Doctoral Thesis

Analysis of Adaptation to Climate Change

- Perception and Behavior of Apple Farmers in Cheongsong, Korea -

(気候変動に対応した適応策の分析
- 韓国青松郡における林檎農家の認識と行動 -)

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Abstract

Climate change poses an enormous threat to the environment, economic and social components of society and it is particularly a vital issue for a sector such as agriculture which depends fundamentally on the climate vulnerable resources. To respond adequately to climate change, agricultural sector requires operational adaptation measures within the community. International, regional and national communities, undertake rigorous researches to find out the solutions to confront climate risks. However, the livelihoods of farmers and rural communities are still facing the great threats from changing climate. It is because most of the introduced adaptation policies fail to address the factors motivating private adaptation behaviors. Climate change adaptation policies without considering farmers' perceptions on climate change and adaptation practices, private adaptation strategies are unlikely to be effective. This dissertation, therefore, investigates the perceptions and behaviors of apple farmers in Cheongsong County, a major apple-producing region of Korea, in response to climate change.

This dissertation aims to examine and analyze local knowledge and perception on consequences of climate variability and change. Therefore, it critically studies how adaptation is governed at micro-level. To meet such objectives, this study based on an integrated theory that has a prominent theory in Protection Motivation Theory (PMT). Integrating the theory which posits that individual action of adaptation is based on social psychological and behavioral economic theories, a Model of Private Proactive Adaptation to Climate Change (MPPACC) explains individual's intention of adaptive behavior that needs to be understood from socio-cognitive factors: climate change risk appraisal and adaptation assessment. In addition to the two most important factors, some cognitive factors such as maladaptation and trust of government are found to have significant role motivating an individual to adapt in response to climate variability and change. This dissertation, based on the socio-cognitive models, has four primary objectives that are: 1) to investigate farmers' awareness and relative issues associated with climate variability and change; 2) to analyze farmers' perception of climate change risk and investigate the influencing factors; 3) to analyze farmers' perception on adaptation efficacy and investigate the influencing factors; 4) and to examine socio-cognitive factors determining farmers' intention to adaptation behaviors. Aiming for such objectives, this dissertation examined the importance of integrating farmers' perceptions into to local adaptation policies to enhance the adaptive capacity of local people.

To analyze the climate change risk and adaptation perceptions and behaviors of apple farmers in Cheongsong County, this dissertation applied mixed methods including, extensive literature review, field observation, farm household survey, and focus group discussions and in-depth individual interviews with local farmers, agricultural government officers, and experts. A structured questionnaire survey of 170 randomly chosen apple farm households in Cheongsong County equipped the primary data on farmers' characteristics, awareness, perceptions, and behaviors. The results of the agricultural household survey together with field observation, focus group discussions and interviews amplified understanding of the process of the farmers' climate change adaptation practices.

The local farmers' were found to have own ways to detect trends of local climate variability and change. A comparative analysis was applied to compare and contrast between the farmers' assessments and scientific findings on climate change. The analysis found that in general, local knowledge on climate change, impacts, and attributes, in fact, were by scientific findings. The local knowledge was found to be shaped by farmers' experiences with climate variability and change. This finding presents policy implication for the local and regional adaptation policy. To develop appropriate strategies to encounter local climate change, and increase resilience to climate risks, it is necessary to incorporate the local knowledge with scientific data, and the integration of the knowledge could deliver a more accurate understanding of practical issues that farmers' faces associated with local climate change.

Farmers' climate risk perception was measured by perceived risk probability and severity of apple production, income, assets, physical health, natural resources, social network, and mental health. Linear regressions emphasized that some demographic and socioeconomic factors, climate change awareness, fear of the future climate risks, climate risk experiences, and information influence the farmers' perception of climate risks. The results pose some policy implications that in designing and disseminating adaptation policies, farmers' risk perception should be considered as an important factor in the adaptive process. Moreover, the quality and sources of information, communicating climate risk issues through local context should be deemed to exploit the promotion of private adaptation policies in rural areas.

Farmer's perception of adaptation efficacy was investigated through examining the factors influencing the farmers' evaluation of adaptation measure, self-capacity, and adaptation costs. The factors including some farm household characteristics and information were found to affect the farmers' perceived adaptation efficacy. The result suggests that improving designing of contents and source of information can enhance farmers' perceptions of adaptation effectiveness. Moreover, some socioeconomic factors including crop insurance were found to be a crucial factor for farmers' perceptions. More localized and specified designing and careful management of the system could enhance the farmers' credibility and perception on adaptation efficacy.

This dissertation, using logistic regressions, found that the farmers' intentions to adaptive behaviors are affected by socio-cognitive factors such as climate risk perception and perceived adaptation efficacy. The findings imply that the cognitive factors significantly influence the farmers' intention of some private adaptation behaviors. Therefore to enhance the farmers' adaptation capacity, relative policies should consider developing cognitive indicators to evaluate the farmers' adaptive responses. Further, the local governments should develop educational programs with integrated climate change risk information and management and the local elder figures can have a significant role in disseminating adaptation information. To promote farmers climate resilience sustainably, it also suggests that the local climate change policy to balance adaptation and mitigation and create international networks to have exchange training programs so as to farmers themselves can share and learn from the experiences.

In sum, this dissertation provides an advanced understanding of the process of farmers' adaptation behavior on socio-cognitive aspects. The findings determine that climate change and rural development research and policies must consider integrating the cognitive factors. Integrating cognitive indicators into farmers' adaptation capacity may enhance long-term climate resilience of agriculture and rural communities.

Acknowledgement

The journey of this doctoral study would never have been successfully completed without the support and contribution of numerous people who I would like to acknowledge and express my deepest gratitude.

Foremost, I would like to express my sincere appreciation to my supervisor Professor Eiji Yamaji, who accepted me as his student and offered me thoughtful advice, patiently supervising me and always guiding me in right direction. I feel privileged to have him as my supervisor, and it has been an excellent experience to learn from his insightful minds. I sincerely appreciate his understanding and support for my study progress. I also deeply appreciate his sincere care for the students.

I also deeply appreciate the committee members, Professor Kazuhiko Kobayashi, Professor Aya Suzuki, Professor Riki Honda and Professor Mikiyasu Nakayama, for their significant and invaluable comments, which enable me to make the necessary improvements according to their comments.

I am very grateful to the Fruit Crop team at the Departments of Agriculture of Cheongsong County for their great support in farm household survey, interviews and local guides. I would like to thank also the apple farmers and local agricultural government officers in Cheongsong that I cannot mention their names one by one; but to mention some are Mr. Jong Seo Lee and Mr. Tae Won Choi for helping me with field trip preparation, implementation and data collection. I owe them so much for their warming hospitality. I am deeply grateful to Dr. Du Hwan Kim for his willingness to help to plan and conduct the field work.

Special appreciation goes to Dr. Ho Seok Kim, Dr. Kong-Jang Cho, Dr. Yeo Ra Chae, and Dr. Jong ho Kim at Korea Environment Institute. I have learned not only academic expertise on climate change and environmental policies but also the attitude of working professionally. I am also thankful to my colleagues at the Global Green Growth Institute for their encouragement.

I want to express my special thanks to my colleagues at the University of Tokyo; Dr. Sophy Ches, Dr. Pun Ishwar, and Miki Nakano and many other friends from AEE laboratory for their support and friendship. My special thanks are with Yu Ri Kim and Geun Woo Lee for their willingness to share their knowledge and experience in the data analysis and application of statistical methods. I enjoyed our conversation regarding many different issues. I am thankful for our time together. I also acknowledge the support from faculties at the International Studies Department for their assistantship in administrative matters. My heartfelt thanks go to my friends in Korea for their support and love. Their support truly encouraged me to move forward.

I am gladly indebted to Dr. Yumiko Tanaka for her infinite support for every stage of this journey. Without her support and encouragement, I would not have had the courage to embark on this journey in the first place. The joy and enthusiasm she has for her profession in international development were motivational for me, and I am also thankful for the admirable example she has provided as a successful woman at work and home. I would also like to thank Dr. Hiromasa Tanaka for his support ever since I came to Tokyo. I owe the Tanaka's so much for their care and hospitality. My appreciation also goes to Ms. Kazuko Noguchi and Ms. Kaoru Noguchi for thoughtful care and support during my stay in Tokyo.

I would like to convey my heartfelt thanks to my parents for their incredible and never ending support and love. They always encourage me to pursue higher education and let me know how much they are proud of me, which motivates me to work harder and stay strong. I am truthfully indebted to their huge support. I would also like to express my thanks to a beloved grandmother who was the biggest supporter of mine. I miss her very much. I truly appreciate my only sister, Bo Yoon Choi, her husband Hyung Taek Byun, and my lovely nephew Aleph Byun for their unlimited support and love for our family. I am deeply grateful to my parents-in-law for their understanding and support.

Lastly but not least, I am greatly indebted to my devoted husband, Jae Chan Hong. It is not sufficient to express my gratitude with only a few words. JC has been a true and great supporter during my good and bad times. His encouragement and support made me feel confident to fulfill my aspiration and to overcome every difficulty I encountered. His unconditional love and support enabled me to complete this journey.

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List of Acronyms and Abbreviations

AGO	Agricultural government officers
AR4	Fourth Assessment Report
AR5	Fifth Assessment Report
AWS	Automatic Weather Station
CC	Climate Change
CCAM	Climate Change Adaptation Measure
CDM	Clean Development Mechanism
COP	Conference of Parties
CCAMP	Climate Change Adaptation Master Plan
CI	Crop Disaster Insurance
ET	Emission Trading
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GMT	Greenwich Mean Time
IPCC	Intergovernmental Panel on Climate Change
JMA	Japan Meteorological Agency
JI	Joint Implementation
KACCC	Korea Adaptation Center for Climate Change
KOSTAT	Statistics Korea
KMA	Korea Meteorological Administration
KREI	Korea Rural Economic Institute
MAL	Maladaptation
MoAFRA	Ministry of Agriculture, Food and Rural Affairs
MoE	Ministry of Environment
MoI	Ministry of Interior
MPPACC	Model of Private Proactive Adaptation to Climate Change
NCDSS	National Climate Data Service System
NDC	Nationally Determined Contributions
NIER	National Institute of Environment Research
PBT	Planned Behavior Theory
PAE	Perceived Adaptation Efficacy
PME	Perceived Adaptation Measure Efficacy
PMT	Protection Motivation Theory
PCE	Perceived Adaptation Cost Efficacy
PSE	Perceived Self-efficacy
RP	Risk Perception
PRP	Perceived Risk Probability
PPS	Perceived Risk Severity
RCP	Representative Concentration Pathways
RDA	Rural Development Administration
ToG	Trust of Government
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VIF	Variance Inflation Factor
VRI	Vulnerability-Resilience Index
WGII	Working Group II
WMO	The World Meteorological Organization

Chapter 1 Introduction

1.1 Research Overview

Climate is a vital factor for human society, economic and environmental systems. Since human activities are inevitably separable from climate, even a small changes or variability in the climate can affect the activities in many different ways. Climate variability and change can have a direct and indirect impact on the agricultural communities where its social and economic systems closely depend on natural resources. Agricultural sector depends heavily on natural resources, and climate is one the most important factors influencing many aspects of the communities associated with the sector. Mitigation and adaptation strategies have received much attention from the global and domestic politics in , and multidisciplinary research communities in responding to climate change. To lessen the damages from the impact of climate change, an effort to achieve adequate mitigation and adaptation strategies is essential. Although mitigation has been the main focus in various discourses, to increase resilience to the impact of climate change, adaptation to climate change is also a vital issue. Unlike mitigation which is a measure to lessen the future consequences of climate change by lessening the greenhouse gas effect, adaptation is a measure to enhance resilience to a vulnerability that is already embedded in the system. Although the climate change is a global issue, to enhance adaptation capacity in the agricultural sector, it is required to understand adaptation in local agenda. South Korean Government has been working arduously to establish a leading role in climate change adaptation policies by developing localized adaptation policies. However, unlike its efforts, Korean farmers associated with the most climate-sensitive crops, such as apples, are confronted with climate risks by high vulnerability and low resilience to climate change. In addition to planned adaptation formed by policies, further understanding of adaptation strategies of people involved in the climate-sensitive agricultural sector can amplify farmers' resilience to climate impacts. However, empirical studies on such farmers' adaptation to climate change are limited. Not only there is a limited study on farmers' adaptation strategies, but not much attention has been given to the process of farmers' adaptation including their perceptions of climate risks and adaptation. Therefore, this dissertation is to investigate the factors influencing Korean farmers' perception and behavior of adaptation to climate change; and is one of the first empirical studies to examine both socioeconomic and socio-cognitive aspects in the process of farmers' climate change adaptation in Korea.

1.2. Research Background

According to many studies including IPCC, it is widely understood that the community where the reliance on natural resources are relatively heavy are more vulnerable to climate change (IPCC, 2007; Abid et al., 2015). This section of the dissertation provides background information: definition of climate change adaptation; the framework of vulnerability; international discourse and the key challenge of climate change; and factors determining farmers' adaptation to climate change.

1.2.1. Definition of Climate Change and Adaptation

Climate change refers to "a change in the state of the climate that can be identified by changes in the mean and/or the variability of its prosperities, and that persists for an extended period, typically decades or longer" (IPCC, 2014 p. 120). Similar to IPCC's definition, the United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as " a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (UNFCCC, Article 1) statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period. Moreover, according to the recent IPCC's fifth assessment report, climate change simply refers to "any change in climate over time due to natural internal processes or external forcing" (IPCC, 2014, p. 120). In many of climate change empirical studies base on this term and climate change is specifically interpreted as changes in temperature, precipitation, rainfall patterns, more frequent and more intense extreme climate events, including rainfall and wind brought by typhoons, floods, drought, heavy rain, heavy heat, etc., sea level rise, unusual timing of seasons and tropical cyclones including typhoon (Deressa, Hassan and Ringler, 2011; Zheng and Dallimer, 2016).

Mitigation and adaptation are major two mechanisms to counter climate variability and change (Smit et al., 1999). Mitigation is an action to reduce the emission of greenhouse gas while adaptation is to moderate the adverse effects of climate variability and change through specific actions (Fussel, 2007). Although there is no universally defined definition of adaptation to climate change, many climate change and adaptation studies bases its understanding of adaptation as defined by IPCC that defines adaptation to climate change as "the process of adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2007, P. 869). Unlike mitigation, the concept of adaptation is not a new mechanism in the history. It existed along with human existence as a human being is faced with climate variability and change throughout the history (Merkuriaw, 2013). However, in recent years the climate variability and change inflict an additional burden on our natural and socioeconomic systems (Berkhout et al., 2004), adaptation emerged as in climate change lexicon as a systematic notion that cannot be continued to be as a habitual way of development. Moreover, unlike mitigation which is the preventative notion of future climate change impact, adaptation is to offset the risks associated with already exposed past emission of greenhouse gas. By increasing adaptation capacity, the system is not only be addressed with the risk associated with climate impacts but also can increase the resilience of the system to the future risk of climate change vulnerability. Climate change adaptation is now an unavoidable option to lessen the damage of climate change.

In many studies on climate change risk, it is argued that there are three different determinants of climate change: vulnerability, exposure, and adaptation. Climate risks or climate "vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed with its sensitivity and its adaptive capacity" (IPCC, 2001; Moss et al., 2001; Yoo et al., 2008). In this framework, IPCC (2007) defines the terms in climate exposure, sensitivity and adaptive capacity as follow: 1) exposure is the degree of climate stimuli received from either long-term changes in climate conditions, or by changes in climate variability, including the magnitude and frequency of extreme events, 2) sensitivity is the degree to which a system will be affected by, or responsive to climate stimuli (Smit et al., 2006) and it can either be biophysical effect climate change and socio-economic changes, and 3) adaptive capacity is the capability of a system to adapt to impacts of climate change, or, it is the potential or capability of a system to adjust to climate change, including climate variability and extremes, so as to moderate potential damages, to take advantage of opportunities, or to cope with consequences (Smit et al., 2006). As in Figure1.1, this study takes IPCC (2007) approach of defining climate change vulnerability that a system's total vulnerability is composed of climate change exposure and sensitivity subtracted by adaptation capacity.

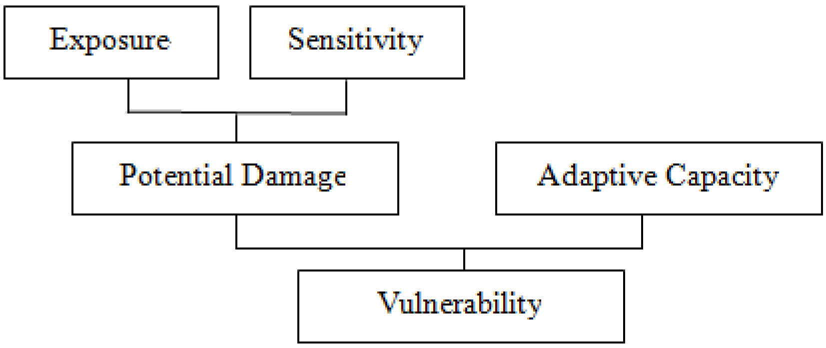

Figure 1.1 Framework of climate change vulnerability

Source: IPCC (2007)

As described above, many related studies cited the definition of adaptation as "the process of adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploit beneficial opportunities" (IPCC, 2007, P. 869). In this definition of adaptation, there are several main points that should be acknowledged. Further, this definition of adaptation is a needed process of the natural and human system to 'adjust' to the existence of actual and anticipated climate conditions.

Moreover, adaptation is also understood not only as the mechanism to lessen the vulnerability of climate impact but also is a mechanism to capture any opportunities that are derived from the climate changes. For example, increasing temperature may influence a place with tropical fruit production negatively on their usual production of tropical fruit. Another place with a temperate place with same climate change may provide a new opportunity for tropical fruit production.

Conceptualizing climate change adaptation should fulfill three basic questions including 'adaptation to what,' 'who or what enact adaptation' and 'how of adaptation' (Smit et al., 1999). The first question of 'adaptation to what' refers to the specific signs of climate variability and change. Different definitions of adaptation may have different 'signs of climate variability and change.' According to IPCC (2001) definition of adaptation, it is 'actual or expected climate stimuli' whereas other definitions may note this as 'climate change,' 'climate,' 'external stresses and so on. The second question of 'who or what enact adaptation' implies to 'individual, group and institutional behavior' (Pielke, 1998) and some cases it implies to 'natural or human system' (IPCC, 2001). Finally the third question on 'how of adaptation' implies the process of adaptation as if it is in 'reactive or anticipatory' (Smit et al., 1999). For a human system of adaptation can be distinguished between administrative and private adaptation, and between reactive adaptation during the climate impact (such as a flood) and precautionary adaptation before the impact of climate variability and change hit the system (Grothmann & Reusswig, 2006). Sometimes the term administrative is interchangeably used with planned, and the term private is used with autonomous adaptation. Administrative or planned adaptation refers to an adaptation action by policy decision, and autonomous, or private adaptation refers to an adaptation initiated and implemented by individuals, households or private companies, and in this private adaptation, it is usually in the actor's rational self-interest (IPCC, 2001). Another definition of private adaptation is "a behavioral response by an individual or a firm to an environmental change for one's own benefit" (Mendelsohn 2000). Another category of adaptation, reactive and precautionary, as defined above, is related to the timing of adaptation. Reactive adaptation refers to an adaptation that takes place in response to previous climate stimuli; whereas precautionary adaptation refers to adaptation to anticipatory climate stimuli (IPCC, 2007). The adaptation under reactive classification is associated with adaptation behavior of natural and ecological systems whereas adaptation behavior of the human system can be associated with reactive or precautionary adaptation (Jones, 2010).

Table 1.1 Examples of proactive and reactive adaptation to climate change

Categories		Proactive (anticipatory)	Reactive
Natural System		• None	• Changes in the length of growing season • Changes in the ecosystem composition • Migration into wetlands
Human system	Private (Autonomous)	• Purchase of insurance • Construction of house on stilts • Search on information • Changes in farm practices	• Changes in farm practices • Changes in insurance premiums • Purchase of air conditioning
	Public (Planned)	• Early-warning system • New building standards • Incentive for relocation • Subsidies for crop insurance	• Compensatory payments and subsidies • Enforcement of building codes • Beach nourishment

Source: Reproduced from Klein (2001)

As noted, there is an existence of different definitions among studies focusing on various perspectives of climate change, impact, system, actor, and adjustment. Many scholars in adaptation studies explain contexts and parameters of adaptation in their studies to lessen the confusion (Smit et al., 2000). In this dissertation, adaptation is referred to 'private (autonomous) proactive (anticipatory)' adaptation that is initiated and implemented by individuals, households or private companies and usually in the actor's rational self-interest (IPCC, 2001). More specifically, by corresponding to the basic three questions, 'adaptation to what', 'who or what enact adaptation' and 'how of adaptation', introduced by Smit et al. (1999), adaptation in this dissertation refers to individual apple farmers' proactive (anticipatory) adaptation behavior to perceived climate variability and change; temperature rise, precipitation change, and extreme weather events. Farm level adaptation to climate change includes farm production practice and farm financial management (Smit & Skinner, 2002). Previous empirical studies on farm-level adaptation indicated that some selected adaptation behavior related to farm production practice are switching crop and varieties, changing the location of production, irrigation, planting trees, production intensification, changing fertilizer uses and changing the timing of farming practices (IPCC, 2007; Dang 2014). Financial management associated with private farmer adaptation includes buying crop or livestock insurance, using income stabilization programs, or diversifying income sources (Deressa et al. 2009; Mendelsohn, 2000; Smit & Skinner, 2002). Moreover to in farm practices, there are some off-farm adaptation strategies by farmers. Some off-farm adaptation strategies are diversifying income source, off-farm employment, and migration (Smit & Skinner, 2002).

1.2.2. An Overview of Climate Change: International Discourse and Key Challenges

International Discourse on Climate Change

Since the nineteenth century, when the concept of Green House Gas effect was introduced by Svente Arrhenius in 1896 (Bodansky, 2001; Bolin, 2007; NAS 2010), the contribution of carbon dioxide to the global environment and global warming began to emerge as a global concern. However, it is until the 1950s that international society was triggered by climate change concerns (Philander, 2008). With earlier studies, two prominent American researchers, Roger Revelle and Charles Keeling who revealed the amount of carbon dioxide in ocean and air, respectively, increased global temperature (Bolin, 2007), raised concerns about climate change as a serious problem and risks that the human being may face in the near future. During the 1970s and 80s, scientific confidence in the global warming studies with the help of sophisticated computer models and experiments increased to support the idea of global warming as an effect to carbon dioxide emission (Bondasky, 2001; Philander, 2008). Gradually, the scientific hypothesis of global warming raised concern in intergovernmental discussions. The first international conference on climate change organized by World Meteorological Organization (WMO) was held in Geneva in 1979 (Bolin, 2007). The main outcome of the conference was to confirm the concern over global warming and required the effort of preventing climate change which is induced by human activities (Philander, 2008). With these concerns, in 1988, the Intergovernmental Panel on Climate Change (IPCC), a UN scientific body with the aim of providing a comprehensive assessment of climate change, is established jointly by World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) (Philander, 2008). Since its first assessment report in 1990 and until the recent publication of the fifth assessment report in 2014, IPCC has been served as the basis for international discussions. Based on IPCC's first assessment report, nations agreed on the problem and signed the United Nations Framework Convention on Climate Change (UNFCCC) at the Earth Summit held in Rio de Janeiro, an international treaty acknowledging the consequences of climate change and aims to lessen the negative impact and stabilize the concentration of greenhouse gas in the atmosphere at a level that would prevent the dangerous impact from anthropogenic cause of climate change (UNFCCC, 1992).

The first international agreement to take serious action to reduce the emission of anthropogenic greenhouse gas was adopted in Kyoto, Japan, in 1997. This agreement in Kyoto, also known as Kyoto Protocol, is a remarkable step toward the actual action of developed countries that are the achievers of earlier economic development that caused immense emission of anthropogenic greenhouse gas into the atmosphere. The first agreement of countries' effort to reduce the emission of a greenhouse gas to reduce any negative impact of climate change was to reduce a combined greenhouse gas emission of 5% during 2008 to 2012 with respect to the 1990s levels (UNFCCC, 1998). Although some success to reducing the sum of emission of greenhouse gas among the committed countries and some increase in emission from other countries including China, the first commitment of Kyoto Protocol ended in 2012 and the second commitment period started in 2013 and will end in 2020. During the second commitment period, committed countries are to reduce greenhouse gas emissions by at least 18 percent below 1990 levels (UNFCCC, 2015). Under the Protocol, countries are to meet the target of emission level primarily through national measures and through three market-based mechanisms including International Emission Trading (ET), Clean Development Mechanism (CDM) and Joint Implementation (JI), offered by the Protocol. The mechanisms are to stimulate green investment and support the countries to meet their emission target in a cost-effective way (Morel & Shishlov, 2014). In December 2015, international negotiation was made to develop 'Paris Agreement' which will be enacted from 2020 when the Kyoto Protocol ends. The major result of this agreement is to enforce 195 countries to achieve 'Nationally Determined Contributions (NDC)' set by each of the countries. Figure 2 shows the key milestones of international climate negotiations since 1992 to the recent Paris Agreement.

Figure 1.2 Key milestones in International Climate Negotiations

Source: Morel & Shishlov (2014)

With regard adaptation, the Kyoto Protocol is designed to assist countries in adaptation to climate change, and the Adaptation Fund was established to finance adaptation projects and programs in developing countries that are committed in the Protocol (UNFCCC, 2015). Although discourse may seem active on the global level, on the contrary, the impacts of climate change are observed at the local love, where the impact might be significantly understood through local people's knowledge and perspectives. Local farming communities largely remain unaware of ongoing scientific and policy debates on the global level, and therefore, they live largely detached from the scientific understanding of climate change and the responding mechanisms to lessen the risks from it.

Current and Future Climate Change

With global and national level efforts to combat the consequences of climate variability and change, there has been a massive improvement of understanding climate variability and change. Climate data became more accurate information are prosperous on the global and national climate variability and change throughout the history and future. According to the most recent IPCC Assessment Report (AR5) published in 2014, "Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia". The report noted that the period from 1983 to 2012 was likely the warmest 30 year period of the last 1400 years in the Northern Hemisphere that it recorded the global temperature has increased 0.85℃ over the period of 1880 to 2012 (IPCC, 2014a). Looking at the observed change in annual global precipitation from 1901 from 2010, since 1951 through current, precipitation has been increased in the countries of mid-latitude land areas of the Northern Hemisphere and the frequency of heavy precipitation events trends to increase in North America and Europe. In contrast, other regions are faced with a significant decrease in precipitation. As global warming progresses, changes in climate extremes appear more. Since 1951, there have been hotter days that were recorded while cold days are less likely shown. Including Asian countries, many countries are now faced with hotter days and heat waves. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen" and projected climate change also shows the rising temperature with more often and lasted longer heat waves, more intense extreme and frequent extreme precipitation events (IPCC, 2014a, 2). As shown in Figure 1.3, future projections of global mean temperature indicate that during 2081~2100, relative to 1986~1995, will at least be higher by 0.3 ℃ and to a maximum 4.8℃. The temperatures of in-lands will rise faster than ocean temperature in the future. The difference in projected increased the temperature of 0.3℃ and 4.8℃ is caused by different solutions for global warming in different scenarios (IPCC, 2014a).

As noted, changed frequency and rate of precipitation and extreme events have been imposing various water-related risks, and it is also projected that progress of global warming will increase the water risk significantly. More specifically, one of the risks that are projected is water scarcity. In one of the scenarios of IPCC, that projects the most rapid global warming, indicated that the current dry places would suffer more severely from the water shortages from more frequent droughts. This will cause serious problem to food shortages. However, in some places with high latitudes will suffer from heavy rains and floods with the progress of global warming. Further, climate change is projected to reduce the quality of raw water and quality of drinking water. In Figure 1.4, from IPCC AR5, shows the increasing number of people who are exposed to large- scale floods in the future.

The AR5 of IPCC indicate that the cause of the changes is clearly influenced by human activities and the recent anthropogenic emission of greenhouse gas are the highest in the history, and this climate change has had "widespread impact on human and natural systems" (IPCC, 2014a, 4). Albeit the efforts to reduce the emission of greenhouse gas, climate change will augment existing risks and creates new risks for the natural and human system. Also, the risks will be presented in unevenly, and more severe for disadvantaged people and communities and the report gave impetus to act upon climate change adaptation (IPCC, 2014a, 13).

Asian countries are experiencing risks from changing climate, and various studies assess future climate change and its impacts on the economy, society, and ecosystems. For example, according to a report published by Ministry of Environment and Japan Meteorological Agency (JMA, 2015), in Japan, the national future climate change also show the change in temperature, precipitation, and extreme events. More specifically, in Japan, there will be about 0.5℃ to 1.7℃ increase in future annual mean temperature and intense rainfall and dry season are both projected according to various scenarios. Although there is significant uncertainty involved with estimating future climate change, the temperature in Japan is projected to increase all around the country, and particularly the northern Japan will increase the most. Impact assessment of the country show that with regard agriculture, in all scenarios, the suitable sites for cultivating citrus Unshiu, a most produced citrus in Japan, will shift to northern areas (MoE, 2015) and apple is also projected to shift its cultivation site to northern part of the country (Fujisawa and Kobayashi, 2012).

Moreover, the significant impact of climate change is also experienced in Korea. In Korea, various institutes are putting their efforts to understand the current and future climate change and the impact of such changes. Similar to Japan, it is projected to have an increasing annual mean temperature which will reduce quality and pattern of crop cultivation in Korea. More specifically, Korean Meteorological Agency data showed that the annual mean temperature in Korea had increased more than the increase in global mean temperature. It indicated that during 1954 and 1999, the mean temperature is recorded to have about 0.23°C/10 years increase but from 1981 to 2001, the data showed 0.41℃/10 years increase, and during 2001 to 2010, it recorded 0.5°C/10years increase. With such changes in climate, Korean agricultural sector has faced with several challenges. In Korea, the most noticeable climate change impact in the agricultural sector is that, because of increasing temperature and other climate-related changes, there has been a shifting cultivation site for climate-sensitive crops (MoE, 2015c). Apple is found to be one of the most climate-sensitive crop cultivated in Korea (MoE 2015c). It becomes crucial consequences that farmers and government officers have to find how to response to climate change impact that the cultivation sites for apple are significantly shifted to the north, and it is projected to continue as the annual mean temperature increases (Kim, 2015). More specifically, in Korea, the projected climate change indicated that there would be a significant shifting of fruit cultivation site to northern part of Peninsular and this consequences of climate change is already experienced in the country and adapting to changing climate is vital for areas where a specific fruit is specialized. Apple is one of the major fruit produced and consumed in Korea and cultivation of apple has been specialized mostly in southern part of Korea, including North Gyeongsang province (RDA, 2013). However, recent years, with the process of global warming, apple is hardly cultivated in the Southern parts of North Gyegonsang province, and the cultivation sites for the apple cultivation are shifting to northern provinces such as Gangwon and Gyeonggi of Korean Peninsula (MoE, 2015c). Climate change augments existing risks and creates now risks that are associated with rural societies (IPCC, 2007), particularly those counties, including Cheongsong County, where the county's economy and the farmers' well-being are heavily depended on climate-sensitive crop, apple. Such county where current and future climate change impact can threat farmers' lives is required to have adequate adaptation measures and the assistance to enhance stakeholders' adaptation capacity to climate change.

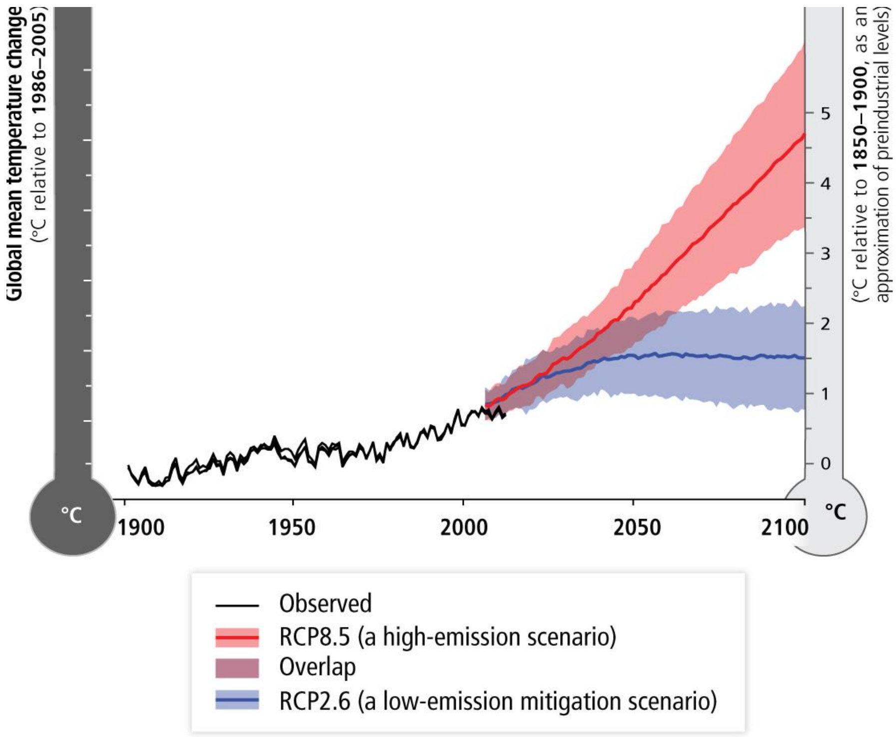

Figure 1.3 Global mean temperature change relative to 1986-2005

Source: IPCC (2014) AR5 WGII TS Box TS 5. Fig.1

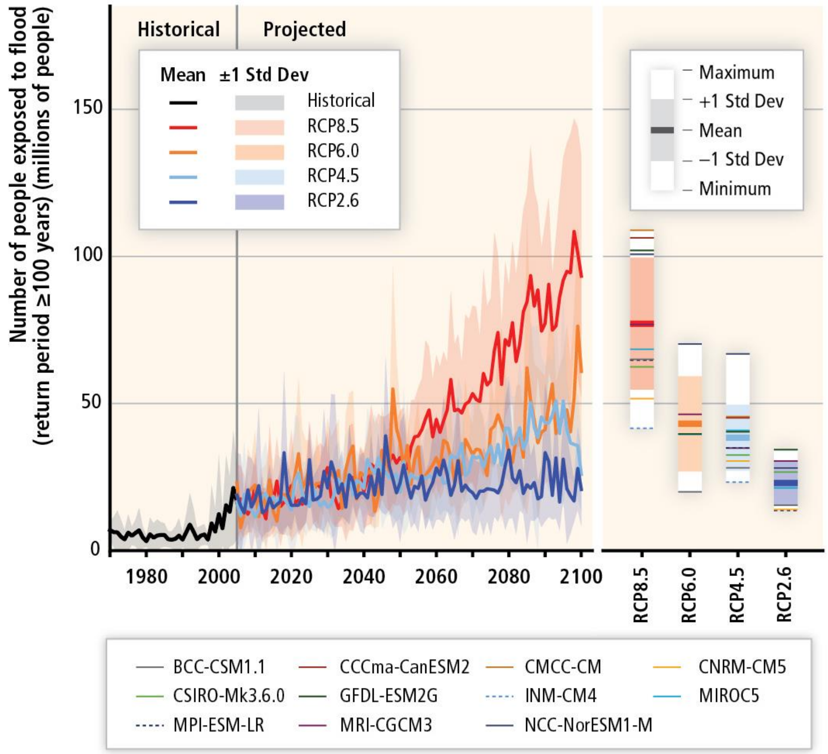

Figure 1.4 World population exposed to flooding projection

Source: IPCC (2014) AR5 WGII TS Fig.6(c)

1.2.3. Factors of Farmers' Adaptation to Climate Change

In some of environmental and development studies, it has been understood that local people's knowledge and perception provides problem-solving strategies and decision-making platforms (World Bank, 1998). However, in the context of climate change and adaptation, the studies that engage local knowledge are limited. Some studies are pointing out the importance of understanding local knowledge into scientific inquiry and formal adaptation strategies (Kelman & West, 2009; Cobb, 2011; Raygorodetsky, 2011; Mekuriaw, 2013). However, most of the related works are only done as tracking and documenting rather than analyzing and incorporating into existing policies. With regard climate change adaptation and farmers' perception and knowledge, it is often challenging to obtain farmers' perception of long-term continuous changes. However, it is crucial in developing regional climate adaptation policies and to fill a paucity of scientific data (Grothmann & Reusswig, 2006; Green & Raygorodetsky, 2010; Mekuriaw, 2013).

Farmers' knowledge and perceptions of climate variables and change have been found vital to adaptive decisions (Maddison, 2006; Hassen & Nhemachena, 2008; Deressa et al., 2009; Gbetibouo, 2009; Mertz et al., 2009, Fujisawa & Kobayashi, 2011). Many studies analyzed the factors influencing farmers' adaptive behaviors, however, not including cognitive factors. Some of the socioeconomic and institutional factors defined by previous studies are access to a resource (Wall & Marzall, 2006). Access to resources including extension service, information, credit, and land can be the main barrier to the adaptive capacity of farmers (Bryan et al., 2009). However, most of the studies weigh the importance of other factors, rather than climate risk perceptions, influenced the adaptive behavior and explain adaptive behavior through a two-step approach. The studies only explain farmers' adaptive capacity is a process of farmers' ability associated with characteristics and resources, and those resources and ability lead to adaptation behavior. By explaining only with this two-step process, the studies try to identify socioeconomic and institutional determinants that lead to adaptation. In other words, the studies only have the concern of what socioeconomic and institution factors other than perception influence adaptation which is borrowed from adoption theories of agricultural innovations.

Although the importance of those factors to understand farmers' adaptive behavior is beyond doubt, explaining those socioeconomic and institutional factors per se might not be sufficient for understanding comprehensive farmers' adaptive behaviors. Some studies indicated that the strength of belief in the reality of climate change and in adaptive capacity explains the adaptation (Blennow & Persson, 2009). It is important to note that how farmers interprete perceived signal is rather important than the signal itself (Mekuriaw, 2013). The perceived risks of individuals are empirically proven to affect the motivation to adapt to climate change (Osberghaus, Finkel & Pohl, 2010). Perceived risks together with the perception of self-efficacy to undertake adaptive measures and the efficacy of adaptation measures to cope with perceived climate variability and change can be a significant role in adaptation decision of farmers. Cognitive factors such as risk perception and perceived adaptive capacity have been examined in previous studies on climate-related risks and verified their influences on farmers' adaptive capacity and decisions (Grothmann & Patt, 2005; Grothmann & Reusswig, 2006; Zheng & Dallimer, 2016). However, the process of adaptation from this cognitive perspective has been limited in determining farmers' adaption to climate change.

1.3 Research Objectives

This dissertation aims to study critically on climate change adaptation process in micro-level and the behavior of apple farmers in Korea, and suggest policy implications encourage and enable effective adaptation of farmers. To achieve the objective, the study pursues the following specific objectives.

- To assess the trends and characteristics of local climate variability and change based on perception of apple farmers in Cheongsong County in Korea and meteorological data;

- To investigate how the farmers perceive risks of climate variability and change and identify the determinants of the farmers' risk perception;

- To investigate how the farmers perceive climate adaptation measures to climate variability and change and identify determinants affecting farmers' perception on adaptation efficacy;

- To investigate cognitive factors affecting the farmers' intention to adaptation to climate change.

1.4 Research Questions and Hypotheses

This study is organized in four main questions that the study strives to address with several hypotheses under those questions.

Question 1: How do apple farmers in Cheongsong perceive climate variability and change?

Hypothesis 1.1: Apple farmers are aware of climate variabilities such as changes in temperature, precipitation, and extreme events similarly as scientific data (meteorological recordings).

Hypothesis 1.2: Subjective assessments of impacts and causes of climate change identified by farmers are in accordance with the objective data provided by scientific literature

Question 2: How do farmers' perceive risks of climate variability and change and what are the factors affecting the farmers' risk perceptions?

Hypothesis 2.1: Farmers have different perceptions on different dimensions of impacts of climate risk

Hypothesis 2.2: Farmers' perception of risk is influenced by previous experience, information, fear, awareness of climate variability, farm demographic and socioeconomic factors

Question 3: How do farmers perceive different adaptation measures to climate variability and change and what are the factors affecting farmers' assessment of adaptation behaviors?

> Hypothesis 3.1: Farmers evaluation of climate adaptive measure is explained by perceived adaptation measure efficacy, perceived self-efficacy and perceived adaptation costs
>
> Hypothesis 3.2: Farmers' perception on adaptation is influenced by farm demographic and socioeconomic factors and climate change and adaptation information

Question 4: What are the cognitive factors that are influencing farmers' intention to adaptation behaviors?

> Hypothesis 4.1 Farmers' adaptation behavior is influenced by risk perception, perceived adaptation appraisals, maladaptation and trust of government

1.5 Significance of the Research

Although Korean government's effort to lessen the damage of climate change, farmers are still suffering from negative impacts of climate variability, and change and the magnitude of damage have been increasing in recent years (Kim et al., 2015). Moreover, carefully projected climate change scenario predicts it to be more severe (MoE, 2014). With concerns of increasing impact of climate change, especially more severe on specific crops such as apple, studies on climate change related topics are actively done in Korea. The major discussions are mostly emphasis on social and economic impact assessment (Kim, Heo & Lee, 2010), the economics of adaptation (Chae, 2010; Kim 2015), vulnerability assessment (Yoo, 2008) and perception of climate change adaptation (Park, Lee & Kim, 2014).

Segregation from the previous studies

This study can contribute as to provide additional findings from the empirical studies on farmers' adaptation and determinants of farmers' motivation to such behaviors that have not been studied in the past. Moreover, farmers' adaptation behavior from the risk response behavior process perspectives is not understood. So far, there is no study investigating cognitive factors on adaptive behaviors process in Korea. Further, there is no investigation of farmers' adaptive behavior from the perspective of risk management including the cognitive factors as important factors for the farmers' climate change adaptive behaviors in Korea.

This dissertation aims to analyze integrated understanding of factors affecting farmers' adaptive behaviors by investigating farmers' awareness of climate change variability and change; factors affecting the perception of risk; factors affecting the perception of adaptation efficacy. Through a theory of protection motivation theory, a key theory in health risk, and a socio-cognitive model on individuals' adaptive behaviors' to climate change, MPPACC, farmers' adaptation behavior to climate change can be investigated. The findings' of this dissertation produce some policy implications for assisting effective adaptation strategies for apple farming communities in Korea. The implication found in this dissertation can be amended to be applied in observing other contexts on climate change adaptation behaviors.

1.6 Thesis Structure

The overall structure and contents of this thesis are depicted in Figure 1.5. Including all of the components in the figure, this thesis is constructed into 7 chapters. The first chapter provides the study background that motivates the investigation of the perceptions and behaviors of apple farmers in response to climate change in Korea. The objectives, the significance and the structure of the dissertation are presented in the chapter. Next, the second chapter provides the information regarding the issues related to climate change in South Korea. Moreover, the second chapter examines information regarding public efforts to enhance resilience and lessen the negative impact of climate change. The third chapter provides previous studies regarding farmers' climate change adaptation. The fourth chapter introduces the research methods for this dissertation. The fifth and sixth chapter provides the results and discussions of analysis on socioeconomic and cognitive factors of farmers' perceptions and behaviors of climate change adaptation in Korea. Finally, the seventh chapter provides the implication of the study and concludes with the summary and the limitation of this dissertation.

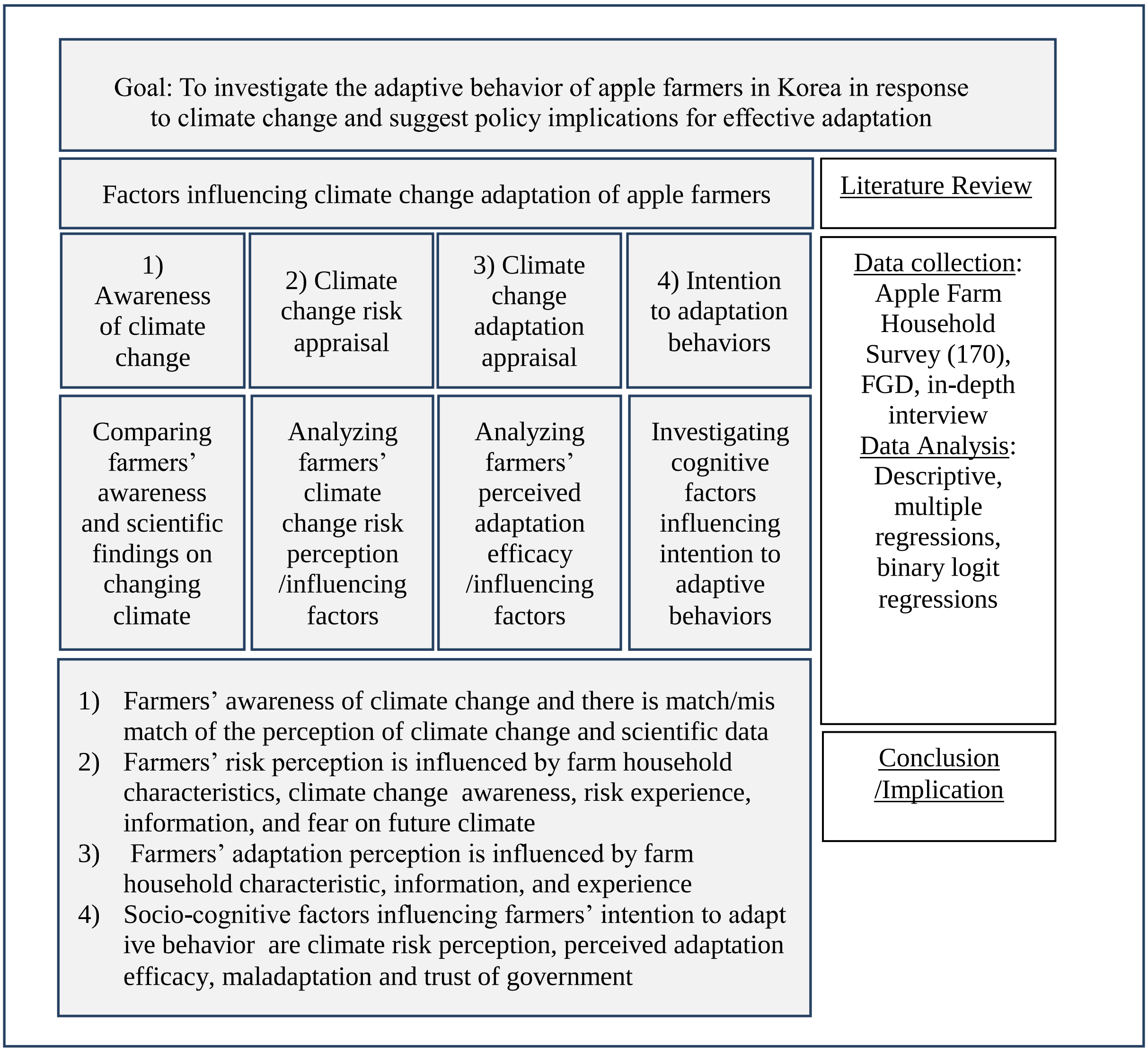

Figure 1.5 Dissertation structure

Chapter 2 Climate Change, Impact and Responses in Korea

2.1 Physical and Human Geography

The Korean Peninsula is located in the northeastern part of East Asia and bordered to the north by China and Russia, and it is lies adjacent to Japan. The west coast of the Korea Peninsula is bounded by the Korean Bay to the north and the Yellow Sea to the south; the east coast faces the East Sea (NGII, 2010). Since 1945, the end of the World War II, the Peninsula is divided into two countries, the communist North Korea and the Republic of Korea in the Southern part of the peninsula by the line at the 38th parallel. From the northern border of North Korea to the southern tip of the South Korea, the length of the Korean Peninsula is approximately 1,100 Km, and the length of east to west is approximately 300km (NGII, 2010). The size of the country is about half of the size of California (Connor, 2009) and 45% constitutes the territory of South Korea, and 55% constitutes North Korea. The peninsula and all of the associated islands lay between 33°06´43" N and 43°00´42" N parallels and 124°11´04" E and 131°52´22"E meridians (NGII, 2010). The latitudinal location of Korea is similar to that of the Greece (NGII, 2010). Longitudinally, Korea shares the same standard meridian of 135°E with Japan. Seoul and Tokyo local time is nine hours earlier than Greenwich Mean Time (GMT). One thing that the Korean Peninsula can be distinguished with other countries is that it has the demilitarized zone (DMZ), which was created by the Korean Armistice Agreement in 1953, that ended the Korean War in a stalemate (Conner, 2009). The zone is created to be used as border protection that extends about 241km through both Koreas and it has about 9.5km wide zone that has more than 1million troops from both Koreas (NGII, 2010).

Since this dissertation focus is on South Korea, it will discuss on only the Republic of Korea or South Korea (Korea). Korea is comprised of three administrative tiers, first tier composed of seven metropolitan cities that are an urban area with a population over one million (Seoul, Busan, Daegu, Incheon, Gwangju, Daejeon and Ulsan with descending order) and nine provinces (*do*). Each of the provinces (*does*) are divided into cities (*si*) that have a population of more than 50,000 and counties (*gun*). Both cities and counties are subdivided into smaller administrative levels. Moreover, Korea can be divided, by geographical sphere, into three regions: Central and South. In the Central region, the capital of Korea, Seoul is included with Gyeonggi, Chungcheong, and Gangwon Provinces; in the South, Gyeongsang, Jolla, and Jeju Provinces are included. Considering its size, Korea has a relatively large number of long rivers that six of the major rivers are more than 400 km long (NGII, 2010). However, most of the Korean lands are not encompassed with arable lands since it is covered mostly with mountainous areas. Approximately 64% of Korea's 100,000 km^2 territory is a mountainous area, and only the remaining 36% of the land (17.1% of farmland and 19.4% others) accommodates over 50 million people (NGII, 2010). As a result, the country's population density is recorded to be the third highest in the world. This status causes the country to face with some disadvantages in managing the environment fragmentation (MoE, 2015d).

Figure 2.1 Map of South Korea

Source: Schäfer (2015) p13

As of 2016, the total registered population in Korea is 51,634,618 that is 26th of world population and among the total population, the male population is about 2,582,692 and female population of 25,831,926 (MoI, 2016). According to the data provided by the Ministry of Land, Infrastructure, and Transportation of the Republic of Korea (MoLIT, 2016), the population density of Korea is high that the most recent data show 500 people per 1 $km^{2,}$ and this is great problem for Korea since it is highly ranked as the densest population rate in the world. As in line with other developing countries, the population growth rate of Korea has been decreasing since 1970 (2.21%) that as of 2013, the growth rate recorded only 0.43%. With decreasing rate of birth, Korea is in the process of aging society that as of 2013, the population with older than 65 covers 12.2% of the total population which has been increasing since the 1980s (MoI, 2016). The population living in urban area accounted for only 28% in the 1960s, however, in recent days, the rate increased to 90% (Connor, 2009). The most populated province in Korea is Gyeonggi Province followed by Seoul city.

2.2 Climate

Korea is located in the middle latitude temperate climate zone and has distinctive seasons of spring, summer, autumn and winter. Generally, in Korea, during the winter season, it is cold and dry while in the summer season, hot and moist climate exist. The cumulative record of weather data is started since the 1900s. However, it is only limited to a certain region, and after the 1970s, about 60 of weather stations recorded the various data related to weather and climate (MoE, 2014). Although the general annual mean temperature of Korea is about 12.4℃, because of the long north-south distance and the complicated topography, the country faces with a wide diversity of local annual mean temperature from 6.4℃ to 16.2℃ (KMA, 2015). According to Korea Meteorological Administration (2015), changes in annual mean temperature of Korea is higher than changes in global mean temperature the process of global warming in Korea is faster as the increased annual mean temperature of Korea recorded as +0.23℃/10years (1954-1999), +0.41℃/10years (1981-2010), +0.5℃/10years (2001-2010). In 2015, the annual mean temperature was 13.4℃ with the maximum annual mean temperature as 18.8℃ and the minimum annual mean temperature as 8.7 ℃ demonstrating higher rate compared to the previous year by 0.9℃, 0.7℃, 1.0℃ respectively. The annual mean temperature of 2015 was the fourth highest year of annual mean temperature since 1973.

According to Korea Meteorological Administration (2015), annual mean precipitation rate in Korea is about 1,200mm which is relatively abundant, however, as in temperature, regional differences are large. In the central area in Korea, the annual mean precipitation rate is from 1,100mm to 1,400mm, and the southern area is about 1,450mm to 1,850mm. Generally, the southern part of Korea has more precipitation rate that on the southeastern coast. And it is visible on the coast of Jeju special self-governing province that the province has the most precipitation in Korea recording a mean annual total of 1,850.7mm (KMA, 2015). More than half of the precipitation is concentrated in the summer season, and this is called *Jangma* (a heavy rainy season in the summer) (NGII, 2010). In 2015, the duration of *Jangma*, were longer in central and southern part of Korea while shortened in Jeju special self-governing province. The rate of precipitation of central (220.9mm) and southern (254.1mm) provinces have shown the decreasing rate, while Jeju (518.8mm) Province has shown increasing rate from a previous year. The annual mean precipitation rate of 2015 was about 240.1mm. Snow season begins during late fall and continues until early spring. Over the mountainous regions, a lower temperature causes the snow season to begin early and end late. Often in the southern province, the snow season begins later and ends earlier, and as a result, the first frost occurs later in the southern part of Korea (KMA, 2015).

In recent years, there has been increasing number of days with extreme events including heat waves, heavy rain, heavy snow or tropical cyclone (typhoons). According to KMA, as of July 2016, the mean temperature for the month recorded 26.2 ℃ which is 0.9℃ higher than July of 2014. Moreover, the average number of days with heat waves in Korea hit the records of 5.5days which is 1.6 days increase from annual days of heat waves (3.6 days). Further, the number of tropical nights also showed that it had been increased by 1.7 days than average tropical nights in Korea (KMA, 2016). Moreover to the heat waves, the number of weather warning has been increasing in recent years.

Global temperature is projected to have the continuous progress of global warming with increasing greenhouse (IPCC, 2014b). Korea will also face such global trend. According to "*Korean Peninsula Climate Change Outlook Report*" (KMA, 2012), Korea will continuously have increasing temperature until 2100. The Future climate scenario concerning the same level of greenhouse gas emission as present level indicated that Korea would increase its annual mean temperature during the beginning, middle and end of the 21st century by +1.4℃, +3.2℃, and +5.3 ℃ respectively. Although less than previous projections with no action on the efforts to mitigation, the projection with scenario considering substantially fulfilled greenhouse gas reduction policies, also indicates increasing temperature during 21st century by +1.2℃, +2.2℃ and +2.8℃ respectively. Both of the scenarios predict the increase in precipitation on the Korean peninsula after the mid-21st century. Particularly during the late-21st century, the precipitation rate is predicted to increase about 3.9 times the global average. Extreme weather indicators such as days of heat waves, tropical nights, and heavy rains are also predicted to increase rapidly according to the scenarios. For instance, annual heat wave duration is expected to be doubled from 10.1 days to 11.7, 15.3 and 17.9 days in the scenario of early, middle and late 21st century, respectively, with substantially fulfilled greenhouse gas emission. However, there will further increase in the days of heat waves, if there is no action performed for the mitigation. The projection indicates that it will increase about four times from current climate, 10.1 days to 40.4 days in the late 21st century. Consequently, even with the intensive effort of mitigation of greenhouse gas, the results of climate projection of Korea require preparing climate change adaptation measures.

Table 2.1 Projected climate change in Korea for 21st century

Categories	**Current Climate (1981-2010)**	**21st Century**			**Tendency (Every 10-years)**
		Early (2011-2040)	***Middle (2041-2070)***	***Late (2071-2100)***	
Average temperature, ℃	12.5	13.7 (13.9)	14.7 (15.7)	15.3 (17.8)	0.31 (0.59)
Maximum temperature, ℃	18.1	19.3 (19.5)	20.3 (21.2)	20.8 (23.4)	0.30 (0.59)
Minimum temperature, ℃	7.7	9.0 (9.1)	9.9 (11.0)	10.6 (13.1)	0.32 (0.60)
Precipitation, mm	1307.7	1,402.9 (1,366.6)	1,442.5 (1,562.5)	1,563.9 (1,549.0)	28.47 (26.81)
Days of heat waves	10.1	11.7 (13.9)	15.3 (20.7)	17.9 (40.4)	0.87 (3.37)
Days of tropical nights	3.8	6.1 (8.9)	14.8 (25.5)	22.1 (52.1)	2.03 (5.37)
Days of heavy rain	2.3	2.6 (2.3)	2.8 (3.3)	3.3 (3.2)	0.11 (0.10)

Source: KMA (2012) Table. 4.2 in page 74.

Note: Numbers in the parentheses indicate the result of using scenario with no action to lessen the emission of greenhouse gas emission. Maximum temperature and minimum temperature are on a daily basis. The tendency is calculated by subtracting data of current climate from a late-21st century and converted to 10-year value.

2.3. Agriculture

During the last 60years, Korea has achieved enormous economic development, and it has become an important country in world economic development. In the past, Korea was a largely agrarian society. However, the modernization and industrialization are the main cause of the growth of Korean economic development. As seen in many of the advanced and developing countries, with such advancement in economic development, a fraction of the primary sector, agriculture, fisheries, and forestry, has been decreasing in Korea. For instance, the number of workers in agriculture was about 1.45 million that is only 5.5% of total workforce in Korea (KREI, 2015). With regard its nation GDP, Korean economy is considered to be one the advanced level, however, considering its relative ratio of agriculture show the country is still in developing level. Although its share of total economy has been decreasing in Korea, according to Korea Rural Economic Institute (2015), the role of Korean agriculture are; 1) producing and supplying food; 2) contributing to development of other industries; 3) preserving the natural environment and the national territory; 4) promoting the preservation of genetic resources and 5) promoting economic and social stability.

