understand all of the factors that can shape individuals’ behavioral responses to address climate change. Instead, it aims to better understand the connections among these factors, risk perception, and behavioral responses and articulate the role of risk perception as a mediator. While this approach may not capture some of the antecedent variables that are theoretically related to individuals’ risk perception and behavioral responses to climate change, it allows this study to zoom into factors that are both recognized across different literatures as proximal to behavioral responses, and which have policy relevance (also see pp. 61–62).
Integrated Research Model

Higher risk perception affected by personal factors (experience, knowledge, and policy assessment) related to climate change may intensify individuals’ behavioral responses.

Theoretical Foundation for Individuals’ Behavioral Responses

Previous research projects investigating the causal relationship among personal factors, risk perception, and behavioral responses associated with climate change lack theoretical, conceptual, and methodological coherence. To enhance the theoretical foundation and to derive hypotheses and a research model, this dissertation introduces three works, Kates (1971), Rogers (1983), and Grothmann and Patt (2005). These three studies provide insights that suggest risk perception acts as a causal mechanism linking personal factors and behavioral responses to address the risk.

First, Kates (1971) proposes a general systems model of human adjustment to natural hazards. The purpose of Kates’ model is to identify key components of the human response system, to present the strengths and direction of the linkages among those components, and to simulate the processes derived from the components and linkages. Simply, he posits that hazard experiences influence risk perception, and risk perception leads to human responses. Figure 1 presents Kates’ general systems model (Kates, 1971, p. 447). Kates’ model hints that individuals’ hazard experiences have a positive relationship with their risk perceptions, and these risk perceptions lead to adjustment strategies. However, it does not specifically describe a process of forming risk perception.40

40 While some natural hazard-related studies (e.g., Hanson, Vitek, & Hanson, 1979; Mitchell, 1974; Pulwarty & Riebsame, 1997) have introduced the work of Kates (1971), no empirical research project related to climate change employed Kates’ general systems model.
Figure 1. Kates’ (1971) general systems model of human adjustment to natural hazards

Second, Rogers (1975; 1983) introduces Protection Motivation Theory (PMT). He presents the cognitive steps of individuals’ coping action against a risk, which include: a) “the threatened event is severe;” b) “that, oh yes, it can happen to you;” c) “but that there is an effective way to avoid the danger” (Rogers, 1983, p. 153). Briefly, the purpose of PMT is to reveal how a threat leads to coping actions (i.e., behavior changes) through protection motivation. It has widely been applied in diverse fields, such as health (Floyd, Prentice-Dunn, & Rogers, 2000; Milne, Sheeran, & Orbell, 2000), technology (Ifinedo, 2012; Vance, Siponen, & Pahnila, 2012), and environment (Bockarjova & Steg, 2014; Kim, Jeong, & Hwang, 2013; Rainear & Christensen, 2017) based on broader applicability. Rogers’ (1983) PMT consists of three parts: The acquisition of information, perceptual process, and responses. First, people obtain information from environmental and intrapersonal sources. Second, the acquisition of

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42 Tunner, Day, and Crask (1989) note that PMT explains “how individuals process threats and select responses to cope with the danger brought about by those threats” (p. 267).
information initiates the perceptual process. Throughout this process, people compare rewards with the threat severity and their vulnerability (i.e., the expectancy of being exposed to the threat), called threat appraisal. They also compare self and response efficacy with response cost. This process is called coping appraisal.\footnote{These appraisals can be described by the following questions from an individual’s perspective:
(1) Does an individual obtain rewards from the threat? (i.e., perceived rewards)
(2) Does an individual believe that the threat is severe? (i.e., perceived severity)
(3) Does an individual feel vulnerable? (i.e., perceived vulnerability)
(4) Does an individual believe that the adaptive response can be an effective way of avoiding or minimizing the threat? (i.e., response efficacy)
(5) Is an individual confident in his or her capacity to accomplish the adaptive response? (i.e., perceived self-efficacy)
(6) Are the costs related to the adaptive response small and affordable? (i.e., perceived response costs) (Cismaru, Lavack, & Markewitch, 2009; Rogers, 1983).}

Lastly, protection motivation is formed by the results of the two appraisals, and it leads to certain responses. Figure 2 lays out the schema of Rogers’ protection motivation theory (Rogers, 1983, p. 168). PMT also depicts a consecutive process among influential factors, risk perception, and coping actions.

\textbf{Figure 2.} Rogers’ (1983) protection motivation theory

Some research projects applied PMT to natural hazards and climate change. In the case of natural hazards, Mulilis and Lippa (1990) utilized PMT to study whether a negative, threat-inducing message influences home owners’ earthquake preparedness in California, the U.S. Martin, Martin, and Kent (2009) investigated the relationship among direct experience with wildfire, risk perception, and the risk mitigation process based on the data derived from three
homeowner associations in the western U.S. Poussin, Botzen, and Aerts (2014) applied PMT to flood preparedness in three flood-prone regions in France. Overall, the findings of these studies support Rogers’ (1983) PMT. In terms of climate change, Cismaru et al. (2011) investigated a mix of eleven communication campaigns associated with climate change deriving from English-speaking countries (e.g., “ACT ON CO₂” in the United Kingdom (U.K.), “Change.ie” in Ireland, “Climate Change Household Action Campaign - Think Change” in Australia, “Fight Global Warming” in the U.S., and “You Control Climate Change” in the E.U.) (pp. 69‒76). The study reports that most PMT variables that affect behavioral changes are utilized by all of the campaigns. Rainear and Christensen (2017) explored whether the five PMT constructs (e.g., severity, vulnerability, and response costs) have a relationship with intentions to engage in pro-environmental behaviors (i.e., mitigating global warming). The findings of this study strongly match PMT. Similarly, the work of Kim, Jeong, and Hwang (2013), which examines behavioral intentions related to climate change mitigation among American and Korean students, reports that some components of PMT (e.g., perceived severity and response efficacy) are significant predictors of behavioral intentions to cope with climate change.

Lastly, Grothmann and Patt (2005) develop a process model of private proactive adaptation to climate change based on Rogers’ (1983) PMT. Similar to PMT, This model has two major cognitive processes, called climate change risk appraisal and adaptation appraisal, and each process has two (i.e., “perceived probability and severity”) and three (i.e., “perceived adaptation efficacy, self-efficacy, and adaptation costs”) subcomponents, respectively (p. 204). This model has several features compared with PMT. First, considering the characteristics of

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44 While the work of Rainear and Christensen (2017) strongly verifies PMT, it has some limitations. Their work focuses on the stage of cognitive mediating processes. The authors do not utilize specific influential factors, such as experiences and knowledge, except socio-demographic characteristics. Also, respondents are limited to a certain job (i.e., students enrolled in a large public university) and a certain area (i.e., a northeastern part of the U.S.).
climate change which generally do not bring benefits, this model does not reflect intrinsic and extrinsic rewards in the risk appraisal process. Second, reliance on public adaptation, which negatively affect risk appraisal, is newly added to the model.\textsuperscript{45} Third, an additional cognitive process, called \textit{avoidant maladaptation} consisting of fatalism, denial, and wishful thinking, is placed between the appraisals and the adaptation intention (i.e., PMT’s protection motivation).\textsuperscript{46} This model posits that influential factors, such as personal experiences, public adaptation, and social discourse, have a relationship with risk perception, and this perception formed by the two appraisals influence personal adaptive responses. Figure 3 describes Grothmann and Patt’s (2005) model (Grothmann & Patt, 2005, p. 204).

\begin{figure}
\centering
\includegraphics[width=\textwidth]{grothmann_patt_model.png}
\caption{Grothmann and Patt’s (2005) model of private proactive adaptation to climate change}
\end{figure}

\textsuperscript{45} Grothmann and Patt’s (2005) posit that successful adaptation policies conducted by public agencies will make people less likely to take action to adapt to climate change.

\textsuperscript{46} Avoidant maladaptation, also called \textit{maladaptive coping} or \textit{nonprotective responses}, has been operationalized by many previous studies (e.g., Abraham \textit{et al}., 1994; Bubeck, Botzen, & Aerts, 2012; Fruin, Pratt, & Owen, 1992; Grothmann & Reusswig, 2006; McCrae, 1984). Rippetoe and Rogers (1987, p. 598) provide the definitions of the following core modes: a) avoidance—an “attempt to evade actively or deny the threat;” b) wishful thinking—a “strategy that prompts the use of panaceas or unrealistic solutions to a problem;” c) fatalism—the “acceptance of a stressful situation as unchangeable and complacency in the face of danger because nothing can be done anyway;” and d) hopelessness—“absence of belief in possible solutions to a threat without acceptance.”
Research Modeling Approach

It is true that Kates’ (1971), Rogers’ (1983), and Grothmann and Patt’s (2005) models have the potential to analyze the causal relationship among personal factors, climate change risk perception, and behavioral responses to address climate change. However, this study argues that an adjusted research model, which is more practical and tailored to the research question and policymakers’ needs, is necessary when considering the following three important points.

First, diverse personal factors that can be linked to the establishment of climate policy should be included in the research model. Kates’ (1971) model solely focuses on an experience factor. Rogers’ (1983) PMT has both experience and knowledge factors. However, this knowledge factor is limited to observational learning (“seeing what happens to others”) (Rogers, 1983, p. 167). Grothmann and Patt’s (2005) model includes experience, knowledge, and policy-related factors. While this research project focuses on key personal factors identified by the three works (e.g., experience, knowledge, and policy assessment), these personal factors will be specified to provide multifaceted policy implications based on the findings of previous empirical studies related to climate change risk perception and individuals’ behavioral responses.

Second, cognitive processes connecting personal factors and behavioral responses need to be simplified. Some components in Rogers’ (1983) PMT and Grothmann and Patt’s (2005) model, such as response efficacy, self-efficacy, and response costs, play an important role in deciding adaptive behavioral responses. Generally, adaptive behavioral responses in certain

47 Also, Rogers’ (1983) PMT regards “verbal persuasion (especially fear appeals)” as a factor which initiates the cognitive mediating processes (p. 167). Knowledge related to risks may be transmitted during the process of verbal persuasion. But, this study does not view it as an explicit knowledge factor.

48 Actually, social discourse on climate change risk and adaption is not a personal factor, but it might affect personal knowledge related to climate change. Also, Grothmann and Patt (2005) posit that personal knowledge affects behavioral responses via the adaptation appraisal.
fields (e.g., agriculture and stock-farming) can bring both significant costs and benefits directly to people who take action, and a significant level of capacity is required to accomplish those responses. For instance, when farmers suffering from climate change alter their crops, which are less vulnerable to climate change than current ones, they might consider these questions: a) how much can these crops endure climate change and minimize the losses caused by climate change? (i.e., response efficacy); b) is it possible for me to grow these crops? (i.e., self-efficacy); and c) can I afford costs triggered by changing the crop and do the additional benefits derived from altered crops outweigh the costs? (i.e., response costs). However, in the case of the general public’s behavioral responses associated with climate change mitigation or adaptation (especially drought), they typically do not pay high costs and do not receive direct and significant benefits from their behavioral responses (small benefits and costs are often mixed together). High capacity is not necessary for completing behavioral responses. Also, many mitigating activities (e.g., less driving, energy saving, and others) and their significant impacts on the reduction of GHG emissions are well known to the general public, and they are not difficult to practice. Namely, those efficacy-related components seem less important to this study’s research model. Besides, data from two surveys utilized in the following national and local level analyses unfortunately do not include the measurement of efficacy-related components. Thus, the research model excludes the adaptation appraisal and just focuses on the climate change risk appraisal (i.e., climate change risk perception).

Third, the ways in which different personal factors influence behavioral responses to address climate change can vary. The works of Kates (1971), Rogers (1983), and Grothmann and Patt (2005), suggest that personal factors, such as experiences and knowledge, influence risk perception through a cognitive process, and risk perception affects behavioral responses.
However, O’Connor, Bard, and Fisher (1999) present a different approach. They do not regard risk perception as an independent cause of environmentally friendly or hostile behaviors, but an essential by-product of environmental beliefs. Namely, O’Connor, Bard, and Fisher (1999) posit that behavioral responses to address climate change are a partial function of climate change risk perception. Some studies pay attention to both a direct path (from personal factors to behavioral responses) and an indirect path (from personal factors to behavioral responses via risk perception). For example, Niles, Lubell, and Haden (2013) investigated the relationship among farmers’ factors, risk perception, and responses in the U.S. They identify both the impact of a direct-path (e.g., from climate change experience to government program participation) and an indirect path (e.g., from climate change experience to government program participation via climate change risk perception). Zaalberg et al. (2009) explored the relationship among past flooding experiences, cognitive appraisals, and coping efforts in the Netherlands. They also verify the direct and indirect impacts through using mediated models predicting coping responses. Therefore, there is a possibility that individuals’ behavioral responses to address climate change are functions of both personal factors and climate change risk perception. To clarify these functions, the research model should be designed to explore the dual path impacts, directly between personal factors and behaviors as well as indirectly via risk perception.

**Hypotheses and Research Model**

**Hypotheses.** Based on the identified theoretical foundation, research modeling approach, and the findings of existing empirical studies, five hypotheses are proposed.

**Experiences.** Many studies (e.g., Keller, Siegrist, & Gutscher, 2006; Slovic et al., 2004; Weinstein, 1989) note that risk perception is deeply influenced by past experiences. Regarding climate change, the perception and reaction of the public are largely based on their own
experiences, “when they feel that they themselves have been subjected to tangible signs of climate change” (Rebetez, 1996, p. 495). Spence et al. (2011) also stress the importance of the “first-hand experience of its potential consequences” in perceiving and responding to climate change (p. 46). These arguments are theoretically supported by the works of Kates (1971), Rogers (1983), and Grothmann and Patt (2005), which consider personal experiences as one of the key influential factors on risk perception and behavioral responses.

Empirical evidence about the relationship between personal experiences and risk perception related to climate change has been provided by previous studies. This evidence is based on the experiences of certain extreme weather events, such as flood (O’Connor et al., 2005; Siegrist, & Gutscher, 2006; Whitmarsh, 2008) and drought (Dessai & Sims, 2010; Diggs, 1991), or the experiences of global warming (Akerlof et al., 2013; Donner & McDaniels, 2013; Li, Johnson, & Zaval, 2011). For example, Diggs (1991) studied whether drought experiences affect Great Plains farmers’ perceptions of climate change based on a mail survey in the western North Dakota and northeastern Colorado in 1989. He notes that peoples’ risk perceptions can be solidified by drought experiences. O’Connor et al. (2005) reveal that managers of community water systems who have experience of a flood emergency in the last five years show a higher flood risk perception than managers who do not by analyzing survey data in two eastern American states (South Carolina and Pennsylvania). The work of Akerlof et al. (2013) explored whether perceived personal experiences of global warming (e.g., changes in seasons, weather, and lake levels) have a relationship with risk perception in the U.S.’s Alger County, Michigan. They conclude that respondents who have more perceived personal experience of climate change present higher perceptions of local climate change risks. Based on long-term climate and survey data, Donner and McDaniels (2013) investigated the impact of national temperature fluctuations...
on individuals’ concerns about climate change in the U.S. The authors report that mean temperature anomalies are correlated with greater concerns about anthropogenic climate change.

While these studies identify the positive correlation between personal experiences and climate change risk perception, Whitmarsh (2008) provides mixed results. He explored how personal experiences of flooding and air pollution affect individuals’ knowledge, attitudes, risk perception, and behavioral responses related to climate change based on interview and survey data in the south of England. The study reports that the experience of floods makes little difference between flood victims’ and non-victims’ risk perceptions of climate change, whereas the experience of air pollution affects air pollution victims’ and non-victims’ risk perception of climate change differently.

The number of studies on the relationship among personal experience, risk perception, and behavioral efforts related to climate change has been growing. For example, O’Connor, Bard, and Fisher (1999) state that perception related to the bad consequences of climate change has a significant positive relationship with both voluntary actions to mitigate climate change and voting intentions on climate policy proposals. Lubell, Zahran, and Vedlitz (2007) hypothesize that perceived climate change risk positively influences global warming activism (i.e., policy support, political participation, and environmental behaviors). Their empirical test based on telephone survey data in the U.S. successfully verify the hypothesis. Based on survey data in China, Yu et al. (2013) investigated whether public concern about climate change and perception of the impact of climate change affect willingness to take individual actions to address climate change. While public concern about climate change has a significant positive relationship with behavioral intentions, perception of the impact of climate change shows mixed results. Spence et al. (2011) investigated the relationship among personal experience of flooding, concern over
climate change, and willingness to save energy based on the data of the national survey across the U.K. in 2010. They reveal not only the positive correlation among them, but also the direct and indirect (via risk perception) impacts of flooding experience on energy-saving behavioral intentions through utilizing path analysis.

Meanwhile, based on structural equation modeling, Deng, Wang, and Yousefpour (2017) explored whether drought experiences influence two perceptions (i.e., climate change and saving water) and water saving behaviors in southwestern China. While path 2 (experience–perception of saving water–behaviors) presents a significant correlation among the three variables, path 1 (experience–perception of climate change–behaviors) shows a significant positive relationship only between perception and adaptive behaviors. In the case of Niles, Lubell, and Haden (2013), they studied the relationship among farmers’ past experience of climate change (i.e., water availability), climate change risk perception, and government program participation through employing path analysis. While the past experience significantly affects the two variables, surprisingly, it has a negative relationship with the government program participation.

Personal experience itself does not ensure a positive relationship with risk perception. This is because each experience is based on the diverse conditions of severity and vulnerability and can bring different subjective appraisals about risks. While experiences of climate change with high severity and vulnerability can present a positive relationship with risk perception, climate change experiences with low severity and vulnerability can have no relation to risk perception and even can have a negative relationship. Also, because risk perception is likely to be shaped by other factors (e.g., core values, education, and gender), the impact of these experiences can be mitigated by these other factors. However, previous studies have found that the impacts of climate change are getting more severe, and many nations and local areas are
highly vulnerable to those of climate change. The majority of existing empirical studies identify positive relationships between personal experiences and risk perception associated with climate change.

To better understand the structural relationship among personal experiences, risk perception, and behavioral responses to address climate change, this study divides personal experiences related to climate change into two types: *Short-term experience* and *long-term experience*. This approach reflects the definition of personal climate change experience described in Appendix A. The short-term experience consists of the personal experiences of extreme weather events (i.e., drought and flood). The long-term experience is composed of the personal experiences of four climate change features (i.e., the rising of average temperature, the change in precipitation, the increase of the danger of flood, and the increase of the danger of drought in the last ten years). While some research projects (e.g., Mase, Gramig, & Prokopy, 2017; Niles, Lubell, & Haden, 2013) view individuals’ statements about climate change features (e.g., the global climate is changing and average global temperatures are increasing) as climate change beliefs, this study considers that the individuals’ statements about climate change features based on a long-term period (e.g., at least a decade) can be treated as experiences. Based on the identified theoretical approaches (i.e., Grothmann & Patt, 2005; Kates, 1971; Rogers, 1983) and much empirical evidence, this study posits that personal experiences (both the short-term and long-term experiences) related to climate change have a positive correlation

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49 The words, *short* and *long terms*, are subjective, and there is no clear guideline about them. Considering the IPCC’s analysis period (more than decades) (IPCC, 2014b), this dissertation views a long-term as at least a decade. Füssel and Klein (2006) also note that the lead time of mitigation is decades.

50 Climate change, which is a long temporal, extensive spatial, and far from our daily environment phenomenon, cannot be easily experienced by individuals (Swim *et al*., 2011). However, recent studies (e.g., Akerlof *et al*., 2013; Howe *et al*., 2013) indicate that climate change in the local level has been fairly accurately detected by individuals. Therefore, this study views the long-term experience as perceived experiences. Nevertheless, it might be true that individuals’ perception of climate change experiences is tightly intertwined with beliefs.
climate change risk perception. Additionally, given some studies (e.g., Niles, Lubell, & Haden, 2013; Spence et al., 2011; Zaalberg et al., 2009) have identified the direct impact of past experiences on behavioral responses, along with the indirect impact via risk perception, this study also expects the existence of the direct and significant path impact between the short-term experience and behavioral responses to address climate change. The first hypothesis is proposed:

*Hypothesis 1: The more experience with climate change people have, the higher level of climate change risk perception they will have (and in the case of the short-term experience, the more actions to address climate change they will take).*

Additionally, to analyze the relationship among personal experiences, drought risk perception, and adaptive behaviors against drought, experience of water supply problems (e.g., limited water supply, low water pressure, etc.) during a drought period is utilized as an experiential factor.

*Knowledge.* The knowledge theory, which is the most widely held theory of risk perception, implies that “people perceive technologies (and other things) to be dangerous because they know them to be dangerous” (Wildavsky & Dake, 1990, p.42). Rogers’ (1983) PMT posits that cognitive mediating processes (i.e., shaping risk perception), which lead to coping actions, can be initiated by observational learning. Grothmann and Patt’s (2005) model considers knowledge as a significant factor influencing climate change risk perception. Kates’ (1971) model also implicitly indicates that knowledge influences human adjustments to cope with natural hazards.

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51 Experience with climate change and climate change risk perception include experience with drought and drought risk perception, respectively.

52 Wildavsky and Dake (1990) investigated the relationship between several influential factors (e.g., knowledge, personality, political orientation, and cultural biases) and risk perception. They identify a minimal relationship between self-rated knowledge and risk perception.
Knowledge-related factors have been used in a number of empirical research projects. There is no doubt that knowledge is a potential factor increasing climate change risk perception or behavioral responses to address climate change. For instance, Malka, Krosnick, and Langer (2009) studied the relationship between knowledge and concern about global warming based on data from two surveys in the U.S. They conclude that more knowledge leads to greater concern among Democrats, Independents, and people trusting scientists to convey dependable information. In New Zealand, Milfont (2012) explored the relationship among knowledge, risk perception, and perceived efficacy related to global warming and climate change by utilizing panel data (three time points from 2008 to 2009). The author reports that concerns about global warming and climate change are significantly intensified by knowing more about them. Lee et al. (2015) examined the significant predictors of the public’s climate change awareness and risk perception. By analyzing the data of 119 countries, which derived from the Gallup World Poll in 2007–2008, they note that climate change risk perceptions are strongly predicted by the understanding of human-caused climate change, especially in Latin America and Europe. In the same vein, based on online survey data of six countries (e.g., Canada, China, the U.K., and the U.S.), Shi et al. (2016) investigated the relationship between three knowledge factors (i.e., physical characteristics, causes, and consequences) associated with climate change and concern about climate change. The research findings unveil that the knowledge factors, especially the causes of climate change, are important drivers of climate change risk perception.

O’Connor, Bard, and Fisher (1999) use knowledge, measured by the level of understanding about the causes of climate change, as an independent variable when assessing

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53 Also, Milfont (2012) stresses that higher concerns about global warming and climate change increase perceived efficacy and responsibility to help address them.
voluntary actions to alleviate climate change and voting intentions about climate policy proposals. They find that knowledge has a significant positive relationship with both voluntary actions and voting intentions. Halady and Rao (2010) explored the linkage between awareness to climate change and behavioral changes amongst individual managers in India. They report that behavioral changes of individual managers are significantly influenced by awareness to climate change. In the case of Yu et al. (2013), they categorize the causes of climate change as a perception factor instead of a knowledge factor. The results of their study are consistent with previous studies: The less that people perceive climate change as natural consequences, the more that people take action to cope with climate change. Meanwhile, Lubell, Zahran, and Vedlitz (2007) hypothesize global warming knowledge as a positive factor on global warming activism (i.e., policy support, political participation, and environmental behaviors). Unlike the perceived risk factor, which has a positive relationship with the three activities, they find that global warming knowledge significantly and positively affects only one activity (i.e., policy support). Based on survey data from an Alpine region in Switzerland, Jaeger et al. (1993) also reveal that while the level of educational achievement is a significant predictor of climate-relevant behaviors, knowledge about climatic risks is not.

Considering the findings of both theoretical and empirical studies, knowledge, mostly associated with general features of climate change (e.g., causes and consequences), typically shows a positive correlation with climate change risk perception or coping actions against climate change. The catch here is that many empirical studies employing knowledge-related factors (e.g., Kellstedt, Zahran, & Vedlitz, 2008; Malka, Krosnick, & Langer, 2009; Milfont, 2012; Shi et al., 2016; Stevenson et al., 2014) focus not on behavioral responses to address climate change, but on climate change risk perception. While some studies (e.g., Halady & Rao,
2010; Lubell, Zahran, & Vedlitz, 2007; O'Connor, Bard, & Fisher, 1999) verify the statistically significant relationship between knowledge and behavioral responses to address climate change, they do not consider that climate change risk perception can be a significant medium for connecting them (i.e., the process of personal knowledge—risk perception—behavioral responses). Also, in light of the identified theoretical foundation (i.e., Grothmann & Patt, 2005; Kates, 1971; Rogers, 1983), knowledge associated with climate change, especially general characteristics of climate change, should be regarded as an influential factor mediated by climate change risk perception on behavioral responses to address climate change.

To investigate individuals’ behavioral responses to mitigate and adapt climate change, this study utilizes four general knowledge factors, which are commonly used by previous studies, and two specific knowledge factors related to government policy. In the case of mitigation, three factors (i.e., awareness of climate change, the understanding of the cause of climate change, and the familiarity with a government GHG reduction plan) are used as knowledge-related factors. In terms of adaptation, the remaining three factors (i.e., awareness of water quantity conditions, the exposure to water saving information, and the familiarity with subsidy policy during a drought period) are utilized. The application of policy-related knowledge can give policymakers an opportunity to witness whether or not the knowledge diffusion related to climate policy facilitates individuals’ behavioral responses to address climate change. However, no research project provides clear evidence about the impacts of climate policy-related knowledge on risk perception or behavioral responses related to climate change. This study asserts that the

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54 Both Lubell, Zahran, and Vedlitz (2007) and O’Connor, Bard, and Fisher (1999) utilize climate change risk perception and knowledge as influential factors on behavioral responses to address climate change independently. Their findings reveal that the impact of climate change risk perception is much stronger than that of knowledge on behavioral responses to cope with climate change.
familiarity with government policies to address climate change will lead people to support these policies through their behavioral responses to cope with climate change.55

In summary, this research project views general knowledge of climate change and climate policy-related knowledge as influential factors related to climate risk perception and individuals’ behavioral responses to address climate change, respectively. As an exception, the impact of the exposure to water saving information, one of the general knowledge related adaptations, is investigated through both direct and indirect paths. It refers to individuals’ participation in a campaign, publicity, or education related to water saving. Usually, these events not only inculcate people with general knowledge related to drought and action guidelines to save water, but also motivate them to take action. In other words, unlike the other three knowledge factors, this factor is likely to influence both climate change risk perception and individuals’ behavioral responses against drought. Hypothesis 2 and 3 are proposed:

**Hypothesis 2:** The more general knowledge associated with climate change people have, the higher level of climate change risk perception they will have (and in the case of the impact of the exposure to water saving information, the more actions to address climate change they will take).

**Hypothesis 3:** The more policy-related knowledge associated with climate change people have, the more actions to address climate change they will take.

**Policy assessment.** Unlike personal experience and knowledge, policy assessment has received minimal attention from scholars. Adger et al. (2009) write, “Policies and non-climatic drivers…currently play perhaps an even more important role [than climatic drivers] in

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55 According to O’Connor, Bard, and Fisher (1999), knowledge can directly influence environmental behaviors when providing cues for appropriate behavioral strategies. Knowledge related to government policies generally give the general public useful clues what it takes in order to address certain risks.
influencing adaptive behaviors to climate change” (p. 335). However, only a few empirical studies utilize assessment factors related to government policy. For example, in 1999, O’Connor, Bard, and Fisher used government helpfulness (i.e., the scale for government working well) as an independent variable that affects individuals’ voting intentions to climate policy proposals (e.g., tax and regulation). The findings of the study reveal that the government helpfulness and individuals’ voting intentions have a significant positive relationship. The research framework of Yu et al. (2013) adopts a policy assessment factor, “confidence on government’s response to climate change” (p. 467). This factor is measured by the level of trust in the effectiveness of the government’s responses to climate change. Based on survey data in China, they unveil that the policy assessment factor has a significant positive relationship with individual behaviors to curb climate change. Also, Niles, Lubell, and Haden (2013) studied the relationship among farmers’ past experience with environmental policies, climate change risk perception, and their response (i.e., intention about government program participation). While prior research finds a significant negative relationship between past policy experience (positive policy assessment) and risk perception, and a significant positive relationship between risk perception and government program participation, the direct impact of past policy experience on government program participation is not detected.

From an empirical perspective, O’Connor, Bard, and Fisher (1999) utilize a policy assessment factor, but the authors do not investigate the relationship between government helpfulness and voluntary actions to address climate change. While Yu et al. (2013) identify a significant relationship between a policy assessment-related factor and behavioral responses to address climate change, they do not consider that climate change risk perception can act as a bridge between them. Lastly, Niles, Lubell, and Haden (2013) fail to verify the direct
relationship between personal policy assessment and behavioral responses, whereas their findings validate the process of personal policy assessment shaping risk perception, which in turn shapes behavioral responses related to climate change. From a theoretical perspective, Grothmann and Patt (2005) include the factor, ‘reliance on public action,’ in their process model of private proactive adaptation to climate change. Reliance on public actions has a negative correlation with climate change risk appraisal, which leads to individuals’ adaptive responses against climate change. Namely, they expect that individuals’ risk perception related to climate change will decrease if climate policies implemented by public agencies can successfully address climate change risk.

Given the results of empirical research projects and the theoretical approach of Grothmann and Patt (2005), policy assessment associated with climate change can be regarded as a negative influential factor on climate change risk perception. Four policy assessment factors are utilized to explore the relationship with climate change risk perception. Concerning mitigation, drought policy assessment and flood policy assessment are employed. Regarding adaptation, water supply assessment and water infrastructure assessment are utilized. Hypothesis 4 is proposed:

_Hypothesis 4: The lower people’s level of satisfaction with climate policy is, the higher level of climate change risk perception they will have._

_Risk perception._ Based on the identified theoretical approaches (i.e., Kates, 1971; Rogers, 1983; Grothmann & Patt, 2005) and the findings of numerous empirical studies, the fifth and last hypothesis is proposed:

_Hypothesis 5: The higher people perceive climate change risk, the more actions to address climate change they will take._
Controls: Socio-demographic characteristics. Many existing studies associated with climate change risk perception and behavioral responses to address climate change include socio-demographic characteristics, such as age, gender, and education, in their research model. While some factors significantly affect risk perception and behavioral responses, other factors do not. Also, no factor always influences the dependent variables. For example, Semenza et al. (2008) reveal that education and age have a significant relationship with behavioral changes to address climate change. In the study by O’Connor, Bard, and Fisher (1999), only gender significantly affects willingness to take voluntary actions to reduce GHG emissions, whereas gender, age, and education significantly influence voting intentions to climate policy proposals. Yu et al. (2013) report that none of their demographic factors (i.e., age, gender, and the length of residence) are significantly correlated with behavioral intentions to address climate change.

Table 1. Significant socio-demographic factors of previous studies

<table>
<thead>
<tr>
<th>Authors</th>
<th>Socio-demographic Factors</th>
<th>Affected Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>O’Connor, Bard, &amp; Fisher (1999)</td>
<td>Gender(Female, +)<strong><em>, Gender(Female, ‒)</em>, Age(+)*, Education(+)</strong></td>
<td>Behavioral intentions, Policy preferences</td>
</tr>
<tr>
<td>Leiserowitz (2006)</td>
<td>Gender(Female, +)*, Member of environmental groups(+)**</td>
<td>Risk perception</td>
</tr>
<tr>
<td></td>
<td>Race(White, ‒)*, Education(+)<strong>, Political ideology (Conservative, –)</strong>, Member of environmental groups(+)**</td>
<td>Policy preferences</td>
</tr>
<tr>
<td>Zahran et al. (2006)</td>
<td>Gender(Male, ‒)**<em>, Education(+)</em></td>
<td>Policy preferences</td>
</tr>
<tr>
<td>Semenza et al. (2008)</td>
<td>Age(–)**<em>, Education(+)</em></td>
<td>Behavioral responses</td>
</tr>
<tr>
<td>Keshavarz &amp; Karami (2016)</td>
<td>Age(+)**, Income(–)****</td>
<td>Behavioral responses</td>
</tr>
<tr>
<td>Rainer &amp; Christensen (2017)</td>
<td>Race(no-White, +)*, Age(+)**</td>
<td>Behavioral intentions</td>
</tr>
</tbody>
</table>

* Significant at .05, ** significant at .01, *** significant at .001; all two-tailed tests.

