Farmers' Risk Perceptions, Attitudes and Management Strategies, and Willingness to Pay for Crop Insurance in Nepal

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Declaration

I, Bibek Sapkota, declare that the work contained in this thesis has been substantially accomplished during the enrolment in this degree.

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The research involving human data reported in this thesis was assessed and approved by The University of Western Australia Human Ethics Committee (Human Ethics Ref: RA/4/20/4795, UWA).

This thesis contains work prepared for publication, some of which have been co-authored.

I certify that help received in preparing this thesis and all sources used have been duly acknowledged.

I have attempted to use inclusive language throughout the thesis.

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Abstract

Weather-related risks coupled with rainfed farming conditions and inadequate risk management options are some of the major impediments to the growth of the Nepalese agricultural economy. Increased frequency and intensity of extreme weather events in recent years indicate Nepal's high vulnerability to these risks. Unmanaged farming risks have negative impacts on the well-being of farming communities and the overall economy. Given that most farmers are subsistence smallholders, they have a low capacity to manage risks without external support. To assist farmers in managing risks, the Government of Nepal initiated an agricultural insurance program in 2013 using a public–private partnership model. However, farmers' participation in the agricultural insurance program is low, despite a 75% premium subsidy. Farmers' needs, preferences and willingness to pay are important factors determining their demand for insurance products. The agricultural insurance products currently available in the market were based on a feasibility study that only addressed supply-side issues and implementation mechanisms of the insurance program. Information on farmers' risk perceptions, risk attitudes and risk management strategies are lacking, which are important indicators of the demand for risk management products and policy interventions. This study analyses the demand–supply incongruity in the Nepalese agricultural insurance market, focusing on farmers' risk perceptions, risk attitudes, existing risk management strategies and willingness to pay for crop insurance.

The study follows a sequential mixed-methods research design using cross-sectional data collected from the decision-makers of randomly selected farming households from the Terai region of Nepal. The qualitative study employs in-depth interviews with 45 farmers followed by content analysis and cognitive mapping techniques to present the relationships between various constructs related to farming risk. The subsequent quantitative study employs a semi-structured questionnaire survey with 420 farmers. The survey included psychometric scaling questions to elicit farmers' perceptions of risk and uncertainties, a monetary lottery-choice experiment to measure their risk attitudes, and a discrete choice experiment to measure their willingness to pay for crop insurance.

The qualitative study established a broad context of farming risk in Nepal, identifying major concerns for farmers, such as uncertainties in labour supply, technical knowledge on modern farming technologies, and supply of farm inputs (seeds, fertilisers and agrochemicals). Climatic risk factors such as erratic rainfall patterns and increased temperature were major sources of production risks. Farmers' low bargaining power, unstable policies and increased market competition were major sources of market risks. The study also found that male and female farmers have different concerns in farming, which can be linked to the gender-specific division of roles. Despite their willingness to buy crop insurance to supplement traditional risk management, many farmers were unaware of the

availability of such products in the market. Therefore, awareness campaigns and training programs could improve the adoption of crop insurance. Moreover, the qualitative study validated the applicability of the cognitive mapping approach to study risk in the farming context. Future researchers and industries can apply such a qualitative method to complement the psychometric method to understand risk perceptions more comprehensively and communicate the findings.

Consistent with the qualitative study's findings, psychometric analysis of farmers' risk perceptions revealed that the risks associated with labour supply are the most important concerns in farming. Similarly, farmers' low bargaining power is the major source of market risk. Farmers' risk perception is highly correlated with their past risk exposure. Farmers' perception of drought risk is associated with drought experience, age, family size, migration status, access to infrastructure and services, and rice productivity, whereas the perception of flood risk is associated with flood experience, farm size, migration status, rice productivity and joint family system. We also found spatial variation in farmers' perceptions of both risks. These relationships reinforce the findings of earlier studies that risk perception is a combined function of objective risk factors and the perceiver's characteristics. Farmers rated on-farm self-insurance options such as farm diversification more important than market-based risk management options such as insurance.

On average, farmers showed a risk-averse attitude to the lottery-choice gamble used in the experiment. We found that farmers' risk attitude is associated with their gender, age, family size, farm size, numeracy skill, geographical location and flood risk perception. Similarly, their risk attitude is correlated to various farming decisions, such as farm mechanisation, monetary saving, involvement in groups and cooperatives, production diversification, crop varietal diversification, use of stress-tolerant crop varieties, and crop insurance adoption. However, the perceptions of drought and flood risks do not significantly influence farmers' decision-making, except for the positive association of drought risk perception with loan use in farming. These findings suggest that farmers' decision-making is influenced more by risk attitude than risk perception.

The discrete choice experiment reveals that the utility of crop insurance has a positive association with risk coverage level, while the same has negative associations with insurance premium and deductible. Moreover, farmers' risk aversion increases their willingness to pay for crop insurance. Among the attributes used in the experiment, the sum insured had the dominant effect on the utility of insurance. However, such utility is unaffected by insurance type, indicating that farmers are indifferent about loss-based insurance and rainfall-index insurance. The results also suggest considerable preference heterogeneity among farmers for crop insurance attributes, indicating a potential for diversifying crop insurance products. Farmers' willingness to pay for the existing crop insurance product is less than the current premium, partly explaining the demand–supply mismatch in the insurance market.

The research contributes to academic literature examining the theories to explain interrelationships between risk perception, risk attitude and decision-making in the context of small-scale subsistence farming, such as that of Nepal. Moreover, the findings have practical implications for improving risk management products and policies. Policy suggestions emerging from this study include: 1) Given that considerable heterogeneity exists in farmers' risk perception, attitude and willingness to pay for crop insurance, identifying target groups in terms of income status, geography, crops, farm size, etc. and customizing risk management products according to their specific needs and preference may improve insurance uptake; 2) Increasing risk coverage level is likely to increase the adoption of crop insurance by farmers because they prefer insurance products that protect potential income to the existing insurance product that only covers production cost; 3) Educating farmers about the concept and benefits of insurance is essential to help them make informed decisions and choose the optimum risk management strategy that suits their circumstances; 4) A holistic approach is needed for the management of farming risks, as agricultural insurance is suitable for managing only weather-related risks; 5) This study focusses on the management of weather-related risks using crop insurance. Further research is necessary to identify appropriate strategies to mitigate market risks.

Authorship Declaration

This thesis contains co-authored papers prepared for publication.

Details of the papers:

1. Sapkota, B., Rola-Rubzen, M.F., and Murray-Prior, R. (2021). Cognitive Mapping of Nepalese Farmers' Risk Perceptions (*currently being revised for submission to Agricultural Systems*).

Location in thesis: Chapter 4

2. Sapkota, B., Burton, M., Rola-Rubzen, M.F., and Murray-Prior, R. (2021). A Psychometric Analysis of Farmers' Perceptions of Risks, Uncertainties and Management Strategies in Nepal (c*urrently being revised for submission to the Australian Journal of Agricultural Economics*).

Location in thesis: Chapter 5

3. Sapkota, B., Burton, M., Rola-Rubzen, M.F., and Murray-Prior, R. (2021). Linkages Between Farmers' Risk Attitudes, Sociodemographic Factors and the Choice of Risk Management Strategies (c*urrently being revised for submission to the Journal of Risk Research*).

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4. Sapkota, B., Burton, M., Rola-Rubzen, M.F., and Murray-Prior, R. (2021). Farmers' Willingness to Pay for Crop Insurance in Nepal (c*urrently being revised for submission to the Journal Agricultural Economics*).

Location in thesis: Chapter 7

The student's contribution to each manuscript is approximately 80%, while co-authors share the remaining 20%. I have permission from the co-authors, undersigned, to include these papers in my thesis.

[redacted]

Bibek Sapkota Maria Fay Rola-Rubzen Michael Burton Roy Murray-Prior

November 2021

Presentations Resulting from this Research

1 Sapkota, B., Rola-Rubzen, M.F., Burton, M., and Murray-Prior, R. (2021). Linkages Between Farmers' Risk Attitudes, Sociodemographic Factors and the Choice of Risk Management Strategies. West Australian Agricultural and Resource Economics Society Conference, 18 October 2018, UWA, Perth.

2 Sapkota, B., Rola-Rubzen, M.F., Burton, M., and Murray-Prior, R. (2021). Farmers' Willingness to Pay for Crop Insurance in Nepal. Australian Agricultural and Resource Economics Society Conference, 10-14 February 2020, UWA, Perth.

3 Sapkota, B., Rola-Rubzen, M.F., Burton, M., and Murray-Prior, R. (2021). A Psychometric Analysis of Farmers' Perceptions of Risks, Uncertainties and Management Strategies. UWA School of Agriculture and Environment, Agricultural and Resource Economics (ARE) Seminar Series, 12 March 2021, UWA, Perth.

Abbreviations and Acronyms

ACIAR	Australian Centre for International Agricultural Research
ADS	Agriculture Development Strategy 2015–2035
AFP	Actuarially Fair Premium
AGDP	Agricultural Gross Domestic Product
AISI	Access to Infrastructure and Service Index
ANOVA	Analysis of Variance
BE	Behavioural Economics
C	Certain Amount
CA	Conjoint Analysis
CC	Climate Change
CE	Certainty Equivalent
CL	Conditional Logit
CM	Cognitive Mapping
CRRA	Constant Relative Risk Aversion
CT	Cultural Theory
CVDI	Crop Varietal Diversity Index
CVM	Contingent Valuation Method
DADO	District Agriculture Development Office
DCE	Discrete Choice Experiment
DM	Decision-Maker
DV	Dependent Variable
ETR	Eastern Terai Region
EU	Expected Utility
EUT	Expected Utility Theory
FAO	Food and Agriculture Organization
FMI	Farm Mechanisation Index
GDP	Gross Domestic Product
GEI	Gender Equality Index
GoN	Government of Nepal
Ha	Hectare
HH	Household
IID	Independent and Identically Distributed
ILO	International Labour Organization
IPCC	Intergovernmental Panel on Climate Change

IV	Independent Variable
L	Lottery
LBI	Loss-Based Insurance
LCE	Lottery-Choice Experiment
Max WTP	Maximum Willingness to Pay
mm	Millimetre
ML	Mixed Logit
MoALD	Ministry of Agriculture and Livestock Development
MPCI	Multi-Peril Crop Insurance
MPL	Multiple Price List
Mt	Metric tonnes
MTR	Mid-Terai Region
NAPA	National Adaptation Program of Action
NARC	Nepal Agriculture Research Council
NPCI	Named-Peril Crop Insurance
NPR	Nepalese Rupee (120 NPR ≈ 1 USD, as of 9 April 2021)
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Square
P	Probability Value
PDI	Production Diversity Index
PPP	Public–Private Partnership
PT	Psychometric Theory
QUAL	Qualitative
QUANT	Quantitative
r	Pearson Correlation Coefficient
RCT	Rational Choice Theory
RII	Rainfall-Index Insurance
RP	Revealed Preference
RPL	Random Parameter Logit
RUT	Random Utility Theory
SD	Standard Deviation
SDGs	Sustainable Development Goals
SDI	Sale Diversity Index
SE	Standard Error
SEU	Subjective Expected Utility
SP	Stated Preference

SQ	Status-Quo
STRV	Stress-Tolerant Rice Variety
TEPC	Trade and Export Promotion Centre
UN	United Nations
USD	United States Dollar
VNM	von Neumann & Morgenstern
UWA	The University of Western Australia
VIF	Variance Inflation Factor
WII	Weather-Index Insurance
WTP	Willingness to Pay
WTR	Western Terai Region

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This study involved lengthy interviews with farmers and painstaking numerical exercises. I would like to extend my special gratitude to the farmers for their participation and the enumerators for helping me carry out the survey.