Table 2.2 Changes in share of agriculture in Korean economy

Year	GDP (%)				Employment (%)		
	Agriculture, forestry & fisheries	*Agri-culture*	*Forestry*	*Fisheries*	*Agriculture, forestry & fisheries*	*Agriculture & Forestry*	*Fisheries*
1970	29.1	25.4	2.0	1.7	50.4	49.5	0.9
1980	16.0	13.7	1.1	1.2	34.0	32.4	1.6
1990	8.7	7.5	0.4	0.8	17.9	17.1	0.8
2000	4.4	3.7	0.2	0.4	10.6	10.2	0.4
2005	3.1	2.7	0.1	0.3	7.9	7.6	0.3
2010	2.5	2.0	0.2	0.3	6.6	-	-
2014	2.3	2.0	0.1	0.2	5.7	-	-

Source: Korea Rural Economic Institute (2015) Table 1-2 in page 30.
Note: Since 2009, workers associated with agriculture, forestry, and fisheries have not been classified.

Since the pre-industrial period when Korea established its government after gaining the freedom from Japanese colonial rule, the country majored in agriculture. However, Korean agriculture has been evolving over course over history with changing national and international policies and trends. Korean agriculture suffered from low productivity and received food aid from the United States of America up to the mid-1980s (KREI, 2015). However, a rapid improvement in the productivity achieved through several policy reforms and farmers' activities. Moreover, policies supported farm household cultivating cash crop rather than staple grains and also supported farm household to engage in non-farming activities to diversify income portfolio. With globalization, the Korean agricultural market opened during the late 1980s, and the imported agricultural good has increased. According to Korea Rural Economic Institute (2015) as the import of agricultural products increased, the farm household in Korea suffered from competitive price, and the government had to come up with policies to respond to it. Various efforts have been made by government and farmers themselves to protect and secure the Korean agriculture from diversified problems including decreasing land and labor force in agriculture, import and export of agricultural products and so on. In addition to such difficulties in the development of agriculture and rural communities in Korea, global warming and the impact of such phenomena increased risks in Korean agriculture and rural communities. In this section, current and future impact and vulnerability of climate change on Korean agriculture and rural communities will be explored. Moreover, Korean government's efforts to respond to climate change impact and vulnerability, particularly the adaptation to climate change, on agriculture and rural communities will be reviewed.

2.3.1. Current Impact and Vulnerability of Climate Change

According to AR5 of IPCC (2014), the global temperature has been risen by 0.85℃ during 1880 to 2012, and during the same period of time, the average temperature has been risen by 1.8℃. The impact of such phenomenon is the strongest in the vulnerable communities and sectors, such as agriculture, that is heavily depended on the natural resources (Adger et al. 2003). Climate variability and change affect agricultural production through temperature change, precipitation change and extreme events (Merkuriaw, 2013). Currently, there are many studies analyzing the impact of such changes in climate on different kinds of agricultural products. Particularly in Korea, as KMA (2012) published a report projecting Korean peninsula as to be in subtropical climate zones except for limited local communities, many scholars are putting their efforts to find out the impacts of climate change in agriculture and rural communities. As a result, a collaborative report of climate change assessment has been published by Ministry of Environment and the National Institute of Environment Research (NIER) in 2015. According to the report, climate change has been affecting Korean agriculture by increased temperature, increased days of crop period, increased days with no frost and increased damages from extreme events such as heat waves, heavy snow, abnormally hot and cold weather and heavy rain caused by tropical cyclones (typhoon). The most recognized impacts of climate change in Korea are; changes in cultivation and flowering season; production changes of crops; quality changes of crops; changes in insect and pests; and changes in major production areas for crops following the northerning latitudinal shift of suitable lands for cultivation (NIER, 2015; KREI, 2015).

According to a study investigating the changing crop cultivation period by analyzing one farmers' agricultural activity diary during 1980 to 2006, although there was not much of significance, the negative correlation between cultivation period and higher temperature has been found and it indicated increased temperature induced the farmers to cultivate the crop in advance period (Cho, 2008). With regard to the impacts of climate change on the amount of crop production appear to be diverse in different crops, increased magnitude of climate variability by global warming have changed the amount of rice production in Korea relative to past years (MoE, 2011). According to a study analyzing the impact of climate variability and rice yield during 1971-2010 using Granger causal-effect method, climate variabilities such as precipitation, the number of days with rain, duration of sunshine and temperature are showed to have caused changes in rice yields. Moreover, this study, since there is increasing yields of rice by a positive relationship with is increasing temperature in July and August, precipitation increase with less sunshine duration had a negative influence on the rice yields (Noh, 2012). Moreover, RDA (2011) analyzed the rice yield data from 1985 to 2010 found that in recent years with increased extreme event and abnormal climate variability increased the change of rice yield that was steady in past years. With regard, climate variability impact on increased insect and pests, Jung et al. (2014) analyzed climate change and its impact on insect and pest of rice cultivation area panel models, indicated that increasing temperature and precipitation rate have a significant relationship with increased damaged from insect and pets. Moreover, with changing climate variability, Korean agriculture is faced with a new variety of insects that were not found in Korean climate in the past and the diffusion of such impact from newly introduced insects and pests is becoming a serious problem in Korea (Choi et al., 2011). The current status of changes in suitable cultivation areas shows that the cultivation for winter Chinese cabbages, winter potatoes, rye, apples, peaches, tangerines, and green tea have already moving to the northern part of the continent, considerably (MoE, 2011; Kang et al., 2011; Choi et al., 2011; Kim & Lee., 2011; RDA, 2012; RDA, 2014; NIER, 2015; Kim 2015).

Among the vulnerable crops, apple is especially indicated as the most vulnerable to climate change. Apple is one of the perennial crops that are greatly influenced by climate and soil condition (Seo, 2003; RDA, 2004). In Korea, albeit the different variety of apple, generally, adequate cultivation area for apple's annual mean temperature between 8~11℃, during the crop growing season (April to October), the annual mean temperature is between 15~18℃. More specifically, during the summer season (June to August), the adequate mean temperature should be below 26℃, and during the winter season (December to February), the adequate mean temperature should not go below -10.5℃ (Kim et al., 2010). For instance, in Korea, apple is the most cultivated and consumed fruit in Korea (RDA, 2013) and it has been cultivated mostly in the southern part of Korea, North Gyeongsang Province (Kim et al., 2010). In the past, most of the counties of North Gyeongsang Province met the adequate annual mean temperature for apple cultivation, which is 8-11℃, however, in recent years, it has been increased for most of the counties and the future temperature is projected to increase more, requiring careful adaptation measures for such impact of climate change.

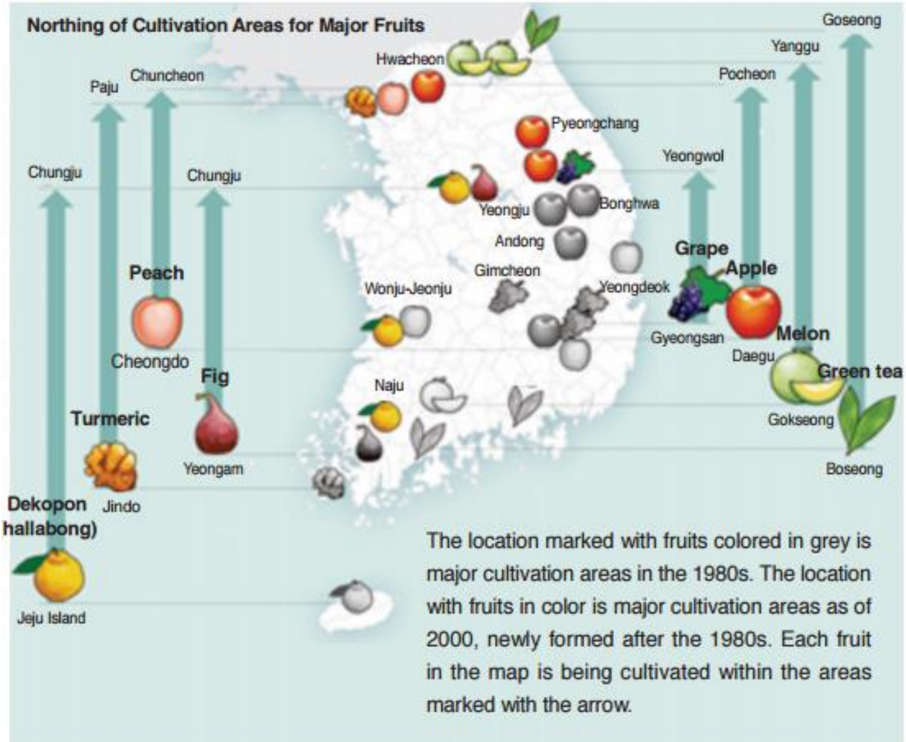

Figure 2.2 Climate change impact on the cultivation area for fruit crops

Source: KREI (2015) p. 428. Fig. 6-12.

2.3.2. Projected Impact and Vulnerability of Climate Change

Until the recent years, typical apple variety produced in Korea is more likely to have greater quality with a cooler climate, however, with increasing temperature, the quality of apple is found to be less advantageous. Particular impacts of climate change on crop production, such as apple, in Korea, are damages from extreme events, changing cultivation period and area, changing productivity quality of crops and insect and pest increase (RDA, 2014). In the coming years, currently found the impact of climate change is projected to continue in the future. Adequate arable temperature is to be 15℃ and because of global warming, days with arable temperature will increase. Not only the number of arable days is projected to increase but also the number of days with the extreme event is projected to increase. Increasing number of days with the extreme event and abnormal climate variability will increase potential damages to farming communities which will increase the vulnerability to climate change with absent of efficient adaptation capacity. In addition, the most noticeable projection of climate change impact is a change of crop planting and cultivation period, change of crop cultivation area, change of production (quantity and quality) of the crop, and change of impact of insects (MoE, 2015c). More specifically, using different climate scenarios, studies found that changing climate variability will change the current period of crop cultivation and this will certainly have a change in crop production and socioeconomic variables from farmers to consumers. Cho (2012) and RDA (2013) project the cultivation areas of major fruits, apple, pear, grape, peach, and persimmon, in Korea and like the results, all of the analyzed crops will lose its cultivation area until the 2090s. For instance, the area of apple cultivation will decrease from 48%, 13% and 1% in 2020, 2050 and 2090 respectively. Previous studies predict the changes in quality and quantity of rice, barley, vegetable and fruits with changing the climate in Korea. Most of the studies indicated that with increasing temperature and vulnerability, there would be decreasing amount and quality of crops.

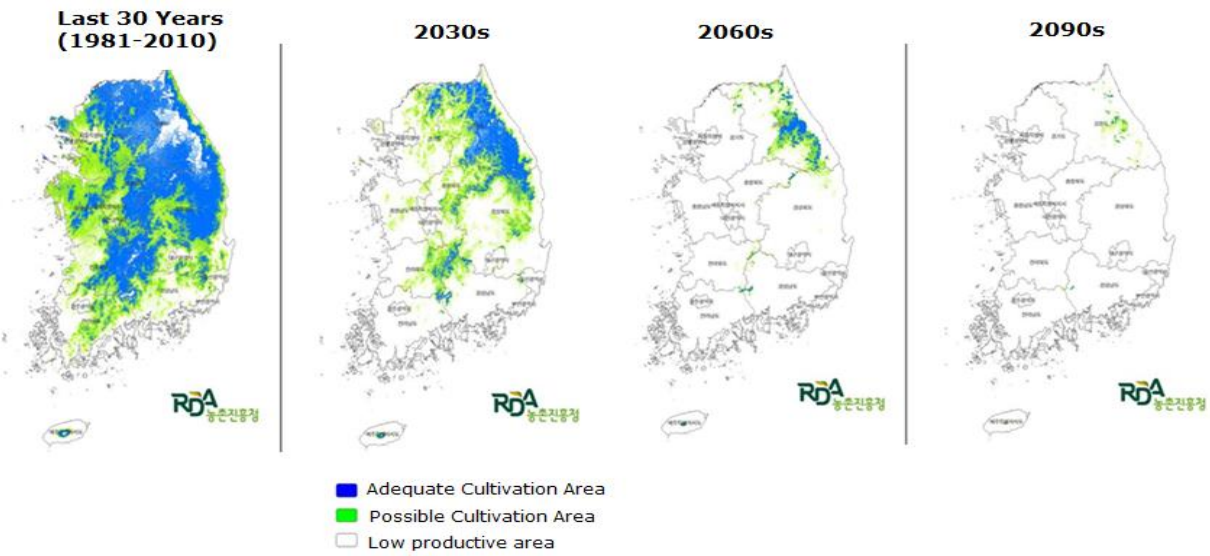

Figure 2.3 Projected cultivation area for apple crop in Korea

Source: Revised from RDA (2014)

Yoon (2010) argues that intensity and dispersion of damage of newly introduced insect and pest on crop will increase with the process of global warming and globalization. Although there are limited studies on the integrated impact assessment of climate change on agriculture, current and future impacts of climate change are found as certain and some impacts found are: biological changes, such as flowering and heading of crops; quality changes of crops; increasing insect and pests; and changes in major production areas for crops moving to northern provinces (MoE, 2015c). With changing the climate, Jeju self-governing province, where produced about 90% of tangerine produced in Korea, now produce subtropical fruits such as mango and kiwi. Cultivation areas for apples, which were focused only in Daegu and north Gyeongsang province in the past, have also been expanded to the most northern regions of Korea including Paju, Pocheon, and Yeoncheon of Gyeonggi province (Choi & Yamaji, 2016). According to RDA (2013), in general, an a1℃ increase of temperature will shift cultivation area north to 80km, and 150 m increase in altitude for suitable cultivation areas. Therefore, it is projected to increase cultivation of subtropical fruits due to changing the climate. In addition to crop production, cultivation area, insects and pest, alleviation of climate change due to greenhouse gas is predicted to have a severe impact on farmers' well-being and rural communities. Although Korean government actively engaged in activities for countermeasure the impact of climate change, without the adequate adaptive capacity of a farmer and rural communities, negative impacts and vulnerability of climate change is an inevitable problem in the future. In the next section of this dissertation will explore the current effort of Korean government to enhance adaptive capacity in agricultural sector

2.3.3. Government Effort for Climate Change Adaptation

Climate change and its impact have been a major concern for international society, economic development, and environment. It is a progressive phenomenon that affects all aspects of society, and it needs to be integrated adaptation approaches. The Korean government, with a growing awareness of necessity and urgency of such approaches, has been setting great efforts for developing adaptation measures to climate change. Specifically, Korean government developed national plans and establishing support organizations for climate change adaptation. In this section, Korean government's systematic approach to climate change adaptation including Climate Change Adaptation Master Plan and associated plans and organization are reviewed. Moreover, crop disaster insurance, a financial instrument of the adaptation measure that prevents farmers from massive climate damages on their farms, is also reviewed in this section.

Korea Adaptation Center for Climate Change (KACCC)

In December 2008, an integrated national climate change adaptation plan with the cooperation of 13 different government ministries called the 'National Comprehensive Plan on Climate Change Adaptation (2009-2030)' was developed and in July 2009, though Presidential Committee on Green Growth, the ' National Strategy for Green Growth and Five-year Plan" was established. The plan included 10 different major national policy tasks, and one of the tasks is to "reinforce climate change adaptation capacity." In July 2009, Korea Adaptation Center for Climate Change (KACCC) was founded to perform strategic climate change related research to provide and support specifically for climate change adaptation related policies. The KACCC acts as various functions to support the government to formulate public adaptation measures to enhance national adaptation capacity. The main functions of KACCC are; to analyze impacts of climate variability and change, to perform climate change vulnerability assessment, to analyze damages and risks of climate variability and change; provide necessary information to policy makers regarding climate change adaptation; to develop network between and among private and public to cooperate on climate change adaptation; to enhance public awareness of climate change and adaptation; to enhance international network on climate change adaptation; and to support government delegations at international discussions on climate change adaptation. The KACCC, as a supporter of government adaptation policies, have been playing the main actor to develop and implement 'Climate Change Adaptation Plan' and support regional and local governments to develop the provincial-level and local-level climate change adaptation plans.

Figure 2.4 Organization chart of Korea Adaptation Center for Climate Change

Source: KACCC (2012) p. 9

Climate Change Adaptation Master Plan (CCAMP) in Korea

In this section, a *summary of the second climate change adaptation master plan (2016-2020*) published by Ministry of Environment (2015e) is applied as the main reference to introduce the overall information regarding the Climate Change Adaptation Master Plan in Korea. In April 2010, the "Framework Act on Low Carbon, Green Growth" was enacted through the national strategy for the low carbon; green growth is to be established every five years and implemented for the period. The framework includes both mitigation and adaptation policies, and for mitigation policy, Korea sets a national goal of reducing greenhouse gas emission and perform necessary measures. Under the Framework Act, 14 ministries with Ministry of

Environment as supervisor, Korea is to develop every 5-year 'Climate Change Adaptation Master Plan (CCAMP).' In 2010, the first 'Climate Change Adaptation Master Plan (2011-2015)' was developed and it includes climate change adaptation plans for 10 different sectors with 87 specified projects. The 10 sectors in the plan include; health, disasters, agriculture, forestry, forestry, marine, and fishing industries, water management, ecosystems, climate change monitoring and prediction, adaptation businesses and energy, education and promotion, and international cooperation.

In 2012, the first CCAMP was revised to apply newly introduced climate change scenario called 'representative concentration pathways (RCP)' by IPCC (MoE, 2015e). Moreover, the specified implementation plan based on the first CCAMP was developed to be implemented during 2013-2015 for nine different sectors with 65 tasks. The basic principle of the 1st CCAMP is to carry out impact analyses and vulnerability assessment in each sector according to the newly introduced scenario, develop the adaptation measures and designate the priority for a vulnerable community that will be most directly impacted by climate change, and focus on identifying cooperative projects. Based on the first CCAMP, each regional and local government are required to develop and implement customized climate change adaptation measures, and each government's performance will be reviewed by Ministry of Environment. The KACCC will support each government on the development of climate change adaptation plan and enhance its adaptive capacity by; providing adaptation plan development manuals, operating workshops, experts' consultation, develop adaptation policy inventory, develop vulnerability maps and analysis tools, and enhance network between governments. Although the first CCAMP created the basis for the micro level such as local level and sectoral climate change adaptation measures, the first stage of the plan needs to move forward to the actual implementation of plans.

The second CCAMP from 2016-2020 is developed and released in December 2015. The second CCAMP is developed by cooperation of 20 different ministries based on the first CCAMP. The second CCAMP is improved from the first CCAMP that it is to analyze risk factors using scientific methods and to consider more on societal concerns such as increasing aging society and vulnerable population. The main principle of the second CCAMP is to develop safer and happier society through climate change adaptation and set the goal to lessen the climate change risks and actualization of opportunities from climate change. The main tasks of the second CCAMP are; to provide more scientifically plausible information and database, to provide safer society by giving priority concerns to vulnerable populations and systematic measures for health and disaster management, to support industries to transfer climate change as opportunities and realize climate change as an important factor for their competitiveness, to provide effective ecological resource management and to participate actively in international cooperation on climate change adaptation. The ministries and regional governments will revise existing adaptation plans based on the second CCAMP by the end of 2016.

Table 2.3 Climate Change Adaptation Master Plan in Korea

Categories	1st term (2011-2015)	2nd term (2016-2020)
Structure	• 14 ministries • 9 sectoral adaptation policy with 67 specific project	• 20 ministries • Integrated adaptation policy categories (Scientific management of climate risk, Development of safe society, Secure industrial competitiveness, sustainable natural resource management) with 20 core projects
Scientific bases	• Major adaptation measures by each sector	• 87 prioritized climate risks
Climate change information	• Vulnerability assessment by sectors • Information from each relative ministries	• Integrated vulnerability assessment • Integrated climate change information and data service
Social Security	• No differentiated measures	• Improve management of vulnerable population and regions
Evaluation	• Annual progress assessment	• Indicators • Integrated assessment

Source: Revised from MoE (2015e) p. 1.

The efforts of the Korean government to combat consequences of climate change has been involved in both mitigation and adaptation policies. Some of the major adaptation measures are being implemented in order to increase agricultural productivity. First, in the agricultural sector, the R&D projects are being actively implemented to produce new varieties resistant to high temperature and disasters. Second, the systems to predict and diagnose plant diseases and insect pests were developed. Third, the early warning system for climate disasters was established and actively operated to provide detailed weather forecast customized for farming activities and households. Fourth, the crop disaster insurance, which functions as a risk-management tool, has been actively expanded widely in Korea (MoE, 2015e). The crop insurance became available since 2005 in Korea and had been evolved to expand the range of crops. Fifth, water management has been strategically systemized to restructure or newly developed to prevent from the negative impact of climate change on water use in agricultural sectors. Sixth, ICT convergence-type smart farms as the result of disaster prevention facilities have been made to reduce the input of energy, water, and chemical fertilizers and increase agricultural productivity (KREI, 2015).

Climate change adaptation is vital to agricultural sector since its direct and profound dependence on natural resources. Because of this reason, the stakeholders, particular farmers, are the most vulnerable people to the climate change risks. Although farmers have their own ways to respond to risks, the farmers' adaptive capacity to climate change is still limited. Moreover, climate change threatens various parts of farmers' lives including crop production, income, assets, and health. Government's adaptation policies can attenuate the potential damage from climate change and amplify to enhance the adaptive capacity of farmers.

Vision	To achieve safer and happier society through climate change	
Goal	To lessen the climate risks and transfer the risks to opportunities	
Main policy	Scientific management of risks	Development of safe society
	•Climate monitoring and warning system •Korean climate change scenario •Climate risk monitoring system •Integrated vulnerability assessment and risk management •Integrated information service	•Vulnerable population protection •Health risk prevention/ management •Vulnerable region/ infra management •Natural disaster management
	Secure industrial competitiveness	Sustainable resource management
	•Enhance adaptive capacity of industries •Enhance adaptive infrastructures •Development of adaptive technologies •Develop bases for international markets	•Species management •Ecosystem revitalization /management •Management of climate risk on ecosystem
Execution Base	Develop bases for domestic and international activities	
	•Enhance effectiveness of policy •Promote regional level adaptive activities	•Enhance international cooperation •Education and promotion of adaptation
Evaluation	Core Plan Index, Progress Index	

Figure 2.5 Summary of Climate Change Adaptation Master Plan in Korea

Source: Revised from MoE (2015e) p. 1.

Crop Disaster Insurance (CI)

To lessen and prevent increasing risks from climate change and natural disaster, Korea has been implemented Crop Disaster Insurance (CI) as a method to manage risk and stabilize the economy for the stakeholders in the agricultural industry. Crop insurance (CI) was first activated in 2001 covering the most sensitive crops: apple and pear in Korea. Some improvements are made in the structure of CI by including more variety of crops to be covered. As of 2015, there are 46 different of crops are included to be covered by CI (MoAFRA, 2015). Table 2.4 shows the overview of CI system in Korea. Within less than 15 years of history, the rate of CI in Korea has been increased rapidly, and it is in continuously increasing trends and settled as an economically securing measure. Moreover, the government having the responsibility of the CI, Ministry of Agriculture, Food and Rural Affairs (MoAFRA) (2015), reports that the CI has been contributing to recovery and secured of farm household from disaster risks. During 2001 to 2014, farm households received about four times of what they actually have invested into CI. The objective of CI is a bottom-up measure to increase farmers' resilience to climate change and natural disasters. The facilitating institution implementing CI is Nonghyup Property & Causality Insurance, a company under Nonghyup, a major farmers' cooperative in Korea. The two coverage options given to the farm households are 70 percent and 80 percent coverage. Apple crop is identified as the most sensitive that is covered from the beginning of the CI, and it is the second highest in the rate of insurance holder (CI covered area divided by targeted area for CI) and the highest in a total insurable amount in total CI in Korea.

Increasing temperature and more unpredictable climate-related events have increased the rate of CI in Korea. Although CI is playing a major financial system to promote farmers' resilience to climate-related risks, some limitations need to be improved: awareness of the importance of CI by farm household without benefit; limited human resources; no existence of differentiated programs for different regions and crops; and low capacity of recording data.

Table 2.4 Overview of Crop Disaster Insurance in Korea

Categories		2001	2002	2006	2007	2008	2009	2010	2011	2012	2013	2014
Program	**Crops covered (Cum.)**	2	6	7	10	15	20	25	30	35	40	43
	Newly added crops	Apple Pear	Grape Peach Sweet-Persimmon Mandarin -	Persimmon	Chestnuts Kiwi Prune	Pea Potato Onion Hot pepper Water-melon	Rice Sweet potato Corn Garlic Plum	Straw-berry Tomato Cucumber Oriental melon Jujube	Pepper Zucchini Rose Chrysan-themum Raspberry	Paprika, Melon Ginseng Odi Tea leaf	Mush-rooms (Oyster , Shiitake) Spinach Lettuce Chinese chives	Cabbage Eggplant Green-onion
Natural disasters damage		Typhoon Hail Frost	(additional) Heavy rain →				All damages excluding insect/disease for newly added crops (formal crops: typhoon, hail, frost, and heavy rain) →					
Subsidy	**Premium**	30	50	58.4	55.6	52.8	50	50	50	50	50	50
	Operatio-nal fee	50	70	100	100	100	100	100	100	100	100	100
Records	**HH 1)**	8	19	27	29	33	46	53	68	75	95	89
	Area 2)	4	11	21	24	26	48	53	87	108	160	134
	Rate3)	17.5	18.3	24.0	22.7	23.1	12.5	13.0	13.6	13.7	19.1	16.2
Claimed settle-ment	**HH1)**	0.4	6.96.9	5.2	7.2	3.4	8.7	14.3	19.6	46.3	8.6	10.8
	Amount4)	14	347	211	615	249	662	903	1,326	4,910	451	1450
	Loss rate3)	45.7	433.4	36.6	110.4	45.0	105.8	104.6	119.5	357.1	21.9	66.9

Source: Revised from MoAFRA (2015)

Note: 1)1,000 households, 2) 1,000 ha, 3) %, 4) 1billion KRW

Chapter 3 Farmers' Adaptation to Climate Change

3.1 Sustainable Development and Farmers' Climate Change Adaptation

Climate change is a threat to the global environment and development. It is projected to have a severe impact on global food security, and the agriculture would be hit most severely and cause suffering, particularly for farmers. Agriculture that is incredibly sensitive to changing climate is the main source of income for the majority of the rural households. Climate change adaptation is widely accepted and may be necessary to assure global, regional and local food security and to protect the livelihood of rural households. According to many studies, adaptation is found to be the effective measure at the farm level, which can reduce climate vulnerability by enhancing rural households and communities capacity to prepare themselves and their farming to changes brought by climate change, avoiding projected damages and supporting them in dealing with adverse events (Abid, 2015).

Adaptation capacity, ability to adapt, is said to be built on the state of development because underdevelopment fundamentally constrains adaptive capacity by limited resources to hedge against climate change threats (Smit et al., 2002). The process of strengthening the adaptive capacity is not simple but involves similar requirements as the promotion of sustainable development. According to Smit et al. (2002), similar requirements as the promotion of sustainable development and climate change adaptation have similarity. It includes;

- Improved access to resources
- Reduction of poverty
- Lowering of inequities in resources and wealth among groups
- Improved education and information
- Improved infrastructure
- Diminished intergenerational inequities
- Respect for accumulated local experience
- Moderate long-standing structural inequities
- Assurance that responses are comprehensive and integrative, not just technical
- Active participation by concerned parties, especially to ensure that actions match local needs and resources
- Improved institutional capacity and efficiency

Enhancing climate change adaptation can be regarded as one component of broader sustainable development initiatives (Ahmad and Ahmed, 2000). Hazards related to climate change have the potential impacts that undermine progress with sustainable development (Simt et al., 2002). Clearly, the adaptive capacity to respond to climate threats is closely associated with sustainable development equity and enhancing climate change adaptation is vital to sustainable development (Smit et al., 2002). Albeit those reasons, not much progress has been made in integrating climate change risks and adaptation into development policies. Enhancing farmers' climate change adaptation will directly or indirectly lead to sustainable development.

3.2 Farmers' Adaptation to Climate Change: Review of Empirical Studies

A substantial number of studies have been conducted to find how farmers are responding to changing climate from different disciplines and various countries' studies explore the determinants of farmers' adaptation behaviors (Abid, 2015; Bruant et al., 2009; Deressa et al., 2009; Hassan and Nhemachena, 2008; Mekuriaw, 2013). Despite the existence of wide-ranging research on adaptation in the agriculture sector to climate change in the international research arena, there is still limited studies on climate change, and adaptation has been done in Korea. Particularly in Korea, the scope of research linking climate change to agriculture is very restricted (Kim, 2015). Most of the studies on climate change and agriculture in Korea have been entirely limited to impacts of climate change on specific crops or sectors, and only a few have looked into economic benefit of climate change adaptation. None of the studies carefully analyzed the aspects of climate change adaptation from the farmers' point of view. Hence, this study was deliberate to segregate from the previous studies and filled the existing gap in Korea with respect to climate change adaptation in the agricultural sector. This chapter reviews existing studies related to farmers' climate change adaptation. First, it reviews various adaptation strategies that are introduced as farmers' adaptation behaviors and review studies on the determining factors of such behaviors.

3.2.1 Farmers' Climate Change Adaptation Behaviors

There have been various themes that are studied under adaptation to climate change in agriculture. The major discussion themes covered in the studies are; climate change impact assessment (Benhin 2008; Kurukulasuriya and Rosenthal 2013; Misara 2013; NIER, 2015) adaptation options and strategies (Binternagel et al., 2010; Conway and Schipper, 2011; Escham and Garforth, 2013), influencing factors to farmers' adaptation (Abid, 2015, Below et al., 2012; Bryan et al., 2009; Deressa et al., 2009; Fujisawa & Kobayashi, 2012; Hassan and Nhemachena, 2008,) and farmers' perception of climate change (Apata et al., 2009; Dang et al., 2014; Deressa et al., 2009; Kim et al., 2015; Mertz et al., 2009, Mekuriaw, 2013). Albeit with different specific objectives in the studies, each of the themes provided significant knowledge and understanding of climate change and adaptation to the research community; and formulated relevant and effective adaptation strategies in agriculture.

Adaptation serves to cushion agricultural impacts from the changes in the climate and will also help to improve the resilience of agricultural structures to uncertain climate impacts (Mekuriaw, 2013). The essentiality of agricultural adaptation is self-evidenced by agriculture's multiple roles in farmers' livelihood. It is not only the source of income, but it also plays to give identity to the farmers. Adaptation to climate change in agricultural sector usually takes place at two broad scales: macro- and micro- levels (Kandlikar & Risbey, 2000). According to the previous studies, macro-level adaptation is associated with adjustments of agricultural production systems at national and regional levels. Particularly through domestic institutions, international policies, markets and other strategic issues (Mekuriaw, 2013). On the other hands, micro-level adaptation in agricultural indicates the adjustments and decision-making at farmers level (Kandlikar & Risbey, 2000; Kim et al., 2016; Kurukulasuriya & Rosenthal, 2003; Nhemachena & Hassan, 2007).This study is at the micro-level of climate change adaptation and therefore, farmers' level of climate change adaptation is reviewed here under.

Climate variation and extreme events can have significant impacts on farm level production, food security and hence, the livelihood of farmers. Climate stimuli, variability and change force farmers to adopt new practices or increase the intensity and quality of traditional adaptation strategies. Although it might be expected that farmers who recognize climate change will take some actions to buffer themselves against its adverse effects (Komba & Muchpondwa, 2015), there are certain strategies that farmers implement to prevent damages from changing the climate. Farmers may implement various types of adaptation strategies which might include changing planting dates, adopting a range of crop varieties, and drought resistant crops, planting trees, increase usage of fertilizer or pesticides, irrigation, some other arm practices which might vary in location and time. Moreover, some farmers can search for other income sources by the exit from agriculture or search for some financial support from the government (Mekuriaw, 2013, Kim et al., 2015). There can be abundant strategies or measures that could be acted as a response to climate change and be undertaken in agriculture stakeholders to adapt to climate change (Smit & Skinner 2002) and also can have numerous characteristics by which adaptations can be distinguished. However, typical ways to characterized farmers' adaptation are adjusting planting dates and techniques, diversifying crops and varieties, managing irrigation, diversifying income sources, gather information to reinforce human and asset safety, moving to other provinces and buying insurance.

According to Below (2010), a study reviewing several studies analyzing data from the countries in Africa, the Americas, Europe, and Asia found that there can be around 104 different practices associated with adaptation to climate change. The adaptation measures are categorized into farm management and technology, financial management, diversification of income profile apart from the farm, government interventions in rural infrastructure, the rural health care services, and risk reduction for the rural population, knowledge management, networks, and governance (Below, 2010). In the study, the selected literature covering various regions and levels indicated that farm management and technology was found to include the highest number of different practices mentioned followed by government interventions in infrastructure; health and risk reduction, knowledge management, networks, and governance; diversification on and beyond farm; and farm financial managements. However, as mentioned, this study includes not only the micro-level adaptation strategies but also macro-level strategies.

According to a study on farmers' perception and the influencing factor of adaptation behavior in Vietnam (Dang, 2014) indicate that the farmers in Mekong delta in Vietnam mentioned several private adaptive measures as their current responses towards perceived climate variability. The author categorizes the climate adaptation options mentioned by the farmer as adjusting planting calendars, adjusting planting techniques, diversifying crops and varieties, managing water use, diversifying income sources, reinforcing human and asset safety, and other measures (Dang et al., 2014).

In Korea, as indicated in the most recent and only study on farmers' adaptation behavior by Kim et al., 2015, farmers' climate change adaptation behaviors are categorized and reviewed. Although the author grouped adaptation measures as to include macro-level adaptation measures, it is important to understand adaptation measures that are taken mostly by Korean farmers. The author groups the climate change adaptation as adaptation technology (development of crops and varieties to substitute, development of production technology, infrastructure, and climate information system), economic measures and policies (insurance, resource management system), training and education (training work skill, education and public relations) and monitoring (climate information monitoring). Table 3.1 shows the categorized adaptation measures and some specific adaptation actions implemented by farmers based on various studies. The grouping is mostly referenced from Dang et al. (2014) that studied on the micro-level, private and farmers' adaptation behaviors.

Table 3.1 Farmers' private climate change adaptation behaviors

Categories	Adaptive Behaviors
Adjusting planting dates	Early planning or harvesting Shortening growing seasons
Adjusting use of resources	Changing the timing of irrigation Changing the timing and amount of fertilizer use Changing the timing and amount of chemical use (pesticides and herbicides) Improve soil condition
Diversifying crops and varieties	Switching to resilient climate crop Diversity crop varieties Using different variety of crop Using crop rotation
Diversifying income portfolios	Changing from farming to non-farming activities Moving from crops to livestock Moving from livestock to crop
Added investments	Buying crop insurance Buying facilities (safety toolkit) Planting trees
Other measures	Paying more attention to warning systems Gathering climate change information Attending more training and education programs

Sources: Revised from Dang et al. (2014) p. 542 and Kim et al. (2015) p. 32

As mentioned, to act on adaptation behavior, farmers must observe changes in climate in advance, however, just observing changing climate itself does not induce farmers to behave in climate change adaptation measures. There are many different factors and reasons motivating farmers to act. Moreover, farmers have their own ways of performing adaptation mechanisms that involve processes that govern their adaptive behavior. An understanding of the process is fundamental as it helps to explore possibilities in dealing with climate change and provide efficient knowledge for better choices for effective adaptation. Next two sections will review studies on the key issues and variables to understanding farmers' behaviors by looking at it from socioeconomic and cognitive perspectives.

3.2.2 Framing Adaptive Behaviors from Socio-economic Perspectives

Studies have been undertaken by experts on farmers' awareness of climate change and the factors influencing choices of adaptation methods. With regard to the studies on farmers' awareness of climate change have found different results on farmers' awareness on changing climate relative to their study areas. For instance, Ishaya and Abaje (2008) found a lack of awareness and knowledge of local climate variability and change by farmers in Jema'a, Nigeria. On the other hand, a study in the Rift Valley and the Blue Nile Basin in Ethiopia, Mekuriaw (2014), reports 96.4 percent of the surveyed households observed changes in the trend of precipitation and the perception of farming households that temperature is rising coincides with temperature recordings of the weather stations. Moreover, the most recent study on awareness of Korean farmers, Kim et al. (2015), found that 82.8 percent of surveyed farmers answered that they acknowledge changing the climate and 97.4 percent of the farmers believe that climate change will continue in the future. As such, farmers' perceptions of climate change have been found important to adaptive decisions (Deressa, Hasan & Ringler, 2011; Gbetibouo, 2009; Mertz et al., 2009). It might be that farmers' perception of climate variability and change play an important role in adaptive behaviors that Deressa (2009) reports, in the Ethiopian study, 58 percent of farmers who are found to detect changes in climate over the past 20 years had responded to it by undertaking some adaptation measures. However, Bryan et al. (2009) indicate that although the majority of the sampled farmers in South Africa and Ethiopia perceived increase in temperature and a decline in rainfall, in fact, many of them did not adapt to the changes perceived.

The concern is that what factors other than simple detection of climate variability and change influence adaptation behaviors. Several factors have been found to explain the adaptation behavior of farmers. It is important to understand factors affecting adaptation behavior since the factors influence the ability to adapt also determine the farmers' adaptive capacity (Smit & Wandel, 2006). In precise terms, Smit & Wadel (2006, p. 287) states that:

> *At the local level, the ability to undertake adaptations can be influenced by such factors as managerial ability, access to financial, technological and information resources, infrastructure, the institutional environment within which adaptations occur, political influence, kinship networks, etc.*

Moreover to the factors indicated in the above study, Smit & Wadel (2006), Nhemachena and Hassan (2007) identify the main factors of adaptation in South Africa, Zambia and Zimbabwe as access to credit and extension, and also awareness. The study suggests enhancing access to credit and information about climate and agronomy to enhance the adaptation capacity. Gbetibouo (2009) presents the main driving factor, for farmers' adaptation in Limpopo basin in South Africa, is the way that they devise their future expectations on future climate in dealing with the changing weather patterns. According to the study, the factor influencing barriers of farmers' adaptation is inadequate access to credit.

Further, farmers' income, the size of the household, farmers' experience, and engaging in non-farm activities affect the adaptive capacity (Asfawa & Admassie, 2004; Below, 2012; Deressa et al., 2009; Hassan & Nhemachena, 2008; Knowler & Bradshaw, 2007). A study in Tanzania, Below (2012), show that main factors influencing farmers' adaptation behaviors are education with gender equality, availability of agricultural extension services, availability of financial services such as microcredit services, access to agricultural inputs and acknowledge the role of public investments.

To form adaptation behaviors, accessing to appropriate information through education seem to have great influence. Education allows farmers to access appropriate information and enhance farmers' knowledge and encourages them to consider adoption of new technologies. Deressa et al. (2009) conclude that farmers' education level increased adaptive measures such as soil conservation and changing planting dates. Deressa et al. (2011) also report that education level and gender of the head of the household, the size of the household, livestock ownership and availability of credit significantly influence the presence of farmers' adaptation in Ethiopia.

Hassan and Nhemachena (2008) found that farming experience as one of the main factors influencing farmers' adaptive behavior that farmers were also more likely to take adaptive measures if they had more experience in farming. However, some other studies (Shiferaw and Holden, 1998) found the age is negatively impacting the adoption of improved soil conservation techniques on their farms in North Shewa since aged farmers are more conservative to change and have the difficulty of adopting new technology to practice. The differences in the ways of thinking between different genders are to influence adaptive behavior differently (Asfawa & Admassie, 2004; Nhemachena & Hassan 2007). However, matter of gender seem to be more contextual rather than innate to gender when we discuss pro-activeness in farming adaptation behavior because some study show male farmers are more likely to be risk-takers, to obtain new technologies and to adjust their farming practices (Asfaw & Admassie, 2004) while other studies show female are more likely to undertake adaptive measures due to their active, intensive involvement in farming practices in some regions (Nhemachena & Hassan, 2007). Farmer households' income level also found to be an important factor influencing their adaptive behaviors (Knowler & Bradshaw, 2007). A higher income allows farmers to perform adaptive measures that are more effective yet more expensive. Not only the income from crop production but also non-farming income influence farmers' adaptation behavior positively that higher farm income significantly increased farmers' behaviors on soil conservation, changing planting dates, crop variety diversification, planting trees and irrigations (Deressa et al., 2009). Not only the level of income matters in adaptation behaviors, but also the mechanisms of selling the crop influence farmers' adaptation behaviors. For instance, Japanese apple farmer is to have higher adaptation behavior if they sell their apple directly to the consumers. (Fujisawa & Kobayashi, 2012).

Access and availability of resources, services, and technologies have been identified to have great influence on adaptation behaviors. To access to agricultural extension, credit and farm assets are more likely to influence farmers' adaptation behavior positively (Bryan et al., 2009). Moreover, access to information on climate change and adaptation options can be crucial for conducting adaptation behaviors (Muller & Shackleton, 2013). Access to some climate and weather information such as temperature and rainfall is found to have a positive influence on farmers' adaptation measures such as probability o using crop variety diversification (Deressa et al., 2009). Moreover to the argument that the information increases the probability of adoption, it can also direct farmers to adopt particular adaptation measures for their farm situation (Deressa et al., 2009). Further, technology availability and accessibility are found to have a significant role in African farmers' adaptation behaviors (Hassan & Nhemachena 2008). Government institutions can play an important factor in farmers' adaptation. Different local were shown to have different impacts on the adaptation of farmers in Benin, and more importantly, the barrier to farmers' adaptive behavior is also found as a lack of trust in state institutions (Baudoin, 2013).

There is a wide range of demographic and socioeconomic factors that have been found to influence farmers' adaptive decisions or to be the barriers to farmers' adaptation. Among various factors, some of the farm characteristics found to be the main factors of adaptation, are age, gender, education, household size, income, sales channel, access to resources, services, and technologies, information, institution, trust of governments, are found to have significant role in farmers' adaptation measures in previous studies. Nevertheless, the reviewed studies were based on selected regions that the factors best describe their particular research contexts, it could be relatively difficult to collate two or more factors. Moreover, each study has different objectives to investigate on specific groups of factors to explain farmers' adaptive behavior. Albeit the different objectives and settings, all of the studies discussed above has offered implications on the importance of socioeconomic factors on farmers' adaptive behavior. Some socioeconomic variables do contribute to whether farmers are willing to conduct adaptive measures. However, to understand the process of adaptation to climate variability and change at farmers' level fully, socioeconomic and institutional factors neglects the role of psychological factors in guiding adaptive behavior (Mekuriaw, 2013).

3.2.3. Framing Adaptive Behavior from Cognitive Perspective

The studies reviewed in the previous section suggested socioeconomic as incentives and assistance to enhance farmers' actual implementation of adaptive behaviors. Such approach is mostly motivated by the influence of traditional economic analysis in the field which has placed its foundation on resource-based assessment paying little or no consideration to psychological factors (Grothmann & Patt, 2005). The importance of socioeconomic related factors in facilitating and determining adaptation is certain. However, when we discuss individual adaptation behavior, such as farmers' adaptive behavior to climate change, the existence of these socioeconomic factors per se does not necessarily motivate individuals to conduct adaptive measures. Furthermore, even in some cases, implementing an adaptive strategy does not necessarily require the collection of objective resources, for instance, adjusting planting dates based on the timing of rainfall. It is probably associated with the perception of climate variability and perception on the risk that motivates farmers to practice on adaptive behaviors. In social science research, there has verified the strong influence of risk perception on people's decision in countering to hazards and environmental stress (Mekuriaw, 2013). Although limited, there are some studies investigating cognitive and psychological factors in farmers' adaptive behaviors to climate variability and change.

According to Gbetibouo (2009), although a large number of farmers are found to be able to detect changes in climate, only a bit larger than a quarter of them had taken adaptive measures since the farmers lacked risk perception even in the availability of enabling socioeconomic factors. Moreover, it was found that farmers who had concerns about the impacts of climate change on their farming activities had a more positive attitude to the adaptive behaviors (Arbuckle Jr. et al., 2013). Human cognition was found to be an important factor of adaptation in Sri Lanka (Esham & Garforth, 2013) and when Australian farmers are skeptical about the climate projections, and they believe that climate change is a part of a natural cycle, their willingness to conduct adaptive behavior was very limited (Kuehne, 2014). Moreover, Vietnamese farmers' intention to adaptation climate change was found to be influenced by various factors including perceived risk of climate change and effectiveness of adaptation measure (Dang, 2014).

A study on individuals' adaptation behaviors explained by socio-cognitive factors was introduced by Grothmann and Patt (2005). Although the study of understanding adaptive behavior from psychological aspect has been ignored by many of the studies, Grothman and Patt (2005), based on Protection Motivation Theory (PMT), developed a conceptual framework for a model of private proactive adaptation to climate change (MPPACC). Although PMT and MPPACC are not directly associated with farmers' adaptation behavior, it is necessary for discussing the model and theory, as it offers a conceptual framework for most of the studies attempt to explain the adaptive behavior of farmers.

Protection Motivation Theory (PMT)

Protection Motivation Theory (PMT) is a psychosocial theory originally developed to explain the protective behavior of people against health threats or risks (Rogers 1983). PMT is one of the four major theories within the domain of psychological research on health behavior (Grothmann & Reussiwg, 2006). However, it has been applied in a wide range of risk-related studies such as protective behavior studies, natural hazards and environmental issues, consumer decision making, biodiversity protection, online safety and climate change (Wolf, Gregory & Stephan; 1986, Grothmann & Reusswig, 2006; Zaalberg & Midden, 2010; Cismaru & Lavack, 2006; Menzel & Scarpa, 2005; Bockarjova et al, 2009; Osberghaus et al., 2010, Dang et al, 2014; Mekuriaw, 2013; Zheng & Dallimer, 2016). PMT was originally proposed by Though Rogers, and it provides many elaborate frameworks for understanding human behavior, overcoming many of the theoretical problems that lead to low correlations between perceptual variables and behavior (Grothmann & Reussiwig, 2006). A feature of PMT is engaged with two major perceptual processes. Although the terms may apply differently in different studies, the general processes explained in PMT are; 1) information observation 2) Threat appraisal (risk perception) and 3) Coping appraisal.

Information is mediated from two sources: information from friends, neighbors and relatives and information from self-observing; and intrapersonal information from personality variables and individual experiences (Dang et al., 2012). With regard information observed by farmers with regard climate, change information is most likely to be obtained from self-observation, public media, neighbors, agricultural extension services, cooperative, or self-experience.

Threat appraisal, also known as risk perception, describes how a person perceives a probability of threat and damage potential (severity) to things that the person values, assuming no change in the person's own behavior Dang et al., 2012). Under the concept of threat appraisal, there are two major subcomponents. 'Perceived probability,' a person's expectation of being exposed to the threat, such as climate change impact on his/her farms. Another component in threat appraisal is 'perceived severity,' the person's approximation of how harmful the consequences of the threat would to the person's valued assets (Grothmann & Patt, 2005).

A coping appraisal is an assessment of one's own ability to cope with and effectiveness of coping measures and with the costs of coping (Grothmann & Patt, 2005). The coping appraisal must come after threat or concern of consequences. According to Grothmann & Patt (2005), It has three subcomponents such as, 'protective response efficacy,' 'perceived self-efficacy,' and' protective cost efficacy.' The first subcomponent, 'protective response efficacy' is a persons' belief that the protective actions will, in fact, be effective to protect from being damaged by the threat, for instance, it is a farmer's belief that diversifying crop variety would be an effective way to lessen the damage from climate change threats. The second component, 'perceived self-efficacy' is a person's evaluation of self-capacity of actually act on the protection responses, for instance, it is the farmers' evaluation of his/her ability to perform diversification of crop variety as to protect from damages of climate change threats. The third component is 'perceived protective response cost efficacy.' It is an evaluation of costs of performing the protective measures. For instance, it is the farmers' evaluation of costs including not only the money invested in the new crop plantation but also the time and effort that could be involved with diversifying crop variety as adaptation measures (Bockarjova et al., 2009; Grothmann & Patt, 2005).

By passing through theses appraisal processes, threat appraisal and coping appraisal directs to either adoption or neglect of preventive behavior (Bockarjova et al., 2009). Gorthmann & Patt (2005) developed a model based on PMT to the context of private (individual) climate change adaptation behavior, called Model of Private Proactive Adaptation to Climate Change (MPPACC). The authors, as PMT, recognized the importance of the two processes in individual's motivation to adapt or not to adapt. According to the authors, a person adapts when there is high threat appraisal and high coping appraisal. In addition to the two process for adaptation, the authors extended PMT model to include variables as maladaptation. According to Grothmman and Patt (2005):

Maladaptation is an avoidant adaptive behavior where people evade actual adaptation process through avoidant reactions such as denial of threat and wishful thinking due to their low levels of objective means to respond or carry out wrong response actions that rather increase damages. Furthermore, maladaptation is considered as an adaptive response where people react by denying or think wishfully to protect their psychological well-being, even though the responses (denial, wishful thinking, etc.) are not adaptive ones in the sense of preventing damage from a threat.

Because of this reason, when a person is willing to adapt to the threat, objective adaptive capacity, including socioeconomic variables, can only explain one's adaptation partially. In MPPACC, objective variables are the direct determinants of adaptation and included supplement variables, such as social discourse and adaptation incentives, which are said to influence perception. Moreover, the model includes other complex cognitive factors that might affect perception irrationally, such as cognitive biases and heuristics, their interest in empirically testing the model was limited to risk perception and perceived adaptive capacity, as the two important components of adaptation process (Mekuriaw, 2013).

The model was applied to two different case studies. The first study was aimed to find out influential factors of individual adaptation measure to flood threats in Germany. The study was conducted with 157 randomly selected residents in Cologn, Germany. The sample residents were living in the area that is high with a probability of flood threats and have four kinds of adaptation measures to prevent flood threats. The authors run two regression models to see the influential factors of such behaviors. One regression model was of socioeconomic factors, including age, gender, school degree, net income and housing tenure, and another regression model with socio-cognitive factors, including risk perception and perceived adaptation capacity. The results show that socioeconomic factors explained 3 to 35 percent of the variation in three of the four adaptive behaviors while socio-cognitive factors explained 26 to 45 percent of the variation in all four cases. In sum, the study shows the stronger influence of psychosocial variables on adaptation decision to prevent flood threats of the residents than that of the selected socio-economic factors (Grothmann & Reusswig, 2006).

Another study applying MPPACC is a qualitative study on farmers' adaptation in Zimbabwe. Farmers are informed of the projected climate variability and change and examined on their behavior change on adaptation to informed climate change. However, the results show that farmers did not have any change regarding responding behavior or adaptation behavior. The farmers not only behaved in an adaptive manner but also had no intention to conduct adaptation. The reasons behind such behavior were found that the farmers' perceived risk and perceived adaptive efficacy were not high or even low. These results support cognitive factors as significant determining factors for adaptation (Grothmann & Patt, 2005).

Individual's intention of adaptive behavior can be determined indirectly by influencing the two main cognitive processes, climate change risk perception, and adaptation appraisal. Several factors have been known to determine risk perception (Botterill & Mazur, 2004; Dang et al., 2014; Grothmann & Patt, 2005; Weistein 1989). Botterill and Mzur (2004) identified psychological issues of decision making of people who make decisions. Grothman & Patt (2005) also indicate that trust of governments' adaptation policies can influence individuals' adaptive behavior that if one trust on public adaptation, as an individual, do not necessarily intent to conduct adaptive behaviors for oneself. Base on this study, it can be assumed that trust in public adaptation can influence how farmers perceive climate change risk (Dange et al., 2012).

Cognitive bias has been an essential element in the decision-making process in uncertainty involved in the environment (Dang et al., 2012). Different cultural backgrounds, social backgrounds, or information can cause an individual to judgment to deviate from rationality (Grothmann & Patt, 2005). The model developed in Grothmann & Patt (2005), the MPPACC, indicate that social relations matter in individuals' risk perception and adaptation assessment. Not only the information received from public media, neighbors, extension services, village leaders, and friends, but also the social interaction between farmers, friends, and other stakeholders can influence farmers' assessment of climate change risk and adaptation.

Risk experience is an another factor found to affect farmers' adaptation behavior Weinstein (1989), argued that having direct experience with climate risks in the past can influence individuals' to perceive themselves as more possible to become the risk recipients and concerns on the climate risks more often than those who do not have risk experience. and it is found that individuals' past risk experiences influence their perception of the relative risks and the responding adaptation behaviors, particularly to flood risks (Grothmann & Reusswig, 2006). Moreover, a protective method that the people choose does have influenced by their risk experience (Weinstein, 1989).

The above studies on developed and developing countries illustrated the significance of psychological factors which has not been addressed in other climate change adaptation studies. Further questions raised by the authors of the two studies are;

- As to what extent the model could be applicable in various cultures and conditions, and in planned and aggregated adaptation decisions?
- What could other socio-cognitive factors be incorporated to enrich the model?
- How could policy influence cognitive factors to improve adaptive capacity?

Answering those questions will be partly an attempt of this dissertation. This dissertation will be to apply and assess the model among subsistence farmers in the Korean context. In addition, this dissertation extends the previous study of Grothman & Patt (2005) by specifically identifying the contributing factors of each of the elements that make up climate change risk perception and perceptive adaptive capacity. The importance of socioeconomic factors in facilitating and determining climate change adaptation is beyond doubt. However, social science research clearly reveals the importance of subjective assessment of risk in individual's decision to respond to threats. Therefore framing farmers' adaptation behavior from cognitive aspect is the aim of this dissertation. This can solve the limitation of limited political implications of the previous studies by providing specific factors that influence cognitive factors to offer more specified and targeted policy implications.

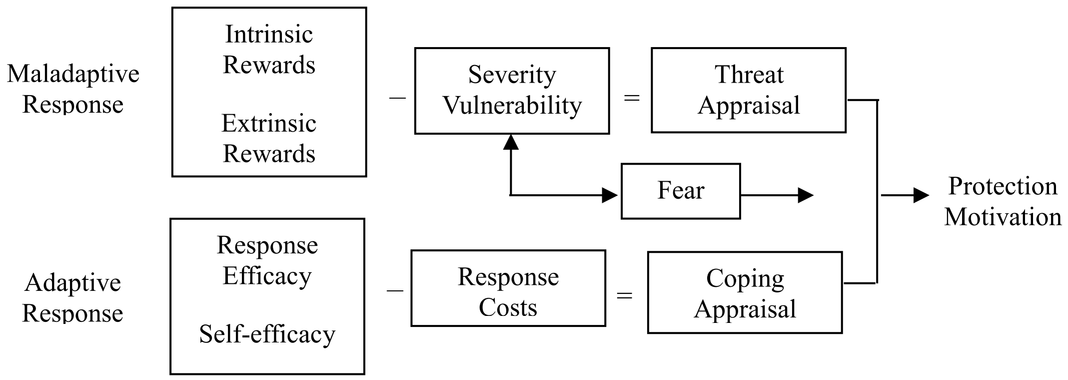

Figure 3.1 Cognitive process of Protection Motivation Theory (PMT)

Source: Floyd, Prentice-Dunn & Rogers, 2000

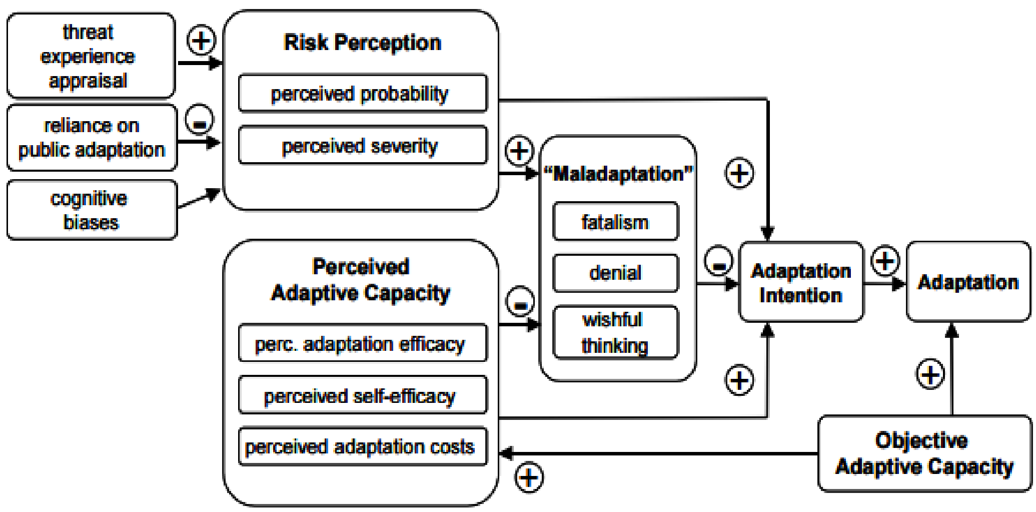

Figure 3.2 Socio-cognitive Model of Proactive Private Adaptation to Climate Change (MPPACC)

Source: Grothmann & Patt (2005) p.7 fig. 1

Table 3.2 Examples of influencing factors of farmers' climate change adaptation

Groups	Influencing factors
Demographic & socioeconomic factors	Age, Gender, Education, Income, Assets, Household size, Farm size, Farming experience, migration off-farm activities, tenure, livestock ownership, past experience
Resources, technologies	Access to credit, access to subsidy, access to funds, availability, and access to information on climate change, availability, and access to information on adaptation, availability and access to agricultural extension services, access to irrigation, access to market, access to new technology, sales channels
Institutional factors	Organization, structure of interactions, government policies, government directions, institutional arrangement on land
Cognitive factors	Cultural or social norms shared values and understandings, belief in the reality or impacts of climate change, the trust of The government, denial, perceived adaptation efficacy, perceived risks, awareness on climate change

Source: Revised from the review of Dang et al. (2014) p. 30, Table 2.