Note 1. Behavioral intentions and responses mean willingness to take individual actions and self-reported actions to mitigate (or adapt to) climate change, respectively.
2. Policy preferences refer to the extent of supporting climate policies (e.g., taxes and regulations) to curb climate change.
Table 1 arrays the significant socio-demographic factors of several studies related to climate change. When testing the five hypotheses, this study reflects five socio-demographic factors in the research model. Considering the commonly-used factors of previous research projects, gender, age, education, and income are selected as control variables. Lastly, the type of a residential area is added to explore the difference between urban and rural areas. While some inter-personal factors, such as individual’s personal networks and political affiliations, could be relevant theoretically in explaining individuals’ behavioral responses, these factors are outside the scope of this study.

**Research Model.** Consequently, a research model is provided in Figure 4, based on climate change risk perception, three types of personal factors (i.e., experience, knowledge, and policy assessment), and five socio-demographic factors (i.e., gender, age, education, income, and residential area). Additionally, key concepts to test the hypotheses are defined and operationalized in Appendix A.

**Figure 4.** Research model of factors affecting individuals’ behavioral responses to address climate change
Potential Issues in the Methodology

Scope of the research. Many empirical studies have explored various influential factors on climate change risk perception, such as values or worldviews (e.g., egalitarianism, individualism, and fatalism) (Akerlof et al., 2013; Leiserowitz, 2006), media coverages (Leiserowitz, 2004; Lowe et al., 2006), past experiences (Spence et al., 2011), and knowledge (Shi et al., 2016). van der Linden (2015) states that four dimensions (i.e., cognitive—knowledge, experiential—affect and personal experience, socio-cultural—culture, values, worldviews, and social construction, and socio-demographic—gender, race, income, age, education, and political ideology) primarily affect climate change risk perception. While this dissertation covers van der Linden’s three dimensions (i.e., cognitive, experiential, and socio-demographic), socio-cultural dimension, such as values (deep core beliefs) or worldviews about climate change, is also likely to be associated with risk perception or behavioral responses including policy preference, especially based on research in the U.S. (e.g., Akerlof et al., 2013; Kahan et al., 2012; Leiserowitz, 2006; Smith & Leiserowitz, 2012). Assessing socio-cultural dimension is outside the scope of this study, which is a possible limitation of the research but a potentially important area for additional study. However, given the context of South Korea which is a relatively small-size, largely homogenous, and same cultural country, it may not be a critical problem, as deep core beliefs around climate change (e.g., belief in climate change) do not vary as much in South Korea as in the U.S., and values/worldviews positions could be more homogenous.

56 Values (deep core beliefs) or worldviews may even get intertwined with personal factors. For example, individuals’ beliefs could shape what experiences they get or what knowledge they seek, and individuals’ beliefs could be informed by their experience and knowledge. Nevertheless, this dissertation differentiates experience and knowledge from beliefs, and in line with much of the literature.

57 Social norming (e.g., influence of neighbors or friends’ actions) is also viewed by previous studies (e.g., Lo, 2013; van der Linden, 2015) as a potential source of influence on behavioral responses to climate change. The role of this factor will be covered in Chapter VI (see pp. 155–156) by using the dataset of the local-level analysis.
Additionally, from a policymaker’s perspective, the scope of this dissertation has a practical advantage. Evidence about the impacts of the socio-cultural factors derived from different contexts (e.g., cultures, countries, or societies) might not be practically useful information in shaping climate policies and encouraging individuals’ behavioral responses to address climate change within their own cultures, countries, or societies. Even if policymakers try to utilize the socio-cultural factors for affecting individuals’ risk perceptions, it is challenging for them to control those factors, and, even if possible, it may take a significant amount of time and effort. Instead, evidence about the impacts of three factors (i.e., experience, knowledge, and policy assessment) and risk perception can be relatively easy-to-apply information in any contexts when addressing climate change. Also, these factors are possibly adjusted by governments’ efforts.

**Measure of behavioral responses.** Some studies, such as O’Connor, Bard, and Fisher (1999), Yu et al. (2013), and Raineat and Christensen (2017), employ behavioral intentions to measure individual’s behavioral responses. According to Ajzen and Fishbein (1980), behavioral intentions have a correlation with actual behaviors.\(^{58}\) Meanwhile, Grothmann and Patt (2005) hold a different view: Even though people have intentions, they often do not translate their intentions into actual behaviors due to a lack of resources (e.g., time, money, and staying power), which are not considered during the process of forming the intentions. Some others (e.g., Deng, Wang, & Yousefpour, 2017; Keshavarz & Karami, 2016; Semenza et al., 2008) utilize self-reported behavioral responses instead of behavioral intentions. Gifford, Kormos, and McIntyre (2011) warn of the discrepancies between self-reported behaviors and actual behaviors brought

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\(^{58}\) Ajzen and Fishbein (1980) present two important factors for the correlation between intention and behavior. First, the measure of intention must be consistent with the “behavioral criterion in action, target, context, and time.” (p. 51). Second, behavior can be predicted by the measure of intention “only if intention does not change before the behavior is observed.” (p. 52). In other words, to obtain an accurate prediction, the measurement of intention should be as close as possible to the behavioral observation within proper behavioral criterion.
by several bias-factors such as personal wishes toward strong pro-environmental scores and social desirability. Namely, regarding the reliability of behavioral response data, there can be a difference between self-reported and observed behavioral responses. However, in reality, it is almost impossible to observe individuals’ daily behaviors. Even if possible, collecting data of individuals’ behavioral responses at the national and local levels requires painstaking efforts, time, and money. A survey method has many advantages, such as providing more effective means of social description, acquiring many information from a single survey, and saving considerable time and money, compared to observation (Singleton & Straits, 2017). Overall, despite problems triggered by the bias-factors, this study practically utilizes self-reported behavioral response data based on the survey.

**Relationship with pro-environmental action literature.** Pro-environmental behaviors, which Kollmuss and Agyeman (2002) define as “behavior that consciously seeks to minimize the negative impact of one’s actions on the natural and built world” (p. 240), have been investigated by many previous studies (e.g., Dahlstrand, & Biel, 1997; Karp, 1996; Kollmuss & Agyeman, 2002; Sia, Hungerford, & Tomera, 1986; Stern, 2000; Vining & Ebreo, 1990). Actually, individuals’ behavioral responses to mitigate and adapt to climate change somewhat correspond to pro-environmental behaviors (e.g., using less energy, eating vegetarian food, and saving water). However, while pro-environmental action literature has generally focused on social norms, environmental values, and personal propensity as influential factors, this study zooms into the influence of three personal factors (experience, knowledge, and policy assessment) and risk perception on behavioral responses to mitigate long-term climate change and adapt to severe drought. Despite some overlap, this research is worth exploring, and its findings could provide insights both climate change and pro-environmental action literatures.
CHAPTER IV
NATIONAL-LEVEL ANALYSIS

To explore the relationship among personal factors, climate change risk perception, and behavioral responses to mitigate climate change, this research project analyzes survey data of individuals from across South Korea. Given the context of South Korea which has rapidly achieved economic growth over the past decades and has experienced the increase of GHG emissions, the findings of this analysis can be meaningful not only to South Korea, but potentially many countries with similar socio-economic conditions in managing GHG emissions and shaping climate policies.

Research Contexts

Economic Development

After the Korean War (1950–1953), South Korea has been able to achieve rapid economic growth based on the government’s development-oriented growth plans, strong leadership, a highly educated and hardworking workforce, and large business groups (“chaebol”) (Amsden, 1989, p. 9; Yoo & Lee, 1987). Its rapid economic growth, known as “the miracle of the Han River,” was accompanied by the advancement of heavy chemical industries and manufacturing (Yoo & Lee, 1987, p. 95). Even though the South Korean economy faced a financial crisis in December 1997, the Korean government promptly overcame that crisis in 2001 through painstaking efforts, such as downsizing the government, restructuring economic systems, privatizing several state-owned enterprises, and fostering information technology (Kim & Moon, 2002). Since the 2000s, South Korea has been regarded as one of the leading

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59 The International Monetary Fund declared a liquidity crisis and asserted that South Korea was experiencing a “systematic breakdown in economic relations” (Crotty & Lee, 2009, p. 149). In the process of overcoming this crisis, large numbers of businesses went bankrupt, and South Korea struggled against extensive national level economic restructuring and severe public sector reform (Ito, 2007).
countries in the Information Communication Technology (ICT) (Larson & Park, 2014; Lee & Ungson, 2008). For instance, According to the ICT Development Index released by the International Telecommunication Union, it ranked the 1st and 2nd out of the one hundred and seventy-six countries in 2016 and 2017, respectively (International Telecommunication Union, 2017). This social and economic development helped yield an increase of GDP per capita, which rose from US$944 in 1960 to US$25,459 in 2016 (World Bank, 2018).60

**Greenhouse Gas Emissions**

Rapid economic growth is likely to trigger the increase of GHG emissions. As of 2014, Korea ranked 4th (around 568 million tonnes) among thirty-five Organization for Economic Cooperation and Development (OECD) member states in terms of the total amount of carbon dioxide (CO₂) emissions, and ranked 2nd (around 145 percent) among them in growth of emissions, from 1990 to 2014 (OECD, 2017).61 Similarly, regarding the amount of CO₂ emission per capita and its growth rate from 1990 to 2014, Korea ranked 6th and 1st among thirty-five OECD member countries, respectively (OECD, 2017). Overall, while South Korea has enjoyed economic growth, it now faces challenges in alleviating GHG emissions.

**Literatures related to Climate Change Risk Perception in South Korea**

According to the 2013 national survey on environmental conservation conducted by the Ministry of Environment (2014), in South Korea, the general public indicates climate change as the second most serious problem among ten environmental issues (e.g., household waste, toxic materials, and water pollution), following industrial waste. Also, regarding the improvement

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60 Data are expressed constant 2010 U.S. dollars.

61 Carbon dioxide is regarded as “one of the major greenhouse gases” (Worrell _et al._, 2001, p. 304). According to OECD (2017), greenhouse gases include seven gases, such as carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), chlorofluorocarbons (CFCs), and hydrofluorocarbons (HFCs).
priority of environmental issues, climate change is ranked third among the ten problems, following the natural environment and water.62 While many Koreans perceive climate change as a serious and urgent environmental problem, there are very few studies that deal with climate change (risk) perception in South Korea. Also, these existing studies mostly focus on particular fields, such as education (Seo et al., 2013), agriculture and fisheries (Kim, Lee, & Jeong, 2014; Park, Lee, & Kim, 2014), and tourism (Ahn, Lee, & Hwang, 2016; Kim & Kim, 2013; Lee, Hwang, & Seo, 2015; Min, Kim, & Kim, 2015), or certain sub-national locations (Choi, Park, & Jeon, 2014; Kim, Kim, & Lee, 2014; Koh & Yi, 2016). In other words, there is no clear evidence about the causal relationship among personal factors, risk perception, and behavioral responses related to climate change at the national level. Thus, this study will become a stepping stone for future research investigating climate change risk perception and behavioral responses of the general public in South Korea. Also, the findings of this national-level analysis could help policymakers design effective climate policies in both South Korea and countries with similar socio-economic conditions.

Research Methods

Data Collection

Research tool. Data were collected from a web-based survey implemented in South Korea. Climate change risk perception and climate policy assessment formed by a psychological process are typically invisible. Personal experiences, knowledge, and behavioral responses to

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62 Since 1982, the Ministry of Environment has conducted surveys associated with the national consciousness on environmental conservation in South Korea, typically once every five years (e.g., 2003, 2008, and 2013). The respondents of the 2013 survey consist of 1,500 citizens and 200 environmental experts.

63 Kim, Kim, and Lee (2014) investigated public awareness of climate change in Chungnam province, located in the west of South Korea. Choi, Park, and Jeon (2014) studied public perception of climate change in Gangnam-gu, Seoul metropolitan government, to support municipality’s climate policy.
mitigate climate change at the national level cannot be easily measured by experiments and field studies. The majority of empirical research projects introduced in the literature review chapters depend on survey (e.g., questionnaires or interviews) data or secondary survey data. Therefore, this study obtains these personal and hard-to-observe data at the national level from the Korea Water Resources Corporation (K-water)’s survey results. K-water conducted the survey for establishing South Korea’s water policy against climate change.

While Web-based surveys can reduce costs, save time, and offer flexibility in the questionnaire design, this method has a major weakness, called coverage error (i.e., “difference between the target population and the sampling frame”) (Singleton & Straits, 2017, p. 271). As of 2016, the proportion of total fixed and wireless broadband subscriptions in South Korea was over 100% (National Information Society Agency, 2016; OECD, 2016), and about 90% of the entire population utilize smart phones (Statistics Korea, 2017a). Also, large scale Web-based survey platforms, such as ‘www.opensurvey.co.kr’ (around four hundred thousand panels) and ‘www.marketlink.co.kr’ (around half million panels), operate in South Korea (Open Survey, 2017; Marketlink, 2017). Overall, South Korea has a favorable environment for a Web-based survey with less coverage error.

**Survey design and refinement.** Good survey instrument design is one of the key ingredients to the success of survey research (Singleton & Straits, 2017). A questionnaire was developed by researchers at the research center for water policy and economy in the K-water institute, who have substantial experience conducting climate (or water) policy-related studies.

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64 One approach for solving this drawback is to utilize “probability-based, Web-enabled panels designed to be representative of target population” (Singleton & Straits, 2017, p. 280).

65 Singleton and Straits (2017) go on to say that “no matter how carefully the sample is selected, a sample survey is only as good as the design of the questionnaire or interview schedule” (p. 301).
Singleton and Straits (2017), in evaluating drafts of survey questions, highlight that “whether respondents clearly understand and are able to answer them” (p. 336) is a prerequisite for minimizing the risk of study failure. To evaluate and improve the design of the questions, expert reviews of the survey questionnaire were carried out. Based on the results of the expert reviews, the questionnaire was refined. Key questions in the questionnaire reflect the following topics: a) climate change risk perception (e.g., the seriousness of the adverse impacts of climate change); b) experiences of extreme weather events (e.g., experiences of property damage by drought and flood); c) experiences of climate change (e.g., the rising of average temperature, the change in precipitation, and the increase of the danger of flood and drought); and d) behavioral responses to mitigate climate changes (e.g., saving energy, reducing the use of disposable items, and utilizing renewable energy). Appendix B presents the key questions of the questionnaire. Most questions are closed-ended, mainly in the form of a four point scale.66

**Representativeness.** This self-administered survey was carried out by the online survey platform, ‘www.opensurvey.co.kr,’ on August 10, 2016 and had 1,500 respondents who were randomly selected among its panels. The target population was individuals who reside in South Korea, 51.7 million as of 2016 (Statistics Korea, 2017b). These respondents represent a good cross-section of gender, age, and region in South Korea.67 The socio-demographic characteristics of the respondents compared to those of the South Korean population are shown in Table 2.

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66 According to Singleton and Straits (2017), while it is difficult to develop closed-ended questions, they require less respondent effort and facility with words than open-ended questions. Also, they have merits in “classifying respondents with respect to some well-understood attitude or behavior” and “enhancing standardization by creating the same frame of reference for all respondents” (pp. 306–307).

67 This survey appears to oversample more educated people compared to the population. However, the proportion of people with higher education (i.e., undergraduate and above) among the entire population is increasing quickly (e.g., from 40% in 2011 to 47% in 2016) (Ministry of Education, 2018).
Table 2. 2016 survey respondents’ socio-demographic characteristics

<table>
<thead>
<tr>
<th>Classification</th>
<th>Respondents</th>
<th>South Korean Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>755</td>
<td>50.3%</td>
</tr>
<tr>
<td>Female</td>
<td>745</td>
<td>49.7%</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0 -19)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-29</td>
<td>257</td>
<td>17.1%</td>
</tr>
<tr>
<td>30-39</td>
<td>292</td>
<td>19.4%</td>
</tr>
<tr>
<td>40-49</td>
<td>343</td>
<td>22.9%</td>
</tr>
<tr>
<td>50-59</td>
<td>325</td>
<td>21.7%</td>
</tr>
<tr>
<td>60-</td>
<td>283</td>
<td>18.9%</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under middle school</td>
<td>32</td>
<td>2.1%</td>
</tr>
<tr>
<td>High school</td>
<td>416</td>
<td>27.8%</td>
</tr>
<tr>
<td>Undergraduate</td>
<td>888</td>
<td>59.2%</td>
</tr>
<tr>
<td>Graduate and above</td>
<td>164</td>
<td>10.9%</td>
</tr>
<tr>
<td>Income (Average Monthly Income before Tax)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I &lt; KRW 1 million (US$ 909)</td>
<td>49</td>
<td>3.3%</td>
</tr>
<tr>
<td>KRW 1 million (US$ 909)≤ I &lt; KRW 2 million (US$ 1,818)</td>
<td>158</td>
<td>10.5%</td>
</tr>
<tr>
<td>KRW 2 million (US$ 1,818)≤ I &lt; KRW 3 million (US$ 2,727)</td>
<td>309</td>
<td>20.6%</td>
</tr>
<tr>
<td>KRW 3 million (US$ 2,727)≤ I &lt; KRW 4 million (US$ 3,636)</td>
<td>348</td>
<td>23.2%</td>
</tr>
<tr>
<td>KRW 4 million (US$ 3,636)≤ I &lt; KRW 5 million (US$ 4,545)</td>
<td>237</td>
<td>15.8%</td>
</tr>
<tr>
<td>KRW 5 million (US$ 4,545)≤ I &lt; KRW 6 million (US$ 5,455)</td>
<td>178</td>
<td>11.9%</td>
</tr>
<tr>
<td>KRW 6 million (US$ 5,455)&lt; I</td>
<td>221</td>
<td>14.7%</td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seoul Metropolitan Government</td>
<td>322</td>
<td>21.5%</td>
</tr>
<tr>
<td>Busan Metropolitan City</td>
<td>105</td>
<td>7.0%</td>
</tr>
<tr>
<td>Daegu Metropolitan City</td>
<td>72</td>
<td>4.8%</td>
</tr>
<tr>
<td>Incheon Metropolitan City</td>
<td>85</td>
<td>5.7%</td>
</tr>
<tr>
<td>Daejeon Metropolitan City</td>
<td>44</td>
<td>2.9%</td>
</tr>
<tr>
<td>Gwangju Metropolitan City</td>
<td>41</td>
<td>2.7%</td>
</tr>
<tr>
<td>Ulsan Metropolitan City</td>
<td>33</td>
<td>2.2%</td>
</tr>
<tr>
<td>Gyeonggi Province</td>
<td>382</td>
<td>25.5%</td>
</tr>
<tr>
<td>Gangwon Province</td>
<td>41</td>
<td>2.7%</td>
</tr>
<tr>
<td>North Chungcheong Province</td>
<td>43</td>
<td>2.9%</td>
</tr>
<tr>
<td>South Chungcheong Province</td>
<td>51</td>
<td>3.4%</td>
</tr>
<tr>
<td>North Jeolla Province</td>
<td>51</td>
<td>3.4%</td>
</tr>
<tr>
<td>South Jeolla Province</td>
<td>48</td>
<td>3.2%</td>
</tr>
<tr>
<td>North Gyeongsang Province</td>
<td>69</td>
<td>4.6%</td>
</tr>
<tr>
<td>South Gyeongsang Province</td>
<td>89</td>
<td>5.9%</td>
</tr>
<tr>
<td>Jeju Special Self-governing Province</td>
<td>18</td>
<td>1.2%</td>
</tr>
<tr>
<td>Sejong Special Self-governing City</td>
<td>6</td>
<td>0.4%</td>
</tr>
<tr>
<td>Total</td>
<td>1,500</td>
<td></td>
</tr>
</tbody>
</table>

*Note: The data of the South Korean population are provided by Statistics Korea (2017b)—Gender, Age, and Region—and Ministry of Education (2018)—Education.*
Variable Description

Mediating and dependent variables. Climate change risk perception and behavioral responses to address climate change are employed as a mediating (both dependent and explanatory) variable and a dependent variable, respectively.

Climate change risk perception. This study utilizes a single item, the seriousness of climate change, as an indicator of climate change risk perception. According to Rogers’ (1983) PMT, threat appraisal is conducted based on the two following questions: a) does an individual believe that the threat is severe? (i.e., perceived severity); and b) does an individual feel vulnerable? (i.e., perceived vulnerability). This study considers that perceived seriousness (i.e., the quality of worrying because of possible risks) of climate change can embrace both perceived severity and vulnerability of climate change. For example, if an individual perceives the higher level of severity and the lower level of vulnerability related to climate change, the level of his or her perceived seriousness of climate change may be moderate, and vice versa. If an individual perceives the higher levels of both severity and vulnerability associated with climate change, the level of his or her perceived seriousness of climate change also may be higher, and vice versa. Respondents were asked to select their level of seriousness on the adverse impacts of climate change. They presented their level of seriousness for the question on a four point scale, where 1 was strongly serious and 4 was not serious. This study reverses the scale of the question. Thus, higher values indicate greater perception of the seriousness of the problem.

Behavioral responses to address climate change. This paper uses the number of behavioral responses to mitigate climate change as a dependent variable. Considering the definition of behavioral responses to climate change in Appendix A, this variable includes not only direct behavioral efforts to reduce GHG emissions (e.g., saving energy and utilizing
renewable energy), but also indirect behavioral efforts (e.g., donations to environmental organizations) to mitigate climate change. Based on a single question, respondents were asked to indicate all activities they were practicing to address climate change among the following eight activities: a) saving energy; b) saving water; c) using public transportation instead of a privately-owned car; d) reducing the use of disposable items; e) utilizing renewable energy; f) enjoying a vegetarian diet instead of a meat diet; g) donations to environmental organizations; and h) voting based on environmental-related election promises. Recycling, which has usually been utilized by previous studies (e.g., Masud et al., 2016; Semenza et al., 2008; Whitmarsh, 2009a), is excluded from the activities because it is required by law in South Korea (Ministry of Government Legislation, 2015a). The number of practicing activities are coded on a nine point scale (from 0 to 8). Additionally, the practice of each activity is employed as a sub dependent variable to reveal more details of the relationship between risk perception and behavioral responses. The answers of the respondents are divided by each activity, and the practice of each activity is dichotomously coded, where 0 = no and 1 = yes.

**Independent variables.** Three experience variables, three knowledge variables, and two policy assessment variables are utilized as independent variables.

**Short-term experiences.** Given that drought and flood are most commonly regarded as significant weather events intensified by climate change, the experiences of drought and flood are employed as the indicators of short-term experiences. To clarify the range of drought and

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68 While each activity has the potential to mitigate climate change, it is very challenging to compare the impacts of those activities. Therefore, this study posits that they have similar effects on climate change mitigation (i.e., giving the same weight to each response), and it might not be highly problematic.

69 The heat wave is also viewed as one of the significant weather events associated with climate change. (Akompab et al., 2013; Beniston & Diaz, 2004; Hansen, Sato, & Ruedy, 2012). However, it is not dealt with in this analysis due to a lack of data.
flood experiences, this study focuses on experiences of property damage by drought and flood. Respondents were asked to choose their answers among four items, where 1 = no experience, 2 = by drought, 3 = by flood, and 4 = by both drought and flood. Experiences of property damage by drought (hereafter the experience of drought) is measured as a dichotomous variable, where no = 0 and yes = 1 (those who selected 2 or 4). Also, experiences of property damage by flood (hereafter the experience of flood) is coded in the same way, where no = 0 and yes = 1 (those who chose 3 or 4).

**Long-term experiences.** Climate change has long-term features such as variations in temperature and precipitation. To measure the experiences of those features, respondents were asked to indicate their level of experiences on the rising of average temperature, the change in precipitation, the increase of the danger of flood, and the increase of the danger of drought in the last ten years, respectively. They pointed out their level of experiences for each question on a four point scale, where 1 = definitely, 2 = somewhat, 3 = little, and 4 = not. The scales of the questions are reverse coded, where 0 = not, 1 = little, 2 = somewhat, and 3 = definitely. Those values are summed into a single measure, the index of climate change experiences. Cronbach’s alpha of this index is 0.6982. Also, this study tests whether those four items all fall along one dimension. According to principal component factor analysis (the critical point of Eigenvalue is 1), the number of retained factor is one. Specifically, the Eigenvalue of the first factor is 2.16. This is fifty-four percent of the total possible of 4. By comparison, that of the second factor is just 0.74. All correlation values are greater than 0.3 except correlation between the rising of average temperature and the increase of danger of flood (0.27). The overall value of Kaiser-Meyer-Olkin (KMO) measure is 0.7384, and it is located in the middling range (0.70–0.79)
Lastly, the result of Bartlett’s test of sphericity is significant at the p<.001 level. Overall, those four items are adequate for creating the index of climate change experiences. The range of this index is from 0 to 12. In other words, the higher the index is, the more intense people’s experience with long-term climate change is.

**Knowledge.** Two general knowledge variables (i.e., awareness of climate change and the understanding of the cause of climate change) and one specific knowledge variable (i.e., the familiarity with a government GHG reduction plan) were measured.⁷¹ First, awareness of climate change is simply coded as a dichotomous variable where no = 0 and yes = 1. Second, regarding the understanding of the cause of climate change, respondents were asked to present the contribution of human activities to climate change by numeric scores from 0 up to 100. The former means that climate change has nothing to do with human activities (e.g., GHG emissions), and the latter means that climate change is caused mainly by human activities. Given the scientific evidence identifying human’s GHG emissions as the main cause of climate change, those who indicate higher scores have a higher understanding of the cause of climate change than those who indicate lower scores. Lastly, the reduction of GHG emissions is a core strategy of governments to mitigate climate change. Respondents’ level of familiarity with a government GHG reduction plan was measured on a four point scale, where 1 was *precisely* and 4 was *not*. This study reverses the scale of the question: Higher values indicate greater familiarity with the government GHG reduction plan.

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⁷⁰ Kaiser’s (1974) evaluation for the levels of KMO measure values is as follows: unacceptable—0.00 to 0.49; miserable—0.50 to 0.59; mediocre—0.60 to 0.69; middling—0.70 to 0.79; meritorious—0.80 to 0.89; and marvelous—0.90 to 1.00.

⁷¹ The understanding of the consequences of climate change is also one of the important components in climate change knowledge (see Appendix A). Unfortunately, there is no proper item for measuring that component in the survey data.
Policy assessment. As alluded to above, drought and flood are extreme weather events deeply associated with climate change. Therefore, policies to address these events are important parts of governments’ coping strategies for climate change. To measure respondents’ assessment of drought policy and flood policy, respondents were asked to answer their level of evaluation for each policy on a five point scale, where 1 = very poor, 2 = poor, 3 = fair, 4 = good, and 5 = excellent.\(^{72}\)

Control variables. Five socio-demographic variables are included to isolate the influence of personal factors on climate change risk perception and behavioral responses to mitigate climate change. First, gender is coded as a dichotomous variable, where 0 = male and 1 = female. Second, this study includes age expressed in years. Third, the level of education is measured on a four point scale, where 1 = under middle school, 2 = high school, 3 = undergraduate, and 4 = graduate and above. Fourth, this analysis includes the level of income (i.e., average monthly income before tax last year) as a seven point scale variable, range from 1 for those earning less than KRW 1million (around US$ 909) to 7 for those earning over KRW 6million (around US$ 5,455). Lastly, residential area is coded on a three point scale, where 0 = metropolitan government or cities, 1 = middle or small cities, and 2 = counties.\(^{73}\)

Data Analysis

Given that this study focuses on the relationship among personal factors, risk perception, and behavioral responses related to climate change, regression analysis, a “statistical technique

\(^{72}\) Considering the conceptual map in Appendix A, these policies should be specifically evaluated on their necessities, validities, efficiencies, etc. However, in reality, it is difficult for the general public to precisely assess the policies on those points. Also, the survey includes a single-item for each policy assessment. This study assumes that the overall evaluations for each policy can represent an indicator of policy assessment and will not be problematic.

\(^{73}\) In South Korea, the populations of counties, cities, and metropolitan cities are generally less than 100,000, more than 100,000 and less than 1,000,000, and more than 1,000,000, respectively (Ministry of Government Legislation, 2017b; Statistics Korea, 2019).
for investigating and modeling the relationship between variables” (Montgomery, Peck, & Vining, 2012, p. 1), is a suitable tool to evaluate data. Among diverse regression methods (e.g., linear, logistic, and structural), this study employs Structural Equation Modeling (SEM) (Goldberger, 1972). While most regression methods allow analysis of the relationship between variables separately, “only one layer of linkages between independent and dependent variables at a time” (Gefen, Straub, & Boudreau, 2000 p. 4), SEM, including confirmatory factor analysis, path analysis, and others, enables to analyze the relationship among all the variables in the model simultaneously (Gefen, Straub, & Boudreau, 2000; Kline, 2015; Schumacker & Lomax, 2004) and to produce better performance in systematic and comprehensive analyses rather than other regression models (Iacobucci, Saldanha, & Deng, 2007). By utilizing SEM, not only can this study conduct simultaneous analysis of the dynamic relationship among the variables, but also identify the direct and indirect effects of the personal factors on climate change risk perception and behavioral responses to mitigate climate change.

This analysis is composed of four phases. First, socio-demographic characteristics and descriptive results are introduced. Second, bivariate correlations between dependent and other variables are computed. Third, prior to SEM analysis, model fit is evaluated based on the values of chi-square statistic ($\chi^2$) and several fit indices, such as the Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Squared Residual (SRMR), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI). Lastly, SEM regression analysis is operated by 

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74 According to Hu and Bentler (1999), the primary goals in the application of SEM are “the assessment of goodness of fit and the estimation of parameters of the hypothesized model(s)” (p. 2). There are two popular methods to assess model fit: The chi-square statistic ($\chi^2$) and fit indices. Many studies (e.g., Hooper, Coughlan, & Mullen, 2008; Hu & Bentler, 1999) categorize fit indices into two types: absolute fit indices and incremental fit indices, also known as relative fit indices (McDonald & Ho, 2002). The former, which measures “how well a priori model reproduces the sample data” (Hu and Bentler, 1999, p. 2), includes the Goodness-of-Fit Index (GFI; Jöreskog & Sörbom, 1984), Root Mean Square Error of Approximation (RMSEA; Steiger & Lind, 1980), Standardized Root Mean Squared Residual (SRMR; Bentler, 1995), etc. The Chi-Square ($\chi^2$) value is also included in this type. The latter, which evaluates “the proportionate improvement in fit by comparing a target model with a more restricted,
using STATA’s SEM package and an appropriate estimation method. Pathways in the national-level research model are presented in Figure 5. In addition to the main model, eight sub models that utilize each behavioral response coded dichotomously as a dependent variable are analyzed by Generalized Structural Equation Modeling (GSEM), and the results are reported in the alternative model specifications section.\footnote{Specifically, these sub models are analyzed by GSEM—logit. GSEM regression analysis in STATA does not provide model fits.}

**Figure 5.** Pathways in the national-level research model

Before finalizing the research model, several pilot models, including pathways among personal factor variables, were tested. These pilot models included causal relationships among the subset of personal factor variables, such as between short-term experience and policy assessment (e.g., more drought experiences could be negatively associated with the level of nested baseline model” (Hu and Bentler, 1999, p. 2), consists of the Comparative Fit Index (CFI; Bentler, 1990), Normed Fit Index (NFI; Bentler & Bonett, 1980), Tucker-Lewis Index (TLI; Tucker & Lewis, 1973), etc.

\footnote{Specifically, these sub models are analyzed by GSEM—logit. GSEM regression analysis in STATA does not provide model fits.}
drought policy assessment) and between general knowledge and policy-related knowledge (e.g., greater general knowledge of climate change could be positively associated with the level of policy-related knowledge). However, while these models may help understand the relationship among the personal factors, their model fits are very poor and not acceptable. The final models therefore exclude pathways that examine the inter-relationships among the personal factor variables in unveiling individuals’ behavioral responses related to climate change.

**Analysis Results**

**Socio-demographic Characteristics**

The respondents are from all regions (i.e., seven metropolitan cities, eight provinces, and two self-governing areas) in South Korea. They range in age from 20 to 87 years (M = 44.40, SD = 13.62) and 49.7% are females. More than half have a bachelor’s degree and 10.9% have an advanced degree. Approximately 65.5% earn over KRW 3million (US$ 2,727) and a bit more than a quarter earn over KRW 5million (US$ 4,545) a month.