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Chapter 1: Introduction

This chapter provides background to the research, presenting a brief overview of Nepalese agriculture, risks in farming, previous research on farming risks, research problems and study objectives. It includes a glossary of key terms relevant to this study. The chapter concludes by describing how the research outcomes are organised in this thesis.

1.1 Overview of Nepalese agriculture

Agriculture is the mainstay of the Nepalese economy, contributing about 23% of the Gross Domestic Product (GDP) and employing about 60% of the total population (MoALD-Nepal, 2021). As shown in Figure 1.1, the growth rates of GDP and agricultural gross domestic product (AGDP) have a highly correlated fluctuation, indicating that Nepal's economic growth largely depends on the performance of the agriculture sector. Recognising its role in the economy, most national plans and policies, including the current Agriculture Development Strategy (ADS 2015–2035), prioritise agriculture as the sector with the most potential for contributing to development and poverty alleviation (MoALD-Nepal, 2014). However, the stagnation and instability in agricultural growth in the past two decades has resulted in Nepal spending more than USD 3 billion a year importing food grains (TEPC-Nepal, 2016). Overcoming the growth stagnation, building climate resilience and enhancing the performance of the agriculture sector are of utmost importance for achieving 'No Poverty' and 'Zero Hunger', a commitment by the Government of Nepal in its sustainable development goals (SDGs) (NPC-Nepal, 2020).

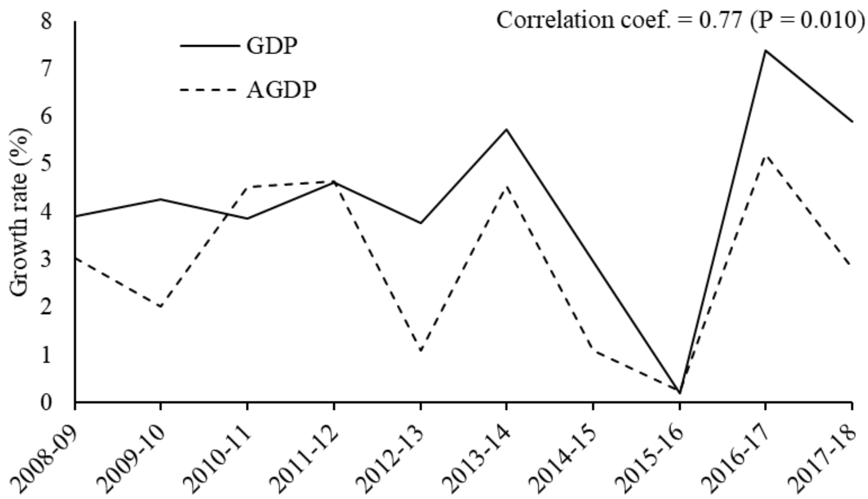

Figure 1.1 GDP and AGDP trends

Source: MoF-Nepal (2021)

Rice, maize and wheat are major cereal crops grown in Nepal. These crops contribute about 31% to the total AGDP altogether, with rice alone contributing about 15% (MoALD-Nepal, 2021). Figure 1.2 shows the area, production and productivity of rice, maize and wheat in the last 20 years. The area of these crops remained almost constant over this period, while the production and productivity have slightly increased. Among these crops, rice ranks highest in terms of area, production and productivity. The average growth rate of rice productivity over the last 50 years has been around 1.6%, which is far below the population growth rate (IRRI, 2021). In 2020, 5.55 million mt of rice was produced from 1.46 million ha of land, with average productivity of 3.80 mt/ha (MoALD-Nepal, 2021). The government of Nepal has recommended 114 improved rice varieties (70 open-pollinated and 44 hybrid varieties) for farmer cultivation (NARC, 2018).

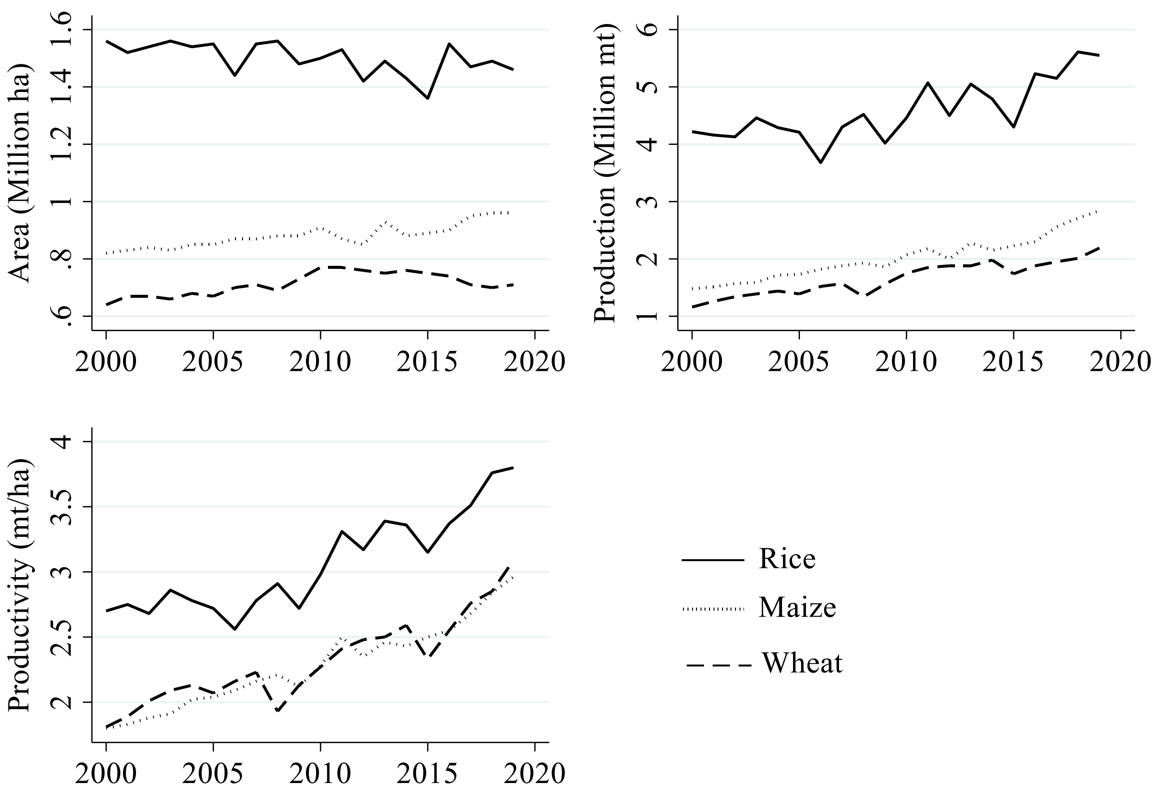

Figure 1.2 Area, production and productivity of Rice, Maize and Wheat in the last 20 years
Source: (MoALD-Nepal, 2020b)

1.2 Risks in Nepalese farming

The stagnation and high variability in agricultural growth can be attributed to some inherent features of agriculture in general and specific characteristics of Nepalese farming systems that lead to various risks, coupled with inadequate arrangements for risk management. Agriculture is exposed to numerous risks stemming from various sources because it is mainly undertaken in open environments and involves managing inherently variable living things (Hardaker et al., 2015). Farming risks arise from the uncertain and uncontrollable variability of several factors that determine farm production and income (OECD, 2009), particularly. Among such factors, climatic variables and market forces are the most important ones, which are becoming increasingly unpredictable due to climate change and increased market liberalization (Iturrioz, 2009). Further, production risks have more severe consequences than market risks for the livelihoods of subsistence farmers, such as those in Nepal, because much of what they produce is consumed at home.

Although climate change remains an issue of widespread political debate, the scientific literature agrees that it is a natural phenomenon aggravated by human factors, with primarily negative impacts on agriculture. For instance, the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2014) warns that, by the mid-21st century, climate change coupled with increasing food demand will pose considerable risk to global food security and poverty reduction efforts and negatively impact agricultural production systems if appropriate adaptation measures are not implemented in time. The report also predicts that poverty traps and hunger hotspots will be intensive in developing countries like Nepal. Based on the global climate risk index, Nepal was ranked fourth most affected country by climatic hazards in 2017 and 11th for the last two decades (Eckstein et al., 2019). Moreover, numerous studies have shown evidence of climate change in Nepal, such as increased incidence of extreme weather events, increased overall temperature, more erratic rainfall pattern and adverse effects on agricultural production (see Acharya, 2018; Chhetri & Easterling, 2010; Devkota & Gyawali, 2015; Karn, 2014; Khadka et al., 2014; Khanal et al., 2018; Malla, 2008; Palazzoli et al., 2015; Shrestha & Nepal, 2016; Shrestha et al., 2019; Sujakhu et al., 2016).