3.3 Farmers' Adaptation to Climate Change in Korea

Although there are limited studies, this section introduces the previous literature on micro-level adaptation to climate change in Korea. As indicated in the previous chapters, issues relevant to climate change and adaptation have been receiving great attention to scholars and policy makers. Impact and vulnerability analysis of climate change has been actively presented, and some of the studies assessed economic benefits and costs of conducting adaptation measures. However, most of the studies are focused on the macro-level (national or regional level) that local or micro-level studies are limited. Albeit the climate change and adaptation from individuals' approach has been limited so far, it is important to present the previous studies to understand further on climate change impact and adaptation in Korea and to achieve this dissertation's objectives. As noted, climate change and adaptation studies in Korea are mostly focused on impact and vulnerability analysis and economic analysis of the adaptation strategies. In recent years, only a few studies are examining the process of adaptation behaviors and introduced important roles of some psychological influence of taking adaptation actions. However, the studies indicate awareness of climate change or impact of such climate variability and change only partially to their economic or impact analysis. In this chapter, presents previous climate change and adaptation studies focused on agricultural sectors since there are limited studies on climate change and adaptation from micro-level or farmers' perspective,

3.3.1. Climate Change Impact Analysis

Since the agricultural sector is found to have higher sensitivity and lower adaptive capacity, the sector is known to have a relatively greater impact on changing the climate (IPCC, 2014). Most noticeable and serious impact on Korean agriculture is that cultivation area for fruit crops are moving to a northern part of Peninsula. This changes not only the quality and quantity of produced fruits but also the life of farmers engaged many years in producing previously available fruits. As the temperature in Korea increased more than a global temperature increase, the impact of climate change in the agricultural sector is massive and conducting adaptation measure to respond to climate change is urgent in farming communities in Korea (Jung et al., 2014).

The impact of climate change in agricultural sectors in Korea is identified by various studies (Jung et al., 2014; Kim, Heo & Lee, 2010; Kim, Jeong & Park, 2015; Yoon et al., 2010, MoE, 2015c). As presented in the previous chapters, a major result of the macro-level assessment of climate change impact in Korea is that the cultivation area of crop production is moving to northern parts (MoE, 2015c). According to Kim, Jeong & Park (2015), the authors found that in recent years, increasing number of farmers do perceive climate change as to have negative impacts on their farming practices. This was found from the studies done during the year 2015 and year 2009. Although it is limited to the farmers' crop production and quality issues, the survey presents that compared to the year 2009, more farmers perceive the negative impact of climate change on their crop production (Kim, Jeong, & Park, 2015). With such impact, farmers have to change their farming strategies to produce crops, change crop variety or work in off-farm jobs. Some micro-level impacts that climate change imposed in Korea are identified by some studies (Kim et al., 2016). Increased temperature, less precipitation rate, and increased number of days with extreme events have influenced agricultural production, such as quantity and quality of crop produced in the farms (Part et al., 2012). An impact study on the increased insects and pests on farms, the study found that more damages associated with increased insects and pests have been increased in Korean farms and those damages are an association with quality and quantity of crop production (Jung et al., 2014). The loss of livestock also found to be the consequences of climate change along with crop production loss (KMA, 2013). According to Noh (2012), climate variability, particularly increasing temperature would have a serious loss in rice crop. The study found that, from the result of Granger regression model, there is a significant relationship between rice production and climate variability during summer period and although increased temperature may have induced higher production in rice crop in recent years, in longer term, precipitation rate and increased extreme events might have negative impact on rice crop production in Korea (Noh, 2012).

Kim, Hoe, & Lee (2010) present impact of climate change on apple cultivation area and production by using regression models. The study uses apple data from the statistical yearbook and climate data from Daegu, Uiseong, and Jangsu weather station and found out that how temperature is rising during the 1970s, 1980s, 1990s, and 2000s. The study showed that during the 1970s, the apple grew mostly in the southern part of North Gyeongsang Province between regions in and around Daegu, however, in recent years, the cultivation are, and the yields of apple were concentrated on the northern part of the same province between regions in and around Uiseong and Mungyeong. The mean temperature from April to October is good in Uiseong and Jangsu, whereas the mean temperature is higher than the optimal condition in Daegu. The study resulted that the rising mean temperature during the apple growing season (April to October) had a great influence on the cultivation area and the yield. The authors assert that although some fruit cultivation may have the new opportunity from increased temperature, however, the apple cultivation which requires at least 5 years to have first crop production may have a negative impact on increased temperature and require carefully developed strategy growing the apple crop (Kim, Heo & Lee, 2010).

Climate variability and change impact not only the production of the crops but also the physical and psychological health of people engaged in agriculture (MoE, 2015c). More extreme events have been reported to have more damages to farmers' farming facilities, homes and other assets (MoE, 2015c). Thus, although the impact of climate change is mostly focused on production and quality of crop production, there are several impacts that are identified from previous studies. Further research needed for more specific impacts from farmers' perspectives.

3.3.2. Vulnerability Analysis using Index

Assessment of vulnerability to climate change has been understood as an important area of climate change adaptation related studies in Korea. Promoting farmers' resilience of climate change, vulnerability assessments are necessary. Measuring vulnerability to climate change still, embraces limitation which uncertainty of future climate change makes it difficult to determine physical impact with precision. However, there is nevertheless an emerging literature aiming to measure and assess vulnerability (Choi & Yamaji, 2015). Yoo & Kim (2008) conducted the first vulnerability assessment using quantitative measure, indices, on a national level. Yoo et al. (2008) develop Vulnerability-Resilience Index (VRI) to assess climate change vulnerability of 16 provincial governments in Korea. The authors revise VRIP model (Moss et al., 2001) to fit regional-level assessment. 33 proxy variables were examined under the themes, climate exposure, sensitivity and adaptive capacity. The study indicates that provinces located in the island and coastal areas are shown to have higher vulnerability than those located in urban areas, including Gyeonggi province. However, with the impact of climate change becoming increasingly visible locally, understanding of areas vulnerable to climate change risks and how these vulnerabilities are differently shown in lower-level context are important. Although a number of literature are aiming to measure and assess vulnerabilities, there are still limited studies on vulnerability assessment in municipal levels (Choi & Yamaji, 2015a).

According to Choi & Yamaji (2015a), most of the agriculture areas are located in the rural areas, and a vulnerability of rural area compared to urban areas are studied to understand and identify variables that can promote rural areas' vulnerability to climate change. By identifying relative vulnerability across municipalities, the study aims to provide useful information to rural adaptation policies and development policies. Choi & Yamaji (2015a) is based on Vulnerability-Resilience Index (VRI) (Yoo et al., 2008) to assess vulnerabilities of two urban (Suwon and Seongnam) and two rural (Yeoncheon and Gapyeong) communities of Gyeonggi province, a northern part of Korea where is known to have increasing apple cultivation area. The three indices; climate exposure, sensitivity and adaptation capacity, are developed to assess the vulnerability of the regions in the study. Z-scores of each of indicators in each of three indices are identified and compared. Climate exposure indicators are to assess how the system is vulnerable to climate elements such as heat waves and precipitation. If a region is more exposed to those climate variables, it is more vulnerable to the impact of climate change than the other regions that are compared. Vulnerability on how the regions are sensitive to changing climate is assessed by regions' geography (land use) and socio-economical elements (population and infrastructure). Sensitivity indicator is positively related to climate change vulnerability. Adaptive capacity refers to "the potential or capability of a system to adjust to climate change"(IPCC, 2001), so as to lessen the potential damages or to take advantage of opportunities from changing climate. When a system has a lower adaptive capacity, a system is vulnerable even to moderate changes in climate. However, if a system is higher in resilient, it is high in adaptive capacity and not too much sensitive to changing climate. The results of z-scores show that the rural areas (Gapyeong and Yeoncheon) are more vulnerable than urban areas (Suwon and Seongnam) by higher climate exposure and sensitivity. Moreover, the rural areas have the lower adaptive capacity. The study suggests lessening the vulnerability rural community where agriculture is main industry, although climate exposure cannot be adjusted by human control, the inclusion of climate change adaptive capacity with development policies such as aging society and physical infrastructure development should be considered to enhance the resilience of agricultural communities in Gyeonggi Province. Although this study provides vital information to develop adequate adaptation measures by providing the different elements that induce vulnerability of climate change impacts that rural and urban have, more targeted and specified study on climate change adaptation in Korea can be found in Choi & Yamaji (2016).

To effectively respond to climate change impact, it is necessary to understand the vulnerability of different crop varieties. The vulnerability assessment using index has been applied to apple farming community in Korea (Choi & Yamaji, 2016). As indicated in the previous chapters in this dissertation, as an impact of climate change, Korean apple cultivation areas have been moving to northern parts of Korea. Gyeonggi province, a province placed in the most northern part of South Korea, is now producing apple crops and as one of the adaptation strategy, the government also support the farmers in the province to start to grow the crop to increase income. Choi & Yamaji (2016) provides quantitative analysis of the vulnerability of four apple farming municipals in Gyeonggi province to compare and identify variables determining climate change vulnerability in the four municipals (Icheon, Gapyeong, Paju and Yeoncheon). Proxy variables are selected as a function of exposure, sensitivity, and adaptive capacity, as framed by IPCC and in scrutiny based on the intensive review of previous studies, particularly on Vulnerability-Resilience Index (VRI) (Yoo et al., 2008). Since the indicators are selected particularly for the assessment of apple farming, review of various government reports and guidance on apple cultivation are conducted. Finally, 12 proxy indicators are selected, and selected proxy variables are analyzed by calculation of the z-score normalization of data.

Among four apple farming communities, Icheon is shown to be the most vulnerable followed by Gapyeong, Yeoncheon, and Paju with regard the climate exposure. Vulnerability assessment is related to analyzing how sensitive the communities are related to changing climate shows Gapyeong as the most sensitive followed by Incheon, Yeoncheon, and Paju. Gapyeong is more vulnerable compared to other three municipals because of its demographical characteristics, increasing the rate of elderly agricultural household and beneficiaries of basic national livelihood. Gapyeong municipal requires measures to support agricultural labor productivity in the region to maintain apple cultivation. Unlike climate exposure and sensitivity, adaptive capacity is higher in Icheon and Gapyeong compared to Paju and Yeoncheon. Farmers in Icheon and Gapyeong have adopted apple cultivation earlier than farmers in Paju and Yeoncheon. Earlier adaptors of apple cultivation have already created their own communities to share their know-how and developed technologies to cope with climate damages. However, municipal governments in Paju and Yeoncheon are increasing its support for new apple farmers through several projects to increase adaptation capacity of apple farmers in the regions. The results of Choi & Yamaji (2016) in vulnerability assessments are useful in identifying variables to provide vital information on allocation of critical resources in each apple farming municipals to develop effective adaptation measure and policies. However, this only suggests policies on community levels and not on individual levels since it neglects to understand how the processes of individual farmers' adaptation behaviors work. The results of Choi & Yamaji (2015) and Choi & Yamaji (2016) are presented in the Appendix of this dissertation.

3.3.3. Economic Analysis of Climate Change Adaptation

Since the late 2000s, studies on economic aspects of climate change adaptation in the agricultural sector have been conducted by related institutions. Han et al.(2008) suggested the national master plan on climate change adaptation and provided climate change adaptation programs and different roles and duties to stakeholders in agricultural sectors. Moreover, the authors proposed future research projects and programs to promote climate change adaptation in the agricultural sector. Economic analysis of climate change adaptation considering the farmers level is first introduced by Kim et al. (2009) using ORYZA 2000, analyzing the impact of climate change on a unit of crop yield and analyzed farmers' willingness to pay for adaptation measures. Moreover, the study estimated economic effects of conducting individual farmers' adaptation measure such as adjusting planting dates or buying crop disaster insurance. With the collaboration of various research centers, academic institutes, and governmental bodies, a massive project on economic analysis climate change in Korea was conducted (Lee et al., 2011). The study analyzed costs of climate change impact on different sectors such as health, water resource, coast, food, and forest in Korea. It resulted that in the agricultural sector if there is no adaptation measure conducted to respond to the past, current and future climate change, the agricultural marginal return would decrease and by 2100, about 6,134 hundred million Korean won would be lost (Lee et al., 2011). Cho et al. (2012) introduced global cases of climate-related insurance which is not actively developed in Korea. The study suggests the promotion of weather index insurance in Korea and recommends developing such insurance scheme in Korea.

Kim, Jeong & Park (2015) analyzed economic effect of climate change adaptation measures such as insurance, information use, and crop switch by survey 433 farmers in Korea. In this study, several different analysis methods are applied for the economic benefit and cost analysis of the different adaptation measures. The stochastic production frontier model of Just-Pope is used to measure the economic benefit and cost of the Crop Insurance as a strategy to climate change adaptation (Kim et al., 2015). The farmers' decision-making model of Chavas-Holt is used to analyze the economic effectiveness of the farming practice that is associated with climate change adaptation including crop-switching. Moreover, logistic regression is used to analyze decision-making factors of crop switching method, and Positive Mathematical Programming is used to investigate the best climate-resilient crops which can cope with climate change. In addition, the ordinal logistic regression model is used for the economic analysis of using information related to weather and climate change on farmers' income. The results revealed that economic effect of crop insurance is greater as the number of extreme events increases that the farmers in the study are shown to have the benefit of 1.39 million won in comparison with uninsured farmers. With regard the analysis of identifying the best crops with economic effects of switching crops revealed that subtropical crops including mangos, asparagus, melons and kiwi would account for 1.2 to 1.9 percent of the entire crop cultivation are in the Jeollanam-do (Southern Jeolla Province) region around 2040 (Kim et al., 2015).

According to the study (Kim et al., 2015), factors determining farmers' decision to switch crops as adaptation measure are found; the size of cultivation areas, the number of training participated, use of weather and climate information and interest in joining crop insurance. More specifically, farmers with less cultivation area, more training on farming, more attention to weather and climate information and higher interest in buying crop insurance are more likely to switch their crop in response to the impact of climate variability and change. Moreover, when farmers are using more of weather and climate information in their farming, the income of that farmer are more likely to be ensured. Therefore, the study proposes policy implications related to promoting crop insurance and using weather and climate information to increase farmers' income against climate change and importance of farmers' engagement in the smart farming by using innovative technology and systematic training of stakeholders including farmers and government officers. Although this study is the one of limited study to conduct research on farmers' level and consider farmers' perception on their adaptive behaviors, this study only aim to analyze from economic approaches and did not specifically and comprehensively argued on why some farmers do adapt such adaptation measures and other do not decide to conduct adaptive behaviors. The study using logistic regression provided some factors that influence one of the farmers' adaptive behaviors, switching crops. Only socioeconomic factors are considered and found to have influenced the farmers in various crop production. The results of the study are insightful and important to understand adaptive behaviors of farmers in Korea. However, more empirical studies and broader consideration of farmers' perspectives are required for understanding and developing efficient adaptation to respond and prevent from climate risks.

Chapter 4 Research Methods

This chapter presents the methods applied in this study in order to achieve the research objectives. This chapter outlines the theoretical framework and methodological approach that direct the dissertation's effort to tackle gaps presented in the previous chapters. It entirely focuses and addresses the overall strategy of the research design that lies behind the research approach, selection of study area, sampling, data collection and analysis instruments. The dissertation is multidisciplinary, which brings together concepts and terms from various fields, it proposes a comprehensive theoretical framework that captures its multidisciplinary character with core variables and concepts dealt in the dissertation. Mixed methodology, both qualitative and quantitative approaches, is applied throughout the study to achieve the objective of the dissertation. Multiple linear regressions, binary logistic regressions, and descriptive analysis are used for quantitative research while focus group discussions (FGD), one-to-one interviews with farmers, agricultural officers, and experts were used to generate an understanding of the research context and supplement the questionnaire designed for quantitative data collection.

4.1. Conceptual Framework

As stated in the previous chapters, this dissertation is to investigate perceptions and behaviors of climate change adaptation of apple farmers in Cheongsong County, North Gyeongsang Province in Korea. And the study suggests policy implications for stakeholders involved in the society and climate linkages, particularly for local governments and agricultural extension officers to be able to disseminate adaptation measures effectively that would actually enhance farmers' adaptation capacity in response to climate change. To attain such objectives, the dissertation asks questions including: how local farmers perceives the past and current climate variability and change, particularly engaged with temperature, precipitation, and extreme weather; what are the factors affecting farmers' perceived risk related to climate variability and change; what are the factors affecting farmers' perceived adaptation efficacy related to climate change variability and change; and what are the socio-cognitive factors that affect farmers' adaptation behaviors in response to climate change.

Climate variability in this dissertation is used to refer to short-term climate variations and year-to-year fluctuation around the long-term mean and in the timing of the local climate (Mekuriaw, 2013). Whereas this definition has a qualitative aspect, quantitatively it is depicted by annual mean values of the local climate and deviation from long-term mean values (30 years). Moreover, climate change is referred to continuous change or trend in the state of the local climate. Since temperature, precipitation, and extreme events are essential climate factors for agriculture, the three climate variable are considered in the analysis of climate variability and change at the local level in this dissertation.
As indicated in Chapter 1, this study has four interrelated research themes. The four themes that this dissertation attempts to answer are:

Theme 1: Exploring farmers' awareness and perceptions of climate variability and change;

Theme 2: Assessing farmers' risk perception on climate variability and change and identifying determinants of farmers' risk perception to climate variability;

Theme 3: Investigating farmers' perception on adaptation measures to climate variability and change and identify determinants affecting farmers' perceived adaptation efficacy;

Theme 4: Investigating the socio-cognitive factors affecting farmers' intention to adaptation behaviors to climate change.

To understand a process of farmers' adaptive behaviors, understanding how farmers perceive climate change that influences the farmers to have the intention to perform adaptation practices to respond to climate variability and change. Farmers' knowledge influences their perception of climate change and adaptation behaviors. Further, their perceptions of climate change have been found to be important to adaptive decisions. The concern is what factors influence those perceptions and finally how cognitive factors influence farmers to behave in different courses of adaptive measures. A number of studies emphasized the importance of resources and socio-economic variables in determining farmers' climate change adaptation. However, the role of psychological factors in that process has received little attention (Grothmman & Patt, 2005). Therefore, an integrated framework involving socioeconomic and cognitive variables can assist in the understanding of farmers' decision-making process. Identifying that farmers' climate change adaptation is a human decision-making process under uncertainty, behavioral economics, a theory incorporating psychology and economics in explaining human decision making and socio-psychological theories are integrated into a systematic framework. From behavioral economic viewpoints, an integrated conceptual framework is developed based on two different theories, protection motivation theory, and planned behavior theory. An integrated conceptual framework incorporates socioeconomic factors that influence farmers' risk perceptions of climate change, perceptions of adaptation measures and adaptation intention to behavior. The integrated model is developed by Grothmaan and Patt (2005), and it is called the Model of Private Adaptation to Climate Change (MPPACC) which aims to provide a comprehensive understanding of individuals' adaptive behaviors.

To answer the questions asked for this dissertation, the socio-cognitive model, the Model of Private Proactive Adaptation to Climate Change (MPPACC) by Grothmann & Patt (2005) to explain individual's adaptive behavior in response to climate change is applied. The conceptual framework is developed based on Protection Motivation Theory (PMT) originally developed by Rogers (1983) majorly applied in health risk studies. However, the PMT has been applied to various disciplines to explain from protection behavior, consumer decision making, and environmental problems and to natural hazard studies.

As provided in chapter 3, main components of PMT and MPPACC are risk appraisal (perception on risk probability and severity) and adaptation appraisal (adaptation measure efficacy, self-efficacy, and adaptation costs). Moreover to these two processes, individual decide on adaptation or maladaptation (fatalism, denial, wishful thinking). Fear and experience also play an important role in farmers' decision to adaptation. In addition, the trust of governments' adaptation measures also influences farmers' intention to decide on the adaptation measures.

In advance to investigate farmers' adaptive behaviors, it is important to identify how farmers perceive climate risks and its impacts. Individual perceptions of the risks are often identified by consumer behavior studies. Those studies found the several aspects of perceived risks: performance, physical, social, convenience, financial, psychological and behavioral intention aspects (Dowling, 1985). With regard to climate risks, damaging impacts of climate variability and change have become apparent and frequent in many countries including Korea. For instance, reduced yields and crop failure (Jung, Kim & Moon, 2014) have been attributed to prolonged heat waves, droughts and rainfall failure (MoE, 2015c). Human health also has been shown to have detrimental impacts from the heat wave, and air pollution (Lim & Kim, 2011; Kang, 2008) and climate change also can negatively affect household income by increasing costs (Lee, 2011). In addition, climate change can have a solemn influence on natural resources such as biodiversity and soil (Oh et al., 2012; Bellard et al., 2012).

In this dissertation, along with all of the stated aspects of the detrimental impact of climate change, additional aspects are included in analyzing farmers' perception on risk and adaptation behavior to climate variability and change. Additionally included aspects are physical assets (Paavola & Adger, 2006; Dang et al., 2014; Kim, Jeong, & Park, 2015), mental health (Gifford & Gifford, 2016) and social network (Adger, 2003). Those additionally included dimensions are not acknowledged in Korean contexts. However, the dimensions are found to have a significant impact on climate change in the previous studies, and those were indicated by the farmers in the pre-test, and therefore it should be considered in this dissertation. Although limited, those added dimensions are to some extent pointed out in macro-level studies in Korean contexts (Kim, Jeong & Park, 2015; Lee et al., 2011; Shin, 2009). Therefore the seven dimensions considered in this dissertation are crop production and quality, income, physical assets (capital needed for farming, house, and cars), physical health, and natural resources, social networks (social communication with neighbors, friends, and family members) and mental health (stress).

Demographic and objective resources are expected to influence both risk perception and adaptation assessment. The relationship between demographic variables such as age, education, income, gender, successor, cultivation area, crop insurance, sales channel (direct and indirect) and risk perception and adaptive behavior have been discussed in several studies. In this dissertation, demographic and socioeconomic factors influencing risk perception and adaptation assessments are selected through an intensive review of previous studies on the farmers' adaptation behavior and socio-economic factors that affect the behaviors discussed in Chapter 3.

Table 4.1 Summary of the variables in the dissertation

Categories	Dependent and independent variables	
Climate variability and change	Temperature Precipitation Extreme events	
Dimensions of climate risks	Crop production & Quality Income Physical assets Physical health Natural resources Social network (communication) Mental health (Stress)	
Demographic & socioeconomic factors (Resources) Information Experience	Age Gender Education level Cultivation area Farming experience Income level % of income from apple Non-farming job Moving experience Successor	Training prog. participation Cell-phone use Sales channel (direct/indirect) Network joined Ownership of farm Crop insurance (CI) Cum. years buying CI Cultivation of other crops Information (climate change/adaptation) Climate risk experience
Cognitive factors	Awareness of climate variability and change Fear of future climate risks Risk perception (perceived risk probability, perceived severity) Adaptation perception (perceived adaptive measure efficacy, self-efficacy, adaptation costs) Maladaptation (fatalism, denial, reliance on public adaptation) Trust of government (training programs, warning system, information)	
Adaptive behaviors	Adjustment of planting dates Adjustment of pesticides/fertilizer use Switching to different crop Collecting climate change information Diversifying crop varieties Buying crop insurance Improving soil condition Changing variety of the crop Searching for non-farming job	

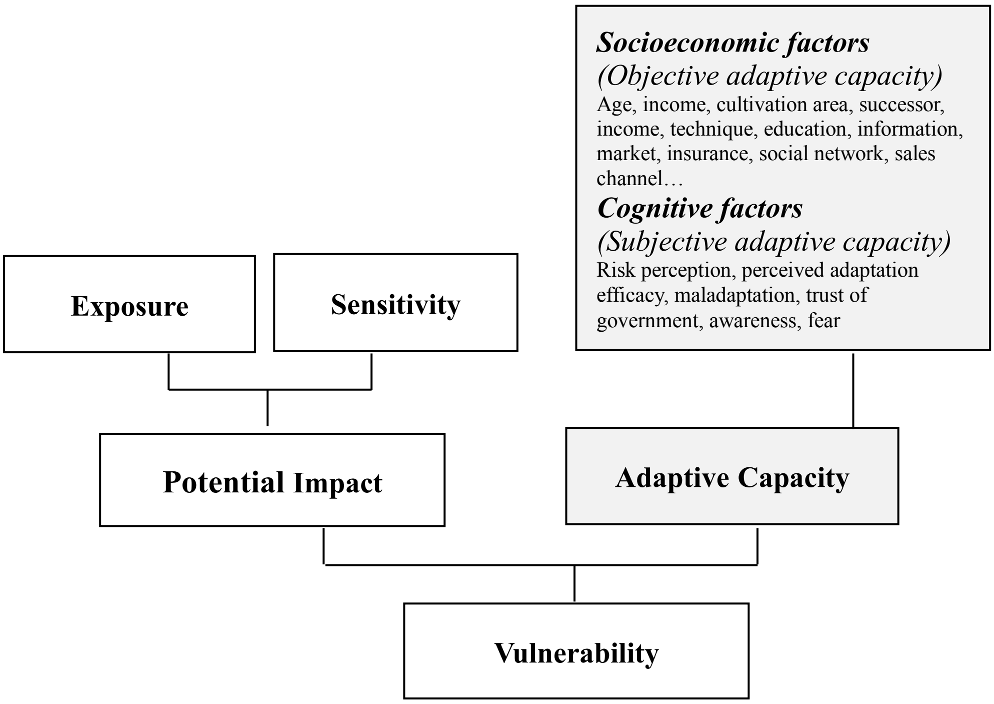

Figure 4.1 Research scope

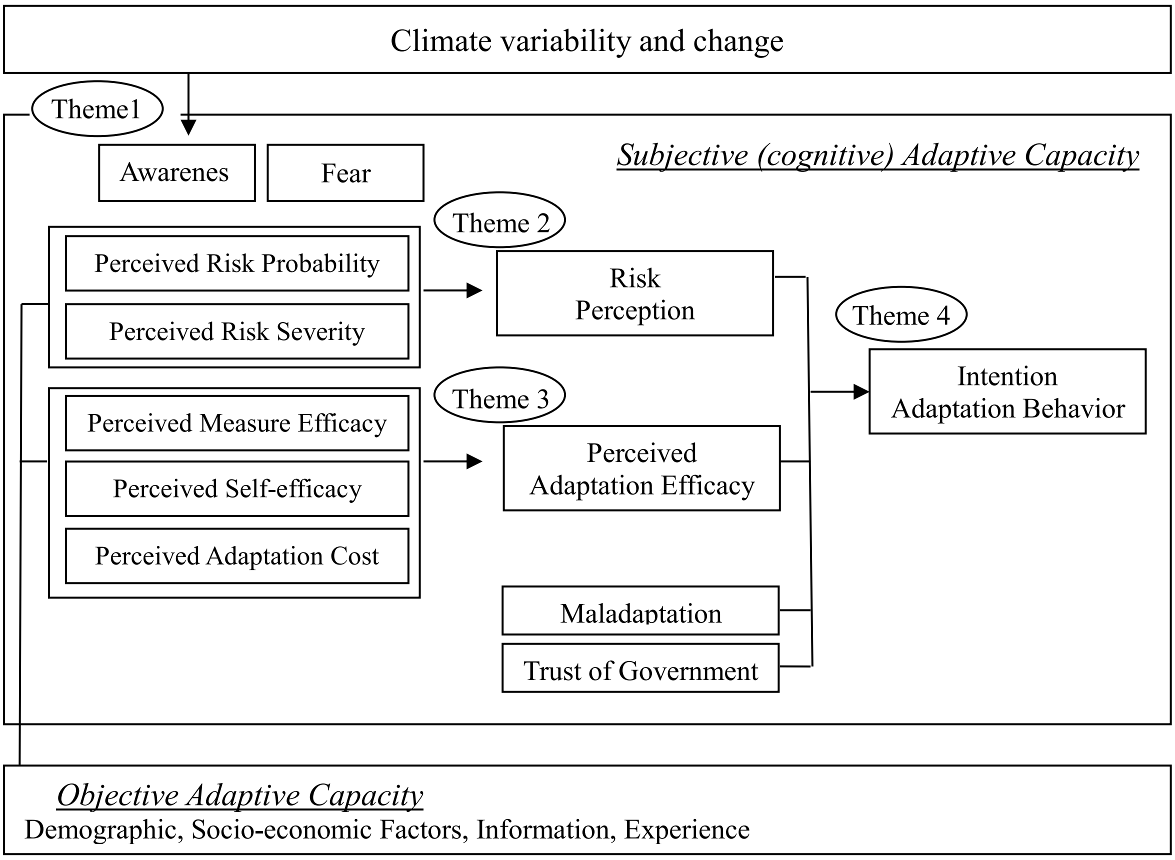

Figure 4.2 Conceptual frameworks for the dissertation

4.2 Information on the Study Area

The North Gyeongsang Province, the major apple production region of Korea, is a region in the southeast of Korean Peninsula. Table 4.2 shows the apple production in Korea by provinces. The North Gyeongsang province is composed of 25 smaller Counties including 13 *si* (urban Counties) and 12 guns (rural Counties), and it is the largest province in South Korea. The province is surrounded by mountains that divide the province from neighbor provinces. Cheongsong County is one of the major Counties producing high quality of apples in the Province. The County is located in east-central of the North Gyeongsang Province. Cheongsong itself has composed of 8 different communes, and apple cultivation contributes significantly to the agricultural production of the County and the whole country.

Table 4.2 Apple cultivation areas and production in Korea in 2015

Province	Cultivation (ha)	Yield (kg/10a)	Production (ton)
Busan	1	2,660	27
North Chungcheong	3,984	1,738	69,242
South Chungcheong	1,283	1,914	24,560
Daegu	66	2,345	1,548
Daejeon	4	1,277	51
Gangwon	721	620	4,472
Gwangju	0	0	0
Gyeonggi	330	830	2,740
North Gyeongsang	**19,247**	**1,936**	**372,627**
South Gyeongsang	3,444	1,966	67,491
Incheon	24	0	0
Jeju	0	0	0
North Jeolla	2,223	1,560	34,688
South Jeolla	289	1,841	5,320
Seoul	0	0	0
Ulsan	4	1,995	80

Source: Retrieved on 18 July 2016 from Statistics Korea website, Korean Statistical Information Services(KOSIS):http://kosis.kr/statisticsList/statisticsList_01List.jsp?vwcd=MT_ZTITLE&parmTabId=M_01_01 *Located in Domestic statistics→ Statistics in categories→ Agriculture and fisheries → Fruits→Cultivation area/production*

Cheongsong County has an area of around 846.08km^{2,} and it is covered with many mountainous roads that mountain Tabaek surrounds north, south, and east of Cheongsong (Cheongsong County, 2014). As of 2014, out of 846.05 km^2, a total area of Cheongsong County, 692.2km^2 (81.8 %) is covered with forest and 89.3 km^2 (10.5%) of farming fields, 21.1km^2 (2.5%) of river, 9.0km^2 (1.1%) of orchard fields and 7.9km^2 (0.9%) of roads. Most of the land is located altitude of 250~ 400m that of fruits and vegetables are actively cultivated in the area. The County is located about 357.74km from a capital of Korea, Seoul. Because of its location and land setting, the County has less communication with other Counties. Figure 4.3 shows a map of Cheongsong Province developed by ArcMap 10.2.1.

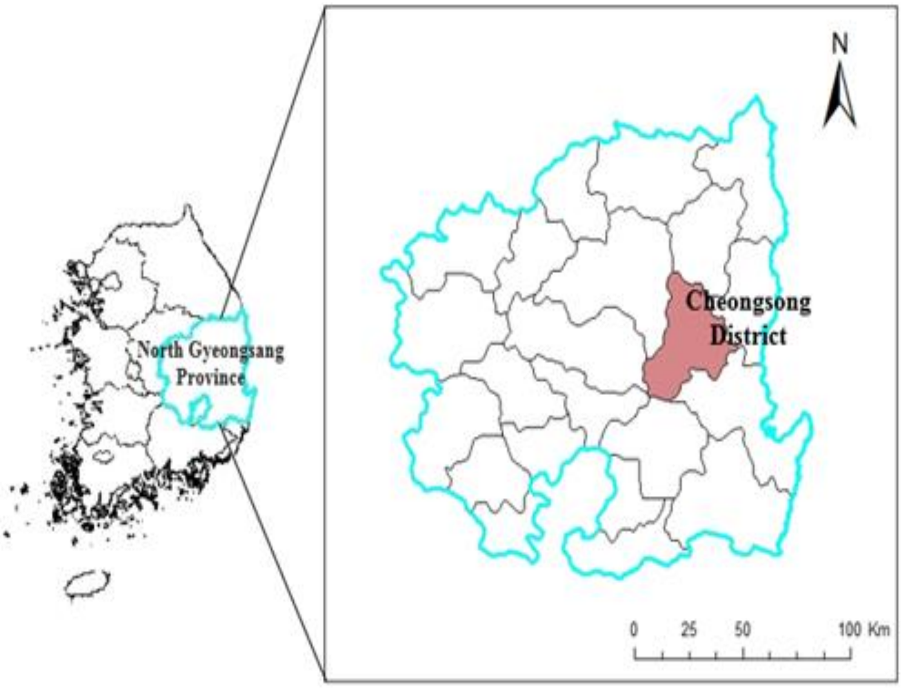

Figure 4.3 Map of the study area

Table 4.3 Population overview of Cheongsong County

Years	Total	Male	Female	Age over 65	Density	Farm households*
2010	26,883	13,256	13,627	7,739	31.8	3,425
2011	26,745	13,214	13,531	7,786	31.6	3,738
2012	26,697	13,157	13,540	7,977	31.6	3,750
2013	26,707	13,217	13,490	8,176	31.6	3,675
2014	26,732	13,253	13,479	8,325	31.6	3,868

Source: Revised from Cheongsong County (2015)
Note: Farmer households in this table present only full-time farm households

Table 4.4 Apple production in Cheongsong County

Year	Apple farm households	Cultivation Area *(ha)*	Production (ton)	Production (kg/10a)
2010	2,498	2,479	45,245	1,824.6
2011	2,424	2,464	36,983	1,501.2
2012	2,579	2,589	36,765	1,420.2
2013	2,700	2,676	41,626	1,546.7
2014	2,884	3,002	45,515	1,516.3
2015	3,145	2,976	54,833	1,842.5

Source: Revised from Cheongsong County (2015) and Cheongsong County (2016)

As of 2014, a total population of Cheongsong County is 26,732 and male population covers 13, 253 and female population is 13,479. In line with the global trends of aging society and decreasing population in agricultural communities, Cheongsong County also faces a decreasing population with increasing population with age over 65. Population density in the area is 31.6 and the total number of population of 65 years old and over is 8,325, about 30 percent of total population (Cheongsong County, 2015)

According to annual statistical reports published by Cheongsong County (2015), agriculture is an important industry in Cheongsong County that around half of the total population registered in this County is involved in agriculture. Apple production takes up about 62.3 percent of total agricultural production, and it is the most produced fruit in the County. Other fruits cultivated in the area are peach, Asian pear, grapes, and jujube. Cheongsong County is located in North Gyeongsang Province where produces about 60 percent of total apple in Korea, and the county contributes about 10 percent of total apple produced in the province. As of 2015, it is reported that total of 5,243 farming households is in this County and among them, about 60 percent of farming households (3,145 farming households) are involved in apple production. Total area for apple cultivation in the county is 2975.8ha which is decreased by about 26.5 ha from the year 2014. The total yield of the apple production in the area is 54,833 ton which is increased around 9,318ton from the previous year (Cheongsong County, 2016). The main variety of apple, which takes up about 80 percent of total apple produced in this area, is Fuji apple. Although the major portion of apple produced in this area is consumed domestically, but some portion of the production also exported to other countries.

Although production and the quality of apple can be influenced by many different elements during a year around, annual temperature, maximum temperature during the summer period, precipitation rate and the wind during apple harvest period are considered to the main climate factors that affect the apple cultivation. Not satisfying the annual average temperature between 8℃ and 11℃ would be the cause of insufficient cultivation of apple crop (MoE, 2015c). Moreover, temperature over 26℃ during summer period can produce an undesirable effect on the shape of an apple. The sweetness of apple is affected by precipitation rate. With higher precipitation, the level of sweetness of apple will fall. In addition to the quality of apple, abscission of apple also influences the production of apple cultivation (MoE, 2015c). Cheongsong County has been well fitted for the climate requisites for apple production that in addition to suitable annual average temperature, it is surrounded by mountains causing high differences in temperatures for day and night and the less rate of precipitation than other neighbor Counties.

Because of the climatic and environmental privileges for its production, Cheongsong apple became to be well known for producing high-quality apples. In Korea, apple is one of the most consumed fruit and Korean people not only consume apple for everyday life, but the highest quality of apples are consumed for ritual ceremonies for ancestors. Because of its profound quality, Cheongsong apples are highly preferred for both occasions. Since agriculture specialization in apple crops, people living in Cheongsong County are proud of its high quality of apple production and the local government also identify apple as a symbol of the County. The local government organizes the local events such as Cheongsong Apple Festival and Cheongsong Apple National Mountain Marathon Race to promote tourism in the region. The Festival is the biggest local event, including Cheongsong apple goblin parade, apple dance contest, apple-picking event, apple photo event, apple-drawing event, apple-cooking exhibition, good agricultural products exhibition, is annually held in early November for 4 to 5 days since

2005 (Cheongsong County, 2015). To the farmers and people in Cheongsong County, apple is more than the agricultural products that produce income to the farmers, but it is also the identity and the pride of the County. Although Chengsong County has been able to enjoy its climatic and environmental privileges to produce high quality of apple, the County is not an exception to the impact of climate change. As discussed in the previous Chapters, in recent years, the County has been facing with increasing temperature, decreasing precipitation and unusual climate consequences. Moreover, Korea agricultural sector, as other parts of the world, is facing with moving cultivation of crops and apple crop is found to be the most climate-sensitive crop which will have significant moving of its cultivation areas to the northern parts of the peninsula.

As of 2015, the annual mean temperature of the County was 12.9℃ which was the highest annual mean temperature recorded in the history (Cheongsong, 2016). As introduced in the above, the adequate annual average temperature for the apple growing is between 8 ℃ to 11℃. In Table 4.5, all of the annual average temperature for last 5 years show that the area has been over the suggested adequate annual average temperature for apple cultivation. Moreover to the annual average temperature, the climate condition during April to October is important for apple cultivation. It is suggested that average temperature during the apple growing season to be 15℃ to 18℃ (MoE, 2015c). Table 4.5 shows that during 2011 to 2015, except for the year 2013 when the mean temperature was slightly over 18, all of the last 5 years had a quite adequate temperature for apple growing season. With regard to the precipitation rate, the area is experiencing decreasing rate for last 5 years. However, according to the guides to the adequate climate condition for apple cultivation, the rate of precipitation during April to October is 450mm to 600mm (MoE, 2015c). This indicates that the climate data for the last 5 years show inadequate condition for precipitation rate except for the year 2015. Wind speed over 3m/s is indicated to influence apple crop by causing a drop of the fruit from the tree. The climate data for last 5 years shows that in Cheongsong, there has been increasing number of days with wind speed over 3m/s. Moreover, as the temperature of the summer of 2016 was recorded as the highest in the global history, Cheongsong County was not an exception to suffer from the droughts and heat waves. Because of such high temperature, apple production, a major agricultural product produced in the region, suffered from sunscald and farmers in the region were depressed about the damage of heat waves on apple quality since entire North Gyeongsang Province temperature hit 35℃ for about 30 days during summer of 2016 (Jeong, 2016, August 15).

Table 4.5 Climate condition for apple cultivation in Cheongsong County, 2011-2015

Indicators	Current climate condition in Cheongsong County				
	2011	2012	2013	2014	2015
Annual average temperature (℃)	12.2	12.2	12.4	12.5	12.9
Average temperature (℃) (April-October)	17.9	18.0	18.3	17.8	17.9
Number of days over 26℃ (days) (April-October)	100	97	114	94	118
Precipitation rate (mm) (April – October)	877.5	865.1	747.3	740.6	528.6
Number of days with wind over 3m/s (days) (April-October)	162	174	167	179	184

Source: Retrieved from Korea Meteorological Administration National Climate Data Service System (NCDSS, 2016). *Note: Temperatures have been recorded at Andong County AWS.*

In addition to the some climate change impact that the farmers experiences in recent years, Cheongsong County, which is located in the south-eastern part of the Peninsula, is also identified as vulnerable to a future climate change and projected to be an inadequate area for future cultivation of current apple crops ((MoE, 2015c). According to the climate change outlook report for the County, KMA (2014), the latest climate change and agricultural impact assessment for Korea confirms that temperature is projected to rise by +2.1℃ ~2.4℃ by 2040 and + 5.4℃~5.6℃ by 2090 with 2000 as a baseline. Moreover, the number of days with heat waves is also projected to increase by 4.7 times by the late 21st century. In addition, frost days, crop growing period, summer days, and days with heavy rain are also shown to increase by the last 21st century. Such projected climate variability and change would have a severe impact on farming communities in the County. From crop production to the physical and psychological health of the people in the community might be influenced by the potential impact of climate change. Particularly, the region's most produced agricultural crop is apple and apple are found to be the most vulnerable fruit crop to changing climate since it is the most sensitive fruit crop to increased temperature and eventually enable to be cultivated in the southern parts of Korea, including Cheongsong County (MoE, 2015c).

Further to the climate change, as a rural community, Chegngsong County also faces with the issues associated with aging society. As discussed in above, the share of the more elderly population in this region has been increasing, and the share is likely to increase continuously in the future. Aging society can be a crucial issue for the agricultural sector, particularly for apple cultivation because the activities associated with apple cultivation is labor intensive (MoE, 2015c). For apple farmers' in Cheongsong County, the climate is a vital factor for their well-being. The projected climate change can have an extreme impact on various aspects of their lives. To lessen the negative impact of climate risks, the apple farmers are inevitably required adaptation. To enhance the adaptive capacity of apple farmers, it is fundamental to understand the factors influencing private proactive adaptation behaviors.

4.3. Data Collection and Analysis Methods

In this section, a method of collecting and analyzing data is presented. In this dissertation, both primary and secondary data obtained from various sources are presented. Primary data was collected from apple farming households, experts, local agricultural government officers, and farmers, and focus group discussions (FGD). Household characteristics, socioeconomic and cognitive information and adaptation strategies were collected from sample households in each of the eight communes in Cheongsong County with the support of semi-structured questionnaire. On the other hands, secondary data was obtained from National Climate Data Service System (NCDSS), Statistics Korea (KOSTAT), agricultural offices in Cheongsong County, Korea Adaptation for Center Climate Change (KACCC), and Ministry of Environment (MoE). Objective meteorological data was collected solely from NCDSS. This section presents the specific process of data collection and analysis for this dissertation.

4.3.1 Field Observation

Field observation was done to acquire the actual image of the apple fields and the farmers' lifestyle. Moreover, the observation was done to aim the better knowledge and understanding of apple farming communities and the activities. Furthermore, through the field observation, the author was able to develop the constructive networks with local government officers, farmers, and experts which provided a more comfortable environment that the interviewers were able to provide more personal perceptions on the issues. Moreover, field observation was also done to conduct and collect household survey, FGD, and one-to-one interviews.

4.3.2 Document Review

Research papers and journal articles on climate change, climate change adaptation, climate change impact on agriculture, protection motivation theory, a model of private proactive adaptation to climate change and other related issues were reviewed and discussed critically for previous chapters and discussion chapters of this dissertation. In addition, published papers from various institutions and reports from public sectors on climate change information and impact analysis are reviewed to acquire available and relevant information of Korea as well as other countries and international communities.

4.3.3 Household Survey: Questionnaire Design, Sampling, Pre-test, and Implementation

The household survey was conducted to collect primary data to be used in the quantitative analysis in this dissertation. To collect the primary data on the analysis of farmers' perception and their intention to adaptive behavior to respond to climate change, randomization method was conducted for the sample of the household survey. Since this study aims to analyze apple farmers' particularly, the largest apple growing province in Korea, North Gyeongsang Province, where it is projected to be highly vulnerable to climate change, is selected. After selecting the province, assessment for the apple production counties in the province is conducted. Cheongsong County, one of the biggest apple producing county in North Gyeongsang Province, is considered. As indicated in the discussion of the study area, Cheongsong County has 8 different towns. The randomly selected samples for the household survey in this study are from all the 8 towns. The farm house Farm household characteristics, socioeconomic and cognitive information and adaptation strategies were collected from a total of 170 apple farming households in 8 communes in Cheongsong County. Originally, the total number of survey collected was 185. However, 15 of the total survey collected were either not filled with any answer or only answered some parts of the questionnaires. It is about 92 percent of response rate. Therefore information from only 170 completed surveys was collected to analyze in this dissertation.

To conduct the household survey, the questionnaire was developed based on the conceptual framework in the previous section and past studies. The questionnaire was developed by going through the process indicated in Zikmund & Bain (2010). The features considered throughout the development of the questionnaires are the information to be asked; the ways of phrasing questions; the art of asking questions; the order of the questions; the layout of the questionnaire; and the required amount of pre-testing and revising. The information from Agricultural Government Officers (AGO) and the result of pre-test were included in the questionnaires.

To fulfilled the ‘the information to be asked’ element in the development of survey questionnaires, the research objectives, key concepts, conceptual framework, main components, and measurement units were considered to make sure the information collected from the questionnaire was adequate for the dissertation topic. Characteristics of respondents and communication methods were also considered. For this dissertation, the respondents were the apple farmers in Cheongsong County, and their general education levels, age groups, gender groups, and their knowledge and language regarding weather, climate, and agricultural activities were carefully reflected to develop the questionnaires.

In the pre-test questionnaires, some opened questions, and pre-developed questions were both considered while the finalized questionnaire, questions except for household characteristics, was conducted by developed structured questionnaires. The reasons that latter was dominantly used for this dissertation are that, first, the farmers and AGO did not have a clue on what to discuss on the open-ended questions. This resulted to collect a vast amount of responses as inaccurate or irrelevant information. Second, the former method was mostly used for FGD and one-to-one interviews with farmers and AGO. Third, according to Zikmund & Bain (2010), using pre-developed fixed questions is more appropriate since it requires less time and fewer interviewer skills and easier answering the questionnaires. In this dissertation, questions on scales, yes/no questions, frequency determination questions are mostly asked in the questionnaires. As personal face to face, the survey was conducted to collect the survey; the questions were phrased in conversational format and instructions were given as respondent were conducting the survey. This could avoid inaccurate phrasing of questionnaires.

Pre-test and revising ensured that the questionnaires are clear, understandable, and answerable to the farmers. The pre-test was done for 15 farmers and three AGOs during February of 2016, about three months before the first survey was done. After the pre-testing, the questionnaires, some modifications, and revision of the questionnaires were conducted to utilize to work more effectively. The length of the questionnaire was shortened, and the words used in the questionnaires were modified into more conversational words. For instance, climate change elements such as precipitation rate and extreme events were modified into the amount of rain, days with typhoon or droughts. Moreover, some of the words relevant to impacts of climate change, assets, mental health, natural resources, and social networks are modified into the house, car, farming facilities, stress, soil, trees, neighbors, and friends.

The questionnaire was originally written in English and then translated into Korean. In addition, the translated questionnaire was revised several times to check the accuracy. The survey was developed to keep the questionnaires to include words that are usually used by farmers in the area. Moreover, the questionnaires were revised several times to phrase using the local dialect. The questionnaire was developed utilizing back-translation technique (Usunier & Lee, 2005). In phrasing questionnaires, expressions and the measurements units were carefully deployed to consider local knowledge and cultures. For instance, ‘*Pyeong’* is generally used measurement unit for the area in Korea. The word ‘*Pyeong’* was used interchangeably with hectare in measuring apple farming area. 1 *pyeong* is about 3.30m^2 which are equal to about 0.000331ha. Moreover, cultural aspects of local people (or Korean people) were carefully considered in development and instruction of survey. For instance, it is generally not polite to ask the age of a person in Korea. Moreover, Korean people usually count their age as they are 1 year old from the day they were born. In another word, in Korea, if one says he or she is 51 years old, means 50 years old in international standards. Therefore, in most of the cases, the birth year was asked instead of age. Moreover to age, asking one’s income is also thought as rude in Korea, and people usually give estimated income and less than actual total income. Therefore, in this study, the multiple choices with a range of income which is used in the most recent economic analysis of climate change adaptation of farmers (Kim, Jeong, and Park, 2015) is used to collect information regarding households' income.

The order and the layout of the questions is an important element in successful interviews and collection of high quality of data (Zikmund & Babin, 2010). Particularly, the types of interviews selected predicate the layout that generates the best outcome (Zikmund & Babin, 2010). The questionnaires were developed to have easier questionnaires, such as household characteristic questionnaires in the beginning parts to bring engagement of respondents' cooperation and involvement and build their confidence (Zikmund & Babin, 2010). More personal (perceptions) and difficult questions were put in the middle to end of the survey. In this dissertation, although some arrangements of the questionnaire and survey are reviewed and revised to make sure the format of the questionnaire is too unfamiliar to farmers. The questionnaire formats and layout was developed to follow some of the surveys that were done in the previous studies done in Korean agricultural studies and government surveys. Moreover, since the personal collection of households' survey, was conducted, the physically attractive survey was not necessary (Dange, 2014).

Through above process, the survey questionnaires for this dissertation finally developed into 10 different sections as: household characteristics (demographic and socioeconomic information), climate change awareness, risk experience, fear, risk perception, access to resources (information), perceived adaptation efficacy, maladaptation, trust of government, and intention of adaptation behaviors.

Directly visiting farmers' house, training centers, community centers, and other social community facilities were chosen for the implementation of households' survey because first, telephone or mail interviews can have higher costs and higher probability of failure due to farmers' impatience and low responses and second, the topic of the survey may not be familiar to the local farmers and require interaction and communication directly with interviewers. Simple random sampling was utilized as apple farm households were randomly chosen from all eight communities of Cheongsong County. Twenty to thirty respondents per communes were targeted, and the unit of analysis is the apple farm household, and the interviewee is household heads or their spouses.

4.3.4 Focus Group Discussions (FGD)

In this dissertation, four FGD were implemented: 1) two FGD with the apple farmers, 2) one FGD with AGOs and 3) one FGD with expert, AGOs and apple cooperative representative. The FGD were conducted to explore how farmers' perceive climate change, the impact of climate change, crop insurance, how much they trust of governments and maladaptation. Moreover, the FGD with experts and AGOs were conducted to explore governments' supports to farmers' adaptation, some existing adaptive measures, and barriers to farmers' adaptation.

- **FGD with apple farmers**: FGD did to explore the perception of climate change and its impact, perception on adaptive measures suggested by the government, maladaptation, and barriers to adaptation. First FGD was composed of two male farmers (both in their 60s) and one female farmer (in her late 50s) who is a spouse of one of the male farmers. The discussion was conducted at one of the male farmers' and lasted for about an hour. The FGD was arranged before the visit. The second FGD was composed of 3 farmers, 3 male (in their early 50s and early 60s). The second FGD was conducted for 50 minutes.at the social community center and was not arranged before the visit.

- **FGD with AGOs**: three AGOs were invited to join the FGD. All of them were affiliated with the 'Apple unit,' a team, under environmental friendly agriculture section, to focus only on the tasks related to apple farms and production in the County. The discussion was arranged previously with the support of one of the AGO. The discussion was done at the government office and lasted for an hour. Unlike the FGD with farmers, the topics discussed during the FGD with AGOs covered perception of climate change, future apple farming industry in Cheongsong County, adaptation measures (crop insurance) and any efforts of the government to prevent damage from climate risks, barriers for promoting farmers' adaptation.

- **FGD with expert, AGO and cooperative representative (farmer):** One expert (Dr. Ueom, Jae Yeol) on insects and disease on apple crops, two AGOs (different from the ones from FGO with AGO) and one apple cooperative representative (Mr. Choi). The topic that was covered from this FGD is mostly focused on the impact of climate change with regard increasing insects and disease on apple farms and adaptation measures such as crop insurance and adjustment of pesticides use. The discussion was conducted at the experts' house. The discussion lasted for one hour and was randomly visited but introduced by AGO.

All of the FGD were started by the introduction and warm-up explanation of the purpose of the FGD and research. Guidance was announced to make sure that all of the participants acknowledge that; all of the participants can have different opinion with others, there is no yes or no or right or wrong answer, only one person can talk at a time, participants do not have to discuss the issue that they are uncomfortable with, and the either audio or handwriting recording is required. The audio recording was transcribed in Korean.

4.3.5 In-depth Interviews

In-depth one-to-one, interviews were conducted with four apple farmers and two AGOs. Interviewed apple farmers were randomly selected by visiting directly to the house to house. First, the interviewer asked for the permission for recording the interview and implemented the interview for about 30 minutes to one hour. Three male and one female farmer participated in the in-depth interview. The interview topics were same as topics discussed during FGD with farmers. The interview topic for the AGO was similar to the topic in FGD with AGOs. However, the topic was generally opened to provide any opinion regarding apple farming and climate change in the County. An in-depth interview with an expert on agriculture in Korea, however, was conducted in the developing state of the dissertation rather than conducting research specifically on the apple farmers in Cheongsong County. Although the discussion topics discussed with the expert was not directly utilized in analyzing Cheongsong County's case, it was used to select the research sites, research methods and refine and the questionnaires.

4.3.6. Data Analysis

Since this dissertation consists multiple themes, the dissertation followed different courses of analysis in addressing each of the specific themes. Therefore, the methods are detailed separately by each theme under this section. However, a general process of the methods of data management could be depicted.

The discussions from FGD and in-depth interview were summarized, and data obtained from the questionnaire were entered into the statistical software. Subjective assessments (perceptions, detection, impacts, and characterization) of farmers, AGOs, and experts were analyzed descriptively. The data was further analyzed by content analysis to identify key themes, and major ideas and views were depicted by direct quotes and personal accounts of respondents. Further, a comparative analysis was conducted to compare and contrast subjective assessments with objective meteorological data. The collected household survey data were coded into Microsoft Excel, and then using STATA, the preliminary data cleaning was conducted. To detect any errors that may have produced during data coding stage, frequency counts and other descriptive statics were employed. Multiple regressions were conducted and applied for estimating the factors influencing perceived risk and perceived adaptation efficacy. Logistic regression was also employed to identify interrelationships among the cognitive factors influencing the adaptive behaviors. All of the explanatory variables in the models were tested for multicollinearity and its statistical fits.

Theme 1: Exploring farmers' awareness on climate variables and change

Both quantitative and qualitative data were used to analyze farmers' awareness of climate variability and change. As indicated in the previous sections, the qualitative data is obtained from interviews and FGD. The quantitative data was obtained from the household survey, meteorological recordings and other literature and reports from Government. While content analyses were used to analyzing the qualitative data, descriptive method and statistical methods such as regression were used in analyzing the quantitative data.
Audio recording and note recording from interviews and FGD were transcribed verbatim, and texts and descriptions with similar connotation under each of climate variables and topics were identified and coded. The process provided the categories with similar behaviors and perceptions, and direct quotations and instances were supplemented to support the discussion. Descriptive statistical analysis was conducted with regard the quantitative data. Moreover, graphs with regression functions were presented to analyze meteorology data.

To analyze farmers' awareness of climate variability and change, impact and attributes, the comparative analysis was applied to compare and contrast household survey and meteorological data. Farm households' awareness of the changes in temperature, precipitation rate, and extreme events are compared and contrasted with nationally and internationally published climate data. Particularly the climate data provided by Korea Meteorological Administration were used to analysis the data resulted from households' detection on the trends of climate variability and change.

Theme 2: Identifying affecting factors of farmers' risk perception of climate variability

Both quantitative and qualitative data were applied in analyzing farmers' risk perception of climate change. To identify farmers' perceived probability and severity of climate risks, climate change impact of the seven dimensions of the farmers' lives identified in the previous section. The seven dimensions that might have impact of climate change are: apple production and quality, household income, physical assets (house, cars, and farming machinery- SS spray machine), physical health, natural resources (soil degradation, biodiversity loss), social networks (communication with neighbors, friends, and family members), and mental health (stress). Some of the dimensions, such as physical assets, natural resources, social networks and mental health are further explained as indicated in the prentices to assist local farmers understanding of unfamiliar terms.

The seven dimensions were assessed for perceived probability and severity of climate risks with 4 different scales. For perceived probability, the farmers were asked if they perceive probability of climate risk on the each of the dimensions by 'not likely,' 'somewhat likely,' 'likely,' or 'very likely.' For perceived severity, the farmers were asked if they perceive the severe level of impact of climate risk on each of the dimensions by 'Not severe,' 'somewhat severe,' 'severe,' and 'extremely severe.' This dissertation uses four points scale, from 1 to 4, since more points in the scale may increase sensitivity and require more effort of respondents to score (Dang et al., 2014).

Overall perceived risks were calculated by borrowing method used in Dowling (1986) that is used mainly in marketing and psychology (Dang et al., 2014). Moreover, the application of the computation is congenial with perceived cognitive efficacy of PMT and MPPACC. The estimation of perceived risk for each of the impact dimensions was calculated by multiplying perceived risk probability with perceived risk severity.

Overall Climate Change Risk Perception

$$= \sum_{i=7}^{n} \text{Perceived risk probability}_{i} \ \text{x} \ \text{Perceived risk severity}_{i}$$

Where, n=7 dimensions (production and quality, income, physical assets, physical health, natural resources, network, and mental health). Overall climate change risk perception was calculated by summing up all of the 7 perceived risks.

Descriptive statistics and regression models were applied as to understand farmers' perceived risk of climate change and identifying factors influencing farmers risk perception which can eventually influence farmers' intention to adaptive behaviors. A total of eight different regression models was conducted with dependent variables (Production and quality, income, assets, physical health, natural resources, network, mental health, and overall perceived risks) and independent variables (Demographic and socioeconomic factors, awareness, fear, information, experience). The specific variables of independent variables analyzed in this theme are summarized in section 4.1. The expected relationships between variables of perceived risks of climate change are in turn positive for awareness, fear, and experience and either positive or negative for demographic and socioeconomic factors, and information from various sources. The linear relationship is assumed for all eight models under the following function:

Climate Change Risk Perception = *f* (Demographic and socioeconomic characteristics, climate change awareness, fear, information, climate risk experience)

Where the demographic and socioeconomic characteristics include: age; gender; education level; apple farming cultivation area; farming experience; income; % of income from apple farming; have successor of farming; participated training program; sales channel; ownership of farm; network joined; crop insurance; and cumulative years of buying crop insurance. Climate change awareness includes awareness on temperature increase, precipitation change, and increased extreme events. Climate change information and adaptation information from public media, neighbor farmers, community leader, agricultural extension center, and farmers' cooperatives are considered. Moreover, risk experience on increased temperature, precipitation, and extreme weather are also included in the function. More specified descriptions for each of the variables are given in Table 4.5.