**Descriptive Results**

Most of the respondents are aware of climate change (M = 0.96, SD = 0.21) and view human activities as the key driver of climate change (M = 75.37, SD = 16.36). When asked to consider the impacts of climate change, nearly 98% of the respondents answered that the negative impacts of climate change (M = 3.55, SD = 0.55) are either strongly serious (57.1%) or serious (40.9%). Regarding personal experiences, 11.6% and 21.9% of the respondents have

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76 For example, the pilot model adding the pathways between short-term experiences and policy assessment and between general knowledge and policy-related knowledge presents unacceptable model fits (e.g., χ² = 1205.787 (df = 35, p<.001), RMSEA—0.150, CFI—0.269, TLI—0.253, and SRMR—0.079). Also, while drought experience and awareness of climate change significantly and positively affect drought policy assessment and familiarity with a government GHG reduction plan respectively, flood experience and understanding of the cause of climate change do not have a significant relationship with flood policy assessment and familiarity with a government GHG reduction plan, respectively.
experiences of drought and flood, respectively. Meanwhile, the majority of the respondents answer that they (either definitely or somewhat) experience climate changes in the last ten years.

As shown in Figure 6, the rising of average temperatures (M = 2.80, SD = 0.45), the change in precipitation (M = 2.52, SD = 0.62), and the increase of the danger of drought (M = 2.55, SD = 0.61) are experienced by more than 90%, respectively. The increase of the danger of flood (M = 2.08, SD = 0.80) is experienced by 75.7%.

![Figure 6. Results of four long-term climate change experiences](image)

Concerning the government’s flood and drought policies, while 38.1% and 47.7% of the respondents negatively (either poor or very poor) evaluate the flood and drought policies, respectively, only 8.5% and 6.3% of the respondents positively (either good or excellent) assess them, respectively. Many of the respondents are on neutral ground (fair), 53.4% for the flood policy and 46.0% for the drought policy. The proportion of the respondents who are familiar with the government GHG reduction plan (either moderately or precisely) (44.8%) is slightly less than that of the respondents who are not (either hardly or not) (55.2%) (M = 2.33, SD = 0.84).

Lastly, as shown in Figure 7, the respondents are practicing around three behavioral responses to address climate change on average (M = 3.49, SD = 1.48).
Figure 7. Results of individuals’ behavioral responses to address climate change

Bivariate Correlation Coefficients among Variables

Table 3 presents the inter-correlations of the key variables in the research model. In the case of the relationship between climate change risk perception and independent variables (Table 3.1), all correlations between them show the hypothesized directions (i.e., three experience and two knowledge factors—positive; two policy assessment factors—negative). However, climate change risk perception does not have a statistically significant correlation with short-term experiences, whereas other relationships are significant at the p<.001 level. Among socio-demographic variables, gender and age have a significant positive relationship with climate change risk perception at the p<.001 and p<.05 levels, respectively. In terms of the correlations between behavioral responses to mitigate climate change and other variables, including climate change risk perception (Table 3.2), the number of behavioral responses are significantly correlated with climate change risk perception and three personal variables at the p<.001 level, and all these correlations show positive directions. Among socio-demographic variables, age and income have a significant positive relationship with the behavioral responses at the p<.001 and p<.05 levels, respectively.
### Table 3. Inter-correlations of key variables in the national-level analysis

#### 3.1. Risk perception variable, independent variables, and control variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Risk perception</th>
<th>Experience</th>
<th>Knowledge</th>
<th>Policy assessment</th>
<th>Socio-demographic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate change risk perception</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drought experience</td>
<td>0.034</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flood experience</td>
<td>0.009</td>
<td>0.337***</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate change experience</td>
<td>0.431***</td>
<td>0.068**</td>
<td>0.030</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Awareness of climate change</td>
<td>0.138***</td>
<td>-0.023</td>
<td>-0.026</td>
<td>0.147***</td>
<td>1.000</td>
</tr>
<tr>
<td>Cause of climate change</td>
<td>0.255***</td>
<td>-0.029</td>
<td>-0.006</td>
<td>0.214***</td>
<td>0.074**</td>
</tr>
<tr>
<td>Familiarity with a GHG policy</td>
<td>0.109***</td>
<td>0.195***</td>
<td>0.120***</td>
<td>0.224***</td>
<td>0.131***</td>
</tr>
<tr>
<td>Assessment of drought policy</td>
<td>-0.108***</td>
<td>0.064*</td>
<td>0.011</td>
<td>-0.084**</td>
<td>-0.125***</td>
</tr>
<tr>
<td>Assessment of flood policy</td>
<td>-0.092***</td>
<td>0.064*</td>
<td>-0.019</td>
<td>-0.100***</td>
<td>-0.026</td>
</tr>
<tr>
<td>Gender</td>
<td>0.136***</td>
<td>-0.073**</td>
<td>-0.090***</td>
<td>0.082**</td>
<td>-0.024</td>
</tr>
<tr>
<td>Age</td>
<td>0.064*</td>
<td>0.028</td>
<td>0.106***</td>
<td>0.103***</td>
<td>-0.008</td>
</tr>
<tr>
<td>Education</td>
<td>-0.001</td>
<td>-0.023</td>
<td>-0.039</td>
<td>0.013</td>
<td>0.069**</td>
</tr>
<tr>
<td>Income</td>
<td>0.022</td>
<td>-0.035</td>
<td>-0.003</td>
<td>-0.013</td>
<td>0.086***</td>
</tr>
<tr>
<td>Area</td>
<td>-0.030</td>
<td>0.062*</td>
<td>0.015</td>
<td>-0.032</td>
<td>-0.014</td>
</tr>
</tbody>
</table>

#### 3.2. Behavioral response variable, risk perception variable, independent variables, and control variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>The number of behavioral responses</th>
<th>Climate change risk perception</th>
<th>Experience</th>
<th>Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral responses</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate change risk perception</td>
<td>0.126***</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drought experience</td>
<td>0.104***</td>
<td>0.034</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Flood experience</td>
<td>0.088***</td>
<td>0.009</td>
<td>0.337***</td>
<td>1.000</td>
</tr>
<tr>
<td>Familiarity with a GHG reduction plan</td>
<td>0.166***</td>
<td>0.104***</td>
<td>0.195***</td>
<td>0.120***</td>
</tr>
<tr>
<td>Gender</td>
<td>0.021</td>
<td>0.136***</td>
<td>-0.073**</td>
<td>-0.090***</td>
</tr>
<tr>
<td>Age</td>
<td>0.197***</td>
<td>0.064*</td>
<td>0.028</td>
<td>0.106***</td>
</tr>
<tr>
<td>Education</td>
<td>-0.014</td>
<td>-0.001</td>
<td>-0.023</td>
<td>-0.039</td>
</tr>
<tr>
<td>Income</td>
<td>0.063*</td>
<td>0.022</td>
<td>-0.035</td>
<td>-0.003</td>
</tr>
<tr>
<td>Area</td>
<td>-0.014</td>
<td>-0.030</td>
<td>0.062*</td>
<td>0.015</td>
</tr>
</tbody>
</table>

*p<.05, **p<.01, ***p<.001 (two-tailed test)
Model Fit

While the Chi-Square value ($\chi^2$) has traditionally been measured for evaluating model fit for SEM, it has a critical limitation, sensitivity to sample size (i.e., mostly rejecting the model with large samples) (Hox & Bechger, 2007; Hu & Bentler, 1999). Therefore, diverse fit indices, such as Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Squared Residual (SRMR), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI), have been proposed by researchers to supplement the Chi-Square ($\chi^2$) test (Hooper, Coughlan, & Mullen, 2008; Hox & Bechger, 2007; McDonald & Ho, 2002). Regarding the research model, this study reports the results of $\chi^2$ (Satorra-Bentler scaled) and several fit indices: $\chi^2 = 19.122$ (df = 6, p<.01), RMSEA = .038 (90% CI), SRMR = .010, CFI = .970, and TLI = .867. Given acceptable thresholds of fit indices in the previous studies, the research model fits the data well.77

Regression Analysis

This study hypothesizes that personal factors influence climate change risk perception ($H1$, $H2$, and $H4$), and some personal factors and climate change risk perception lead to behavioral responses to address climate change ($H1$, $H3$, and $H5$). SEM is utilized to test the hypotheses about the relationship among personal factor, risk perception, and behavioral responses related to climate change. Prior to analysis, the selection of an appropriate estimation method is needed. Most SEM-related programs set Maximum likelihood (ML) as a default method due to the precision of estimates (smallest variance) (Ullman & Bentler, 2003).

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77 Based on previous studies, Hooper, Coughlan, and Mullen (2008) [1] and Hu and Bentler (1999) [2] provide the acceptable thresholds (conventional cutoff values) of fit indices. Those are as follows:

<table>
<thead>
<tr>
<th>Fit indices</th>
<th>Acceptable thresholds (cutoff values)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-square statistic ($\chi^2$)</td>
<td>[1] An insignificant $p$ value ($p &gt; .05$)</td>
</tr>
<tr>
<td>Root Mean Square Error of Approximation (RMSEA)</td>
<td>[1] Values less than .07 / [2] less than .06</td>
</tr>
<tr>
<td>Standardized Root Mean Squared Residual (SRMR)</td>
<td>[1] [2] Values less than .08</td>
</tr>
<tr>
<td>Comparative Fit Index (CFI)</td>
<td>[1] [2] Values greater than .95</td>
</tr>
<tr>
<td>Tucker-Lewis Index (TLI)</td>
<td>[1] [2] Values greater than .95</td>
</tr>
</tbody>
</table>
However, an important assumption for ML estimation is the full joint normality of all the variables (i.e., multivariate normality) (Chou & Bentler, 1995; Finney & DiStefano, 2006; Ullman & Bentler, 2003; West, Finch, & Curran, 1995).\textsuperscript{78} Univariate and multivariate normality tests are conducted for variables in the research model. While all univariate skewness and kurtosis of each variable except one variable (i.e., awareness of climate change) are placed beyond the range of non-normality concern (i.e., $|\text{skewness}| > 2, |\text{Kurtosis}| > 7$) suggested by previous studies (Chou & Bentler, 1995; West, Finch, & Curran, 1995), the results of Mardia’s multivariate (skewness and kurtosis) test indicate that multivariate normality assumption is not satisfied. Namely, the normality assumption is violated. Considering several approaches for non-normality (see Footnote 78), the results of SEM regression analyses with different estimation methods (or options) (i.e., ML, ML with robust standard errors, ML with bootstrapping, ADF, and Generalized SEM) are presented in Appendix C. This appendix includes the results of GSEM, specifically Poisson regression which fits models with count outcome variables (Coxe, West, & Aiken, 2009), by assuming that the dependent variable (i.e., the number of behavioral responses) is a count variable. Overall, directions and significance of coefficients are almost identical. Therefore, this study tries to answer the research question by interpreting the results of the SEM regression analysis using ML estimation with robust standard errors.\textsuperscript{79} The results of

\textsuperscript{78} When violating the normality assumption, there are several approaches to dealing with non-normality, such as ML with the Satorra-Bentler scaled chi-squares and robust standard errors (Satorra & Bentler, 1988; 1994), bootstrapping (Efron, 1979; Yung & Bentler, 1996; Finney & DiStefano, 2006), and Asymptotically Distribution-Free (ADF) (Browne, 1984). While ADF makes no assumption of normality, it does not show good performance with sample size less than 2,500 (Hu, Bentler, & Kano, 1992; Ullman & Bentler, 2003). Bootstrapping, which refers to “establishing an empirical sampling distribution associated with a statistic of interest by repeatedly sampling from the original parent sample data,” is viewed as a promising method to correct standard errors (Nevitt & Hancock, 2001, p.355). However, it may also present erratic results with small sample size (e.g., 200 or less) (Nevitt & Hancock, 2001). Generally, ML with the Satorra-Bentler scaled chi-squares and robust standard errors is regarded as a good approach to handling non-normality (Curran, West, & Finch, 1996; Hu, Bentler, & Kano, 1992).

\textsuperscript{79} There is no evidence of multicollinearity, heteroscedasticity, influential outliers, and other significant statistical problems.
the SEM regression analysis and significant pathways in the research model are described in Table 4 and Figure 8, respectively. Also, direct, indirect, and total effects of independent variables on behavioral responses to alleviate climate change are presented in Appendix D.

**Table 4.** Results of SEM regression analysis about the relationship among personal factors, risk perception, and behavioral responses related to climate change

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Coeff.</th>
<th>Robust Std. Err.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Climate change risk perception</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drought experience</td>
<td>.049</td>
<td>.039</td>
</tr>
<tr>
<td>Flood experience</td>
<td>.001</td>
<td>.032</td>
</tr>
<tr>
<td>Climate change experience</td>
<td>.108***</td>
<td>.008</td>
</tr>
<tr>
<td>Awareness of climate change</td>
<td>.216**</td>
<td>.079</td>
</tr>
<tr>
<td>Understanding of the cause of climate change</td>
<td>.005***</td>
<td>.001</td>
</tr>
<tr>
<td>Assessment of drought policy</td>
<td>-.065**</td>
<td>.021</td>
</tr>
<tr>
<td>Assessment of flood policy</td>
<td>.021</td>
<td>.022</td>
</tr>
<tr>
<td>Gender (female)</td>
<td>.132***</td>
<td>.026</td>
</tr>
<tr>
<td>Age</td>
<td>.002</td>
<td>.001</td>
</tr>
<tr>
<td>Education</td>
<td>-.008</td>
<td>.022</td>
</tr>
<tr>
<td>Income</td>
<td>.005</td>
<td>.008</td>
</tr>
<tr>
<td>Area</td>
<td>-.003</td>
<td>.021</td>
</tr>
<tr>
<td>Constant</td>
<td>1.830</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The number of behavioral responses</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate change risk perception</td>
<td>.260***</td>
<td>.069</td>
</tr>
<tr>
<td>Drought experience</td>
<td>.300</td>
<td>.156</td>
</tr>
<tr>
<td>Flood experience</td>
<td>.118</td>
<td>.099</td>
</tr>
<tr>
<td>Familiarity with a government GHG reduction plan</td>
<td>.206***</td>
<td>.049</td>
</tr>
<tr>
<td>Gender (female)</td>
<td>.078</td>
<td>.075</td>
</tr>
<tr>
<td>Age</td>
<td>.017***</td>
<td>.003</td>
</tr>
<tr>
<td>Education</td>
<td>-.027</td>
<td>.060</td>
</tr>
<tr>
<td>Income</td>
<td>.044</td>
<td>.024</td>
</tr>
<tr>
<td>Area</td>
<td>-.036</td>
<td>.063</td>
</tr>
<tr>
<td>Constant</td>
<td>1.147</td>
<td></td>
</tr>
</tbody>
</table>

*n* 1,484

*Note: Sixteen respondents who did not answer at least one question out of the four questions related to the experiences of climate change are excluded from the SEM regression analysis.*

*p<.05, **p<.01, ***p<.001 (two-tailed test)
Figure 8. Significant pathways in the national-level research model

Climate change risk perception. Four independent and one socio-demographic variables show a statistically significant relationship with climate change risk perception. Consequently, the results fully identify Hypothesis 2 and partially verify Hypothesis 1 and 4.

Experience. Long-term climate change experiences have a significant positive relationship with climate change risk perception (b = .108, p<.001). This result indicates that the respondents with more intense climate change experiences are likely to have higher levels of climate change risk perception and corroborates the findings of Akerlof et al. (2013), Donner and McDaniels (2013), and Li, Johnson, and Zaval (2011). Contrary to expectation, two short-term experiences do not significantly influence climate change risk perception.

General knowledge. As hypothesized, both awareness of climate change (b = .216) and the understanding of the cause of climate change (b = .005) have a positive correlation with climate change risk perception at the p<.01 and p<.001 levels, respectively. The more the
respondents are aware of climate change or understand the cause of climate change, the higher levels of climate change risk perception they have. These results are not surprising as previous studies (e.g., Lee et al., 2015; Milfont, 2012; Shi et al., 2016) report that more knowledge about climate change, such as the cause and consequence of that, is correlated with greater concern about climate change.

**Policy assessment.** While this study predicts that the assessments of both drought and flood policies would negatively influence climate change risk perception, only the assessment of drought policy negatively affects climate change risk perception ($b = -.065$, $p < .01$). The lower respondents’ levels of satisfaction with drought policy are, the higher levels of climate change risk perception they have. This result provides partial evidence to support the argument of Grothmann and Patt (2005) that individuals’ climate change risk perception is expected to increase if climate policies implemented by governments fail to alleviate climate change risk.

**Socio-demographic variables.** Only gender ($b = .132$) has a positive relationship with climate change risk perception at the $p < .001$ level. Among the respondents, women have higher levels of climate change risk perception than men. This finding supports other research projects which find that women tend to be more concerned about environmental problems (Blocker & Eckberg, 1997; Bord & O’Connor, 1997; McCright, 2010; Xiao & McCright, 2015).80

**Behavioral responses to mitigate climate change.** Five independent and two socio-demographic variables directly or indirectly (i.e., via climate change risk perception) affect individuals’ behavioral responses to mitigate climate change. Based on the results of the SEM regression analysis, *Hypothesis 3 and 5* are fully substantiated.

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80 However, even though numerous research projects have investigated gender difference in environmental concern, this topic is still controversial. McCright (2010) goes on to say that “the upshot is a mix of both robust patterns and inconclusive results” (p. 66).
Climate change risk perception. This analysis verifies the significant and positive relationship between climate change risk perception and behavioral responses to mitigate climate change \((b = .260, p<.001)\). The respondents with greater climate risk perception are more likely to take behavioral responses to alleviate climate change. This finding is consistent with many existing studies, which show climate change risk perception to be a significant motivator of behavioral responses to cope with climate change \(\text{e.g., Deng, Wang, \\& Yousefpour, 2017; Lubell, Zahran, \\& Vedlitz, 2007; O’Connor, Bard, \\& Fisher, 1999; Spence et al., 2011; Yu et al., 2013}\). Long-term climate change experiences, two knowledge variables \(\text{i.e., awareness of climate change and the understanding of the cause of climate change}\), and the assessment of drought policy significantly and indirectly affect behavioral responses to mitigate climate change via climate change risk perception \(\text{see Appendix D}\).

Short-term experiences. Unexpectedly, there are no significant direct effects of short-term experiences on behavioral responses to mitigate climate change. As a result, both drought and flood experiences fail to influence behavioral responses through direct and indirect paths.\(^{81}\) Overall, these findings are not in line with the empirical evidence or arguments of previous studies that show direct experiences of extreme weather events have a positive impact on risk perception or precautionary \(\text{(or preparedness)}\) actions \(\text{Demski et al., 2017; Deng, Wang, \\& Yousefpour, 2017; Diggs, 1991; O’Connor et al., 2005; Zaalberg et al., 2009}\). However, this lack of impact from direct experiences is also shown in some other studies \(\text{e.g., Carlton et al., 2016; Martin, Martin, \\& Kent, 2009}\). This dissertation considers that the relationship between

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\(^{81}\) The pilot model, which included three types of short-term experiences \(\text{i.e., only drought, only flood, and both drought and flood}\), showed similar results. No significant relationship between short-term experiences and climate change risk perception and between short-term experiences and behavioral responses to mitigate climate change was found except the weak relationship between both drought and flood experience and behavioral responses to mitigate climate change \(b = .434, p<.05\).
short-term experiences and behavioral responses to mitigate climate change should be more deeply investigated, and it will return to this relationship in the expert-level analysis.

*Policy-related knowledge.* The familiarity with a government GHG reduction plan shows a significant positive correlation with behavioral responses (b = .206, p<.001). This novel finding identifies that the respondents with more climate policy-related knowledge have a tendency to take more behavioral responses to curb climate change.

*Socio-demographic variables.* Age shows a positive relationship with behavioral responses through a direct path (b = .017, p<.001). The elderly are more likely to take behavioral responses to mitigate climate change than the youth. This finding supports several studies (Keshavarz & Karami, 2016; Rinear & Christensen, 2017) and contradicts the argument of Semenza *et al.* (2008) that young people are more likely to change their behaviors to mitigate climate change than elderly people. With regard to other variables, only gender indirectly influences behavioral responses (b = .034, p<.01). Among the respondents, women tend to be more engaged in behavioral responses to mitigate climate change than men.82 Education, income, and area do not significantly affect behavioral responses both directly and indirectly.

**Alternative Model Specifications**

**Regression analyses of sub models.** Eight sub models, employing each dichotomous behavioral response (0 = *no* and 1 = *yes*) as a dependent variable, are investigated by GSEM regression analysis. The results of the analyses are presented in Table 5. The findings complement those derived from the main model by unveiling the several noteworthy patterns of the relationship between behavioral responses and core independent variables.

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82 Meanwhile, Blocker and Eckberg (1997) take a different stance. They mention that while women generally have greater concern about the environment than men, it is unlikely that they take more pro-environmental actions than men.
First, climate change risk perception has a much greater impact on direct behavioral responses to mitigate climate change, such as saving energy, reducing the use of disposable items, and utilizing renewable energy, rather than indirect behavioral responses such as saving water, donations to environmental organizations, and voting based on environmental-related election promises. Using public transportation instead of a privately-owned car is the sole direct behavioral response not affected by climate change risk perception, and it is negatively influenced by area. The respondents who live in urban areas are more likely to use public transportation instead of a privately-owned car than those who live in rural areas. Given higher levels of public transportation infrastructure and traffic congestion in urban areas, this result is understandable, and their impacts are likely to make inroads on the influence of climate change risk perception to this response. Second, the familiarity with a government GHG reduction plan intensifies three indirect behavioral responses, but only one direct behavioral response. Considering the necessity of both direct and indirect behavioral responses in addressing climate change, these results imply that policy-related knowledge and risk perception are helpful to one another. Third, the relationship between drought experience and each response shows contradictory results. While four activities, such as utilizing renewable energy and donations to environmental organizations, are positively influenced by drought experience, two activities, such as saving energy and saving water, are negatively affected. These conflicting impacts might lead to the insignificant relationship between drought experience and the number of behavioral responses in the main research model. This dissertation does not try to reveal more details of this phenomenon due to a lack of data. Last, age has a significant impact on both direct and indirect behavioral responses. Five responses are intensified by age. Also, gender, income, and area are related to a couple of activities. Overall, the results in the sub models enrich those in the research
model, and the identified patterns can help both practitioners and researchers practically and academically.

**Table 5.** Results of GSEM regression analysis about the relationship among personal factors, risk perception, and each behavioral response associated with climate change

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Dependent variables (each behavioral response)</th>
<th>Direct behavioral responses for mitigation</th>
<th>Indirect behavioral responses for mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Saving energy</td>
<td>Using public transport</td>
<td>Reducing the use of disposable items</td>
</tr>
<tr>
<td>Climate change risk perception</td>
<td>.323*** (1.382**)</td>
<td>-.025 (.099)</td>
<td>.299*** (1.348**)</td>
</tr>
<tr>
<td>Drought experience</td>
<td>-.473* (.623*)</td>
<td>-.044 (.179)</td>
<td>-.373 (.689)</td>
</tr>
<tr>
<td>Flood experience</td>
<td>-.249 (.780)</td>
<td>.173 (.188)</td>
<td>.012 (.102)</td>
</tr>
<tr>
<td>Familiarity with a GHG reduction plan</td>
<td>.122 (1.129)</td>
<td>.025 (.067)</td>
<td>.149 (.077)</td>
</tr>
<tr>
<td>Gender</td>
<td>-.168 (.845)</td>
<td>.269* (.1308*)</td>
<td>.449*** (1.567**)</td>
</tr>
<tr>
<td>Age</td>
<td>.027*** (1.028****)</td>
<td>-.002 (.004)</td>
<td>.021*** (.098)</td>
</tr>
<tr>
<td>Education</td>
<td>.069 (.1072)</td>
<td>-.070 (.086)</td>
<td>-.133 (.098)</td>
</tr>
<tr>
<td>Income</td>
<td>.057 (.041)</td>
<td>-.007 (.033)</td>
<td>.134** (.039)</td>
</tr>
<tr>
<td>Area</td>
<td>.027 (.109)</td>
<td>-.301*** (.086)</td>
<td>-.078 (.099)</td>
</tr>
<tr>
<td>Constant</td>
<td>-.1440</td>
<td>.553</td>
<td>-.1595</td>
</tr>
<tr>
<td>n</td>
<td>1.484</td>
<td>1.484</td>
<td>1.484</td>
</tr>
</tbody>
</table>

*Note 1. The relationship between personal factors and risk perception is omitted to avoid duplication.
2. The first and second parentheses display robust standard errors and odds ratios, respectively.
3. Multicollinearity, influential outliers, specification errors, and other statistical problems are not detected.
4. p<.05, **p<.01, ***p<.001 (two-tailed test)
**Relationship between socio-demographic characteristics and personal factors.** When looking at the research model, personal factor variables are described as exogenous variables. However, as mentioned earlier, there could be a causal relationship among the personal factor variables (see pp. 76–77). Also, even though five socio-demographic characteristics are only utilized as the control variables of risk perception and behavioral response variables in the research model, some may have a causal relationship with these personal factor variables. Table 3 already showed the several significant correlations between the personal factor and socio-demographic characteristic variables. Intuitively, the level of education and age may positively affect knowledge and experience variables, respectively. It is not surprising that the results of regression analyses about the relationship between each personal factor variable and five socio-demographic characteristic variables in Appendix E are mostly consistent with those expectations.

Nevertheless, this dissertation leaves these relationships out of the research model because of the following reasons. First, identifying the causal relationship between them may not be a significant and innovative contribution to the development of climate change literature. Second, the impacts of the socio-demographic characteristic variables, mediated by the personal factor and risk perception variables successively, on the behavioral response variable would be minimal. Third, it is difficult and ineffective for policymakers to implement policies that can influence individuals’ socio-demographic characteristics to promote their behavioral responses against climate change. Last, when the research model includes these relationships, its model fits are greatly undermined and become unacceptable. Overall, revealing the causal relationship between the personal factors and socio-demographic characteristics is somewhat meaningful, but not critical to this study.
Reverse pathway between risk perception and behavioral responses. Contrary to this study’s core hypothesis that climate change risk perception positively affects behavioral responses to address climate change, some studies (e.g., Bem, 1965; Kiesler, 1971; Olson & Stone, 2005) in the social sciences imply that individuals’ perception can be influenced by their behaviors. To ensure the appropriateness of the research model, the reverse relationship between risk perception and behavioral responses related to climate change is carefully checked by employing the following two approaches: a) switching the boxes of the risk perception and behavioral response variables (i.e., personal factors → behavioral responses → risk perception) in Figure 5, leaving the pathways unchanged; and b) reversing the causal pathway between the risk perception and behavioral response variables (i.e., personal factors → risk perception ← behavioral responses) in Figure 5 without changing others.

In the case of the first reversed-model, the behavioral response and risk perception variables have a significant and positive relationship at the p<.001. However, its model fits are drastically reduced compared to the research model and do not meet acceptable levels of model fit (e.g., RMSEA: 0.038 → 0.196, CFI: 0.970 → 0.417, TLI: 0.867 → -1.626, and SRMR: 0.010 → 0.046). In terms of the second reversed-model, while its model fit scores are only slightly weakened compared to the research model (e.g., RMSEA: 0.038 → 0.050, CFI: 0.970 → 0.949, TLI: 0.867 → 0.772, and SRMR: 0.010 → 0.015), the behavioral response variable does not significantly affect the risk perception variable. Consequently, it may be difficult to perfectly certify which pathway between the risk perception and behavioral response variables is right, based on the cross-sectional survey data. Nevertheless, considering those results, the causal pathway from climate change risk perception to behavioral responses to mitigate climate change seems more convincing than the reversed pathway.
Policy Implications

The results of this national-level analysis reveal that most personal factors significantly affect individuals’ behavioral responses to alleviate climate change directly or indirectly (via climate change risk perception). There is a need for government efforts that facilitate positive factors on climate change risk perception and individuals’ behavioral responses as well as mitigate the effects of negative factors on them. Relevant policy implications are as follows:

First, policies for helping individuals understand long-term climate change experiences are necessary. Unlike short-term experiences, long-term climate change experiences, including the patterns of extreme weather events, influence individuals’ behavioral responses via climate change risk perception. Not only can miscommunication concerning climate change cause the general public’s indifference toward climate change policy, it can dampen their behavioral responses to address climate change. Short-term experiences would no longer be a suitable way of communicating with the general public regarding climate change in South Korea. Thus, policymakers should pay attention to the way in which they can help individuals perceive long-term climate change experiences as well as remind individuals of the importance of these experiences. Previous research projects provide some meaningful lessons. Rebetez (1996) emphasizes an appropriate form of data representation, such as the frequency calendar and cumulative frequency graph related to weather events. Thaker, Zhao, and Leiserowitz (2017) highlight the reality and accuracy of climate change information, including mitigation and adaptation strategies. Yu et al. (2013) indicate the importance of more current climate change information delivered timely. In the era of ICT, the timely provision of long-term, up-to-date, and precise information related to climate change can be realized based on the establishment of an on-line climate change information system. By the system, individuals can easily and quickly
obtain climate change information and clearly and confidently perceive their long-term climate change experiences.

Second, systematic education on climate change needs to begin in earnest. Awareness of climate change, including its major cause and formidable outcomes, can lead to the increase of climate change risk perception, and this risk perception finally enhances individuals’ behavioral responses to curb climate change. Therefore, policymakers must seek to educate the general public about climate change. Yu et al. (2013) suggest the expansion of publicity to diffuse the knowledge of climate change. Bai and Liu (2013) advise the active use of low-carbon education facilitating low-carbon awareness and action skills of the general public. Berse (2017) proposes the educational system equipped with educational materials in children’s learning on climate change. Policymakers should utilize diverse education methods (e.g., on-line information system and educational broadcasting), and those methods should target all citizens, regardless of their socio-demographic characteristics. Particularly, given that age significantly and positively affects behavioral responses to alleviate climate change, climate change education included in the primary, secondary, or tertiary curriculums can be a proper way to expand the behavioral responses of the younger generations.

Third, governments should set a goal of finding a proper balance between the level of their efforts and that of individual efforts to address climate change. While governments’ ongoing efforts to enhance climate policy are essential to minimize the adverse effects of climate change, not only can too much government-driven efforts accompanied by huge investments inevitably increase the burden on government coffers, but they can also accelerate the contraction of individuals’ behavioral responses against climate change. Also, the general public might feel that governments and municipalities have to assume full responsibility. In fact,
according to the K-water survey, the vast majority of the respondents think that the government and municipalities should play a bigger role in addressing climate change.\(^8^3\) So, complementary policies which offset the weakening of individuals’ behavioral responses due to climate policy have to be implemented. A variety of attractive financial incentives, such as tax reduction linked to less driving, subsidy and free parking service for electric cars, and electricity or water bill reduction based on an annual energy or water usage pattern, might be plausible strategies.

Last, governments are asked to make diligent efforts to share their GHG reduction target and detailed plans to achieve it with individuals. The familiarity with the government plans positively affects individuals’ behavioral responses to mitigate climate change. But more importantly, as shown in Table 5, policy-related knowledge intensifies indirect behavioral responses to mitigate climate change, while climate change risk perception facilitates direct behavioral responses. This factor can be a great companion for risk perception in encouraging individuals’ behavioral responses to curb climate change. Further, some indirect responses, such as donations to environmental organizations and voting based on environmental-related election promises, involve political and social impacts and place individuals’ behavioral responses on a path of a virtuous circle.\(^8^4\) Governments should make reasonable goals related to the reduction of GHG emissions, unveil their achievement to the public in a transparent manner, and try to propagate the significant role of individuals’ behavioral responses in realizing their goals. These activities can be effectively achieved with the implementation of the first two implications.

\(^8^3\) Concerning the question of who should play the most important role in addressing climate change, 81.3% of the respondents indicate the government (76.0%) or municipalities (5.3%), whereas 11.6% of them point out individuals. The remaining respondents (7.1%) select private and public corporations, educational institutions, etc.

\(^8^4\) If individuals donate more money to environmental organizations and vote more enthusiastically for environment-oriented politicians, these organizations will try to strengthen a national consensus about the seriousness of climate change, and policymakers will try to implement more effective climate policies. These efforts will attract more public attention and motivate more people to take behavioral responses against climate change.
In brief, governments should try to enhance individuals’ behavioral responses to address climate change by implementing a variety of policies, such as providing proper climate change information by a Web-based integrated system, diffusing climate change and policy-related knowledge by various educational methods, and utilizing financial incentives. A balanced set of these measures can maximize individuals’ efforts against climate change, instead of depending on a particular policy. The thing policymakers always remember is not the implementation of those policies, but the iterative refinement of them.