Rainfed lowland is the dominant agricultural ecosystem of Nepal, with only one-third of the total crop area having reliable irrigation facilities (Bagazonzya et al., 2009). Due to the high dependency on precipitation, Nepalese agriculture is highly vulnerable to weather-related risks such as drought and flood resulting from erratic rainfall distribution. For instance, about 90% of crop losses in Nepal are caused by hydro-meteorological hazards, of which drought and flood account for 38.9% and 23.2%, respectively (FAO, 2014). The value of crop losses from 1983 to 2005 due to such hazards was more than 288 million USD (FAO, 2010). Rice accounts for 78% of the total crop loss due to drought and flood (Ghimire, 2017). While about two-thirds of the rice area is rainfed and prone to both drought and flood at any stage of crop growth, the average area affected by drought and flood is 30% and 15%, respectively (Yadaw et al., 2017). Even more alarming is that weather-related disasters have escalated since the 1990s and will be more frequent and intensive in the future (FAO, 2010, 2014). While initial temperature increases (up to 2.5°C increase) will slightly increase agricultural production up to 2050 due to the carbon fertilisation effect, further increases will reduce production by 4.8% by 2080 and 17.3% thereafter (see Cline, 2007). Since these predictions do not account for the production losses due to natural disasters, which are likely to increase during that period, the impact of climate change on Nepalese agriculture will be more substantial than these figures (FAO, 2010).

1.3 Importance of risk management

Managing farming risk is critical as agriculture is a major contributor to anthropogenic greenhouse gas emissions, and climate change has primarily negative effects on agriculture (see IPCC, 2014). Unmanaged farming risks negatively affect the well-being of farming households and weaken the overall economy. According to Cervantes-Godoy et al. (2013), agricultural shocks result in depletion of assets and decreased disposable income of the smallholders leading them into a poverty trap. They note that a credit constraint is the main feature of such a poverty trap attributed to moneylenders' unwillingness to finance the smallholder farmers. Consequently, risk-affected farmers are forced to invest in less productive technologies, use insufficient inputs and resort to low-risk/low-return options. The inability to cope with the consequences of risks can force poor households into a long-term debt trap and bonded labour contract (Fafchamps, 2004). Unfortunately, in the pursuit of avoiding further risk, smallholders often miss opportunities that might help them escape the poverty trap (Cervantes-Godoy et al., 2013). A crisis resulting from several adverse consequences of unmanaged farming risks was the leading cause of the increasing spate of farmer suicide in India (Vasavi, 2009). Adverse production outcomes can also increase gender disparity because the burden of hardships is often disproportionally shared among family members, with female members sharing the most (Dercon & Krishnan, 2000).

The lack of risk management also challenges the sustainability of the farming profession because it can deteriorate farm conditions, making it unworthy to hand over to the next generation (Hardaker et al., 2015). In contrast, appropriate arrangements for risk management stabilise farm income and improve farmers' creditworthiness, consequently motivating them to adopt high-risk/high-return innovations (Singla & Sagar, 2012). Risk management also increases farm productivity (Lien et al., 2016), improves the well-being of the farming community, and ensures the survival of the agribusiness sector (Hardaker et al., 2015). Hence, risk management mechanisms are needed to create an environment that promises a predictable return on investment and enhances the economic viability of the farming business. However, more than two-thirds of farmers in Nepal are smallholders who cultivate less than one ha of land (CBS-Nepal, 2013), with a low capacity to deal with risks without external support. Realising the need to assist smallholder farmers, the Government of Nepal initiated a subsidised agricultural insurance program in 2013.

1.4 Status of agricultural insurance in Nepal

The current agricultural insurance program in Nepal is implemented through a public-private partnership model. The government designated 20 non-life insurance companies to provide insurance products to farmers throughout the country. The local stations of the Department of Agriculture facilitate the linkage between farmers and companies. The existing crop insurance product is yield-loss-based, multi-peril crop insurance. A farmer who owns at least 0.03 ha of land is eligible for crop insurance. The level of insurance coverage is equivalent to the cost of cultivation for the given crop, which is determined by the local representatives of the Department of Agriculture. The insurance premium rate is equal to 5% of the sum insured before the subsidy. The Ministry of Agriculture and Livestock Development provided a 50% subsidy for the insurance premium until the second year, which was later increased to 75%. In the case of loss, the indemnity to be paid out is based on a joint evaluation of technicians and insurance companies as agreed when underwriting the policy (MoALD-Nepal, 2020a). Figure 1.3 shows that the total value of agricultural insurance has increased spectacularly from about 55 million NPR in 2013 to more than 9000 million in 2017. The number of insurance claims has increased by a similar rate. However, the adoption rate of agricultural insurance in Nepal is only around 1%, the lowest among Asian countries (Bhushan et al., 2016). Bhushan et al. (2016) pointed out infrastructural issues, lack of farmers' awareness, premium affordability by farmers, and poor implementation mechanisms as major obstacles in increasing agriculture insurance penetration in Nepal.

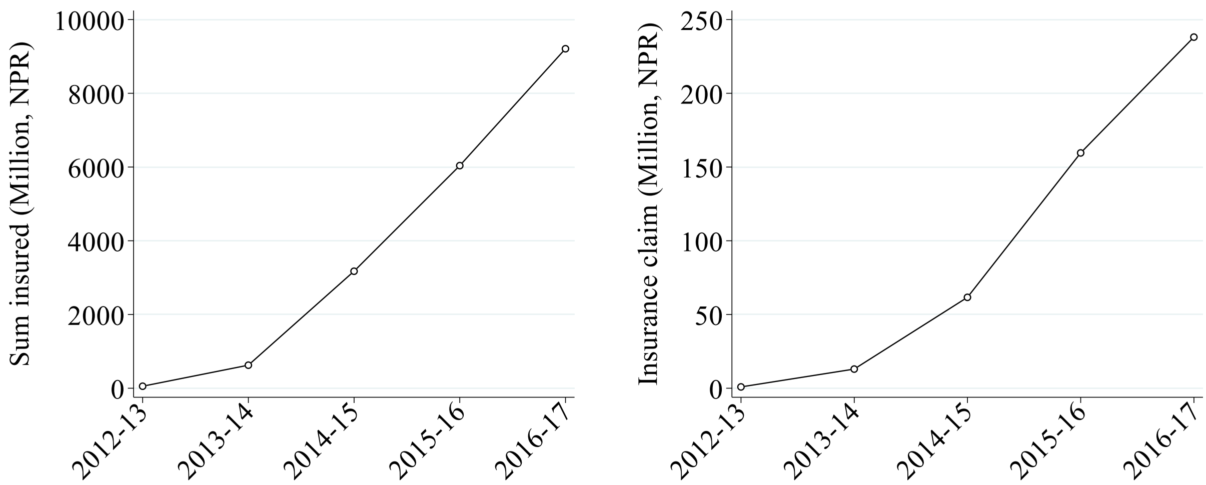

Figure 1.3 Adoption of agricultural insurance in Nepal
Source: *MoALD-Nepal (2020b)*

1.5 Research on farming risk in Nepal

The literature related to farming risk in the Nepalese context is limited and has not covered major aspects of risk management. Some published works related to farming risk in Nepal are cited below. Hamal and Anderson (1982), who were the first to study Nepalese farmers' risk preferences, found that farmers were risk-averse in general, and their risk aversion was negatively correlated with wealth.

They also found that farmers' risk aversion limited their adoption of modern farming technologies. However, the study only involved 60 households from two Central Terai districts. Recently, Sharma (2016) elicited the risk attitude of coffee producers in two districts, namely Lalitpur and Gulmi, using contextualised lottery-choice experiments and found that smallholder farmers were risk-averse with total household income negatively affecting risk aversion. They also found that risk aversion did not affect land allocation but did affect labour allocation for coffee farming. This study addressed a few important questions about the implications of risk attitude on some variables related to coffee farming, which is an important export commodity for Nepal. However, the findings may not generalise to other contexts with different geographic conditions, socio-economic settings, crops and risk profiles.

With the main aim of assisting the Government of Nepal to develop an overall framework for crop insurance programs, The World Bank conducted a feasibility study of crop insurance in Nepal (Bagazonzya et al., 2009). They conducted risk assessments in crop and livestock sectors using time-series district-level production and yield data. They also found crop insurance products, including weather-index insurance, as feasible in the Nepalese context and recommended a public-private partnership model to implement the insurance program. However, they admitted that their report drew heavily on international experience and suggested a comprehensive demand assessment for agricultural insurance products in Nepal. Ghimire et al. (2016b) identified key issues related to implementing the insurance program in the banana sector and suggested refinement of insurance products based on farmer preferences. Similarly, Malla (2008) presented evidence of the negative impacts of climate change on Nepalese agriculture and recommended crop insurance as an appropriate risk management strategy. Budhathoki et al. (2019) is the only study that looked at farmers' general interest in index-based insurance schemes, their willingness to pay (WTP) for rice and wheat crop insurance, and factors affecting the adoption of crop insurance. However, they only covered a small geographic area and used a contingent valuation method (CVM) which does not offer insight into farmer preferences and trade-off behaviours among crop insurance attributes.

Other than the studies discussed above, which looked at farmers' risk attitude and risk management strategies, most studies have limited their focus to issues related to climate change (see Acharya, 2018; Chhetri & Easterling, 2010; Haefele et al., 2014; Karn, 2014; Khanal, 2018; Palazzoli et al., 2015; Shrestha & Nepal, 2016; Sujakhu et al., 2016). Although these studies have made important contributions to understanding the prevalence of weather-related risks and identifying or developing risk management strategies, there remains a lack of systematic studies in Nepal on farmers' perceptions of risks, attitudes towards risk and decision-making in the presence of risk.

1.6 Research problem

Substantial resources are being invested in developing countries to implement research and development (R&D) projects to uplift smallholder farmers' livelihoods through the development and dissemination of improved farming technologies (see Beintema et al., 2020). The theory of change and impact pathways envisaged by these projects are underpinned by the assumption that farmers, being rational agents, adopt the technologies they perceive are superior to existing technologies. However, a common issue faced by most of these R&D projects is that farmers vary in their adoption behaviours. Most farmers often dis-adopt the technologies promoted by such projects as soon as the projects end. Research has shown that modern farming technologies have a long adoption lag in smallholder farming. For instance, a farm-level survey conducted in Nepal by Gautam et al. (2013) (cited in Gauchan, 2017, p. 642) found that a new rice variety takes 12 years to reach a peak adoption level; once adopted, farmers do not replace it for the next 18 years. Kumar et al. (2020) also noted that the adoption rates of improved crop varieties and fertilisers are lower in Nepal compared to other South Asian countries. These findings imply that both the adoption and replacement rates of farming technology are low in Nepal. Despite well-known theories of the innovation-decision process (e.g., Rogers, 2003), why farmers respond differently to an intervention that offers obvious benefits compared to their existing practices is a persistent research question.