Table 4.6 Description of independent variables used in the models for farmers' risk perception

Variables	Mean	SD	Description
Demographic and Socioeconomic variables			
Age	54.60	12.28	Continuous
Gender	0.25	0.44	Dummy (0=Male, 1=Female)
Education level	12.14	3.37	Continuous
Farming Area	1.52	0.94	Continuous
Farming Experience	16.13	10.94	Continuous
Income	4.59	1.68	Continuous
% of income from apple cultivation	89.94	17.11	Continuous
Successor	0.25	0.43	Dummy (1= have successor, 0= no successor)
Agriculture Education	5.69	5.15	Continuous
Sales channels	0.51	0.50	Dummy (1= direct sale, 0= indirect sale)
Land Tenure	2.66	1.92	Dummy (1= owned, 0= not owned)
Network	0.92	0.28	Continuous
Buying Crop Insurance (CI)	0.66	0.47	Dummy (1= bought CI, 0= no CI)
Cumulative years of Buying CI	4.23	4.33	Continuous
Awareness			
Increased Temperature	2.84	0.91	Continuous (1-not at all to 4-extremely)
Changed Precipitation	2.39	0.92	Continuous
Changed Extreme events	2.12	0.99	Continuous
Risk_Experience			
Risk Experience 1 (Temperature)	1.95	0.86	Continuous (1-not at all to 4-extremely)
Risk Experience 2 (Precipitation)	1.81	0.81	Continuous
Risk Experience 3 (Extreme events)	2.00	0.92	Continuous
Fear			
Fear on future climate risks	2.60	0.85	Continuous (1-not at all to 4-extremely)
Information Access			
Climate change info. 1 (Public media)	3.19	0.82	Continuous(1-not at all to 4-always)

Climate change info 2 (Neighbor farmers)	2.28	0.86	Continuous
Climate change info 3 (Village Leader)	1.53	0.82	Continuous
Climate change info 4 (Agri. Ext. Cent.)	2.24	0.85	Continuous
Climate change info 5 (Cooperative)	2.00	0.92	Continuous
Adaptation info. 1 (Public media)	3.04	0.88	Continuous
Adaptation info 2 (Neighbor farmers)	2.12	0.84	Continuous
Adaptation info 3(Village Leader)	1.59	0.85	Continuous
Adaptation info 4 (Agri. Ext. Cent.)	2.18	0.91	Continuous
Adaptation info 5 (Cooperative)	1.99	0.94	Continuous

Theme 3: Investigating factors affecting farmers' appraisal of adaptation efficacy

To investigate the factors affecting farmers' perceived efficacy of adaptation, one of the main factors of farmers' intention to adaptive behaviors. Adaptation behaviors or measures, assessed in this study are identified in the previous studies and reports from governments and listed in chapter 3 and the previous sections of this chapter in this dissertation. To make sure if those adaptive measures can be used to analyze apple farmers in Cheongsong County, the adaptation measures indicated in the previous chapter and section are discussed in FGD and personal interviews with farmers and AGOs. The adaptive measures used for analyzing perceived adaptation efficacy are an adjustment of planting dates; adjustment of pesticides/fertilizer use; switching to different crop; collecting climate change information; diversifying crop varieties; buying crop insurance; improving soil condition; changing a variety of the crop, and searching for a non-farming job.

For the evaluation of farmers' perception on how each of the adaptation measures is effective to prevent climate risks, farmers are asked to rate each of the adaptation measures from 'not effective at all,' 'somewhat effective,' 'effective,' or 'very effective.' For self-evaluation of adaptive capacity, self-efficacy, farmers were to answer from 'not at all,' 'somewhat,' 'capable,' 'extremely capable.' Finally, for the farmers' perception of the costs of implementing the adaptive measure, farmers were asked to answer from 'extremely costly,' 'costly,' 'somewhat costly,' and 'not costly at all.' It was given 4 scale points from 1 to 4 successively. The variables were summated for perceived adaptation measure efficacy, perceived self-efficacy, and perceived adaptation costs. The function is shown as:
The estimation of perceived adaptation efficacy was shown below.

Overall Perceived Adaptation Efficacy =

$$\sum_{j=1}^{9}\left(\frac{\text{Measure efficacy}_j + \text{Self efficacy}_j + \text{Costs}_j}{3}\right)$$

Descriptive statistics and multiple regressions were used to investigate the farmers' perception of adaptive measure efficacy, self-efficacy, and adaptive costs and significant factors determining the perception. Dependent variables for the regression models have perceived adaptation measure efficacy, perceived self-efficacy, and perceived adaptation costs. The linear relationship is assumed for all eight models under the following function:

Perceived Adaptation Efficacy= *f* (Demographic and socioeconomic characteristics, climate risk experience, information)

Where demographic and socioeconomic characteristics include: age; gender; education level; apple farming cultivation area; farming experience; income; % of income from apple farming; have successor of farming; participated training program; cell-phone; sales channel; network joined; ownership of farm; crop insurance; and cumulative years of buying crop insurance. Climate change information and adaptation information from public media, neighbor farmers, community leader, agricultural extension center, and farmers' cooperatives are considered. Moreover, risk experience with climate change variability and change are also included in the function. Independent variables represented in this function are presented in Table 4.6.

Table 4.7 Independent variables used in the models for farmers' perceived adaptation efficacy

Independent variables in the regression models	
Demographic and Socioeconomic variables	
Age	Agriculture Education
Gender	Smart-phone
Education level	Sales channels
Farming Area	Land Tenure
Farming Experience	Network
Income	Buying Crop Insurance (CI)
% of income from apple cultivation	Cumulative years of Buying CI
Successor	
Risk Experience	
Risk Experience 1 (Temperature)	
Risk Experience 2 (Precipitation)	
Risk Experience 3 (Extreme events)	
Information Access	
Climate change info. 1 (Public media)	Adaptation info. 1 (Public media)
Climate change info 2 (Neighbor farmers)	Adaptation info 2 (Neighbor farmers)
Climate change info 3 (Village Leader)	Adaptation info 3(Village Leader)
Climate change info 4 (Agri. Ext. Cent.)	Adaptation info 4 (Agri. Ext. Cent.)
Climate change info 5 (Cooperative)	Adaptation info 5 (Cooperative)

Theme 4: Investigating cognitive factors affecting farmers' intention to adaptation behaviors

As discussed in the previous chapters, PMT and MPPACC have been applied in analyzing farmers' adaptive behaviors in Chengsong County, Korea. In this dissertation, main variables of PMT, risk perception, and perceived adaptation efficacy are retained and applied by fitting into the dissertation's context. As discussed in the previous parts of this dissertation, Grothmman & Patt (2005) developed MPPACC which is an extended model of PMT applied in the climate change context. Similar to MPPACC, the appliance of PMT, the individual intention of farmers' adaptive behaviors to climate variability and change is framed as the function of 7cognitive factors: perception of risk probability, the perception of risk severity, the perception of adaptive measure efficacy, perceived self-efficacy, perceived adaptation costs, maladaptation and trust of government.

Intention of adaptation behavior =
f (perceived risk probability, perceived risk severity, perceived adaptive measure efficacy, perceived self-efficacy, perceived adaptation costs, maladaptation and trust of government, farm household characteristics)

Both perceived risk probability and severity of the impact of climate change identified in the previous sections are summed to have overall perceived risk probability and perceived severity. In other words, farmers' perceive climate risk probability of apple production and quality, income, assets, physical health, natural resources, network, mental health is summed to get the perceived risk probability. The Same calculation is applied to perceived climate risk severity. Assessment of adaptive efficacy, perceived adaptation measure efficacy, perceived self-efficacy, perceived adaptation costs, are calculated by summing up each of three perceptions with 9 different adaptation measures identified in the previous sections. In other words, farmers perception on adaptation measure efficacy, self-efficacy, and costs of adaptation measures such as: adjustment of planting dates; adjustment of pesticides/fertilizer use; switching to different crop; collecting climate change information; diversifying crop varieties; buying crop insurance; improving soil condition; changing variety of the crop; and searching for non-farming job are calculated. Moreover, maladaptation, as identified in the previous sections is restated in below:

Maladaptation is an avoidant adaptive behavior where people evade actual adaptation process through avoidant reactions such as denial of threat and wishful thinking due to their low levels of objective means to respond or carry out wrong response actions that rather increase damages (Grothmann & Patt, 2005). Furthermore, maladaptation is considered as an adaptive response where people react by denying or think wishfully to protect their psychological well-being, even though the responses (denial, wishful thinking, etc.) are not adaptive ones in the sense of preventing damage from a threat.

In this dissertation, as denoted in the previous studies (Dang, 2014; Grothmann & Patt, 2005; Grothmann & Reusswig, 2006; Mekuriaw, 2013; Zheng & Dallimer, 2015), maladaptation means avoidant behavior by personal belief that climate change risk and the consequences of such events are: 1) all of God's will that an individual cannot do anything to prevent it (fatalism); 2) not really happening and my farm will not be affected by such event (denial); and 3) the problem that government should solve, not individual farmers, therefore, government will protect the individuals from the consequences (wishful-thinking). Farmers were asked to scale their perception on the maladaptation as 'disagree,' 'somewhat agree,' 'agree,' and 'extremely agree.' Points are given from 1 to 4 successively.

Further to maladaptation, MPPACC placed reliance on governments' adaptation as a factor of risk perception, however, in this dissertation, the trust of governments' ability to respond to climate risks are considered to influence intention of adaptation behavior directly to fit the context of the study area. FGD and personal interviews revealed that although there are limited information or knowledge regarding climate change risk or adaptation measure, farmers tend to take adaptive behaviors if they believe governments' previous activities are efficient and adequate. To investigate the relationship between farmers' intention of adaptation behavior and their perception of governments' capacity, three mostly conducted adaptation activities are considered in this study: government agricultural training programs, warning system, and climate change and adaptation information. Farmers were asked to answer if the government provided activities, such as agricultural training programs, warning systems, and information is useful in their farming and well-being by 'not useful,' 'somewhat useful,' 'useful,' and 'extremely useful.' Points are given from 1 to 4 respectively.

Cognitive factors influencing farmers' intention of adaptation behaviors are investigated by using binary logistic regression model. Particularly the binary logistic regression analysis was used to examine the factors influencing the different adaptation behaviors applied by the apple farmers in Cheongsong County. Previous research finding has shown that logistic regression models are the most appropriate econometric models to pertain to the assessment of qualitative dependent variables that have dichotomous groups with independent variables that are categorical, continuous and dummy (Long and Freese, 2006). Logit models are commonly used since the models guarantee that the estimated probability increases lie within the range of 0 to1 and display a sigmoid curve conforming to the theory of adoption (Ndamani & Watanabe, 2016). Moreover to the usefulness of logistic regression, binary logistic regression analysis is commonly applied in the previous studies on adaptation behaviors.

Adaptation decision to 'adapt' or 'not adapt' decision is viewed as the outcome of a binary choice model. This study is to investigate farmers' adaptation behavior in intention stage. As explained in the section on PMT, adaptation intention is directly associated with adaptation behavior. This dissertation aims to provide vital information to increase adaptation capacity and resilience of apple farmers by investigating factors influencing intention of farmers' adaptation behaviors. Therefore, in this dissertation, the binary logistic regression models assume that a variable Y has only two possible outcomes, 'have the intention to adapt' and 'no intention to adapt' to climate variability and change. Moreover, a discrete vector of regressors X, which are hypothesized to influence the outcome Y, in this dissertation, factors that influence farmers' intention to behave on each of the adaptation measures. In this study, a farmer is assumed to have 'intention to adaptation behavior' if a farmer answered either 'adapted' or 'have the plan to adapt' in the questionnaire for all of 9 different measures. On the other hand, a farmer is identified as 'no intention to adaptation behavior' if the farmer answered as 'no plan to adapt.' Therefore, the observations ('has the intention to adapt' or 'no intention to adapt') are the outcome of the binary choice model, each farmer's choice to adapt is defined as follows:

$$Y_i = \begin{cases} 1 \text{ if the farmer has intention to adapt to climate change} \\ 0 \text{ if the farmer has no intention to adapt to climate change} \end{cases}$$

Again, logistic regression model has been chosen by many previous studies on similar topics (Abid, 2015; Bryan et al., 2013; Deresssa et al., 2009; Kato et al., 2011; Kiue et al., 2016; Mekuriaw, 2013) and this study, as applied in Abid (2015), Kibue et al. (2016) and Mekuriaw (2014), binary logistic regression is applied to estimate the probability that a characteristic is present (farmers having the intention to behave in the adaptation measure) given the values of explanatory variables. Again, let Y be a binary response variable ($Y_i = 1$, if a farmer has an intention to perform the adaptation behavior; $Y_i=0$, if the farmer does not have any intention to perform the adaptation behavior). Explanatory variables ($X_1, X_2 \ldots X_k$) include socio-cognitive variables, as explained above, are risk perceptions, adaptation perceptions, maladaptation and trust of government and household characteristics which can be discrete or continuous. It is important to note that albeit this dissertation's main focus is to analyze the socio-cognitive variables' contribution to farmers' adaptation behaviors, household attributions such as household characteristics and socioeconomic factors are controlled in the each of ten logistic regression models. This was done to avoid the underestimation differences in farm households' characteristic's contributions to their adaptation behaviors. However, the logistic regression results with the farm household attribution variables are indicated in APPENDIX II in this dissertation. Therefore, farmers' household characteristics are also considered in the binary logistic regression models, and the results of the variables are located separately with socio-cognitive variables to provide more focus on the socio-cognitive perspectives of farmers' adaptation behaviors.

The probability of a farmer having the intention of performing a behavior can be specified as:

$$P_i = E(Y = 1|X_i) = \frac{1}{1+e^{-\mathrm{zi}}} = \frac{e^{Z_i}}{1+e^{Z_i}}$$

Where:

- $Pi=E(Y_j=1)$ is the probability that the farmer is having the intention of performing adaptation.
- Z_i is a set of explanatory variables of the i^{th} farm household and $\mathrm{Z_i} = \alpha + \beta_k X$.
- α is the coefficient on the constant term.
- β is the coefficient(s) of the explanatory variable(s)
- X is the explanatory variable(s). (k^{th} explanatory variables)
- *e* denotes the exponential function.

The probability of farmers not having the intention to perform adaptation measures can be expressed as:

$$1 - \mathrm{Pi} = \frac{1}{1+e^{Z_i}}$$

The odds of a farmer having the intention of behaving in adaptation measure thus can be:

$$\frac{\mathrm{P_i}}{1 - \mathrm{P_i}} = \frac{e^{Z_i}/1 + e^{Z_i}}{1/1 + e^{Z_i}}$$

And finally, logarithmic transformation for the logit model could be expressed as:

$$\mathrm{In}(\mathrm{P_i}/1 - \mathrm{P_i}) = \alpha + \beta_k \mathrm{X_{ik}}$$

The estimated parameters, β_k, of the binary logistic model only give the direction of the effect of the independent variables on the binary dependent variable and statistical significance associated with the effect of increasing an independent variable just like ordinary least square (OLS) coefficients (Abid et al., 2015). Thus, to interpret and quantify the results, marginal effects needs to be calculated (Abid et al., 2015). It is to show that an independent variable X_k increases the likelihood of adaptation of a particular adaptation measure, Y_i =1. The coefficient (β_k,) only cannot give the explanation how much the probability of household *i* adopting a particular adaptation measure (Y_i =1) will change but only gives the odds of the ratio of the probability of adaptation. In other words, no magnitude of the effect of a change in the explanatory variable on $P[Y_i = 1]$. The estimation of marginal effects describe the effect of a unit change in the independent variable on the probability of a dependent variable can be shown as follows:

$$\frac{\Delta P_i}{\Delta X_i} = \frac{\partial P_i}{\partial X_i}$$

The final equation of the marginal effect (Y'_{ij}) after derivation is shown below:

$$Y'_{ij} = P[Yij = 1] \cdot [1 - P[Yij = 1]]$$

Unlike linear regression model, coefficients in logistic regression are estimated using maximum likelihood estimator require a test of the models for significance and accuracy of predictions. There are different ways to measure test the model fitness for logistic regressions. However, to assess the performance of a logistic regression model, overall model evaluation, goodness-of-fit statistics and validation of predicted probabilities should be performed (Abid et al., 2015; Peng et al., 2002). For the overall model evaluation, Likelihood ratio test is performed for this study. The test is comparable to the F-test for model testing in linear regression. This test can evaluate the model with predictors that if the model fits significantly better than the model containing only the intercept or constant. The difference between the two models yields Chi-square (χ^2). A significant Chi-square provides a signal on how well the explanatory variables explains or affect the outcome of the dependent variables. If the P-value of the overall model fit show less than 0.05 indicate the significance, it indicates that at least one of the explanatory variables contribute to the outcome.

In the linear regression model, R-squared explains the proportion of variance in the dependent variable explained by a set of explanatory variables. This measure to goodness –of-fit is not meaningful in logistic regression since the dependent variable takes only two values (0,1). With regard to goodness-of-fit in logistic regression models, there are several methods that are proposed. However, there is no one universally agreed method to be used (Peng et al., 2002). The most widely used method to calculate Pseudo R-squared for the goodness-of-fit in logistic regression includes Cox & Snell R-squared, McFadden R-squared (also called as the likelihood ratio index, LRI) and Nagelkerke R-squared. As found in the R-square of linear regression, the three methods of goodness-of-fit in logistic regression measure vary between 0 and 1 (maximum value is not 1 for Cox & Snell R-squared). The value is expected to be much less than R-squared measured in the linear regression. This study considered all of the three methods to measure the goodness-of-fit.

The classification table is calculated to show the validation of predicted probabilities by showing the proportion of correctly and incorrectly classified predictions (Mekuriaw, 2014). Higher percentages indicate a better fit of the model (Abid et al., 2015). In this study, all of the ten logistic regression models' correctness are calculated based on the classification table.

In logistic regression, testing multicollinearity is not necessary because of its functional form (Menard, 2001) however, it is suggested to run a linear regression model with the same variables used in the logistic regression and compute VIF/Tolerance test for checking the relationship between the explanatory variables (Mekuriaw, 2014). Therefore, in this study, takes such suggestion to test multicollinearity of the explanatory variables in the model.

Table 4.8 Description of independent and dependent variables in logistic regression models

	Variables	Description
Farm household characteristics		
1	Age	Age
2	Gender	Gender (DV) 1=female, 0=male
3	Education level	Number of years of formal schooling received Elementary = 6, Junior high= 9, high=12, college=14, university = 16 (years)
4	Farming Experience	Number of total years in apple farming (years)
5	Income	Income from apple cultivation in last year (2015) 1= less than 5 million, 2= more than 5 million to 10 million, 3= less than 20 million, 4= Less than 30 million, 5= less than 40 million, 6= more than 40 million (KRW)
6	% of income from apple cultivation	Number of percent of income from apple cultivation
7	Successor	Successor of the apple farming 1=yes, 0=no
8	Market Access (Sales channel)	Way of selling apple 1= Direct selling, 2= mass sale market, 3= national agricultural cooperative federation 4= farmers' organization
9	Network	Number of networks joined directly related to apple farming (union, study group, farmers' group, etc.) joined
10	Number of years buying CI	Number of years buying crop insurance (years)
Socio-cognitive variables		
	Perceived Probability (PRP)	Variables from 11 to 17, 1=unlikely, 2=somewhat likely, 3=likely, 4=very likely
11	Perceived probability_ Production	Perception on probability of climate change risk on apple production and apple quality
12	Perceived probability_ Income	Perception on probability of climate change risk on income
13	Perceived probability_ Assets	Perception on probability of climate change risk on assets
14	Perceived probability_ Physical Health	Perception on probability of climate change risk on physical health (disease and injury) of myself and family
15	Perceived probability_ Natural resource	Perception on probability of climate change risk on natural resources (biodiversity etc.)
16	Perceived probability_ Network	Perception on probability of climate change risk to network with family, neighbors, and friends
17	Perceived probability_ Stress	Perception of climate change risk on mental health (stress)
	Perceived Severity (PSR)	Variables from 18 to 24, 1= not severe, 2=somewhat severe, 3= severe, 4= extremely severe
18	Perceived severity_ Production	Perception of severity of climate change risk on apple production and apple quality
19	Perceived severity_ Income	Perception of severity of climate change risk on income
20	Perceived severity_ Assets	Perception of severity of climate change risk on physical Assets
21	Perceived severity_ Physical health	Perception of severity of climate change risk on physical health (disease and injury) of myself and family
22	Perceived severity_ Natural resource	Perception of severity of climate change risk on natural resources (biodiversity etc.)
23	Perceived severity_ Network	Perception of severity of climate change risk to network with family, neighbors, and friends
24	Perceived severity_ Stress	Perception of severity of climate change risk on psychological health (stress)
Perceived adaptation Measure Efficacy (PME)		Variables from 25 to 33, Perception effectiveness of adaptation strategy of each of strategies 1=not effective, 2= slightly effective, 3=effective, 4=very effective

25	Perceived measure efficacy_ Dates	Adjustment of planting and cultivation dates
26	Perceived measure efficacy_ Fertilizer	Adjustment of fertilizer/pesticides use
27	Perceived measure efficacy_ New crop	Switch to different crop adequate for changed climate
28	Perceived measure efficacy_ Information	Collect information related to weather/climate change etc.
29	Perceived measure efficacy_ Diversifying crops	Diversifying crop varieties for the income besides apple crop production
30	Perceived measure efficacy_ Insurance	Buying crop disaster insurance
31	Perceived measure efficacy_ Soil	Improve soil condition
32	Perceived measure efficacy_ Variety	Change variety of apple
33	Perceived measure efficacy_ Non-farm	Search/Involved in non-farm activities for income outside of farming
Perceived Self-efficacy (PSE)		Variables from 34 to 42 Perception on self-adaptive capacity on each of the strategies 1=not at all, 2=somewhat, 3= capable, 4= extremely capable
34	Perceived self-efficacy_ Dates	Adjustment of planting and cultivation dates
35	Perceived self-efficacy_ Fertilizer	Adjustment of fertilizer/pesticides use
36	Perceived self-efficacy_ New crop	Switch to different crop adequate for changed climate
37	Perceived self-efficacy_ Information	Collect information related to weather/climate change etc.
38	Perceived self-efficacy_ Diversifying crops	Diversifying crop varieties for the income besides apple crop production
39	Perceived self-efficacy_ Insurance	Buying crop disaster insurance
40	Perceived self-efficacy_ Soil	Improve soil condition
41	Perceived self-efficacy_ Variety	Change variety of apple
42	Perceived self-efficacy_ Non-farm	Search/Involved in non-farm activities for income outside of farming
Perceived Adaptation Costs (PAC)		Variables from 43 to 51, Perception of costs of each of the strategies 1= extremely expensive, 2=somewhat, 3= not expensive, 4= not expensive at all
43	Perceived costs_ Dates	Adjustment of planting and cultivation dates
44	Perceived costs_ Fertilizer	Adjustment of fertilizer/pesticides use
45	Perceived costs_ New crop	Switch to different crop adequate for changed climate
46	Perceived costs_ Information	Collect information related to weather/climate change etc.
47	Perceived costs_ Diversifying crops	Diversifying crop varieties for the income besides apple crop production
48	Perceived costs_ Insurance	Buying crop disaster insurance
49	Perceived costs_ Soil	Improve of soil condition
50	Perceived costs_ Variety	Change variety of apple
51	Perceived costs_ Non-farm	Search/Involved in non-farm activities for income outside of farming
Maladaptation (MAL)		Variables from 52 to 54, 1=no, 2=somewhat agree, 3= agree, 4= strongly agree
52	Maladaptation (1) _ Fatalism	A human cannot do anything since climate change is Gods.' Act
53	Maladaptation (2) _ Denial	The impact of climate change is not real
54	Maladaptation(3) _ Wishful thinking	No need for adaptation by individual farmers since the government will do it
Trust of Government (ToG)		Variables from 55 to 57, 1=no, 2=somewhat agree, 3= agree, 4= strongly agree
55	Trust of Government (1) _ Programs	Governments' agricultural support programs (educational or financial new crop, technique.., etc.) are very effective
56	Trust of Government (2) _ Warning	Governments' disaster warning system is very effective

57	Trust of Government (3) _ Information	Weather and climate related information provided by government is very effective in apple farming
Dependent variables		
Intention to Climate Change Adaptation Behaviors (CCAM)		Variables from 58 to 66, 0=no action/plan, 1= have a plan to perform , 2= in action
58	CCAM1: Adjusting farming dates	
59	CCAM2: Adjusting use of pesticides/fertilizer	
60	CCAM3: Switching to climate resistant fruits or vegetables	
61	CCAM4: Colleting weather/climate information	
62	CCAM5: Diversifying crop varieties	
63	CCAM6: Buying crop disaster insurance	
64	CCAM7: Increasing use of soil improvement techniques	
65	CCAM8: Changing apple variety	
66	CCAM9: Searching for non-farming activities	

Chapter 5 Finding

5.1 Characteristics of Sample Population

This chapter presents the results of the demographic statistics, comparative analysis, and regression models. STATA software and Microsoft Excel were applied to produce the results. The sections are divided according to the themes.

5.1.1. Demographic and Socioeconomic Characteristics of Sample Farm Households

This section presents the selected characteristics of apple farming households. Some of the data were collected on the continuous data form. However, for the presentation in this section, the information and data were grouped into categories for the purpose of figurative depiction.

In the rural household of Korea, male-headed households are dominant. This is also reflected in the apple farming community in the study area that male farmers dominate the respondents. As in Table 5.1, the overwhelming majority of the apple farmers in this survey are headed by men.

Table 5.1 Gender distribution of the respondents

Gender of the respondents	Frequency	Percentage
Female	43	25.3
Male	127	74.7
Total	170	100

The average age of the head is 54.6 years old, and the minimum age is 24, and the maximum stands at 80 years of age. More than 70 percent of the farmers are above 50 years old. Further, the percentage increases to 85.9 percent when the farmers over the age of 40 are tabulated together. Figure 5.1 depicts the age of the respondents with detail on the ages of male and female respondents.

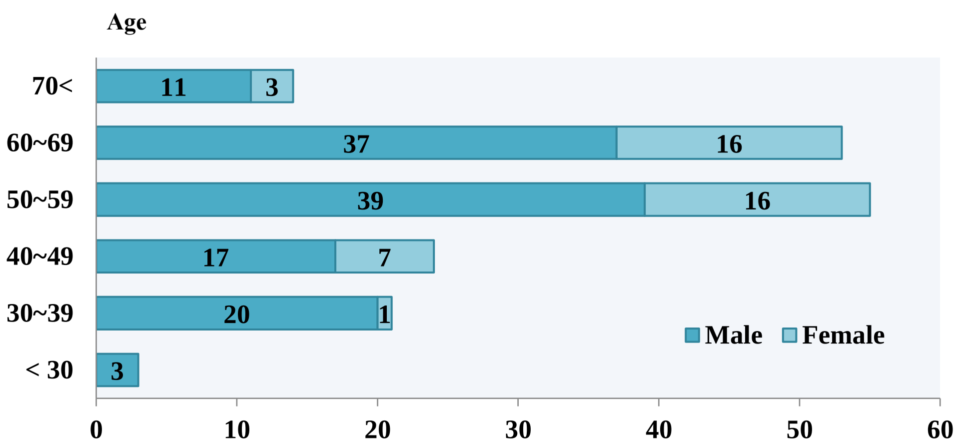

Figure 5.1 Age of the male and female respondents in categories

Note: Numbers in the prentices are the total number of respondents in each age range

As regard to education, only 1.2 percent of the heads had never attended school. The respondents with at least of college education level are 34.1 percent, less than half of the respondents. Almost a half of the respondents finished their high schools (grade 10-12). Only 9.4 percent of the farmers are elementary graduates (grade 1 to 6), and 14.1 percent of the respondents are middle school graduates (grade 7-9). In Korea, there are two kinds of college level education; one is called 'professional 2-year college', which is only focusing only on the major subjects and have only 2-year courses. The regular university level college is called '4 years college' that provide 4-year courses. Because of the different characteristics of the two kinds of colleges, it is important not to consider two educational levels as the same one. The 5.9 percent of the respondents finished their 2-year college, and 27.1 percent of the respondents have the regular university level degree. Further, 2 of the respondents (1.2 percent) have finished a master degree. Figure 5.2 shows the distribution of the respondents' education level.

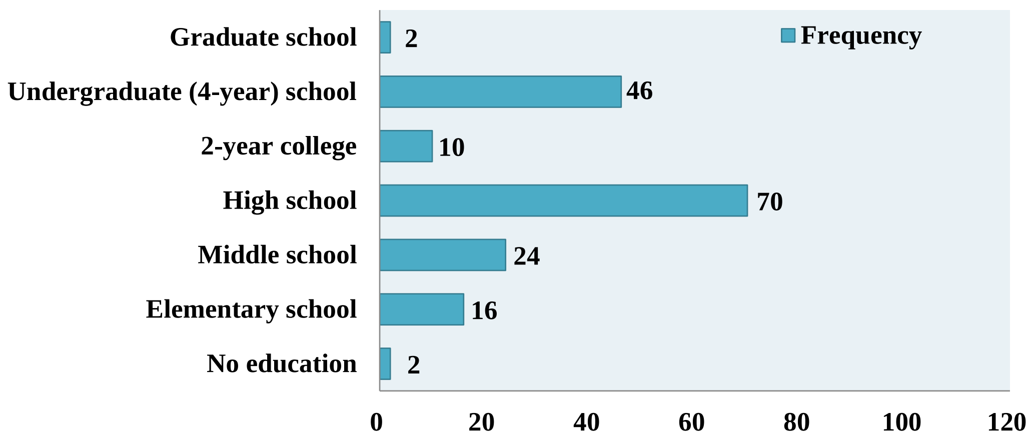

Figure 5.2 Education levels of the respondents

The total year of experience in farming goes up to 60 years with an overall average of 16.13 years. 115 of the respondents (68 percent) have more than 10 years of farming experience, and 58 of them (34.52 percent) have at least twenty years of experience. Apple tree is said to produce its first product after five years of tree plantation. The farmers with the farming experience less than 5 years are only 13 farmers (7.74 percent) in this study. Figure 5.3 shows the distribution of the respondents' years of experience in farming. Most of the farmers are born and raised in Chengsong and know about the place well. According to the survey, 75.9 percent of the respondents have no experience of living in outside of Cheongsong County. Some of the respondents (24.1 percent) have moved from other county or provinces, including Busan, Pohang, and Daegu, to start apple farming in Cheongsong. Although most of the respondents were working as farmers before they become apple farmer in Cheongsong, some of them worked as office workers in the previous years and moved to the County to become apple farmers after the retirement.

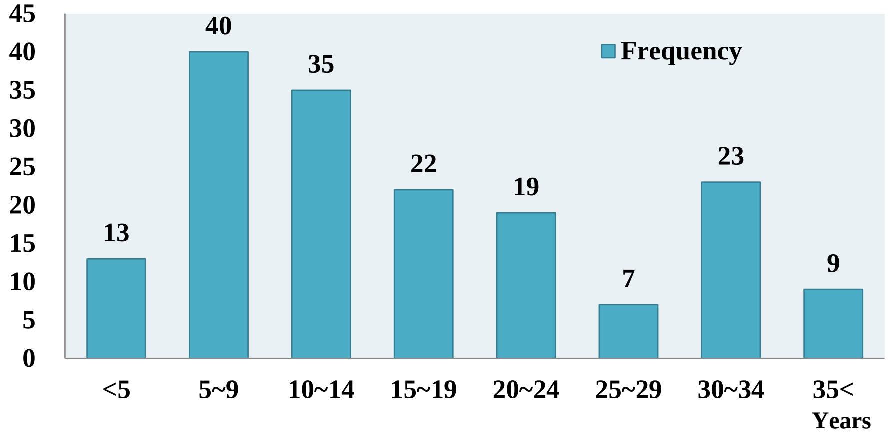

Figure 5.3 Farming experiences of the respondents in years

The largest apple farming area of the respondents goes up to 5.9 hectares, while the smallest area was found to be 0.1 hectares. Farmers with more than 0.5 hectares are 161 farmers (94.7 percent), and 73 of farmers (42.94percent) have apple cultivation area between 1 hectare and 1.9 hectares. 57 farmers (33.5 percent) have the apple cultivation area larger than 1.9 hectares. Most of the respondents own the farms (91.8 percent). However, about 8.2 percent of the respondents do not own the apple farm (Figure 5.4).

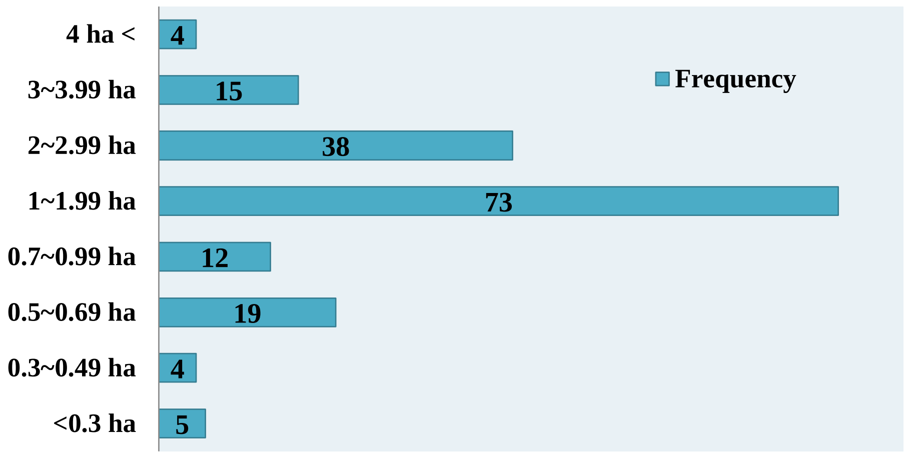

Figure 5.4 Cultivation areas of the respondents in hectare

Income distribution of the respondents shows that more than half of the farmers are producing more than 30,000,000 KRW. As seen in Figure 5.5, 42.9 percent of the respondents have more than 40,000,000KRW of annual income in 2015. The overall average shows in between 20,000,000 KRW to 39,999,999 KRW. The income from the year 2015 is recorded.

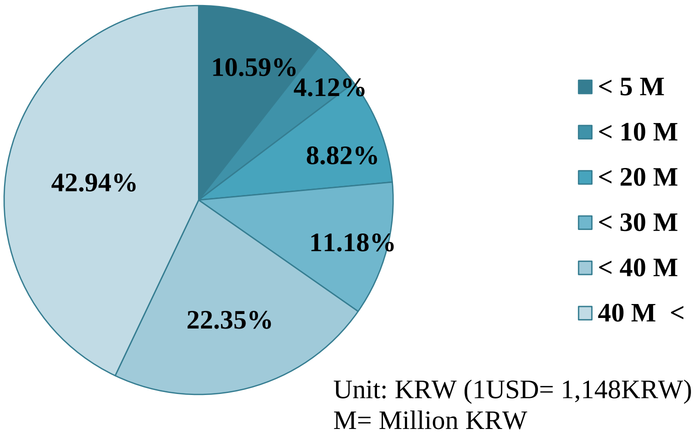

Figure 5.5 Income of the respondents in percentage

Although most of the farmers (81.6%) are the full-time farmers, working only for apple production, some of the farmers (18.4) are engaged in other kinds of jobs such as part-time jobs, part-time office works and owning the markets selling their crops and other products.

The local government, mostly through the agricultural extension service center, provides various agricultural training programs to the farmers in the county. According to the survey, about 93 percent of the farmers, out of 170 respondents 158 of the farmers, participated in the training program in 2016 provided by the government. Moreover, the maximum number of participation was 20 times, and the overall average indicates 5.69 times. Figure 5.6 shows the number of a training program that the respondents participated only for the year 2016.

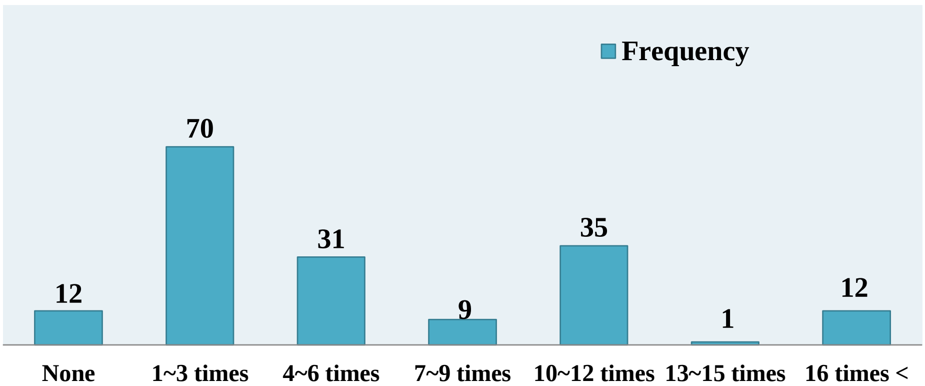

Figure 5.6 Number of training program participated by the farmers

Most of the respondents have joined at least one of the official apple production related networks. Only 5.88 percent of the respondents do not have joined any official networks. The overall average of networked joined by the farmers is 2.66, and the maximum is 10 official networks joined by one farmer (Table5.2).

Table 5.2 Number of networks joined by the respondents

Number of network joined	None	1	2	3	4	5	6≤
Frequency (Percentage)	10 (5.9)	46 (27.1)	39 (22.9)	33 (19.4)	8 (4.7)	21 (12.4)	13 (7.7)

The main method of sale channels of apple farmers in Cheongsong is direct sales and the sale via markets. The National Agricultural Cooperation Federation called Nonghyup (NH) is the main market for selling the apple other than direct sales. Many farmers, more than half of the respondents (51.18%) rely on the market such as NH on the selling the product. The buyer from the markets comes to the farm to buy the product and sell it to consumers. 48.82 percent of the respondents sell apple crops directly to the consumer through internet and phones (Table 5.3). The farmers selling the apple through direct sales communicate with the consumer directly giving the specific feedback about the product to the farmers. Most of the consumers buying a product through phone calls are regular buyers, not only one-time consumers.

Table 5.3 Sales channels of the apple farmers

Sale channel	Frequency	Percentage
Direct sales	83	48.82
Indirect sales	87	51.18

Since the Crop disaster Insurance (CI) is introduced in Cheongsong in 2005, since then, the farmers were able to buy CI to response to the impact of climate change and natural disasters. The CI is issued every year and farmers who want to buy the CI have to pay every year, but 80 percent of the payment is paid by the government that the farmers only pay 20 percent of total CI. As of July 2016, 66.5 percent of the farmers responded that they bought the CI for 2016 and about 66 percent of the farmers indicated that they bought the CI more than one year. 23.53 percent of the farmers have been buying the CI for more than 10 years. Below figure shows the share of farmers who bought CI and the cumulative years of buying CI in Cheongsong area.

Table 5.4 Crop Disaster Insurance (CI) bought in 2016

Crop Insurance in 2016	Frequency	Percentage
Did not buy Crop Insurance	57	33.5
Bought Crop Insurance	113	66.5

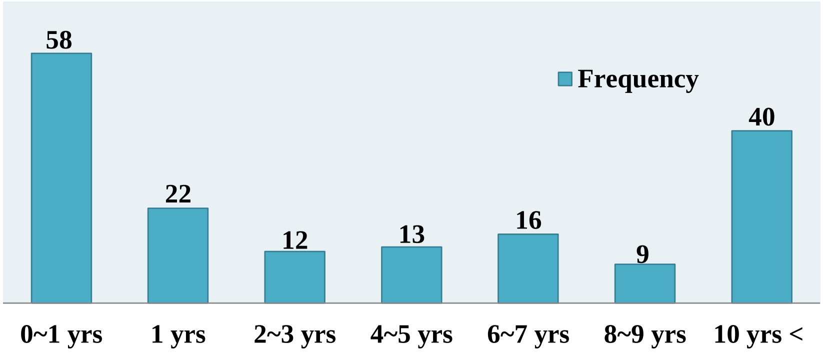

Figure 5.7 Cumulative years of buying Crop Insurance

5.2 Farmers' Awareness on Climate Change Variability and Change

To analyze the farmers' awareness of climate variability and change and compare it with meteorological recordings, the farmers were asked to indicate the perception about the trend of temperature, precipitation and extreme weather events such as typhoons and floods for last 10 to 30 years. To understand the climate variability and change, rather than weather changes, the farmers are asked to recall long term memories. The reason that the duration is limited to 10 to 30 years was taken as a reference is to consider the ages and experience in farming of the respondents. A total of 170 farmers, each representing a household, were surveyed and interviewed. All of the households gave responses to the respective questions referring to the temperature, precipitation, and extreme weather events. Moreover, by using comparative analysis, such subjective assessments of climate variability and change are compared and contrasted with objective climate records provided from national meteorological institutions.

5.2.1 Farmers' Perception of Climate Variability and Change

The first question posed was about as to the trend of temperature, and a change was mentioned nearly all of the respondents. The farmers are asked to rate the change in temperature as no change, somewhat increased, increased and extremely increased. As shown in Figure 5.8, the great majority of the households (90.59 percent) perceived a rise in temperature compared to the past. Only 16 farmers (9.4 percent) of the 170 farmers responded the temperature has 'no change.' 43.53 percent of the farmers indicated the rise in temperature while 24.71 percent indicated the extreme rise in temperature. Chi-square test also shows statistically significant difference between the proportions of the groups of respondents with χ^2=440.19, $p < 0.05$ and 2 degrees of freedom, when all groups of respondents are considered together.

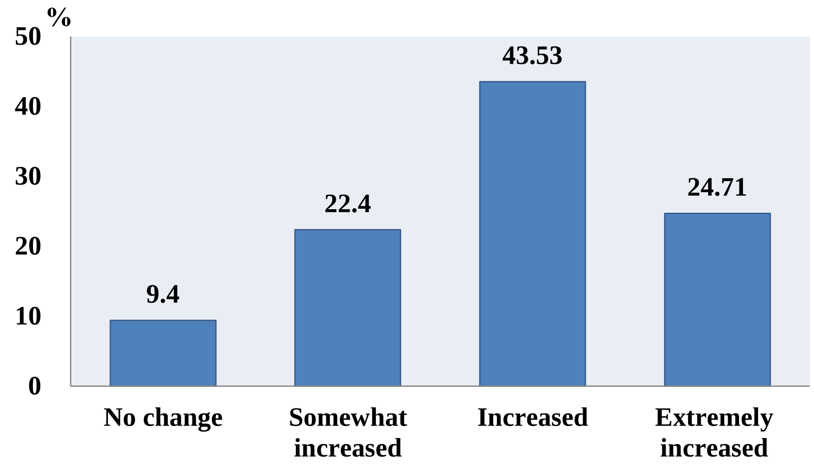

Figure 5.8 Awareness of the farmers about the trend of temperature in percentage

The second question posed was about as to how the amount of precipitation has been presenting over the past years. The farmers were asked about their perception of the changed trend and amount of precipitation as 'no change,' 'somewhat changed,' 'changed' and 'changed extremely.' Accordingly, 82.94 percent of the farmers recognized changes in the trends of precipitation and 17.06 percent of the farmers indicated that they did not recognize any change in trend or amount or precipitation in the area (Figure 5.8). Chi-square test was administered to determine if there exists a statistically significant difference between the groups of the respondents. The test statistics reveals that the proportions of the frequencies are significantly different ($p < 0.05$) to each other.

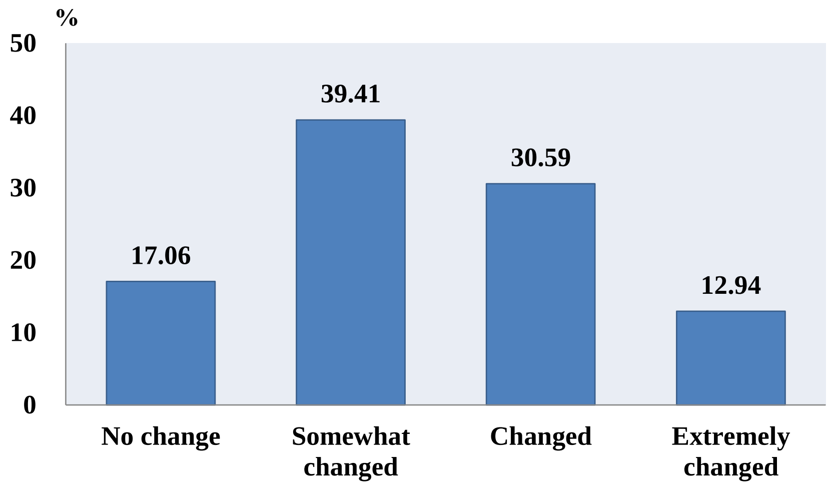

Figure 5.9 Awareness of the farmers about the trend of precipitation in percentage

In addingtion to temperature and precipitation changes, a similar question was posed to the farmers as regard to the trend of extreme events. The farmers were asked to indicate their awareness of increased any extreme events such as typhoon, drought, heavy rain and wind, heat waves and floods. However, the specific definition of extreme events is not limited to provide ones but to be defined by the farmers themselves. Similar to previous questions, the farmers are to indicate a trend of extreme events as ‘no change,' ‘somewhat increased,' ‘increased’ and ‘extremely increase.' Although more than half of the responded farmers aware of some level of increased number of days with extreme events, unlike other two climate variability, the extreme event is not much perceived by farmers. 66.47 percent of the farmers indicated to perceived some levels of increase in a number of days with extreme events, and 33.53 percent of the farmers does not become aware of the increase in such climate variability and change. As shown in Figure 5.9, the farmers perceived increased extreme events as somewhat increase, increased and extremely increased as 31.18 percent, 25.29 percent, and 10 percent, respectively.

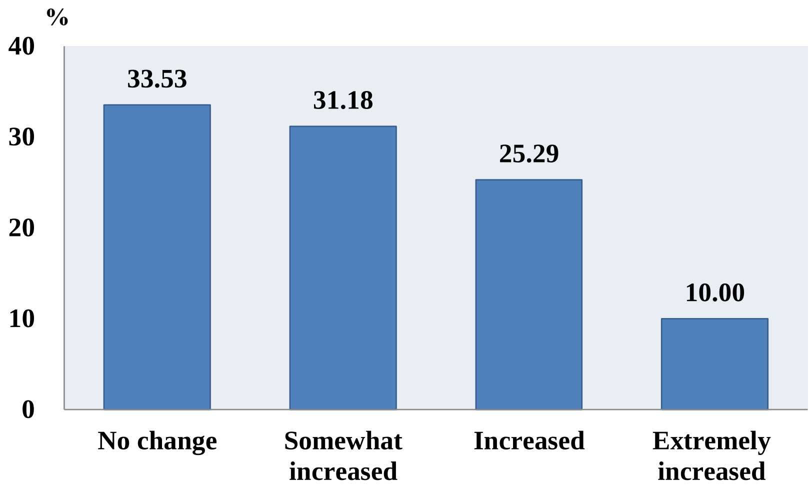

Figure 5.10 Awareness of the farmers about the trend of extreme events in percentage

5.2.2 Meteorological Data on Climate Variability and Change

To understand awareness of the farmers about the trend of the climate variables, as one of the local knowledge on climate variability and change, it would be plausible to first to verify perceptual judgment through available objective assessment methods, including available meteorological data. As the first analysis of this dissertation, the accuracy of awareness of the farmers was compared against scientific data, long-term meteorological data, of temperature and precipitation and specific extreme events such as typhoon recordings of the automatic weather station (AWS) and the Annual Climatological Reports by Korea Meteorological Administration (KMA) nearby the study over 30 year period from 1986 to 2015. The AWS in Cheongsong County was not established since 2011. Therefore the nearest AWS in Andong County is used as annual mean precipitation and annual mean temperature data records.

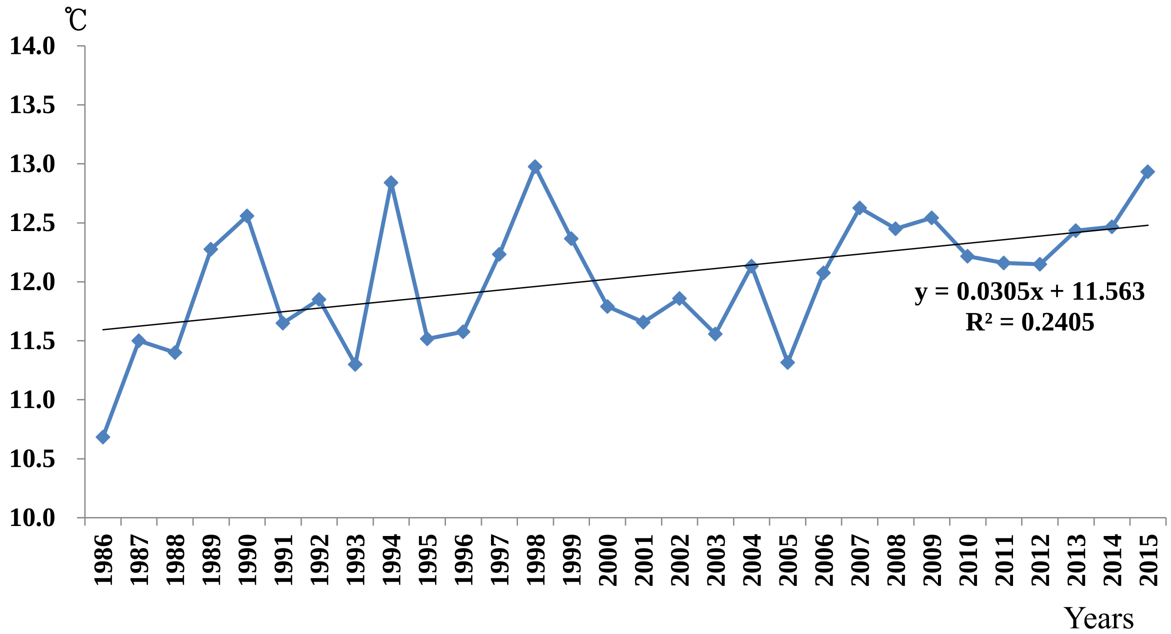

Figure 5.11 Annual mean temperature in Cheongsong County in North Gyeongsang Province, Korea, 1986-2015

Source: Constructed from a raw data of Andong County AWS, Korea Meteorological Administration National Climate Data Service System (NCDSS, 2016).

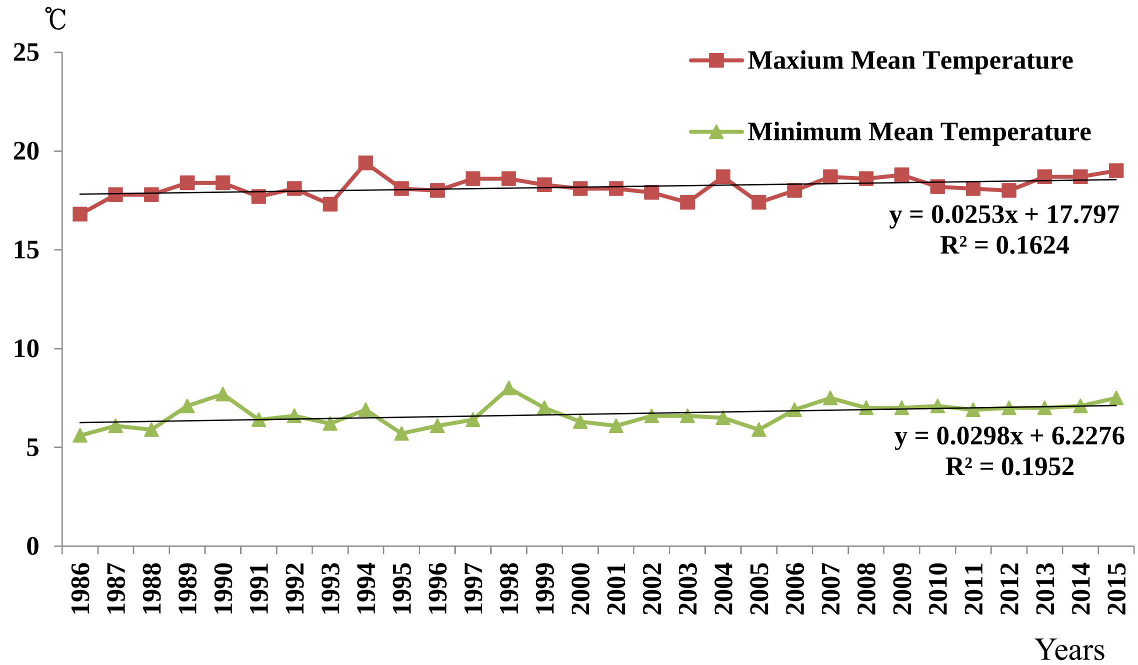

Figure 5.12 Maximum mean temperature and minimum mean temperature in Cheongsong County in North Gyeongsang Province, Korea, 1986-2015

Source: Constructed from a raw data of Andong County AWS, Korea Meteorological Administration National Climate Data Service System (NCDSS, 2016),.

Observed meteorological data proves farmers' awareness on trends of climate variability and change. According to the Korea Meteorological Administration (KMA, 2016), the County did endure higher mean temperature in the period. Moreover, increased frequency and severity of extreme events caused much damage to apple farming community in the County.

Graphic analysis of the weather station regarding temperatures is presented in Figure 5.11 and Figure 5.12. Moreover, the statistical significance of the correlation between temperature change and time was also calculated and analyzed in Table 5.5. The regression and correlation that were used to assess the trend of climate variables with time in years. With regard to the temperature increase, the local climate data on the annual mean temperature, maximum mean temperature, and minimum mean temperature for last 30 years were examined to compare the trends of the actual meteorological data to the local farmers' awareness on changing climate. Figure 5.11 shows the annual mean temperature of the Andong AWS which is located in the north of Cheongsong County. As shown in the Figure 5.11, the annual mean temperature in the area is visibly increasing as time goes on. More specifically, during last 10 years, from 2006 to 2015, the annual mean temperature is the highest as all of the years recorded the temperature higher the 12℃. During last 30 year period, the annual mean temperature of the most recent year, 2015, recorded the highest as 12.9℃. Annual mean temperature is an important element for growing apple. As indicated, the adequate annual mean temperature for growing apple in Korea is 8-11℃. (RDA, 2011). However, according to the meteorological data shown Figure 5.11, indicate that the annual mean temperature in Cheongsong County is over the standard and became more visibly over the standard temperature since the 2000s. The regression analysis reveals that annual mean temperature in the area. As presented in Table 5.5, the trend of annual mean temperature is increased at 0.0305 per year with statistically significant at 1 percent levels. Similarly, correlation of annual mean temperature with time is significant at 1 percent level with a positive relationship.

Moreover, maximum mean temperature and minimum mean temperature during the same period also show the increase (Figure 5.12). As seen in the annual mean temperature, the local climate data on maximum and minimum mean temperature are visibly increasing as time goes on. Table 5.5 shows that time and both maximum (0.403) and minimum (0.442) mean temperature are positively correlated in the area. Both mean temperature are statistically significant but at 5 percent level and 1 percent, respectively. Similarly, the rising trend of maximum and minimum mean temperature are statistically significant at 10 percent significance level.

The meteorological data recording shows the consistent trend as the farmers' perceptions, an upward temperature in Cheongsong County. Except for 1994, the most recent years show the higher temperature in annual mean temperature, maximum, and minimum mean temperature. Accordingly, the perception of farming households that temperature is increasing coincides with temperature recordings of the weather station.

With regard precipitation, the national meteorological data records, Figure 5.13, show that the annual total precipitation rate of the area is decreasing during last 30 years. Assuming the negative sign in the trend of precipitation, the farmers' perception appears to be in accordance with meteorological data. Moreover, the regression analysis reveals that annual total precipitation in the area is declining. As can be seen in Table 5.5, precipitation decline 5.931mm per year with statistically significant at 10 percent. Similarly, the correlation of precipitation with time also show the significant decline. Subjective assessment of the farmers did consistent with the meteorological data, however, from the one-to-one interview of the farmers indicated that although the farmers assess the overall decreasing trend of precipitation, but they are also a concern with frequent unexpected heavy rains in the area. The meteorological data are shown in the Figure 5.13, lack such information since it cannot capture the intensity and uniformity of precipitation over last 30 years. Although the figure cannot show the exact trends such as heavy rain, the decline of precipitation is at least in line with the farmers' awareness of precipitation. Therefore the discussions indicate that apple farmers in Cheongsong County are conscious local precipitation change.