**Limitations and Future Research Directions**

The main limitations of this empirical analysis are two-fold. First, while this analysis focuses on risk perception, individuals’ behavioral responses to address climate change also can be affected by other factors, such as individual’s environmental value, personal benefits, and external contexts. For instance, behavioral responses to alleviate climate change are mostly in line with pro-environmental behaviors (e.g., minimizing resource and energy consumption) practiced by the public for a long time. Those who have positive environmental value are likely to practice pro-environmental actions (Brandon & Lewis, 1999; Kollmuss & Agyeman, 2002), regardless of the level of climate change risk perception. Tangible or intangible benefits, such as saving money and improving health, can be a significant motivation to engage in behavioral responses against climate change (Bai & Liu, 2013; Whitmarsh, 2009a). External contexts, such as the condition of public transportation and technological developments related to electric facilities and cars, may also cause actions that correspond to behavioral responses to address climate change. Second, instruments for measuring variables have room for improvement. Many personal factors used in this analysis, including climate change risk perception, are measured by a single item due to the limitation of utilizing existing data. Especially, short-term experience
variables do not reflect the frequencies and intensities of extreme weather events. Depending on single-item measures is likely to weaken reliabilities (Keller, Siegrist, & Gutscher, 2006). This analysis may have underestimated (or overestimated) the effects of those variables on climate change risk perception and behavioral responses to mitigate climate change.

The findings of this national-level analysis should be considered not as the last pitch, but a new momentum for unveiling this topic. Based on the limitations above, the following future research directions are put forward. First, future research should try to investigate processes initiating individuals’ behavioral responses to address climate change more precisely by utilizing a wider range of influential factors (e.g., risk perception, environmental propensity, and economic benefits). The expansion of a research scope will provide a rich source of policy alternatives aimed at enhancing individuals’ behavioral responses. Along with these efforts, researchers need to identify favorable circumstances and potential barriers to the implementation of those policy alternatives and expected outcomes. Second, to obtain more robust results, future studies should be conducted based on much more refined and standardized survey instruments. Most previous research projects exploring similar topics have utilized cross-sectional survey data measured by different questions and point scales. The stepwise refinement and standardization of survey instruments would not only lead to more robust analyses in cross-sectional studies, but also increase the likelihood of comparative and longitudinal studies.

85 In fact, experimental and longitudinal nature of research is better than non-experimental and cross-sectional studies in identifying causality (Grothmann & Reusswig, 2006; Mase, Gramig, & Prokopy, 2017; Singleton & Straits, 2017; Thaker, Zhao, & Leiserowitz, 2017). However, when exploring this topic, the latter has been preferable to the former due to practical problems such as a lack of time, money, and instruments.

86 This direction somewhat echoes the argument of Marquart-Pyatt et al. (2014). They emphasize the importance of designing survey which can be commonly used in the social science community: “This would help increase the likelihood that future teams of social scientists utilize the same reliable, valid measures of climate change perceptions, ultimately improving the coherence in this literature, and accumulation of knowledge, over the long-term” (Marquart-Pyatt et al., 2014, p. 255).
Conclusion

This national-level analysis explores the causal relationship among personal factors, climate change risk perception, and behavioral responses to address (mitigate) climate change. SEM regression analysis is conducted based on survey data of South Korea, and the results mostly substantiate this study’s hypotheses. As predicted, climate change risk perception is significantly and positively correlated with behavioral responses to mitigate climate change. This evidence is consistent with the argument of many previous studies that climate change risk perception plays a pivotal role in enhancing individuals’ behavioral responses to address climate change. All the knowledge factors positively affect behavioral responses directly or indirectly via climate change risk perception. Especially, considering the analysis results of the sub models, policy-related knowledge, promoting indirect behavioral responses such as donations to environmental organizations and voting based on environmental-related election promises, shows the potential to complement climate change risk perception which mostly facilitates direct behavioral responses such as saving energy and utilizing renewable energy. While long-term climate change experiences have a positive relationship with behavioral responses indirectly via climate change risk perception, contrary to this study’s expectation, short-term (extreme weather event) experiences fail to intensify both risk perception and behavioral responses. Also, only the assessment of drought policy, except that of flood policy, negatively influences behavioral responses mediated by climate change risk perception. Among control variables, gender and age have impacts on risk perception or behavioral responses associated with climate change. Despite some limitations, there is no doubt that this national-level analysis conveys significant information on the causal relationship among personal factors, risk perception, and behavioral responses associated with climate change.
The findings of this analysis leave some significant policy implications. Simply, policymakers should pay more attention to how to support the general public’s long-term climate change experiences, how to initiate systematic education on climate change, how to share their GHG reduction plan with individuals, and how to keep a balance between government’s efforts and the general public’s efforts to address climate change. Developing a Web-based integrated information system and utilizing various educational programs and financial incentives might be practical methods to settle these pending questions. Besides climate change risk perception, other factors, such as individual’s environmental values, financial benefits, and social and technological contexts, have a potential to change individuals’ behavioral responses related to climate change. When exploring this topic in the future, researchers need to expand a range of influential factors beyond risk perception. Also, they have to keep in mind that continued efforts to refine and standardize survey instruments related to climate change risk perception and individuals’ behavioral responses against climate change could lead to more robust and fruitful results.
CHAPTER V

LOCAL-LEVEL ANALYSIS

South Korea has been regarded as a country with a water shortage by water-related international organizations. Especially, South Chungcheong Province, situated in the west of South Korea, has repeatedly experienced droughts since 2010 (Ministry of Infrastructure and Transport (MOLIT) & K-water, 2017). Based on survey data of individuals living in South Chungcheong Province, this chapter investigates the causal relationship among personal factors, climate change (drought) risk perception, and behavioral responses to adapt to climate change (drought). The results of the analysis will be helpful to South Chungcheong Province in overcoming droughts and shaping effective and efficient climate policies. Also, given that data were collected from a face-to-face survey during the 2015 drought period, the findings might help both policymakers in many drought-prone areas and scholars across the world better understand the features of individuals’ water consumption during drought.

Research Contexts

Water Management and Climate Change

Water has played an important role in human history. The major ancient civilizations of the world were developed based on efforts to manage water, such as the Nile, Indus, Yellow, Tigris, and Euphrates Rivers (LaMoreaux, 2001). Since the Industrial Revolution, water management has contributed to successful industrialization and urbanization in many countries through providing domestic and industrial water (K-water, 2016a), generating hydropower

87 The amount of available water per capita (index) is commonly used by several organizations, such as the United Nations Environmental Program and the Population Action International, for determining the conditions of each country’s water resources. According to the data released by the Population Action International in 2003, the index of South Korea was 1,453 cubic meters. It was ranked 129 among 153 nations. This organization categorized South Korea within the group of water stressed countries (i.e., the index is less than 1,700 cubic meters) (MOLIT & K-water, 2017).
(Tvedt, 2010), transporting heavy materials and products cheaply (Aldcroft, 1983), and securing stable urban environment (Novotny, Ahern, & Brown, 2010). However, drastic climate change in the 21st century has made it difficult to manage water quantity as well as quality and requires more water-related investments (Bates et al., 2008). Many nations across the world are experiencing climate change and South Korea is no exception.

**Water Management in South Korea**

Since the 1960s, the South Korean government has initiated full-scale water resources development based on long-term plans, such as the 1st Comprehensive Water Resources Development (10-years) Plan (1966–1975) and the Comprehensive Four Major River Basin Development Plan (1971–1981) (K-water, 2016a). Many hydroelectric dams (e.g., Uiam (1967: The time of completion) and Paldang (1974)) and multi-purpose dams (e.g., Seomjin River (1965), Soyanggang (1973), and Andong (1977)), were constructed to secure water resources and energy (MOLIT & K-water, 2017). The construction of wide-area waterworks, which can provide raw or purified water to two or more local governments (Ministry of Government Legislation, 2016), also started nationwide in the 1970s to supply domestic and industrial water. As a result, in 2000, the percentage of households with direct, potable water reached 87.1. After 2000, water policies were transformed from securing water quantity to restoring water quality and ecosystems based on the 4th Comprehensive Water Resources Plan (2001–2020) (K-water, 2016a). The increasing construction cost of dams and public concerns about environmental damage have made the government focus on the development of new water sources, such as small dam construction and desalination, instead of the development of large-scale dams (MOLIT & K-water, 2017).
According to the United Nations Water (2006), rapid urbanization, population concentration, and droughts triggered by climate change have exacerbated global water scarcity. South Korea also has not directly suffered from less precipitation, but high density of population, sharp fluctuations of seasonal precipitation, and the intensification of climate change make it difficult to manage water resources. For example, the annual precipitation per capita is just 2,546 cubic meters, one sixth of the world average, whereas the average annual precipitation is 1,300 millimeters (1986–2015), 1.6 times the global average (MOLIT & K-water, 2017). Moreover, since the 2000s, severe regional droughts are getting more frequent in South Korea.

**Water Condition in South Chungcheong Province**

South Chungcheong Province, abbreviated as Chungnam, is located in the west of South Korea. The Boryeong dam, the main water source for several cities in Chungnam, was constructed in 1998. Since then, it has supplied water regularly to Chungnam for over 15 years. The total water storage capacity of the dam is 116.6 million cubic meters, including flood control storage capacity (i.e., 10 million cubic meters). The water supply capacity is 106.6 million cubic meters (i.e., domestic and industrial water—90.6 million, agricultural water—4.7 million, and stream maintenance water—11.3 million cubic meters) (K-water, 2013).

In 2015, the Boryeong dam was nearly drained due to a prolonged drought in the region. The amount of water in the Boryeong dam was just around twenty-two percent of its capacity (Kim, Chang, & Won, 2015). Chungnam inevitably planned to cut down water supply in eight cities (e.g., Boryeong and Seosan cities) (Song, 2015). MOLIT and K-water, who were in charge of water (quantity) management in South Korea, considered several measures to tackle the water shortage in Chungnam. Urgently, they constructed a pipeline from one of the sixteen dammed pools (reservoirs) on the four major rivers (i.e., the Han, Geum, Yeongsan, and Nakdong Rivers),
called the Baekje-bo, to the Boryeong dam (MOLIT, 2015). Unfortunately, Chungnam’s water shortage in 2015 was not the last. As of June 5, 2017, the national average of accumulated precipitation was just 166.6 millimeters, down forty-seven percent from the previous year. It marked the second lowest record since the government started to make weather forecasts in 1973 (Kim, 2017). The average amount of water in reservoirs also fell under fifty percent (Kim, 2017). In 2017, once again, Chungnam suffered from water scarcity (Choi, 2017).

Water scarcity occurs for two main reasons: a) the excessive use of water or the inefficient operation of water sources and facilities (i.e., man-made water scarcity); and b) the lack of water quantity brought by drought (i.e., natural water scarcity) (Pereira, Cordery, & Iacovides, 2009). According to Collier and Webb (2002), climate change has intensified extreme cycles involving severe droughts and deadly floods. There is no evidence that K-water, which is responsible for the management of the Boryeong dam, failed to control the dam water level, and citizens and industries in Chungnam excessively used water. Namely, the lack of water quantity brought by drought is the cause of Chungnam’s water shortage. To solve this problem, securing more water in advance or saving water during drought (or both of them), can be a possible solution. While the former (e.g., building new dams and desalination facilities) typically requires time and money and is likely to come up against sturdy opposition by citizens and environmental organizations, the latter (e.g., individuals’ water saving effort) can be an inexpensive and less time-consuming settlement with no severe resistance. Overall, it is increasingly difficult to manage water due to climate change and there is a high probability that drought will continue to occur in Chungnam. In this regard, the role of individuals in addressing drought will be much more important, and this analysis, exploring individuals’ behavioral responses during drought, could offer practical and economical lessons to adapt to natural water scarcity in Chungnam.
Research Methods

Data Collection

Research tool. This analysis is based on survey data of local citizens in Chungnam. In late 2015, the K-water institute conducted a survey in north-west Chungnam to investigate water consumption pattern and water policy preference under the drought in the second half of 2015. North-west Chungnam consists of three cities (i.e., Dangjin, Boryeong, and Seosan) and five counties (i.e., Seocheon, Yesan, Cheongyang, Taean, and Hongseong). A regionally representative quota sample of north-west Chungnam population aged 19 years and older was surveyed face-to-face in their own homes between 10 and 23th December, 2015.88

Survey design and representativeness. Similar to the questionnaire used in the national-level survey, researchers at the research center for water policy and economy in the K-water institute developed a questionnaire. Before conducting the survey, they evaluated and improved the design of the questions based on expert reviews of the survey questionnaire. The questionnaire includes key questions associated with the following topics: a) drought risk perception (e.g., the seriousness of drought); b) self-vulnerability perception related to limited water supply (e.g., tolerance against limited water supply situations); c) experiences of water problems during drought (e.g., experiences of water supply restriction and low water pressure); and d) behavioral responses to adapt to drought (e.g., daily actions and device utilization related to water saving). Most questions are closed-ended, mainly in the form of a four point scale. Appendix F lays out the key questions of the questionnaire.

88 This study views that most individuals living in Chungnam associate drought with climate change. For instance, in 2016, the Chungnam institute surveyed 1,000 local citizens throughout Chungnam. More than ninety-five percent of the respondents believed that climate change (moderately, seriously, or very seriously) intensifies drought and increases its frequency in their province (Chungnam institute, 2016). Also, according to the survey data of the national-level analysis, all respondents who reside in Chungnam (N=51) answered that the danger of drought is either somewhat or definitely increasing in the last ten years in relation to climate change.
Table 6

2015 survey respondents’ socio-demographic characteristics

<table>
<thead>
<tr>
<th>Classification</th>
<th>Respondents</th>
<th>Population in north-west area of Chungnam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>156</td>
<td>30.3%</td>
</tr>
<tr>
<td>Female</td>
<td>359</td>
<td>69.7%</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0-18)</td>
<td>68</td>
<td>13.2%</td>
</tr>
<tr>
<td>19-39</td>
<td>182,377</td>
<td>28.3%</td>
</tr>
<tr>
<td>40-49</td>
<td>115,738</td>
<td>18.0%</td>
</tr>
<tr>
<td>50-59</td>
<td>125,546</td>
<td>19.5%</td>
</tr>
<tr>
<td>60 and above</td>
<td>220,794</td>
<td>34.3%</td>
</tr>
<tr>
<td>No answer</td>
<td>1</td>
<td>0.2%</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under middle school</td>
<td>191</td>
<td>37.1%</td>
</tr>
<tr>
<td>High school</td>
<td>261</td>
<td>50.7%</td>
</tr>
<tr>
<td>Undergraduate and above</td>
<td>61</td>
<td>11.8%</td>
</tr>
<tr>
<td>No answer</td>
<td>2</td>
<td>0.4%</td>
</tr>
<tr>
<td>Income (Average Monthly Income before Tax)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I &lt;KRW 1million (US$ 909)</td>
<td>66</td>
<td>12.8%</td>
</tr>
<tr>
<td>KRW 1million (US$ 909)≤ I &lt;KRW 2million (US$ 1,818)</td>
<td>180</td>
<td>35.0%</td>
</tr>
<tr>
<td>KRW 2million (US$ 1,818)≤ I &lt;KRW 3million (US$ 2,727)</td>
<td>135</td>
<td>26.2%</td>
</tr>
<tr>
<td>KRW 3million (US$ 2,727)≤ I &lt;KRW 4million (US$ 3,636)</td>
<td>103</td>
<td>20.0%</td>
</tr>
<tr>
<td>KRW 4million (US$ 3,636)&lt; I</td>
<td>29</td>
<td>5.6%</td>
</tr>
<tr>
<td>No answer</td>
<td>2</td>
<td>0.4%</td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dangjin city</td>
<td>87</td>
<td>16.9%</td>
</tr>
<tr>
<td>Boryeong city</td>
<td>73</td>
<td>14.2%</td>
</tr>
<tr>
<td>Seosan city</td>
<td>96</td>
<td>18.6%</td>
</tr>
<tr>
<td>Seocheon county</td>
<td>51</td>
<td>9.9%</td>
</tr>
<tr>
<td>Yesan county</td>
<td>36</td>
<td>10.9%</td>
</tr>
<tr>
<td>Cheongyang county</td>
<td>35</td>
<td>6.8%</td>
</tr>
<tr>
<td>Taean county</td>
<td>53</td>
<td>10.3%</td>
</tr>
<tr>
<td>Hongseong county</td>
<td>64</td>
<td>12.4%</td>
</tr>
<tr>
<td>Total</td>
<td>515</td>
<td></td>
</tr>
</tbody>
</table>

Note: The data of three cities’ and five counties’ population in Chungnam is provided by Statistics Korea (2017b).
**Representativeness.** The face-to-face survey, based on a structured questionnaire, was conducted by fully trained surveyors who belong to the Gallup Korea (http://www.gallup.co.kr/) and took approximately one hour on average to complete. Individuals who reside in north-west Chungnam, around 770,000 as of 2016, was the target population (Statistics Korea, 2017b). Total 515 respondents were selected randomly from a stratified sample of the eight areas. The socio-demographic characteristics of the respondents, along with those of north-west Chungnam population, are presented in Table 6. The proportions of female (69.7%) and 50s age (31.1%) in the respondents appear to be somewhat higher than those of female (49.1%) and 50s age (19.5%) in north-west Chungnam population. Regarding the patterns of water consumption in South Korea, women play a key role in domestic water use, as they typically bear primary responsibility for water-intensive activities such as washing dishes and doing laundry. Even though these two groups are over-represented in the dataset, this study views that it is not seriously problematic because they are more likely to be aware of water issues in the household and play a significant role in deciding water consumption patterns of the household.

**Variable Description**

**Mediating and dependent variables.** Drought risk perception and behavioral responses to address drought are utilized as a mediating (both dependent and explanatory) variable and a dependent variable, respectively.

**Drought risk perception.** Similar to climate change risk perception which is measured by the perceived seriousness of climate change, respondents were asked to indicate their level of seriousness of drought in Chungnam on a four point scale, where 1 was very serious and 4 was not serious. This analysis reverses the scale of the question so that higher values indicate greater perception of the seriousness of the problem.
Behavioral responses to address drought. From an individual perspective, actions to save water (reduce water consumption) are practicable behavioral efforts to adapt to drought, which is viewed as a water shortage due to less precipitation than normal.\textsuperscript{89} Two types of individuals’ behavioral responses, daily action and device utilization, are utilized as dependent variables. In the case of the daily action, a total of seven items are used to create a holistic assessment of respondents’ water saving efforts. On a four point scale, where 1 = strongly, 2 = moderately, 3 = hardly, and 4 = not, the respondents were asked to indicate the level of how much they were committed to practicing the following water saving behaviors than usual: a) using a glass with water when brushing my teeth; b) using a wash basin with water when washing my face; c) shortening shower time; d) turning off the faucet which I’m not using it; e) doing laundry in a larger quantity; f) using a washing-up bowl when washing dishes; and g) inspecting a leakage of water. This study reversely codes the scale of the questions, where 0 = not, 1 = hardly, 2 = moderately, and 3 = strongly, so that higher values indicate more efforts on daily actions to save water. The index of daily action is created by summing each value of the seven questions (Cronbach’s alpha = 0.8384).\textsuperscript{90} The range of this index is from 0 to 21. In terms of the device utilization, on a dichotomous scale, where 1 = yes and 2 = no, the respondents were asked to indicate whether they were using the following water saving devices: a) a water saving faucet; b) a water saving toilet bowl; and c) a water saving shower. The scale of the questions are recoded, where 0 = no and 1 = yes. Like the index of daily action, each value of the three questions is

\textsuperscript{89} In fact, Appendix A does not clearly provide the conceptual map for the local-level analysis. Nevertheless, it, along with the background chapter, helps identify the proper indicators of this analysis’ concepts.

\textsuperscript{90} Principal component factor analysis indicates that the number of retained factor is one. While the first factor has an Eigenvalue of 3.61 which is 52\% of the total possible of 7, the second factor has an Eigenvalue of just 0.77. All correlation values are greater than 0.3. The overall value of KMO measure, 0.8598, is placed in the meritorious range (0.80–0.89) (Kaiser, 1974). The result of Bartlett’s test of sphericity is also significant at the \(p<.001\) level. In sum, those seven questions are suitable factors for establishing the index.
summed to develop the index of device utilization (Cronbach’s alpha = 0.8185).\textsuperscript{91} In other words, the higher the index is, the more water saving devices a respondent uses.

**Independent variables.** One experience variable, three knowledge variables, and two policy assessment variables, along with self-vulnerability perception related to limited water supply, are employed as independent variables.

*Experience of water problems.* It is not easy for the general public to know that they are experiencing drought because of the difficulty in recognizing when it starts and ends which Wilhite (2000) introduces as one of the characteristics of drought. Instead, this study argues that the restriction of residential water supply due to a water shortage can be the most obvious experience of drought to them. The respondents were asked whether or not they experienced any water supply problems, such as limited water supply, low pressure, etc., during the drought. Based on the respondents’ answers, experience of water problems is coded as a dichotomous variable, where no = 0 and yes = 1.

*Knowledge.* Two general knowledge variables (i.e., awareness of water quantity condition at the national level and the exposure to water saving information) and one specific knowledge variable (i.e., the familiarity with a subsidy policy related to drought) were measured.\textsuperscript{92} First, concerning water quantity condition in South Korea, respondents were asked to select their answers among four items, where 1 = very abundant, 2 = abundant, 3 = scarce, 4 = scarce.

\textsuperscript{91} The critical point of Eigenvalue is 1 in principal component factor analysis. The Eigenvalues of the first factor and second factor are 2.21 (74\% of the total possible of 3) and 0.51, respectively. There is no correlation value which is 0.3 or less than 0.3. The result of Bartlett’s test of sphericity is significant at the p<.001 level, and the overall value of KMO measure is 0.6859 locating in the mediocre range (0.60–0.69). Consequently, those three items are adequate for generating the index.

\textsuperscript{92} Unlike climate change, the general public is quite familiar with drought itself and its causes (e.g., less precipitation than normal) and consequences (e.g., severe water shortages). The reduction of individuals’ water consumption during drought is one of the important strategies to governments in addressing drought. Therefore, this study believes that the above-mentioned variables might be appropriate indicators for drought knowledge.
and 4 = very scarce. Second, the exposure to water saving information through a campaign, publicity, or education is simply coded as a dichotomous variable where no = 0 and yes = 1. Lastly, respondents’ level of familiarity with a government subsidy policy associated with water saving during a drought period was measured on a four point scale, where 1 was precisely and 4 was not. This study reverses the scale of the question, where 1 = not, 2 = hardly, 3 = moderately, and 4 = precisely. Therefore, higher values point out greater familiarity with the government subsidy policy related to water saving during a drought period.

Policy assessment. Core policies influencing water management during drought are water supply and water infrastructure policies (K-water, 2016b). In the case of water supply policy, the respondents were asked to answer their level of evaluation for inconvenience in using water in Chungnam on a four point scale, where 1 = very serious, 2 = moderately serious, 3 = hardly serious, and 4 = not serious. In terms of water infrastructure policy, the respondents were asked to answer their level of evaluation for water infrastructure in Chungnam on a four point scale, where 1 = very good, 2 = good, 3 = poor, and 4 = very poor, and their answers are reverse coded. Overall, higher values point out higher satisfaction with water management policies.

Self-vulnerability perception related to limited water supply. This analysis utilizes the perception of self-vulnerability to the restriction of water supply as an additional independent variable. When facing a prolonged drought, there is a high possibility of cutting off water supply intermittently, and the execution of limited water supply tends to cause both inconvenience for individuals and losses to industries. Especially, people who themselves feel highly vulnerable to limited water supply are likely to suffer more inconvenience from actual limited water supply than people who themselves do not, and the former might want to avoid the restriction of water supply more than the latter. Generally, the public notices that not only can water saving efforts
by individuals and industries delay the timing of limited water supply, but also shorten the hours of restricting water supply. Thus, this study views that higher self-vulnerability perception has a potential to stimulate individuals’ behavioral responses to save water during drought.\textsuperscript{93}

Four items are used to create an overall assessment of respondents’ vulnerabilities to limited water supply. On a five point scale, where $1 = \textit{from one to three days}$, $2 = \textit{from four to seven days}$, $3 = \textit{from eight days to less than a month}$, $4 = \textit{from one month to less than three months}$, and $5 = \textit{more than three months}$, the respondents were asked to indicate the level of how long they can tolerate the following limited water supply situations (per day): a) from three to less than six hours; b) from six to less than twelve hours; c) from twelve to less than eighteen hours; and d) from eighteen to less than twenty-four hours. Similar to drought risk perception, the scale of the questions are reversely coded, where $1 = \textit{more than three months}$, $2 = \textit{from one month to less than three months}$, $3 = \textit{from eight days to less than a month}$, $4 = \textit{from four to seven days}$, and $5 = \textit{from one to three days}$. Based on the summation of each value of the questions, the index of self-vulnerability perception is generated (Cronbach’s alpha = 0.8923).\textsuperscript{94} The range of

\textsuperscript{93} This variable was recommended by K-water researchers, who have explored drought for a long time and conducted the local-level survey, as a potential factor influencing individuals’ water saving behaviors during drought. This study tested several pilot models with self-vulnerability perception as a mediating variable by adding pathways from other (independent and control) variables. Their model fits are poor, whereas few significant pathways are identified. For example, in the pilot model assuming that self-vulnerability perception variable is affected by water problem experience, the exposure to water saving information, and socio-demographic variables, only the income variable positively affects this variable, and model fits are unacceptable (e.g., $\chi^2 = 30.945$ (df = 9, p<.001), RMSEA—0.070, CFI—0.862, TLI—0.447, and SRMR—0.022). Also, the literature does not provide enough evidence that this variable can act as a mediating variable in the research model. Considering these results and the core of this study which reveals the role of risk perception in the process of individuals’ behavioral responses, this analysis employs self-vulnerability perception as an independent variable. According to the regression analysis results, utilizing self-vulnerability perception as an independent variable does not significantly change the results of the relationships among other variables and improves model fits.

\textsuperscript{94} Given the results of principal component factor analysis, the number of retained factor is one. Specifically, the Eigenvalue of the first factor is 3.08, and this is 77% of the total possible of 4. By comparison, that of the second factor is just 0.54. There is no correlation value which is 0.3 or less than 0.3. The overall value of KMO measure is 0.7806, and it is situated in the middling range (0.70–0.79). Also, the result of Bartlett’s test of sphericity is significant at the p<.001 level. Overall, those four questions are suitable factors for creating the index.
this index is from 4 to 20. In other words, the higher the index is, the shorter period of limited water supply a respondent can tolerate (i.e., the higher levels of self-vulnerability perception a respondent has).

**Control variables.** To isolate the influence of personal factors on drought risk perception and behavioral responses to adapt to drought, this study utilizes five socio-demographic variables. Each variable is coded in a similar way that the national-level analysis does. First, gender is measured as a dichotomous variable, where 0 = males and 1 = females. Second, age is expressed in years. Third, the level of education is coded on a three point scale, where 1 = under middle school, 2 = high school, and 3 = undergraduate and above. Fourth, the level of income (i.e., average monthly income before tax last year) is coded on a seven point scale, range from 1 for those earning less than KRW 1million (around US$ 909) to 7 for those earning over KRW 6million (around US$ 5,455). Lastly, residential area is coded as a dichotomous variable, where 0 = urban area (city) and 1 = rural area (county).

**Data Analysis**

Considering the structural relationship among personal factors, risk perception, and behavioral responses related to drought, the analysis plan of this chapter is along the same lines as that of the previous national-level chapter. SEM is employed to test hypotheses. This empirical analysis is performed based on the following steps. First, socio-demographic characteristics and descriptive results are presented. Subsequently, bivariate correlations between the dependent variables and other variables are measured. Finally, SEM regression analysis is conducted by utilizing STATA, following the evaluation of model fit. Pathways in the local-level research model is described in Figure 9. Prior to this research model, some pilot models, adding pathways among personal factor variables, are analyzed and provide mixed-results with poor
model fits. Following the national-level analysis, the relationship among the personal factors is not covered in the local-level analysis.

**Figure 9.** Pathways in the local-level research model

**Analysis Results**

**Socio-demographic Characteristics**

The respondents range in age from 20 to 83 years (M = 54.38, SD = 12.12) and 69.7% are females. The majority of the respondents are equal to a high school graduate in scholastic achievement, and approximately 12% have a bachelor’s or graduate degree. About 25.6% earn over KRW 3million (US$ 2,727) a month.

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For example, one of the pilot models includes the pathways between water problem experience and policy assessment and between general knowledge and policy-related knowledge. According to the regression analysis results, while the assessment of water supply is significantly and negatively affected by water problem experience (p<.001), the assessment of water infrastructure is not. Also, while the exposure to water saving information significantly and positively affects the familiarity with a subsidy policy (p<.001), awareness of water quantity condition does not. Model fits are not acceptable (e.g., $\chi^2 = 142.825$ (df = 31, p<.001), RMSEA—0.085, CFI—0.605, and TLI—0.298).
Descriptive Results

Most of the respondents are aware of the inferior condition of water quantity at the national level \((M = 2.83, \ SD = 0.46)\). Nearly 80\% of the respondents indicate that water quantity in South Korea is either scarce \((76.7\%)\) or very scarce \((3.1\%)\). More than half \((55.9\%)\) have been exposed to a campaign, publicity, or education related to water saving \((M = 0.56, \ SD = 0.50)\).

When asked to consider the seriousness of drought in Chungnam, approximately three quarters of those surveyed perceive that it is either serious \((60.8\%)\) or very serious \((13.4\%)\) \((M = 2.88, \ SD = 0.61)\). Concerning personal experiences, 13.6\% of the respondents have experiences of water supply problems, such as limited water supply and low pressure, during this drought. In terms of the government’s water management policies, 82.3\% and 61.1\% of those surveyed positively (either good or very good) assess the water supply and infrastructure policies, respectively, whereas 17.7\% and 38.9\% of those surveyed negatively (either poor or very poor) evaluate them, respectively. The proportion of the respondents who are familiar with the government subsidy policy related to water saving (either moderately or precisely) is a little bit less than that of the respondents who are not (either hardly or not) \((M = 2.12, \ SD = 0.99)\).

Lastly, as shown in Figure 10, the majority of the respondents answer that they are either strongly or moderately practicing the following water saving behaviors than usual: a) using a glass with water when brushing my teeth \((M = 3.41, \ SD = 0.74)\); b) using a wash basin with water when washing my face \((M = 3.30, \ SD = 0.81)\); c) shortening shower time \((M = 3.36, \ SD = 0.68)\); d) turning off the faucet which I’m not using it \((M = 3.55, \ SD = 0.61)\); e) doing laundry in a larger quantity \((M = 3.49, \ SD = 0.67)\); f) using a washing-up bowl when washing dishes \((M = 3.15, \ SD = 0.86)\); and g) inspecting a leakage of water \((M = 3.31, \ SD = 0.66)\). All items are
practiced by more than 80% of those surveyed. Four items among them, such as the third, fourth, fifth, and seventh, are practiced by over 90% of the respondents.

Figure 10. Results of seven water saving efforts than usual

Bivariate Correlation Coefficients among Variables

The inter-correlations of the key variables in the research model are shown in Table 7. In the case of the relationship between drought risk perception and independent variables (Table 7.1), all relationships between them show the hypothesized directions (i.e., one experience and two knowledge factors—positive; two policy assessment factors—negative). The four independent variables except the assessment of water supply show a significant correlation with drought risk perception. Among the socio-demographic variables, gender and income have a positive relationship at the p<.01 level and a negative relationship at the p<.05 level, respectively. In terms of the correlation between behavioral responses against drought and other variables, including drought risk perception (Table 7.2), as expected, the familiarity with a subsidy policy associated with water saving is significantly and positively correlated with both daily action and device utilization responses. Meanwhile, the exposure to water saving information shows a significant positive correlation only with daily action responses (p<.001).
Table 7. Correlation matrix of key variables in the local-level analysis.