Adopting new technology is a risky decision because the farmers must choose among competing alternatives whose potential returns and associated probabilities are not precisely known beforehand (Greiner et al., 2009). High-yielding technologies often entail higher risk in terms of yield variability and market acceptance. For example, the high-yielding rice and wheat varieties developed during the "green revolution" period were more profitable but riskier than the traditional varieties (Andrew & Mark, 1995). Research has shown that farmers' decision-making involves evaluating not only the potential outcomes but also the variability of outcomes (Chavas & Nauges, 2020). Risk, uncertainty, and learning play many important roles in the process of farmers' adoption decisions (Marra & Carlson, 1990). Therefore, understanding the dynamics of farmers' decision-making, which is an ongoing interest of both researchers and policymakers, is incomplete without the knowledge of farmers' risk perceptions and risk attitudes.

The science of farming risk management in Nepal is in its initial stage, lacking vital information and evidence-based policies. A few studies have found that farmers are risk-averse in general; their risk aversion influences decision-making (see Budhathoki et al., 2019; Hamal & Anderson, 1982; Sharma, 2016), and they are willing to pay three times more than the existing premium for the current crop insurance product (see Budhathoki et al., 2019). However, these studies involved small sample sizes representing small geographic domains, limiting the generalizability of their findings. These findings may not generalise to other contexts that involve different geographic locations, socio-economic settings, crops and risk profiles. The contribution of most other studies on this topic is limited to identifying climate change as the major risk factor and discussing adaptation measures. More importantly, none of these studies could influence policy change except for the feasibility study conducted by the World Bank (Bagazonzya et al., 2009), which was undertaken to inform the development of the agricultural insurance program. However, the scope of their study was limited to reviewing international experiences, mapping objective risks and addressing institutional challenges for the implementation of the insurance program. They did not look at many important demand-side issues, such as farmers' risk perceptions, risk attitudes, existing risk management strategies and willingness to pay for modern risk management tools such as insurance. These are the variables of utmost importance for both the risk market and policy space to predict farmer demand for risk management products and potential response to policy interventions.

In the absence of an efficient risk market that supplies modern risk management products, farmers rely on traditional self-insurance strategies or government disaster relief payments in the case of adverse production outcomes in agriculture (Mahul & Stutley, 2010). Despite 75–90% subsidies in premiums, farmer participation in the crop insurance program has been negligible thus far (Ghimire et al., 2016a). Although Figure 2 shows a rapidly increasing trend of the sum insured and insurance claims, the adoption rate remains the lowest among Asian countries (Bhushan et al., 2016). A case study on banana insurance conducted by Ghimire et al. (2016b) identified the insurance product design as the major factor responsible for demand-supply mismatch and suggested refinement and diversification of insurance products based on farmer preferences. Bagazonzya et al. (2009) also suggested further research to understand farmer preferences about crop insurance products. Knowing how farmers value and trade off the attributes of crop insurance products is necessary to diversify the agricultural risk market. Knowledge of existing risk management practices is also important to predict farmer demand for crop insurance products. Therefore, a comprehensive understanding of how farmers perceive risk, how tolerant they are to risk, and how they deal with risk is necessary to inform future risk management efforts.

This study aims to overcome the information gap in farming risk management in Nepal, focusing on prevailing risks and risk factors from the farmer perspective, their attitude towards risk, existing risk management practices and their willingness to buy formal risk management products. Such information can help the government and insurance companies refine policies and risk management products and help farmers improve their decision making.

1.7 Aim and objectives

The overarching aim of this study is to stimulate policy change related to farming risk management and crop insurance program in Nepal, embracing a holistic approach that is responsive to the needs and preferences of farming communities. This aim will be accomplished with the following specific objectives:

1 Examine the applicability of the cognitive mapping approach for studying risk perceptions.

2 Evaluate farmers' risk perceptions and identify the factors influencing drought and flood risk perceptions.

3 Estimate farmers' risk attitudes and identify factors associated with risk attitude.

4 Compare farmers' risk management strategies in terms of applicability and efficacy.

5 Estimate farmers' willingness to pay for crop insurance.

1.8 Definition of key terms

This thesis applies qualitative and quantitative research methods to analyse risk, risk perception and risk attitude. Accordingly, the key variables and concepts have methodology specific definitions. A more detailed explanation of various terms and concepts has been made in the chapters they appear. Below is a brief glossary of key variables and concepts in general terms.

Risk: refers to a situation with the uncertain possibility of undesirable outcomes, but the probability distribution of such outcomes can be estimated with some accuracy. Risk has two major elements: probability and impact. Probability refers to how often the given outcome is likely to occur, and impact refers to the size of the potential loss. The product of probability and impact is the measure of objective risk. Subjective risk refers to the risk perceived by individuals. The literature has also distinguished between upside and downside risks, the former is the uncertain possibility of gain, and the latter is the uncertain possibility of loss. This thesis focuses on downside risks.

Uncertainty is the felt possibility of an undesirable outcome but with no estimates of probability or potential impact. Uncertainty also refers to the risk factor or source of risk.

Ambiguity is a situation that can be perceived in more than one way. We use uncertainty and ambiguity synonymously to refer to situations where the probability distribution of outcomes is unknown.

Risk perception is a latent construct indicating the subjective evaluation of risk in terms of probability and impact of outcomes. We calculate risk perception as the product of subjective probability and the size of the potential loss. Risk perception also refers to the expectation of loss by individuals.

Expected value is the sum-product of all possible outcomes and their probabilities.

Risk attitude is a personal characteristic, indicating how individuals evaluate risk in terms of a certain outcome. It is also a measure of their risk acceptance or tolerance. The certain amount that provides equal utility as the risk is called the certainty equivalent of the risk. By eliciting the certainty equivalents of a given risk, we can derive individual utility curves and categorise them as risk-neutral, risk-averse or risk-preferring individuals. The certainty equivalent equal to the expected value of the risk indicates risk neutrality, while higher and lower certainty equivalents than the expected value indicate risk preference and risk aversion, respectively.

Risk management is taking action (or sometimes not taking action) to reduce the probability or impact of an undesirable outcome.

Willingness to pay is the maximum value that a consumer is willing to pay for an economic good or service.

1.9 Thesis organisation

This thesis comprises four research papers arranged into four separate chapters along with Introduction, Research Methodology, Literature Review, and Summary and Conclusion chapters. Thus, it has eight chapters.

Chapter 1 (Introduction) establishes the research context, discusses research problems and formulates research objectives. Chapter 2 (Literature Review) presents the review of concepts, theories, methods and findings of previous works relevant to this thesis. Chapter 3 (Research Methodology) discusses the overall methodology applied to achieve the research objectives. The common elements across the individual papers are covered in Chapters 1 to 3 to minimise redundancy. However, some elements, such as sampling design, may reappear in the individual papers to improve the coherence of the content for reading them as stand-alone papers. Each chapter contains a separate reference section. The appendices are presented as a combined section at the end.

Chapter 4 (Paper 1) is based on the qualitative study, which looks at farmers' perceptions of risk, sources of uncertainty, existing management strategies, risk attitude and their willingness to adopt crop insurance. The study uses cognitive mapping techniques to analyse data and present findings. There are two main contributions of this paper. First, it establishes a broad context of farming risk in Nepal, explores farmers' risk perception and attitudes, and prioritises the risks, sources of risk and management strategies from the farmer perspective. Second, the paper validates the applicability of the cognitive mapping approach in the farming context to elicit and analyse attitudinal variables, such as risk perception and attitude, and present the findings concisely. Moreover, the qualitative study's findings were used to develop research concepts and survey instruments for the following quantitative study.

Chapter 5 (Paper 2) is the outcome of the quantitative study, which looks at farmers' perceptions of risks, uncertainties and management strategies. It assesses prevailing risks and uncertainties in farming and ranks risk management strategies using psychometric scaling methods. It also identifies the factors affecting farmers' perceptions of drought and flood risks estimating Tobit regression models.

Chapter 6 (Paper 3) is mainly the outcome of the lottery-choice experiment (LCE). The paper begins with the derivation of the constant relative risk aversion (CRRA) coefficient for each respondent, analysing the choices they made between an equally likely monetary lottery against a series of certain amounts. The paper identifies socio-demographic and individual variables affecting the CRRA and examines the relationship between CRRA and the choice of risk management strategies estimating Multivariate Linear and Probit models.

Chapter 7 (Paper 4) presents the outcome of the discrete choice experiment (DCE) for crop insurance products. The choice alternatives are defined by crop insurance type (loss-based crop insurance and rainfall-index crop insurance), deductible (15%, 20%, and 25%), insurance sum (NPR 60000 and 90000 per ha), and premium price (six levels: NPR 250 to 15000). The DCE followed a block design with six blocks, each having four choice scenarios. A Mixed Logit model with a random distribution of parameters was estimated to analyse the effect of the attributes on the utility of choice alternatives and derive farmers' WTP for crop insurance. The model also includes CRRA values from Paper 3 to examine the effect of risk attitude on farmers' WTP for crop insurance.

Chapter 8 synthesises the conclusions from the four papers and discusses future research directions.

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Chapter 2: Literature Review

The Introduction chapter and individual papers include literature reviews that identify research gaps leading to the formulation of research objectives. This chapter aims to develop a broad understanding of the theories, methodology, concepts, and findings of previous works relevant to this thesis. First, we discuss the theories of human decision-making followed by a review of the relationships between various socio-economic factors, risk perception and risk attitude. Then, we present the importance of managing drought risk in farming. Next, we discuss risk management strategies focusing on crop insurance, the evolution of agricultural insurance, issues in the insurance market, and the government's role in the insurance market. Finally, we present a chapter summary and conclusion.

2.1 Decision theories

There are two contrasting schools of theories describing human decision-making in the presence of risk and uncertainty. The neo-classical economic theories portray humans as '*homo economicus*' (perfectly rational agents) who have a stable preference for the optimal ends based on their subjective evaluation of the attractiveness of competing alternatives (see Becker, 1976). The behavioural economic theories assume that human decisions incorporate systematic errors because rationality is often bounded by heuristics, cognitive biases, and framing effects (see Fox, 2015). Behavioural economics believes that human decisions result from a less deliberate, non-linear, and less controlled process than we assume (Samson, 2014). The landmark contributions in the development of behavioural economics are Simon (1955)'s idea of bounded rationality, Gigerenzer and Goldstein (1996)'s concept of ecological rationality, Kahneman and Tversky (1979)'s prospect theory, and Thaler (1999)'s concept of mental accounting. This thesis aligns with rational choice theories, which are discussed below.