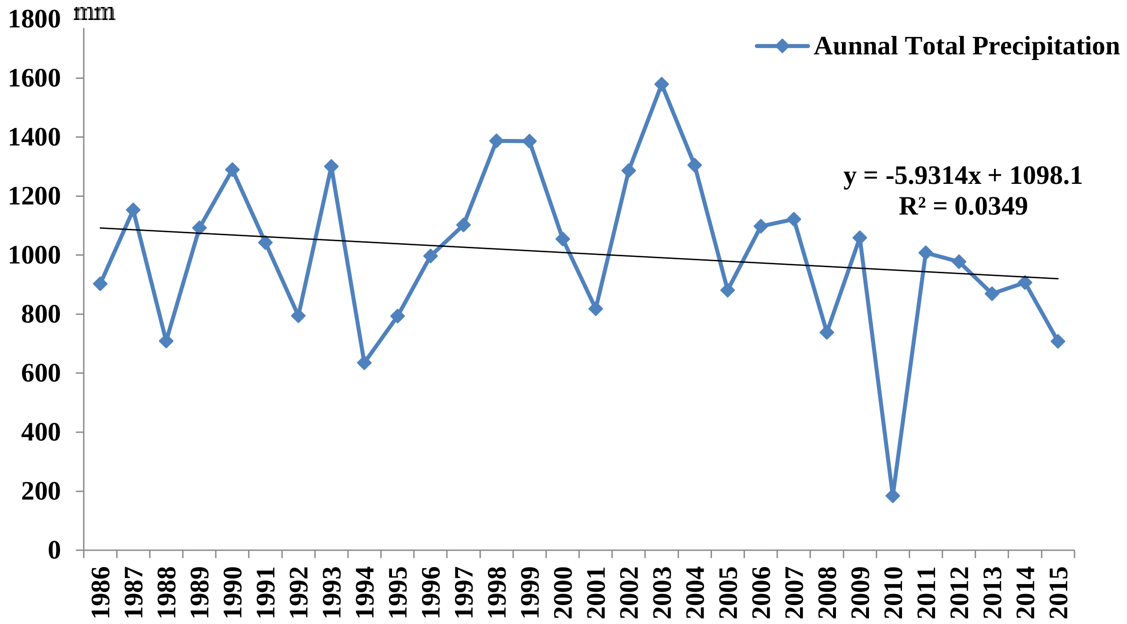

Figure 5.13 Annual total precipitation in Cheongsong County in North Gyeongsang Province, Korea, 1986-2015

Source: Constructed from a raw data of Andong County AWS, Korea Meteorological Administration National Climate Data Service System (NCDSS, 2016).

Table 5.5 Analysis of temperature and precipitation data from 1986 to 2015

	Temperature (°C)			**Precipitation(mm)**
	Annual mean	Maximum mean	Minimum mean	Annual total
Mean	12.089	18.19	6.69	1049.65
Standard Deviation	0.542	0.5535	0.594	231.861
Correlation with time	0.487***	0.403**	0.442***	-0.0295**
Trend	0.0305***	0.0253*	0.0298*	-5.9314*

*Significant at 10% level ($p<0.1$), ** Significant at 5% level ($p<0.05$), *** Significant at 1% level ($p<0.01$)

Source: Estimation from a raw data of Andong County AWS, Korea Meteorological Administration National Climate Data Service System (NCDSS, 2016).

Recent and direct experiences with extreme weather conditions have structured and shaped farmers' awareness and perceptions of climate variability. Particularly with regard farmers' perception of extreme events such as typhoon is more likely influenced by the direct experience with the events. Albeit the influence of climate change on tropical cyclones, including typhoon, is still equivocal, international and national discourses increasingly concur that climate change is expected to affect tropical cyclones by increasing sea surfaces temperatures, which is a major influencing factor for cyclone formation and behavior. IPCC (2013) projects that more likely than not; tropical cyclones will become more intense over the 21st century, with higher wind speeds and heavier rains. Moreover, Korea recognizes typhoon, a type of tropical cyclones, as an extreme event associated with climate change by including typhoon as an indicator for assessing and projecting climate change impact and vulnerability in Korea. MoE (2015, c) indicated that because of its complex topography, a tropical cyclone is a major meteorological system where circulation may interact with such land causing more intensive and frequent heavy rainfall in local areas.

To compare the results of the survey on the farmers' awareness of the trends of events, a major typhoon hit Korea were selected. Figure 5.14 and Table 5.6 shows the major typhoons hit Korea past. Those typhoons created the most damages to the country, and the bolded ones in the Table are the ones that hit the study area, Cheongsong County. It clearly shows that the major typhoons are recorded as hit more in the recent years. Compare to the temperature and precipitation changes, the results of the perception of farmers indicated that there are not many extreme events perceived, there are some increased typhoons shown in the meteorological data. Since extreme events, such as typhoon only have direct experience with a certain population, overall awareness of extreme event might be limited by farmers than other changing trends of climate.

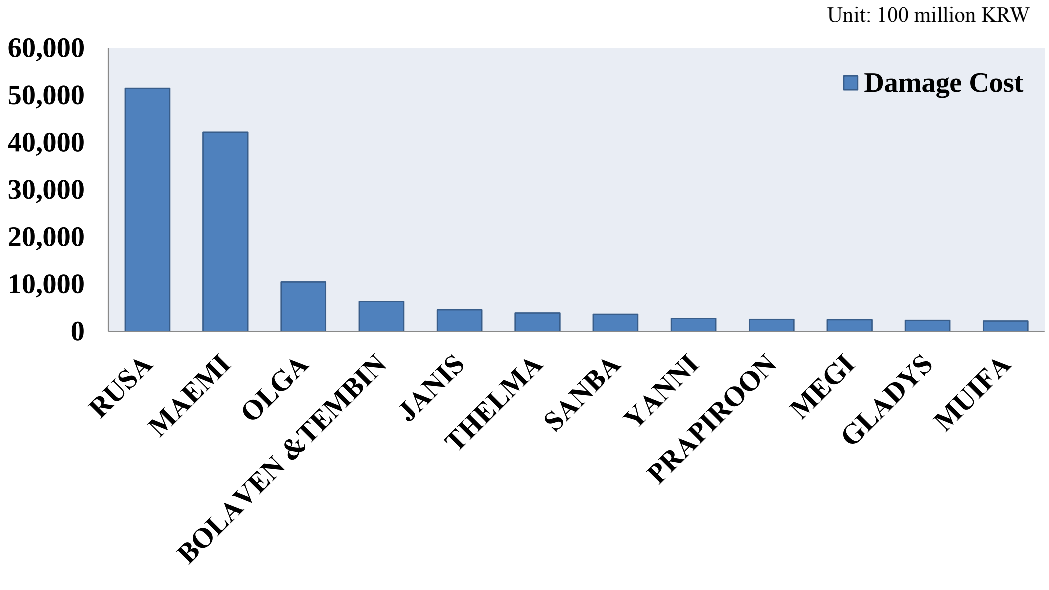

Figure 5.14 Damage costs of major typhoon in Korea

Source: Constructed from a raw data of Korea Meteorological Administration (2016).

Note: Bolded events caused mass damages to Cheongsong County

Table 5.6 Major typhoon in Korea

Period	Typhoon	Damage Costs (hundred million KRW)
2012.09.15. ~ 09.17.	SANBA	3,657
2012.08.25. ~ 08.30.	**BOLAVEN &TEMBIN**	**6,365**
2011.07.28. ~ 08.09.	MUIFA	2,183
2004.08.17. ~ 08.20.	**MEGI**	**2,508**
2003.09.12. ~ 09.13.	**MAEMI**	**42,225**
2002.08.30. ~ 09.01.	**RUSA**	**51,479**
2000.08.23. ~ 09.01.	PRAPIROON	2,520
1999.07.23. ~ 08.04.	**OLGA**	**10,490**
1998.09.29. ~ 10.01.	YANNI	2,749
1995.08.19. ~ 08.30.	JANIS	4,563
1991.08.22. ~ 08.26.	GLADYS	2,357
1987.07.15. ~ 07.16.	**THELMA**	**3,913**

Source: Constructed from a raw data of Korea Meteorological Administration (2016).
Note: Bolded events caused mass damages to Cheongsong County

It is essential to explore farmers' awareness of climate change and how accurate the awareness is when it is compared to the actual meteorological data. Such studies are barely done in Korea. Accordingly, local farmers' awareness has demonstrated pronounced changes in the local climate. Through cross-examination, whenever possible, with metrological recordings, this knowledge system, awareness of local farmers, is found to be in compliance with objective data. This would offer valuable information on assessment and perception of the impact of climate variability and change in the local context. Such studies are barely done in Korea context.

5.3 Farmers' Climate Change Risk Perception

In this chapter, the results of quantitative analysis of risk perception are presented. Main components of risk appraisal, perceived risk probability, and risk severity, are examined along with overall climate change risk perception.

5.3.1 Farmers' Risk Perception

Farmers' climate risk perception is examined with perceived risk probability and perceived severity of the seven specific areas. Each of perceived risk probability and perceived severity is calculated, and the overall result of farmers' perceived risk of climate change on seven different risks are calculated by summing all the seven risks by multiplying perceived probability and perceived severity. Since the farmers are asked to provide their perception as 'Never', 'Somewhat agree', 'Agree', and 'Extremely agree', theoretically there should be 1 to 16; hence the overall perceived risks, since there are seven different risk dimensions; apple production, income, assets, physical health, natural resources, network and psychological health (stress), the possible minimum and maximum of each specific perceived risk can be 7 and 112 and is normally distributed. It cannot be asserted that the level of the farmers' perception of climate change risk as low or high since there is no previous study or indicators to compare or contrast the level of perceived risks among the farmers.

Table 5.7 Mean and standard deviation (SD) of the farmers' perceived probability, perceived severity and overall perceived risk

Dimensions	Perceived risk probability		Perceived risk severity		Overall Perceived risk	
	Mean	SD	Mean	SD	Mean	SD
Apple production	2.95	0.76	2.95	0.78	9.20	4.28
Income	2.85	0.72	2.85	0.76	8.55	3.98
Assets	2.58	0.78	2.59	0.78	7.16	3.97
Physical Health	2.45	0.84	2.41	0.87	6.52	4.20
Natural Resources	2.46	0.82	2.42	0.84	6.52	3.97
Network	2.19	0.90	2.15	0.90	5.37	4.02
Stress	2.56	0.90	2.49	0.96	7.06	4.64

With the farmers' perceived probability of the climate change may impact on apple production, income, assets, physical health, natural resources, network and stress of farmers, Table 5.7 shows that apple production attained the highest means of probability (2.95). Since the study area, Cheongsong County is specializing in apple production, farmers most attention prioritized on apple production. Similar to the apple production, farmers perceive a high probability of climate change impact on their income (2.85). Again, since the farmers specialized in apple production and their income will mostly come associated with apple production and sales of the crop, apple production and income are considered to have the highest probability of climate change risks compare to other dimensions such as assets (2.58), physical health (2.45), natural resources (2.46), network (2.19) and stress (2.56). While livelihood issue is main concerns of the farmers, they might perceive assets, physical health, natural resources, network, and stress is indirectly associated with the impact of climate change. In sum, the result of perceived probability of climate change risk on seven different dimensions of lives shows that farmers perceive the probability of climate change risks will be high on apple production, income, assets, natural resources, stress, physical health, and network, respectively. Different perception of the probability of risks on different dimensions influence the responses of climate change by farmers. Farmers may place time, efforts and other resources onto the dimension that the perceived probability of the climate change risk is high.

Regarding the farmers' perceived severity, Table 5.7 shows that farmers perceive apple production as the dimension that will have the most severe risk by climate change. In line with perceived probability of the climate change risk, farmers perceive climate change will have the most severe risk on apple production (2.95) and income (2.85) while assets (2.59), physical health (2.41), natural resources (2.42), network (2.15) and stress (2.49) are perceived to have relatively lower severity. Farmers feel that that climate change would have relatively less impact on their social relationship network with neighbors and friends, as both of the dimensions score the lowest mean of perceived severity.

The mean of overall perceived risk is 50.38, and the standard deviation is 21.41. Farmers perceive the different level of risks for each dimension of risks, and except for apple production and income, our statistics show that mean overall perceived risks of each dimension show lower than the mean overall perceived risks. In other words, when considering perceived risk probability and perceived severity of seven different dimensions of the risks, the farmers perceive climate change risk associated with apple production and income are perceived higher while assets, physical health, natural resources, network and stress found to be lower than the mean perception of all of the seven dimensions. The means of climate change risks in apple production and income that the farmers seem to perceive high risks are 9.20 and 8.55 respectively. Meanwhile, the farmers seem to pay less attention to climate change risks associated with assets, physical health, natural resources, network and stress that the mean is 7.16, 6.52, 6.52, 5.37 and 7.06 respectively. Table 5.7 shows the statistical result of mean and standard deviation of each of the dimensions.

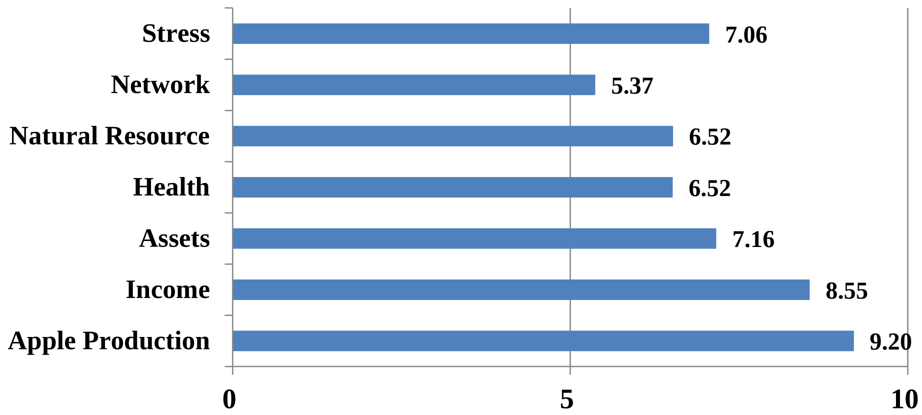

Figure 5.15 Farmers' overall perceived risks of seven dimensions

To compare more in detail regarding the farmers' perception of the climate risks, Figure 5.15 shows the means of overall perceived risk on seven different dimensions of the farmers' lives presented in Table 5.7. As the figure shows, the farmers seem to situate the higher priority on apple production and income while assets, stress, physical health, natural resources and network as a lower priority. Since the farmers perceive higher probability and severity of climate change risk on apple production and income, one can expect an adjustment in farming practices and diversifying income portfolio as their adaptation strategies to climate change risks. Farmers can consider adjusting the dates, use of fertilizers, switch to other crop or a different variety, or look for non-farming jobs. However, looking for non-farming job option is relatively limited for the apple farmers in Cheongsong County where apple farming is an intergenerational business. Moreover, some specified qualifications are needed for non-farming jobs that will not be available for the farmers. Moreover, in the area of Cheongsong County, there are not many opportunities for non-farming jobs since the area is dependent heavily on apple farming. Investing in the crop insurance can be other options for farmers to prepare climate risks. Farmers' climate change adaptation behaviors are certainly influenced by how farmers perceive climate risks on dimensions of lives. Hence, it is important to understand how farmers perceive climate change risks as to different dimensions of their lives and how they interpret it is important to in understanding farmers adaptation and finally to support to enhance the farmers' adaptive capacity.

5.3.2 Factors Influencing Farmers' Risk Perception

This section of the dissertation describes the factors influencing farmers' perceived risks of climate change to seven different dimensions and overall perceived risk through the results of multiple regression models. Dependent variables of each of eight regression models are perceived risk (probability and severity) on apple production, income, assets, physical health, natural resources, network, and stress and overall perceived risk. Explanatory variables are the same for all eight models. Table 5.8 presents the regression coefficients in the eight regression models which show how much-perceived risks to each dimension and overall perceived risks are changed as a result of one unit change in each explanatory variable. In addition, the R-square and adjusted R-square are reported with F-test at the bottom of Table 5.8. As shown in Table 5.8, R-square for the eight regression models indicates that 33% to 65% of the variation perceived risks of climate change can be explained by the explanatory variables in the models. The F-test indicates that all of the models are highly significant (p-value < 0.01). It is plausible to say that the assumptions of normality, linearity, and homoscedasticity of the residuals are met. Moreover, the Variance Inflation Factor (VIF) was calculated to test the level of multicollinearity of explanatory variables. If the VIF is under 10, it does not imply a high degree of multicollinearity. The explanatory variables for the regression model for farmers' risk perception of different dimensions of impact and overall were tested for the VIF, and as shown in Table 5.9, all of the VIF are substantially below the cut-off threshold 10, and the maximum VIF is 2.98. Thus, it is justified that the multicollinearity problem should not be implied in the model.

Apple production

Farmers' perception of climate change risk on apple production is found to be the highest among the seven dimensions. As a result of the linear regression model, some of the factors are found to have a significant influence on the farmers' risk perception of climate change on producing apple corps. Among the explanatory variables related to demographic and socioeconomic factors, age (0.0715), education(0.2016) and crop sales channel (-0.2265) are found to significantly influence farmers' perception on the apple production by the significant level at 5, 5 and 1 percent, respectively. Farmers' perceived risk on the apple production seems to increase as the farmer gets older and receive highly educated farmer. Moreover, farmers selling apple crop through direct market are more likely to perceive climate risk on apple production. Farmers selling their products directly to consumers may communicate with non-farming people more often that gather more information regarding climate and them also able to various feedbacks from consumers directly regarding their production which have been influenced by changing the climate.

With regard to farmers' awareness on climate variability and change, except for the awareness of precipitation, awareness on changing temperature (1.6179) and extreme events (-0.9431) found to significantly influence farmers' perception of risk in apple production with the significant level at 1 and 5 percent, respectively. Since farmers in the County are well-developed irrigation system which farmers' are easy to access such system, declining precipitation trends might not affect farmers' perception of climate risk on the apple production particularly. One of the most important factors influencing farmers' perception of risks can be noted as farmers' previous experience with climate risks. The regression shows that farmers who have risk experience related to changing temperature (1.4178) and extreme events(-0.9431) seem to have a higher perception of climate risk on apple production. The coefficients show that the farmers with more experience with increased temperature have higher climate risk perception with apple production while farmers with more experience with changed extreme events can have less risk perception associated with apple production. Some farmers do fear (1.0151) that there will be a threat by climate change and those farmers with fear show significantly influence the higher perception of risks. Further, what kind of information that farmers receive can influence their perception of the climate change risks. Perception of risk on apple production is significantly influenced by the adaptation information received from neighbors (-0.8859) and village leader (1.0102). This implies that farmers receiving information regarding adaptation measures from neighbor farmers can have less perception regarding climate risk on apple production. By sharing experiences regarding adaptation strategies among neighbor farmers, the farmers may perceive climate-related risks similar to something that can possibly have a remedy. However, information from community leader can increase farmers' risk perception on apple production. This clearly implies that adaptation information from different sources, even within the local setting, may be taken differently by the farmers.

Income

From the findings in the previous section, Table 5.7 and Figure 5.15, it is understood that the farmers' perception of climate risk on income is as high as apple production. Since, to most of the farmers in Cheongsong County, apple is the only crop that to be produced as an important income source, it can be expected to see that farmers' perception on apple production and income moving in the same direction. However, the factors influencing perceived risk on income may differ from apple production. With regard to the climate change risk on income, farmers' socioeconomic factors such as age, land ownership, the number of networks joined, crop insurance and the number of years buying crop insurance show the statistically significant influence on the perception of risk on income. The regression results show that older farmers perceive climate risk as more importantly associated with income. Unlike younger generation farmers who are challenging themselves to be involved in new experiences rather than focusing only on apple as a main income source, older farmers who perceive higher climate risk on income, are less likely to challenge themselves in a new environment and depend only on apple cultivation as the income source. Moreover, it is found that the farmers owning farmland are more likely to perceive climate risk on income. The number of the network that joined by farmers also shown to be a significant influencing factor. The coefficient is 2.1991 that farmers with one unit more networks joined are more associated with the higher perception of climate risk on income. It is perhaps that they received information through the network and may have opportunities to communicate with other farmers in similar circumstances.

Unlike the regression results with apple production, crop insurance and year of crop insurance are found to have statistically significant influence on the farmers' perception of the climate risk on income. Farmers invested in crop insurance seem to consider climate change risk on income more than others. Moreover, years of buying crop insurance have a negative relationship with perception with a coefficient of -0.3264 and significant at 1% level. With one year increase in investment of crop insurance will lessen the perception or concern regarding climate risk on income. This may present the current crop insurance system in the local area. As indicated, the farmers' who perceive the risk of climate change invest in crop insurance. However, the current crop insurance in Korea only covers the damages from extreme climate events, including typhoon, heavy rains, and hail, that has not been happened in the area for several years. Since the crop insurance was introduced in this County, 2005, the major typhoon has been limited in this area while the non-extreme climate events, such as increasing temperature has been causing damages to the farm activities. Therefore, as the number of years increases in buying crop insurance, farmers have not received much of the return or benefit from the investment caused farmers' perception of climate risk less likely.

The cognitive factors such as awareness of temperature and fear show the statistically significant relationship with perception of climate change risk on income. Experience with climate variability and change matters to farmers' perception that experience with higher temperature (0.7102), precipitation change (0.7930) and increased extreme events (0.7764) show significant at 10 percent, 10 percent, and 5 percent, respectively (Table 5.7). The farmers' direct experience with climate variability may influence farmers' perception of general climate risk on such dimension. The coefficient of adaptation information received from farmers' cooperatives such as NH has a negative sign (-0.6531) that one more unit of adaptation information received from NH can lower farmers' perception of risk on income. This may present that the contents of information may not clearly disseminate the objective of adaptation as the measures to prevent climate risk.

Assets

Although the definition of assets is opened for each of the interviewed farmers, some of the general elements included in the assets are house, car, television, and equipment for apple farming. According to the previous findings, the risk perception of farmers on assets seems to have received less attention than apple production or income. However, the dimension still shows the higher perception than other dimensions such as physical health, natural resources, and network. The regression model (Table 5.7) shows the factors influencing the assets. Interestingly, the asset is the only dimension that is not influenced by any of the socioeconomic factors of farmers. None of the socioeconomic factors show the statistically significant relationship with the perception of climate change risk on assets. In fact, the awareness of changing trends of extreme events, climate risk experiences, fear of future climate risks, and information related to adaptation measures are found to be significantly influential in farmers' risk perception related to assets. The coefficient of awareness of extreme events is 1.1484 with significant at 1 percent level. Farmers with higher awareness of increasing extreme events seem to have a higher perception of climate risk on their assets. Moreover, farmers' previous experience with climate variability and change, higher temperature, changed precipitation and changed extreme events variability and trends, influence farmers' perception with the coefficient of 0.814, 0.8235 and 1.2489, respectively. The significant levels of those experiences are at 5 percent, 5 percent, and 1 percent, respectively. Fear of future climate risk may increase the perception of climate risk on assets, but the regression did not show the significant relationship to the risk perception on the asset. Some information from reliable outside sources, for instance, the adaptation measure information from a community leader (0.7254), is shown to have a significant influence on the perception of climate risk on assets. The findings on farmers' perception of climates risk on assets imply, that regardless of farm household characteristics farmers' climate change related experience and enhancing farmers' awareness on climate variability and change may increase farmers' perception of climate risk specifically with assets.

Physical Health

According to the regression model, farmers' perceived risk to physical health is the only dimension influenced by years of farming experience and a number of training programs that farmers participated during 2016. As shown in the figures of Table 5.8, the coefficient of the variable, year of experience in farming (-0.0707) has a negative sign explaining one more year in farming; farmers do perceive fewer climate risks with regard to their physical health. Farmers who have been in same farming activities for longer periods may have more experiences with different risk circumstances and may have developed own know-how to prevent and cure damage. Those farmers may become less sensitive to climate-related risks, causing them to be less likely to perceive climate risk on physical health. Farmers' participation in agricultural training program influences their perception of climate change risk to physical health with a coefficient of 0.1105 with significant at 10 percent level (Table 5.8). Since the issues of climate change are considered major threat to the national and global economy and direct and serious threat to health, agricultural training programs provided by public institutions may have many contents regarding climate change and health issues. Agricultural training programs such as technical training on using fertilizers and pesticides may also provide some information about climate change. Farmers who trust the government on their climate change adaptation capacity perceive climate risk to physical health more than others.

Moreover, farmers' income is another factor that influences farmers' perception of climate risk to physical health. A farmer with higher income is less likely to perceive climate risk on the health. During the cultivation and flower removal seasons, farmers may need some help from family members or pay some labors to assist with the farming work. Since the season of such farming works is mostly done in summer seasons in Korea, farmers with higher income could pay for more labors to assist in the work. This might result that farmers with greater help from others in doing flower removal and cultivation might not have to be exposed to the sunshine during the daytime. Other factors such as experience on precipitation change and extreme events also influence the perception of climate risk to physical health. Experience with less water resource and damage from extreme events may increase perception on their physical health.

Natural Resources

According to the findings of the previous theme, the farmers do not perceive climate risk on natural resources as serious as other dimensions as apple production and income. It is because most of the farmers do not reflect the natural resource as scarce or limited but perceive it as abundance resource for a human being. However, some farmers do perceive climate risk on the natural resource as important, and the factors influencing that perception is found in the regression model show the farmers with successor has a higher perception of climate risk to natural resources. Generally, in Korea, sons are the ones who are considered to be the successors of the family business. In the past, almost all of the farmers turn their farms over to their son and teach them their know-how and take very good care of the farms for the next generation. However, the young generations do not want to continue work on farms but to work in the cities in recent years. Therefore, not many farmers think they will leave the farms over to their sons, and they do not really think of the condition of their farms or environment of the next generation. General understanding of natural resources is something that is not owned by one person but can be used by everyone by farmers. Therefore, they do not have a serious concern regarding damage to natural resources. However, farmers with the successor of their farms do have a concern regarding the next generations and a higher perception of climate risk to the natural resource. Moreover, farmers with a negative experience with climate change such as extreme events have a higher perception of risk on natural resources. Therefore, the farmers' perception of climate risk to natural resources will increase if the farmers have more experience with changed extreme events.

Network

In the previous section, it is found that the level of farmers' perception of climate risk to their social networks is found to be the least among all other dimensions. This means it is not usual that farmers considering the social network directly with climate change risk. However, some factors in the regression model are shown to influence farmers' perception of climate risk associated with the network. Factors influencing farmers' social network are income, the experience of temperature increase and extreme events. Farmers with higher income have a higher perception of climate change risk to network with a coefficient of 0.3405 with the significant level of 10 percent (Table 5.7). Farmers' experience with temperature increase and extreme weather events may have experience of the cut off network. With extremely high temperature, heat waves, and extreme weather events, farmers cannot work outside and may not have enough facilities to have a chance to communicate with neighbors and families and friends in other areas. Therefore, the perception of climate risk to the network can be influenced by those factors, such as income level, experiences with temperature increase and extreme events.

Stress

Climate change may increase various stresses and have a negative impact on farmers' physical and mental health. Some of the factors indicated in the regression model are found to have significant relationships with farmers' perception of climate risk to stress. The share of farmers income from apple farming is shown to have a coefficient of 0.0585 with significant at 1 percent level (Table 5.7). Farmers with a higher percentage of income from apple farming are more likely to have a higher perception of climate risk to stress because their income depends mostly on apple production and it is highly depended on climate condition, climate change can have a direct impact on apple production and concerns to adjust their farming strategies. The coefficient of awareness of abnormality of extreme events shows 0.7577. With abnormally increasing unexpected extreme events, farmers specializing apple production as their main source of income have to be prepared for such abnormal climate conditions. The experience of temperature increase is also associated increasing the perception of climate risk to stress by 1.5253 with one unit increase in experience. The significant level with regard to such factor shows at 1 percent. Farmers with experience of increasing temperature can have knowledge of potential damage of climate variability, and it might be connected to the perception of risk to stress. Farmers with a higher perception of climate risk to stress will have different ways to response to projected climate change from farmers who do not perceive climate risk to stress. They will induce adaptation measures that would lessen the damage from climate variability and change to lessen the stress from such consequences.

Table 5.8 Multiple regression results on the perceived climate change risk

Independent Variables	Dependent Variables: Risk Perception of Each Dimension and Overall Perceived Risk							
	Apple Production	Income	Assets	Physic. Health	Nat. Resource	Network	Stress	Overall
Age	0.0715**	0.0672**	0.0267	0.0034	-0.0340	-0.0171	0.0265	0.1442
Gender	0.4037	-0.5258	-0.3953	1.0997	-0.3093	0.0674	0.2826	0.6230
Education level	0.2016**	-0.0518	0.0441	0.0249	0.0016	-0.0511	0.0973	0.2666
Farming Area	0.4054	0.1840	-0.1490	0.2665	-0.2732	-0.5705	0.0618	-0.0751
Farming Experience	0.0050	-0.0354	0.0029	-0.0707*	-0.0221	0.0007	-0.0343	-0.1540
Income	-0.0588	0.0058	0.1324	-0.0511*	-0.0098	0.3405*	-0.0669	0.2921
% of income from apple cultivation	-0.0025	-0.0156	0.0085	-0.0063	0.0097	0.0104	0.0585***	0.0627
Successor	0.2261	0.3443	0.1544	0.9849	1.0530*	0.5707	0.5412	3.8746
Agriculture Education	-0.0217	0.0241	0.0011	0.1105*	0.0871	0.0447	0.0641	0.3099
Sales channels	-0.2265*	-0.3749	0.3864	-0.0191	0.0142	0.0536	-0.2701	-0.4364
Land Tenure	0.1331	0.2715*	-0.0338	0.1358	0.0750	-0.0245	0.1834	0.7405
Network	1.3017	2.1991**	-0.1613	2.2920*	0.2011	1.6709	0.9822	8.4857
Buying Crop Insurance (CI)	1.0106	1.6608**	-0.0385	0.6397	0.0453	0.4218	-1.0037	2.7359
Cumulative years of Buying CI	-0.1425	-0.3264***	-0.0038	-0.0108	-0.0452	-0.0999	-0.0689	-0.6976*
Increased Temperature	1.6179***	0.8178**	0.4826	0.4614	0.2073	0.1939	-0.0444	3.7364**
Changed Precipitation	-0.0595	-0.1865	-0.5696	0.1049	-0.1438	-0.3740	0.5536	-0.6749
Changed Extreme events	-0.9431**	0.1602	1.1484***	0.1763	0.6577	0.7577*	0.8153*	2.7725*
Risk Experience 1 (Temperature)	1.4178***	0.7102*	0.8140**	0.0472	0.2688	0.8288*	1.5253***	5.6122***
Risk Experience 2 (Precipitation)	-0.1572	0.7930*	0.8235**	1.2536***	0.8372*	0.2148	0.7340	4.4988**
Risk Experience 3 (Extreme events)	1.0151***	0.7764**	1.2489***	1.7529***	1.6172***	1.0891***	0.6092	8.1087***
Fear on future climate risks	1.1694	1.0989	0.6042	-0.0290	0.0316	-0.0610	0.3120	3.1261
Climate change info. 1 (Public media)	0.1764	-0.1713	0.4303	-0.7827*	-0.3109	0.3376	0.3595	0.0389
Climate change info 2 (Neighbor farmers)	0.6341	0.4834	0.0184	0.1052	0.0627	-0.2823	0.3358	1.3572
Climate change info 3 (Village Leader)	0.2995	0.4567	-0.4554	-0.3985	-0.3278	0.3103	-0.4120	-0.5272
Climate change info 4 (Agri. Ext. Cent.)	-0.0566	-0.1566	-0.2882	0.2401	0.3404	0.2941	0.3063	0.6795
Climate change info 5 (Cooperative)	0.1275	0.4369	0.0268	-0.4963	-0.1356	-0.1314	-0.1708	-0.3429
Adaptation info. 1 (Public media)	0.0452	0.0851	0.2458	0.3863	0.3966	-0.0773	-0.3408	0.7410
Adaptation info 2 (Neighbor farmers)	-0.8859*	-0.4669	0.0380	-0.3853	-0.2962	-0.0841	-0.3560	-2.4364
Adaptation info 3(Village Leader)	1.0102 **	0.4583	0.7254*	0.7181	0.3838	-0.3854	0.2506	3.1609
Adaptation info 4 (Agri. Ext. Cent.)	0.4120	0.2346	0.4860	0.3867	0.6123	-0.3857	-0.0257	1.7202
Adaptation info 5 (Cooperative)	-0.5181	-0.6531*	0.1497	-0.1283	-0.1823	0.1984	-0.2882	-1.4218
_cons	-9.9143	-5.2312	-9.4569***	-2.7371	-0.8919	-1.7589	-9.8123	-39.8025
R-square	0.53	0.56	0.60	0.47	0.45	0.33	0.45	0.67
Adjusted R-square	0.38	0.42	0.47	0.30	0.28	0.35	0.29	0.60
F-test, p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

*Significant at 10% level (p<0.1), ** Significant at 5% level (p<0.05), *** Significant at 1% level (p<0.01)

Overall climate change risk perception

Factors influencing the farmers' overall perceived risk of seven different dimensions are analyzed through a regression model in Table 5.8. The table shows the dependent variable of overall perceived risk and explanatory variables that are equivalent to the regression models on perceived risk of each of the dimension. Among various factors, some socioeconomic variables including having successor and years of buying crop insurance show the significantly related to increase in overall perceived risk. Farmers having successors who will take over their apple farming have a higher perception of overall perception risks to climate change than farmers who do not have successors. Table 5.7 shows a coefficient of successor variables shows 3.8746 with significant at 10 percent levels.

Crop insurance shows the significant relationship with overall perception of climate risks. Although investing in crop insurance itself does not significantly associated with the perception of climate risk, years of buying crop insurance (Coefficient: -0.6976) has significant at 1 percent level of influence on farmers' perception of climate risks (Table 5.7). As farmers continue to invest in crop insurance, farmers may expose to climate change information and experience benefits of buying crop insurance. However, in the study area, Cheongsong County had not been broadly exposed to extreme events in the past. Only some parts of the country are exposed to extremely damage from extreme events and farmers become negative about crop insurance. This certainly influenced their perception of climate risk may decrease. Therefore, according to the of the regression model, farmers with a longer period of buying crop insurance have a lower perception of climate risks.

Several cognitive factors such as awareness of increasing temperature and extreme events and fear of damage from climate change significantly influence farmers' perception of climate risks. Awareness of increasing temperature with a coefficient of 3.7364 with significant at 5 percent level has influenced the perception of climate risks. In addition to the awareness of climate temperature, farmers with one unit higher in awareness of extreme events are found to be higher in the perception of climate risk by 2.7725 (the significant level at 10 percent). Farmers with a higher level of fear of damage from climate change have a higher perception of climate risks by 3.1261 with a significance level of 5 percent (Table 5.7).

Experiences of climate variability, particularly with temperature increase, precipitation change, and extreme events, have shown to be the significant influential factors of farmers' perceptions of climate risks. Farmers with experiences of temperature increase and extreme events show the coefficients of 5.6122 and 8.1087 with 1 percent of significant levels, respectively. Moreover, farmers' experience on precipitation change and extreme events show coefficient of 4.4988with 5 percent of significant levels (Table 5.7)

Farmers' perception of climate risks can be influenced by information on climate change and adaptation measures received from various sources. However, the regression model in this dissertation shows no significant levels of the coefficient for all of the information sources. Although there was no significant level of influence of climate change information and adaptation information from various sources, the coefficient shows mixed results of positive and negative signs. Climate change information from a community leader (-0.5272) and cooperative (-0.3429) show negative signs while climate change information from public media (0.0389), neighbors (1.3572), agricultural extension center (0.6795) show positive signs. With regard to adaptation information, the coefficient of the model has both negative (neighbors (-2.4364) and cooperative (-1.4218)) and positive (public media (0.7410), village leader (3.1609) and agricultural extension center (1.7202)) for overall perceived risk.

Table 5.9 Variance Inflation Factor (VIF) for the farmers' climate change risk perception regression models

Explanatory Variables	VIF	Explanatory Variables (continue)	VIF
Age	2.54	Risk experience 1 (Temperature)	1.94
Gender	1.36	Risk experience 2 (Precipitation)	2.18
Education level	1.70	Risk experience 3 (Extreme events)	2.00
Farming area	1.49	Fear of future climate risks	1.54
Farming experience	2.30	Climate change info. 1 (Public media)	1.70
Income	1.50	Climate change info 2 (Neighbor farmers)	1.92
% of income from apple cultivation	1.68	Climate change info 3 (Village Leader)	2.19
Successor	1.30	Climate change info 4 (Agri. Ext. Cent.)	1.92
Agricultural training program	1.49	Climate change info 5 (Cooperative)	2.20
Sales channels	1.46	Adaptation info. 1 (Public media)	1.76
Land ownership	1.31	Adaptation info 2 (Neighbor farmers)	2.33
Network	1.57	Adaptation info 3(Village Leader)	2.66
Buying Crop Insurance (CI)	2.82	Adaptation info 4 (Agri. Ext. Cent.)	2.14
Cumulative years of buying CI	2.98	Adaptation info 5 (Cooperative)	2.53
Awareness (Temperature)	2.03		
Awareness (Precipitation)	2.68		
Awareness (Extreme events)	2.43		

Summary on the farmers' risk perception

The section is developed to investigate how the farmers perceive climate risk on different dimensions in their lives and analyze determinants of the perception. It is found that farmers perceive climate risk differently and climate risk was perceived mostly on apple production, and income while an asset, physical or mental health, natural resources, and social network are perceived to have less impact on climate risks. It can be implied that as most of the adaptation literature in agriculture focus on the climate change impact on agricultural production and economic benefit and costs, the farmers also perceive climate-related risks associated with the production and income. However, the study found that the farmers also perceive climate risk on a wider range of dimensions including physical and mental health, natural resources and social network.

The regression analysis on factors influencing farmers' risk perception shows that farmers' perception of climate risk on different dimensions is influenced by different factors. For instance, through direct communication with consumers, farmers may receive information regarding climate change and its impact, and this may influence farmers' perception of climate risk on apple production. Further, it is found that farmers can perceive higher climate risk on their mental health if the farmers' income focuses only on apple crop. Crop insurance is also found to play an important role in farmers' perception of climate risk. More importantly, a higher level of awareness on increasing temperature and changing extreme events are found to influence farmers' perception and the farmers' direct climate risk experiences attribute to a higher perception of climate risk on most of the dimensions.

5.4 Farmers' Perceived Climate Change Adaptation Efficacy

In this chapter, farmers' perceived adaptation measure efficacy, self-efficacy and adaptation costs and the results of regression analysis on the factors influencing are presented. As presented in the previous sections, nine general adaptation measures are practiced by apple farmers in the Cheongsong area. The adaptation measures presented are; 1) Adjustment of farming dates (CCAM 1), 2) Adjustment of farming techniques (CCAM 2), 3) Switching to new crop (CCAM 3), 4) Gathering additional information on climate change (CCAM 4), 5) Diversifying crop varieties (CCAM 5), 6) Buying crop insurance (CCAM 6), 7) Improving soil condition (CCAM 7), 8) Changing to different variety of apple (CCAM 8), 9) Diversifying income portfolios by searching for non-farming jobs (CCAM 9).

5.4.1. Farmers' Perceived Adaptation Efficacy

Table 5.10 shows actual percentage of farmers using each of adaptive measures. In general, a high percentage of farmers were using the adaptive measures that mostly related to their farming techniques such as adjusting the use of pesticides (67.6%). Apple produced from Cheongsong County is well-known in Korea for its high quality. To keep its quality and reputation, the government is putting its efforts in various ways. From in-depth interviews with the farmers, it was found that in Cheongsong County, using pesticide is broadly spread to farmers and this is led by an expert, Dr. Ueom. Dr. Ueom's professional is on making pesticides combating insects and disease on apple crops. Dr. Ueom helps farmers on using pesticides that are to keep a good quality of Cheongsong apple. Farmers in the area trust Dr. Ueom, and they do believe that using pesticides that are introduced by Dr. Ueom would protect their crops from unpleasant damages from insects and disease. With regard to the results of interviews, further discussion is presented in the next chapter.

Buying crop insurance (61.8%) was also highly performed by farmers as to prevent and prepare to the damages from climate variability and change (Table 5.10). Although the apple farmers in Cheongsong County has been introduced to crop disaster insurance only from 2005, apple farmers have been the major crop insurance investors. It is because apple farmers have easier access to the crop insurance. Although in Korea, crop disaster insurance is only applicable for some of the crops, apple crop is included to covered in the insurance from the beginning of the crop insurance was introduced in Korea. Moreover, 80 percent the premium of crop insurance is paid by the government and only 20 percent would be covered by apple farmers. However, from the interview, crop insurance is now starting to lose its reputation of easy access with good benefit with less investment. It is because the farmers are unhappy with the benefit from all the years that they invested in the insurance. The insurance only provides benefits to the certain population of the farmers who has been impacted by serious damages from natural disasters and climate change.

Until now, in Cheongsong County, the impacts from extreme events such as typhoon only happens few times and a typhoon hit the same local areas most of the times. While the premium prices are same for all apple farmers in the County, the farmers with damaged from the typhoon areas are only those who has been getting the benefits. Therefore, the farmers without the experience of serious damage of climate change become doubt about the effectiveness of the insurance system. However, the percentage of farmers investing in insurance is still high because farmers are worried about future uncertainties. Moreover, the farmers emphasized that although they think it is not fair to pay the same premium or to receive no benefit from buying insurance, they feel nervous or fear without the insurance.

More than half of the farmers paid attention to climate change information (55.3%) (Table 5.10). Increasing access to information is not limited to urban people in Korea. People living in rural areas also have good access to information through the internet and public media in Korea. Most of the farmers interviewed had mobile phones, and almost all of the mobile phone users were using Smartphone that able farmers to access to information whenever and wherever they want. Although elders were not familiar getting information through the internet, they were very comfortable with getting information from public media such as television and radios. Moreover, disaster warning information is sent to farmers by text message system. Farmers indicated that they try to pay attention to the disaster warning information because they are uncertain about the climate variability and they experienced with an increasing number of unexpected climate variability and change in recent years.

Most of the interviewed farmers aware of increased temperature pointed out the changed farming dates (45.3%) with advanced dates of flowering and cultivating seasons. Growing period of the apple crop in Korea is from April to October (Table 5.10). According to farmers, they became conscious about increasing temperature by advanced flowering season in recent years. Because of the changed flowering time, the farmers have to adjust their farming calendar. In Korea, apple is consumed as usual daily fruit, but more importantly, the best quality of apples are consumed as valuable fruit that is to be presented to important people and served in the ritual ceremony for the ancestors during thanksgiving in autumn (*Chuseok*), one of the major holidays in Korea. In other words, apple is the most important and reputational fruit consumed during autumn and *Chuseok* in Korea. However, in recent years, because of advanced flowering and farming dates, the cultivation season of apple crop also advanced, and the best quality of apples are hardly left to be sold during *Chuseok* holidays. Adjusting farming calendar to meet the increased temperature and change climate is unavoidable for farmers, but the consequences brought by enacting adaptive measure is certainly undesirable for farmers and consumers in Korea because of the cultural means of apple served in the country.

Only a few farmers practiced improving soil condition (11.2%) and changed to a different variety of apple crop (11.2%) as adaptive measures (Table 5.10). In the study area, soil improvement is not an accustomed practice for apple cultivation that such practice is only known to be necessary when the trees become rampikes. After cultivating long years of apple, degradation of soil and tree become a problem for apple production. Farmers involved in those adaptive measures are the ones who have been the apple farmer for the longer period of time. Since the farmers with a longer period are well trained for apple farming, and it would not be hard for them to reinforcing quality for apple production environments when they perceive any disadvantage of keeping current condition.

Switching to new crop (2.9%), diversifying crop variety (6.5%), and searching for non-farming jobs (4.1%) were seen as almost the very last option for adaptive measure for climate change (Table 5.10). The agriculture that is specialized in apple farming in Cheongsong County can be an explanation for those low rates, to some extent. In Cheongsong County, as indicated in previous sections, most of the population is involved in apple farming. Particularly, apple is the major cash crop for all surveyed farmers. Among the surveyed farmers, 77.1 percent of the farmers are involved in only apple farming, 20.6 percent of the farmers were growing one another crop in addition to apple, and 1.2 percent of farmers were involved in 3 and 4 different crops. Although some of them grow other crops such as tomato, peppers, and blueberries but only on small parcels of land and mostly for the farm household consumption. There are very limited numbers of farmers who are involved in switching to new crop or to finding jobs outside of farming, however, the interviewed farmers in this categories are mostly the ones who have been involved in the apple farming for 5 years at the most and some of them had moved from southern provinces and have experience of extreme damages from climate variability and change. However, it is certain that one of the reasons that the farmers are involved in this adaptive measure can be their perception of climate change and its impact on the apple farming. With consideration of the current use of adaptive measures by farmers, next section will present the results of farmers' perception on the efficiency of the measures, self-capacity to enact, and the costs of each of nine adaptation measures.

Table 5.10 Number of the apple farmers using climate change adaptation measures

Climate Change Adaption Measures (CCAM)	Farmers using CCAM
CCAM 1: Adjustment of apple farming dates	77
CCAM 2: Adjustment of using pesticides	115
CCAM 3: Switching to new crop	5
CCAM 4: Gathering information on climate change	94
CCAM 5: Diversifying crop varieties	11
CCAM 6: Buying crop disaster insurance	105
CCAM 7: Improving soil condition	19
CCAM 8: Change to different variety of apple	19
CCAM 9: Searching for non-farming jobs	7
No adaptation	15

Perceived adaptation measure efficacy

Most of the apple farmers in Cheongsong County have a long period of experience in apple farming, and they have been preventing the crops from risks from various sources. Particularly with regard climate variability and change, farmers have been using several ways to response to the impact. The farmers are asked to provide their perception on the efficiency of each of nine adaptation measures. Table 5.11 shows the result of the survey. The first column shows the farmers' perception on the adaptation measures. Along with Table 5.11, Figure 5.14 indicates the survey results on the farmers' perception of adaptation measure efficacy. As shown in the Table 5.11 and the Figure 5.16, among nine practiced adaptation measures, the mean of the farmers' perception of adaptive measure efficacy on the adjustment of using pesticides (2.74) is highest followed by buying crop insurance (2.71).

The result is equivalent to the percentage of actual use of an adaptive measure that is shown in the previous section. It might be that farmers use what they perceive as effective, or in another way, that they want to perceive what they use as the adaptive measure is effective. In either way, it is certain that the farmers perceive that there is a change in the apple production condition related to climate and they have to change their tasks to prevent further damages. The means for gathering information related to climate variability and change and Adjusting apple cultivation period to changed flowering and cultivation scored 2.59 and 2.48, respectively. Improving soil condition as to improve the environment for apple production is found to be 2.21 and switching to new crop and diversifying crop variety as adaptive measures are found to be 2.19 and 2.10, respectively. Just a few of farmers perceive changing to a different variety of apple (2.04) as effective as other measures. Furthermore, farmers perceive searching for a non-farming job (1.96) as the least effective adaptive measure to climate change (Table 5.11).

Table 5.11 Summary of the farmers' perceived adaptation measure efficacy, self-efficacy and adaptation costs

Categories	**Perceived Measure Efficacy (PME)**		**Perceived Self-Efficacy (PSM)**		**Perceived Adaptation Costs (PAC)**	
Statement	It is an effective adaptation measure to climate change		I have capacity to implement the adaptation measure		It is cheap to adapt the measure	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**
CCAM 1: Adjusting farming date						
Disagree	18	10.6	20	11.8	21	12.4
Somewhat agree	68	40.0	81	47.7	59	34.7
Agree	68	40.0	59	34.7	71	41.8
Strongly agree	16	9.4	10	5.9	19	11.2
Mean (SD)	2.48 (0.81)		2.35 (0.76)		2.52 (0.85)	
CCAM 2: Adjusting use of pesticide						
Disagree	7	4.1	14	8.2	25	14.7
Somewhat agree	55	32.4	72	42.4	71	41.8
Agree	83	48.8	69	40.6	63	37.1
Strongly agree	25	14.7	15	8.8	11	6.5
Mean (SD)	2.74 (0.76)		2.50(0.77)		2.35(0.81)	
CCAM 3: Switching to new crop						
Disagree	47	27.7	50	29.4	33	19.4
Somewhat agree	58	34.1	70	41.2	51	30.0
Agree	50	29.4	38	22.4	60	35.3
Strongly agree	15	8.8	12	7.1	26	15.3
Mean (SD)	2.19(0.94)		2.07(0.89)		2.46(0.97)	
CCAM 4: Gather information on climate change						
Disagree	23	13.5	24	14.1	24	14.1
Somewhat agree	49	28.8	65	38.2	58	34.1
Agree	72	42.4	58	34.1	63	37.1
Strongly agree	26	15.3	23	13.5	25	14.7
Mean (SD)	2.59 (0.91)		2.47(0.90)		2.52 (0.91)	
CCAM 5: Diversifying crop varieties						
Disagree	54	31.8	54	31.8	29	17.1
Somewhat agree	55	32.4	61	35.9	60	35.3
Agree	51	30.0	43	25.3	47	27.7
Strongly agree	10	5.9	12	7.1	34	20.0
Mean (SD)	2.10(0.92)		2.08(0.92)		2.51(1.00)	
CCAM 6: Buying crop insurance						
Disagree	28	16.5	24	14.1	53	31.2
Somewhat agree	29	17.1	51	30.0	68	40.0
Agree	78	45.9	67	39.4	36	21.2
Strongly agree	35	20.6	28	16.5	13	7.7
Mean (SD)	2.71(0.98)		2.58(0.93)		2.05(0.91)	
CCAM 7: Improving soil condition						
Disagree	49	28.8	45	26.5	37	21.8
Somewhat agree	51	30.0	76	44.7	57	33.5
Agree	55	32.4	37	21.8	47	27.7
Strongly agree	15	8.8	12	7.1	29	17.1
Mean (SD)	2.21(0.96)		2.09(0.87)		2.40(1.01)	

CCAM 8: Changing to a difference variety of apple						
Disagree	60	35.5	52	30.6	37	21.8
Somewhat agree	52	30.8	68	40.0	54	31.8
Agree	47	27.8	41	24.1	48	28.2
Strongly agree	10	5.9	9	5.3	31	18.2
Mean (SD)	2.04(0.93)		2.04(0.87)		2.43(1.03)	
CCAM 9: Searching for non-farming job						
Disagree	71	41.8	66	38.8	39	22.9
Somewhat agree	50	29.4	59	34.7	51	30.0
Agree	34	20.0	36	21.2	41	24.1
Strongly agree	15	8.8	9	5.3	39	22.9
Mean (SD)	1.96(0.99)		1.93(0.90)		2.47(1.08)	

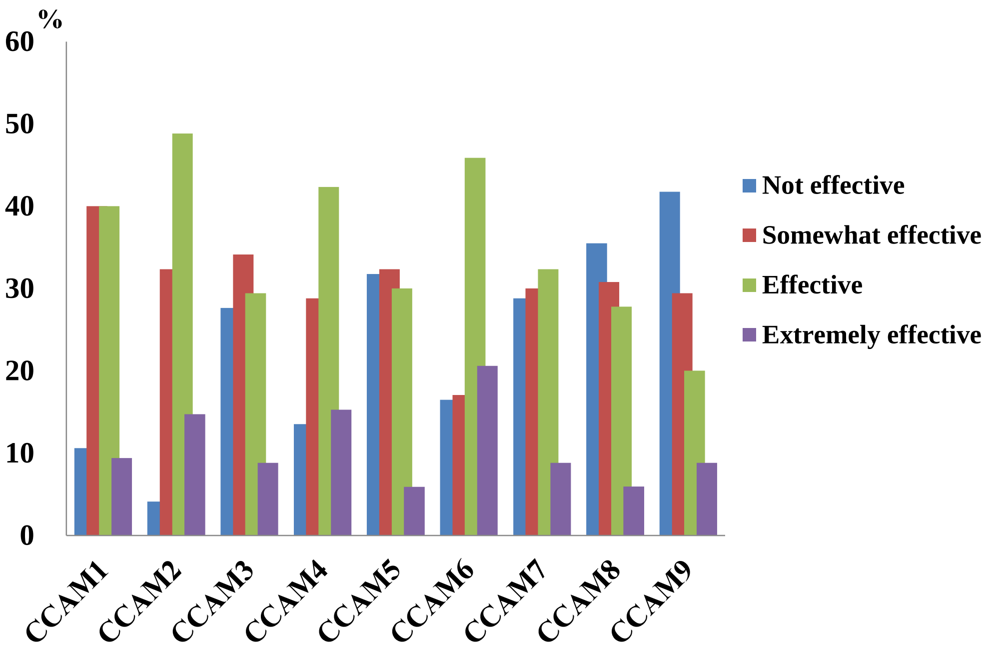

Figure 5.16 Percentage of the farmers' perception of adaptation measure efficacy

Perceived self-efficacy

The farmers' adaptation assessments on self-efficacy, self-assessments on the capacity of performing the adaptation measures, are presented in the second column of the Table 5.11. Also, a percent of perception on self-efficacy on each of adaptation measures are presented in Figure 5.17 Buying crop insurance had a highest farmers' perception on self-efficacy. This means that among all other adaptive measures, farmers perceive that they have the highest capacity of performing adaptation by preventing and lessen the damage of climate change through investing in crop disaster insurance. Adjusting use of pesticides had second highest perceived self-efficacy. Overall, the adaptive measures with high perceived self-efficacy, like perceived adaptive measure efficacy, was actually performed by many interviewed farmers as discussed in the previous sections. Gathering information on climate change and adjusting apple cultivation period were also found to have precisely high means by 2.47 and 2.35, respectively. Farmers perceived improving soil condition (2.09), diversifying crop varieties (2.09), switching to new crop (2.07) and change to a different variety of apple (2.04) with similar levels of self- efficacy. Only a few farmers indicated that they are capable of finding non-farming jobs (1.93).

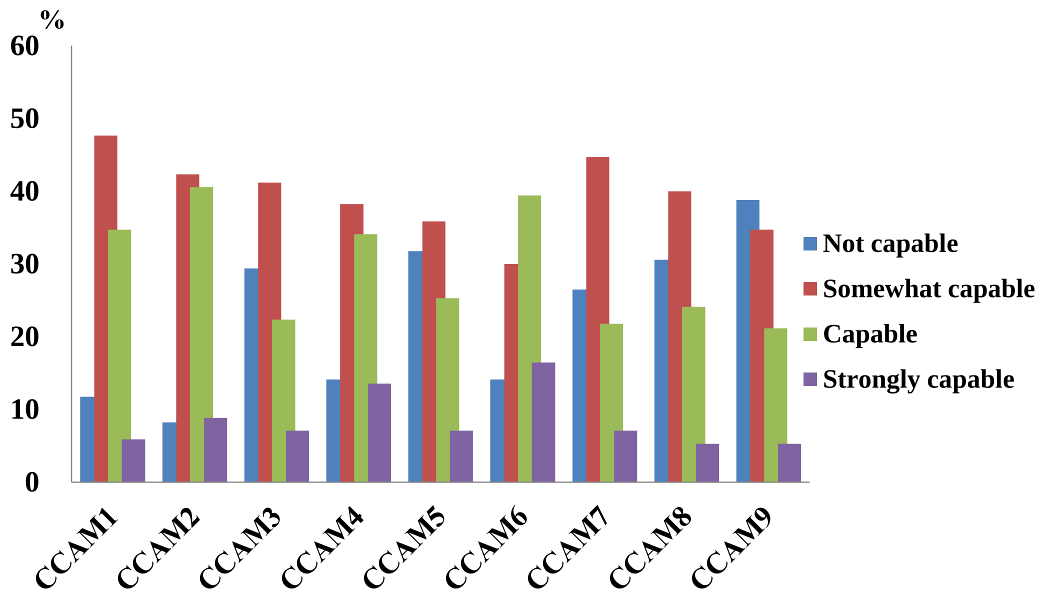

Figure 5.17 Percentage of the farmers' perceived self-efficacy of adaptive measures

Perceived adaptation costs

The result of farmers' perception on costs to perform the adaptive measure is shown in the third column of the Table 5.11 and Figure 5.18. The cost of performing the adaptive measures was opened to be defined by farmers, and it includes not only the monetary costs but also the time, effort and so on. Overall, farmers perceive performing adaptation is not cheap and requires some level of costs since all of the perceived costs of adaptive measures show over 2 which is 'somewhat costly.' However, Farmers perceived adjusting apple farming dates (2.52) and gathering information (2.52) on climate change are the least expensive. To adjust farming dates, farmers must decide cautiously on the dates since with small changes in the date of selling the crop can have a large effect on the price that they get.

With regard to climate change information, although in recent days, farmers require extra efforts to learn how to use new devices to get better and faster information, some methods that farmers obtained from the past can sometimes help farmers to project weather. Both of the adaptation measures are already practiced from long period time, and the farmers have the know-how to perform the adaptive measures. Diversifying crop varieties (2.51), switching to new crop (2.46), change to a different variety of apple (2.43) and improving soil condition (2.40) all require some amount of monetary investment and new knowledge. Searching for a new non-farming job (2.47) was also perceived to obtain some costs to farmers. Among the adaptive measures, adjusting the use of pesticides (2.35) was perceived as the most costly adaptation measure. It is because farmers in the past used the unnecessarily large amount of pesticides and with training provided by experts on the pesticides, they realized that they could use less amount of pesticides. However, with increasing temperature with less rain, newly introduced insects and disease now appeared in the farms, but the measures to prevent the damages are yet to be generally used by farmers. Therefore the continuously implementing pesticides might induce farmers to perceive that the cost of such adaptation is more costly than others. Buying crop insurance (2.05) is perceived to be most expensive to perform as an adaptive measure for farmers. It might be the reason that the crop insurance for apple farmers in Korea is supported by government and only 20 percent of the premium is paid by farmers.