7.1. Risk perception variable, independent variables, and control variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Drought risk perception</th>
<th>Experience</th>
<th>Knowledge</th>
<th>Policy assessment</th>
<th>Socio-demographic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drought risk perception</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water problem experience</td>
<td>0.108*</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Awareness of water quantity condition</td>
<td>0.215***</td>
<td>0.038</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposure to water saving information</td>
<td>0.145**</td>
<td>0.124**</td>
<td>0.143**</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Familiarity with a subsidy policy</td>
<td>0.008</td>
<td>0.033</td>
<td>-0.026</td>
<td>0.206***</td>
<td>1.000</td>
</tr>
<tr>
<td>Assessment of water supply</td>
<td>-0.049</td>
<td>-0.228***</td>
<td>0.025</td>
<td>0.006</td>
<td>0.041</td>
</tr>
<tr>
<td>Assessment of water infrastructure</td>
<td>-0.195***</td>
<td>-0.102*</td>
<td>-0.117**</td>
<td>0.152***</td>
<td>-0.008</td>
</tr>
<tr>
<td>Gender</td>
<td>0.121**</td>
<td>0.027</td>
<td>0.048</td>
<td>-0.007</td>
<td>0.022</td>
</tr>
<tr>
<td>Age</td>
<td>-0.002</td>
<td>-0.070</td>
<td>0.001</td>
<td>0.024</td>
<td>-0.008</td>
</tr>
<tr>
<td>Education</td>
<td>-0.042</td>
<td>0.017</td>
<td>0.003</td>
<td>-0.021</td>
<td>0.117**</td>
</tr>
<tr>
<td>Income</td>
<td>-0.104*</td>
<td>-0.026</td>
<td>-0.082</td>
<td>-0.019</td>
<td>0.087*</td>
</tr>
<tr>
<td>Area</td>
<td>0.008</td>
<td>0.111*</td>
<td>0.176***</td>
<td>0.385***</td>
<td>0.032</td>
</tr>
</tbody>
</table>

7.2. Behavioral response variables, risk perception variables, independent variables, and control variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Behavioral responses</th>
<th>Perception</th>
<th>Experience</th>
<th>Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily action responses</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Device utilization responses</td>
<td>0.010</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drought risk perception</td>
<td>0.013</td>
<td>-0.014</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Self-vulnerability perception</td>
<td>-0.095*</td>
<td>-0.258***</td>
<td>-0.049</td>
<td>1.000</td>
</tr>
<tr>
<td>Water problem experience</td>
<td>-0.034</td>
<td>-0.070</td>
<td>0.108*</td>
<td>0.064</td>
</tr>
<tr>
<td>Exposure to water saving information</td>
<td>0.213***</td>
<td>-0.075</td>
<td>0.145**</td>
<td>-0.004</td>
</tr>
<tr>
<td>Familiarity with a subsidy policy</td>
<td>0.161***</td>
<td>0.144**</td>
<td>0.008</td>
<td>-0.018</td>
</tr>
<tr>
<td>Gender</td>
<td>0.044</td>
<td>-0.011</td>
<td>0.121**</td>
<td>-0.030</td>
</tr>
<tr>
<td>Age</td>
<td>0.281***</td>
<td>-0.066</td>
<td>-0.002</td>
<td>-0.031</td>
</tr>
<tr>
<td>Education</td>
<td>-0.194***</td>
<td>0.145**</td>
<td>-0.042</td>
<td>0.018</td>
</tr>
<tr>
<td>Income</td>
<td>-0.077</td>
<td>-0.091*</td>
<td>-0.104*</td>
<td>0.156***</td>
</tr>
<tr>
<td>Area</td>
<td>0.196***</td>
<td>-0.269***</td>
<td>0.008</td>
<td>-0.042</td>
</tr>
</tbody>
</table>

*p<.05, **p<.01, ***p<.001 (two-tailed test)
Surprisingly, drought risk perception and water problem experiences do not have a significant relationship with both daily action and device utilization responses. While self-vulnerability perception related to limited water supply has a significant correlation with both behavioral responses, their directions are negative contrary to this analysis’ expectation. Regarding socio-demographic variables, age, education, income, and area have a significant relationship with daily action, device utilization, or both responses. Gender does not have any significant effects on both behavioral responses.

**Model Fit**

The values of model fit indices for the daily action model are as follows: \( \chi^2 = 10.493 \) (df = 5, \( p > .05 \)), RMSEA = .047 (90% CI), SRMR = .011, CFI = .959, and TLI = .793. Also, those of model fit indices for the device utilization model are as follows: \( \chi^2 = 3.278 \) (df = 5, \( p > .05 \)), RMSEA = .000 (90% CI), SRMR = .007, CFI = 1.000, and TLI = 1.051. Considering the conventional cutoff values of fit indices (see Footnote 77), their model fits are acceptable.

**Regression Analysis**

To identify the relationship among personal factors, risk perception, and behavioral responses related to drought, this chapter employs SEM regression analysis utilizing maximum likelihood estimation with robust standard errors.\(^{96}\) Those things that personal factors affect drought risk perception (\( H1, H2, \) and \( H4 \)) and some personal factors and drought risk perception (and self-vulnerability perception) influence behavioral responses to adapt to drought (\( H1, H2, \)

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\(^{96}\) This local-level analysis also conducts univariate and multivariate normality tests for variables in the research models. Similar to the national-level analysis, the results of Mardia’s multivariate (skewness and kurtosis) test indicate that multivariate normality assumption is violated, whereas all univariate skewness and kurtosis of each variable are not located within the range of non-normality concern (i.e., |skewness| > 2, |Kurtosis| > 7) (Chou & Bentler, 1995; West, Finch, & Curran, 1995). Considering the identified approaches to dealing with non-normality, Appendix G provides the results of SEM regression analyses with different estimation methods (or options). Consequently, directions and significance of coefficients are almost identical. Thus, the results of ML with robust standard errors are interpreted to address the research question (see pp. 81–82 for more information). Additionally, multicollinearity, influential outliers, and heteroscedasticity are not detected in both research models.
$H3$, and $H5$) were hypothesized in the literature review chapter [III]. Table 8 and Figure 11 lay out the results of the SEM regression analysis and significant pathways in the two models, respectively. Also, Appendix H shows direct, indirect, and total effects of independent variables on behavioral responses to address drought.

**Table 8. Results of SEM regression analyses about the relationship among personal factors, risk perception, and behavioral responses related to drought**

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Independent Variables</th>
<th>Daily action model</th>
<th>Device utilization model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drought risk perception</strong></td>
<td>Water problem experience</td>
<td>.094</td>
<td>.076</td>
</tr>
<tr>
<td></td>
<td>Awareness of water quantity condition</td>
<td>.206***</td>
<td>.058</td>
</tr>
<tr>
<td></td>
<td>Exposure to water saving information</td>
<td>.198***</td>
<td>.056</td>
</tr>
<tr>
<td></td>
<td>Assessment of water supply policy</td>
<td>-.007</td>
<td>.059</td>
</tr>
<tr>
<td></td>
<td>Assessment of water infrastructure policy</td>
<td>-.186***</td>
<td>.051</td>
</tr>
<tr>
<td></td>
<td>Gender (female)</td>
<td>.124*</td>
<td>.058</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>-.001</td>
<td>.003</td>
</tr>
<tr>
<td></td>
<td>Education</td>
<td>-.022</td>
<td>.056</td>
</tr>
<tr>
<td></td>
<td>Income</td>
<td>-.047*</td>
<td>.022</td>
</tr>
<tr>
<td></td>
<td>Area</td>
<td>-.045</td>
<td>.058</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>2.787</td>
<td></td>
</tr>
<tr>
<td><strong>Behavioral responses</strong></td>
<td>Drought risk perception</td>
<td>.040</td>
<td>.250</td>
</tr>
<tr>
<td></td>
<td>Self-vulnerability perception</td>
<td>-.101</td>
<td>.051</td>
</tr>
<tr>
<td></td>
<td>Water problem experience</td>
<td>-.407</td>
<td>.484</td>
</tr>
<tr>
<td></td>
<td>Exposure to water saving information</td>
<td>1.049**</td>
<td>.372</td>
</tr>
<tr>
<td></td>
<td>Familiarity with a subsidy policy</td>
<td>.398*</td>
<td>.161</td>
</tr>
<tr>
<td></td>
<td>Gender (female)</td>
<td>.568</td>
<td>.339</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>.070***</td>
<td>.015</td>
</tr>
<tr>
<td></td>
<td>Education</td>
<td>-.301</td>
<td>.324</td>
</tr>
<tr>
<td></td>
<td>Income</td>
<td>.206</td>
<td>.115</td>
</tr>
<tr>
<td></td>
<td>Area</td>
<td>.931**</td>
<td>.337</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>11.834</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td></td>
<td>501</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Fourteen respondents who did not answer at least one question out of the seven questions related to daily action and twelve respondents who did not answer at least one question out of the three questions associated with device utilization are excluded from the SEM regression analyses of the first model and second model, respectively.  
*p<.05, **p<.01, ***p<.001 (two-tailed test)*
*p<.05, **p<.01, ***p<.001 (two-tailed test)

**Figure 11.** Significant pathways in the daily action and device utilization models

**Drought risk perception.** Three independent and two socio-demographic variables are significantly correlated with drought risk perception. Consequently, the results of the SEM

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97 Regarding drought risk perception, the first and second models show the slightly different coefficients of independent variables due to the different numbers of respondents. However, there is no significant difference. This study explains the results of the analysis based on the daily action model.
regression analysis support *Hypothesis 2* and partially verify *Hypothesis 4*. They fail to substantiate *Hypothesis 1*.

*Experience.* This study finds no significant relationship between water problem experiences, such as limited water supply and low pressure, and drought risk perception. This result indicates that there is no evidence that the respondents with water problem experiences are likely to have higher levels of drought risk perception. It is reminiscent of the national-level analysis’ finding that extreme weather event experiences (i.e., flood and drought) do not have a significant impact on climate change risk perception. Again, exploring this relationship more in depth is recommended.

*General knowledge.* As predicted, drought risk perception is positively affected by both awareness of water quantity condition (b = .206, p<.001) and the exposure to water saving information (b = .198, p<.001). The respondents who are more aware of water quantity conditions in South Korea or have been exposed to water saving information tend to have higher levels of drought risk perception. This result supports the findings of the national-level analysis as well as existing literature (e.g., Malka, Krosnick, & Langer, 2009; Shi *et al.*, 2016, Wildavsky & Dake, 1990).

*Policy assessment.* While the assessment of water infrastructure policy has a significant negative relationship with drought risk perception (b = -.186, p<.001), the assessment of water supply policy has no impact on drought risk perception. The respondents who have lower satisfaction with water infrastructure are likely to have higher levels of drought risk perception. This finding, along with that of the national-level analysis, does not fully verify the hypothesized negative relationship between the performance of climate policy and climate change risk perception of the general public.
Socio-demographic variables. Gender and income significantly influence drought risk perception. While gender is positively correlated with drought risk perception ($b = .124, p<.05$), income has a negative relationship with drought risk perception ($b = -.047, p<.05$). These results indicate that the female respondents and low-income respondents tend to be more concerned about drought than the male respondents and high-income respondents, respectively.98

Behavioral responses to address drought. Three independent and four socio-demographic variables directly influence daily action, device utilization, or both responses. Considering the findings of the SEM regression analysis, while Hypothesis 2 and 3 are supported, Hypothesis 1 and 5 are not verified.

Drought risk perception. Although this study hypothesizes that drought risk perception has a positive relationship with behavioral responses to address drought, no evidence of a significant relationship between drought risk perception and behavioral responses is found in both the daily action and device utilization models. Some existing research (e.g., Bubeck, Botzen, & Aerts, 2012; Wachinger et al., 2013) tries to explain the discrepancy (or the weak relationship) between individuals’ risk perception and their behavioral responses to address risks. For instance, Wachinger et al. (2013) report that the perceived benefits outweighing the potential adverse impacts, strong trust in the effectiveness of governance structures, and a lack of resources (capacity) can trigger “the risk perception paradox,” the situation that high risk perception does not lead to appropriate preparedness measures (p. 1054). Based on the reviews of flood-related empirical literature (e.g., Botzen, Aerts, & van den Bergh, 2009; Grothmann &

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98 The positive impact of gender on drought risk perception is in accordance with the results of the national-level analysis (see p. 83). Meanwhile, van der Linden (2017) states that while the negative relationship between income (and resources) and the self-evaluation of vulnerability to the impacts of climate change has been hypothesized, empirical evidence provided by previous research projects are quite inconsistent. The impact of income on drought risk perception in this analysis is also not consistent with the results of the national-level analysis (see p. 83).
Reusswig, 2006; Siegrist & Gutscher, 2006), Bubeck, Botzen, and Aerts (2012) conclude that several factors, such as government compensation for damages, a lack of the sense of responsibility, fatalism, and wishful thinking, have the potential to inhibit behavioral responses of individuals having high risk perception against floods.\(^9\) Their argument points to the potential need to account for values or worldviews in studying these behavioral questions, which was previously discussed in the final section of Chapter III. Overall, the explanation for this unexpected relationship is still unclear. This issue will be reassessed in the next chapter.

**Experience.** No significant effect of water problem experiences on behavioral responses to address drought is detected in the models. The behavioral responses of the respondents with water problem experience are not significantly different from those of the respondents with no water problem experience. This result suggests that forceful limited water supply or low water pressure may have a direct impact on the reduction of individuals’ water consumption at that time, but it may not make a broader impact on water conservation by encouraging individuals’ voluntary water saving during a drought period.

**Policy-related and general knowledge.** The familiarity with a subsidy policy related to water saving during drought shows a significant positive correlation with both daily action (b = .398, p<.05) and device utilization (b = .119, p<.01) responses to save water. The respondents who are more familiar with the subsidy policy are not only more likely to change their daily actions, but also to utilize devices to save water. This finding corroborates evidence about the influence of climate policy-related knowledge on behavioral responses to address climate change in the national-level analysis.\(^{10}\) Meanwhile, the exposure to water saving information influences

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\(^9\) Grothmann and Patt’s (2005) model and Footnote 46 (see p. 44) help understand fatalism and wishful thinking.

\(^{10}\) It might be true that this variable is intertwined with a financial benefit, which is regarded as one of the potential factors of facilitating individuals’ behavioral responses to climate change (Bai & Liu, 2013; Whitmarsh, 2009a).
only daily action responses \((b = 1.049, p<.01)\). The respondents who have been exposed to water saving information are more likely to change their daily actions to save water, but they do not tend to use more water saving devices.

**Self-vulnerability perception related to limited water supply.** The correlation between self-vulnerability perception and behavioral response variables is statistically significant in the device utilization model \((p<.001)\). However, contrary to expectations, it has a negative direction. The respondents who feel more vulnerable to limited water supply due to drought are less likely to practice device utilization to save water in the household. Some possibilities exist in interpreting these results. They may lack capacity or self-efficacy, meaning they are not likely to perceive their actions as mattering. Also, the inconvenience of reducing water consumption is greater than that of the respondents who feel less vulnerable. Therefore, while the former may be reluctant to bear current high costs (i.e., inconvenience triggered by reducing water consumption) for uncertain future limited water supplies, the latter may be willing to pay relatively low costs. This dissertation will return to these interpretations in the expert-level analysis.

**Socio-demographic variables.** Age \((b = .070, p<.001)\) and area \((b = .931, p<.01)\) are positively correlated with daily action responses. The elder respondents and those that live in counties are more likely to change their daily actions to save water than the younger respondents and those that live in cities, respectively. Education \((b = .266, p<.01)\), income \((b = -.141, p<.001)\), and area \((b = -.551, p<.001)\) have a significant relationship with device utilization responses. While education has a positive relationship with device utilization responses, income

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\(^{101}\) When using bootstrapping or ADF, the relationship between self-vulnerability perception and behavioral responses in the daily action model also becomes statistically significant \((p<.05)\) (see Appendix G).
and area have a negative relationship with them. The more highly educated respondents are more likely to use water saving devices in their households than respondents with lower levels of education.\(^\text{102}\) The high-income respondents and those that live in counties are less likely to utilize water saving devices in their households than low-income respondents and those that live in cities, respectively.

**Alternative Model Specifications**

**Relationship between socio-demographic characteristics and personal factors.** Like the national-level analysis, it is possible that socio-demographic characteristics directly influence the personal factors modeled in this research. Appendix E provides the results of regression analyses about the relationship between each personal factor variable and five socio-demographic characteristic variables in the research model. Even though these results identify some significant relationships between them, this analysis also excludes these relationships in the research model due to several theoretical and practical problems presented in the national-level analysis (see p. 90).

**Reverse pathway between risk perception and behavioral responses.** The reverse relationship between risk perception and behavioral responses associated with drought is also checked. It is tested in the same ways as the national-level analysis: a) switching the places of the risk perception and behavioral response (daily action) variables in Figure 9; and b) reversing the causal pathway between the risk perception and behavioral response (daily action) variables in Figure 9. The relationship between the behavioral response and risk perception variables is not statistically significant in both the first and second reversed models. The model fits of the first

\(^{102}\) This result is in line with the findings of previous studies (e.g., Leiserowitz, 2006; Patchen, 2006) that those with better education are more likely to take pro-environmental actions than less-educated people.
one are drastically aggravated (e.g., RMSEA: 0.047 → 0.123, CFI: 0.959 → 0.714, TLI: 0.793 → -0.431, and SRMR: 0.011 → 0.027) compared to the research model and are not acceptable. Those of the second one are also slightly weakened compared to the research model (e.g., RMSEA: 0.047 → 0.051, CFI: 0.959 → 0.951, TLI: 0.793 → 0.755, and SRMR: 0.011 → 0.011). These results imply that the causal pathway from drought risk perception to behavioral responses to drought is more persuasive than the reversed pathway.

**Policy Implications**

Regardless of drought, individuals’ steady efforts to save water can be a great help to governments’ water management. However, in reality, individuals are less likely to recognize the need for water saving and to take actions to save water until governments announce that they are experiencing drought. As alluded to previously, drought is more difficult to cope with than floods due to its peculiar characteristics. It is almost impossible for governments to accurately catch the starting point of drought and to effectively address severe drought without the cooperation of individuals. Also, it is not easy for individuals to realize the necessity of their behavioral responses to save water and to voluntarily take action without government’s warning of drought. Therefore, to reduce the adverse effects of drought, governments need individuals’ behavioral responses to save water, and individuals need governments to help them understand the emergence of drought, its expected severity, and possible response methods. The results of this local-level analysis convey several policy implications to policymakers.

First, instead of depending on drought risk perception, active communication to facilitate individuals’ behavioral responses is recommended for addressing drought. While some personal

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103 For instance, governments’ water-related activities, such as the development of new water sources (e.g., dams, groundwater, and seawater desalination), the operation of multi-purpose dams (e.g., discharge timing and volume and hydroelectric power generation), and the distribution of water (e.g., domestic, industrial, and agricultural water), can be optimized based on self-controlled water consumption of individuals.
factors (e.g., awareness of water quantity conditions and the assessment of water infrastructure policy) significantly affect drought risk perception, their impacts are not carried on to individuals’ behavioral responses to address drought. In other words, a traditional drought strategy is for governments to stimulate drought risk perception by transmitting simple information about local water (quantity) conditions to individuals, which presumably then leads to individuals’ water saving activities. This, however, is not a reliable approach for addressing drought. Instead, demonstrating the efficacy of individuals’ behavioral responses on water management during drought has a positive impact on public responses (Whitmarsh, 2008). Two-way communication (e.g., between governments and citizens and between citizens and citizens) will be another good alternative. Lorenzoni and Pidgeon (2006) highlight that individuals are likely to take behavioral responses to address climate change when they “perceive the rest of society to be moving in the same direction” (p. 88).

Second, the provision of more specific and practical wisdom about water saving is required to cope with drought. While the exposure to water saving information fails to facilitate behavioral responses to address drought by an indirect path (via drought risk perception), it directly affects daily action responses to save water. Also, the familiarity with a drought policy has a positive impact on both daily action and device utilization responses. “Sound bites and other baby talk” are bad options to educate the public about climate change (Berk & Schulman, 1995, p. 31). When facing drought, governments have to crystallize the expected intensity and duration of drought, detailed response plans (e.g., limited water supply and redistribution of

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104 Dessai and Sims (2010) also regard effective communication as the engine of the public’s behavioral changes to address drought.

105 Lorenzoni and Pidgeon (2006) point to the potential influence of social norming on individuals’ behavioral responses to climate change. As mentioned before (see Footnote 57), this dissertation briefly accounts for the role of social norming in the next chapter.
water among domestic, industrial, and agricultural areas) by scenarios, water saving practice guidelines for citizens, and policies of water saving promotion (e.g., subsidies for households which use less water than usual) or water consumption deterrence (e.g., temporary water price hike and fines for households which use more water than usual). And then, along with public, private, and civic organizations, governments should conduct activities, such as education programs, campaigns, and public discussion, to share those practical wisdom with the public.\^106

Third, different socio-demographic characteristics require different strategies. Age, education, income, and area are significant influential factors on daily action or device utilization responses related to water saving. To maximize the effects of individuals’ behavioral responses, governments must consider different responses derived from socio-demographic features when designing educational programs, water saving promotion and water consumption deterrence policies, and other activities.\^107 Even though this analysis does not deal with the interaction effects of independent (and socio-demographic) variables, revealing these effects might help governments better understand individuals’ behavioral responses to address drought and prepare tailored strategies for individual groups with fine-grained socio-demographic characteristics.

In sum, to cope with drought effectively, individuals’ behavioral responses should be maximized by governments’ appropriate strategies. Bear in mind that drought risk perception might not be a reliable factor in boosting individuals’ behavioral responses to address drought in South Korea. The findings of this local-level analysis make it clear that drought policy should be shifted from ready-made (depending on risk perception) to tailor-made approaches.

\^106 In doing that, governments should try to minimize the consumption of citizens’ time and resources. Piwowarczyk et al. (2012) state that time and resources are obstacles to individuals’ learning processes related to climate change.

\^107 Similarly, Leiserowitz (2006) writes, “Messages about climate change need to be tailored to the needs and predispositions of particular audiences” (p. 64).
Limitations and Future Research Directions

Some limitations need to be acknowledged. A primary limitation relates to a survey period. The K-water survey in north-west Chungnam was conducted between 10 and 23th December, 2015, during the midst of the drought of 2015–2016. Normally, a survey period of two weeks is not problematic in analyzing data. However, the threat of drought can become significantly aggravated day by day. This short time-gap between initial and late respondents may influence their answers associated with drought risk perception and behavioral responses.\textsuperscript{108} A second limitation is a lack of consistency in measuring variables. While some variables, such as behavioral responses and drought risk perception, are measured by several items, others depend on a single item. The final caveat is the difficulty in extending the findings to other drought-prone areas. This analysis focuses on north-west Chungnam where the Boryeong dam is a main source of domestic water. The types of main water sources (e.g., dam, river, and ground water) in areas may lead to different responses of individuals in addressing drought.

Regarding future research directions, ceaseless efforts for widening the research scope and elaborating survey instruments are not only valuable for the national-level analysis but also this local-level analysis. Additionally, more research projects have to actively utilize open-ended questions and qualitative methods in analyzing this topic. Not only revealing the causal relationship among personal factors, risk perception, and behavioral responses related climate change, but also unveiling individuals’ real minds surrounding that relationship are vital. Given that most previous studies related to this topic have depended on quantitative methods to verify causalities, taking a different angle (i.e., utilizing a qualitative approach) is likely to help not

\textsuperscript{108} There is a possibility that while the respondents in the early stage of the survey were hesitant to take action against drought even they considered drought as a serious problem, the respondents in the last stage of the survey were active in behavioral responses with high drought risk perception.
only fill the gaps in existing quantitative research, but also find novel information. In doing that, interdisciplinary research, including scholars from diverse fields (e.g., sociology, economics, and psychology) as well as practitioners from public agencies, may contribute to achieving more meaningful results.109

Conclusion

The purpose of this analysis was to explore the relationship among personal factors, drought risk perception, and behavioral responses to address drought at the local level. Data were derived from a face-to-face survey conducted in South Chungcheong Province, South Korea. SEM regression analysis was conducted to test this study’s hypotheses and shows mixed-results. Unexpectedly, drought risk perception does not have a significant impact on either daily action or device utilization responses to save water. Even though three factors (i.e., awareness of water quantity condition, the exposure to water saving information, and the assessment of water infrastructure policy) are significantly correlated with drought risk perception, they also fail to have an indirect impact on individuals’ behavioral responses. Meanwhile, two knowledge factors (i.e., the exposure to water saving information and familiarity with drought policy) and four control factors (i.e., age, education, income, and area) directly affect daily action, device utilization, or both responses to save water. While self-vulnerability perception associated with limited water supply shows a significant relationship with device utilization responses, its direction is negative opposite to this study’s expectation.

In light of this analysis’ results, there is no clear evidence that drought risk perception plays an important role in facilitating individuals’ behavioral responses to adapt to drought.  

109 To obtain better ideas for addressing climate change, collaborative research projects (between scholars and practitioners, between natural and social scientists, etc.) are recommended by many previous studies in the climate change field (e.g., Gifford, Kormos, & McIntyre, 2011; Le Dang et al., 2014; Schmidt, Striegnitz, & Kuhn, 2014).
However, keep in mind that different contexts (e.g., the timing and period of a survey and the types of the main water sources in areas) are likely to create different results. In other words, it is too early to underestimate the role of risk perception in addressing drought. Further research projects in diverse contexts and with much more refined instruments are needed to unlock the effects of drought risk perception on individuals’ behavioral responses to cope with drought. Additionally, qualitative and interdisciplinary approaches will help seek missing parts of the previous studies’ findings which are mostly based on quantitative analyses. Regardless of whether drought risk perception works on behavioral responses, multi-faceted communication (e.g., between governments and citizens and between citizens and citizens), the provision of more specific and practical water saving wisdom, and tailored strategies for different socio-demographics might be recommendable methods for the enhancement of individuals’ behavioral responses to address drought. Despite some limitations, this study asserts that the findings of the analysis provide important insights that help practitioners design drought policy fitted in their areas as well as encourage researchers to further the study of individuals’ behavioral responses against drought.
CHAPTER VI
EXPERT-LEVEL ANALYSIS
The findings of the national and local level analyses not only help understand the causal relationship among personal factors, risk perception, and behavioral responses related to climate change, but also provide valuable policy implications. Meanwhile, it is difficult for the quantitative analyses to explain the gaps between this study’s hypotheses and the analysis results and to convey both the individuals’ diverse thoughts and the meaningful stories that help policymakers refine climate policy in interpreting their findings. Thus, in this last analysis, the research question is investigated more in depth based on expert knowledge. This dissertation argues that experts can not only provide insights on the causal relationship among the variables, but also insights on other factors affecting the relationship among them (e.g., cognitive factors or national contexts which hamper the relationship). Interviews and survey data of climate change experts are analyzed from a qualitative approach to explore this study’s primary research question and help interpret the results of the quantitative analyses.

Research Contexts
Necessity of Mixed Methods Research
In response to a long and fierce debate between the supporters of quantitative and qualitative research paradigms, the necessity of mixed methods research incorporating both has been raised by many researchers (e.g., Almalki, 2016; Creswell et al., 2003; Johnson & Onwuegbuzie, 2004; Johnson, Onwuegbuzie, & Turner, 2007; Riccucci, 2010). Mixed methods research combines quantitative and qualitative data collection and analysis techniques to provide a more comprehensive understanding of the research question. This approach allows for the integration of different types of data, which can lead to a more nuanced and rich understanding of the research topic. Mixed methods research is particularly useful in complex research settings where multiple perspectives and layers of data are needed to fully understand the phenomenon under study.

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110 Actually, experts are different from the general public. Nevertheless, climate change experts, who have scientific and technical knowledge as well as knowledge of individuals’ behavioral responses based on communication with the general public, can help answer the research question and interpret the findings of the previous two chapters.

111 Riccucci (2010) describes the term paradigm, coined by Thomas Kuhn (1962), as the “model that governs scientific inquiry in a discipline at any given time” based on Lakatos and Musgrave (1970) and Rainey (1994).
methods research has several advantages, such as “providing stronger evidence for a conclusion through convergence and corroboration of findings” and “adding insights and understanding that might be missed when only a single method is used” (Johnson & Onwuegbuzie, 2004, p. 21).  

Similarly, Creswell (2009) goes on to say that “there is more insight to be gained from the combination of both qualitative and quantitative research than either form by itself. Their combined use provides an expanded understanding of research problems” (p. 203).

It does not mean that all research projects can benefit from combining quantitative and qualitative methods (Tashakkori & Creswell, 2007). The choice of a research method should be determined by whether it is appropriate for answering research questions or not (Carey, 1993; Creswell & Plano Clark, 2007; Johnson & Onwuegbuzie, 2004). In other words, research questions reflecting both qualitative and quantitative aspects are subject to such mixed-methods research (Tashakkori & Creswell, 2007). This dissertation’s research question aims to explore the causal relationship among personal factors, risk perception, and behavioral responses associated with climate change. It primarily focuses on the verification of the causal relationship among them. However, other issues, such as revealing why some relationships are insignificant, identifying what stories are appropriate to explain unexpected results, and finding how those relationships can change over time, are also integral parts of solving the research question. Therefore, this study can answer the research question more successfully by mixing quantitative with qualitative approaches.

112 According to Johnson and Onwuegbuzie (2004), the core of mixed methods research is “mix[ing] or combin[ing] quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study” (p. 17). Johnson, Onwuegbuzie, and Turner (2007) introduce diverse definitions of mixed methods research suggested by many leading researchers.

113 However, mixed-methods research also has disadvantages. It can be more time-consuming, expensive, and difficult to carry out than a single method research (Johnson & Onwuegbuzie, 2004). Also, further investigation is needed when different results are detected within the data sets (Almalki, 2016).
Advantages of Utilizing Experts

In a qualitative approach, data are collected by several methods such as participant observation, documentary analysis, and in-depth interviews (Rubin & Rubin, 2012). According to Kvale (1996; 2003), qualitative interviews are a powerful method of obtaining quality information to address research questions by exploring people’s views in greater depth. Therefore, this analysis garners data from in-depth interviews with experts.\textsuperscript{114} Compared to participant observation and ordinary interviews, there is a high possibility that expert interviews can be conducted with less resources (e.g., time and money) and obtain more comprehensive and authoritative information from a relatively small number of interviews, respectively (Bogner, Littig, & Menz, 2009; Libakova & Sertakova, 2015; Meuser & Nagel, 2009). In other words, expert interviews are the best method to gather quality information swiftly, efficiently, and intensively.

Expert knowledge, which Martin \textit{et al.} (2012) defined as “substantive information on a particular topic that is not widely known by others” (p. 30), is available in diverse stages of research, such as defining problems, selecting variables, developing models, and interpreting results and characterizing uncertainty (Martin \textit{et al.}, 2012; McBride & Burgman, 2012).\textsuperscript{115} More importantly, expert knowledge is a desirable method to resolve issues surrounding uncertainty and a lack of data (Kuhnert, Martin, & Griffiths, 2010; Martin \textit{et al.}, 2012; McBride & Burgman, 2012). There are also several risks related to expert interviews. For instance, like laypeople,

\textsuperscript{114} Interviews have been widely used by the humanities and technical studies with various topics (Libakova & Sertakova, 2015). Since the 1990s, expert interviews have been grown as one of qualitative methods (Meuser & Nagel, 2009).

\textsuperscript{115} Some studies use different words, “expert opinion.” While Krueger \textit{et al.} (2012) describe opinion as “the preliminary state of knowledge of an individual (subjective opinion)” (p. 4), they also note that the distinction between expert knowledge and opinion is not clear.
experts are subject to various biases, such as cognitive (e.g., anchoring and inconsistency) and motivational (e.g., group think and wishful thinking) biases (Booker & McNamara, 2004; Krueger et al., 2012; O’Hagan et al., 2006). Also, the findings of expert interviews can be in conflict with those of quantitative analysis based on empirical data (Martin et al., 2012). Nevertheless, expert interviews have a potential to enrich the findings of this study, under the premise of selecting experts and conducting interviews rightly.

**Core Components of Experts**

The term “expert” is well understood by people and frequently used in their daily lives. Many research projects in diverse fields, such as politics (Benoit & Laver, 2007; Ray, 1999), technology (Buchholz, Luzadis, & Volk, 2009; Catenacci et al., 2013), and environment (Krueger et al., 2012; McBride & Burgman, 2012), have actively utilized experts to investigate their research topics. Martin et al. (2012) describe an expert as “someone who holds information about a given topic and who should be deferred to in its interpretation” (p. 30). Krueger et al. (2012) suggest “relevant and extensive or in-depth experience in relation to a topic of interest” as a condition for an expert (p. 4). Given these existing definitions, the answer to the question “who are experts?” depends not only on the levels of knowledge, experiences, or skills (hereafter, knowledge represents these factors), but also on their relevance to the research topic.

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116 According to Booker and McNamara (2004), anchoring refers to depending heavily on the first piece of information when solving a problem. Inconsistency can be triggered by confusion related to assumptions or definitions, memory problems, and fatigue. Group think and wishful thinking are related to dysfunctional judgements which reflect group social pressure and experts’ hope, respectively (see Booker and McNamara (2004, p. 334) and Kuhnert, Martin, and Griffiths (2010, pp. 906–907) for more information about expert biases).

117 To minimize these biases, several techniques, such as calibration and weighing, are recommended by previous studies (e.g., Ayton & Pascoe, 1995; Booker & McNamara, 2004; Krueger et al., 2012).