The development of the modern probability theory of human decision-making began in the 17th Century, mainly to solve elite people's gambling problems. Early decision theories (e.g., Blaise Pascal and Pierre de Fermat) assumed that a gamble offering the payoffs $x_1, \ldots, x_n$ with probabilities $p_1, \ldots p_n$ is worth its expected value $\bar{x} = \sum x_i p_i$ (Machina, 1987). However, theorists were not satisfied with the idea of probabilistic expectations because they observed that people consider more than just the expected value in gambling. One of the major contests to the expected value maximization theory is the famous 'St. Petersburg Paradox' presented by Nicolas Bernoulli in 1728, who showed how a gamble worth only a trivial amount can have an infinite expected value (Machina, 1987). Bernoulli (1738) explained this phenomenon with a logarithmic utility function that showed the diminishing marginal utility of wealth. He illustrated that it is not the expected value but the logarithm of expected value (expected utility) that people tend to maximize while gambling. However, Bernoulli (1738) did not suggest any method to measure utility. Much later, von Neumann and Morgenstern (1944) developed four axioms: completeness, transitivity, continuity, and independence, which provided necessary and sufficient conditions for Bernoulli (1738)'s hypothesis. Furthermore, Savage (1954) introduced the concept of personal probability to von Neumann and Morgenstern (1944)'s Expected Utility (EU) model, which is known as the subjective expected utility (SEU) theory. According to the SEU hypothesis, a single value index that combines the decision-maker's VNM utility function and subjective probability distribution, can be used to order the attractiveness of risky alternatives.

Hardaker et al. (2015) suggest that the decision theory based on SEU maximization is equally applicable for both descriptive analysis (explaining how people behave) and prescriptive analysis (advising how people ought to make choices). However, they suspect that the SEU theory may not reliably predict human behaviour in all cases. Other experiments have shown that individuals do not always adhere to Savage axioms. For instance, the 'Allais Paradox' (Allais, 1953) and 'Ellsberg Paradox' (Ellsberg, 1961) are the two most prominent criticisms that challenged the Savage axioms. Popular alternatives to the SEU theory include Kahneman and Tversky (1979)'s 'prospect theory' and Quiggin (1993)'s 'generalised expected utility theory,' which are more helpful in describing behaviour rather than prescribing good choices under risk (Hardaker et al., 2015). Therefore, despite many criticisms, SEU maximization remains the best normative model of human decision-making in the presence of risk.

Based on the SEU theory, researchers developed several methods to measure individual risk perception and risk attitude. These methods are discussed in the relevant papers. In what follows, we discuss earlier findings on the factors determining farmers' risk perception, risk attitude and the effect of these constructs on their decision-making.

2.2 Factors affecting risk perception

The literature has extensively covered the factors underpinning individual variation in risk perception. However, the findings vary across decision domains and study regions, as cited below. While various authors (e.g., Fonta et al., 2015; Gebrehiwot & van der Veen, 2015; van Winsen et al., 2016) reported a negative correlation between age and risk perception, others (e.g., Cohn et al., 1995; Okoffo et al., 2016; Otani et al., 1992) reported the opposite relationship. Similarly, Legesse and Drake (2005) reported a domain-specific relationship between age and risk perception. They found a negative correlation between age and the perception of wind risk and a positive correlation between age and the perception of price risk, while the relationship was non-significant for the perception of other risks. Likewise, Ahsan (2011) and Meuwissen et al. (2001) reported a significant relationship between age and risk perception.

Gender and education are other important variables that have varied associations with risk perception. For instance, while researchers (e.g., Boholm, 1998; Finucane et al., 2000; Karpowicz-Lazreg & Mullet, 1993; Wieland & Sarin, 2012) reported women to have higher risk perception than men, Legesse and Drake (2005) did not find any relationship between gender and risk perception except for the impact of flood and likelihood of disease and pest. Likewise, while Pidgeon (1998) reported a positive correlation between women and risk perception, they argued that sex differences in risk perception might disappear in deprived communities. We are aware of only one study (i.e., Tucker et al., 2013) that found women's risk perception rating lower than men's. Tucker et al. (2013) argued that such sex differences in risk perception might be due to the gendered division of work in farming, with women practising low-risk activities. Similarly, the relationship between education and risk perception has been reported as positive (see Fonta et al., 2015; Gebrehiwot & van der Veen, 2015; Okoffo et al., 2016; Wang et al., 2016), negative (see Legesse & Drake, 2005; Savage, 1993; van Winsen et al., 2016), and non-significant (see Ginder et al., 2009; van Winsen et al., 2016). Ahsan (2011) also reported a significant but varied correlation between education and the perceptions of various risks.

Variables that represent the wealth of the decision-maker also have varied relationships with risk perception. For instance, while many researchers found a negative correlation (e.g., Ginder et al., 2009; Lefebvre et al., 2014; Okoffo et al., 2016; Santeramo et al., 2016) and Lucas and Pabuayon (2011) found a positive correlation between farm size and risk perception, van Winsen et al. (2016) found a non-significant result. Three authors (Gebreegziabher & Tadesse, 2013; Gebrehiwot & van der Veen, 2015; Ullah et al., 2015) reported a positive correlation between the scale of farming and risk perception, while Legesse and Drake (2005) reported a negative relationship between the number of plots and the perception of drought and disease risk. Similarly, Legesse and Drake (2005) found asset level positively associated with the perceptions of institutional, market, land scarcity, flood, weed, and human risks, while asset level was negatively associated with the perceptions of drought risk and disease/pest risks. Patt and Schroter (2008) also suggested an endowment effect on risk perception, implying that we fear losing things we own more than we do not.

Similarly, Legesse and Drake (2005) found a positive association of risk perception with access to information and infrastructure. They argued that such access makes them dependent on these facilities, leading to higher risk perceptions related to the facilities. Other variables that have positive associations with risk perceptions include land ownership (see Ahsan, 2011), full-time involvement in farming (see Ahsan, 2011), promotional campaigns about risk management (see Ginder et al., 2009; van Winsen et al., 2016; Wang et al., 2016), perception of climate change (see Falco et al., 2014; Fonta et al., 2015) and proximity to the sources of risk (Brody et al., 2008). Likewise, other variables that negatively influence risk perception include family size (see Fonta et al., 2015; Legesse & Drake, 2005; Okoffo et al., 2016), distance to market (see Lefebvre et al., 2014), and geographic location (see Legesse & Drake, 2005).

2.3 Determinants of individuals' risk attitudes

While studies have extensively explored the factors that explain the variation in individuals' risk attitudes, the results are not consistent across studies or regions. These factors are discussed below in two broad categories: individual characteristics and socio-economic factors.

2.3.1 Individual characteristics

Individual characteristics include the variables related to intrinsic attributes such as gender, age and education. Among these, gender is the most widely studied variable for its potential association with risk attitude. For instance, in a meta-analysis of 150 studies conducted from 1967 to 1997, Byrnes et al. (1999) concluded that women are more risk-averse than men. While many studies reported females as more risk-averse than males (e.g., Brick et al., 2012; Croson & Gneezy, 2009; Eckel & Grossman, 2002, 2008; Hermann & Mußhoff, 2017; Nielsen et al., 2013; Weber et al., 2002; Ye & Wang, 2013), others reported a non-significant correlation between gender and risk attitude (e.g., Harrison et al., 2007; Schubert et al., 1999). In Holt and Laury (2002)'s experiment, females showed higher risk aversion than males at low payoff lotteries, but the gender difference disappeared at high payoff levels.

Similarly, the variables that represent decision-makers' age have varied associations with their risk attitudes. While several authors reported a positive association between age and risk aversion (e.g., Hallahan et al., 2004; Nielsen et al., 2013; Tanaka et al., 2010; van Winsen et al., 2016; Vroom & Pahl, 1971) and Ullah et al. (2015) reported the opposite result, many authors found risk attitude and age uncorrelated (e.g., Holt & Laury, 2002; Picazo-Tadeo & Wall, 2011; Ye & Wang, 2013). Some researchers have examined the association of farming experience with risk attitude. For instance, three studies found a positive correlation between farming experience and risk aversion (Iqbal et al., 2016; Ullah et al., 2015), whereas Ye and Wang (2013) reported mixed results across study groups.

Education is another important attribute of individuals that influences their risk attitude. For instance, while many authors found individuals' risk aversion increased with increasing education level (e.g., Bar-Shira et al., 1997; Harrison et al., 2007; Tanaka et al., 2010; Ullah et al., 2015), others found the opposite result (e.g., Hartog et al., 2002; Iqbal et al., 2016; Moscardi & De Janvry, 1977; Nielsen et al., 2013; Shapiro & Brorsen, 1988; Ullah et al., 2015; Velandia et al., 2009). Anderson and Mellor (2009) and Nielsen et al. (2013) found risk attitude unaffected by education. Ye and Wang (2013) also reported a non-significant correlation between education and risk attitude, while such a relationship was positive for freelancers. In addition to measuring the education variable, researchers have examined the correlation between respondents' numeracy skills or cognitive abilities with their risk attitudes. For instance, three authors reported a negative correlation between cognitive ability and risk aversion (e.g., Benjamin et al., 2013; Dohmen et al., 2010; Frederick, 2005), whereas Sherman (1974) found a similar result for ambiguity aversion. Likewise, Dohmen et al. (2010) reported that farmers' risk aversion decreases with increasing intelligence.

2.3.2 Socio-economic factors

Socio-economic factors include variables that characterise the decision-makers' wealth or income status, family structure and social capital. Among these variables, wealth is the most widely discussed variable influencing risk attitude. The classical theories of absolute risk aversion (ARA) and relative risk aversion (RRA) derive risk aversion coefficients as a ratio of derivatives of the utility function with respect to wealth (Arrow, 1965; Pratt, 1964). Consistent with the theory of decreasing ARA, many studies reported that individuals' risk aversion decreased with increasing wealth (e.g., Binswanger, 1980; Hamal & Anderson, 1982; Holt & Laury, 2002; Tanaka et al., 2010; Wik et al., 2004; Ye & Wang, 2013; Yesuf & Bluffstone, 2009). However, the findings of Cohen and Einav (2007) and Dohmen et al. (2011) contradict the theory. Nielsen et al. (2013) also found that individuals from the middle-wealth group were risk-preferring, while those from the poorest and wealthiest groups were risk-averse to the lottery used in the experiment. Two studies (Brick et al., 2012; Mosley & Verschoor, 2005), along with Binswanger (1980) at high payoff levels, also reported that individuals' risk attitudes were not associated with their wealth.