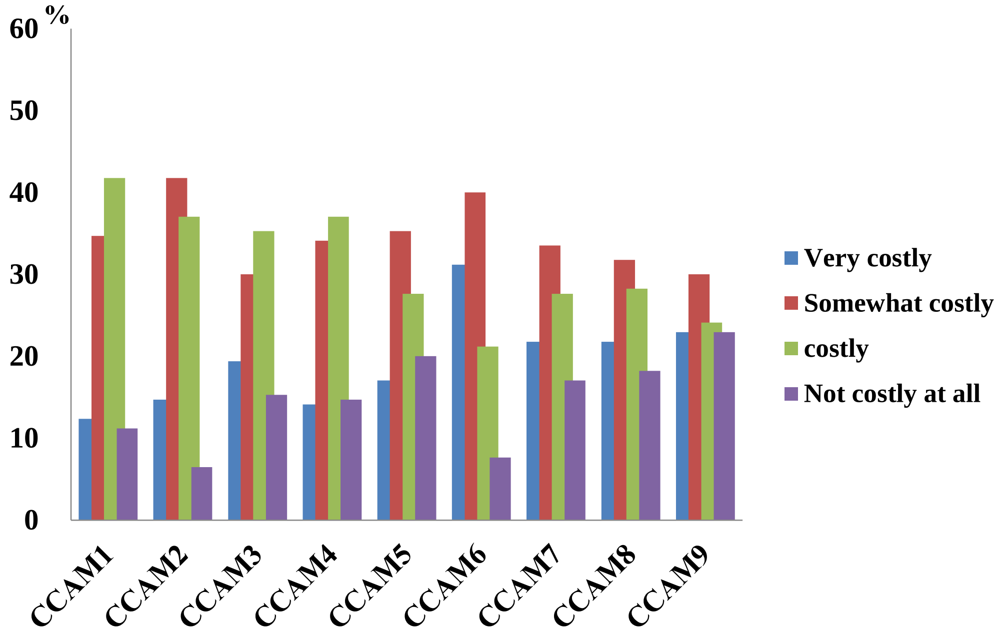

Figure 5.18 Percentage of the farmers' perception of adaptation costs

Table 5.12 Mean values of actual use of adaptive measures, perceived adaptive measure efficacy, perceived self-efficacy, and perceived adaptation costs

Mean value	Actual adaptive measure used	Perceived adaptation measure efficacy	Perceived self-efficacy	Perceived adaptation costs*
Highest	CCAM 2	CCAM 2	CCAM 6	CCAM 1 & 4
↑	CCAM 6	CCAM 6	CCAM 2	CCAM 5
	CCAM 4	CCAM 4	CCAM 4	CCAM 9
	CCAM 1	CCAM 1	CCAM 1	CCAM 3
	CCAM 7 &8	CCAM 3	CCAM 7	CCAM 8
	CCAM 5	CCAM 5	CCAM 5	CCAM 2
	CCAM 9	CCAM 7	CCAM 3	CCAM 7
↓	CCAM 3	CCAM 8	CCAM 8	CCAM 6
Lowest		CCAM 9	CCAM 9	

*Note: * perceived adaptation cost was indicated by 1-extremely costly to 4-not costly at all.*

5.4.2 Factors Influencing Perceived Adaptation Efficacy

This section demonstrates the factors influencing farmers' perception of adaptation measure efficacy, self-efficacy, adaptation costs, and overall adaptation efficacy. The regression models with dependent variables (perception of adaptation measure efficacy, self-efficacy, adaptation costs, and overall adaptation efficacy) and explanatory variables are presented in Table 5.13.

The adaptation measure efficacy, self-efficacy, and adaptation costs for each of the nine different adaptation measures are all summed up for each of the assessments and calculated. In addition, to assess the statistical significance of the four regression models, the bottom of Table 5.13 shows the R-square, adjusted R square, and F-test. As shown in the table, the F-test values show that all of the p values less than 0.01. This indicates that the regression models are statistically significant. Explanatory variables are able to explain around 46 percent to 57 percent of the variation of farmers' perception on adaptation efficacy. Further, the multicollinearity problems were assessed by reviewing Variance Inflation Factor (VIF) of all of the explanatory variables in the regression models, and the results are presented in Table 5.14. No multicollinearity was found as all of the VIF is presented as less than 10. Therefore the regression models met with the assumptions of normality, linearity, and homoscedasticity of the residuals.

Perceived Adaptation Measure Efficacy

Farmers' private autonomous adaptation measures are performed if the farmers perceive the adaptation measure is effective for preventing and lessening the risks from climate variability and change. Moreover, the adaptation measures should be perceived to produce any positive benefit or opportunity to the farmer. The estimated coefficients for farmers' perception on adaptation measure efficacy are shown in the first column of dependent variables of Table. 5.13. Some of the demographic and socioeconomic factors found to have a significant influence on apple farmers' perception of adaptation measures as effective strategies to respond to climate change are; age, cultivation area, sales channel and year of buying crop insurance. The estimated coefficients of factors influencing perceived adaptive measure efficacy are -0.0085, 0.0966, -01084, and -0.0472 with significance level at 10%, 5%, 5% and 1%, respectively (Table 5.13). With one unit increase in the farmers' age, the farmers' perception of the effectiveness of adaptation measures decreases by 0.0085. This may imply that older farmers who already experienced some of the adaptive measures, including adjustment of cultivation dates and pesticides, that are generally used by the apple farmers may experience the benefit from such measures. Younger farmers who may have more information regarding climate change and adaptation measures are less likely to have direct experiences may doubt on the adaptive measures to prevent future climate risks on their farm. Farm household who have more apple cultivation land perceived the adaptive measure more effective than others. For instance, this can be the case for buying crop insurance as an adaptation measure. If a farmer with more cultivation area invests in more crop insurance might have a higher perception of the adaptation measure, buying crop insurance, as more effective than those who have smaller cultivation land.

The regression model shows that the way of selling apple crop counts when farmers assess the effectiveness of adaptation measure to respond to climate change. Whether apple crops are sold through direct selling or indirect selling (i.e. Agriculture federation, Nonghyup), do influence how farmers perceive adaptation measures. The result of regression shows that in this model, the farmers selling their crops directly to consumers perceive adaptive measure relatively effective than the farmers selling through indirect sale channels. It might be that direct communications with consumers have influenced farmers by providing feedbacks related to their crops fast and accurate mode. Another socioeconomic factor shown to influence the perception of adaptive measure efficacy is years of buying crop insurance, and the estimated coefficient indicates that if a farmer is buying crop insurance longer than others would perceive adaptation measure relatively less effective. This might be applied to perception of crop insurance efficacy more than others, however, here, it is important to note that crop insurance, an adaptation measure, can influence the perception of other adaptive measures. The uncertainty of climate change leads farmers to buy crop insurance, however, as the times goes by and not many direct risks occurred and no benefits were received from crop insurance might influence farmers to think that the adaptation measure is not effective but costly. Moreover, this might have led farmers to think that projection regarding climate change is not real and not necessarily need to be prepared for it.

When farmers obtained information on climate change from public media, agricultural extension center, and farmers' federation (Nonghyup (NH)) significantly influenced farmers' perception on adaptation measure efficacy. Moreover, information on adaptive measures from village leaders, agricultural extension service center, and NH did significantly influence how farmers assess the effectiveness of adaptation measures. The estimated coefficients of climate change information obtained from public media, agricultural extension service center and NH are 0.1195, 0.1138, and 0.1414. The significant levels of each of the factors are at 10 percent, 10 percent, and 5 percent, respectively. Farmers obtaining one more unit of information regarding climate variability and change through public media, agricultural extension service center and NH are higher in perceived adaptation measure as effective. Objective information on climate change is often more accurate than subjective estimation. It seems as if farmers trust public media and farmers' federation to obtain objective knowledge regarding climate variability and change. On the other hands, information regarding adaptive measures from village leaders, agricultural extension service centers, and NH are inuencing the perception of adaptation measures. The estimated coefficient of adaptation measure information obtained from village leaders, agricultural extension service center and NH are 0.2003, 0.1734 and -1.095 with significant levels at 1 percent, 1 percent, and 5 percent, respectively. The village leaders are thought to have more experience and knowledge regarding the local situation and farming. By looking at the results of the regression models, farmers trust the village leader' regarding adaptation measures have a higher perception of adaptive measure efficacy.

As a result, to enhance farmers perception on adaptation are found to be associated with factors including; age (older), larger cultivation area, direct selling, less years of buying crop insurance, obtaining climate change information from public media, agricultural extension service centers, and farmers' federation such as NH, obtain climate change adaptation information from village leader, agricultural extension service center and less information from NH .

Table 5.13 Multiple regression results on the farmers' perceived adaptation efficacy

Explanatory Variables	Dependent Variables: Perceived Adaptation Efficacy for 3 variables and overall			
	Perceived Measure Efficacy	Perceived Self-Efficacy	Perceived Adaptation Costs	Overall
Age	-0.0085*	-0.0018	-0.0021	-0.0124
Gender	-0.1663	-0.1197	-0.0866	-0.3725*
Education level	-0.0224	-0.0113	-0.0259	-0.0597**
Farming Area	0.0966**	0.0664	-0.0960*	0.0671
Farming Experience	0.0032	-0.0001	-0.0017	0.0013
Income	-0.0047	0.0398	-0.0822***	-0.0471
% of income from apple cultivation	-0.0001	0.0026	0.0004	0.0029
Successor	0.1136	0.2233**	0.1030	0.4399**
Agriculture Education	0.0040	0.0230***	-0.0119	0.0151
Smart-phone	-0.1632	-0.0712	-0.2509**	-0.4854
Sales channels	-0.1084**	-0.0658	0.0181	-0.1562**
Land Tenure	-0.0121	-0.0183	0.0337	0.0033
Network	-0.0067	0.1984	0.3122	0.5039
Buying Crop Insurance (CI)	0.1830	0.0781	0.4582***	0.7193***
Cumulative years of Buying CI	-0.0472***	-0.0250*	0.0087	-0.0636**
Risk Experience 1 (Temperature)	0.0207	-0.0085	0.1027	0.1149
Risk Experience 2 (Precipitation)	-0.0605	-0.0998	-0.0224	-0.1827
Risk Experience 3 (Extreme events)	0.0329	0.0319	-0.0395	0.0253
Climate change info. 1 (Public media)	0.1195*	0.1043*	0.0015	0.2253*
Climate change info 2 (Neighbor farmers)	-0.0405	-0.0484	0.0270	-0.0618
Climate change info 3 (Village Leader)	-0.0837	0.0220	-0.1639**	-0.2256*
Climate change info 4 (Agri. Ext. Cent.)	0.1138*	0.0943	0.1130	0.3210***
Climate change info 5 (Cooperative)	0.1414**	0.1479**	-0.0208	0.2686**
Adaptation info. 1 (Public media)	0.0428	0.0403	-0.0387	0.0444
Adaptation info 2 (Neighbor farmers)	0.0792	0.2847***	-0.0224	0.3414***
Adaptation info 3 (Village Leader)	0.2003***	-0.1358**	0.0635	0.1281
Adaptation info 4 (Agri. Ext. Cent.)	0.1734***	0.0134	-0.0952	0.0916
Adaptation info 5 (Cooperative)	-0.1095*	0.0173	0.0786	-0.0136
_cons	1.8514	0.7020	2.9339	5.4874
R-square	0.53	0.49	0.46	0.57
Adjusted R-square	0.38	0.33	0.28	0.43
F-test, p-value	0.00	0.00	0.00	0.00

*Significant at 10% level ($p<0.1$), ** Significant at 5% level ($p<0.05$), *** Significant at 1% level ($p<0.01$)

Table 5.14 Variance Inflation Factor (VIF) for the explanatory variables in the farmers' perceived adaptation efficacy regression models

Explanatory Variables	VIF	Explanatory Variables (continue)	VIF
Age	2.4	Risk experience 1 (Temperature)	1.78
Gender	1.32	Risk experience 2 (Precipitation)	2.11
Education level	1.61	Risk experience 3 (Extreme events)	1.84
Farming area	1.40	Climate change info. 1 (Public media)	1.68
Farming experience	2.17	Climate change info 2 (Neighbors)	1.89
Income	1.44	Climate change info 3 (Village Leader)	2.12
% of income from apple cultivation	1.66	Climate change info 4 (Agri. Ext. Cent.)	1.72
Successor	1.29	Climate change info 5 (Cooperative)	2.06
Agricultural training program	1.32	Adaptation info. 1 (Public media)	1.73
Smart-phone	1.30	Adaptation info 2 (Neighbor farmers)	2.29
Sales channels	1.41	Adaptation info 3(Village Leader)	2.52
Land ownership	1.28	Adaptation info 4 (Agri. Ext. Cent.)	2.02
Network	1.46	Adaptation info 5 (Cooperative)	2.38
Buying Crop Insurance (CI)	2.63		
Cumulative years of buying CI	2.92		

Perceived Self-efficacy

Autonomous adaptation measures must be practiced by individual farmer themselves, and farmers are required to have a certain capacity to perform adaptive measures. The second column of Table 5.13 shows the farmers' perception regarding self-capacity or self-efficacy of performing the nine adaptive measures. The regression model shows the factors that are significantly influencing farmers' assessment of self-capacity to carry on the adaptive measures. Demographic and socioeconomic factors associated with self-efficacy are; successor, the number of participation in agricultural training programs and number of years buying crop insurance. The estimated coefficients of the factors are; 0.2233, 0.0230, and -0.0250 with significant at 5 percent, 1 percent, and 10 percent levels, respectively. Farmers with successors are more likely to have higher self-efficacy that they have to turn their knowledge and techniques to the next generation. With a higher number of participation in agricultural training programs provided by agricultural extension service centers, have a positive influence on farmers' higher perception on self-efficacy. Farmers by having more training programs learn to perform the various farming activities and have opportunities to share knowledge with other farmers can also learn the know-hows from direct experience of other farmers. Those activities may influence farmers to put themselves in the position and evaluate if themselves can perform the activities. Moreover, a number of years on buying crop insurance is negatively associated with perception on self-efficacy. Famers' with fewer years of buying crop insurance have higher self-efficacy of performing adaptation measures. Some farmers perceive the crop insurance as an additional investment for unpredictable damage from climate risks. They invest on such measure because they assess additional support required for recovering from such damage. However, since the incidents of major climate disasters are limited in this area, as the number of year increases in investing in crop insurance, farmers may assess the level of damage less likely and evaluate themselves as capable of responding to such damages.

Farmers obtain climate change information from public media, and farmers' federation shows significant influence to the perception of self-efficacy. The coefficients of two factors are shown as 0.1043 and 0.1479 with significant at 10 percent and 5 percent, respectively. Climate change adaptation information from neighbor farmers and community leader are also found to have a significant influence on the perception of self-efficacy but in different directions. The coefficients are found as 0.2847 and -0.1358 with significant at 1 percent and 5percent. Farmers are likely to have a higher perception on self-capacity to perform adaptation measures when more successful cases of neighbor farmers are obtained. Because of the similar condition of farmers in the neighborhood encourage the farmers to perform the adaptive measures.

In sum, farmers are influenced to have higher perception on self-efficacy of adaptation measures by; having successors, more participation in training programs, less year of buying crop insurance, climate change information obtained from public media and farmers' federation (NH), climate change adaptation information obtained from neighbor farmers and adaptation information collect less from community leader.

Perceived Adaptation Costs

Cost is an important factor when a farmer assesses to perform adaptation measures. The regression model for farmers' perceived adaptation costs is presented in the third column of Table 5.13. The estimated coefficients show significant factors that influence farmers' perception on adaptive costs. Demographic and socioeconomic factors influencing farmers' perception on adaptation costs are; the size of cultivation area, income level, use of smart-phone and investment on crop insurance. Videlicet farmers with the larger size of cultivation area, higher income level or using smartphone perceive adaptation costs as more expensive while farmers with crop insurance perceive adaptation costs as less expensive. In general, farmers with larger cultivation area have a larger amount of production and farmers in this category have more things to prevent from climate variability and changes. The farmers with larger farms, they might have more loss by adapting to climate change. In one hand, farmers with owned cultivation land probably have their lands from the ancestors and turn the lands to next generations. Farmers in this category might have personal value to the lands and would try to protect the land from any outside impacts. On the other hand, Farmers buying crop insurance perceive climate change adaptation measures are less costly compared to those who do not have crop insurance. Those farmers may perceive that by not having crop insurance, the loss brought from typhoon and other extreme climate events can be greater by not having crop insurance.

Information on climate change and adaptation measures attribute to the farmers' perception of adaptation costs. Particularly the regression results show that the climate change information collected from village leader as a significant factor to influence farmers' perception of adaptation costs. The coefficient of the factor is -0.1639 at 5 percent significant level. Farmers obtaining more climate change information from village leaders seem to have a perception of climate change adaptation costs as more expensive. This may present the farmers' relationship to the village leaders. Most of the village leaders in this area are more likely the superior figure or richer than general farmers. The living standards of the village leaders are more likely to be higher than others. This may influence farmers to perceive the adaptation information from the village leaders is expensive.

Overall Perceived Adaptation Efficacy

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The regression model of overall perceived adaptation efficacy, a sum of perceived adaptation measure-efficacy, self-efficacy and adaptation costs, is presented in the last column of Table 5.13. The model shows that demographic and socioeconomic factors such as gender, education level, having a successor, direct sales of apple, investment in crop insurance and the years of crop insurance investment significantly influence overall perceived adaptation efficacy. The estimated coefficient of gender, -0.3725 (significant at 10 percent level), indicate that compared to female, male farmers are more likely to have a higher perception of adaptation efficacy. This is because, in Cheongsong County, male farmers are the main decision maker and actual performer in apple farming activities. Female farmers are not much involved directly with work on the farm. Male farmers have direct experience with farm work and probably have more experience and knowledge regarding climate change and adaptation measure. Moreover, farmers with less education level seem to have higher adaptation efficacy that the coefficient shows -0.0597, significant at 5 percent level. It might be the years of experience in farming may negatively relate with the level of education. Whether the farmers have successors or not can significantly influence the evaluation of the climate change adaptation efficacy with the coefficient 0.4399 (significant at 5 percent level). As discussed in the previous section, generally, apple farming in Cheongsong County is intergenerational business, and it is thought to be important and proud to turn over the family business to the next generation in Korea. Having successor influences farmers' perception of using resources greatly so that the farmers can keep the quality of farm as best as possible.

The ways of selling apple crop influence farmers' perception on adaptation significantly. The result of regression model shows that farmers selling their crop directly to consumers have a higher perception of adaptation efficacy. The estimated coefficient is -0.1562, and it is significant at 1% level. In other words, farmers having direct communication with consumers perceive adaptation measures as an effective strategy to prevent future damage and increase opportunities. Farmers selling apple crops directly to consumers can receive direct and fast feedback on the product, and this also can influence farmers' decision to different strategies from farm activities to marketing. Since farmers can receive the feedback or the comments from the consumers regarding their crops and if farmers performed particular adaptive measures, the farmers' assessment of the adaptive measures could be influenced. Farmers investing in crop insurance and the years of that the farmers investing in crop insurance also influence overall perception on adaptation efficacy. While the results of regression model show that investing in crop insurance, have an influence on higher perception, years of investing in crop insurance are negatively related to the perception of adaptation efficacy. This indicates that albeit investing in crop insurance itself increase trust in adaptation effectiveness, as farmers continue to buy crop insurance, farmers become curious about the effectiveness of adaptation strategies.

Both climate change and adaptation measure information are found to be the significant factors influencing farmers' overall adaptation efficacy. However, the information that they referred has different influences between climate change information and adaptation information. Particularly, climate change information attained from public media, village leaders, agricultural extension service center, and farmers' federation show to have a significant influence on the perception of adaptation efficacy. This indicates that farmers evaluate that the climate change information is more accurate with objective sources. According to farmers' interview, compared to the past when the farmers depend on their feeling and experience to predict climate variability, farmers get information from public media and the internet in recent years. Moreover, information on adaptation measures obtained from neighbor farmers does influence perception of adaptation efficacy by 0.3414 with significant at 1 percent. Farmers attaining successful stories regarding adaptation measures might have effectively influenced farmers' to perceive the adaptation measure efficient.

Summary on the farmers' perceived adaptation efficacy

According to Model of Private Adaptation to Climate Change and Protection Motivation and Protection Motivation Theory, to understand individuals' adaptation behaviors, it is important to assess individuals' perception on adaptation measures. Farmers' positive assessments of the effectiveness of adaptation measures and self-capacity provoke farmers' adaptation behaviors. To assess farmers' perception on adaptation efficacy with adaptation measure efficacy, self-efficacy and adaptation costs, influencing factors for each of the perception are investigated. Moreover, factors affecting overall perception on adaptation efficacy are analyzed with linear regression. As a result, farmers' perception of adaptation efficacy is influenced by the demographic and socioeconomic factors, farmers' higher perception on adaptation measure is influenced by farmer age, longer the farming experience, and selling mechanism (direct sale). Farmers assess themselves as more capable of performing adaptation measures if farmers have a successor and have a higher number of participation in agricultural training programs. However, as the number of years buying crop insurance increases, it is found that the farmers are less likely to perceive adaptation measure as effective and themselves as capable of doing such adaptation measures. More importantly, information is found to attribute the way farmers perceive adaptation, particularly with adaptation measure efficacy, self-efficacy, and overall adaptation. Adaptation information from a local source that is easier to access, more direct and reliable, can influence farmers' assessment of the adaptation behaviors

5.5 Farmers' Intention and Adaptation Behaviors to Climate Change

To reduce the negative consequences (or to increase opportunities) caused by climate variability and change, farmers are presumed to take on various adaptation strategies. The regression analyses in the previous sections revealed the factors influencing climate change risk perception and perceived adaptation efficacy, the main elements in a model of private proactive adaptation to climate change (MPPACC) and protection motivation theory (PMT). Some adaptation behaviors are preferred to another, and some farmers failed to undertake adaptive strategies while others did. Exploring what lies beneath such behaviors would thus be the purpose of this section. Hence, this section of the chapter attempts to identify key issues and variables that help us to understand the adaptive behavior of apple farmers in Cheongsong County. Moreover, the interpretation of the statistical findings from this section is discussed in more detail in Chapter 6.

5.5.1 Famers' Intention to Adaptation Behaviors

The knowledge of climate change and ensuring behavioral responses at the individual level are more of the results of the perceptual process. In fact, this is particularly accurate for farmers in rural areas where basic climate and adaptation information are limited and adaptive capacity is low. From this perspective, perceptual (cognitive) factors play a vital role in understanding the climate change adaptation behaviors of farmers. Thus, this section of the dissertation attempts to investigate cognitive factors in a conceptual model that was built on protection motivation theory (PMT) and model of private proactive adaptation to climate change (MPPACC). In addition to factors introduced in PMT and MPPACC, this dissertation investigates additional cognitive factors such as trust of government. Therefore, in this section of the dissertation apple farmers' intention to adaptive behavior to climate variability and change is framed as the function of cognitive factors: risk perception (perceived risk probability and severity), perception of adaptation efficacy (perceived adaptation measure efficacy, self-efficacy and adaptation costs), maladaptation (fatalism, denial, and wishful thinking) and trust of government (training program, early-warning system, information). The dependent variables are the intention of nine adaptive behaviors.

To investigate the farmers' intention of nine adaptive behaviors, farmers were asked to indicate each of the adaptation as 'in action,' 'have a plan to perform in the future' and 'no action.' Farmers were placed as to have the intention of each of the adaptive behaviors if the farmers answered either 'in action' or 'have the plan to perform in the future.' However, farmers were defined to have no intention of behaving on the adaptive measure if the farmers answered as 'no action.' Therefore, there are two groups of farmers: 1) Farmers with the intention of adaptation behavior or 2) farmers with no intention of adaptation behavior. Table 5.15 shows the percentage of farmers in two groups.

Table 5.15 Summary of intention of adaptation behaviors: frequency, percentage, mean and standard deviation

Adaptation Behaviors	Intention	Freq.	Percent.	Mean	SD
CCAM 1: Adjusting apple farming dates	No intention (0)	30	17.65	0.82	0.38
	Have intention (1)	140	82.35		
CCAM 2: Adjusting use of pesticide	No intention (0)	11	6.47	0.94	0.25
	Have intention (1)	159	93.53		
CCAM 3: Switching to new crop	No intention (0)	99	58.24	0.42	0.49
	Have intention (1)	71	41.76		
CCAM 4: Gathering information on climate change	No intention (0)	28	16.47	0.84	0.37
	Have intention (1)	142	83.53		
CCAM 5: Diversifying crop varieties	No intention (0)	110	64.71	0.35	0.48
	Have intention (1)	60	35.29		
CCAM 6: Buying crop insurance	No intention (0)	43	25.29	0.75	0.44
	Have intention (1)	127	74.71		
CCAM 7: Improving soil condition	No intention (0)	91	53.53	0.46	0.50
	Have intention (1)	79	46.47		
CCAM 8: Changing to difference variety of apple	No intention (0)	76	44.71	0.55	0.50
	Have intention (1)	94	55.29		
CCAM 9: Searching for non-farming job	No intention (0)	100	58.82	0.41	0.49
	Have intention (1)	70	41.18		

5.5.2 Factors Influencing Famers' Intention to Adaptation Behaviors

To quantify the impact of various explanatory factors influencing farmers' intention to adaptation methods, this dissertation used logistic regression for all adaptation models. The coefficients and odds ratio of logistic regression give information on the direction of effect of the factors are presented in the Table 5.16. Although Table 5.16 shows only the results of the logistic regression with the explanatory variables associated with cognitive variables, the models did control the farmers' characteristics and socioeconomic factors. Since the main aim of this chapter is to analyze how the cognitive factors, such as perceptions of risk and adaptation, influence farmers' intention to perform climate change adaptation measures, only the results of the cognitive factors are included and discussed in the main parts of the chapter. However, the results of the logistic regression to provide the variables associated with farm characteristics that were included in the nine different logistic regression models is presented in Appendix II. The results of the marginal effect that explain the effect of a unit change in explanatory variables on the dependent variable are shown in the Table 5.17.

Since logistic regression, unlike linear regression, uses maximum likelihood estimators, the review of model evaluations for overall model evaluation, goodness-of-fit, and correct model specification should be conducted. For the overall model evaluation, the test statistic is calculated by taking the difference of the residual deviance for the model with explanatory variables from the null deviance of intercept-only model. From the bottom part of Table 5.16, Chi-square (χ^2) for all of the 10 different models are positive and vary between 48.03 and 73.22. With regard to associated p-values indicated show less than 0.01 except for the model for CCAM7 (soil improvement) that is significant at p-value 0.01 from which it can be concluded that all of the ten models with predictors fit significantly better than the model with intercept-only. This indicates that we can reject the null hypothesis of intercept-only and accept the alternative models that at least one of the regression coefficients is not zero.

Also, the results of the calculation of pseudo-R-square that verify the goodness-of-fit of the models are shown in Table 5.16. As explained in Chapter 4, this study conducted the goodness-of-fit tests with Cox & Snell pseudo-R^2, McFadden pseudo-$R^2$and Nagelkerk pseudo-R^2 for all of the nine logistic regression models. As a result, the values of pseudo R-square for all models ranged from 0.12 to 0.53. This indicates that the explanatory variables explain between 12 to 53 percent of the variation in adaptive behavior intention. To evaluate the validity of predicted probabilities, the classification table is calculated, and the results are shown in the Table 5.16. Since the higher percentage indicate, the better fit of the model and the overall percentage correctness for all models in this study is above 71 percent, the models are confirmed as the better fit.

Finally, multicollinearity of explanatory variables in the models is tested to see the relationship between the independent variable by VIF test that is shown in the Table 5.18. The maximum VIF is 4.74 (perceived risk Severity). However, all of the VIF in the binary logistic regression in this dissertation are well below the threshold 10, and the mean VIF is 2.09. Thus, the models are free from multicollinearity as the VIF for all of the explanatory variables is much less than the threshold level of 10.

The results of the logistic regression models are analyzed in detail for each of the models. The rest of Chapter 5 examines the regression results by pointing out the explanatory variables that are found to be statistically significant for farmers' intention to different adaptation measures.

Intention of CCAM 1: Adjustment of farming dates

The regression model results in the adaptation behavior on the adjustment of farming dates (CCAM1) are shown in the first column in Table 5.16. The factors influencing farmers' intention of the adaptation behavior were found as perceived risk probability, perceived risk severity, perceived adaptation measure efficacy, perceived self-efficacy, maladaptation associated with fatalism, and trust of government on climate change programs and information. The coefficient of perceived risk probability shows significantly and negatively related to farmers intention of adjusting farming calendar (CCAM1). However, the result of a logistic regression only gives the direction of the coefficient, therefore; marginal probability effect is calculated to the level of influence. The Table 5.18, the marginal probability effects of perceived risk probability to farmers' intention on CCAM1, showed -0.1750. In other words, one unit of increase in perceived risk probability leads to 17.50 percent decrease intention in the likelihood of adjusting farming calendar as an adaptation method. However perceived risk severity coefficient shows positive and significant relation to the intention of CCAM1. The marginal probability effect indicates higher farmers' perception of risk severity increase in the likelihood of their intention to adaptation behavior by adjusting farming dates by 16.57 percent. Farmers' perceived adaptation measure efficacy shows that it has a positive and significant relation to the intention of CCAM1. Farmers' assessment of the effectiveness of adaptive measures influences the probability of farmers' intention to adjust farming dates. In other words, farmers' perception of adaptation measure effectiveness increases the likelihood of farmers' intention CCAM1 by 15.86 percent (Table 5.18).

In addition to how farmers perceive adaptation measures, how farmers assess themselves as to have self-capability to adjust farming dates with regard to changing climate, the odds of having the intention to carry out CCAM1 is 1.2164. Maladaptation variables associated with fatalism has negative and significant relations to farmers' intention to take CCAM1 as an adaptation measure. The marginal probability effect of the variable shows that farmers who believe that human has no capacity to control the result of climate change are less likely to have the likelihood of farmers' intention of CCAM 1 by 4.41 percent. Moreover, how farmers assess government programs and information significantly affects the likelihood of farmers' intention to CCAM 1. The coefficient of logistic regression shows that the odds of having the intention of CCAM1 because the farmer's trust governments' program have positive (0.9110) and significant relation ($p < 0.05$) and with regard to government provide information indicate positive (0.7998) and significant relation ($p < 0.001$).

Intention of CCAM 2: Adjustment of using pesticides

The second column of the Table 5.17 shows the results of the logistic regression model on the farmers' intention to take adaptation measure such as adjustment of using pesticides and fertilizer (CCAM 2). Cognitive factors influencing intention of farmers' adaptive behaviors on pesticide use are risk perception (probability and severity) and maladaptation (fatalism, denial, and wishful-thinking). The logistic regression shows a perceived risk probability as a negative and significant relation to the intention with CCAM2. It is negatively influencing the intention with a regression coefficient of -0.2181. In other words, the odds of a farmer with one unit higher level of perceived risk probability have probability decrease of considering CCAM2 as an adaptation measure. Another risk perception variable, perceived risk severity is indicated as positively and significantly related to intention to CCAM2 with marginal probability effect with 0.0721. It means that a farmer with one unit higher perceived risk severity has a probability to increase their intention to take CCAM2.

All of the three variables, fatalism, denial and wishful-thinking, associated with maladaptation show the significant level of relationship with farmers' intention to perform adaptation measures such as adjusting the use of pesticides. Farmer's belief in climate change as God's act that farmers do not have any capacity to prevent the risk from it have negative and significant relation to considering CCAM2 as an adaptation measure. It is to say that farmers with one unit higher maladaptation in fatalism are negatively associated with intention to CCAM2 by 1.3 percent (Table 5.18). With regards to the maladaptation of denial, the result show that farmers believing climate change are pseudo have more likelihood of intention of performing the alteration of using pesticide (0.0378) with a significant level of 1%. The results also show that the maladaptation on wishful-thinking is positively related to the farmers' intention to perform CCAM2 (0.0399) with a significant level of 5%. This indicates that farmers alleging the risk related would be cured and protected by outside capacity are more likely to adjust their use of the pesticide.

Intention of CCAM 3: Switching to new crop

Intention to switch to new crop (CCAM3) rather than apple crops as adaptation behavior is found to be significantly related to perceived adaptation efficacy, particularly with the perceived adaptation costs, and maladaptation on wishful thinking. The farmers' perceptions of the costs require for the adaptation measure, such as switching to new variety of crop from apple crop do influence significantly on the probability of the farmers' intention to actually carry on the adaptation measure. The odds of having the intention of switching to the new crop (0.1299) show the positive and significant ($p < 0.01$). This result indicates that farmers with the perception that the costs of the adaptation measure are less expensive are more likely to carry on CCAM3. Moreover, the result of maladaptation of wishful thinking on future climate change damages also shows a significant relationship with farmers' intention to CCAM3. The coefficient of the variable is found to be -0.0164 with a significant level of 10 percent. Farmers with the belief that government would do to prevent and solve the problem of climate change, therefore, farmers to perform adaptation measures by themselves are less likely to have the intention to perform on the adaptation measure on switching to new crop. In addition, the results of marginal probability effects show that one unit increase in the belief in governments' responsibility of responding to climate change risk has a probability of decreased intention of switching to new crop by 7.89 percent.

Intention of CCAM 4: Gathering information on climate change

Farmers' intention of paying more attention to gathering climate change information (CCAM4) is found to have significant relation with risk perception, adaptation m maladaptation (fatalism and denial) and trust in governments' early warning system and information on climate change. The fourth column of Table 5.17 shows the estimated coefficients that perceived risk probability as -1.7733 at a significant level of 10 percent. According to this result, the perceived risk probability is negatively and significantly related to farmers' intention to take CCAM4 as a measure to response to climate change. The result of marginal probability effect shows that one unit increase of perceived risk probability has a likely of decreasing intention to gather climate change information as to response to climate change by 13.85 percent. Unlike perceived risk probability, how the farmers perceive risk severity is positively and significantly related to intention to pay more attention to climate change information. The odds of the farmers to have the intention to gather additional information on climate change with perceived risk severity is 1.5159 with a significant level of 10 percent. This denotes that the farmers perceiving risk associated climate change more severe are more probable to pay additional attention to information with regard to climate change.

Further, the odds of farmers who have less belief that climate change is not what human can fight back to and ancestors are more likely to have the intention of gathering climate change information as to prevent climate change damages. The coefficient of the logistic regression shows -0.7192 with a significant level of 1 percent. In addition, maladaptation belonging to the belief that climate change is not a real fact is shown to be negatively related to the CCAM4. The coefficient show -0.4940 with the significant level of 1 percent. Finally, the trust of government on early warning system and the climate change information are also found as an important, influential factor as the coefficients show -1.3710 and 0.9927 with significant levels at 5 percent each. However, the coefficients only show the direction of relationship to the CCAM4; it is important to observe marginal probability effects of the variables. The marginal effects are -0.0979 and 0.0827 for the farmers' evaluation of government's capacity to responses to climate change through early warning system and climate change information, respectively. This means that one unit of higher evaluation of government's capacity to response to climate change by observing its operation of early warning system, farmers' intention to take CCAM4 as climate change adaptation measure is more likely to decrease by 9.79 percent. With regard to one unit higher in farmers' evaluation of governments' climate change information, the results of the coefficient of the binary logit regression model marginal probability effects show that the intention of farmers taking CCAM4 is probably to increase by 8.27 percent.

Intention of CCAM 5: Diversifying crop varieties

Factors influencing farmers' intention of diversifying their crop cultivation portfolio (CCAM5) as to prevent climate risks or benefit from new opportunities are; perceived adaptation measure, maladaptation associated with fatalism and trust of government information on climate change. How farmers perceive adaptation measure, diversifying the crop portfolio, is found to have positive and significant relation to the probability that the farmers to have an intention for performing CCAM5. The regression coefficient shows 1.1775 with the significant level of 5 percent. In addition to the perception of adaptation measures, farmers regard climate change is the act of God is more likely to have the lower intention of the adaptation behavior with the estimated coefficient of -0.3907 at 1 percent of significant level. The marginal effect is -0.0652 means that with increasing maladaptation of fatalism can have a probability of decrease intention to CCAM5 by 6.52 percent. The results of the regression show that how much a farmer trusts the governments' capacity related to climate change such as its warning system and information may influence positively and significantly on farmer's intention to diversify the crop variety as their income source. The odds of increasing the motivation of farmers to CCAM5 by increasing farmers' trust in the capacity of the warning system and information show 1.1750 and 1.3272 with a significant level of 1 percent each.

Intention of CCAM 6: Buying crop insurance

The cognitive factors that significantly correlated with farmers' intention to buy crop insurance (CCAM6) as to prevent from the climate are perceived measure efficacy, maladaptation (fatalism) and trust of government (warning system). To compare the results of risk perception and adaptation perception, farmers' perception on adaptation is found to be more significantly associated with the motivation of buying crop as an adaptation measure. The assessment of the competency of crop insurance to cure the damage from climate change shows positive (1.0219) and significant ($p < 0.001$) association with the probability of buying crop insurance. Moreover, lesser the farmer involves themselves in the maladaptation (fatalism) on future climate change damage influenced farmers to buy crop insurance as an adaptation measure. The logit regression model shows that the estimated coefficient of maladaptation on fatalism at -0.5885 with significant at 1 percent level. It means that maladaptation is negatively and significantly related to the intention of CCAM6 and the probability of farmers buying crop insurance would increase if farmer deviates themselves from maladaptation. Moreover, the marginal effect of the factor of maladaptation with regard to thinking climate change is not controllable by human being increase is more likely to decrease farmers' intention by 7.24 percent. The farmers' intention to carry on CCAM 6 can also be associated with the trust that they have in the accuracy of warning systems. This is evident from the coefficient for the logistic regression model show 0.9829 with a significant level of 10 percent.

Intention of CCAM 7: Improvement of soil condition

Farmers' intention of improving soil condition (CCAM 7) as climate change adaptation is associated with perceived self-efficacy and maladaptation (fatalism). The perception on the self-capacity (0.4380) to improve soil condition seems to be positively related. Since, as indicated in the previous sections, the farmers are not familiar with the farming practices related to improving the soil condition. Farmers without experiences or knowledge on such practice would not be confidence in their own capacity to carry on as amendment or prevention for climate risk. The results of the regression show the probability of farmers to have the intention of performing CCAM 7 would be higher if the farmer has a higher perception on self-efficacy. Farmers associated with maladaptation, particularly with fatalism, are shown to have a higher probability of motivated to consider to practice farm activities related to improving soil condition as a climate change adaptation measure.

Intention of CCAM 8: Changing apple variety

According to the results of the logistic regression model, adaptive behavior of changing apple variety (CCAM 8) is significantly influenced by perceived risk severity, perceived adaptation measure efficacy, and maladaptation. The coefficient of perceived risk severity for CCAM 8 shows 0.0043 with the significant level of 10 percent. This indicates that how farmers perceive climate risk in different severity can positively relate to the motivation of CCAM 8. Farmers with the higher perception that the climate risk would be severe than others would be more likely to be motivated to perform CCAM 8. In addition to perceived risk severity, adaptation assessment also plays a significant role in motivating CCAM 8. Among three different variables in assessing adaptation efficacy, how farmers perceive the costs of the adaptation measure show the coefficient of 0.2391 with a significant level of 5 percent. This denotes that farmers assessing changing the apple variety as less expensive are more likely to have the intention of the adaptation strategy. Moreover, maladaptation, particularly the fatalism is shown to have negatively and significantly influence farmers' intention to consider CCAM8 as to climate change adaptation behavior. This means less dependent on god or ancestors on preventing climate risk can influence higher intention of adaptive behavior, and the marginal effects of the variable are 8.14 for CCAM 8 (Table 5.18).

Intention of CCAM 9: Searching for non-farming job

Searching for a non-farming job to diversify income profile is influenced significantly by risk perception, perceived adaptation efficacy, and maladaptation. Both variables of risk perception, perceived risk probability, and severity, are found to have positively significant relation to farmers to search for a non-farming job as to response to climate change. Perceived severity is relatively more significantly influence the intention that it shows the 5 percentage of significance while perceived risk probability shows 1 percent. According to the results of the marginal effects in Table 5.18, with one unit of increased perception of risk probability can have 28.28 percent increase of the intention of CCAM 9 while the perception of severity can have 41 percent of probability of a decrease in the intention of CCAM9. Moreover, the odds of having the intention to behave in the CCAM9 show more significantly related to farmers' assessment of self-efficacy. A unit increase of perceived adaptation self-efficacy also influences farmers to search for a non-farming job in positively and significantly by 15.95 percent. In addition to risk perception and perceived adaptation efficacy, maladaptation inherent in denial of climate change has influence intention of farmers' adaptation negatively. With stronger belief in climate change as nonsense have less of intention to go for non-farming jobs by 8.91 percent.

Overall: Farmers' intention to overall adaptation

The binary logit regression also shows the probability that the farmers have the intention to behave in adaptation is analyzed through socio-cognitive factors. Table 5. 16 shows the results under dependent variable overall. As the coefficients show, farmers' overall adaptation intention is influenced by all of the socio-cognitive factors. More specifically, farmers' perception on the level of severity of climate risk is found to increase farmers' intention to adaptation behavior. This can imply that climate risk should be perceived as a serious risk to the farmers to consider adaptation measures. With regard to the assessment of adaptation, not surprisingly, perception on adaptation measure efficacy and self-capacity are found to be significantly related to farmers' intention to adaptation behaviors. How farmers evaluate the effectiveness of adaptation measure itself and farmers themselves as capable of performing the adaptation measures can positively affect the probability of having the intention to adaptation. Maladaptation, particularly associated with the belief that climate change cannot be controlled by a human being or climate change is something that government should be responsible for, are found to be negatively related to the farmers' intention. This means that if farmers have a belief that human being or farmers themselves are not capable of preventing the damage from climate change may step back from responding to climate change by performing on adaptive measures. Moreover, farmers evaluating government provided information as useful may have a higher probability of having the intention to adaptation. In Sum, the findings clearly indicate that cognitive factors may play as a barrier to farmers' intention to adaptation behaviors.

Table 5.16 Parameter estimates of logistic regression models of the farmers' intention of adaptation behavior

Explanatory Variables	Dependent Variables: Intention for adaptation behaviors									
	CCAM1: Adjustment of farming dates	CCAM2: Adjustment of using pesticides	CCAM3: Switching to new crop	CCAM4: Gathering information on CC	CCAM5: Diversifying crop varieties	CCAM6: Buying crop insurance	CCAM7: Improving soil condition	CCAM8: Changing to diff. variety	CCAM9: Searching for non-farming job	Overall
PRP	-1.9291**	-0.2181***	-0.0533	-1.7733*	0.7155	0.0973	-0.0945	-0.0089	1.3186*	-1.0911
PRS	1.8213**	0.2629***	0.1129	1.5159*	0.9878	0.6103	-0.0801	1.2023*	-1.6127**	1.5193***
PME	1.8567***	-0.0252	-0.0500	0.3262	1.1775**	1.0219*	0.1689	0.0043**	0.5994	0.4876**
PSE	1.2164**	0.0202	0.0392	0.2644	0.7883	-0.0103	0.4380*	-0.0147	0.3800*	0.2154*
PAC	-0.0742	0.0147	0.1299*	0.5949	0.0168	-0.1792	0.1318	0.2391*	0.4521	0.3834
MAL (F)	-0.5644**	-0.0285*	-0.0069**	-0.7192***	-0.3907*	-0.5885***	-0.1082**	-0.1538**	-0.0800	-0.6590***
MAL (D)	0.2996	0.0378*	0.0182	-0.4940*	0.3877	0.5655	-0.1776	-0.1541	-0.2852*	-0.0769
MAL (W)	-0.3995	0.0399**	-0.0164	0.4067	0.5066	-0.0132	0.0886	-0.1504	0.0065	-0.2350*
ToG (P)	0.9110**	0.0353	0.0087	0.2103	0.0337	-0.1271	0.1149	0.2103	0.1916	0.4033
ToG (W)	0.2586	0.0101	-0.0484	-1.3710**	1.1750***	0.9829*	0.0851	-0.0061	0.1991	-0.3208
ToG (I)	0.7998*	-0.0043	0.0925	0.9927**	1.3272***	-0.6437	0.2073	0.4948	0.4579	0.6152**
con	-4.6627	0.5918	0.0292	-4.9491	-4.6463	-10.9383	-1.6384	-1.5075	-3.3197	3.5995
Farm HH Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Likelihood ratio test										
χ^2	60.11	67.14	72.51	73.22	52.25	60.34	48.03	69.99	57.45	64.63
df	21	21	21	21	21	21	21	21	21	21
p	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Goodness-of-fit test										
Cox & Snell R^2	0.29	0.33	0.34	0.19	0.17	0.34	0.12	0.22	0.15	0.33
McFadden R^2	0.30	0.42	0.32	0.21	0.19	0.24	0.17	0.28	0.22	0.41
Nagelkerke R^2	0.42	0.53	0.43	0.22	0.23	0.32	0.19	0.22	0.27	0.28
Model Correctness (%)										
	80.90	78.99	91.10	92.11	76.40	74.40	72.18	84.25	71.29	81.11

*Significant at 10% level (p<0.1), ** Significant at 5% level (p<0.05), *** Significant at 1% level (p<0.01)

Note:

PRR: Perceived Risk Probability, PRS: Perceived Risk Severity, PME: Perceived Measure Efficacy, PSE: Perceived Self Efficacy, PAC: Perceived Adaptation Costs, MAL(F): Maladaptation 1(fatalism), MAL(D): Maladaptation 2 (denial), MAL(W): Maladaptation 3 (wishful-thinking), ToG(P): Trust of Goverment1 (program), ToG(W): Trust of Government 2 (warning system), ToG(I): Trust of Government 3 (Information)

Table 5.17 Marginal effects of the binary logistic regression models of the farmers' intention of adaptation behavior

Explanatory Variables	Dependent Variables: Intention for adaptation behaviors									
	CCAM1: Adjustment of farming dates	CCAM2: Adjustment of using pesticides	CCAM3: Switching to new crop	CCAM4: Gathering information on CC	CCAM5: Diversifying crop varieties	CCAM6: Buying crop insurance	CCAM7: Improving soil condition	CCAM8: Changing to diff. variety	CCAM9: Searching for non-farming job	Overall
PRP	-0.1750	-0.0628	-0.0842	-0.1385	0.1064	0.0289	-0.0038	-0.0234	0.2828	-0.0911
PRS	0.1657	0.0721	0.0491	0.1060	0.0367	0.1329	-0.0901	0.1326	-0.4100	0.0766
PME	0.1586	-0.0042	-0.0828	0.0314	0.0013	0.0423	0.0525	0.0462	0.1595	0.0263
PSE	0.0813	0.0184	0.0195	0.0470	0.0592	-0.0472	0.1391	-0.0426	0.0631	0.0151
PAC	-0.0253	0.0229	0.0713	0.0169	0.0635	-0.0043	0.0036	0.0402	0.0136	0.0022
MAL (F)	-0.0441	-0.0130	-0.0223	-0.0719	-0.0652	-0.0724	-0.0445	-0.0814	-0.0357	-0.0813
MAL (D)	0.0017	0.0012	0.0061	-0.0303	0.0078	0.0438	-0.0697	-0.0511	-0.0891	-0.0125
MAL (W)	-0.0461	0.0010	-0.0789	0.0043	0.0206	-0.0396	0.0641	-0.0801	0.0256	-0.0250
ToG (P)	0.0650	0.0115	0.0031	0.0238	0.0174	-0.0031	0.0303	0.0170	0.0010	0.1003
ToG (W)	0.0274	0.0118	-0.0032	-0.0979	0.1062	0.1216	0.0174	-0.0181	0.0039	-0.0208
ToG (I)	-0.0479	-0.0010	0.0652	0.0827	0.1675	-0.0035	0.0776	0.1077	0.0748	0.0010
Farm HH Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note:
PRR: Perceived Risk Probability, PRS: Perceived Risk Severity, PME: Perceived Measure Efficacy, PSE: Perceived Self Efficacy, PAC: Perceived Adaptation Costs, MAL(F): Maladaptation 1(fatalism), MAL(D): Maladaptation 2 (denial), MAL(W): Maladaptation 3 (wishful-thinking), ToG(P): Trust of Goverment1 (program), ToG(W): Trust of Government 2 (warning system), ToG(I): Trust of Government 3 (Information)

Table 5.18 Variance Inflation Factor (VIF) for the explanatory variables in the binary regression models on farmers' intention to adaptive behaviors

Explanatory Variables	VIF	Explanatory Variables (continue)	VIF
Age	2.71	PRR: Perceived Risk Probability	4.66
Gender	1.24	PRS: Perceived Risk Severity	4.74
Education level	1.64	PME: Perceived Measure Efficacy	1.94
Farming experience	2.11	PSE: Perceived Self-efficacy	1.83
Income	1.38	PAC: Perceived Adaptation Costs	1.76
% of income from apple cultivation	1.56	MAL(F): Maladaptation (fatalism)	1.25
Successor	1.32	MAL(D): Maladaptation (denial)	1.31
Sales channels	1.26	MAL(W):Maladaptation (public)	1.69
Network	1.41	ToG(P): Trust of Gov. (program)	1.59
Cumulative years of buying CI	2.78	ToG(W): Trust of Gov.(warning system)	2.89
		ToG(I): Trust of Gov. (Information)	2.80

Summary on the farmers' intention on adaptation behaviors

In the study area, apple farmers have been reacting and coping with changing climate. The previous sections in this Chapter found that the farmers are associated with various adaptive measures, and some behaviors are preferred by others. This section is to explore how the socio-cognitive factors are influencing the adaptive behaviors. Hence, this section of the chapter attempts to identify key issues and variables that help us to understand the adaptive behavior of apple farmers in Cheongsong County. The farmers are asked to indicate if they are already performing on the adaptive measures or have any plan to perform such adaptation measures. The result is not surprising that in this study area that most of the farmers are found to have the intention to carry on the adaptation that is generally used by farmers in the area. However, those adaptation measures that is associated with changing crop or apple variety are found to have lowest intention to carry on. The result is not surprising since, in this county, the apple production is usually the only crop that the farm households are involved with, and the role of the apple crop in the farmers' lives and the County is more than the economic source. 10 binary regression analysis were conducted for investigating how the socio-cognitive factors are affecting farmers' intention on the different adaptation behaviors. The result of the regression model shows that the socio-cognitive factors such as risk perception, perceived adaptation efficacy, maladaptation and trust of government do have a significant influence on farmers' intention to different adaptation measures.

Although the different cognitive process is found to be involved in the probability of having the intention of adaptive behaviors, in overall, how farmers perceive the severity of climate risk is found to influence farmer's motivation to adaptation measures. Moreover, assessment of adaptive measure-efficacy and self-capacity are found to be the significant cognitive factors influencing farmers' adaptation intention. Maladaptation, particularly with fatalism and wishful-thinking, and how farmers evaluate the effectiveness of government provided information are also found to be the determinants of the intention. Therefore, as the results of the regression models show, cognitive factors can play the crucial roles in the farmers' motivation to adaptation to climate change and underestimating the roles that the cognitive factors play in farmers' motivation to adaptation behavior may cause inadequate results.

Chapter 6 Discussions

In this chapter, an extended analysis of results in chapter 5 is further discussed. The chapter is devoted to building discussion on the results of quantitative analysis in chapter 5 of farmers' awareness of climate change variability and change, risk perception, perception on adaptation efficacy, and their intention to behave in various adaptive strategies to prevent negative impacts of climate variability and change. The discussion in this chapter is based on reflections obtained from Focus Group Discussions (FGD) and in-depth one-to-one interview with farmers, Agricultural Government Officers (AGO) and experts.

6.1. Perceived Climate Variability and Change and its Impacts

Farmers' awareness on the trends of variability and change in temperature, precipitation, and extreme events can have the vital role of assessing and recording on local climate change. Further, it is certainly an important element to understand insights of micro-level studies on local climate change and adaptation. The results of chapter 5.1 that depict the trend analysis provide such information in some extends. However, without exploring local farmers' thoughts and experiences with climate variability and change, the trend analysis only provide a partial understanding of local knowledge. Therefore, in this section, in addition to the results given in the previous chapter, aims to explore farmers' awareness on local climate change by discussing results of FGD and individual interviews.

Characteristics, experiences, and causes of changing climate

At the beginning of the each FGD session and interview, the farmers are asked if they have heard the word '*Gihubyeonwha*' which is equivalent to a term 'climate change.' Most of the farmers expressed that they have heard the word. However, farmers seem to use the word '*Gihubyeonwha (climate change)*' interchangeably with '*Nalsi (weather or climate variability)*.' Although the two terms, climate change and climate variability (or weather) have different meanings in the academic sphere, local farmers did not distinguish two terms and used interchangeably during the sessions. However, the local farmers referred climate variability and change in specific elements such as temperature increase, precipitation change, and typhoon or droughts.

Most of the local farmers expressed that they have detected climate variability and change through increasing temperature in recent years. Moreover, increasing trends of temperature during summer and winter seasons were mostly mentioned by the farmers. Temperature increase was expressed by farmers as warmer or hotter days or strong sunshine. They expressed some hardship that they have with farming activities. Because of strong sunshine, farmers cannot work longer in their farms resulting delay of achieving the tasks that they have. It is important to note that some farmers expressed temperature by referring to the decreased insect in their farms. Moreover, some of the farmers in FGD indicated that they had experienced the bad quality of apples produced in their farms because of inadequate temperature during the summer. They had a hard time selling the apple to consumers directly, and they are worried about the apple quality that to be sold during '*Chuseok* (Thanksgiving day).' Korean people buy the high-quality apple during '*Chuseock'* that is 15^{th} of August in Lunar calendar, which is around late September to early October in the western calendar. The farmers expressed that they used to cultivate the best quality apples to be ready for '*Chuseok'* season. However, several farmers expressed that because of the hotter days in the summer, the best quality apples have been cultivated much earlier than the '*Chuseok'* season. Some farmers expressed their experience of increased temperature with increased yield of apple crops which resulted in lower prices for the crop.

On the other hand, the local farmers expressed the trends of precipitation in various ways. More specifically, some of the interviewed farmers expressed that they have not perceived any change in the precipitation since the farmers did not have any problem of conducting irrigation in farming until now. Other farmers expressed that they have noticed the frequency of rainy days is changed in recent years. This was what the farmers had said in the focus group discussion.

> *FGD 1: I think we now have no 'Jangma (monsoon).' Because when I was younger, I used to plan to visit my relatives in Pusan during the first of July every year, and took a break for several days because we had the rain during Jangma season, but now, I never really take break during summers because of we don't know when we will have Jangma. Instead, I may have been taking a break from the hot weather.*

According to the farmers, raining seasons were more likely to be predicted in the past. However, in the recent years, the rainy season became unpredictable and influenced their daily life. Moreover, fluctuation of the amount of precipitation in the Cheongsong County has been depicted during the interviews. A farmer said as follow:

> *Farmer 1: I think there are less rainy days, but when it rains, it comes as big as Typhoon. I was extremely feared that it was raining so hard. I was so worried that the apple trees would be hurt from the heavy rain.*

According to the farmers, the rain intensity in the present become more severe than the past, but the duration of rainfall is less than the past. Moreover, rainy season such as monsoon seasons is no more predictable that have affected their summer plans.

With regard to extreme weather events, most of the farmers referred to Typhoon. Not as much as farmers perceived the changes or increase in extreme events. If the farmers expressed that there is changing trends of extreme events, all of them referred to the Typhoon Maemi, and Rusa hit in 2003 and 2002, respectively. Farmers did not express any other typhoon that hit the County. Only some of the farmers experienced the damages from such events. The local farmers did not refer heat waves and heavy rain as an extreme weather event, although extreme events include such climate variability in the climate change studies.

During the interviews and FGD, farmers continuously commented on their thoughts regarding the causes of increasing temperature, changes in trends of precipitation and changed extreme events. Most of the elders expressed that they think the changes are caused by Gods' will. In other words, climate variability and change in the local community are controlled by God or ancestors. More specifically, climate change related to increasing temperature was not generally mentioned when the farmers expressed such belief. Most of the farmers who mentioned on the will of God or ancestors as the main cause of changing climate expressed that intensified climate events, such as heavy rain and climate events (typhoon and droughts).

They expressed that these changes are happening because the present generation does not behave well to take care of the surrounding natures, the neighbors, and parents (elders). Some farmers blamed fast economic development as one of the causes of the climate change. Only one of the farmer and the AGOs expressed the term "Greenhouse gas." Moreover, particular matter (PM) was also mentioned during the individual interviews with some farmers. The amount of serious level amount of PM has been detected in Korea in recent years, and the farmers indicated that PM is also a serious problem that caused increasing temperature.

Not only the perceptions of climate change in terms of present and past are discussed during FGD, and individual interviews, but also their perception of the future climate change also was discussed. With regard to the future climate change, most of the farmers did think that there will be climate change continuously.

In sum, from the above information, it could result that the climate variability and change is happening in Cheongsong County. The farmers perceived changes of various elements of climate in the region. Although their perception and awareness have been more likely to receive from their own experience with climate variability and change, the level of awareness of climate change was found to be high. The AGOs, in the interview, did not think that farmers would be aware of changing the climate and did not care about what is happening. Moreover, the interviewed AGOs think that farmers would not think that climate change is an actually happening but will happen in the next generation. However, throughout the FGD and interviews, AGOs perception on the level of awareness of climate change by local farmers was denied. Although there were much fewer farmers mentioned on the anthropogenic cause of climate change but mostly asserted that the climate change is caused by God's will, it is noteworthy that in, either way, the farmers do aware of changing the climate and the consequences belong to such changes.

However, it might be more logical to conduct comparative analysis by using objective data such as meteorological data provided by the government and farmers' awareness. Although it is plausible to consider such objective data to understand local circumstances, it only gives partial information regarding how farmers' perceive the circumstance and how they interpret climate variability and change. Therefore, it is important to analyze and explore the farmers' expressions, experience, and perception on the cause of climate variability and change to understand fully on the local climate change and perception of local farmers on climate change.

Table 6.1 Summary of characteristics, consequences, and causes of local climate variability and change identified by the apple farmers in Cheongsong County

Categories	Descriptions
Characteristics	• Temperature hotter days, strong sunshine, warmer winter, increasing temperature • Precipitation Less rain, unpredictable of monsoon season, heavy rain at once, no rain for longer terms • Extreme events Less but more intensive typhoons
Consequences (Impacts)	• Apple production & quality Yield loss, yield increase, lower quality, earlier flowering and cultivation season, fewer insects, more new insects and moles • Income & assets Less income caused by lower price of apple, earlier production of apple (not adequate for *Chuseok*), additional cooling devices, frequent breakdown of machinery • Heath More heat stroke, skin illness, stress, headache • Socializing (social networks) Less visit to and from friends/relatives, less commute to social community centers (to meet neighbors)
Causes	• Anthropogenic Rushed economic development, governments' ruthless development of road and buildings, greenhouse gas emission, particular matters • Wills of gods and ancestors Carelessness of nature and elders by current generation, not thanking what we have caused god (ancestors) to be angry and place punishments

Source: Own fieldwork (FGD and in-depth one-to-one interview with farmers and AGOs)

6.2 Influencing Factors of Farmers' Climate Change Risk Perception

In this section, the results of an investigation of farmers' perception with regard to climate change risk appraisal reported in chapter 5 are further discussed by information from FGD and individual interviews. As presented in the previous chapters and sections, impacts of climate variability and change, temperature increase, precipitation change and change in extreme events, on various dimensions of the apple farmers' lives are discussed first. Then, the farmers' perception with regard to risk probability and severity of each of the dimensions are discussed.