118 In light of general definitions of an expert provided by many dictionaries (e.g., Collins dictionary (https://www.collinsdictionary.com/) and Oxford dictionary (https://www.oxforddictionaries.com/)), an expert might be a person who has comprehensive knowledge, experiences, or skills in a particular field.
Expert Interviews

Data Collection

Subjects. Regarding climate change, the typology of experts can vary, such as meteorologists, ecologists, hydrologists, and national and local public managers, depending on its specific sub-topics. The experts of the sub-topics linked to scientific and technological knowledge can be identified with relative ease. However, those of the sub-topics associated with a hybrid of scientific (or technological) and societal knowledge cannot be easily detected. The same goes for this study’s research question. When selecting experts for interviews, this analysis should consider knowledge both of climate change itself and of the process of individuals’ behavioral responses addressing climate change. The right choice of experts is a prerequisite for acquiring reliable and quality information. Informants should have both of the above-mentioned knowledge. Furthermore, it is worth noting that the latter can be more powerful by accumulating many interpersonal experiences with the general public, rather than depending on academic learning. In this regard, this analysis pays attention to K-water.119

From a domestic perspective, K-water operates numerous water-related facilities, such as sixteen multi-purpose dams, integrated regional water supply systems, and twenty-two local water supply systems (K-water, 2018). Also, it acts not only as the number one renewable energy enterprise by providing about twenty-five percent of the national facility capacity of renewable energy, but also as the leading company in developing eco-friendly waterfront cities (K-water, 2018). From an international perspective, K-water has aggressively advanced its overseas

119 In 1967, K-water was founded as the Korea Water Resources Development Corporation in accordance with the national development plan of the Korean government both to improve citizens’ lives and to support the heavy chemical industries and manufacturing (K-water, 2018). In 1974, it was reorganized into the Industrial Sites and Water Resources Development Corporation (K-water, 2018). Finally, in 1988, K-water was reformed into the Korea Water Resources Corporation in accordance with the ‘Korea Water Resources Corporation Act’ (Ministry of Government Legislation, 2015b).
business since 1994. It completed numerous oversea projects such as the Philippine’s Angot dam and has undertaken 32 overseas projects in 21 nations, including the construction of the Partrind Hydroelectric Dam in Pakistan (K-water, 2018). Overall, K-water, founded in 1967, is the only water-specialized organization in South Korea as well as one of the leading organizations in global water management. Also, its business sectors are deeply associated with climate change.

The K-water institute, affiliated with K-water, has many researchers from diverse fields, such as public policy, economics, business, ecology, meteorology, and civil, mechanical, electrical engineering. Based on these professional personnel, it has conducted numerous research projects related to climate change, including extreme weather events (e.g., flood and drought). Among them, several studies deal with scientific and technical knowledge as well as societal knowledge, including individuals’ behavioral responses, based on communication with the general public (e.g., survey and interviews). Researchers who participated in those studies might have knowledge both of climate change itself and of the process of individuals’ behavioral responses against climate change. Overall, this study views researchers in the K-water institute who have been involved in climate change-related studies as proper experts on the research topic. Given that they have different academic backgrounds, interviews with them can offer us chances to identify diverse perspectives derived from different fields concerning the relationship among personal factors, risk perception, and behavioral responses related to climate change.

**Data collection instruments.** This analysis garners data from in-depth semi-structured interviews with climate change experts. Based on the interview protocol developed by the

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120 This institute consists of six research centers: Research center for water policy and economy, water resources research center, infrastructure research center, water supply research center, water facility research center, and water quality research center (K-water institute, 2018).

121 Campbell *et al.* (2013) view in-depth semi-structured data as “the empirical backbone of much qualitative research in the social sciences” (p. 295).
researcher of this study, expert interviews are conducted by the researcher. Appendix I presents the interview protocol. The identification of the interviewees is based on snowball sampling, which involves current interview subjects recruiting the next round of interview subjects (Biernacki & Waldorf, 1981). The first interviewee is one of the researchers involved in the K-water’s research project, “A study on the strategic plan of water and energy sector for new climate change regime,” which was conducted from 2016 to 2017. The number of the identified subjects are thirteen, and all of them have a PhD degree. They were interviewed face-to-face in the conference room of the K-water institute between 29th October and 3rd November, 2018. The time required for each interview was about one and a half hours. Interview content was recorded by a voice recorder.

**Data Analysis**

**Coding.** According to Patton (2002), “reducing the volume of raw information, sifting trivia from significance, identifying significant patterns, and constructing a framework for communicating the essence of what the data reveal” are challenges in conducting qualitative analysis which deals with massive amounts of data (p. 432). To effectively analyze datasets derived from the interviews, the study utilizes coding which is viewed as a desirable method in analyzing and interpreting the data’s meaning (Miles, Huberman, & Saldaña, 2014). Considering the research variables, the researcher of this dissertation develops a codebook and continually refines it during the analysis phase. Appendix J shows a major part of the codebook.

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122 This interview protocol only describes the main questions. Based on the interviewees’ answers to the main questions, appropriate follow-up questions, which help draw detailed information from interviewees (Rubin & Rubin, 2012), are employed to successfully achieve the above-mentioned goals.

123 Eleven interviewees belong to the K-water institute. The other two interviewees belong to a university and a national institute, respectively.

124 Codes refer to “labels that assign symbolic meaning to the descriptive or inferential information compiled during a study” (Miles, Huberman, & Saldaña, 2014, pp. 71–72).
When coding data, this analysis employs a computer-assisted qualitative analysis software, specifically NVivo software, to enhance the quality of analysis. NVivo is regarded as a useful tool when conducting qualitative data analysis due to several advantages such as reducing manual tasks, facilitating organization of the data, and enhancing team working (e.g., Azeem, Salfi, & Dogar, 2012; Buchanan & Jones, 2010; Hilal & Alabri, 2013; Wong, 2008). The coding of all interviews is completed by this study’s investigator.

**Intercoder reliability.** Reliability is important not only for quantitative research, but also for qualitative research (Golafshani, 2003). Regarding the use of coding, many existing studies (e.g., Hruschka et al., 2004; Tinsley & Weiss, 1975) highlight the importance of intercoder reliability. Simply, it refers to the extent to which different coders code the same data and arrive at the same conclusion (Lombard, Snyder-Duch, & Bracken, 2002). It is assessed by several methods such as percent agreement, Cohen’s kappa (Cohen, 1960), and Scott’s pi (Scott, 1955). To test intercoder reliability, part of the expert interviews (i.e., four interviews) was coded by a second coder, who has studied public affairs in a PhD program. The result of Cohen’s kappa measuring intercoder agreement for categorical scales based on the data of the original coding and second coding indicates that intercoder reliability is quite acceptable (more than .80).

**Analysis.** The expert interviews include thirteen cases (individuals). To begin with, the importance of individuals’ role in addressing climate change and significant personal factors affecting risk perception (or behavioral responses) linked to climate change are identified by

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125 Krippendorff (2004) introduces three types of reliability: Stability, accuracy, and reproducibility. The latter is called intercoder reliability (see Krippendorff (2004) for more information).

126 Regarding an acceptable level of intercoder reliability, there are no coherent standards (Campbell et al., 2013; Lombard, Snyder-Duch, & Bracken, 2002). Instead, based on the reviews of various rules of thumb suggested by previous studies (e.g., Banerjee et al., 1999; Landis & Koch, 1977), Neuendorf (2017) writes, “agreement reliability coefficients that account for chance (e.g., Cohen’s kappa) of .80 or greater would be acceptable to all, .60 or greater would be acceptable in most situations, and below that, there exists disagreement” (p. 168).
immersing in each case. Subsequently, the general relationship among personal factors, risk perception, and behavioral responses related to climate change, supported by the majority of the experts, is described based on the comparisons of all cases. Lastly, the iterative process of comparisons in all cases (moving back and forth between each and cross interviews) is executed to discover significant issues or stories that contribute to filling the gaps between this study’s hypotheses and the results of quantitative analyses. By utilizing these two complementary analytical processes (i.e., within each case and cross cases), this chapter can achieve more robust and reliable findings.127

Analysis Results

The results of the qualitative analysis consist of three parts. First, the importance of individuals’ role in addressing climate change is evaluated. Second, the level of experts’ support for each hypothesis is explained. The final section of the results will discuss how the findings from the interviews can help fill the gaps between the hypotheses and the results of the quantitative analyses at the national and local levels.

Importance of individuals’ role. As mentioned earlier, many previous studies (e.g., Bostrom et al., 1994; Leiserowitz, 2006; Ruddell et al., 2012) highlight that individuals can play a significant role in coping with climate change by perceiving its risk and taking action. The results of the expert interviews also correspond to their view. All interviewees (hereafter to be referred as EI, from EI–1 to EI–13) conclude that the role of individuals in addressing climate change is either very or somewhat important. Some crucial points related to their role emerge.

First, some experts recognize that individuals’ risk perception and behavioral responses significantly influence policymakers’ decision-making related to climate change [EI–3, EI–8,

and EI–10]. Conversely, two experts acknowledge that policymakers in South Korea justify the allocation of limited resources to climate change based on citizens’ perceptions and responses to climate change [EI–3 and EI–9].

Second, six of the interviewees believe that individual behaviors are essential for both mitigating and adapting to climate change. Without securing individuals’ behavioral responses (e.g., following policies, purchasing goods provided by GHG reduction-oriented companies, and utilizing items which minimize GHG emissions), the efforts of governments and industries against climate change would not be effective. One interviewee states, “The impact of each individual’s behaviors seems to be tiny, but those impacts eventually add up to a great solution to address climate change” [EI–7].

Third, seven experts feel that despite the importance of individuals’ role, governments are still playing the leading role in addressing climate change. Instead, all interviewees recognize that individuals’ behavioral responses can reduce the burden of policymakers (governments) in designing and implementing climate policies. They believe that those behavioral responses help governments not only alleviate climate change without enforcing strong regulations to the general public and industries, but also save valuable resources (e.g., time and money).

Last, two interviewees predict that the role of individuals in combating climate change will become increasingly important in the long run [EI–3 and E–11]. Additionally, some others discreetly point out that benefits derived from the role of individuals can only be reaped from the highly proactive efforts of individuals [EI–1 and EI–5] and behavioral responses based on proper mitigation and adaptation guidelines [EI–7]. Also, two experts warn that remarkable impacts on the mitigation and adaptation of climate change can only be realized not by behavioral responses of few individuals, but by behavioral responses with mass participation [EI–7 and EI–12].
Together, the role of governments is considered more important than that of individuals in addressing climate change so far. Nevertheless, it is obvious that individuals play a significant role in fighting climate change by influencing both governments and industries, and their behavioral responses have a potential to release the burden of governments. More importantly, when the individuals’ role is accompanied by enthusiastic efforts, appropriate knowledge, and mass participation, its impact can be strengthened and contribute more to achieving effective and successful results in solving the problem. “Individuals are those who are directly affected by the adverse impacts of climate change. Therefore, their more proactive and voluntary activities to mitigate and adapt to climate change are indispensable,” says one of the experts [EI–4].

**Expert perspectives on the hypotheses.** To obtain reliable and specific answers, the expert interviews considered both the mitigation and adaptation contexts. The experts provide insights that may run counter to some of this study’s hypotheses. In doing so they can also help better understand some of the more nuance results of the national and local level surveys. Table 9 summarizes the responses of the interviewees related to this study’s hypotheses. In terms of the mitigation context, most interviewees recognize that personal factors significantly affect risk perception and higher risk perception, along with greater policy-related knowledge, intensifies behavioral responses. The core hypothesis, the positive relationship between risk perception and behavioral responses, is supported by nine interviewees. However, some others believe that several barriers, such as financial costs and inconvenience in daily life, interrupt the relationship between risk perception and behavioral responses. Regarding other hypotheses, thirteen, eleven, and nine interviewees advocate that risk perception is influenced by short-term experiences, general knowledge, and policy assessment, respectively. Unexpectedly, the majority of the experts do not regard long-term experiences as an influential factor on risk perception.
Table 9. Summary of the interviewees’ responses about the relationship among personal factors, risk perception, and behavioral responses in the mitigation and adaptation contexts.

<table>
<thead>
<tr>
<th>Context</th>
<th>Factors</th>
<th>Variables</th>
<th>Hypothesized relationship</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Positive relationship</td>
</tr>
<tr>
<td>Mitigation</td>
<td>Experience</td>
<td>Extreme weather event experiences and climate change risk perception</td>
<td>Positive</td>
<td>13 (100.0%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Long-term climate change experiences and climate change risk perception</td>
<td>Positive</td>
<td>5 (38.5%)</td>
</tr>
<tr>
<td></td>
<td>General knowledge</td>
<td>Climate change knowledge and climate change risk perception</td>
<td>Positive</td>
<td>11 (84.6%)</td>
</tr>
<tr>
<td>(National-level analysis)</td>
<td>Policy assessment</td>
<td>Assessment of climate policy and climate change risk perception</td>
<td>Negative</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Policy-related knowledge</td>
<td>Familiarity with a GHG reduction plan and behavioral responses against climate change</td>
<td>Positive</td>
<td>9 (69.2%)</td>
</tr>
<tr>
<td></td>
<td>Risk perception</td>
<td>Climate change risk perception and behavioral responses against climate change</td>
<td>Positive</td>
<td>9 (69.2%)</td>
</tr>
<tr>
<td>Adaptation</td>
<td>Experience</td>
<td>Water problem experiences and drought risk perception</td>
<td>Positive</td>
<td>11 (84.6%)</td>
</tr>
<tr>
<td></td>
<td>General Knowledge</td>
<td>Drought knowledge and drought risk perception</td>
<td>Positive</td>
<td>8 (61.5%)</td>
</tr>
<tr>
<td>(Local-level analysis)</td>
<td>Policy assessment</td>
<td>Assessment of water policy and drought risk perception</td>
<td>Negative</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Policy-related knowledge</td>
<td>Familiarity with a subsidy policy and behavioral responses against drought</td>
<td>Positive</td>
<td>9 (69.2%)</td>
</tr>
<tr>
<td></td>
<td>Risk perception</td>
<td>Drought risk perception and behavioral responses against drought</td>
<td>Positive</td>
<td>5 (38.5%)</td>
</tr>
</tbody>
</table>

Note: ‘No response’ refers to interviewees who do not provide a clear answer, who have no opinion, or who are not asked about each relationship (due to a lack of time and others).
In the case of the adaptation context, it is doubtful whether drought risk perception is a significant mediator in the process of individuals’ behavioral responses against drought. The majority of the interviewees agree with three hypothesized relationships between personal factors (i.e., water problem experience, general knowledge, and policy assessment) and risk perception. However, the core hypothesis that higher risk perception promotes behavioral responses is supported by only five interviewees. The experts opposing this hypothesis argue that certain conditions, such as government’s top priority on residential water during drought, reliable countermeasures against prolonged drought (e.g., multi-purpose dams and multi-regional water supply systems), and inconvenience in changing behavioral patterns during drought, undermine the influence of risk perception on behavioral responses to drought. In addition, the positive relationship between policy-related knowledge and behavioral responses is identified by nine interviewees both in the mitigation and adaptation contexts. Qualitative insights for each hypothesized relationship are described in the next sub-section.

Overall, from a dichotomous approach whether the majority of the interviewees support each hypothesis or not, personal factors, except long-term experience, can significantly affect risk perception (or behavioral responses) both in the mitigation and adaptation contexts. However, while risk perception can influence behavioral responses in the mitigation context, the role of risk perception as a mediator is quite uncertain in the adaptation context. It is clear that these findings, along with the findings of the expert survey, help accumulate knowledge about the causal relationship among personal factor, risk perception, and behavioral responses related to climate change. Nevertheless, those are still insufficient to interpret the results of the national and local level analyses. More detailed information derived from the in-depth interviews is subsequently presented to complement the results of two quantitative analyses.
Filling the gaps between the hypotheses and the results of quantitative analyses.

Expectations and results do not always go together. The results of two quantitative analyses presented in the previous chapters also do not perfectly correspond to the hypotheses of this dissertation. Ironically, the discrepancies between the analysis results based on statistical methods and this study’s expectation lead to a more careful approach to the research question and makes the findings of the expert interviews all the more worthwhile. This sub-section, the heart of this chapter, tries to fill the gaps between them.

Short-term climate change and water problem experiences. Contrary to this study’s hypothesis, both the national-level and local-level analyses, based on a quantitative approach, fail to identify the positive relationship between experiences and risk perception. Short-term experiences and water problem experiences do not statistically influence climate change risk perception and drought risk perception, respectively. They also do not affect behavioral responses to address climate change. However, it would be rash to conclude that experiences are not an influential factor on risk perception before unveiling the reasons for this discrepancy. Fortunately, some clues to explain the discrepancy are reflected in the expert interviews.

All interviewees believe that individuals’ short-term experiences positively affect their climate change risk perception. Likewise, eleven interviewees support the positive relationship between water problem experiences and drought risk perception. Definitely, experiences are regarded as one of the strong influential factors on risk perception by climate change experts. But, many of them stress that those relationships can happen under certain conditions. For examples, the majority of experts believe that individuals must experience extreme weather events with direct and significant damage before they are likely to respond to climate change. Three interviewees recognize that individuals must feel uncomfortable for quite a long time due
to water problems before adopting behavioral responses [EI–1, EI–2, and EI–7]. “Whether the relationship between experiences and risk perception is significant depends on the extent of damage brought by extreme weather events,” highlights one expert [EI–10]. Also, six of the experts argue that individuals must perceive extreme weather events as part of climate change. Additionally, assuming that short-term and water problem experiences do not statistically influence climate change and drought risk perception in empirical analyses respectively, interviewees were asked to explain why. Table 10 lays out the possible reasons for the insignificant relationship between them based on the interviewees’ responses.

Table 10
Possible reasons for the insignificant relationship between experiences and risk perception

<table>
<thead>
<tr>
<th>National-level analysis</th>
<th>Local-level analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Possible reasons</td>
<td>Respondents</td>
</tr>
<tr>
<td>• They might experience extreme weather events with minor damage (or damage within manageable levels)</td>
<td>[EI–1 and seven others]</td>
</tr>
<tr>
<td>• They might not know that extreme weather events they experienced are climate change</td>
<td>[EI–3 and five others]</td>
</tr>
<tr>
<td>• As time passes, higher climate change risk perception triggered by extreme weather event experiences might return to baseline</td>
<td>[EI–4 and EI–5]</td>
</tr>
<tr>
<td>• After extreme weather event experiences with severe damage, proper countermeasures might be implemented by governments</td>
<td>[EI–1 and EI–3]</td>
</tr>
<tr>
<td>• For individuals who too frequently experience extreme weather events, those events might be taken for granted and might not be regarded as climate change</td>
<td>[EI–10]</td>
</tr>
</tbody>
</table>
All told, while short-term and water problem experiences have the potential to positively affect climate change and drought risk perception respectively, their potential is likely to be actualized under certain conditions, such as experiences accompanied by direct and significant damage (discomfort), experiences with appropriate knowledge about climate change (drought), recent experiences, and instances with no available solution. Given the responses of the interviewees presented in Table 9 and 10, it is possible that short-term and water problem experiences positively affect climate change and drought risk perception in some countries respectively, it is not possible in other countries.

In South Korea, individuals are generally exposed to information about climate change and drought derived from diverse sources, such as off-line and on-line media, government’s climate change-specialized websites (e.g., Korea Information Portal for Climate Change Adaptation—http://climateadapt.kei.re.kr/portal/, My water—https://www.water.or.kr/, and National Drought Information-Analysis Center—http://drought.kwater.or.kr/main.do), and social media, given the country’s high quality internet environment. Meanwhile, some experts (e.g., EI–2 and EI–7) point out that South Korea has a high level of water management capability, based on multi-purpose dams and multi-regional water supply systems, and therefore most individuals do not suffer serious damage from flood and drought. Some others (e.g., EI–1 and EI–5) add that individuals typically do not experience very long-term limited water supply (e.g., dozens of hours), but experience short-term (e.g., a couple of hours) or night-time limited water supply. As shown in Figure 12, in fact, the amount of damage caused by typhoons and heavy rains in South Korea has been on a downward trend since 2002.128 Recently, there was no

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128 Typhoon Lusa in 2002 triggered the greatest amount of damage among the typhoons, which occurred during 1987 and 2017, in South Korea (Ministry of the Interior and Safety, 2017).
catastrophic damage triggered by them (Ministry of the Interior and Safety, 2017).\textsuperscript{129} In other words, while some survey respondents answered that they had short-term or water problem experiences with damage, that damage might not be significant enough to intensify their climate change or drought risk perception. Also, the impact of their experiences on risk perception is less likely to be permanent.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{damagedamage.png}
\caption{Amount of damage caused by typhoons and heavy rains in South Korea (From 2002 to 2015)}
\end{figure}

Note: The data are provided by Ministry of the Interior and Safety (2017). The exchange rate is USD 1 = KRW 1,000

Based on the findings of both quantitative and qualitative analyses, this dissertation tries to describe changes in the relationship between short-term experiences and risk perception related to climate change in Figure 13. Those changes are deeply associated with the levels of the government’s climate change adaptation capacity and information networks. Specifically, while countries with weak adaptation capacity and strong information networks are likely to show the

\textsuperscript{129} The national-level and local-level analyses employ the data of surveys conducted in the middle of 2016 and the end of 2015, respectively. Therefore, Figure 12 presents the amount of damage triggered by typhoons and heavy rains from 2002 to 2015.
strong positive relationship between them, countries with strong adaptation capacity and weak information networks may present the insignificant relationship between them. Both countries with strong adaptation capacity and information networks and countries with weak adaptation capacity and information networks are likely to show the insignificant relationship or weak positive relationship between short-term experiences and risk perception associated with climate change. However, these arguments need much more empirical evidence from future research.

**Figure 13.** Changes in the relationship between short-term experiences and risk perception related to climate change

In light of Table 10 and the above-mentioned South Korean context (e.g., strong adaptation capacity and information networks), the statistically insignificant relationship between short-term (water problem) experiences and climate change (drought) risk perception in the previous empirical chapters might be understandable. Unfortunately, contradictory results of the
relationship between drought experience and each behavioral response to mitigate climate change in the sub models of the national-level analysis remain unsolved.\textsuperscript{130}

*Long-term climate change experiences.* Unlike this study’s hypothesis, the majority of interviewees predict that individuals’ long-term climate change experiences do not significantly influence their climate change risk perception. Five interviewees recognize that while it is possible for individuals to experience long-term climate change, they are likely to adapt to those incremental changes happening over a long time rather than perceiving higher climate change risk. Some of them (e.g., EI‒5 and EI‒11) take ‘boiling frog syndrome’ as an example.\textsuperscript{131} This syndrome is often used as a metaphor for the failure of perceiving creeping risks. Also, one expert believes that government’s response systems for climate change might be advanced in line with long-term climate change [EI‒7]. However, the findings of the national-level analysis and expert survey reveal that long-term climate change experiences significantly and positively influence climate change risk perception. Overall, while the interviewees’ arguments somewhat make sense, this study asserts that the hypothesis, identified by the results of the quantitative analysis and expert survey, are more convincing and reliable rather than the opposing opinion supported by those of the expert interviews.

On the sidelines, while it is challenging to unveil what exactly makes those gaps, this effort might be meaningful to future research related to this topic. This study tries to explain the gaps by raising three plausible possibilities. First, individuals are likely to be more understanding

\textsuperscript{130} Some responses (e.g., utilizing renewable energy and donations to environmental organizations) are positively affected by drought experience. But, some others (e.g., saving energy and saving water) are negatively influenced (see p. 89).

\textsuperscript{131} Boyatzis (2007) describes this syndrome. “If a frog is dropped into a pot of boiling water, it will immediately jump out of the pot. But if the frog is placed in a pot of cool water, which is gradually brought to a boil, then the frog will remain in the water until cooked” (p. 162).
of the adverse impacts of climate change in the future caused by recent incremental changes they have experienced rather than what the majority of the interviewees think. Boiling frog syndrome, assuming a lack of understanding of negative consequences in the future, is an extreme and inappropriate example in describing the relationship between long-term experiences and risk perception associated with climate change. Second, individuals’ long-term climate change experiences might have already reached (or gone beyond) a critical point. Some experts (e.g., EI–1 and EI–10) who are doubtful about the hypothesis add that their answers are based on the assumption that long-term climate change experiences are still below a critical point. When reaching the critical point, they will significantly intensify climate change risk perception. The definitions of a critical point may vary in different fields (e.g., Thermodynamics and Mathematics). This dissertation views that if most individuals believe that they can no longer easily adapt to climate change and the negative consequences of climate change are more than possibility based on their long-term experiences, their long-term climate change experiences reach the critical point. Third, long-term climate change experiences and climate change risk perception affected by these experiences are less likely to travel the same route. One of the interviewees states that while climate change is incremental over a long period (e.g., a straight and gently upward-sloping line), climate change risk perception influenced by long-term climate change experiences repeat the prolonged stability and radical change (e.g., horizontal lines with steep upward-sloping lines) [EI–2]. This argument looks similar to punctuated equilibrium theory. It is a “theory of policy dynamics as it focuses on the mechanisms that lead to policy change” (Jones & Baumgartner, 2012, p. 4) and explains both stability and radical change in the policy process (Baumgartner, Jones, & Mortensen, 2014). Regrettably, the expert interview does not provide detailed information about the mechanism, such as what factor triggers the radical
change and when it occurs. While the majority of the interviewees only consider the stable stage of climate change risk perception, the change stage of that also exists. Both the significant or insignificant relationship between two variables may be possible depending on which stage climate change risk perception affected by long-term climate change experiences is going through. Overall, all of these are mere possibilities, lacking theoretical and empirical foundations. Further research to verify those possibilities can help make a research model for unveiling the process of individuals’ behavioral responses to address climate change more elaborate.

**General knowledge.** “Not only can knowledge associated with a risk help individuals notice the existence of the risk, but it can also help them specifically predict the negative effects of the risk,” says one expert [EI–9]. Most interviewees agree that climate change and drought knowledge positively influence climate change and drought risk perception, respectively. Additionally, some of them point out several cautionary notes in understanding the relationship between risk-related knowledge and risk perception. First, without direct or indirect experiences, higher risk perception triggered by knowledge is likely to decrease gradually as time goes by [EI–1]. Second, sometimes knowledge intensifies dissatisfaction with the government’s response capacity to risks instead of risk perception [EI–9]. Furthermore, there is a possibility that too much scientific knowledge leads individuals to make a mistake of underestimating the adverse impacts of risks [EI–2 and EI–12]. Third, it is necessary to check whether individuals have accurate knowledge about risks [EI–4].

The findings of the expert interviews are consistent with those of the two quantitative analyses with respect to the relationship between climate change knowledge, risk perception, and behavioral responses. Given these results, the interviewees were asked what type of knowledge
that could intensify public perceptions of climate change and drought risk. Ten of the interviewees recognize that short-term and practical knowledge deeply related to individuals’ daily lives (or at least the next generation’s life) is likely to be more effective rather than long-term and scientific knowledge in raising those risk perceptions. Some examples of the short-term and practical knowledge suggested by the experts are as follows:

- Presenting individuals’ expected damage rather than global and national damage if climate change is not adequately addressed [EI–1]
- Spotlighting significant but hard-to-notice changes caused by climate change in the past decades rather than iterating the uncertain future consequences of climate change [EI–4]
- Sharing both success and failure stories related to climate change adaptation rather than focusing only on the failure stories [EI–9]
- Communicating the limitations of government’s capacity regarding climate change adaptation (Perfect adaptation is impossible) [EI–9, EI–10, and EI–11]
- Providing guideline for individuals’ behavioral responses to address climate change (Not only can this knowledge help take action to address climate change, but it can also help intensify climate change risk perception) [EI–1 and EI–8]

Overall, climate change and drought knowledge are significant and reliable factors in intensifying climate change and drought risk perception, respectively. Further, when sharing short-term and practical knowledge rather than long-term and scientific knowledge, individuals might perceive the risk of climate change more clearly and vividly. To strengthen the impacts of knowledge on climate change risk perception, “the academic world needs to speak with one voice about the negative impacts of climate change” says one expert [EI–7].
Policy assessment. This factor, along with short-term experience and knowledge, is regarded by the majority of the interviewees as a significantly influential factor on climate change and drought risk perception. Most experts state that the levels of policy assessment are negatively associated with those risk perceptions. But, they are also wary of some latent obstacles distorting the relationship between them. For example, there is a possibility that individuals evaluate climate or water policies based on their political ideologies [EI–3], the levels of their satisfaction with government [EI–5 and EI–10], or national economic conditions [EI–3], not the levels of the policies. There is also a chance that individuals assess climate or water policies inattentively without careful consideration [EI–1]. The results of the expert interviews are in line with this study’s hypothesis, but those of quantitative analyses present mixed-results. While the assessments of drought policy and water infrastructure policy significantly and negatively affect climate change and drought risk perception respectively, those of flood policy and water supply policy do not. Regarding such minor discrepancies between the hypothesis and the results of empirical analyses, some interviewees note that assessing the government’s response to damage from an extreme weather event is more likely to show a significant relationship with climate change risk perception when the extreme weather event has the following characteristics:

- Getting serious recently and being exposed to the media frequently [EI–3]
- Causing damage throughout a large area and lasting long [EI–4]
- Having difficulties in creating response infrastructures [EI–8 and EI–12]
- Not having a policy or program which indemnifies individuals’ losses [EI–13]

In South Korea, the amount of damage caused by typhoons and heavy rains has been declining for a while (see Figure 12). Also, property damage by floods can be indemnified by

Meanwhile, droughts have occurred more frequently in the 2010s (National Drought Information-Analysis Center, 2018), and they have attracted more attention from the media.  

Droughts typically affect a wider area and continue longer than floods, and a high level of water supply infrastructure is necessary in effectively addressing prolonged droughts. In light of these things, the mixed-results of the quantitative analyses are understandable. Overall, while individuals’ policy assessments can negatively affect climate change and drought risk perception, the influence of each assessment on those risk perceptions may vary with the above-mentioned features, and sometimes that influence even disappears.

*Policy-related knowledge.* The positive relationship between individuals’ policy familiarity and their behavioral responses to cope with climate change (drought) is supported by most interviewees. According to the experts, individuals’ policy familiarity can spark their behavioral responses by acting as a helpful guide for understanding how to address risks [EI–3, EI–7, and EI–11], promoting their social responsibility [EI–4], or providing justification for their behavioral responses [EI–5]. Individuals may be convinced that their behavioral responses finally benefit themselves based on higher levels of policy familiarity [EI–2]. Also, the familiarity with policies combined with incentives is likely to be more effective in enhancing behavioral responses [EI–4]. Consequently, the findings of the quantitative analyses and expert

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132 Based on “the Storm and Flood Insurance Act,” insurance policy holders can receive a portion of the premiums from the state or a local government (Ministry of Government Legislation, 2017a).

133 BIGKinds (https://www.bigkinds.or.kr/), the search engine for news, operated by the Korea Press Foundation (http://www.kpf.or.kr/) helps analyze news from fifty-three media outlets, including broadcasting companies and metropolitan newspapers, in South Korea. When searching BIGKinds for drought under detailed conditions (i.e., keyword—drought, topic category—society and local, and accident category—drought among natural disasters), the number of the searched news is increasing sharply from 767 in 2010 to 4,707 in 2015.
interviews are strongly consistent with this dissertation’s hypothesis. No significant discrepancies are observed among them.

*Risk perception.* In terms of climate change risk perception, some interviewees argue that individuals’ climate change risk perception may not always result in behavioral responses related to climate change, due to several obstacles, such as inconvenience in daily life [EI–4 and EI–12] and financial costs [EI–4 and EI–7]. Nevertheless, most interviewees are convinced that climate change risk perception intensifies behavioral responses against climate change. The results of the quantitative analysis in the national-level chapter also identify the significant relationship between individuals’ risk perception and their behavioral responses. In this regard, climate change risk perception affected by personal factors plays a pivotal role as a mediator in the process of individuals’ behavioral responses to mitigate climate change.

However, in the case of drought risk perception, whether individuals’ drought risk perception is positively associated with their behavioral responses to address drought is inconclusive and debatable. The experts were divided on this question between two groups (i.e., the first group—supporting the significantly positive relationship between them; the second group—arguing the insignificant relationship between them). Further, the results of the quantitative analysis at the local level fail to show a significant relationship between drought risk perception and behavioral responses (both daily action and device utilization responses) against drought. To fill the gap between this study’s hypothesis and the results of the empirical analysis, it is worth noting arguments of the experts who belong to the second group. These are as follows:

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134 However, the time needed to bring out behavioral responses from risk perception may differ from individual to individual [EI–3].