Researchers have also used farm size, income and social capital as proxies for wealth because measuring household wealth is not straightforward. Nevertheless, the association between these variables and risk attitude is ambiguous. For instance, while three studies found a positive correlation between landholding size and risk aversion (Iqbal et al., 2016; Lucas & Pabuayon, 2011; Ullah et al., 2015), Feder (1980) and Velandia et al. (2009) reported the opposite results. Similarly, the correlation between income and risk aversion was positive (see Cohen & Einav, 2007; Iqbal et al., 2016), negative (see Ullah et al., 2015), and non-significant (see Tanaka et al., 2010). Likewise, Hellerstein et al. (2013) found that farmers' risk aversion increased with increasing share of farm income in total income. In contrast, social capital (Steer & Sen, 2010), including linkage with authority and involvement in social organisations (Nielsen et al., 2013), was negatively associated with risk aversion. Other socio-economic factors, such as family size and dependency ratio, have varied associations with individuals' risk attitudes. For instance, three studies reported a positive correlation between risk aversion and family size (Lucas & Pabuayon, 2011; Ullah et al., 2015; Ye & Wang, 2013), while others reported limited relationship between the same (e.g., Binswanger, 1980; Ye & Wang, 2013; Yesuf & Bluffstone, 2009). Likewise, while Hallahan et al. (2004) and Dohmen et al.

(2011) found that an individual's risk aversion increased with increasing number of dependents, Picazo-Tadeo and Wall (2011) found a non-significant relationship between the same variables.

2.4 Relationship between risk experience, risk perception and risk attitude

The literature does not have a consensus on the correlation between past exposure to risk and risk perception. For example, van Winsen et al. (2016) and Menapace et al. (2016) found a positive correlation between past risk exposure and risk perception, while Slovic (1987) argued that familiarity with risk decreases risk perception because people feel that they have more control over the risks when they are more familiar with it. More importantly, the correlation between risk perception and risk aversion is ambiguous. For instance, while several authors reported a positive correlation between risk perception and risk aversion (e.g., Cho & Lee, 2006; Keil et al., 2000; Nielsen et al., 2013; Sitkin & Pablo, 1992), Weber and Hsee (1998) reported a negative relationship and van Winsen et al. (2016) found risk perception and risk aversion uncorrelated.

2.5 Relationship between risk attitude and risk management

A large body of literature has shown that farmers' attitude determines real-life behaviours, such as farm diversification, income diversification, technology adoption, investment, loan taking and insurance purchase, but to varying degrees. For instance, Marra and Carlson (1990) reported that land allocation for double cropping (wheat/soybean) compared to single cropping (wheat) increased with increasing risk aversion. Chavas and Holt (1996) also found a positive association of risk aversion with mixed cropping practices. Likewise, Nielsen et al. (2013) found that cropping pattern was significantly associated with farmers' risk attitude. In contrast, Engle Warnick et al. (2011) reported a negative correlation between risk aversion and crop varietal diversification in Peru, while such diversification was not associated with ambiguity aversion. A study conducted by Hellerstein et al. (2013) is also noteworthy in this context. They used the number of risky choices and coefficient of constant relative risk aversion as measures of risk aversion, but these measures could not predict farming decisions. Then, they constructed a coarser dummy measure of risk aversion that predicted many farming decisions but mostly in unexpected directions. Similarly, while three studies reported the proportion of off-farm income increased with an increase in farmers' risk aversion (Kyle, 1993; van Winsen et al., 2016; Ye & Wang, 2013), Goodwin and Mishra (2004) found off-farm labour supply uncorrelated with farmers' risk attitude.

Farmers' risk attitude has also been linked to the adoption of modern farming technologies (Marra et al., 2003), including the adoption of high-yielding varieties (Smale et al., 1994) and choice of farm inputs (Gong et al., 2016). Various authors (e.g., Feder & Umali, 1993; Knight et al., 2003; Leathers & Smale, 1991; Lindner et al., 1982; Tsur et al., 1990) reported that technology adoption decreased with increasing farmers' risk aversion (see also Marra et al., 2003 for a more detailed review). Similarly, Liu (2013) reported that the adoption of BT cotton was negatively associated with both risk aversion and loss aversion of Chinese farmers. In contrast, Engle Warnick et al. (2011) found such adoption uncorrelated with Peruvian farmers' risk attitude. Similarly, while risk aversion had a positive association with pesticide use on cotton in China, ambiguity aversion had a negative association (Liu & Huang, 2013). Likewise, although the association of Nepali farmers' risk aversion was negative with technology adoption at the low-income level, such an association disappeared as farmer wealth increased (Hamal & Anderson, 1982). Another unusual finding (as noted by the authors) in this context is that of Barham et al. (2014), who used the experimental measures of risk aversion and ambiguity aversion to explain the adoption lag for genetically modified (GM) corn and soybean in the USA. They reported a strong positive correlation between ambiguity aversion and the timing of GM corn adoption, while the same was not correlated with the adoption lag for GM soybean. Similarly, risk aversion had a weak positive association with the adoption timing of GM soybean, but the same had no correlation with the adoption lag for GM corn.

Risk aversion intuitively refers to the willingness to manage risk. This intuition is supported by numerous studies that found a positive correlation between risk aversion and the adoption of risk management tools. However, several counterintuitive findings also exist in the literature. For example, risk aversion was negatively correlated with the adoption of risk-reducing behaviours (Holden & Quiggin, 2017), uptake of insurance (Hellerstein et al., 2013; Just et al., 1999; Menapace et al., 2016), willingness to pay for insurance (Ye & Wang, 2013) and adoption of market-based risk management products (Flaten et al., 2005; Hellerstein et al., 2013; Menapace et al., 2016). Farmers' risk attitude also influences their decisions related to market risk management. For example, farmers' risk aversion had a positive association with the use of futures contracts (Pennings & Garcia, 2001) and the acquisition of loans from informal sources (Jacobson & Petrie, 2009). However, Pennings and Garcia (2001) reported that applying other financial mechanisms to reduce market risks was not associated with farmers' risk aversion. Binswanger (1980) also found farmers' investment behaviour uncorrelated with their risk attitude but negatively associated with constraints in credit, marketing and extension facilities.

2.6 Flood risk in farming

The online Glossary of Meteorology published by the American Meteorological Society (2019) defines drought as *"overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas that are not normally submerged".* Flooding is one of the major abiotic constraints to crop production worldwide, resulting in substantial economic loss. About 14% of the global rice area (approximately 22 million ha) is unfavourably submerged annually, affecting the livelihood of more than 100 million people (Singh et al., 2016). About 10% rice area in Nepal is prone to flood during the early and middle stages of crop growth (Yadaw et al., 2017). Although rice plants require a large amount of water, flooding results in an anaerobic environment leading to severe crop loss (Debabrata & Jijnasa, 2021). The effect of flooding is more detrimental in improved rice varieties because most of them are susceptible to submergence stress (Afrin et al., 2018). The frequency and intensity of floods have increased in recent years as a consequence of climate change and anthropogenic activities.

2.7 Drought risk in farming

The American Meteorological Society (2019) defines drought as *"A period of abnormally dry weather sufficiently long enough to cause a serious hydrological imbalance".* In the context of agriculture, it defines drought as *"the conditions that result in adverse crop responses, usually because plants cannot meet potential transpiration as a result of high atmospheric demand and/or limited soil moisture".* Drought occurs mainly when the rainfall frequency or amount falls significantly below an average level (Dai, 2011). World Bank (2015) points out five conditions that indicate drought: delayed onset of the rainy season, early termination of the rainy season, prolonged periods without rainfall or erratic rainfall distribution, deficit in cumulative rainfall over the cropping season, and soil moisture deficit during critical stages of crop growth. As compared to other climatic hazards, drought often has a slower and quieter onset, develops more steadily, covers a broader geographical area, and may linger for longer (Dahal et al., 2016; Di Lena et al., 2014; Mishra & Singh, 2010; Rossi et al., 1992).

Among weather-related risks, drought is considered the most critical because of its high prevalence and detrimental effects on crop production, which challenges the macroeconomic objectives of global food security, poverty reduction, and environmental protection (Dar et al., 2020; Hill et al., 2019; Kyle et al., 2016; Pandey et al., 2007; Ward et al., 2020). Many historical crop production disasters in different parts of the world have been attributed to low rainfall leading to droughts (see Dahal et al., 2016; Friend et al., 2005; Funk, 2011; Krishna Kumar et al., 2004; Lobell & Burke, 2008; Sivakumar et al., 2005; Wong et al., 2010). Globally, the drought-prone area under major food crops, including rice, maize, wheat, soybean and barley, has increased from 5–10% to 15–25% since 1960 (Jemma et al., 2010).

Drought has more detrimental effects on rice than other crops because it is a semi-aquatic plant (Fukao et al., 2011). Moisture deficit can cause severe damage at any stage of crop growth leading to partial or complete yield loss (Yugi et al., 2014). Only about half of the rice area in Asia is irrigated (Bailey-Serres et al., 2010; Huke & Huke, 1997), which implies that the remaining half is vulnerable to drought risk at some stage of crop growth. Similarly, more than two-thirds of the rice area in Nepal is rainfed (Bagazonzya et al., 2009), which indicates a high vulnerability to drought. A more alarming concern about drought is that it will intensify in the 21st Century in most parts of the world (IPCC, 2014). This thesis considers crop insurance, particularly rainfall-index insurance, as an option for mitigating drought risk in rice farming and examines its relevancy in terms of farmers' willingness to pay for it (Chapter 7).

2.8 Risk management

OECD (2009) defines risk management as a broader risk governance framework comprising three major steps: risk assessment and evaluation, risk management and risk communication. Risk assessment involves quantifying risks in terms of the product of frequency and likely impacts of a given risk, whereas risk evaluation involves prioritising risks based on the risk assessment and societal risk attitude or risk tolerance level. The study of farmers' risk perception and attitude is of utmost importance to accomplish the first stage of the broad risk management framework. Risk management is the application of appropriate measures by farmers and other relevant institutions to reduce, control or regulate risks. The selection of a proper risk management strategy is based on the economic analysis of potential risk management options compared to self-insurance. A farmer's decision to select an appropriate strategy depends on their risk exposure and risk attitude. Similarly, risk communication is the sharing of experience and information about risk and management between farmers, policymakers and other relevant stakeholders. Selection of an appropriate risk management strategy is important and the most complex decision that farmers have to make, which determines the viability and sustainability of farm business (Coble et al., 2000; Ke & Wang, 2002).

2.8.1 Classification of risk management strategies

Risk management involves two main strategies: reducing loss exposure or handling the consequences of adverse outcomes once they occur. A third strategy is not taking any action or taking risk (Hoag, 2010). Nevertheless, risk management strategies have been classified on several bases, as discussed below.