Climate change impacts on the lives of farmers

Through the thorough review of numerous literature on climate change impact and risks, this dissertation developed seven different categories or dimensions of climate change impact that are relevant to the apple farmers' lives in Cheongsong County. The Seven different categories are Apple production (yields and quality); income; assets; physical health; natural resources; network; and mental health (stress). During the FGD and interviews, farmers were asked about their knowledge, mostly the experience-driven knowledge, on the impact of climate change. The seven dimensions cover all of the topics that were discussed during the FGD and interviews. Most of the farmers expressed the consequences related to apple production. More specifically, they expressed on the lowered quality of apple production, earlier periods of a flower blooming and pruning and changed cultivation period. One farmer during the in-depth interview said on the climate change impact on the apple production as follow:

> *Farmer 2: The blooming of flower season for the apple has usually been on the Parents' day. I remember this clearly because my kids usually called on the morning of the parents' day and asked me about if the flower is all opened up. However, since around 3 to 4 year ago, the full blooming of flower became earlier. Last year, it was about a week earlier than before.*
>
> *Farmer 3: In the past, I used to use a large amount of pesticide to prevent the apples from pests, but in the recent years, I do not use much of the pesticide. I only use the small amount recommended by Dr. Ueom. I think it is too hot that insects also die with such environment.*

Most of the farmers interviewed during FGD, and individual interviews mentioned Dr. Ueom, Jae Yeol who is an expert on insect/disease of fruit crops and a former professor at the University of Gyeongbuk, the most well-known university in North Gyeongsang province when they regard on the pesticide use. For about 10 years, Dr. Ueom has been researching on the insects and disease in apple farms in Cheongsong County. Moreover, he has been training the apple farmers on the effective use of pesticides. He visited farms and directly communicated with farmers on such issues. Because of his dedication to lessening the damage of insect/disease on apple farms in Cheongsong County, the farmers trust greatly on the training that Dr. Ueom conducted. After retiring from the teaching at the university, although he has his own house in Busan, Dr. Ueom built another house in Cheongsong to cultivate apple crop for himself. At his own farm, he tests the various kinds of pesticides that would be the most effective to be used by the farmers in Cheongsong. One of the FGD was conducted with Dr. Ueom to discuss the past and current issues of insect/disease in apple farm in Cheongsong County.

The FGD was conducted with Dr. Ueom, one AGO, and an apple producers' cooperative representative. The discussion was started with the current issues regarding insects and disease in apple farm in Cheongsong County. According to Dr. Ueom, in recent years, fewer insects can be found in apple farms. Because of increased temperature with no rain, the air of the region became less humid which is a less desirable condition for insects to grow. Dr. Ueom stated that:

> *FGD (Expert): These days, I cannot see as many as insects in the farm. I used to make money from making pesticides and training farmers and government officers teach the techniques of using such elements. But now, I don't know how I would make money because there is no need to develop pesticides. But it is important that there are new kinds of insects appearing in the farms now. It is very important because farmers or even experts do not know how to prevent the damage from it. We must first invest time and money in research but, there is no time for it. Farms are already suffering from abnormal conditions. We never saw the moles on the farm before, but now, I see dead moles all around the apple field. Farmer, like myself, gets really stressed out about it.*

As presented above, FGD and individual interviews revealed on some impact of climate change that interviewees' perceived during the recent years. The impact of the climate variability and change that are mostly mentioned by farmers were in line with the list of impact presented previously in this dissertation. All of the farmers or interviewed participants claimed that climate change has either direct or indirect influence on their lives.

Factors influencing perceived climate risk of farmers in Cheongsong County

Demographic and socioeconomic factors

Demographic and socioeconomic factors are found to have a significant influence on farmers' perception of climate change and therefore affect farmers' adaptation. In the previous chapter, the quantitative analysis of farmers' risk perception, a one of main factor influencing farmers' adaptive behaviors, is conducted and the factors influencing such perception are also presented. Depending on the category of dimensions, the factors were found to be in either negative or positive direction with risk perception. The regression models for farmers' perceived risk on seven dimensions of impacts of climate change show age, farming experience, sales channel, number of network joined, ownership of farmland, investment in crop insurance, years of investing the crop insurance, education levels, number of participation in agricultural training programs in one year, having children who can continue on apple farming, and percent of income from apple crop are found to have influence on the perception of climate risk significantly. In this section, the factors are discussed further with the information from FGD and interviews. Some of the factors are grouped for discussion.

- *Age and years of experience in farming*

The factors such as age and years of experience in farming have been found to have a significant influence on farmers' adaptation behaviors. In analyzing farmers' perception of climate risk, the factors are also found to be significant according to the result of regression models in this dissertation. Such factors significantly influence the perception of climate risk particularly associated with apple production and income. The interviewees participated in the FGD and interviews had diversified ages and farming experiences. The ages of farmers were from the 30s to 70s. During the discussions, younger farmers were more likely to mention the new opportunities that climate change may bring to their farms. Moreover, some of them were considering of growing the newly introduced fruits such as blueberries and acai berries. However, the older farmers with longer years of experience in farming were more hesitate to use word 'opportunity' and worried more one the price of apple that fluctuates with the total yield. Although the statistical analysis did not show a significant relationship between the two factors on human health (physical or mental), through the interviews, farmers (more female than male) claimed that they think there will be some negative consequences on their physical health from increased temperature.

- *Total income and share of income from apple cultivation*

Factors such as income and perception of income from apple cultivation were found to have a significant influence on farmers' perception of climate risk associated with physical health (income, negatively), network (income, positively) and stress (percent of income from apple, positively). As noted briefly in the previous chapter, farmers with higher income may perceive less probability and severity of climate risks. It was found that farmers during the period of pruning off flower, farmers have work extensive time on the farm to cut the flower off from the tree. However, this has to be one by one and, so far, there is no technology that can assist work of farmers. Thus, farmers pay workers to support their farm works. Workers are coming from the neighbors but also from other provinces. Farmers from the same villages are mostly friends and family members. The farmers who were helped by neighbors have to pay it back by money or helping them on their farms. The costs of hiring part-time workers from other provinces are much higher than those from 'helping hands.'
However, a female farmer in her 60s stated that:

> *Farmer 4: Since my husband got sick, I am the only one working on our farm. Because it became too hot during the spring and summer, I could not do work longer than I wanted to and it left me with a lot of work. I could not finish it by time, so I hired some outsiders (part-time helpers from other provinces) to help me with the farm work. Although it is more expensive and takes time, because I have to teach them how to do it, I prefer to spend money since I have some. I did not have to worry about working under such a strong sunshine.*

Hence, although there might be higher costs engaged in hiring part-time outsiders, farmers with higher income can spend money on it and perceive less risk particularly associated with physical health from working in the strong sunshine.

- *Education and number of participation in training programs*

Education is frankly understood and assumed to be the one of a significant factor in accessing radical information. Education either in the form of the official education system, (elementary, middle, and high school or higher level education) or training program are particularly important to farmers since, through the education programs, they can learn about the new, improved and available agricultural technology for their farm. Although the numbers of participating in educational programs are important to be exposed to newer knowledge, the expert interviewed indicated that the contents of the training programs are more important than how many times that the farmers are exposed to such programs. According to one AGO, the government of Cheongsong County is actively promoting training programs by developing the 'apple university.' The apple university is an agricultural training program that is particularly developed for apple farmers in the region. There are an increasing number of farmers wish to take the course, but they are worried that the contents might not be good enough or fresh enough for the apple farmers who have been farming for a long time.

- *Sales channels and having successor of apple farming in the family*

In Korea, internet shopping is extremely active for the various goods and services. Internet shopping created a connection among consumers in Seoul with the farmers in rural areas including Cheongsong. One of the representative characteristics of Korean culture of '*pali, pali,'* meaning 'hurry, hurry,' made consumers in such longer way to receive fresh fruits that are cultivated in Cheongsong. Farmers in Chengsong are now able to communicate with consumers in urban areas, and able to listen to the comments about their apple products directly from the customers in urban areas. Because of this reason, farmers engaging in direct selling of their apples to consumers can have a higher perception of climate risk on apple production. Moreover, one farmer indicated that:

> *Famer 5: I think it is great that I can communicate with consumers in Seoul. Since they first ordered our apple through online, they order it every year from us. They always tell us that our apple is so sweet and big. My son helps me to use a computer and get orders from the consumers in Seoul. Eventually, he will have to do it all by himself. I try to improve the quality of apple and wrapping system so that the consumers think that our apple is more valuable than others. I have to study continuously because if I don't, my son will not be able to compete with others in the future.*

In this discussion, households with apple farming as an intergenerational business are more likely to pay attention to future farming conditions that are indirectly causing them to perceive more on future climate change risks.

- *Crop Insurance (CI)*

In Cheongsong County, Crop Disaster Insurance (CI) was introduced in 2005. As introduced in the earlier chapters, only selected crops can be insured from damages of climate change and natural disasters. However, apple crop is considered to be one of the most sensitive crops, and apple farmers have been able to get governments' support on buying CI. As discussed in the previous chapter, a farmer in Cheongsong pays only 20 percent of crop insurance. However, during the FGD and interview, it was observed that farmers are not so much satisfied with such measure. The reason is that farmers who have been buying CI for several years, from around 5 to 10 years, were complaining how much they had to pay for CI every year without any benefit from it. Some of the farmers indicated that they would like to exit CI. Because of their negative perspectives on CI, the perceptions of climate risk also seem to be negative. In other words, although CI is found to be economically effective measure to prevent negative and unpredictable damage from climate change and natural disasters, farmers who benefited from investing in CI are not many and therefore, as farmers without any benefit from invested crop insurance increases, farmers do not perceive that there is any significant damage or impact from climate change or natural disasters.

Awareness on climate variability and change

Enhancing awareness on climate change is considered to be one of the most important objectives of Korean climate change adaptation policies to promote adaptation capacity and resilience to climate change. Many surveys on observing public awareness on climate change show high rates of awareness of climate change by farmers in Korea (Kim, Jenog, and Park, 2015) and other parts of the world (Abid et al., 2015; Dang, 2014; Mekuriaw, 2013). In parallel to such finding, this dissertation also found that awareness of apple farmers in Cheongsong is high and in the accurate trend that is comparable to actual metrological data. However, to promote adaptive behavior of farmers, it is necessary to analyze how such awareness can influence farmers' motivation and intention to adaptive behaviors. In this section, as one of the important factors influencing farmers' risk perception, the main factor of adaptation behavior, awareness of increasing temperature, and unpredictable trends of extreme events, are examined. Quantitative analysis is presented in Chapter 5, and this section is to supplement the analysis by including information obtained from FGD and interviews.

- *Temperature and extreme events*

Awareness of the trends of increasing temperature is the most stated climate variability and change by interviewed farmers and AGOs. Since apple farmers are greatly exposed and sensitive to hotter temperatures, increasing temperature, in terms of hotter days, was interchangeably used equally as climate variability and change. With regard to the perception of climate risk, most of the farmers confirmed that they are aware of such change and perceive the probability of impact on various dimensions in their lives. Extreme events, although less likely to mentioned during the interview, farmers are aware of the changing trends and frequency of extreme events in the region. Farmers interviewed stated that although there might be heavier rain and extreme droughts, they can ameliorate the damage by prevention actions taken by governments, the risk might be too severe. Thus, adaptation policy may require being improved from promoting the programs and policies for only enhancing awareness of climate change.

Risk experience and fear

Previous experiences and fear of future climate change have been recognized in many studies in various disciplines. In this dissertation, the previous climate risk experience associated with temperature, precipitation, and extreme events are observed to explore its influence on apple farmers' perception of climate risk. The quantitative study in the previous chapter shows past experience with temperature and extreme events may have influence farmers' perception of climate risk in more various ways. During the FGD and interviews with farmers and AGOs, past experiences were the main indicators of shaping their perception of climate change risk. Although it might be hard to argue on the specific cause of climate variability can have a greater influence on the perception because analyzing quantitative data per se cannot capture the magnitude of each risk experience and the definition of risk experience was opened for each of the respondents. Since the farmers depend solely on their memory of the experiences, they may refer to the risk experience with the greatest damage or the most recent. This was also observed during the interviews that each of farmers when they recalled the risk experiences, each of them had different ways of referring climate change risk experiences. However, it was clear that farmers with climate risk experience from extreme events mentioned more dimensions of impact that climate change, including natural resources, network, physical health, and commodities. Moreover, similar to risk experience, the term fear cannot have exactly the same definitions to each of farmer. A higher level of fear, or farmers' expression on 'I am extremely feared' might not have the same magnitude. However, both quantitative analysis in the previous chapter and the information from FGD and interview indicate farmers who are thought to have more fear are more likely to have perceived risk, especially in apple production and income.

Information

In the similar studies, climate change information itself or access to such information is found to have a great influence on farmers' assessments of climate change risks and adaptive behaviors. However, interestingly, a contradictory result from how climate change was hypothesized to influence perceived climate risk of farmers, was found in the regression model in Chapter 5. Climate change information obtained from heterogeneous sources did not show a high significant relationship to farmers' perceived climate change risk on seven different dimensions. It can be explained by information reached from in-depth interviews. The farmers believed that weather and climate are a very similar concept that they naturally know how the weather would be like and so they do not require any additional information to perceive consequences of weather. Moreover, a majority of farmers stated that because of the cumulative incidents of inaccurate weather forecast from various sources led the farmers not actually to consider climate change information. This also caused the farmers to distrust the information from other sources. It is interesting that the results of the regression models show that information on adaptation rather than climate change had the more significant influence on risk perception. It is important to note that, during the FGD, farmers did indicate that the negative effect of recurrently reported information regarding climate change seems too exaggerated to local farmers. Rather, they remembered more specifically on the successful cases of neighboring provinces. Although the information may have negative or positive relations, adaptation information rather than inaccurately thought climate change information could have a significant influence on increasing farmers' perception of climate risk which would eventually have an influence on farmers' adaptive behaviors.

6.3 Influencing Factors of Farmers' Perceived Adaptation Efficacy

The chapter 5.4, reported the results of regression models regarding farmers' insights on the current uses of adaptation measures, and evaluation of self-capacity and costs to take action on the adaptive behaviors in Cheongsong County. Through an assiduous review of literature and discussion with local AGO and farmers, the nine adaptation measures were identified: adjusting farming calendar (CCAM1), adjusting use of pesticide/fertilizer (including water use) (CCAM2), switching to new crop (CCAM3), gathering information on climate change (CCAM 4), diversifying crop varieties (CCAM5), buying crop insurance (CCAM6), improvement of soil condition (CCAM7), changing into different apple variety (CCAM8), and searching for non-farming jobs (CCAM9). The number of households who have used the specific adaptive strategies in response to climate change is provided in Table 5.10. Moreover, the results of four regression models on the apple farmers' perceived adaptive efficacy, one of the main elements to motivate farmers to behave in adaptation, are identified in the previous chapter. To amplify the understanding of the results of Chapter 5, this chapter discusses the relative results from FGD and in-depth interviews with local farmers, AGOs, and experts. For the discussion of actual using the adaptive measurement of apple farmers in Cheongsong County, the chapter 5.4.1 already analyzed some major findings from the FGD and individual interviews. Along with a discussion of farmers' assessment of adaptation efficacy, this chapter discusses factors influencing the efficacy by scrutinizing discussions from FGD and interviews.

Farmers' assessment of adaptation measures, self-capacity, and adaptation costs

Apple farmers interviewed in Cheongsong were using the adaptive measures that have been identified and discussed in the literature and reports. The most of the commonly used adaptive measure in Cheongsong were adjusting pesticides/fertilizers, buying Crop Insurance (CI), gathering climate change information and adjusting farming dates. Only about 11 percent of the farmers were associated with soil improvement and changing to a different variety of apple crop as adaptive measures. Moreover, exceptionally few percent of farmers were engaged in diversifying crop varieties (6.5 percent) by including other crops such as hot peppers and some vegetables. Moreover, about 4.11 percent of the farmers tried to searching for non-farming jobs to diversify their income profiles from only apple farming to other jobs. Switching to new crop (2.9 percent) was the least used adaptation measure by apple farmers in Chenogsong. Since this study surveyed only apple farmers whose income profile includes more than 50 percent of apple production, the FGD and interviews revealed that some of the farmers who indicated the switching to new crop as their method to adapt to climate change have experience of moving from other provinces.

As explained in the previous chapters, Cheongsong is well-known for its high-quality apple. The people from Cheongsong are proud of such status, and apple means a lot for people living in Cheongsong. How much apple means to the County, and the people living the area could be observed from the field. The entrance of Cheongsong County has a large monument shaped in apple. Moreover, although not many bus terminals and the operations of the public bus are not so much active in the County, the major bus stops were shaped like an apple. Thus, by coalescing the interview and the field observation, it could be observed that apple is more than income source for the farmers. Thus, the above findings related to the use of adaptive measures by apple farmers in Cheongsong are not startling. In other words, adaptation measures that are more related to changing crop or deviating farmers from apple production, are less preferred by farmers because not only that apple, compared to other fruits or crops, produces higher satisfaction in economic well-being of farmers, but diverting from apple farming is assumed to have higher opportunity costs (not necessary in monetary terms) to farmers in Cheongsong.

Along with the actual use of adaptation measures, the results of farmers perceived adaptation measure efficacy show that farmers' evaluation of the effectiveness of adjusting pesticides use, buying crop insurance, gathering information, and adjusting farming dates were high. However, although farmers do not prefer switching to new crop over other adaptive measures, they evaluated that switching to different crop may be an effective way to prevent future climate change.

For instance, one of the farmers in the in-depth interview stated that:

> *Farmer 6: Apple farming is a big part of my life. I know that it is becoming hard to produce high-quality apple as before, but I can't just go for other crops because, Cheongsong is all about apple farming. If I wasn't an apple farmer, I don't think I could have such good friends and neighbors as I do now. We can share the sadness and happiness together. I really think that apple connects us together even though there are hardships throughout the years. There are too much to lose if I go for just money. I know that apple has started to be produced in Gyeonggi area, but I am sure the product is different from here. Because of Cheongsong apple have hearts and spirits of Cheongsong people. We care about apple not just because of the money that we can get from it.*

Farmers' assessments on their capacity to implement each of the climate change adaptation measures were discussed. Farmers perceive high self-capacity of conducting adaptation measures through buying CI. Moreover, farmers perception on self-efficacy on adaptation measures seems to be higher with the measures that are more familiar to them. Although it was found that farmers perceive switching crop as an effective measure to response to climate change risks, farmers' assessments on the self-capacity to implement such measure seem to be low. The perception of lower capacity of implementing the adaptation measures may bottleneck the farmers to consider the adaptive measure to prevent from climate risks. In addition to self-capacity, the adaptation costs also play an important role in motivating farmers to conduct in adaptive behaviors. It was found that apple farmers in Cheongsong area perceive adaptation costs associated with Crop Insurance (CI) as most expensive. While farmers have less experience or knowledge of switching, diversifying or changing crops in their farms, farmers have more information and experience of buying crop insurance. Because farmers investment on buying insurance is understood as 'extra money' that is not required to spend on the farm. During the interviews, many farmers stated that they were buying CI for years, but did not get any benefit, and will try not to buy insurance next year. To avoid serious damage from the uncertain future impact of climate change, farmers are recommended to buy insurance, but there is no requirement to buy the insurance. Therefore, since considering insurance as 'extra cost,' farmers might perceive adaptation costs buying CI is very high.

During the interviews and FGD, other factors rather than climate change were frequently identified to induce farmers to perform the adaptive measures. Farmers seem to respond to climate change but also to other social and economic changes. While these study findings can provide an overview of what the farmers are doing to respond to the risk of climate change, it acknowledges the awareness that the farmers are also managing other rural changes.

Factors influencing farmers' perceived adaptation efficacy

To understand farmers' adaptation behaviors and intention to such behaviors can be contributed by how farmers assess private adaptive measures and factors influencing those assessments. Farmer perception of adaptation efficacy can be defined by perceived adaptation measure (effectiveness of adaptive measure), perceived self-efficacy (ability to conduct adaptive measures), and perceived adaptation costs (assumed costs of conducting adaptive measures). In this section, factors determining farmers' perceived adaptation efficacy are discussed in addition to in conjunction with quantitative results of the regression models in Chapter 5.4.2. The assumed factors influencing farmers' perception on adaptive efficacies are: 1) demographic and socioeconomic factors (age, gender, education levels, farming area, farming experiences, income, percentage of income from apple cultivation, job outside farming, moving experience, successor, agriculture education, smart-phone use, sales channels, land ownership, network buying crop insurance, cumulative years of buying crop insurance and cultivation of other crops); 2) risk experiences associated with climate variability and change (temperature, precipitation, and extreme events); and 3) information on climate change and adaptation (climate change information and adaptation information from public media, neighbors, commune leader, agricultural extension service center, and farmers' cooperative such as NH).

Demographic and socioeconomic factors

- *Age, gender, and successor*

In chapter 5, the results of the four regression models of perceived adaptation measure efficacy perceived self-efficacy, perceived adaptation costs, and overall adaptation efficacy showed that farmers' household characteristics, particularly, age, gender and family members, do have a significant influence on their perception associated adaptation efficacy. Older farmers, compared to younger farmers, and males over females expressed that they are reluctant to take certain risks and changes. However, the results might have changed if the interviews or survey included all of the house members rather than the households. Farm households with children, who will take over their apple farms, are shown to have a higher perception on self-efficacy compared to those who do not have the successor of their farming.

As discussed in the previous section, although the older farmers have less perception to carry on the adaptive measure to climate change, with the help of their younger family members, they can have more information and able to conduct adaptation more effectively than others who do not have such members in their family. In addition to a farmer indicated that his son helps her to use computer and get information regarding current issues related to apple farming, another farmer indicated that his son, who will be coming back to the farming work after graduating from the university, encourages him to start to grow newly introduced and highly valued fruit crops such as blueberry and acai berry. He stated that he did not even know if such fruit exists and it is able to be cultivated in Korea albeit it might have been introduced by training programs organized by agricultural extension services.

- *Farming area, income, smartphone use, and sales channels*

Farming area and income both were found to have a significant influence on farmers' perception of adaptation costs. Farmers with bigger land and higher income were significantly influenced to perceive adaptation measures as more expensive. Farmers with more land and income may have to spend more on adaptation because there are more things to prevent from climate change. Most of the farmers in the survey indicated that they have a smartphone. Although the purpose and how the farmers are using the smartphone may be different from farmers to farmers, having smart-phone per see seem to be important since farmers receive texts on the weather information, including warnings of heat waves, heavy rain, typhoon and heavy winds, automatically. Most of the interviewed farmers mentioned that they receive such information through a smartphone. Farmers with the smartphone being able to receive information or exposed to get information on extreme events more frequently can influence farmers' understanding or perception of expenses that are used to prevent the consequences. However, the findings could be amplified if the purpose and the use of smartphone are investigated further.

Farmers with direct selling of apple perceive adaptive measure as more effective than the farmers who sell their products through another mechanism (such as NH and other mass markets). Direct selling can encourage farmers to pay more attention to current issues including climate change, the marketing techniques, and the quality (size, color, taste) of apple preferred by people that can increase their consumers' satisfaction. Also, the farmers with direct selling of their product stated that they have chances of hearing about apple produced in other provinces and their consumers give some opinion on such products. The farmers can compare and contrast their products' status. Through these mechanisms, farmers are more motivated to take risks and changes.

- *Education (education levels, participation in training programs)*

Education is found to be a significant factor influencing farmers' adaptation behaviors in previous literature. In this study, education is also found to have a significant influence on farmers' perception of the overall adaptation efficacy. Moreover, particular education can influence farmers' perception on self-efficacy of adaptation to climate change. Farmers with higher levels of education may have lesser experience on the farm and do not have enough knowledge about the techniques and have less self-confidence on successful farming. Moreover, farmers with higher education, mostly younger generations, might consider other forms of livelihood than apple farming. Those conditions could lead more educated farmers levels to perceive some adaptation behaviors as unnecessary. However, as farmers increase the participations in agricultural training programs, farmers' perception of self-capacity to perform the adaptation measures increases. At the training programs, instructors, mostly the experts in agriculture, introduces the successful cases and encourage farmers to try new techniques. If farmers are exposed more frequently to these cases, they may perceive that adaptation is not too difficult to conduct and evaluate themselves with highly capable of adopting new environment and techniques.

- *Crop Insurance (CI)*

Crop insurance is an important method related to adaptation to climate change of farmers in Cheongsong. Farmers in the interviews indicated that they buy crop insurance with the purpose not only to secure the income that would be lost from climate change related damages but also to remedy the feelings of insecure if they don't buy the insurance. Even though the farmers think crop insurance is an expensive extra investment, unpredictability, and uncertainty affiliated with the recent climate change trends may influence them to buy insurance. However, like a number of years that they invest on crop insurance increases, farmers' adaptation efficacy of crop insurance and self-efficacy decreases. Farmers with lowered trust of benefits of crop insurance may perceive impotence crop insurance.

Information

- *Climate change information*

Climate change information may be provided by public media, neighbor farmers, commune leaders, agricultural extension service centers and farmers' cooperative such as NH. However, among those various sources providing climate change information, the information obtained from public media, agricultural extension center and farmers' cooperative have the positive and significant influence on farmers' perception on adaptation efficacy while climate change information from village leaders is found to have significantly and negatively influence farmers' perceived adaptation efficacy. More specifically, climate change information from the objective sources such as public media significantly influences farmers to perceive adaptation measure and self-capacity, as well as the overall perceived adaptation efficacy, positively. However, climate change information obtained from subjective sources such as village leaders significantly influence perception on adaptation costs and overall perceived adaptation efficacy.

- *Adaptation information*

Unlike the climate change information, adaptation information attained from neighbor farmers shown to have significant influence rather than the information from public media. Information on successful adaptation of farmers in similar conditions and environment seem to increase farmers' perception on adaptation on self-efficacy which will have an influence on intention and actual adaptation behavior of farmers. In the discussion in the FGD, farmers stated that:

> *FGD: I started to sell the 'Yugwa (Korean tradition cookie)' because Mr. Choi taught me on how much it worth to start a business using apple in the 6^{th} industry. I knew that he had great success in making vinaigrette from apple. When I was depressed with low income from the low quality of apple produced in 2010 because of the less rain, I got information regarding government support on starting to work on the 6^{th} industry from Mr. Choi. I always go to him for more information. He is much nicer than people from government and explains me with easier way if I have to do something with it.*

This farmer started to make *Yugwa* (deep-fried sweet rice cake) using apple cultivated in her farm. The farmer does not only produce and sell *Yugwa* but also open the farm for experiencing tourists and give presentations and teaching courses on apple farming and making *Yugwa.* With government supports the farmers engaging in the 6th industrialization in agriculture, the farmer could diversify her income profile which solely depended on apple cultivation that was vulnerable to climate change. AGOs in the interview stated that:

> *AGO1: Government is promoting farmers' involvement with the 6th industry. The government budget also increased a lot in this part of the policy. However, we don't know what kind of programs should be planned and what kind of information would be adequate information for farmers in our region to promote the 6th industry. We don't have visits from outsiders usually. We don't even have any facility that we can sell our products that are produced by farmers. It is a big homework for the government.*

The 6th industrialization in agriculture is a strategy for integration of agricultural resources. It is a strategy for integrating production with processing and sale and forming a business eco-system which includes tourism or exchange to create jobs and added values in the relevant region (KREI, 2014). As to prevent further damage from climate change and other causes, the farmer in the interview shared her experience with diversifying income profile by involved in the 6th industry that the information provided from neighbor farmers. Although the farmer's participation or activity involved in the 6th industry is quite inactive in the study region, it is assumed to be promoted in the future, and increasing apple farmers in the area would be involved in the industry. As seen in the case of the farmer above and the results of a regression model that adaptation information from neighbor farmers increase farmers' self-efficacy on adaptation, promoting the 6th industrialization and promoting farmers' adaptation capacity could be supported by exchanging information of successful cases in the similar industry.

6.4 Influencing Factors of Farmers' Intention to Climate Change Adaptation

Although there are limited researches on the adaptation behaviors, some of the literature discuss factors influencing the particular adaptive behavior. However, there has been less attention on the factors influencing farmers' intention to take different types of adaptation measures. Moreover, the literature only focuses on the socioeconomic and resources as the main factors influencing adaptive behaviors (Abid et al., 2014; Below et al., 2012; Bryan et al., 2009; Deressa et al., 2009; Hassan & Nhemachena, 2008). In another hand, cognitive factors, such as perception has also been found as a significant factor influencing individual adaptation behavior (Dang, 2014; Grothmann & Patt, 2005; Grothmann & Reusswig, 2006; Mekuriaw, 2013; Zheng & Dallimer, 2015). Particularly, Grothmann & Patt (2005) shows the explanatory power of the socio-psychological model; that influences individual adaptation intention and behavior. An integrated conceptual framework, Model of Private Proactive Adaptation to Climate Change (MPPACC) has been developed based on the Protection Motivation Theory (PMT) and Planned Behavior Theory (PBT). In the model, perceived risk and perceived adaptive efficacy are found to be the main socio-cognitive factors for individual adaptation intention and behavior. This dissertation is based on the integrated conceptual framework, and this section is to provide the supplements of the results that are identified in chapter 5 with the information found through FGD and interviews.

Intention of farmers' adaptation behavior to response to climate change

The farm household survey of 170 apple farmers in Cheongsong County revealed that farmers' intention to climate change adaptation behaviors is more likely to be associated in the same direction as actual adaptive behavior taken by farmers. This is also supported by the previous studies that adaptation behavior is followed after individual's intention to adaptation. Intention to adaptation also interchangeably used as motivation to adaptation is influenced by various factors including cognitive factors such as risk perception (perceived risk probability and perceived risk severity) and perceived adaptive efficacy (perceived adaptive measure efficacy, perceived self-efficacy, and perceived adaptive costs). In addition to these two main factors, this dissertation found that significant influencing factors that maladaptation (fatalism, denial, and wishful thinking) and trust of government (training programs, early warning system, and climate change information) play intention to climate change adaptation.

Risk Perception

- *Perceived risk probability (PRP)*

Perceived risk probability is one of the main factors that are hypothesized to influence farmers' adaptation intention and behaviors. In the binary logistic regression model, PRP is found to have a significant influence on the apple farmers' motivation to climate change adaptation associated with CCAM1, CCAM2, CCAM4 and CCAM 9. More specifically, PRP is found to have a negative influence on CCAM1, CCAM2, CCAM4 and positive influence on CCAM 9. This indicates that farmers' PRP can influence the probability of decreasing motivation of conducting the CCAM1, CCAM2, and CCAM4 while influencing increasing the probability of motivation of CCAM9. Such results can be supported by the interviews that the adaptation measures found to have a negative relation to PRP, CCAM1, CCAM2, and CCAM4 are mostly actually conducted by farmers as habitual behaviors. During the interviews and FDGs, when farmers mentioned responsive behaviors to climate change, they automatically listed those measures. It might be that although without the risk probability perception, those measures were conducted by farmers throughout their farming experience. They might not perceive these measures as to additional effort to prevent climate risks. On the other hands, non-farming job, which mentioned in the previous section, is rarely considered by the apple farmers in Cheongsong because apple farming is not just a mean of income source but also related to various dimensions of their lives. For farmers to search for a non-farming job as to diversify their income profile, it is found that farmers' higher PRP influence significantly.

- *Perceived risk severity (PRS)*

Perceived risk severity (PRS) is another factor composing risk perception of individual in adaptation behaviors. The results of regression model present PRS as a significant influencing factor for CCAM1, CCAM2, CCAM4, CCAM8 and CCAM9. Unlike PRP, PRS is found to have a significant relation to CCAM1, CCAM2, and CCAM4 positively while CCAM 9 in the negative direction. In addition, CCAM 8 is also found to be more likely to be intended by farmers if farmers are more engaged in perceived risk severity (PRS). In other words, this represents that farmers' perceiving less risk probability but perceive the severity of climate change are having a higher probability of readily in climate change adaptation behaviors associated with CCAM1, CCAM2, CCAM4, and CCAM8. However, farmers perceiving higher probability of risk and lower climate risk severity are more readily to take action on searching for a non-farming job (CCAM9). This indicates that evaluation of how farmers perceive on probability and severity should be taken as differently when it is considered with the intention to climate change adaptation. For instance, if a training program has a purpose of promoting farmers' adaptation behavior on adjusting farming dates, it is more likely to be successful by indicating climate risk as the consequences with the high severity. The relative circumstances were not considering such when it is practiced in an actual agricultural information system.

Perceived adaptive efficacy

- *Perceived adaptation measure efficacy (PME)*

Perceived adaptation measure efficacy (PME) is farmers' assessment of the effectiveness of each adaptive measure. PME is found to have positively and significant relation with farmers motivation to CCAM1, CCAM5, CCAM6 and CCAM 9. In other words, farmers' assessments of each of adaptation measures are positively and significantly correlated with farmers' intention to perform on how they adjust farming dates, diversifying crop varieties, buying crop disaster insurance and changing to different apple variety. During the interviews and FDGs, some of the farmers seem to hesitate to give the results of their thoughts or evaluations on the adaptation measures; rather they would provide the information that they received from agricultural extension centers. Unlike CCAM1, the adaptation measures such as CCAM5, CCAM6, and CCAM9 are the measures that farmers in the study area are not familiar with. Particularly, although some of the farmers have been buying crop insurance to prevent damages from climate risks since 2005, not many of the farmers perceived the positive returns from the measure. Moreover, adaptation measures such as diversifying crop variety and searching for a non-farming job are the adaptation measures that are not usually practiced by farmers but might be necessary for the farmers to lessen and prevent the damage from climate risk. Although the direct experience of such adaptation measures might not be available for the farmers, the information providing successful cases could assist farmers to perceive such adaptation measures as effective which have a significant correlation with the intention to behave on the adaptation measures.

- *Perceived self-efficacy (PSE)*

Farmers' assessment on self-capacity of conducting climate change adaptation measures shows significant relation to adaptation measures including CCAM1, CCAM7, and CCAM9 in the logistic models. In this study, CCAM1 is found to be one of the most practiced autonomous adaptation measures by apple farmers. Since the measure is one that is used to farmers already and they are confident with practicing such measure, some farmers do not even consider such behavior as responsive or preventive behavior to climate change. However, farmers' perception of self-efficacy is also shown to have a positive and significant relation to the farmers' intention to practice the adaptation measures including CCAM7 and CCAM9. Unlike CCAM 1 which is practiced by farmers the most, CCAM7 and CCAM9 are the measures that are not much considered by farmers. Moreover, during the interview farmers stated that they do not think to evaluate themselves on the activities that they think they are not associated with. Farmers in the FGD stated that:

> *FGD: I don't' know if I can do this (switching to new crop) or not, it does not matter if I can do it or not because I do not even know what this is and why I have to do it. I am a very productive person. If I know what it is and why it is needed to do, I am sure I can do it.*
> *FGD: I have no knowledge on how to cultivate other crops than apple. I heard that increasing temperature might cause less quality, but I cannot stop producing the apple because I am too old to learn new things.*

The interviewed farmers were divided by their perception on self-capacity to conduct adaptation measure: extremely optimistic farmers or extremely pessimistic farmers. Personality and cultural backgrounds seem to matter when they even assessing themselves in connection with taking risks and new changes.

- *Perceived adaptation costs (PAC)*

Perceived climate change adaptation cost is found to be an important factor influencing farmers' adaptive behavior. Farmers would be more likely to be motivated to take CCAM3 and CCAM8 if they perceive the costs as less. Usually, the farmers do not have information regarding newly introduced crop varieties. Moreover, during the interviews, it was found that farmers' view of having a new crop or different apple variety as an impossible and expensive investment. Although switching to a new crop and changing apple crop variety are two distinguished adaptation behaviors requiring different resources and techniques, with regard to the costs, farmers perceive the measures as comparable. Contrast to the costs associated with pesticide or fertilizer that is easily searched and farmers have a good knowledge about how much the pesticides would cost throughout their experience with apple farming. Therefore, if farmers perceive fewer costs associated with the adaptation measures, farmers might have a higher motivation to take the adaptation measure as to prevent the damage from climate variability and change.

Maladaptation

- *Fatalism*

Farmers' perception of the cause of climate change deviated from scientific findings found to have a significant influence on most of the CCAMs except for CCAM3 and CCAM 9. The fatalism having relation to the intention of the climate change adaptation behaviors are in negative directions. During the FGD, farmers who stated that they do not need to pay attention to the climate or weather information because they know it by looking at the sky in the morning. A farmer from this view stated that:

> *FGD: The information provided by public media or government institute are often inaccurate because the weather is gods' act that we cannot forecast with technology developed by a human being.*

From those statements, it can result that if public media or governmental bodies reporting climate or weather information can provide more accurate information to farmers to build trust on such information may change such perception associated with fatalism.

- *Denial*

The perception of denying the statement of climate change on their farms is found to have significant relation with CCAM2 and with CCAM4 and CCAM9 negatively. Using pesticides and fertilizers are the agricultural practice that is familiar to the farmers in Cheongsong. As indicated in the earlier part of this chapter, farmers in Cheongsong have the confidence of such methods to prevent damages to their crops. Farmers' perception related to the reality of climate change is found to be positively related to farmers' motivation to conducting CCAM2. This may indicate that farmers do not consider CCAM2 as an adaptation measure to climate change risks. CCAM2 may have taken as an everyday practice, and it may not be related to how farmers perceive climate change reality and the risk associated with it. However, gathering additional information on climate variability and change and searching for non-farming jobs are found to be negatively associated with farmers' perception of the reality of climate change. Farmers who affirm climate is changing are more likely to pay more attention to the new information and searching for the ways to diversify their income profile. However, AGO interviewed mentioned that:

> *AGO 1: Some of the farmers here strongly deny the fact that climate change is actually happening and the production of apple might not be able to appropriate in the near future. Those farmers think that the media are exaggerating on such information making public to believe on nonsense. And all these nonsense try to make the Cheongsong apple less desirable to consumers.*

Although the majority of farmers are found to have a high awareness of local climate variability and change, some farmers deny the fact of climate variability, and change still exists. Such subjective assessment of current climate change associated with the cultural background can bottleneck the motivation of adaptation measures particularly related to diversifying income portfolio by considering the non-farming job.

- *Wishful thinking*

Wishful thinking such as buck backing the response to climate change as the responsibility of government bodies can influence farmers' motivation to climate change in significant level. Such belief is significantly associated with CCAM2. As seen in the other cognitive factors earlier, farmers' are used to using pesticides, and this may cause farmers to perceive CCAM2 is not the measure to prevent the damages from climate variability and change. Most of the farmers interviewed indicated that with regard to using pesticides, they rely on the professional instructor, Dr. Ueom, and they somehow perceive the instructor has a responsibility to help them on the particular techniques. If promoting programs to increase farmers' awareness of self-responsibility on the management of environmental resources and climate change, the motivation of conducting CCAM2 may increase that eventually increase the resilience of apple farmers in Cheongsong.

Trust of government

- *Agricultural training program*

The binary logistic regression found that the farmers' evaluation of the government's agricultural training programs can have a significant relation to CCAM1. Trusting the effectiveness of agricultural training programs with regard to lessening the damages from climate variability and change can increase farmers' motivation. Since CCAM1 is found to be effective, affordable and capable by farmers, promoting such adaptation measure through increasing farmers' evaluation of agriculture training programs might enhance farmers' adaptive capacity to adjust farming dates accurately. Increasing the credibility of governments' training programs, might not directly relate to other adaptive behaviors, however, increasing the credibility can play an important role as to enhance farmers' credibility on information provided from agricultural training programs.

- *Early warning system*

Early warning system is one of the climate change adaptation measure provided by the government and farmers' perception of such system as effective or not have to influence on the farmers' motivation to climate change adaptation behaviors. From the logistic regressions, this is found with CCAM4, CCAM5, and CCAM6. Early warning system is closely related to the farmers' farming activities. According to the regressions, if the farmers trust on the effectiveness of the system, the probability of the farmers having the intention of CCAM5 and CCAM6 increase and CCAM 4 decrease. Famers with higher trust on governments' warning system may don't consider themselves to pay attention to climate change information. They may increase the dependency on the warning system. However, from the interviews, it was found that this is not possible if farmers do not have any facility or resources to receive the early warnings of climate risks. Some farmers did not have any experience with such system but only have heard that such system did successfully work for others. Those farmers refused to evaluate the system as either good or bad. Since it is important to increase farmers' positive evaluation of early warning system to motivate farmers to take adaptation behavior, the governments' training programs including experiencing the early warning system should be considered as to promote adaptation behaviors.

- *Climate change information*

Farmers' evaluations on the effectiveness of climate change information provided by the government have the positively significant influence to CCAM1, CCAM 4, and CCAM 5. During the FGD and interviews, farmers indicated that the weather and climate information provided by governmental bodies are often inaccurate and sometimes they have experiences of undesirable conditions by following governments' inaccurate information regarding weather or climate change. Therefore, to promote farmers' climate change adaptation involving more physical (including monetary) and the personal connection should enhance their capacity to provide more accurate and realistic information regarding weather and climate change is necessary.

Chapter 7 Conclusions and Implications

This dissertation has contemplated to investigate and analyze the local knowledge on climate variability and change, assess the local perceptions with special emphasis to the climate risk and adaptation and examine the conditions that govern adaptive behavior at micro-level. In addition, as a starting point, it attentively reviewed the previous literature and unveiled the gaps that have become pivotal in the overall process of this dissertation. This final chapter concludes the thesis by summarizing the major findings and suggest on some implications based on the found results. Finally, with the findings, some implications are presented particularly for the local government officials and agricultural extension services, for enhancing their capacity to disseminate the adequate adaptation measures that would eventually increase farmer's resilience to climate change.

7.1 Summary of findings

Adaptation to climate change is an imperative concern in the agricultural sectors and rural economy. However, the understanding of farmers' adaptation is, limited in climate change discourses and particularly in the Korean context. This dissertation elucidates on private proactive adaptation with a focus on apple farmers in Cheongsong County, a major apple-producing region of Korea.

This dissertation investigated the perception and behavior of climate change adaptation of the apple farmers in Cheongsong. Also, this dissertation suggests policy implications support effective adaptation in local levels. The dissertation has pursued to attain its objective by employing mixed methods approach. The four main theses that have been analyzed in this dissertation are: 1) to explore the farmers' knowledge of climate variability and change by comparing and contrasting such subjective assessment to meteorological data collected; 2) to investigate the farmers' perception of climate risks and identify factors influencing those perceived risks; 3) to investigate farmers' assessment of private adaptive measures to climate change and identify factors affecting that perceived adaptation efficacy; 4) to identify factors affecting farmers' intention to adaptation behavior to response to climate variability and change.

To analyze issues, the conceptual framework developed in Chapter 4 captures the influences of objective and cognitive factors on the apple farmers' perceived risks and perceived adaptation measures. Moreover, farmers' intention to adaptation behaviors is analyzed through the cognitive variables, such as farmers' assessments of climate change risks, adaptation efficacy, maladaptation and trust of government.

Local awareness on climate variability and change

The outcome of the first objective, exploring the local farmers' perception on climate variability, provides a preliminary perceptive of how apple farmers in Cheongsong County perceive the reality of local climate change. As per the perception of farming households, increasing temperature has been increasing over time with changing trend of the corresponding precipitation and extreme events. Famers' awareness on each indicator of climate variability and change are compared and contrasted with meteorological data on annual mean temperature, annual mean precipitation rate and typhoon (heavy rain) occurrence in the study area. Such conformity of farmers' awareness both with meteorological data implies the close match of farmers' subjective assessment with that of the objective and scientific evidence on climate change.

The finding indicated that local farmers are certainly aware of climate change and the perception of climate variability and change are relatively consistent with meteorological data, objective assessment of climate variability and change. Those perceptions were found to be shaped by farmers' experiences with climate variability and change. Moreover, more recent experiences with increasing temperature and severe experiences of extreme events shaped farmers' awareness of climate variability. Interestingly, farmers supported their awareness claims through concrete instances. For instance, with regard to increased temperature, as compared to the past years, farmers witnessed an earlier period of apple flowering and pruning and overall longevity of the final products. This also shows that as scientists attempt to explain climate change through sea level rise and polar ice sheet melting, the farmers have their own ways of significant detection mechanisms.

With regarding the farmers' perception on the causes of climate variability and change, are identified as human cause and god's will. Only a few farmers and AGOs indicated the anthropogenic cause of local climate change. Some specific reasons behind the anthropogenic cause of climate variability were indicated by mentioning of the ruthless local economic development, greenhouse gas, and particular matters. On the other hand, the other cause of climate variability and change is identified as God's will that gods and ancestors are showing their disappointments and anger about this generations' activities. This shows that in scope, the causes of climate change are localized and blended with culture when it comes to farmers.

The impacts of climate variability and change in the dimensions of farmers' lives are identified. The impacts that farmers mostly identified to affect their lives are yields and quality of apple production; income; assets; physical health; natural resources; network; and mental health. It was found that the farmers' perception of probability and severity of each climate risk impacts are different. Impact on crop production is mostly perceived by farmers followed by health, network, and natural resources. This indicates that farmers indeed perceive the diverse impact of climate change and most of the knowledge is taken from personnel and neighbors' experience.

Local farmers' risk perception

Farmers' perceived risk of climate variability and change is one of the main elements that could explain farmers' intention of adaptation behaviors. However, there are limited studies examining perceived risk with regard to climate change. Particularly the factors influencing farmers' perceived risk of climate variability and change has been ignored in understanding farmers' adaptation behaviors. In this dissertation, the seven dimensions of climate change impacts are examined to identify factors influencing perceived risks. In this dissertation, some important factors influencing farmers' perceived risks of climate change include farmers' awareness on climate variability, climate risk experiences, fear of future climate risk, information and some demographic and socioeconomic elements are considered.

Farmers' with more share of their income from apple production, in other words, if the farmers are more likely to produce apple crop only, would have a higher perception of climate risk on their mental health. Interestingly, the number of years that the farmers are invested in buying crop insurance would have lower perceived risks on income.

Farmers' awareness of increased temperature would higher the farmers' perception of climate risk, particularly associated with climate risk on apple production, income, and overall risks. Moreover, awareness of changing trend and intensity of extreme events would have a positive and negative influence on farmers' perception of risks depending on dimensions of such risks is affecting. Farmers' awareness on changing the trend of extreme event, typhoon, would have a higher perception of climate risks on assets, network, and stress. Those farmers also could have higher overall risk perception while lower the perceived risk on apple production. This is because farmers' awareness of increased temperature is directly influenced by experiences in their farm while awareness of extreme events is developed from sources besides personal experience in this region, finding not much relation to their own apple production.

Farmers' risk experience on increased temperature, changed the trend of rain and extreme events could higher the risk perception associated with all of the dimensions with different level of significance. Thus, farmers' direct experiences with climate variability and change, have an important effect on farmers' perceived risks. Risk experience associated with increased temperature could higher the farmers' risk perception of apple production, stress and overall perceived risk with high significantly. Risk experience associated with the changing trend of precipitation would have higher farmers' physical health with the highest significance, and experience with extreme events would have higher perceived risk on assets physical health, natural resources, stress, and overall risks. In addition, farmers' fear of future climate change and its risk can play a significant role in farmers' risk perception related to apple production and income.

Information is found to be a vital factor to influence individuals' perception of risk in the previous literature. In this study, information is further segmented including climate change information and adaptation information from public media, neighbor farmers, village leaders, agricultural extension service centers and farmers' cooperatives are analyzed for factors influencing farmers' perceived risk on the seven dimensions. Interestingly, information on adaptation measures from neighbor farmers, village leaders, and farmers' cooperative would influence more than climate change information. Adaptation information from neighbor farmers and cooperative would lower the farmers' perception of risks with apple production and income, respectively.

Local farmers' perceived adaptation efficacy

How farmers perceived adaptation efficacy, evaluation of private adaptive measure, self-capacity to carry on the measures, and the costs associated with the measures contribute to the understanding of farmers' adaptation. In this dissertation, how the apple farmers assess and conduct adaptation measures with the factors influencing perceived adaptation measure efficacy, self-efficacy, and cost-efficacy are analyzed. The previous literature investigating in farmers' adaptive efficacy and influencing factors is limited in few studies.

Adaptation measures identified in this study are referred from the related literature, particularly from the most recent study on farmers' adaptation, and interviews with farmers, AGOs, and experts in Cheongsong County. It was found that the most commonly used measures regarding farming production were adjusting the use of pesticides and buying insurance. A high proportion of farmers also preferred paying more attention to climate change information and adjusting farming date as adaptation measures. However, not many farmers used switching to new crop and searching for a non-farming job as to response to climate change. Since apple production, unlike other crops, is specialized in Cheongsong County that most of the farmers are engaging in apple farming and apple produced in Cheongsong area are well-known for its higher quality and mostly preferred by domestic consumers. In addition, apple farming, because of it requires a longer period of time to have the first production, it is inflexible for farmers to move on to other crops. More importantly, apple farming in Cheongsong area is not only the income source for the farmers and the whole County but also it plays as an identity of farmers in the area.

With regard to the factors influencing the farmers' perceived adaptation efficacy (measure, self-capacity, and costs) are identified as demographic and socioeconomic variables and information. Particularly, farmers with larger apple farming area would have a higher overall perception on adaptation efficacy. Moreover, those farmers with larger farms would perceive the adaptation measures more effectively, but the adaptation measures as more expensive. Farmers' with higher overall income level perceive adaptation measures to be more costly. Moreover, farmers with successor have a higher perception on self-efficacy and overall perceived adaptive efficacy while farmers with smart-phone have lower overall perceived adaptation efficacy. It is important to note that farmers are investing in crop insurance influence farmers' perception on adaptation costs as more expensive and higher the overall perceived adaptation efficacy. On the other hands, the cumulative years of buying crop insurance would lower overall perceived adaptation efficacy. Particularly, longer year of buying crop insurance influences farmers' to perceive adaptation measure less effective and farmers themselves as less capable of doing adaptation measures.

Climate change information from public media could have a significant and positive influence on farmers' perception of measure effectiveness, self-capacity, and overall adaptation efficacy. Moreover, climate change information from the agricultural extension service center and farmers' cooperation positively and significantly influence perception on adaptation effectiveness and overall perception adaptation efficacy. However, climate change information from village leaders would have lower overall adaptation efficacy and influence farmers' to perceive adaptation costs as more expensive. While no significant influence was found for the adaptation information from public media, adaptation information from neighbor farmers, village leaders, and agricultural extension service centers show the positively significant influence on the perception of adaptation efficacy. Particularly, adaptation information from neighbors shows it significantly influences farmers' perception on self-efficacy and overall adaptation efficacy to be higher. Adaptation information from village leaders and agricultural extension service center would be higher farmers' assessment on adaptation measure as effective.

Local farmers' intention to adaptive behaviors

Notwithstanding the literature investigating the factors determining adaptive behaviors are increasing, studies on factors affecting farmers' intention to adaptive behaviors are limited. Moreover, studies on the factors identified as the major determinants of behaving in adaptation measures are associated with socioeconomic characteristics of farmers and resources; age, cultivation size, gender, and education levels, access to information, credit and government support. Cognitive factors have been inattentive to the literature except in some studies (Grothmann & Patt, 2005; Grothmman & Reusswig, 2006; Osberghaus, Finkel & Pohl, 2010; Dang, 2012; Dang 2014; Zheng & Dallimer, 2016). In this dissertation, a binary logistic regression was applied to investigate factors affecting farmers' intentions to adaptation to climate change based on the major factors in the Protect Motivation Theory and the Model of Private Proactive Adaptation to Climate Change (Grothmman & Patt, 2005). The main factors are risk perception (perceived risk probability and perceived severity), perceived adaptation efficacy (perceived adaptive measure efficacy, self-efficacy and adaptation costs), maladaptation (fatalism, denial, and wishful thinking) and trust of government (training program, early warning system, and information). The results show that the farmers' intention to the adaptive behaviors is found to have a varied relationship with risk perception and perceived adaptation efficacy. While higher perceived risk probability could have a higher probability of the farmers' intention to unfamiliar adaptive behaviors, higher risk severity can have the probability of higher intention of some commonly performed adaptive behaviors. The farmers' assessment of the measured efficacy and self-capacity is shown to have a positive relation to farmers' intention to adaptive behaviors. However, when farmers possess maladaptation, they are less likely to have the intention to adaptation behaviors. Farmers with the higher trust of governments' usefulness of training programs and information have a positive influence on farmers' intention to climate change adaptation while the evaluation of early warning programs could have a negative and positive influence on farmers' intention adaptive behaviors depending on the measures. Farmers are assessing the early-warning system as more useful; they are less likely to have the intent to adaptation. Moreover, the evaluation of information provided by government can increase the probability of the farmers' to enhance the adaptive behaviors such as gathering the climate change information and diversifying crop varieties.

Moreover, how much each of the cognitive variables influences farmers' intention to each of nine adaptation behaviors are analyzed by marginal probability effects. Perceived risk probability have a significant influence on farmers' intention to climate change adaption measure associated with adjusting the use of pesticides. Farmers with a higher perception of risk probability may have higher intention to search for non-farming jobs as a response to climate change. Higher perception of risk severity would have a significant influence on farmers' intention to climate change adaptation with regard to adjusting the use of pesticides to be higher while lower with the search for a non-farming job. Perceived adaptive measure efficacy is shown to have positively and significantly influence farmers' intention to adjust farming dates. In addition, one unit increase in fatalism shows to have negatively and significantly influence farmers' intention to gather information on climate change and buy crop insurance at similar levels. Further, a higher evaluation of the usefulness of climate change information provided government would rank higher the probability of farmers' intention on diversifying crop variety. In sum, PMT was demonstrated to be useful in understanding driving factors of the farmers' adaptation intention and clearly and significantly indicated that different cognitive process involved in different adaptation behaviors.

7.2 Policy implications

The knowledge of climate change and ensuring behavioral responses at the individual level are more of the results of the perceptual process. In fact, this is particularly accurate for farmers in rural areas where basic climate and adaptation information are limited and adaptive capacity is low. From this perspective, perceptual (cognitive) factors play a vital role in understanding the climate change adaptation behaviors of farmers. Thus, this dissertation attempts to investigate cognitive factors in a conceptual model that was built on protection motivation theory (PMT) and model of private proactive adaptation to climate change (MPPACC).

This study has some contributions to the frontiers of knowledge and policy. Theoretically, it fills the gap in the exploitation of local knowledge as an alternative to factor to understanding climate change at local levels with vivid examples and eventually integrate it with scientific inquiry. It also enlightens the influence of cognitive factors in influencing adaptation. This study argues that by considering such factors, local governments and agricultural extension services can better deliver the adequate adaptation measures that actually can improve farmers' adaptation capacity.

Integrating local knowledge in top-down climate change adaptation policy

Even though climate change discourse is depended on and confirmed by scientific conclusions (Cobb, 2011; Mekuriaw, 2013), it still fails to be successful because it is mired in controversy, skepticism, and inaction. Moreover, the international community and national-level communities are increasingly accepting the climate change discourses and starting to acknowledge the importance of adapting to climate change (IPCC, 2014a). However, it is apparent that political and economic interests embedded in the discourse are less likely to take local contexts into account (Choi & Yamaji, 2016; Cobb, 2011; Kim et al., 2015; Zheng et al., 2016). Integrating local knowledge into climate change policy can be a key to enhance understanding of climate change and supplement scientific knowledge to guide policies and decisions (Choi & Yamaji, 2016; Cobb, 2011, Deressa et al., 2009; Dang, 2014; IPCC, 2014; Kim, Jeong & Park, 2015). Indeed, local perception is vital in the development of effective policies and decisions at the local levels.

As presented in this dissertation, the local awareness, and perceptions, on climate change, climate risk and adaptation responses, play the main variable to understand local climate variability and change. Farmers' knowledge has offered an important observation from culture and actual and concrete experiences. Moreover, the farmers' knowledge of climate change through their own observation, culture, and experiences is also found as accurate with the scientific knowledge enhancing the credibility of the knowledge. Despite differences in the levels, local awareness and knowledge on climate change have identified, climate impact, and adaptive responses that international climate change science community endeavor to identify through various scientific methods, process and sophisticated technologies. While the findings of the international community can bring guidance to policy decisions at the global level, local knowledge can contribute to local, regional and national level policy decisions. Moreover, much of global and national level scientific knowledge on impacts and adaptation pay more attention to project climate change and its impact on projected or estimated data in the future. However, local knowledge is developed through real examples involved with social, economic, demographic, cultural conditions and vulnerabilities. Thus, local-level knowledge could enhance understanding and analyzing climate variability and climate with more realistic variables and to develop more appropriate policies to enhance local farmers' livelihoods. For instance, in the process of a vulnerability assessment (measuring and assessing potential impact and adaptive capacity), which is required to be conducted at the local levels in Korea, should include indicators assessing the subjective adaptive capacity of individual farmers along with objective (socioeconomic) adaptive capacity. As a resource affluent society, farmers' adaptation behaviors are more likely to be influenced by their perceptual process rather than resource scarcity. Neglecting the importance of measuring the subjective adaptive capacity could bring undesired adaptation in long-term.

In other words, taking farmers' perception and knowledge into local climate change adaptation, economic and other various policy decisions can amplify realization of top-down policies that is developed through scientific knowledge. Moreover, communicating with local perception and knowledge on the causes, impact, and responses can attribute to lessening the barriers to implementing top-down policies that are often to undermine local contexts and values and eventually able to remedy undesirable and unrealistic top-down policies to desirable and achievable policies that actually advance the well-being of local farmers.