135 This statement is based on the relationship between climate change risk perception and the number of behavioral responses to mitigate climate change.
• In severe drought periods, governments generally prioritize the supply of residential water over that of water for other purposes, and individuals still can use water without any restraints, or with very few restrictions [EI–1, EI–5, and EI–12]

• There are reliable countermeasures against prolonged droughts, such as multi-purpose dams, multi-regional water supply systems, and bottled water [EI–2]

• Drought risk is suddenly dispelled by an unforeseen rain [EI–5]

• Each individual generally thinks that his or her behavioral responses do not help overcome drought [EI–4 and EI–12]

• It is difficult for individuals to suddenly change their patterns of water usage during every drought period [EI–3]

All of these arguments, which are largely consistent with Wachinger et al. (2013) and Bubeck, Botzen, and Aerts (2012), have a potential to neutralize the influence of drought risk perception on behavioral responses to address drought. Especially, the first two arguments, mostly in line with those mentioned in the experience part, are viewed as the main culprits of making the relationship between them statistically insignificant in South Korea. Namely, it is difficult for drought risk perception influenced by personal factors to become a significant mediator in the process of individuals’ behavioral responses against drought in South Korea. Still, drought risk perception may be an important factor in other countries with different contexts. These results imply that it is important to develop more specific hypotheses and elaborate theories in exploring the relationship between risk perception and behavioral responses related to climate change. In doing that, reflecting the different features of climate risks (e.g., long-term climate change, drought, and flood) and different contexts within which these risks arise could be a good strategy.
**Self-vulnerability perception related to limited water supply.** While it has a statistically significant relationship with one of the behavioral response types (i.e., device utilization response) in the local-level analysis, contrary to this study’s expectation, this relationship displays a negative direction. According to the interviews, it is almost natural for individuals who perceive higher self-vulnerability to limited water supply to be reluctant to take water saving actions during drought periods from three points of view. Some experts believe that this may be because individuals perceiving higher self-vulnerability use much water by nature and are not accustomed to water saving behaviors. Four interviewees recognize that they may also try to secure more water than they generally need before limited water supply. It may be a self-defense mechanism. “While limited water supply makes them very uncomfortable, it is uncertain whether this regulation will be implemented in the future. Meanwhile, taking water saving actions immediately inconveniences them,” says one interviewees [EI–2]. Given these things, self-vulnerability perception is likely to work in the opposite way from how climate change and drought risk perception work. Thus, exploring how to reduce this perception seems necessary.

**Alternative factor in adaptation: Social norms.** Some interviewees (e.g., EI–8 and EI–9) argue that the clue to the promotion of individuals’ water saving actions during drought comes from ‘keeping up with the Joneses.’ Existing studies, mostly related to social norms, note that individuals’ behaviors can change by the direct experiences of witnessing neighbors’ behaviors (Graziano & Gillingham, 2014; Terry & Hogg, 2001), by being informed of how most of their neighbors act in a given situation (Allcott, 2011; Schultz, 1999), or by beliefs of how actively their neighbors are engaged in certain behaviors (Nolan et al., 2008). ¹³⁶ “The behavioral

¹³⁶ Numerous research projects have investigated the impact of social norms (or normative social influence) on human behavior (Allcott, 2011; Nolan et al., 2008). Social norms refer to “sets of beliefs about the behavior of others” (Schultz, 1999, p. 26). Cialdini, Reno, and Kallgren (1990) introduce two types of social norms: Descriptive norms—“what is done” and injunctive norms—“what ought to be done” (p. 1015).
responses of individuals to address drought can be motivated by those of their neighbors,” mentions one expert [EI–9]. Namely, there is a possibility that individuals are more aggressively engaged in water saving actions during drought when they positively assess (or have strong beliefs in) the behavioral responses of neighbors. To empirically verify that possibility, this study adjusts the research model in the local-level analysis by adding the following variable. In the local-level survey, respondents were asked to evaluate the levels of their neighbor’s water saving behaviors during the drought period compared to non-drought period on a five point scale, where 1 = strongly saving, 2 = moderately saving, 3 = no difference, 4 = moderately using more, and 5 = strongly using more. The scale of the question is reversed. Higher values indicate greater positive evaluation of neighbor’s water saving behaviors. The regression analysis results, based on the adjusted research model, reveal that the levels of individuals’ evaluation on neighbor’s water saving behaviors have a significant and positive relationship with both their daily action responses (b = .571, p<.05) and device utilization responses (b = .267, p<.001).

Overall, while climate change risk perception is considered by most interviewees as a significant influential factor on behavioral responses to cope with climate change, drought risk perception is not considered influential. The experts’ arguments of why the influence of drought risk perception on behavioral responses to address drought becomes insignificant seem valid in the South Korean context. These results are largely consistent with the findings of two quantitative analyses. Namely, risk perception is a credible factor of intensifying behavioral responses in the mitigation context, but it is less likely to work well in the adaptation context. Instead of drought risk perception, water saving behaviors of individuals are statistically affected by those of their neighbors. Unfortunately, the findings of sub models in the national-level analysis are not treated in the expert interviewees.
Expert Survey

Data Collection

**Subjects.** While the above-mentioned interviewees are regarded as appropriate experts on this study’s research question, most of them belong to a single organization. Therefore, to enhance the reliability of this qualitative analysis, a separate expert survey is conducted to members of the Korea Water Resources Association (KWRA) affiliated with diverse organizations.\(^{137}\) It is hard to say that all KWRA’s members hold expert knowledge on par with K-water researchers’ concerning this study’s topic. However, many of them have higher levels of knowledge on water-related issues including flood and drought. Recall, the relationship between risk perception and behavioral responses related to drought is one of this study’s pillars. The results of this survey can enrich the findings of other analyses.

**Data collection instruments.** A self-administered and Web-based survey to members of the KWRA was conducted by the online survey platform, ‘www.opensurvey.co.kr,’ on May 30, 2018. The survey questionnaire focusing on the mitigation context was developed jointly by the researcher of this study and researchers at the research center for water policy and economy in the K-water institute. It is composed of eleven close-ended and four open-ended questions.

**Socio-demographic Characteristics**

This survey using token financial incentives has one hundred twenty-six respondents. Among the ninety-eight respondents, 69 have a PhD degree (70.4%), 17 are in a PhD program (17.4%), and 12 have a master’s degree with more than a 10‒year professional career (12.2%). These respondents are regarded as appropriate experts and are subject to this analysis. They

\(^{137}\) The Korea Water Resources Association (http://www.kwra.or.kr/) aims to develop water resources research, planning, development, management, and education in South Korea. It has more than two thousand members who belong to different organizations, such as universities, private companies, and public agencies (KWRA, 2018).
range in age from 24 to 83 years (M = 43.73, SD = 10.72) and 88.78% are males.\textsuperscript{138} Forty-eight respondents are practitioners (i.e., 13 from governments; 13 from public corporations; 22 from private companies), and fifty respondents are scholars (i.e., 11 from public or private research institutes; 31 from universities; 8 from research institutes affiliated with universities). On average, they have a 16.4–year professional career.

**Analysis Results**

This study’s hypotheses are strongly supported by the results of the close-ended questions. Regarding the impacts of climate change and the role of individuals in addressing climate change, more than 90% of the respondents answer that the adverse impacts of climate change are \textit{(moderately or very)} serious and individuals’ role in addressing climate change is \textit{(moderately or very)} important. However, around 66% of the respondents believe that the general public does not perceive climate change risk accurately in South Korea. In terms of the relationship among personal factors, climate change risk perception, and behavioral responses to climate change, more than 70% of the respondents indicate that individuals’ climate change experiences, knowledge, and low satisfaction with climate policy intensify their climate change risk perception. Similarly, the majority of the respondents (above 70%) agree that climate change risk perception and policy-related knowledge positively influence behavioral responses both to mitigate and adapt to climate change. Lastly, most respondents either agree (64.3%) or strongly agree (21.4%) that governments’ efforts (e.g., providing quality information and running educational programs) can enhance individuals’ behavioral responses. Table 11 summarizes the respondents’ answers of each close-ended question.

\textsuperscript{138} It is almost impossible to identify the male-female climate change expert ratio in South Korea. Instead, according to Park (2018), the percentages of male professors at universities in South Korea in 2018 are 74.1%. This expert survey seems to somewhat oversample males compared to the population.
Table 11. Summary of the survey to members of the KWRA

<table>
<thead>
<tr>
<th>Questions</th>
<th>Answers (Percentage)</th>
<th>Mean</th>
<th>STD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  What do you think of the adverse impacts of climate change on</td>
<td><strong>Not serious</strong> 1 (1.0%)  Somewhat serious 8 (8.2%)  Moderately serious 61 (62.2%)</td>
<td>3.184</td>
<td>.615</td>
</tr>
<tr>
<td>humans and the ecosystems in South Korea?</td>
<td>Very serious 28 (28.6%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2  To what extent do you think the general public perceives climate</td>
<td><strong>Not accurate</strong> 10 (10.2%)  Somewhat accurate 55 (56.1%)  Moderately accurate 32 (32.7%)</td>
<td>2.245</td>
<td>.643</td>
</tr>
<tr>
<td>change risk accurately in South Korea?</td>
<td>Highly accurate 1 (1.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3  How important is the role of the general public for addressing</td>
<td><strong>Not important</strong> 0 (0.0%)  Somewhat important 6 (6.1%)  Moderately important 57 (58.2%)</td>
<td>3.296</td>
<td>.578</td>
</tr>
<tr>
<td>climate change?</td>
<td>Highly important 35 (35.7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4  To what extent do you think the general public’s climate change</td>
<td><strong>No intensification</strong> 0 (0.0%)  Minor intensification 15 (15.3%)  Moderate</td>
<td>3.122</td>
<td>.646</td>
</tr>
<tr>
<td>risk perception is intensified by their extreme weather event</td>
<td>intensification 56 (57.1%)  Strong intensification 27 (27.6%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>experiences (e.g., flood, drought, and heat wave)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5  To what extent do you think the general public’s climate change</td>
<td><strong>2 (2.0%)</strong>  Somewhat intensified 27 (27.6%)  Moderate intensified 57 (58.2%)</td>
<td>2.806</td>
<td>.668</td>
</tr>
<tr>
<td>risk perception is intensified by their long-term climate change</td>
<td>Highly intensified 12 (12.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>experiences (e.g., the rising of average temperature and the</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>change in precipitation in the last ten years)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6  To what extent do you think the general public’s climate change</td>
<td><strong>2 (2.0%)</strong>  Somewhat intensified 15 (15.3%)  Moderate intensified 72 (73.5%)</td>
<td>2.898</td>
<td>.565</td>
</tr>
<tr>
<td>risk perception is intensified by their knowledge related to climate</td>
<td>Highly intensified 9 (9.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>change (e.g., causes and consequences)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7  To what extent do you think the general public’s climate change</td>
<td><strong>1 (1.0%)</strong>  Somewhat intensified 24 (24.5%)  Moderate intensified 65 (66.3%)</td>
<td>2.816</td>
<td>.581</td>
</tr>
<tr>
<td>risk perception is intensified by their low satisfaction with climate</td>
<td>Highly intensified 8 (8.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>policy?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8  Do you agree that the more the general public perceives high levels</td>
<td><strong>Strongly disagree</strong> 2 (2.0%)  Disagree 7 (7.2%)  Neither agree nor disagree 16</td>
<td>3.786</td>
<td>.865</td>
</tr>
<tr>
<td>of climate change risk, the more actions they will take to</td>
<td>(16.3%)  Agree 58 (59.2%)  Strongly agree 15 (15.3%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mitigate climate change (e.g., saving energy, using public</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>transportation, and less driving)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9  Do you agree that the more the general public perceives high</td>
<td><strong>0 (0.0%)</strong>  Somewhat disagree 3 (3.1%)  Moderate disagree 18 (18.4%)  Agree 57</td>
<td>3.959</td>
<td>.717</td>
</tr>
<tr>
<td>levels of climate change risk, the more actions they will take to</td>
<td>(58.1%)  Strongly disagree 20 (20.4%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>adapt to climate change (e.g., water saving)?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Do you agree that the general public’s knowledge of climate</td>
<td><strong>0 (0.0%)</strong>  Somewhat disagree 6 (6.1%)  Moderate disagree 13 (13.3%)  Agree 63</td>
<td>3.908</td>
<td>.733</td>
</tr>
<tr>
<td>policy (e.g., GHG reduction plan and water saving subsidy during</td>
<td>(64.3%)  Strongly disagree 16 (16.3%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>drought) will facilitate their behavioral responses to address climate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>change?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Do you agree that governments’ diverse efforts (e.g., providing</td>
<td><strong>0 (0.0%)</strong>  Somewhat disagree 4 (4.1%)  Neither agree nor disagree 10 (10.2%)</td>
<td>4.031</td>
<td>.695</td>
</tr>
<tr>
<td>quality information, running educational programs, and strengthening</td>
<td>Agree 63 (64.3%)  Strongly agree 21 (21.4%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>behavioral incentives) can enhance the general public’s behavioral</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>responses to address climate change?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
As mentioned above, this survey includes several open-ended sub questions. When the respondent chose answers which are not consistent with this paper’s hypotheses associated with personal experiences (H1) and behavioral responses triggered by risk perception (H5), they were requested to write a brief description of their selections. In terms of the question 4 and 5, less than 30% of the respondents indicate that individuals’ climate change experiences do not intensify (or weakly intensify) their climate change risk perception. It does not mean that they deny the relationship between climate change experiences and risk perception. Instead, they present certain conditions needed for the significant relationship between them. The important descriptions are summarized in Table 12. In short, repetitive climate change experiences accompanied by direct and severe damages can significantly intensify climate change risk perception. However, many of them assert that extreme weather event experiences of most individuals are not repetitive and are linked to indirect and minor damages in South Korea.

**Table 12. Descriptions about the relationship between climate change experiences and climate change risk perception**

<table>
<thead>
<tr>
<th>Description Summary</th>
<th>Respondents</th>
</tr>
</thead>
</table>
| • Climate change experiences accompanied by a direct damage can significantly affect climate change risk perception | [KWRA‒58]  
| | [KWRA‒91] |
| • Climate change experiences with a minor damage do not significantly influence climate change risk perception | [KWRA‒28]  
| | [KWRA‒98] |
| • Extreme weather event experiences from a long time ago do not significantly affect climate change risk perception | [KWRA‒18]  
| | [KWRA‒54] |
| • Repetitive extreme weather event experiences can significantly influence climate change risk perception | [KWRA‒42] |
| • People tend to forget the seriousness of extreme weather events once those events are over. | [KWRA‒06] |

In the cases of the question 8 and 9, less than 10% of the respondents either disagree or strongly disagree that the increase of individuals’ climate change risk perception enhances their behavioral responses to address climate change, due to several reasons such as social loafing [KWRA‒8], a lack of guidelines [KWRA‒67], no direct benefits [KWRA‒17 and KWRA‒62],
and the discrepancy between higher climate change risk perception and negligible discomforts in everyday life triggered by climate change [KWRA–17 and KWRA–47].

Overall, the results of the close-ended questions supporting this study’s hypotheses are not entirely consistent with the findings of the quantitative analyses. Fortunately, the results of the open-ended questions, along with those of the expert interviews, give clues as to why personal experiences did not clearly have a causal relationship with climate change risk perception and behavioral responses to address climate change in both the national and local level analyses and why drought risk perception did not significantly influence behavioral responses against drought. The findings of the expert interviews and survey are wrapped up in the concluding section of this chapter, following the policy and research implications. Lastly, even though this dissertation tried to identify appropriate experts for the interviews and survey to examine the research question, there is still a possibility that some experts could misunderstand how the general public actually behave and could also engage in the above-mentioned biases (e.g., group think and wishful thinking).

139 “Social loafing,” coined by Latané, Williams, and Harkins (1979, p. 822), means that individuals exert less effort when doing something in groups compared to doing that alone.

140 This dissertation conducts an ordered-logit regression analysis to investigate whether the experts’ socio-demographic characteristics influence their opinions. Ordered-logit models are appropriate when data are discrete values in sequential order, but the exact distance between the response options is unknown (Williams, 2016). Dependent variables are the results of the eleven closed-ended questions. Independent variables are gender (0 = male; 1 = female), age (years), career (years), education (0 = master’s degree; 1 = PhD program; 2 = PhD degree), and a field of activity (0 = the academic world; 1 = the practitioner’s world). There is no statistically significant relationship between the dependent and independent variables, except only the question 6 and 7. In the case of the question 6 related to knowledge, for a one level increase in education, the odds of strong intensification versus moderate intensification (moderate intensification versus minor intensification or minor intensification versus no intensification) are 0.377 times lowers, given the other variables are held constant in the model (p<.05). In terms of the question 7 associated with policy assessment, for the experts in the practitioner’s world, the odds of strong intensification versus moderate intensification are 3.854 times greater than for the experts in the academic world (p<.05). Additionally, whether the answers for the question 1–7 (i.e., the relationship between personal factors and risk perception) affect the answers to the question 8 (i.e., the relationship between risk perception and behavioral responses to mitigate climate change) and 9 (i.e., the relationship between risk perception and behavioral responses to adapt to climate change) is explored based on the regression analysis. Consequently, only the opinion on the question 3 (i.e., the importance of individuals’ role) is positively associated with the opinions on the question 8 (p<.01) and 9 (p<.01).
Policy Implications

The experts end their interviews by suggesting several viable methods to consolidate the process of individuals’ behavioral responses to address climate change. Simply, these methods require stepping up education, financial incentives and penalties, information, communication, infrastructure, and publicity. Not surprisingly, the most-suggested method is the enhancement of education [Eight interviewees]. The interviewees argue that knowledge of climate change should be spread through the regular school curriculum, especially primary and secondary school curriculums, emphasizing the timing of education. This suggestion echoes one of the policy implications, raising the necessity of early and systematic education, in the national-level analysis. The second most-suggested method is the implementation of policies with financial incentives [Six interviewees], followed by that of policies with financial penalties [Four interviewees]. While both financial methods have a greater potential to change individual behaviors related to climate change, which method is better for enhancing their behavioral responses is quite debatable. This study believes that it depends on the features of the policy. The provision of information is also regarded by some experts as a helpful method to strengthen that process. Conveying accurate information constantly [EI‒9], taking real life examples [EI‒9], and securing high-level accessibility and quality information [EI‒13] are the key points to make this method effective. In addition, the facilitation of communicating among stakeholders [EI‒11 and EI‒13], the development of favorable infrastructure to practice behavioral responses [EI‒1], and the promotion of publicity activities [EI‒11] are suggested by a minority of the experts.

It is true that not only the first method, but also the others, mostly overlap with the policy implications suggested in the national and local level analyses, and they are not new and innovative. However, at the other end of the spectrum, it can be interpreted that putting greater
efforts into those ordinary but academically and practically proven methods is a better idea than wandering around looking for innovative but unproven methods in enhancing individuals’ behavioral responses against climate change. This study asserts that the process of individuals’ behavioral responses to address climate change mediated by risk perception can benefit from those ways.

Research Implications

The expert interviews also provide some valuable implications for future research related to this topic. First, it is possible that personal factors have a non-linear relationship (e.g., an inverted U-shaped curve) with risk perception or behavioral responses, depending upon their levels. For example, while knowledge is likely to have a positive relationship with risk perception until a certain level, it may have a negative relationship with risk perception above that level. Second, there is a chance that the impacts of personal factors on risk perception and behavioral responses change over time. For instance, a recent extreme weather event experience (or recent knowledge) may affect risk perception more significantly rather than old one. Third, individuals may show a different time-lag between the formation of risk perception and the practice of behavioral responses. For example, while some immediately take action after perceiving climate change risk, others need some or quite a long time to change their behavior patterns for responding to climate change. Fourth, hypotheses about the relationship among personal factors, risk perception, and behavioral responses against climate change should be proposed with regard to the levels of governments’ system and infrastructure to mitigate and adapt to climate change. Unfortunately, these things cannot be revealed by this dissertation due to the limitation of data and are left to future research projects based on a more standardized and refined survey.
Conclusion

By conducting face-to-face interviews (2018, N=13) and an online survey (2018, N=98) with climate change experts from a qualitative approach, this chapter tries not only to obtain expert knowledge about the process of individuals’ behavioral responses to address climate change, but also to close the gaps between this study’s expectations and the results of quantitative analyses. Looking at the big picture, the experts both in the interviews and survey support this study’s expectations relating individuals’ personal factors to risk perception and behavioral responses to climate change. However, the discrepancies between the hypotheses and the results of quantitative analyses in the national and local level chapters revealed some limitations in the literature guiding these hypotheses. Fortunately, the experts offer clues to these challenges. Three considerable discrepancies and expert explanations for these phenomena are as follows.

First, short-term and water problem experiences show an insignificant relationship with climate change and drought risk perception, respectively. While most experts both in the interviews and survey advocate that short-term experiences can intensify climate change risk perception, they commonly voice concern that this relationship is likely to disappear under certain conditions such as experiences with indirect or minor damage, experiences with a lack of or inappropriate knowledge, old experiences, and instances with a viable solution. Similarly, the relationship between water problem experiences and drought risk perception may be affected by these conditions. Second, the relationship between the assessment of policy and risk perception leaves mixed-results in both quantitative analyses. The negative relationship between policy assessment and risk perception is also supported by most experts both in the interviews and survey. However, according to some interviewees, if an extreme weather event is serious and
receives significant media attention, damages a wide area for a long time, and these damages are not compensated, then individuals’ assessment of policy will significantly influence climate change risk perception, and vice versa. Also, some experts believe that the core concern of the general public experiencing prolonged drought is not the level of water supply service, but that of water supply infrastructure. The latter is more likely to have a significant relationship with drought risk perception. Lastly, drought risk perception fails to intensify water saving actions. Unlike climate change risk perception, the role of drought risk perception in promoting water saving actions is somewhat doubtful from the experts’ point of view. Half of the respondents in the expert interviews disagree that drought risk perception can intensify behavioral responses to address droughts. They highlight that individuals generally experience minor damage from droughts due to prioritized residential water supply policy and established response infrastructure. Also, it is not easy for individuals to change their patterns of water usage whenever drought is happening, and an unexpected rain often relieves drought abruptly.

As for the South Korean context, the amount of damage brought by typhoons and heavy rains has decreased over the last decade (Ministry of the Interior and Safety, 2017). A higher level of water management has been achieved through multi-purpose dams and multi-regional water supply systems [EI–1 and EI–5]. Information networks for climate change and drought have been well established. The government has prioritized residential water supply during drought periods. Based on the strong adaptation capacity, information networks, and government’s top priority on citizens’ quality of life, individuals generally do not experience severe damage from extreme weather events and very long-term limited water supply triggered by drought. But, it is also clear that droughts have been getting serious and frequent and have
drawn attention from the media (National Drought Information-Analysis Center, 2018). In light of these facts, the above-mentioned discrepancies may come as no surprise.

Overall, given the results of the expert interviews and survey, this study finds support for the expectation that personal factors affect risk perception and higher risk perception will lead to behavioral responses to climate change. However, what is important to know is that this process does not operate perfectly and is influenced by the context of each country (or region or locality). Additionally, the expert interviews offered several suggestions for policymakers, such as the enhancement of education, financial benefits, and publicity to facilitate individuals’ behavioral responses to cope with climate change. Some research implications, such as non-linear relationships among variables and time effects on those relationships, were also presented to encourage further studies related to this topic. One of the limitations of this research is whether the survey and interview participants adequately represent all experts related to this topic in South Korea, or whether the experts fully understand individual-level risk perceptions and behaviors. Those limitations might weaken the validity of this analysis.
CHAPTER VII
CONCLUSION

Although climate change has attracted the international community’s attention over the past decades, it is still getting worse due to insufficient global efforts in reducing GHG emissions. According to previous studies (e.g., Clayton et al., 2015; Semenza et al., 2008; Shove, 2010), individuals’ daily actions, along with governments’ policies, can be alternatives for alleviating the negative impacts of climate change. Further, activating individuals’ voluntary behavioral responses to address climate change can ease the financial and legal burden of policymakers in designing and implementing climate policies, including rules and regulations. So, unveiling the process of individuals’ behavioral responses against climate change is a very meaningful challenge both academically and practically.

Personal factors and climate change risk perception have drawn much attention from scholars in that they have the potential to intensify individuals’ behavioral responses to address climate change. However, empirical evidence about the causal relationship among personal factors, risk perception, and behavioral responses to mitigate and adapt to climate change, especially within the general public, is rare. Additionally, very few studies have focused on studying this relationship in rapidly developing countries such as South Korea, where greenhouse gas emissions are rising. To reinforce that evidence, after reviewing the literature meticulously in Chapter II and III, this dissertation conducts three empirical analyses (i.e., national, local, and expert levels) through Chapter IV—VI by employing survey and interview data from South Korea. Finally, this current Chapter VII summarizes the content of Chapter II—VI and the attainment of study objectives. It then presents lessons for policymakers and researchers respectively, and concludes with an epilogue.
Content of Chapter II—VI

This section sums up two literature review chapters and three empirical analysis chapters.

Chapter II. By introducing climate change, chronological global efforts to cope with it, and significant issues negatively affecting global collaboration (e.g., complicated features, obscure leadership, and insufficient technological advancement surrounding climate change), this background chapter explained why the several decades-long efforts of the international community against climate change still have not come to fruition. Subsequently, policy-related difficulties facing policymakers and individuals’ response options in addressing climate change, along with the advantages of individuals’ behavioral responses, were presented.

Chapter III. Based on the review of theories associated with the process of individuals’ behavioral responses to cope with climate change, this chapter identified the significant role of risk perception in that process and cast a research question, shedding light on the causal relationship among personal factors (experience, knowledge, and policy assessment), risk perception, and behavioral responses related to climate change. Three identified theoretical approaches (i.e., Kates, 1971; Rogers, 1983; Grothmann & Patt, 2005) and previous empirical studies contribute to setting up five hypotheses and research modeling.\(^{141}\) The kernel of the hypotheses is that higher risk perception affected by personal factors intensifies behavioral responses to address climate change.

Chapter IV. To test the hypotheses, this first empirical analysis chapter focused on climate change risk perception and personal behaviors to mitigate climate change among individual members of the general public at the national level. Data collected from a web-based

\(^{141}\) Simply, four of the hypotheses posit the positive relationship between experience and risk perception (\(H1\)), between general knowledge and risk perception (\(H2\)), between climate policy-related knowledge and behavioral responses (\(H3\)), and between risk perception and behavioral responses (\(H5\)). The other one posits the negative relationship between policy assessment and risk perception (\(H4\)).
survey implemented in South Korea (2016, N=1,500) were analyzed quantitatively. The results of the SEM regression analysis largely supported the expectations from the literature. Even though the analysis found some personal factors, such as short-term experiences (e.g., flood and drought) and the assessment of flood policy, have no relationship with climate change risk perception, most variables, such as long-term climate change experiences, the understanding of the cause of climate change, and the assessment of drought policy significantly affect risk perception. Finally, the results showed that higher climate change risk perception, along with greater climate policy-related knowledge, intensifies behavioral responses to mitigate climate change.142 This chapter, along with the remaining empirical analysis chapters, also provided descriptive results and bivariate correlation coefficients among variables and concluded with policy implications, study limitations and future research directions, and wrap-up.

Chapter V. In the second empirical analysis chapter, the hypotheses were tested by studying drought risk perception and personal behaviors to adapt to drought among individuals at the local level. Also, this analysis included an additional independent variable, self-vulnerability perception related to limited water supply. Based on survey data from north-west area of South Chungcheong Province, South Korea, during severe drought (2015, N=515), this local-level analysis employed SEM regression analysis. The results were somewhat different from what this dissertation predicted. Many personal factors, such as awareness of water quantity condition, exposure to water saving information, and the familiarity with water saving subsidy policy, have a statistically significant relationship with drought risk perception or behavioral responses against drought. However, drought risk perception affected by the personal factors fails to

142 These results are derived from the analysis of the main research model which utilizes the number of behavioral responses as a dependent variable. In the sub models which employ each behavioral response as a dependent variable, risk perception and policy-related knowledge tend to promote direct (e.g., saving energy) and indirect (e.g., donations to environmental organizations) behavioral responses to mitigate climate change, respectively.
significantly influence behavioral responses (both the index of daily action and that of device utilization associated with water saving). Self-vulnerability perception has a negative relationship only with the index of water saving device utilization.

**Chapter VI.** The last empirical and qualitative analysis chapter tried to fill the gaps between this study’s hypotheses and the results of the national and local analyses by lending an ear to expert knowledge. Based on climate change expert interviews (2018, N = 13) and survey (2018, N = 98), the following three important points were drawn. First, most hypotheses were supported by the majority of the experts both in the interviews and survey. Second, some hypotheses (e.g., the positive relationship between experiences and risk perception) are likely to be actualized under certain conditions (e.g., direct, significant, and recent damage). Third, while risk perception plays a significant role in encouraging individuals’ behavioral responses to climate change, its impact is not absolute every time and everywhere. This chapter concluded that individuals’ behavioral responses may operate differently depending on socio-economic contexts (e.g., government’s adaptation capacity), the features of extreme weather events (e.g., recent patterns), or a complicated aspect of human nature (e.g., difficulty in changing behavioral patterns), and that the South Korean context helps explain some of the unexpected results.

**Summary of empirical evidence.** Considering empirical evidence from the national, local, and expert level analyses, policymakers in South Korea should not assume that higher climate change risk perception will necessarily result in higher behavioral responses to climate change. Nevertheless, the findings from this dissertation suggest that risk perception is a credible mediator in the process of individuals’ behavioral responses to address climate change, and governments’ active efforts, such as education, financial incentives, and communication, can facilitate that process. Table 13 summarizes the results of all empirical analyses.
### Table 13. Summary of three empirical analyses

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>National-level analysis</th>
<th>Local-level analysis</th>
<th>Expert-level analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>Positive relationship between experience and RP</td>
<td>water problem experience and DRP (F)</td>
<td>(S) extreme weather event: 84.7% climate change: 70.4%</td>
</tr>
<tr>
<td></td>
<td>Flood experience and CCRP (F)</td>
<td>(I_A) water problem: 84.6%</td>
<td>(I_A) 61.5%</td>
</tr>
<tr>
<td></td>
<td>Drought experience and CCRP (F)</td>
<td>(I_A) water problem: 84.6%</td>
<td>(I_A) 61.5%</td>
</tr>
<tr>
<td></td>
<td>Climate change experience and CCRP (3.086****)</td>
<td>(I_A) water problem: 84.6%</td>
<td>(I_A) 61.5%</td>
</tr>
<tr>
<td>H2</td>
<td>Positive relationship between general knowledge and RP</td>
<td>Awareness of climate change and CCRP (2.216**)</td>
<td>(S) 82.7%</td>
</tr>
<tr>
<td></td>
<td>Understanding of the cause of climate change and CCRP (3.054****)</td>
<td>Awareness of water quantity condition and DRP (3.062****)</td>
<td>(I_A) water problem: 84.6%</td>
</tr>
<tr>
<td></td>
<td>Assessment of flood policy and CCRP (F)</td>
<td>Exposure to water saving information and DRP (1.987****)</td>
<td>(I_A) 61.5%</td>
</tr>
<tr>
<td></td>
<td>Assessment of drought policy and CCRP (1.062****)</td>
<td>Assessment of water supply policy and DRP (1.086****)</td>
<td>(I_A) 61.5%</td>
</tr>
<tr>
<td>H3</td>
<td>Positive relationship between policy assessment and RP</td>
<td>Familiarity with a government GHG reduction plan and BRCC (2.066****)</td>
<td>(S) 74.5%</td>
</tr>
<tr>
<td>H1_1</td>
<td>Positive relationship between experience and BR</td>
<td>Drought experience and BRCC (F)</td>
<td>Water problem experience and DAR (F)</td>
</tr>
<tr>
<td></td>
<td>Flood experience and BRCC (F)</td>
<td>Water problem experience and DUR (F)</td>
<td>Not asked</td>
</tr>
<tr>
<td>H2_1</td>
<td>Positive relationship between general knowledge and BR</td>
<td>Not hypothesized</td>
<td>Exposure to water saving information and DAR (1.049*)</td>
</tr>
<tr>
<td></td>
<td>Not hypothesized</td>
<td>Exposure to water saving information and DUR (F)</td>
<td>Not asked</td>
</tr>
<tr>
<td>H3</td>
<td>Positive relationship between policy-related knowledge and BR</td>
<td>Familiarity with a government GHG reduction plan and BRCC (2.066****)</td>
<td>Familiarity with a subsidy policy related to drought and DAR (1.396*)</td>
</tr>
<tr>
<td></td>
<td>Familiarity with a subsidy policy related to drought and DUR (1.119***)</td>
<td>Familiarity with a subsidy policy related to drought and DUR (1.119***)</td>
<td>(I_M) 69.2% / (I_A) 69.2%</td>
</tr>
<tr>
<td>H5</td>
<td>Positive relationship between RP and BR</td>
<td>CCRP and BRCC (2.605****)</td>
<td>DRP and DAR (F) and DUR (F)</td>
</tr>
<tr>
<td></td>
<td>CCRP and BRCC (2.605****)</td>
<td>SVP and DAR (F) and DUR (1.115****)</td>
<td>(I_M) 69.2% / (I_A) 38.5%</td>
</tr>
</tbody>
</table>

Note 1. This summary focuses a spotlight on the relationship between the dependent and independent variables, except the relationship between the dependent and control variables (e.g., gender, education, and income).