Jafee et al. (2010) classify risk management strategies into ex-ante and ex-post strategies based on when the actions are taken. Ex-ante strategies include the measures applied beforehand to reduce the chances of adverse outcomes and advance arrangements for coping with potential adverse outcomes (e.g., using pest-resistant crop varieties, crop insurance and monetary saving). In contrast, ex-post strategies include the actions undertaken to cope with adverse outcomes after they occur (e.g., selling assets, seeking temporary employment and migration).

Similarly, OECD (2009) classifies risk management strategies into policies and programs implemented by the government, solutions or products supplied by the market, and farm-level actions taken by farmers. Likewise, FAO (2014) classifies risk management strategies into formal and informal strategies. Informal strategies include actions taken by farming households or communities, whereas formal strategies include market-based options or public interventions. Many rural farming households in the Asia-Pacific region practice informal risk management strategies mainly because market-based risk management solutions do not exist (FAO, 2014). Such informal strategies may not provide complete protection against high-impact weather-related risks such as floods and drought. Farm diversification is an example of an informal risk management strategy practised by farmers. However, diversifying investment into several activities to reduce risk often results in low returns (ILO, 2006). Another popular informal strategy to avoid drought risk is the use of local varieties, which are usually resistant to multiple stresses, but the production potential of most of these varieties is low (FAO, 2014).

Based on the objectives, Holzmann and Jorgensen (2001) categorise risk management strategies into risk-reducing, mitigating and coping strategies. Risk-reducing strategies, such as seed treatment to prevent seed-borne diseases in rice crops, involve preventive measures to reduce the probability of risk exposure or magnitude of loss. Risk mitigating strategies include measures such as insurance, which help reduce the potential consequence of risk. Risk coping strategies, such as disaster relief payment, help deal with the consequences once the adverse event has occurred. Prevention and mitigation of risks smoothen income, whereas coping with risks involves consumption smoothening (OECD, 2009).

Among the classifications of risk management strategies available in the literature, we found Rejda and McNamara (2014)'s classification (Figure 2.1) applicable to our analysis of farmers' risk perceptions because we also measured risk perceptions in terms of the probability and severity of the loss. In Chapter 5, we use their risk assessment matrix to examine the applicability of crop insurance against drought and flood based on farmers' perceptions of probability and potential loss associated with these risks.

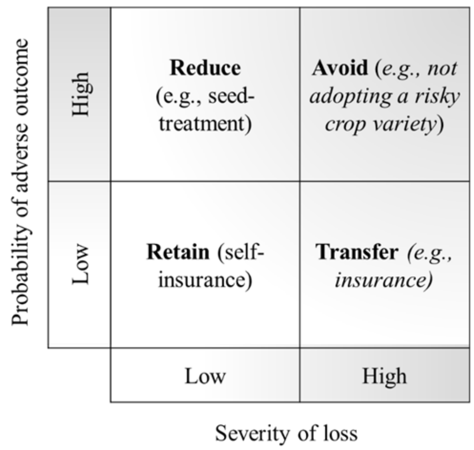

Figure 2.1 Risk assessment matrix used for evaluating insurability of farming risk
Note: Adapted from Rejda and McNamara (2014)

2.8.2 Evolution of agricultural insurance

Although crop-hail insurance started in Germany as early as the late 1700s through small mutual companies (Smith & Glauber, 2012), public involvement in the agricultural insurance industry began in 1938 when the American Congress approved the ‘Federal Crop Insurance Program’ under the ‘Agricultural Adjustment Act’(Joseph, 2013). The value of global agricultural insurance premium tripled from USD 10.2 billion in 2006 to 30.7 billion in 2017, indicating a rapid growth of the agricultural insurance market (see Hohl, 2019). More than half of the countries worldwide had some form of agricultural insurance in 2010 (Mahul & Stutley, 2010). According to FAO (2011), the main reasons for the rapid growth of the agricultural insurance market, especially in developing countries, are increasing global food demand and price, increasing production risks due to climate change, and government preferences for insurance over disaster relief payment. The change from public-funded programs to public-private partnership programs and the emergence of innovative insurance products, such as index-based insurance, especially targeting smallholder farmers, are major transformations that the agricultural insurance industry have experienced in the past three decades (Hohl, 2019).

Nepal’s history of insurance services dates to 1937, when the government of Nepal established Nepal Bank Limited, the first bank of Nepal (Investopaper, 2020). The insurance services were mainly started to safeguard the loans provided by the bank. Indian insurance companies used to provide non-life insurance services in Nepal before the establishment of the first Nepalese insurance company in 1947 called Nepal Malchalani Tatha Beema Company, later named as Nepal Insurance Company Limited. Life insurance services started in 1968 when the Government of Nepal established the first Nepalese insurance company called “Rastriya Beema Sansthan” (Investopaper, 2020). After the restoration of democracy in 1990, the government adopted a liberal economic policy allowing several life and non-life insurance companies to be established. Currently, there are 19 life insurance and 20 non-life insurance companies in the Nepalese insurance market (Singh, 2021). In 2020, insurance companies collected 152 billion NPR premiums altogether, with the life insurance sector sharing about 80% of the total premium (Investopaper, 2021).

The chronology of the development of agricultural insurance in Nepal was comprehensively reviewed by Bagazonzya et al. (2009) and Bhushan et al. (2016). According to these reviews, the history of non-regulated livestock insurance in Nepal dates to 1987 when the Central Bank of Nepal and Deposit Insurance and Credit Guarantee Corporation jointly implemented all-risk livestock insurance schemes, particularly to protect commercial banks’ lending to small farmers to purchase livestock. Simultaneously, Small Farmer Cooperative Limited, Community Livestock Development Program and Centre for Self-Help Development started separate livestock insurance programs. Similarly, crop insurance was introduced in 2007 as pilot programs in selected areas through farmers’ multi-purpose cooperatives in collaboration with the Department of Agriculture. Amid many challenges, these early initiatives indicated significant demand for both livestock and crop insurance. Therefore, upon a joint request from the Ministry of Finance, Ministry of Agriculture and Livestock Development (the then Ministry of Agriculture and Cooperatives), and Insurance Board, the World Bank conducted a feasibility study on agricultural insurance in 2009. Mainly based on the recommendations of their study, the Government of Nepal enacted Agriculture Insurance Directives in 2013, which facilitated the development of livestock and crop insurance products.

2.8.3 Agricultural insurance products

The insurance market offers a range of agricultural insurance products. We focus on two major crop insurance products: loss-based insurance (LBI) and weather-index insurance (WII). Some forms ofLBI are already available in Nepal, and the government has shown interest in introducing WII.

2.8.3.1 Loss-based insurance

LBI is a traditional form of insurance in which the insurer pays a specified indemnity to the insured party according to the assessment of actual yield loss (Diersen et al., 2015). Multi-peril crop insurance (MPCI) and named-peril crop insurance (NPCI) are the two most popular LBI products in the Asia-Pacific region (FAO, 2011). MPCI is popular because it provides loss protection against all perils, including climatic, natural and biological adverse events. NPCI is a demand-based insurance product covering losses due to a specific adverse event, named when underwriting the contract. NPCI is suitable in areas where farmers have a higher perception of a particular risk. Despite being the most straightforward and easy-to-implement instrument, the uptake of LBI is low worldwide (FAO, 2011). Moral hazards and adverse selection are two major issues in the LBI market (Diersen et al., 2015). Similarly, the systemic nature of weather-related risks and high-premium rates are major constraints to the economic feasibility of LBI (FAO, 2011). Because it requires individual loss verification, the operational cost of LBI is so high that only a small part of the premium is left for indemnity payment (Carter et al., 2015). These facts indicate that LBI is not an ideal solution for smallholder farmers.

2.8.3.2 Weather-index insurance

Recently, WII has received the growing attention of donors, policymakers, and insurance companies as a more convenient option than LBI to mitigate weather-related farming risks in developing countries (Alan & Hendrik, 2011; Hill et al., 2019; Odening & Shen, 2014). WII involves an index derived using one or more weather variables to indicate indemnification or production loss (Barnett & Mahul, 2007). The variables used to construct the index should be highly correlated with crop yield (Diersen et al., 2015). A pre-defined yield or loss distribution model, with the index as the explanatory variable, is used to decide whether indemnification is made (Barnett & Mahul, 2007). A long-term average of the weather variable is used as the reference value, and the deficit or excess on the reference value recorded over a specified period is used to determine the indemnification (Barnett &

Mahul, 2007). A threshold level of the deficit or excess on the index value is set as a trigger point for policy activation, and the indemnification per unit index value increases as the deficit or excess increases (Barnett & Mahul, 2007; FAO, 2011). Rainfall-index insurance (RII) is the most popular WII, which is more suitable for drought than other risks (FAO, 2011).

WII offers the following major advantages over LBI (Barnett & Mahul, 2007; Carter et al., 2015; FAO, 2011; Odening & Shen, 2014):

- Insurance contract is simple, and operational cost is low
- Indemnification is fast because loss verification is not required
- Indemnification is based on a measured value of the index, saving the cost for loss estimation
- Information asymmetry is not an issue, eliminating the scope for adverse selection
- No issue of moral hazard because insured agents do not have any control over the index
- Unlike traditional insurance products, insurance companies need not hire agricultural experts because crop monitoring and loss assessment are not required.

Moreover, FAO (2011) suggested three potential contributions of WII in the process of climate change adaptation in developing countries: (1) can be a major risk transfer component of the comprehensive climate change adaptation strategy; (2) can help build a more resilient farming system, increasing farmers' financial capacity, enabling them to invest in resilient crop production technologies and productive inputs; (3) can be bundled with climate-resilient technology, keeping a mandatory condition that the insurance beneficiaries use recommended farming practices or technologies, such as drought-resistant crop varieties, to accelerate the climate change adaptation process.

Demerits of weather-index insurance

The advantages of WII come at the cost of 'basis risks' that arise from the imperfect correlation between crop loss distribution and the index (Adeyinka et al., 2016; Alan & Hendrik, 2011; Odening & Shen, 2014; OECD, 2009; Woodard & Garcia, 2008). The greatest strength of index insurance, i.e., using an index for indemnification, can also be its greatest weakness if the index is weakly correlated with loss distribution at the farm level (Hill et al., 2016). Basis risk is the difference between the indemnity payoff suggested by the index model and actual yield loss at the farm level (Mario & Katie, 2012; Woodard & Garcia, 2008). There are two types of basis risk associated with WII (Barnett & Mahul, 2007; Muneepeerakul et al., 2017). First, production basis risk (also called technical or local basis risk) indicates imperfect correlations between weather index and crop yield. Apart from the climatic factor on which the index is based, crop yield depends on several non-climatic factors such as insect or disease infestation, weed infestation, varietal performance, input use, and other management practices (Barnett & Mahul, 2007). For instance, Odening et al. (2007) showed that cumulative rainfall predicted less than 25% of the variation in wheat yield in Germany. Second, geographical or spatial basis risk arising from the imperfect covariance between the conditions at the reference station and the crop field (Barnett & Mahul, 2007; Muneepeerakul et al., 2017; Odening & Shen, 2014).