Integrating local perception into climate change adaptation policy development

A micro-level aspect of adaptation behavior has been conceptualized to have two main cognitive processes: risk perception and perceived adaptation efficacy. Along with socioeconomic factors, cognitive factors are also found to be important in understanding individuals' adaptation motivation and behavior. In this study, some socioeconomic factors, awareness of climate change, fear, experience, and information play an important role in the process of farmers' intention to adaptation behavior.

Information was found to shape the farmers' perception of risk and adaptation assessment. More importantly, the contents of different mechanisms of accessing information can have an important role in shaping farmers' risk perception and adaptation assessment that would ultimately affect farmers' intention and action on adaptation behavior. Therefore, the quality and sources of information are important for local authorities in developing policies. It was found that some information related to climate variability and change from sources such as internet and television are disseminated with careful design to be realistic to local farmers. Since the quality of via internet and television may not be controlled easily, local sources such as neighbors, commune leader, agricultural extension services and farmers' cooperatives can play a vital role to disseminate more qualified, realistic (including examples of localized examples) and effective adaptation information to enhance farmers' adaptive capacity. For instance, the local government or the local agricultural extension centers can develop informative sessions for cultural representatives or elders on climate change. More specifically, education programs should be developed for those figures on the whole process of risk management from the cause of climate change, the risk associated with changing climate to the possible responses (adaptation and mitigation) with the real local examples. To enhance the understanding of the integrated process of climate change and climate risks to the cultural representative and elders may promote the process of disseminating the adaptation information to farmers more effectively. Accessing the information from those figures may lessen the farmers' belief on maladaptation.

Moreover, the enhancing of casual communication or meetings between farmers to share their experiences on climate risks and responses to climate risks led by farmers themselves might work as the amplifying promotion of adaptation policy at the local level. In addition, educating the successors of farmers on climate change and adaptation through learning from advanced regions and countries at school can assist to increase the adaptive capacity of local farmers in the future. For instances, visiting farms in the region with climate condition which is similar to the projected climate and sharing knowledge on the experiences and barriers in farming can increase the adaptive capacity of local people and give proper information on future climate change and risk associated with such change. This can be applied to other regions or countries, although the sources of such information may differently apply to countries' circumstances.

To disseminating accurate and effective information to farmers in the local context, the elders and cultural representative figures in a local setting can have a significant role. Famers believe in a stronger connection to fatalism and denials are more likely to have less intention to most of the adaptive measures. Thus, informing the representative figures of local culture with accurate climate change and risks and effective responses need to be considered in disseminating the information to promote adaptation strategies in local context.

Crop insurance is found to be an imperative factor for farmers' perception on climate risk perception and perceived adaptation efficacy. Crop insurance is one of the climate-inclusive policies that are to lessen the serious damage of climate change-related consequences to farmers in Korea. Moreover, the recent studies (Kim, Jeong & Park, 2015) show that crop insurance can significantly have an economic benefit to farmers in Korea. However, ten years of implementation, crop insurance has been discouraging farmers to adapt to climate change and to become more likely to condemn in adaptive capacity. More specifically, without judicious and circumspect re-designing of crop insurance system, the climate risk preventive policy for farmers can, in fact, increase the vulnerability to climate change. Crop insurance should be designed to incorporate weather index-base system (Kim, Jeong & Park, 2015). This weather index-based system is a recently introduce a mechanism to lessen and share a farmers' losses from climate change and natural disasters in Korea although, this mechanism has been implemented by India, the United States, Canada, and China. According to Kim, Jeong & Park (2015) to lessen the several problems (moral hazard and adverse selection) associated with the current insurance system, it is necessary to implement 'weather index-based insurance' in Korea. Moreover, the study indicated that Korea has its adequate for such insurance system because the country has substantial ability regarding weather information system, which is a basic required for weather index-based insurance. In addition to improving the insurance system, with the newly introduced system, it is important for the insurance companies to improve its role and capacity to the development and implement crop insurance that would effectively perform its objective. The most of the insurance institutions focus on the importance of increasing the rate of total insurance rather than increasing quality of insurance which should meet the original objective of the insurance as adaptation measures to climate change for vulnerable farmers.

Further, the role of local governments and extension services to disseminate accurate and understandable information to local farmers is important in enhancing farmers' credibility on crop insurance which would eventually increase farmers' adaptive capacity. Moreover, to providing information and actual understanding of insurance, the insurance information programs provided by AGOs and extension services should help farmers not just to rely solely on crop insurance as an adaptation to climate change.

Balancing adaptation and mitigation in local context in local policy development

In conjunction to promote adapting to presented climate variability and change, mitigation and the causes of environmental degradation should be disseminated by local policy of adaptation to climate change to enable the local policy as to be the effective and sustainable solution for climate change vulnerability. It is plausible to indicate that adaptation enables farmers to adjust to the changes in the local and global climate. However, overwhelmed focus on adaptation can undermine mitigation actions which can exacerbate environmental degradation and increase greenhouse gas emissions. Therefore the local policy should undertake not only the measures to promote adaptive capacity but also to increase mitigation capacity of local farmers. Adaptation measures using newer techniques and facilities that do not consider the root cause of climate change risk, environmental degradation, and greenhouse gas emission, not only could heighten unsuccessful adaptation to climate risks but also aggravate vulnerability to climate change and even reckon newer climate risks to local farmers. Moreover, this balanced adaptation and mitigation should be developed including other root causes of vulnerability to climate change. More specifically, rural communities are more vulnerable to climate change by various factors depend on each community; however, most of the rural communities in Korea are associated with the aging society. Thus, it is more than important to consider such circumstances into account when local governments develop climate-related policy.

International network on climate adaptation

As indicated earlier, local economy and policies heavily specialize one crop productions can aggravate farmers' vulnerability to climate change. Many studies found that switching to new crop that is more resilient to climate change and adequate for changed future climate can be economically effective adaptation measure. However, local economy that heavily depends on a specialized crop might not be able to implement such successful adaptation effectively and timely adequately. Therefore, not only the careful planning of local crop production outline is required, but careful design of dissemination of such plan should consider including diversification of crops that are adequate in growing in the region in long-term.

In the present, the Korean government and research institutions have put great effort into projecting future climate and developing new crop variety that is adequate for such climate. A great success has been made with regard to projecting climate in Korea. However, development and implication of introducing new crop variety should require more time for attentive research and pilot cases to produce more effective results. Therefore, to diversify crop profile in local crop production, in shorter term for enhancing the longer resilience of climate change, learning from other countries with a climate similar to projected future climate would have an effective and in time solution to develop local policy. Not only learning from developing country on technologies or techniques, but the farmers or local governments can also develop a network and exchange each other's' knowledge through exchanging programs. More specifically, apple farmers in Cheongsong with increasing temperature can learn from Thai farmers, who grow tropical fruits, where have experiences on crop production which are more resilient to hotter temperature while the Thai farmers can learn agricultural techniques and technology from Korean farmers who have more experience with such capacity.

7.3 Research limitation and future research outlook

While many attempts were put into this dissertation, some limitation was acknowledged in this section. In farmers' livelihood, there are multiple causes of changes for enabling better lives and increase resilience to various causes. In other words, farmers are not only exposed to changing climate but also to global and domestic economic and social trends. This study did not explore directly how important climate change is in relation to the significant drivers of change to which farmers are exposed and how individual farmers responds to these drivers. Rather, this study focuses on the socioeconomic and cognitive condition of local farmers. This certainly induces the future research considering other drivers of changes.

Even with carefully and attentively developed multi-staged sampling method to enable the adequate represent sample farmers, a limited sample size has been employed in this research. This limitation was due to financial and time constraints. Future research should endeavor to include broader survey sample to amplify the findings of the study. Moreover, including survey farmers who in different environmental settings (different vulnerability levels and/or growing different crops) should generate further insights for policy development.

Although farmers' risk and adaptation perceptions are the vital and useful factors in understanding individual farmers' adaptive motivation, the nature of difficulty in measuring and interpreting one's perception as real thinking or real understanding of perceived risks might be the limitation of this study. Future research should investigate and develop an improved measurement of perceived risks and adaptation to climate change. Accomplishing in such measurement should enhance understanding of farmers' adaptive motivation and behavior to climate change.

Further, the concept, amplified from PMT and MPPACC, and analyzing method, a binary logistic regression, used in this dissertation should be applied to broader setting, such other regions and countries to analyze farmers' intention to adaptive behavior should be conducted to improve the construct validity, the measurement of conceptual framework, and method application in climate change adaptation studies.

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APPENDIX

APPENDIX I: Studies on the vulnerability analysis using index

The following below show the results of climate change vulnerability assessments discussed in Section 3. The study is introduced to discuss previous studies on the climate change adaptation in Korea and the factors affecting regional climate change vulnerabilities.

(1) Choi, S.Y. & Yamaji, E.J. (2015). Local level climate change vulnerability assessment using three indices: A case of four municipals of Gyeonggi Province in Korea. *Journal of Rural Planning Association* Vol. 34. Special Issue: 261-266

This study provides an initial understanding of climate change vulnerability among different areas in Korea. The main finding of the study is that the levels of climate change vulnerability are different among the regions depends on the degrees of climate exposure, sensitivity, and adaptive capacity. Moreover, this study found that rural communities where agriculture is the major industry are found to be more vulnerable to climate change by higher sensitivity and lower adaptive capacity.

Definition of vulnerability used in the study:

Vulnerability = Potential Impacts (Exposure + Sensitivity) – Adaptation

< Climate Exposure, Sensitivity and Adaptive Capacity Indexes (Z-Score)>

Theme	Sub-theme	Proxy variables	z-scores			
			Suwon	Seongnam	Yeoncheon	Gapyeong
Climate Exposure	Heatwaves (temperature)	# of days with lowest temperature over 25℃	1.40	-1.30	0.36	-0.47
		# of days with the highest temperature over 33℃	0.34	0.57	0.80	-1.71
	Precipitation	# of days of precipitation over 80mm	-1.34	0.45	-0.45	1.34
		Maximum rate of precipitation per day (mm)	-1.14	1.58	-0.45	0.01
		Average # of days with non-precipitation	-0.76	1.68	-0.76	-0.15
Sensitivity	Land use	Damages from storms and floods per capita (won)	-1.00	-1.00	0.96	1.04
		Agricultural land per total land (%)	-0.74	-0.93	1.61	0.07
	Population	Population density (person/km^2)	1.29	0.66	-0.97	-0.97
		Rate of single elderly (+65) households (%)	-1.11	-0.86	0.78	1.19
		Beneficiaries of national basic livelihood (%)	-1.03	-0.89	0.58	1.34
	Infrastructure	# of houses built before 1970s (%)	1.71	-0.31	-0.76	-0.64
Adaptive Capacity	Economic Capacity	GRDP per capita (won)	0.47	0.75	0.50	-1.72
		Government budget per capita (won)	0.87	1.12	-0.96	-1.03
		Rate of fiscal independence (%)	0.96	1.04	-0.89	-1.10
		Forest area per total area (%)	-0.99	-0.82	0.30	1.51
	Physical Infrastructure	# of hospitals per capita (%)	1.36	0.54	-1.11	-0.78
		Population with water supply (%)	0.78	0.77	0.13	-1.67
		Population with sewerage treatment (%)	0.92	1.01	-0.60	-1.33
	Administrative Preparedness	Government official per capita (%)	-0.99	-0.97	0.72	1.25
		Fire-fighting officials per capita (%)	1.71	-0.29	-0.71	-0.71

Source: Calculated with data from National Climate Data Service System. http://sts.kma.go.kr/jsp/home/contents/main/main.do (accessed 1 May 2015) and Annual Statistic Report of Gyeonggi Province (2014)

< Vulnerability Assessment on 4 Municipal Regions>

Theme	Suwon	Seongnam	Yeoncheon	Gapyeong
Climate Exposure	-1.50	2.98	-0.50	-0.98
Sensitivity	-0.88	-3.33	2.20	2.03
Adaptive Capacity	5.09	3.15	-2.62	-5.58
Total Vulnerability	-7.47	-3.50	4.32	6.63

(2) Choi, S.Y. & Yamaji, E.J. (2016). Assessing climate change vulnerability in rural areas: cases of apple farming in 4 different municipals in Gyeonggi Province, Korea. *International Journal of Environment and Rural Development.* In process.

The following tables are the results of the study on the assessment of climate change vulnerability of apple farming regions in Korea. Proxy variables are selected as a function of exposure, sensitivity, and adaptive capacity, as framed by IPCC and in scrutiny based on the intensive review of previous studies. Unlike previous macro-level studies, this study assesses local level communities that limit authors to select the variables based on the availability of the data. Selected proxy variables are analyzed by calculation of the z-score normalization of data. The z-score method is done by subtracting the mean from the observed value and dividing by the standard deviation for each indicator. This ensures that each of the rescaled variables has a mean of zero and a standard deviation of 1, allowing them to be combined directly. The results of z-score normalization are able to determine positive and negative relations between components. The main finding of the study is that when developing and implementing the adaptation measure, micro-leveled measurement of climate change vulnerabilities, exposure, sensitivity, and adaptation capacity should be carefully considered to enhance the effectiveness of climate change adaptation and to improve resilience to climate change.

< Result of Z-scores on climate exposure index of 4 apple farming municipals >

Proxy Variables	Icheon	Gapyeong	Paju	Yeoncheon
Number of yrs. w/ ann. avg. temperature, ＜8℃ or ＞11℃*	0.79	1.14	-1.31	-0.61
Number of days with maximum temperature over 26℃**	0.00	0.97	-1.62	0.65
Maximum rate of precipitation per day***	1.36	0.35	-1.40	-0.30
Number of days with max. wind speed over 3m/s***	-0.51	-1.18	1.52	0.72
Total vulnerability in climate exposure	**1.64**	**1.28**	**-2.81**	**-0.09**

Source: National Climate Data System (http://sts.kma.go.kr/, accessed October 28, 2015)
*data for 2004-2014, ** data for April to August of 2014, ***data for April to October of 2014

< Result of Z-scores on sensitivity index of 4 apple farming municipals>

Proxy Variables	Icheon	Gapyeong	Paju	Yeoncheon
Damages from storm and flood per capita (KRW)	1.61	-0.10	-1.11	-0.39
Area of apple cultivation per total area (%)	1.53	0.16	-0.52	-1.17
Rate of elderly (+80) agricultural households (%)	-1.00	1.66	-0.45	-0.21
Beneficiaries of national basic livelihood (%)	-0.94	1.33	-0.99	0.60
Total vulnerability in sensitivity	**0.75**	**3.05**	**-3.07**	**-1.17**

Source: Annual Statistics Report of Gyeonggi Province (2014) and statistical year book of each province

< Result of Z-scores on adaptive capacity index of 4 apple farming municipals>

Proxy Variables	Icheon	Gapyeong	Paju	Yeoncheon
Gross Regional Domestic Production per capita (won)	1.37	-0.79	0.53	-1.11
Productivity rate of apple per area (kg/10a)	0.42	1.44	-0.79	-1.06
Rate of household with Speed Spray holder (%)	0.57	-0.16	-1.54	1.13
Rate of cooperative membership (%)	0.34	0.71	0.66	-1.71
Total vulnerability in adaptive capacity	**2.71**	**1.20**	**-1.14**	**-2.75**

Source: Annual Statistics Report of Gyeonggi Province (2014) and statistical year book of each province

APPENDIX II: Logistic regression results on farm households characteristics

The following tables are a part of the results from the binary logistic regression analysis done in Chapter 5. In the chapter, the farmers' intention to 9 adaptation measures and intention to the overall private adaptation measures were analyzed with socio-cognitive factors. The main aim of this study is to analyze how the socio-cognitive factors such as risk and adaptation perception, maladaptation, and trust of government influence individual farmers' intention to adaptation. However, it is important to consider the main socioeconomic factors in the regression analysis since different socioeconomic background may influence individual farmers' intention to adaptation. Although the previous studies (Grothmann & Patt, 2005) found that in analyzing motivation or intention to climate change adaptation of individuals can be better explained by socio-cognitive factors than socio-economic factors, the influence that some farm household characteristics may play in the farmers' intention to adaptation behaviors. Therefore, the farm household characteristics are controlled in the regression for such reason, and the results of the influence of farmers' characteristics are analyzed in this part of the study.

As shown in the table, some farm household characteristics such as age, gender, education level, share of apple in the income portfolio, having successor, apple selling mechanism, number of networks joined and the number of years buying crop insurance do show different relationship regarding the probability of the farmers' intention to perform on different adaptation behaviors and overall adaptation behavior. More specifically, younger farmers are more likely to have the intention of performing the adaptation measures. Farmers in this study are specialized in apple cultivation, and not only the farmers but the county's economy have been depending heavily on apple production. Adjusting the apple farming practices such as changing dates and use of pesticides may not be too new to the farmers. However, changing the variety or switching to new crop rather than apple can be avoided by the farmers in this area. The regression results show that younger farmers are more likely to have the intention to take the challenge cultivating the new apple variety or different crop. Education level is found to influence farmers' intention to exiting farming activities and search for non-farming jobs. Having more education and information may influence farmers to acknowledge other possible activities that the farmers may participate or influence them to be more innovative in managing their income profile.

Farmers with a higher share of income from apple cultivation have a higher probability of having the intention to adaptation measure particularly associated with adjusting the farming practices. Since those farmers' livelihood are more depended on the apple cultivation, it is less likely to have the intention to switch their lifestyle by changing or diversifying crop variety or searching for non-farming jobs. Moreover, farmers with successor are found to be less likely to have adaptation intention. It may imply that the farmers would pass on their family business, apple farming, to their success and adaptation behaviors associated with changing crop variety or searching for non-farming jobs can alter the core value of their lifestyle or the family business.

Farmers with more of network joined received more information on adaptation and learned on the management by exchanging experiences with other members may have a higher probability of having the intention to behave in adaptation. The numbers of year that farmers are buying crop insurance can positively influence farmers' intention to adaptation. Since farmers buying crop insurance are those who are continuously interested in the different damage preventive measures and have more information regarding the damage. In sum, this study found that cognitive factors do influence farmers' intention to adaptation behaviors, and those cognitive factors are influenced by different farm household characteristics. However, it is also found that, although limited, the farm household characteristics may play some important roles in the farmers' motivation to adaptation and it is necessary to consider both socio-cognitive and socioeconomic factors in promoting farmers intention to adaptive behaviors.

Table: Results of the binary logistic regression models (Variables on farmer characteristics only)

Explanatory Variables	Dependent Variables: Intention for adaptation behaviors									
	CCAM1: Adjustment of farming dates	**CCAM2: Adjustment of using pesticides**	**CCAM3: Switching to new crop**	**CCAM4: Gathering information on CC**	**CCAM5: Diversifying crop varieties**	**CCAM6: Buying crop insurance**	**CCAM7: Improving soil condition**	**CCAM8: Changing to diff. variety**	**CCAM9: Searching for non-farming job**	**Overall intention to adaptive behaviors**
Age	0.0089	-0.0087	-0.0140***	-0.0291	-0.1291	0.0304	-0.0584	-0.0724***	-0.0382	-1.1178*
Gender	-0.7759	0.0552	0.0199	0.3625	0.1255	0.8930***	0.0489	-0.0162	0.1165	0.1170
Education level	0.0672	0.0056	0.0100	0.1103	-0.0422	0.1266	-0.0126	0.0213	0.1822**	-0.0240
Farming Experience	-0.0156	0.0029	0.0009	0.0004	0.0049	-0.0268	-0.0026	-0.0023	-0.0198	0.0060
Income level	0.2627	0.0131	-0.0158	-0.0576	0.0374	-0.1030	0.0353	0.0992	-0.0573	0.0127
% of income from apple cultivation	0.0509***	0.0032***	0.0000	0.0063	0.0164	0.0208	-0.0047	0.0047	-0.0089	0.0101
Successor	-0.0887	-0.0138	-0.0009	-1.1188*	-0.3810	0.9025	0.6311	-1.2858**	-1.3698 **	-0.5777
Sales channels	-0.0545	-0.0128	0.0846*	0.3227	0.2802	0.0906	0.1772	0.3089	-0.0280	0.2799
Network	-0.1716*	0.0061	-0.0168	1.4881	0.4597*	1.7917***	0.9306	-0.5611	-0.1965	0.6107
Cumulative years of CI	-0.0221	-0.0016	-0.0111	-0.0318	-0.0145	0.0303	0.0663	0.2183	0.0037	0.0321*

*Significant at 10% level (p<0.1), ** Significant at 5% level (p<0.05), *** Significant at 1% level (p<0.01)

APPENDIX III: Binary logistic regressions on the factors influencing farmers' adaptation to climate change

The main objective of this thesis is to analyze farmers' perception of climate risk and adaptation and to investigate the socio-cognitive factors and its influence on farmers' intention to adaptive behaviors. It is understood that climate change vulnerability is defined as the results of potential impact (climate exposure and sensitivity to climate change) and adaptive capacity (IPCC, 2007). Generally, it is difficult for individual farmers to control components in potential impact to lessen the climate vulnerability (Choi & Yamaji, 2015). Rather, the individuals can enhance their adaptive capacity (subjective and objective) to lessen the climate-related vulnerability. This thesis aims to understand how individual farmer perceives climate change and to understand particularly on the roles of some main cognitive factors play in farmers' subjective adaptive capacity. It is understood that such subjective capacity, intention to adaptation to climate change, can lead to adequate adaptation behaviors (Grothmann & Patt, 2005). Since this thesis' main focus was to analyze subjective adaptive capacity, the main parts of the thesis only focus on cognitive factors and intention to adaptation behaviors. However, if further analysis on the relationship between cognitive factors and actual performance on adaptive behaviors may enhance the understanding of the role that cognitive factors play in individuals adaptation behaviors. This part of the thesis is to have a brief review of the analysis.

The following table shows the binary regression analyzing both cognitive and objective factors influencing farmers' actual adaptation behaviors. Binary logit regression assumes that farmers are actually performing on the adaptation behaviors as Yi=1, otherwise Yi=0. The same methodology discussed in Chapter 4 on binary logit regression analyzing farmers' intention to adaptation behaviors is applied. As a result, except for CCAM3: switching to new crop, the odds of farmers' actual adaptation behaviors are found to have the statistically significant relation with cognitive factors. Perceived risk severity is found to have a positive relation to the probability of performing on the various adaptation measures. As regard to perceived adaptation efficacy, farmers' assessment of the effectiveness of adaptation measure and evaluation of adaptation cost are found to be a significant factor. Farmers who perceive adaptation measure as effective are likely to adapt. Similarly, those farmers who are confident of their resource base are likely to adapt than those who feel unconfident of their resource. Maladaptation, particularly with fatalism and wishful-thinking are found to be a significant factor for the adaptation behaviors. It is important to note that those farmers less likely to perceive climate change as controlled only by supernatural power are more likely to actually perform adaptation. Lastly, how farmers evaluate the effectiveness of government also have an influence on the adaptation behaviors.

Some socioeconomic factors are also found to influence the probability that the farmers perform on adaptation. All of the factors are found to be significant predictors of different adaptation behaviors except for searching for non-farming jobs. Objective factors may play an important role in implementing adaptation and as shown in the regression results, the factors can either positively and negatively related to farmers' adaptation behaviors. Farmers' income level and a number of networks that they joined seem to be the significant predictors for the various adaptive behaviors. It is not surprising that those farmers who have higher income level and access to more information through the network may have better access to various adaptation and capacity to implement adaptation.

In this appendix, going beyond the main objective of this thesis of analyzing farmers' intention of adaptation from cognitive perspectives, farmers' actual adaptation performance is also analyzed. In addition to the main parts of the thesis, this part of the study also demonstrated the explanatory power of the cognitive factors in individual farmers' adaptive behaviors. In doing so, the role of socioeconomic factors never been neglected. As a result, although socioeconomic factors still emerge to be crucial for adaptation, cognitive factors such as perceived risk severity, perceived measure efficacy, and fatalism are also found to be significant predictors for performing the adaptation. Therefore, to promote adaptive behaviors of farmers, it is recommended not to neglect cognitive aspects in assessing adaptive capacity.

Table: Results of the binary logistic regressions on the factors influencing farmers' adaptation performance

Explanatory Variables	Dependent Variables: Intention for adaptation behaviors									
	CCAM1: Adjustment of farming dates	**CCAM2: Adjustment of using pesticides**	**CCAM3: Switching to new crop**	**CCAM4: Gathering information on CC**	**CCAM5: Diversifying crop varieties**	**CCAM6: Buying crop insurance**	**CCAM7: Improving soil condition**	**CCAM8: Changing to diff. variety**	**CCAM9: Searching for non-farming job**	**Overall**
Socio-cognitive factors										
Perceived Risk Probability	-0.5806	0.0019	0.0283	-0.9220	0.9582	-0.1189	-0.8316	-0.9539	0.1547	0.3737
Perceived Risk Severity	1.3766*	1.1884*	-0.0176	1.2511**	-0.9184	0.6693	-0.5614	3.1278**	-1.8082	2.0250*
Perceived Measure Efficacy	1.4102***	0.6511*	-0.0201	0.7687**	3.6637*	0.8055*	0.5571	1.8086*	-0.3196	1.8365*
Perceived Self-Efficacy	1.1120***	-0.3665	0.0074	-0.0084	-2.0463	0.1412	-0.3477	-0.5390	1.1101	0.9253
Perceived Adaptation Cost	-0.1021	-0.1943	-0.0107	0.3989	-0.3268	0.4087	-0.4511	1.1765	1.6700*	0.7836*
Maladaptation (Fatalism)	-0.1710	-0.2895*	-0.0097	-0.2291	-1.4341*	-0.3702**	-0.5127*	-0.5610	-0.5772	-0.0162*
Maladaptation (Denial)	0.2836	-0.2362	-0.0187	-0.1730	1.5538	0.2968	-0.1184	0.0405	0.3247	-0.7846
Maladaptation (Wish.-thin.)	-0.3732*	-0.0490	0.0019	0.3753*	0.7417	-0.0337	-0.4387	0.2548	-0.6413	0.4474
Trust of Gov't (Program)	0.6201**	-0.0559	0.0147	-0.1950	0.3805	-0.6971***	0.3283	0.6527	0.3393	-0.0463
Trust of Gov't (Warn. sys.)	0.4520	0.5964*	0.0218	-0.2293	-1.5766	0.6994*	0.0271	0.0621	-0.2688	1.4243
Trust of Gov't (Information)	-1.2022	-0.5589*	0.0006	0.2321	0.9949	0.0597	-0.3215	0.6351	0.2094	0.4465
Farm household characteristics										
Age	0.0103	-0.0156	-0.0007	-0.0282	-0.2477*	0.0328	0.0640*	-0.0021	0.0413	-0.0671
Gender	0.1692	0.0933	0.0096	0.5834	4.9464	1.1910**	-1.3927	2.9716	1.1612	0.3815
Education level	-0.0683	-0.0914	0.0056	-0.0145	0.9882*	0.1853**	-0.2626**	-0.1235	-0.0149	-0.2702
Farming Experience	-0.0149	0.0065	0.0039***	-0.0077	0.1481	-0.0055	-0.0308	0.0561	-0.0049	-0.0547
Income level	0.2284*	0.0745	-0.0116	-0.0627	-1.1697*	0.3214**	0.4892*	-0.1768	0.1811	0.0629
% of income from apple cultivation	0.0175	-0.0006	-0.0002	-0.0112	-0.0440	0.0033	-0.0047	0.0208	-0.0206	-0.0518*
Successor	0.6360	-0.1090	-0.0376	-0.6321	-0.0115	0.3086	2.3669***	-1.9228*	-0.0460	0.0282
Sales channels	-0.2681	-0.2047	-0.0255*	-0.2655	0.9017	0.1358	-0.1053	-0.0418	-0.0883	-0.7490
Network	0.2392**	0.2390*	0.0120	0.0588	1.1397**	0.4745 ***	0.3405*	-0.2331	0.2126	0.4159
Cumulative years of CI	0.0855	0.0322	-0.0082**	0.1201**	-0.2611	0.1135*	-0.0641	0.2555 *	-0.1581	0.1980*

*Significant at 10% level ($p<0.1$), ** Significant at 5% level ($p<0.05$), *** Significant at 1% level ($p<0.01$)

APPENDIX IV: Data summary

Variable	Obs	Mean	Std. Dev.	Min	Max
Demographic and Socioeconomic variables					
Age	170	54.60	12.28	24	80
Gender	170	0.25	0.44	0	1
Education level	170	12.14	3.37	0	18
Farming Area	170	1.52	0.94	0.1	5.9
Farming Experience	168	16.13	10.94	3	60
Income	170	4.59	1.68	1	6
% of income from apple cultivation	170	89.94	17.11	50	100
Moving Experience	168	0.18	0.39	0	1
Successor	170	0.24	0.43	0	1
Agriculture Education	170	0.25	0.43	0	1
Smart-phone	170	5.69	5.15	0	20
Market Access (Sales channel)	170	0.86	0.40	0	3
Land Ownership	170	0.51	0.50	0	1
Network	170	2.66	1.92	0	10
Buying Crop Insurance (CI)	170	0.92	0.28	0	1
Number of year buying CI	170	0.66	0.47	0	1
Cultivation of other crops	170	4.23	4.33	0	11
Awareness					
Increased Temperature	170	2.84	0.91	1	4
Changed Precipitation	170	2.39	0.92	1	4
Changed Extreme events	170	2.12	0.99	1	4
Risk Experience					
Risk Experience_ Temperature	170	1.95	0.86	1	4
Risk Experience_ Precipitation	170	1.81	0.81	1	4
Risk Experience_ Extreme events	170	2.00	0.92	1	4
Fear					
Fear on future climate risks	170	2.60	0.85	1	4
Perceived Risk Probability					
Perceived probability_ Production	170	2.95	0.76	1	4
Perceived probability_ Income	170	2.85	0.72	1	4
Perceived probability_ Assets	170	2.58	0.78	1	4
Perceived probability_ Physical Health	170	2.45	0.84	1	4
Perceived probability_ Natural resource	170	2.46	0.82	1	4
Perceived probability_ Network	170	2.19	0.90	1	4
Perceived probability_ Stress	170	2.56	0.90	1	4
Perceived Risk Severity					
Perceived severity_ Production	170	2.95	0.78	1	4
Perceived severity_ Income	170	2.85	0.76	1	4
Perceived severity_ Assets	170	2.59	0.78	1	4
Perceived severity_ Physical health	170	2.41	0.87	1	4
Perceived severity_ Natural resource	170	2.42	0.84	1	4
Perceived severity_ Network	170	2.15	0.90	1	4
Perceived severity_ Stress	170	2.49	0.96	1	4
Perceived Adaptive Measure Efficacy					
Perceived measure efficacy_ Dates	170	2.48	0.81	1	4
Perceived measure efficacy_ Pesticides	170	2.74	0.76	1	4
Perceived measure efficacy_ New crop	170	2.19	0.94	1	4
Perceived measure efficacy_ Information	170	2.59	0.91	1	4
Perceived measure efficacy_ Diversifying crops	170	2.10	0.92	1	4
Perceived measure efficacy_ Insurance	170	2.71	0.98	1	4
Perceived measure efficacy_ Soil	170	2.21	0.96	1	4

Perceived measure efficacy_ Variety	169	2.04	0.93	1	4
Perceived measure efficacy_ Non-farm	170	1.96	0.99	1	4
Perceived Self-Efficacy					
Perceived self-efficacy_ Dates	170	2.35	0.76	1	4
Perceived self-efficacy_ Pesticides	170	2.50	0.77	1	4
Perceived self-efficacy_ New crop	170	2.07	0.89	1	4
Perceived self-efficacy_ Information	170	2.47	0.90	1	4
Perceived self-efficacy_ Diversifying crops	170	2.08	0.92	1	4
Perceived self-efficacy_ Insurance	170	2.58	0.93	1	4
Perceived self-efficacy_ Soil	170	2.09	0.87	1	4
Perceived self-efficacy_ Variety	170	2.04	0.87	1	4
Perceived self-efficacy_ Non-farm	170	.93	0.90	1	4
Perceived Adaptation Costs					
Perceived costs_ Dates	170	2.52	0.85	1	4
Perceived costs_ Pesticides	170	2.35	0.81	1	4
Perceived costs_ New crop	170	2.46	0.97	1	4
Perceived costs_ Information	170	2.52	0.91	1	4
Perceived costs_ Diversifying crops	170	2.51	1.00	1	4
Perceived costs_ Insurance	170	2.05	0.91	1	4
Perceived costs_ Soil	170	2.40	1.01	1	4
Perceived costs_ Variety	170	2.43	1.03	1	4
Perceived costs_ Non-farm	170	2.47	1.08	1	4
Information					
Climate change information_ Public Media	170	3.19	0.82	1	4
Climate change information_ Neighbor farmers	170	2.28	0.86	1	4
Climate change information_ Leader	170	1.53	0.82	1	4
Climate change information_ Agr. Extension Center	170	2.24	0.85	1	4
Climate change information_ Farmer cooperative (NH)	170	2.00	0.92	1	4
Adaptation information _ Public Media	170	3.04	0.88	1	4
Adaptation information _ Neighbor farmers	170	2.12	0.84	1	4
Adaptation information _ Leader	170	1.59	0.85	1	4
Adaptation information_ Agr. Extension Center	170	2.18	0.91	1	4
Adaptation information_ Farmer cooperative (NH)	170	1.99	0.94	1	4
Maladaptation					
Maladaptation (1) _ Fatalism	170	2.76	1.19	1	4
Maladaptation (2) _ Denial	170	2.02	1.00	1	4
Maladaptation(3) _ Wishful thinking	170	2.02	1.11	1	4
Trust of Government					
Trust of Government (1) _ Programs	170	2.14	0.94	1	4
Trust of Government (2) _ Warning	170	2.19	0.90	1	4
Trust of Government (3) _ Information	170	2.51	0.99	1	4
Intention to adaptation behavior					
CCAM1: Adjusting farming dates	170	0.82	0.38	0	1
CCAM2: Adjusting use of pesticides/fertilizer	170	0.94	0.25	0	1
CCAM3: Switching to climate resistant crops	170	0.42	0.49	0	1
CCAM4: Colleting weather/climate information	170	0.84	0.37	0	1
CCAM5: Diversification in crop varieties	170	0.35	0.48	0	1
CCAM6: Buying crop disaster insurance	170	0.75	0.44	0	1
CCAM7: Improving soil conditions	170	0.46	0.50	0	1
CCAM8: Changing apple variety	170	0.55	0.50	0	1
CCAM9: Searching for non-farm activities	170	0.41	0.49	0	1

APPENDIX V: Farm household survey questionnaires

(1) English version

Survey Questionnaires

(English Version)

Hello, this questionnaire is designed to understand the determinants of farmers' responses to climate change in Korea. Your participation is completely voluntary and highly appreciated. The result of the questionnaires will be included in my research and will be presented in my Ph.D. dissertation, seminar presentation, reports, conferences and journal articles. I will assure that the information that was provided in this questionnaire is used only for research purposes. Your personal information and identities are confidentially kept and not linked to your responses. Thank you very much for your participation. For the further inquiries Researcher: 000 Email: 000@000 Cell-Phone: 000-0000-0000
Respondent's address: Date of Response: Year Month Day

No	Questionnaires	Answer			
1	**Age**	Years old			
2	**Gender**	Male		Female	
3	**Education level**				
4	**Total cultivation area**	(Pyeong or ha)			
5	**Experience in agriculture**	Years			
6	**Income from last year**	① Less than $,5000		② $5,000~$9,999	
		③$10,000 ~$19,999		④ $20 000~$29,999	
		⑤$30,000 ~$39,999		⑥More than $40,000	
7	**% of income from agriculture**	%			
8	**Off farm job (please specify)**				
9	**Moving experience**	Yes		No	
10	**Existence of Successor (or farm land)**	Yes		No	
11	**Number of attendance of technical education (offered by agricultural extension services)**				
12	**Smartphone use**	Yes		No	
13	**Sales channel**	Direct	Mass Market	Co-op	Farmers' market
14	**Owning of farming land**	Yes		No	
15	**Number of cooperation joined (please indicate name of the cooperation)**				
16	**Purchase of Crop insurance (Please indicate purchase year)**	Yes (year:)		No	
17	**Please indicate years of buying insurance**	**Since**		**For how long?**	

Please indicate your opinion on the happening of climate change. Please choose 1 (No) to 4 (very much) in the below to best describe your opinion. Please circle only one.

No.	Statements	No	Some-what	Yes	Very much
18	Increased average temperature (last 20 -30years)	1	2	3	4
19	Changed pattern and rate of rain (last 20-30 years)	1	2	3	4
20	Changed frequency and severity of extreme weather events (drought, floods, typhoons) (last 20-30 years)	1	2	3	4

Please indicate if you feel fear at any level of the future risks that are related to climate/weather change. Please indicate from 1(Never) to 4(Very Much)					
No	**Statement**	**Never**	**Some what**	**fear**	**Very much**
21	Do you feel any fear related to possible future climate-related risks?	1	2	3	4

Please circle to show if you had any direct negative impact from increased temperature, changed trend and intensity of rain and extreme events. Please circle one.					
No.	**Statements**	**Never**	**Some what**	**Have experience**	**Very much**
22	Risk experience with temperature	1	2	3	4
23	Risk experience with precipitation	1	2	3	4
24	Risk experience with extreme events	1	2	3	4

This questionnaire is to investigate how you get information about climate change in your areas and other areas. Please indicate your opinion from 1 (Never) to 4(All the time) to best describe your opinion.					
No.	**Statements**	**Never**	**Some-times**	**Often**	**All the time**
25	Public media (including newspaper, radio, Television, internet…)	1	2	3	4
26	Neighbor farmers	1	2	3	4
27	Village foremen	1	2	3	4
28	Local agricultural extension service center	1	2	3	4
29	Farmers’ Cooperative (NongHyup)	1	2	3	4

This questionnaire is to investigate how you get information about the responses to climate change in your areas and other areas. Please indicate your opinion from 1 (Never) to 4(All the time) to best describe your opinion.					
No.	**Statements**	**Never**	**Some-times**	**Often**	**All the time**
30	Public media (including newspaper, radio, Television, internet…)	1	2	3	4
31	Neighbor farmers	1	2	3	4
32	Village foremen	1	2	3	4
33	Local agricultural extension service center	1	2	3	4
34	Farmers’ Cooperative (NongHyup)	1	2	3	4

Please indicate your opinion on the probability of below consequences caused by increasing temperature, changing trend and intensity of rain and extreme weather events in the future.

No.	Statements	Unlikely	Somewhat likely	Likely	Very likely
35	Major crop yield, productivity and quality	1	2	3	4
36	Income	1	2	3	4
37	Physical assets (land, house, farming instruments, furniture)	1	2	3	4
38	Health Impact (disease, injuries of oneself and family)	1	2	3	4
39	Natural resources (biodiversity, soil, natural resources)	1	2	3	4
40	Social networks (family, friends, neighbors...)	1	2	3	4
41	Stress (mental health)	1	2	3	4

Please indicate your opinion on how severe each of the consequences of the below would be with regard to increasing temperature, changing trend and intensity of rain and extreme weather events in the future.

No.	Statements	Not Severe	Somewhat severe	Severe	extremely Severe
42	Major crop yield, productivity, and quality	1	2	3	4
43	Income	1	2	3	4
44	Physical assets (land, house, farming instruments, furniture)	1	2	3	4
45	Health Impact (disease, injuries of oneself and family)	1	2	3	4
46	Natural resources (biodiversity, soil, natural resources)	1	2	3	4
47	Social networks (family, friends, neighbors...)	1	2	3	4
48	Stress (mental health)	1	2	3	4

Please indicate your opinion on the effectiveness of each of below behaviors to prevent the climate change risks from 1 (Not effective at all) to 4 (very effective) best describe your opinion.

No.	Statement	Not effective at all	Slightly effective	Effective	Very effective
49	Adjusting farming dates	1	2	3	4
50	Adjusting planting techniques (fertilizer use, chemical use...)	1	2	3	4
51	Switching to new variety of crop that is adequate for changed climate	1	2	3	4
52	Gathering climate change information	1	2	3	4
53	Diversifying income by cultivating various crops	1	2	3	4
54	Buying crop insurance	1	2	3	4
55	Improving soil condition	1	2	3	4
56	Changing variety of apple crop	1	2	3	4
57	Searching for non-farming industry	1	2	3	4

Please indicate your opinion on your own ability to perform behaviors to prevent from clima58te change risks from 1 (Not capable at all) to 4 (extremely capable) best describe your opinion59.

No.	60Statements	Not capable at all	Slightly capable	Capable	Extremely capable
58	Adjusting farming dates	1	2	3	4
59	Adjusting planting techniques (fertilizer use, chemical use...)	1	2	3	4
60	Switching to new variety of crop that is adequate for changed climate	1	2	3	4
61	Gathering climate change information	1	2	3	4
62	Diversifying income by cultivating various crops	1	2	3	4
63	Buying crop insurance	1	2	3	4
64	Improving soil condition	1	2	3	4
65	Changing variety of apple crop	1	2	3	4
66	Searching for non-farming industry	1	2	3	4

Please indicate your opinion on the total costs (including time, efforts and money…)to implement below activities from 1 (Extremely costly-very expensive) to 4 (Not costly at all-very cheap) best describe your opinion.					
No.	**Statements**	**Extremely costly (expensive)**	**Costly**	**Slightly costly**	**Not costly (cheap)**
67	Adjusting farming dates	1	2	3	4
68	Adjusting planting techniques (fertilizer use, chemical use.. .)	1	2	3	4
69	Switching to new variety of crop that is adequate for changed climate	1	2	3	4
70	Gathering climate change information	1	2	3	4
71	Diversifying income by cultivating various crops	1	2	3	4
72	Buying crop insurance	1	2	3	4
73	Improving soil condition	1	2	3	4
74	Changing variety of apple crop	1	2	3	4
75	Searching for non-farming industry	1	2	3	4

Please indicate your opinion on below statements as ‘1 (Strongly disagree)’ to ‘4 (Strongly agree)’.					
No.	**Statements**	**Strongly disagree**	**Disagree**	**Agree**	**Strongly agree**
76	There is nothing that human can do regarding changing climate (Only God, ancestors will protect my farm)	1	2	3	4
77	The statement on climate change is not real	1	2	3	4
78	Government will have appropriate response that I, as an individual farmer have no obligation to do anything	1	2	3	4

Please indicate your opinion on public adaptation to climate change from 1 (Strongly disagree) to 4 (Strongly agree) best describe your opinion.					
No	**Statements**	**Strongly disagree**	**Disagree**	**Agree**	**Strongly agree**
79	Government supports (financial/education programs) to adopt new crop technology are very effective	1	2	3	4
80	Public warning systems are very effective	1	2	3	4
81	Climate/weather information provided by government is very effective	1	2	3	4

Please indicate if you already perform below measures or not. Moreover, please indicate you have the plan to perform on such measures in the near future. Please indicate, 1 ‘no action/no plan’, 2 ‘have plan to perform’, 2-‘ in action’ to best describe your opinion.				
No.	**Statements**	**No plan No action**	**Have plan**	**In action**
82	Adjusting farming dates	0	1	2
83	Adjusting planting techniques (fertilizer use, chemical use...)	0	1	2
84	Switching to new variety of crop that is adequate for changed climate	0	1	2
85	Gathering climate change information	0	1	2
86	Diversifying income by cultivating various crops	0	1	2
87	Buying crop insurance	0	1	2
88	Improving soil condition	0	1	2
89	Changing variety of apple crop	0	1	2
90	Searching for non-farming industry	0	1	2
Have you ever heard of a word ‘Climate Change’?		Yes		No

Thank you very much.

(2) Korean version

안녕하십니까? 본 설문 조사는 기후변화가 농업부문에 미치는 영향과 기후변화로 인한 농업피해를 줄이기 위한 방안을 모색하기 위하여 필요한 농업인의 의견을 수렴하고자 작성되었습니다. 답변해주시는 내용은 연구 자료 (발표자료, 학위논문, 학회 등) 이외에 다른 용도로 사용되지 않을 것이며, 개인에 관한 사항은 일체 공개되지 않음을 약속 드립니다. 바쁘신 와중에도 설문 조사에 응해주심에 감사 드리며 많은 협조를 부탁 드립니다. 감사합니다. 본 설문에 대한 자세한 문의: 연구 책임자: 000 이메일: 000@00000, 전화번호: 000-0000-000
응답자 거주지역: 시/군 면 리 응답작성 날짜: 년 월 일

<table>
<tr><th>No.</th><th>질 문 항 목</th><th colspan="4">응 답 란</th></tr>
<tr><td>1</td><td>나이</td><td colspan="4">세</td></tr>
<tr><td>2</td><td>성별</td><td colspan="2">남</td><td colspan="2">여</td></tr>
<tr><td>3</td><td>최종학력</td><td colspan="4"></td></tr>
<tr><td>4</td><td>총 재배지역 크기</td><td colspan="4">ha</td></tr>
<tr><td>5</td><td>영농기간</td><td colspan="4">년간</td></tr>
<tr><td rowspan="3">6</td><td rowspan="3">지난해 연 농업소득</td><td colspan="2">①5백만 원 미만</td><td colspan="2">②5백만 원 이상
~1천만 원 미만</td></tr>
<tr><td colspan="2">③1천만 원대</td><td colspan="2">④2천만 원대</td></tr>
<tr><td colspan="2">⑤3천만 원대</td><td colspan="2">⑥4천만 원 이상</td></tr>
<tr><td>7</td><td>전체소득 중 농업의 비중</td><td colspan="4">%</td></tr>
<tr><td>8</td><td>농업외 직업 (명칭을 기입하여 주시기 바랍니다.)</td><td colspan="4"></td></tr>
<tr><td>9</td><td>이주 경험 여부</td><td colspan="2">이주경험 있음</td><td colspan="2">이주경험 없음</td></tr>
<tr><td>10</td><td>영농승계자 유무 여부</td><td colspan="2">승계자 있음</td><td colspan="2">승계자 없음</td></tr>
<tr><td>11</td><td>최근 1년 농업기술센터 교육 참여 횟수</td><td colspan="4">회</td></tr>
<tr><td>12</td><td>스마트폰 사용여부</td><td colspan="2">사용</td><td colspan="2">사용하지 않음</td></tr>
<tr><td>13</td><td>농작물 판매경로</td><td>①
직판</td><td>② 대량
판매시장</td><td>③
농협</td><td>④
농민단체</td></tr>
<tr><td>14</td><td>농지 소유 여부</td><td colspan="2">농지 소유</td><td colspan="2">미소유</td></tr>
<tr><td>15</td><td>생산자 모임/조합/연구회 등 가입 수</td><td colspan="4">개</td></tr>
<tr><td>16</td><td>농작물 재해보험 가입여부</td><td colspan="2">가입 (년도:)</td><td colspan="2">미가입</td></tr>
<tr><td>17</td><td>사과 외 농작물 재배여부 및 재배 작물</td><td colspan="2">사과만 재배</td><td colspan="2">사과 외 재배 작물
( )</td></tr>
<tr><td>18</td><td>최근 10년간, 과거에 비하여 기온이 상승하고 있다고 생각하십니까?</td><td>아니오</td><td>조금</td><td>예</td><td>매우</td></tr>
<tr><td>19</td><td>최근 10년간, 과거에 비하여 비내리는 시기 및 비의 양이 변화하고 있다고 생각하십니까?</td><td>아니오</td><td>조금</td><td>예</td><td>매우</td></tr>
</table>

20	최근 10년간, 과거에 비하여 **가뭄, 홍수, 강설, 태풍 등의 횟수가 증가**하였다고 생각하십니까?	아니오	조금	예	매우
21	**고온, 강수, 홍수, 가뭄, 태풍, 강설** 등으로 인해 피해의 **위협을 느끼고 있습니까?**	아니오	조금	예	매우
22	**과거에 높아진 기온 때문에 피해를 본 경험**이 있습니까?	아니오	조금	예	매우
23	**과거에 비 오는 시기 및 양의 변화 때문에 피해를 본 경험이** 있습니까?	아니오	조금	예	매우
24	**과거에 가뭄, 홍수, 태풍, 강설 때문에 피해를 본 경험이** 있습니까?	아니오	조금	예	매우
	날씨, 가뭄, 홍수, 태풍, 강설 등에 대한 정보를 얻는 정도는?				
25	공공매채(신문, 인터넷, 라디오,TV 등)	전혀	가끔	주로	항상
26	주위 농가 및 생산자 모임	전혀	가끔	주로	항상
27	이장	전혀	가끔	주로	항상
28	농진청/농업기술센터	전혀	가끔	주로	항상
29	농협	전혀	가끔	주로	항상
	날씨, 가뭄, 홍수, 태풍, 강설 등으로 인한 위험 및 피해를 줄이기 위한 정보를 얻는 정도는?				
30	공공매채(신문, 인터넷, 라디오,TV 등)	전혀	가끔	주로	항상
31	주위 농가 및 생산자 모임	전혀	가끔	주로	항상
32	이장	전혀	가끔	주로	항상
33	농진청/농업기술센터	전혀	가끔	주로	항상
34	농협	전혀	가끔	주로	항상
	각 항목이 고온, 비 시기/양 변화, 가뭄, 태풍, 홍수, 강설로인한 영향을 받을 것으로 생각되십니까?				
35	사과의 질 저하 및 생산량 감소	아니오	조금	예	매우
36	소득	아니오	조금	예	매우
37	물적 자원 (소유지, 자택, 농업기구 등)	아니오	조금	예	매우
38	건강 (나 자신과 가족의 질병 및 부상)	아니오	조금	예	매우
39	자연자원 (생물다양성, 토지 등)	아니오	조금	예	매우

40	가족, 친구, 이웃들과의 소통	아니오	조금	예	매우
41	스트레스	아니오	조금	예	매우
	각 항목이 고온, 비 시기/양 변화, 가뭄, 태풍, 홍수, 강설로인한 영향을 받는 정도는 어느 정도라고 생각되십니까?				
42	사과의 질 저하 및 생산량 감소	전혀	조금	보통	매우
43	소득	전혀	조금	보통	매우
44	물적 자원 (소유지, 자택, 농업기구 등)	전혀	조금	보통	매우
45	건강 (나 자신과 가족의 질병 및 부상)	전혀	조금	보통	매우
46	자연자원 (생물다양성, 토지 등)	전혀	조금	보통	매우
47	가족, 친구, 이웃들과의 소통	전혀	조금	보통	매우
48	스트레스	전혀	조금	보통	매우
	날씨, 가뭄, 홍수, 태풍 등으로 인한 피해를 줄일 수 있는 효율적 수단이라고 생각하십니까?				
49	사과수확시기의 조절	아니오	조금	예	매우
50	농약 및 잡초의 조절사용, 병해 예방	아니오	조금	예	매우
51	변화한 기후에 적합한 과수 또는 채소로 전환	아니오	조금	예	매우
52	날씨, 홍수, 가뭄, 태풍, 강설 등관련 정보 수집	아니오	조금	예	매우
53	다양한 소득을 위한 여러 작물재배	아니오	조금	예	매우
54	농작물 재해보험가입	아니오	조금	예	매우
55	농지개량	아니오	조금	예	매우
56	현재 재배하고 있는 작물 품종의 변경	아니오	조금	예	매우
57	농외소득을 벌기 위한 직업으로 전환 (회사, 사업 등)	아니오	조금	예	매우
	귀하는 아래의 항목들을 스스로 수행할 능력이 어느정도 있다고 생각하십니까?				
58	사과수확시기의 조절	전혀	조금	적당	매우
59	농약 및 잡초의 조절사용, 병해 예방	전혀	조금	적당	매우
60	변화한 기후에 적합한 과수 또는 채소로 전환	전혀	조금	적당	매우
61	날씨, 홍수, 가뭄, 태풍, 강설 등관련 정보 수집	전혀	조금	적당	매우

62	다양한 소득을 위한 여러 작물재배	전혀	조금	적당	매우
63	농작물 재해보험가입	전혀	조금	적당	매우
64	농지개량	전혀	조금	적당	매우
65	현재 재배하고 있는 작물 품종의 변경	전혀	조금	적당	매우
66	농외소득을 벌기 위한 직업으로 전환 (회사, 사업 등)	전혀	조금	적당	매우
	아래의 작업을 수행할때 발생하는 비용 (돈, 노력, 시간 등) 이 어느정도 발생한다고 생각하십니까?				
67	사과수확시기의 조절	전혀	조금	적당	매우
68	농약 및 잡초의 조절사용, 병해 예방	전혀	조금	적당	매우
69	변화한 기후에 적합한 과수 또는 채소로 전환	전혀	조금	적당	매우
70	날씨, 홍수, 가뭄, 태풍, 강설 등관련 정보 수집	전혀	조금	적당	매우
71	다양한 소득을 위한 여러 작물재배	전혀	조금	적당	매우
72	농작물 재해보험가입	전혀	조금	적당	매우
73	농지개량	전혀	조금	적당	매우
74	현재 재배하고 있는 작물 품종의 변경	전혀	조금	적당	매우
75	농외소득을 벌기 위한 직업으로 전환 (회사, 사업 등)	전혀	조금	적당	매우
76	개인의 능력으로는 날씨,태풍,가뭄,홍수 등으로 인한 피해를 막을 수 없다 (**조상, 신, 하느님이 해결할 수 있는 문제**)	아니오	조금	예	매우
77	날씨로 인한 피해들은 **현실적이지 않다**	아니오	조금	예	매우
78	**정부가 알맞은 대응**을 할 것임으로 개인적으로 대응할 필요가 없다	아니오	조금	예	매우
79	**정부에서 제공**하는 **신소득작물 도입을 위한 기술 및 금전적 지원 (교육) 프로그램**은 효율적이다	아니오	조금	예	매우
80	정부에서 제공하는 **기상위험경보는 효율적**이다	아니오	조금	예	매우
81	정부에서 제공하는 **기후변화/기상 정보는 농업활동에 매우 유용하다**	아니오	조금	예	매우

	기온상승, 비오는 시기 및 양의 변화, 가뭄, 홍수, 태풍, 강풍으로 인한 피해를 줄이기 위한 방법을 '적용 중' '미래에 적용할 계획', '적용 계획없음'으로 선택하여 주시기 바랍니다.			
82	사과수확시기의 조절	이미 적용 중	미래 적용할 계획 있음	적용 계획 없음
83	농약 및 잡초의 조절사용, 병해 예방	이미 적용 중	미래 적용할 계획 있음	적용 계획 없음
84	변화한 날씨에 적합한 과수 또는 채소로 전환	이미 적용 중	미래 적용할 계획 있음	적용 계획 없음
85	날씨, 홍수, 가뭄, 태풍, 강설 등관련 정보 수집	이미 적용 중	미래 적용할 계획 있음	적용 계획 없음
86	다양한 소득을 위한 여러 작물재배	이미 적용 중	미래 적용할 계획 있음	적용 계획 없음
87	농작물 재해보험가입	이미 적용 중	미래 적용할 계획 있음	적용 계획 없음
88	농지개량	이미 적용 중	미래 적용할 계획 있음	적용 계획 없음
89	현재 재배하고 있는 작물 품종의 변경	이미 적용 중	미래 적용할 계획 있음	적용 계획 없음
90	농외소득을 벌기 위한 직업으로 전환 (회사, 사업 등)	이미 적용 중	미래 적용할 계획 있음	적용 계획 없음

귀하는 기후변화에 대해 들어보신적이 있습니까?	예	아니오

감사합니다.

APPENDIX VI: Pictures obtained from field observation

<Picture1>
Focus Group Interview with Dr. Ueom, AGOs, cooperative representative

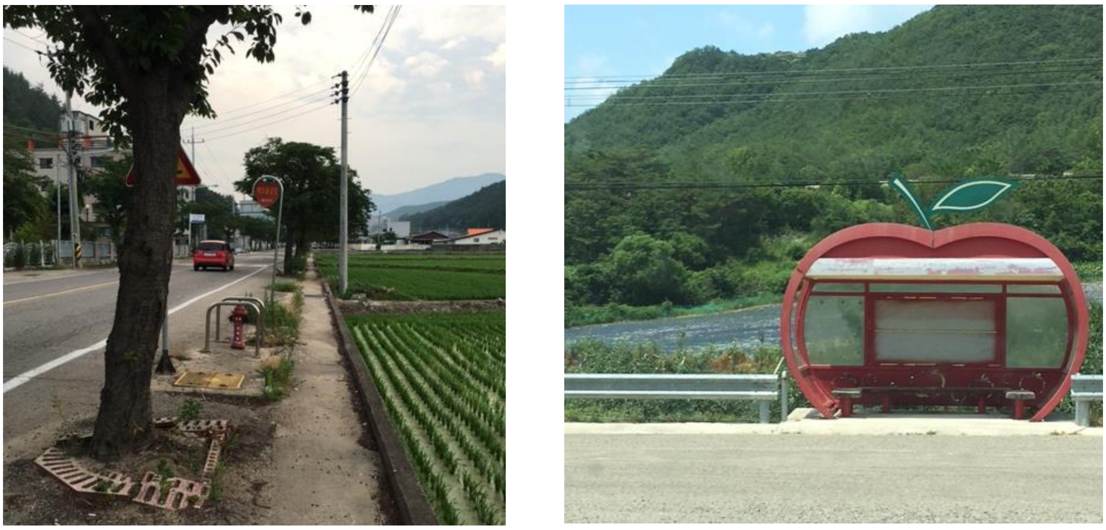
<Picture 2>
Focus Group Interview with farmers

<Picture 3>
In-depth interview with a farmer

<Picture 4>
Focus Group Interview with AGOs

<Picture 5>
In-depth individual interview with an apple farmer

<Picture 6>
Blueberry grew in one of the interviewed farmer : As to diversify crop production, the farmer started to grow blueberry



<Picture 7>
Bus stop in Cheongsong county: Apple shaped bus stops and monuments are easily seen in Cheongsong county.

<Picture 8>
Dead mole found in apple farm:
With changed climate, mole has been appearing in the farms and damage the the quality of soil, trees and crop

<Picture 9>
SS-spray : used for spraying pesticides