2. RP and BR are an abbreviation of Risk Perception and of Behavioral Responses related to climate change, respectively.

3. (F) refers to the failure in identifying the statistically significant relationship between variables

4. CCRP and BRCC refer to Climate Change Risk Perception and Behavioral Responses to mitigate Climate Change, respectively.

5. DRP, SVP, DAR, and DUR refer to Drought Risk Perception, Self-Vulnerability Perception related to limited water supply, Daily Action Responses, and Device Utilization Responses to adapt to drought, respectively.

6. (S), (I_M), and (I_A) indicate survey, interview related to mitigation, and interview associated with adaptation, respectively.

7. Figures in the expert-level analysis mean the percent of experts who support the hypotheses.

*p<.05, **p<.01, ***p<.001 (two-tailed test)
Attainment of Study Objectives

The goals of this dissertation were improving knowledge about the process of individuals’ behavioral responses against climate change, advancing methodology unveiling that process, and providing viable policy implications for policymakers. This section describes in more detail how this dissertation has achieved each of these goals.

**Improvement of knowledge.** The findings of empirical analyses help accumulate detailed knowledge on individuals’ behavioral responses to climate change. These findings advance the literature in several ways. First, according to previous studies (e.g., Niles, Lubell, & Haden, 2013; O’Connor et al., 2005), extreme weather event experiences are a significant factor influencing risk perception or behavioral responses related to climate change. However, this is not always the case, as this study showed. The relationship between them is likely to vary in different socio-economic contexts (e.g., government’s response capacity). Second, individuals can perceive climate change risk based on general knowledge of climate change (e.g., cause and consequence), which echoes existing studies (e.g., Lee et al., 2015; Shi et al., 2016). Further, climate policy-related knowledge may lead individuals to take action against climate change. This articulates the role of each type of knowledge in facilitating individuals’ behavioral responses. Third, a positive assessment of climate policy turns out to be one of the significant factors negatively influencing climate change risk perception in this study. This provides empirical evidence about the assumption of Grothmann and Patt’s (2005) model that people who view the government as doing their job related to climate change are less likely to feel at risk. Lastly, the positive relationship between risk perception and behavioral responses related to climate change, which many previous studies argue, is a reliable formula, but not an absolute
This study identifies that the impact of risk perception can change depending on socio-economic contexts and the types of climate risk (e.g., drought).

**Advancement of methodology.** A qualitative approach based on expert knowledge can enrich the findings derived from a quantitative approach based on surveys or interviews of the general public. To identify the causal relationship surrounding risk perception and behavioral responses against risks, most previous studies collected data by conducting surveys (or obtaining secondary datasets derived from surveys) and analyzed them by utilizing statistical techniques. While the results of these studies help expand knowledge and provide policy implications, they cannot reveal significant issues affecting the relationship among variables and why some hypotheses are not supported. In overcoming this problem, expert interviews requiring less resources (e.g., time and money), but providing comprehensive and authoritative information from a relatively small number of interviews, can act as an alternative to participant observation and ordinary interviews of the general public, which consume much more resources. Importantly, this study demonstrates the significant role of expert knowledge in elaborating the process of individuals’ behavioral responses to climate change.

**Provision of policy implications.** At least two groups of policymakers directly benefit from the policy implications of this dissertation. Policymakers in South Korea, which is experiencing the rapid increase of GHG emissions, and those in countries with similar socio-economic conditions can obtain critical clues about how to encourage the general public to voluntarily engage in behavioral responses alleviating climate change, instead of being fully responsible for climate change or forcing the general public to follow rules and regulations. Specific policy implications were already suggested in each empirical analysis. Lastly, comprehensive lessons for policymakers are described in the following section.
Lessons for Policymakers

For scholars in professional schools, not only accumulating knowledge, but also illuminating practitioners are core missions in conducting research (Simon, 1967). A practical approach in this study ends with the following three lessons for policymakers. First, the ceaseless efforts of policymakers to encourage individuals’ behavioral responses are indispensable factors needed for the world to address climate change. This study identified that higher risk perception influenced by personal factors is likely to promote individuals’ behavioral responses to climate change. Thus, to activate this process, policymakers should implement diverse strategies, such as delivering accurate and timely climate change information, communicating governmental policy against climate change, and providing behavioral guidelines, rather than just standing still.

Second, policymakers’ strategies should be modified to fit various situations. Different contexts, such as mitigation or adaptation and higher or lower response capacity, are likely to require different strategies to facilitate individuals’ behavioral responses, as are the different effects of climate change (e.g., drought and flood). To solve difficulties in selecting the right strategies for a certain context, continuing collaboration between the academic’s and the practitioner’s worlds is recommended by this dissertation. Third, policymakers must remain vigilant not to miss the forest for the trees in coping with climate change. There is a possibility that strengthening the government-driven climate policies, such as constructing large-scale dams and tightening regulation on industries related to GHG emissions, undermines or crowds out individuals’ behavioral responses. All in all, those policies, generally accompanied by the heavy financial or social burden, are in danger of making no significant progress in addressing climate change. Bueno de Mesquita (2016) warns, “Any policy lever that the government pulls to address some issue is likely to cause at least some new problems in some other domain” (pp. 124–125).
Lessons for Researchers

Considering limitations and research directions presented in each empirical analysis chapter, this section also provides lessons for researchers in three points. First, influential factors on individuals’ behavioral responses to address climate change vary. While this study focuses on three personal factors (i.e., experience, knowledge, and policy assessment) and risk perception, the impacts of other factors (e.g., value, media, and financial benefits) on individuals’ behavioral responses have been identified by many previous studies. Utilizing diverse identified factors simultaneously, comparing the impact of each factor, and collecting and analyzing data derived from various contexts might be appropriate strategies for future research to develop knowledge and support policymakers’ decision-making related to climate policy. Second, depending on cross-sectional survey data and single item-based variable measurement is likely to weaken the validity of study findings. Also, while employing secondary data saves researcher’s resources (e.g., time and money), it deprives them of a chance to use more advanced tools in measuring variables. Unfortunately, many variables in the national and local level analyses for this study were measured by single items from the cross-sectional surveys. Based on collaborative efforts between the academic and the practitioner’s worlds, more precise and standardized measurement tools, which are able to go across lots of different countries, should be developed and shared to enhance the findings of research related to this topic. Lastly, breaking away from traditional research methods (e.g., surveys and interviews of the general public) can facilitate the diversity of methodology in unveiling the process of individuals’ behavioral responses to climate change. Not only the expert interviews conducted by this study, but also others (e.g., participant observation) are recommended. This effort also helps solve the controversial question whether the gap between self-administered behavioral responses and actual behaviors is negligible.
**Epilogue**

Either individually or together, climate change risk perception and individuals’ behavioral responses to address climate change have been investigated by many prominent researchers over a couple of decades. Given that climate change is still ongoing and individuals’ behavioral responses can play an important role in addressing it, the process of individuals’ behavioral responses to cope with climate change is expected to remain in the areas of both much-needed research and government strategy in the future. Although this dissertation has made efforts to satisfy the curiosities of the both areas across the chapters and bears fruit to some extent, many things are still left up to future research. I really hope that more vigorous research projects make significant progress in this research field, based on the findings of this dissertation. Finally, to help produce more penetrating and insightful knowledge about this complex topic, Van de Ven’s (2007) engaged scholarship, which embraces different perspectives of core stakeholders (e.g., researchers, policymakers, public managers, and the general public), is recommended for future studies as an appropriate research form.
REFERENCES


## APPENDIX A

Conceptual map for variables

<table>
<thead>
<tr>
<th>Concepts</th>
<th>Definitions</th>
<th>Indicators</th>
<th>Related studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather</td>
<td>The short-term conditions (changes) of the atmosphere in terms of temperature, precipitation, wind, etc.</td>
<td><em>Auxiliary concept</em></td>
<td>NASA (2011); Lombardi and Sinatra (2012); Rebetez (1996); Weber (2010); Whitmarsh (2008)</td>
</tr>
<tr>
<td>Climate</td>
<td>Average weather conditions over a long period of time (a statistical phenomenon)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate change</td>
<td>A change in the typical or average weather caused by (direct and indirect) human activities or natural origin</td>
<td><em>Auxiliary concept</em></td>
<td>IPCC (2001); NASA (2011); Team, Pachauri, and Reisinger (2007); UN (1992); Whitmarsh (2009b)</td>
</tr>
<tr>
<td>Personal climate change knowledge</td>
<td>Awareness of climate change itself, the understanding of the causes and consequences of climate change, and the familiarity with coping strategies acquired by a person through experience or education</td>
<td>(1) Awareness of climate change (2) The understanding of the cause of climate change (3) The familiarity with a government GHG reduction plan</td>
<td>Banks (1993); Halady and Rao (2010); O’Connor, Bard, and Fisher (1999); Shi et al. (2016)</td>
</tr>
<tr>
<td>Personal climate change experience</td>
<td>Experiences of the long-term features of climate change (e.g., variations in temperature, precipitation, etc.) or short-term extreme weather events (e.g., drought and flood) intensified by climate change</td>
<td>(1) Experiences of variations in temperature, precipitation, etc. over a long period of time (2) Experience of drought (3) Experience of flood</td>
<td>Jentsch, Kreyling, and Beierkuhnlein (2007); NASA (2011); Meehl et al. (2000); Mirza (2003); Revi (2008); Rosenzweig et al. (2001)</td>
</tr>
<tr>
<td>Concepts</td>
<td>Definitions</td>
<td>Indicators</td>
<td>Related studies</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td><strong>Personal climate policy assessment</strong></td>
<td>A subjective evaluation of government policies addressing climate change in terms of necessity, validity, efficiency, effectiveness, etc.</td>
<td>(1) Assessment of drought policy (2) Assessment of flood policy</td>
<td>Crabbé and Leroy (2012); Vedung (2017)</td>
</tr>
<tr>
<td><strong>Climate change risk</strong></td>
<td>The probability of exposure to perilous consequences on the health or living conditions of humans and ecosystems brought by anthropogenic or natural origin climate change (or conditions produced by previous climate change)</td>
<td><em>Auxiliary concept</em></td>
<td>Böhm and Pfister (2001); Jones (2001); Pachauri <em>et al.</em> (2014); UN (1992)</td>
</tr>
<tr>
<td><strong>Climate change risk perception</strong></td>
<td>A subjective evaluation of the probability of climate change (or conditions produced by previous climate change) happening and the severity of and vulnerability to its adverse consequences</td>
<td>(1) The seriousness of climate change impacts</td>
<td>Leiserowitz (2006); Rogers (1983); Sjöberg, Moen, and Rundmo (2004)</td>
</tr>
<tr>
<td><strong>Personal behavioral responses</strong></td>
<td>Actual actions to reduce GHG emissions (e.g., saving energy), to adapt to climate change, or to support climate policies and environmental organizations (e.g., voting and donation)</td>
<td>(1) The number of behavioral responses to address climate change (e.g., saving energy, reducing the use of disposable items, and using renewable energy)</td>
<td>Deng, Wang, and Yousefpour (2017); Grothmann and Patt (2005); Masud <em>et al.</em> (2016); Whitmarsh (2009b)</td>
</tr>
</tbody>
</table>
### APPENDIX B

Key questions of the 2016 survey in South Korea

<table>
<thead>
<tr>
<th>Variables</th>
<th>Questions</th>
<th>1) No experience</th>
<th>2) By drought</th>
<th>3) By flood</th>
<th>4) By both drought and flood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience of drought or flood</td>
<td>Question 23. Have you experienced any property damages caused by flood or drought in the past?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experience of climate change</td>
<td>Based on your experiences in the last ten years, Question 4. Average temperature is ____________ rising. Question 5. Precipitation is ____________ changing. Question 6. The danger of flood is ____________ increasing. Question 7. The danger of drought is ____________ increasing.</td>
<td>1) Definitely</td>
<td>2) Somewhat</td>
<td>3) Little</td>
<td>4) Not</td>
</tr>
<tr>
<td>Awareness of climate change</td>
<td>Question 1. Do you know about global warming and its impacts?</td>
<td>1) Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The cause of climate change</td>
<td>Question 3. What do you think of the contribution of human activities to climate change?</td>
<td>1) Precisely</td>
<td>2) Moderately</td>
<td>3) Hardly</td>
<td>4) Not</td>
</tr>
<tr>
<td>The understanding of a GHG reduction plan</td>
<td>Question 9. To what extent do you know about the Korean government’s reduction plan of Green House Gas (GHG) emissions?</td>
<td>1) Precisely</td>
<td>2) Moderately</td>
<td>3) Hardly</td>
<td>4) Not</td>
</tr>
<tr>
<td>Drought policy assessment</td>
<td>Question 17. What do you think of drought policies for addressing climate change?</td>
<td>1) Very poor</td>
<td>2) Poor</td>
<td>3) Fair</td>
<td>4) Good</td>
</tr>
<tr>
<td>Climate change risk perception</td>
<td>Question 2. What do you think of the adverse impacts of climate change brought by global warming?</td>
<td>1) Strongly serious</td>
<td>2) Moderately serious</td>
<td>3) Hardly serious</td>
<td>4) Not serious</td>
</tr>
<tr>
<td>Variables</td>
<td>Questions</td>
<td>Questions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Behavioral responses to alleviate climate change | Question 20. What kind of behavioral efforts are you currently making to address climate change? Please select all items you have been practicing. | 1) Saving energy  
2) Saving water  
3) Using public transportation instead of a privately-owned car  
4) Reducing the use of disposable items  
5) Utilizing renewable energy  
6) Enjoying a vegetarian diet instead of a meat diet  
7) Donations to environmental organizations  
8) Voting based on environmental-related election promises |
| Gender                                         | Basic Inf. What is your gender?                                           | 1) Male  
2) Female |
| Age                                            | Basic Inf. What is your age?                                              | [   ]  
Please express in numbers. |
| Education                                      | Question 24. What is the highest level of education you have completed?   | 1) Under middle school  
2) High school  
3) Undergraduate  
4) Graduate and above |
| Income                                         | Question 25. How much was your average monthly income before tax last year? | 1) $< \text{KRW 1 million (US$ 909)}$  
2) KRW 1 million (US$ 909) $\leq \text{Inc} < \text{KRW 2 million (US$ 1,818)}$  
3) KRW 2 million (US$ 1,818) $\leq \text{Inc} < \text{KRW 3 million (US$ 2,727)}$  
4) KRW 3 million (US$ 2,727) $\leq \text{Inc} < \text{KRW 4 million (US$ 3,636)}$  
5) KRW 4 million (US$ 3,636) $\leq \text{Inc} < \text{KRW 5 million (US$ 4,545)}$  
6) KRW 5 million (US$ 4,545) $\leq \text{Inc} < \text{KRW 6 million (US$ 5,455)}$  
7) KRW 6 million (US$ 5,455) $< \text{Inc}$ |
**APPENDIX C**

Results of SEM regression analyses with different estimation methods (or options) in the national-level analysis

<table>
<thead>
<tr>
<th>Dependent variables Independent variable</th>
<th>SEM/ML</th>
<th>SEM/ML/ROBUST (SBENTLER)</th>
<th>SEM/ML/BOOTSTRAP</th>
<th>SEM/ADF</th>
<th>GSEM/ML/ROBUST (OLOGIT-POISSON)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate change risk perception</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drought experience</td>
<td>.049</td>
<td>.049</td>
<td>.039</td>
<td>.037</td>
<td>.042</td>
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<tr>
<td>Flood experience</td>
<td>.001</td>
<td>.001</td>
<td>.032</td>
<td>.037</td>
<td>.009</td>
</tr>
<tr>
<td>Climate change perception</td>
<td>.108***</td>
<td>.108***</td>
<td>.008</td>
<td>.109***</td>
<td>.007</td>
</tr>
<tr>
<td>Awareness of climate change</td>
<td>.216***</td>
<td>.216**</td>
<td>.079</td>
<td>.216**</td>
<td>.066</td>
</tr>
<tr>
<td>Cause of climate change</td>
<td>.005***</td>
<td>.005***</td>
<td>.001</td>
<td>.005***</td>
<td>.001</td>
</tr>
<tr>
<td>Assessment of drought policy</td>
<td>-.065**</td>
<td>.022</td>
<td>-.065**</td>
<td>.021</td>
<td>-.069**</td>
</tr>
<tr>
<td>Assessment of flood policy</td>
<td>.021</td>
<td>.022</td>
<td>.022</td>
<td>.022</td>
<td>.022</td>
</tr>
<tr>
<td>Gender (female)</td>
<td>.132***</td>
<td>.132***</td>
<td>.026</td>
<td>.132***</td>
<td>.027</td>
</tr>
<tr>
<td>Age</td>
<td>.002*</td>
<td>.002</td>
<td>.002</td>
<td>.002</td>
<td>.001</td>
</tr>
<tr>
<td>Education</td>
<td>-.008</td>
<td>.020</td>
<td>-.008</td>
<td>.022</td>
<td>-.008</td>
</tr>
<tr>
<td>Income</td>
<td>.005</td>
<td>.008</td>
<td>.005</td>
<td>.008</td>
<td>.005</td>
</tr>
<tr>
<td>Area</td>
<td>-.003</td>
<td>.020</td>
<td>-.003</td>
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<td>-.003</td>
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*\( p<.05 \), **\( p<.01 \), ***\( p<.001 \) (two-tailed test)
### APPENDIX D

Direct, indirect, and total effects of independent and control variables on behavioral responses to mitigate climate change

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<tr>
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<td>.206***</td>
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<td>Assessment of drought policy</td>
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<td>Direct</td>
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<td>Indirect</td>
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*p<.05, **p<.01, ***p<.001 (two-tailed test)
APPENDIX E

Relationship between personal factors and socio-demographic characteristics in the national and local level analyses

E_1. National-level analysis

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<td>-.491*** (.614**)</td>
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<td>(.019***)</td>
<td>(.004)</td>
<td>(.010)</td>
<td>(.999)</td>
<td>(.600***)</td>
<td>(.1004)</td>
<td>(.745***)</td>
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<td>.021*** (.004)</td>
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<td>(.006)</td>
<td>(.0109**)</td>
<td>(.004)</td>
<td>(.010)</td>
<td>(.999)</td>
<td>(.1023***)</td>
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<td>.317 (.212)</td>
<td>2.825*** (.740)</td>
<td>.204* (.081)</td>
<td>-.093 (.084)</td>
<td>-.187* (.829*)</td>
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<td></td>
<td>(.136)</td>
<td>(.859)</td>
<td>(.078)</td>
<td>(1.373)</td>
<td>(.740)</td>
<td>(.1277*)</td>
<td>(.911)</td>
<td>(.829*)</td>
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<td>(.049)</td>
<td>(.1003)</td>
<td>(.030)</td>
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<td>(.291)</td>
<td>(.1051)</td>
<td>(.950)</td>
<td>(.968)</td>
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<td>-.083 (.087)</td>
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<td>.094 (.080)</td>
<td>.062 (.082)</td>
<td>.073 (.083)</td>
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<td></td>
<td>(.135)</td>
<td>(.105)</td>
<td>(.087)</td>
<td>(.955)</td>
<td>(.811)</td>
<td>(.1098)</td>
<td>(.1063)</td>
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<tr>
<td>(Pseudo) R²</td>
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<td>.021</td>
<td>.020</td>
<td>.027</td>
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<td>.025</td>
<td>.012</td>
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<td>Logit</td>
<td>OLS</td>
<td>Logit</td>
<td>OLS</td>
<td>Ordered logit</td>
<td>Ordered logit</td>
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</table>

Note 1. All regression analyses are with robust standard errors.

2. The first and second parentheses display robust standard errors and odds ratios, respectively.

3. Multicollinearity, influential outliers, specification errors, and other significant statistical problems are not detected.

*p<.05, **p<.01, ***p<.001 (two-tailed test)
E_2. Local-level analysis

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<td>Awareness of water quantity condition</td>
<td>Exposure to water saving information</td>
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<td>.323 (.231)</td>
<td>.164 (.220)</td>
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<td>-.023 (.015)</td>
<td>.002 (.012)</td>
<td>.003 (.011)</td>
</tr>
<tr>
<td>Education</td>
<td>-.019 (.314)</td>
<td>.261 (.206)</td>
<td>.088 (.206)</td>
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<tr>
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<td>-.185* (.090)</td>
<td>.043 (.086)</td>
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<td>.873*** (.224)</td>
<td>1.677*** (.198)</td>
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<td>.035</td>
<td>.114</td>
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<td>504</td>
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<tr>
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<td>Logit</td>
<td>Ordered logit</td>
<td>Logit</td>
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</table>

Note 1. All regression analyses are with robust standard errors.

2. The first and second parentheses display robust standard errors and odds ratios, respectively.

3. Multicollinearity, influential outliers, specification errors, and other significant statistical problems are not detected.

*p<.05, **p<.01, ***p<.001 (two-tailed test)
### APPENDIX F

Key questions of the 2015 survey in north-west area of South Chungcheong Province

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<th>2)</th>
<th>3)</th>
<th>4)</th>
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<tr>
<td>Experience of water supply problems</td>
<td>Question 19. Have you experienced any water supply problems (e.g., limited water supply, low pressure, etc.) during this drought period?</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>The condition of water quantity at the national level</td>
<td>Question 1. What do you think of water quantity in South Korea?</td>
<td>Very abundant</td>
<td>Abundant</td>
<td>Scarce</td>
<td>Very scarce</td>
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<tr>
<td>Information about water saving</td>
<td>Question 12. Have you been exposed to a campaign, publicity, or education related to water saving?</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>The understanding of a subsidy policy related to water saving</td>
<td>Question 13. To what extent do you know about the Korean government’s subsidy policy related to water saving during a drought period?</td>
<td>Precisely</td>
<td>Moderately</td>
<td>Hardly</td>
<td>Not</td>
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<tr>
<td>Water infrastructure assessment</td>
<td>Question 5. What do you think of water supply infrastructure (e.g., tap water facilities) in your area?</td>
<td>Very good</td>
<td>Good</td>
<td>Poor</td>
<td>Very poor</td>
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<td>Drought risk perception</td>
<td>Question 3. What do you think of the seriousness of drought in your area?</td>
<td>Very serious</td>
<td>Moderately serious</td>
<td>Hardly serious</td>
<td>Not</td>
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<tr>
<td>Behavioral responses to save water (Daily actions)</td>
<td>Question 14. Regarding tap water savings during this drought period compared to non-drought period, Question 14_1. I’m _______ making an effort to use a glass with water when brushing my teeth. Question 14_2. I’m _______ making an effort to use a wash basin with water when washing my face.</td>
<td>Strongly</td>
<td>Moderately</td>
<td>Hardly</td>
<td>Not</td>
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<td>Question 14_3. I’m ________ making an effort to shorten shower time.</td>
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<td>Question 14_4. I’m ________ making an effort to turn off the faucet which I’m not using it.</td>
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<td>Question 14_5. I’m ________ making an effort to do laundry in a larger quantity.</td>
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<td>Question 14_6. I’m ________ making an effort to use a washing-up bowl when washing dishes.</td>
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<td>Question 14_7. I’m ________ making an effort to inspect a leakage of water.</td>
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<td></td>
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</table>

| Gender | Basic Question 4. What is your gender? |
| Age | Basic Question 5. What is your age? |
| Education | Basic Question 6. What is the highest level of education you have completed? |
| Income | Basic Question 8. How much was your average monthly income before tax last year? |
| Region | Basic Question 1. Where do you live in? |

| Gender | 1) Male 2) Female |
| Age | [ ] Please express in numbers. |
| Education | 1) Under middle school 2) High school 3) Undergraduate and above |
| Income | 1) Inc < KRW 1million (US$ 909) 2) KRW 1million (US$ 909) ≤ Inc < KRW 2million (US$ 1,818) 3) KRW 2million (US$ 1,818) ≤ Inc < KRW 3million (US$ 2,727) 4) KRW 3million (US$ 2,727) ≤ Inc < KRW 4million (US$ 3,636) 5) KRW 4million (US$ 3,636) ≤ Inc < KRW 5million (US$ 4,545) 6) KRW 5million (US$ 4,545) ≤ Inc < KRW 6million (US$ 5,455) 7) KRW 6million (US$ 5,455) < Inc |
| Region | 1) Dangjin city 2) Boryeong city 3) Seosan city 4) Seocheon county 5) Yesan county 6) Cheongyang county 7) Taean county 8) Hongseong county |
# APPENDIX G

Results of SEM regression analyses with different estimation methods (or options) in the local-level analysis

## G_1. Daily action (Range from 0 to 21)

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<th>SEM/ML/ROBUST (SBENTLER)</th>
<th>SEM/ML/BOOTSTRAP</th>
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<td>.079</td>
<td>.094</td>
<td>.076</td>
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<td>.059</td>
<td>.206***</td>
<td>.058</td>
</tr>
<tr>
<td></td>
<td>Exposure to water saving information</td>
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<td>.057</td>
<td>.198***</td>
<td>.056</td>
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<tr>
<td></td>
<td>Assessment of water supply policy</td>
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<td>.063</td>
<td>-.007</td>
<td>.059</td>
</tr>
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<td>Assessment of water infrastructure policy</td>
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<td>-.186***</td>
<td>.051</td>
</tr>
<tr>
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<td>.058</td>
<td>.124*</td>
<td>.058</td>
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## Model fits Acceptable thresholds

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*p<.05, **p<.01, ***p<.001 (two-tailed test)
G_2. Device utilization (Range from 0 to 3)

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*p <.05, **p <.01, ***p <.001 (two-tailed test)
APPENDIX H

Direct, indirect, and total effects of independent and control variables on behavioral responses to adapt to drought

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*p<.05, **p<.01, ***p<.001 (two-tailed test)\"
APPENDIX I

Main questions of the climate change expert interview

1) Can you please provide your full name, academic background, professional title, and research center that you work for?

1) How would you describe the mission/purpose of your research center and your job at the center?

※ In this interview, individuals refer to the general public.

2) How would you describe the importance of the role of individuals in addressing climate change?

3) How would you describe the impacts of individuals’ extreme weather event experiences, such as flood, drought, and heat wave, on their climate change risk perception?

4) How would you describe the impacts of individuals’ long-term climate change experiences, such as the rising of average temperature and the change in precipitation in the last ten years, on their climate change risk perception?

5) How would you describe the impacts of individuals’ knowledge related to climate change on their climate change risk perception?

6) How would you describe the impacts of individuals’ subjective assessment of climate policy (e.g., drought and flood policies) on their climate change risk perception?

7) How would you describe the impacts of individuals’ climate change risk perception on their behavioral responses to address climate change?

8) What kinds of policy, programs, or education could contribute to enhancing individuals’ behavioral responses to address climate change?

9) Is there anyone else with whom you’ve worked that we should speak with about these issues, especially at your research center?
APPENDIX J

Part of the codebook for interview transcription

Coding Instructions:
- Coders should …….. before coding.
- When coding, coders should…….

Codebook:

- **INDROLEIM** – Mentions of the importance of the individuals’ role in addressing climate change
  - IRNIM – Mentions that their role is not at all important in addressing climate change
  - IRSWI – Mentions that their role is somewhat importance in addressing climate change
  - IRVRI – Mentions that their role is very important in addressing climate change

- **INDROLECM** – Mentions of the importance of the individuals’ role in addressing climate change compared to that of other stakeholders’ roles
  - IRLIOSR – Mentions that their role is less important than other stakeholders’ roles, such as governments, industries, and environmental organizations, in addressing climate change
  - IRAIAOSNG – Mentions that their role is as important as other stakeholders’ roles (not including the governments’ role) in addressing climate change
  - IRAIAOSR – Mentions that their role is as important as other stakeholders’ roles, including the governments’ role, in addressing climate change
  - IRMIOSNG – Mentions that their role is more important than other stakeholders’ roles (not including the governments’ role), in addressing climate change
  - IRAIAGR – Mentions that their role is as important as the governments’ role in addressing climate change
  - IRMIOSR – Mentions that their role is more important than other stakeholders’ roles, including the governments’ role, in addressing climate change

- **INDROLEPB** – Mentions of the impacts of individuals’ role on the burden of policymakers in designing and implementing climate policies
  - IRDPB – Mentions that their role decreases the burden of policymakers in designing and implementing climate policies
- **IRNPB** – Mentions that their role has nothing to do with the burden of policymakers in designing and implementing climate policies
- **IRIPB** – Mentions that their role increases the burden of policymakers in designing and implementing climate policies

**STEXPERIENCE** – Mentions of the impacts of individuals’ extreme weather event experiences on their climate change risk perception
- **SENECP** – Mentions of individuals believing climate change is less severe when they experience extreme weather events
- **SEPOCP** – Mentions of individuals believing climate change is more severe when they experience extreme weather events
- **SEORCP** – Mentions of other relationships between climate change risk perception and extreme weather event experiences

**LTEXPERIENCE** – Mentions of the impacts of individuals’ long-term climate change experiences on their climate change risk perception
- **LENECP** – Mentions of individuals believing climate change is less severe when they experience long-term climate change (e.g., the rising of average temperature and the change in precipitation)
- **LEPOCP** – Mentions of individuals believing climate change is more severe when they experience long-term climate change (e.g., the rising of average temperature and the change in precipitation)
- **LEORCP** – Mentions of other relationships between climate change risk perception and long-term climate change experiences

**KNOWLEDGE** – Mentions of the impacts of individuals’ knowledge related to climate change on their climate change risk perception
- **KNNECP** – Mentions that individuals’ knowledge related to climate change decreases their climate change risk perception
- **KNPOCP** – Mentions that individuals’ knowledge related to climate change increases their climate change risk perception
- **KNORCP** – Mentions of other relationships between climate change risk perception and knowledge related to climate change

**ASSESSMENT** – Mentions of the impacts of individuals’ subjective assessment of climate policy on their climate change risk perception
- **PANECP** – Mentions that individuals who perceive higher climate change risks will not support climate policy (or individuals who perceive lower climate change risks will support climate policy)
• PAOCP – Mentions that individuals who perceive higher climate change risks will support climate policy (or individuals who perceive lower climate change risks will not support climate policy)

• PAORCP – Mentions of other relationships between climate change risk perception and climate change policy support

• BERESONSE – Mentions of the impacts of individuals’ climate change risk perception on their behavioral responses to address climate change

  • CPNEBR – Mentions that individuals who perceive higher climate change risks are less likely to take action to address climate change (or individuals who perceive lower climate change risks are more likely to take action to address climate change)

  • CPPOBR – Mentions that individuals who perceive higher climate change risks are more likely to take action to address climate change (or individuals who perceive lower climate change risks are less likely to take action to address climate change)

  • CPORBR – Mentions of other relationships between climate change risk perception and behavioral responses to address climate change

• ALTERNATIVE – Mentions of policy, programs, or education that contribute to enhancing individuals’ behavioral responses to address climate change

  • FIENBR – Mentions of financial incentives (e.g., tax reduction linked to less driving, subsidy and free parking service for electric cars, and electricity or water bill reduction based on an annual energy or water usage pattern)

  • FPENBR – Mentions of financial penalties (e.g., higher taxes on gas guzzlers, temporary water price hike during drought periods, and fines for households which use more water than usual during drought periods)

  • ISENBR – Mentions of information systems (e.g., climate change-specific web-based homepages or digital library systems, off-line libraries, and call centers)

  • PCENBR – Mentions of the enhancement of propaganda, public campaign, etc.

  • EDENBR – Mentions of education included in the regular curriculums (e.g., primary, secondary, or tertiary education)

  • CPENBR – Mentions of civil-participatory decision making processes (e.g., public participation in designing climate policy and the above-mentioned incentive or penalty policy)

  • MCENBR – Mentions of the promotion of multidimensional communication (e.g., seminars, workshops, and public hearings)