Researchers have suggested several ways to deal with basis risk. Some spatial basis risk can be mitigated by designing the index more carefully and increasing the density of weather stations (Odening & Shen, 2014). Using an insurance portfolio comprising different contracts for different locations is an alternative method for dealing with spatial basis risk (Berg & Schmitz, 2008; Woodard & Garcia, 2008). For instance, a case study in Germany showed a 20–40% reduction in spatial basis risk when the portfolio insurance-based multi-site rainfall model was compared with a single-site model (Ritter et al., 2012). WII works well in areas where the dominant cause of crop loss is a specific weather variable (Barnett & Mahul, 2007). Therefore, identifying appropriate target areas for a given WII is an important consideration for its success.

2.8.4 Limitations in the agricultural insurance market

The systemic nature of weather risk is the leading cause for crop insurance market failure unless appropriate arrangements for transferring such risks, such as re-insurance, are put in place (Duncan & Myers, 2000; Mario & Joseph, 1997). Weather risks often violate the requirements for insurability because most weather risks are systemic; estimating actuarially fair premiums is difficult due to volatile weather variables leading to non-stationary yield distributions and lack of sufficient data on yield and weather hindering estimation of reliable loss distributions (Odening & Shen, 2014). Moreover, crop insurance markets in developing countries are constrained by small farm size, limited farm record keeping, substantial loss estimation costs, and considerable scope for moral hazard and adverse selection (Hazell et al., 1986). The success of crop insurance in the context of the subsistence farming system is also constrained by low levels of resource-poor farmer knowledge and awareness of risk and insurance, low affordability, and the need to develop a widespread supply channel in the face of low demand (FAO, 2011). Furthermore, insurance is not a panacea that can overcome all risks in farming. It only addresses production risks until the crop is harvested and does not extend to downstream sources of risks such as post-harvest risks, including storage loss and market risks (FAO, 2014). Therefore, agricultural insurance cannot replace sound risk management and should be promoted only by providing essential services such as training and extension, timely input supply, and appropriate arrangement for output marketing (Mahul & Stutley, 2010).

Adverse selection and moral hazard

Underwriting insurance contracts involves specifying the premium rate and all terms and conditions related to the loss estimation process—a threshold level of loss that triggers the insurance policy—and the indemnification process. Information sharing plays a vital role in the insurance market because information asymmetry between farmers and insurers results in adverse selection (He et al., 2019; Knight & Coble, 1997; Quiggin et al., 1993). Due to insurers' lack of information on the actual risk of insuring individuals, the insurance market relies on a generalised measure of risk, selling its crop insurance products at an average premium price. Low-risk individuals will gradually discontinue their contracts when they realise that they are paying more than they should. Consequently, the insurance market is left with high-risk individuals who pay less but are likely to claim more. Such a situation is known as adverse selection (Shiva & Agapi, 2001).

Moral hazard is the lack of incentives for insured agents to prevent loss once the loss has been insured (Diersen et al., 2015). It is more pronounced when several production factors are within the farmer's control, and the losses depend on how well the farm is managed (Alizadeh-Masoodian & Nomikos, 2005). In the Philippines, He et al. (2019) reported that farmers with the cost-of-production insurance invested more on inputs that increase production costs or indemnity amounts and less on inputs that increase productivity but are not entered into the indemnification formula, thus signifying the prevalence of moral hazard. Another study conducted by Quiggin et al. (1993) in the USA found that insured farmers used fewer inputs and had lower yields than uninsured farmers.

Implementing actuarial insurance pricing mechanisms, such as 'bonus-malus incentives' and risk-sharing between the insurer and insured party through 'deductible', are some of the strategies for dealing with adverse selection and moral hazard in the insurance market. Rejesus et al. (2006) suggested that a performance-based premium discounting system could address both issues, improving the actuarial soundness of the crop insurance market. They noted that the existing low-risk participants, who are likely to leave the market when they realise that they are being overcharged, would continue if they receive a premium discount for low loss exposure. Likewise, non-participating low-risk farmers would be motivated to enter the market due to the possibility of a premium discount for their better-than-average performance potential. They further noted that long-term incentives for maintaining a good production record could outweigh short-term incentives for moral hazard.

2.8.5 Government's role in the agricultural insurance market

A high vulnerability of agriculture to weather-related risks indicates the general demand for risk management products, such as insurance. However, the agricultural insurance market is a quasi-market that does not function well without government support (OECD, 2009). Crop insurance does not work effectively in isolation and is not a promising solution for subsistence farmers unless the premium is heavily subsidised (FAO, 2011). The adoption of unsubsidised crop insurance is low even in developed countries. For example, less than 1% of German farmers buy unsubsidised crop insurance despite high-risk perceptions, while farmer participation in the USA, Canada, and some EU countries is high because of massive subsidies of insurance premiums (Odening & Shen, 2014). Agricultural insurance schemes in most countries are government programs, except in countries such as Australia and New Zealand, where the government's role is minimal (FAO, 2011). Premium subsidies are the most common feature of crop insurance markets across the world.

Information asymmetry and difficulty monitoring farmer behaviours lead to adverse selection and moral hazard in the insurance market (Mahul & Stutley, 2010). The government can facilitate information generation on weather patterns, insects, or disease prevalence through research (OECD, 2009). The government can also facilitate sharing information between farmers and insurers, which overcomes information asymmetry (OECD, 2009). The government's extension network can provide technical assistance to farmers and monitor their behaviours, which helps reduce the moral hazard (Mahul & Stutley, 2010).

Insurance companies in developing countries have limited access to international re-insurance markets. Moreover, such international re-insurance companies are less interested in engaging with insurance companies in developing countries that often provide insurance to small businesses. The government can play an important role in assisting insurance companies in accessing the international re-insurance market (Mahul & Stutley, 2010). Moreover, overcoming market and regulatory impediments is necessary to attract insurance and re-insurance companies into the agricultural insurance market.

The need for high-quality weather data and sophisticated infrastructure are major challenges for developing and implementing WII in developing countries (FAO, 2011). Governments, donors and international agencies can facilitate the development of the WII system by establishing a regulatory framework, assessing demand, generating and managing required data, training insurance providers, educating farmers, funding piloting of the insurance products, and providing a level of re-insurance support (Barnett & Mahul, 2007). The government can also help raise farmers' risk awareness and educate them about the concept and benefits of farm insurance, which will increase demand (Mahul & Stutley, 2010).

2.9 Summary and conclusion

Understanding farmers' risk perceptions, attitudes towards risk and decision-making is an ongoing research topic in agricultural economics. There are two contrasting theories to explain human decision-making in the presence of risk. The first is the rational choice theory, which assumes humans are expected utility-maximising agents. The second is behavioural economic theory, which assumes that human decisions incorporate systematic errors due to bounded rationality, cognitive heuristics and framing effects. While the behavioural economic theory helps describe human behaviour, the rational choice theory is equally helpful in understanding human choices and advising how they ought to make choices. Therefore, rational choice theory dominates the decision analysis in various fields. Based on the expected utility maximisation theory, an extensive body of literature has analysed farmers' risk perceptions, risk attitudes and management decisions. However, the relationships between these variables are not consistent across regions, studies and decision domains. This inconsistency indicates the need for a separate analysis of these variables to understand farmer behaviour in each context.

The literature review revealed that drought is the most critical weather-related risk, in global and Nepalese contexts, due to its detrimental effects on crop production and the national economy. A more alarming concern is that the prevalence and intensity of drought are predicted to increase due to climate change. Therefore, managing drought risk is of utmost importance not only for the income stability of farming communities but also for the sustainable growth of Nepal's rural and national economies. Crop insurance can be an important tool for mitigating drought risk in farming and supporting climate change adaptation initiatives.

The agricultural insurance market has many limitations. Due to information asymmetry between farmers and insurance companies, the traditional LBI products suffer moral hazard and adverse selection issues. Likewise, lack of data and insufficient infrastructure result in a poor weather index, which leads to high basis risk in the case of WII. Moreover, systemic weather risks often violate the requirements for insurability criteria. The systemic nature of weather risks also justifies the need for public support in the insurance market. The government can play a crucial role in establishing a thriving crop insurance market by providing premium subsidies and re-insurance support, facilitating information generation and sharing, removing policy hurdles for attracting insurance and re-insurance companies into the market, and educating farmers on the benefits of insurance to increase demand.

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Chapter 3: Research Methodology

This chapter presents the overall methodology used to achieve the research objectives, with specific methods detailed in the individual papers.

3.1 Research design

This study aligns with pragmatism from ontological and epistemological perspectives and follows the abductive research approach using a mixed-methods research design comprising qualitative and quantitative phases in a sequence (Saunders, 2012). The qual=>QUAN design (uppercase letters indicate higher priority and arrow indicates the method sequence) is also called exploratory sequential design, where the qualitative study identifies the themes describing the situational contexts of the issue under study and the follow-up quantitative study tests or confirms the qualitative results (Plano Clark & Ivankova, 2016). The exploratory mixed-methods research design is suitable for studying farming risk in Nepal because it is a relatively less studied topic and relevant variables are not well-known. Such a design is useful for exploring a broad background of the issue using qualitative methods and examining the generalizability of emerging hypotheses to the population using quantitative methods (see Creswell & Plano Clark, 2011). The qualitative results also inform the development and implementation of quantitative methods and survey instruments (Plano Clark & Ivankova, 2016).

The study used primary cross-sectional data collected through interviews and experiments. The qualitative part involved open-ended and in-depth conversational interviews for data collection and cognitive mapping techniques for analysis. The quantitative survey was conducted from October 2018 to January 2019 using a pre-tested questionnaire comprising semi-structured questions to measure socio-demographic variables, psychometric scaling questions to measure perceptions of risk and uncertainties, lottery-choice experiment to measure risk attitude, and discrete choice experiment to measure willingness to pay for crop insurance. The quantitative data were analysed using a descriptive approach, risk mapping and regression analyses. The first paper is the outcome of the qualitative study, which directly contributes to objectives 1, 2 and 4 and indirectly to 3 and 5 as well. Three quantitative papers contribute to one or more objectives, as shown in Figure 3.1.

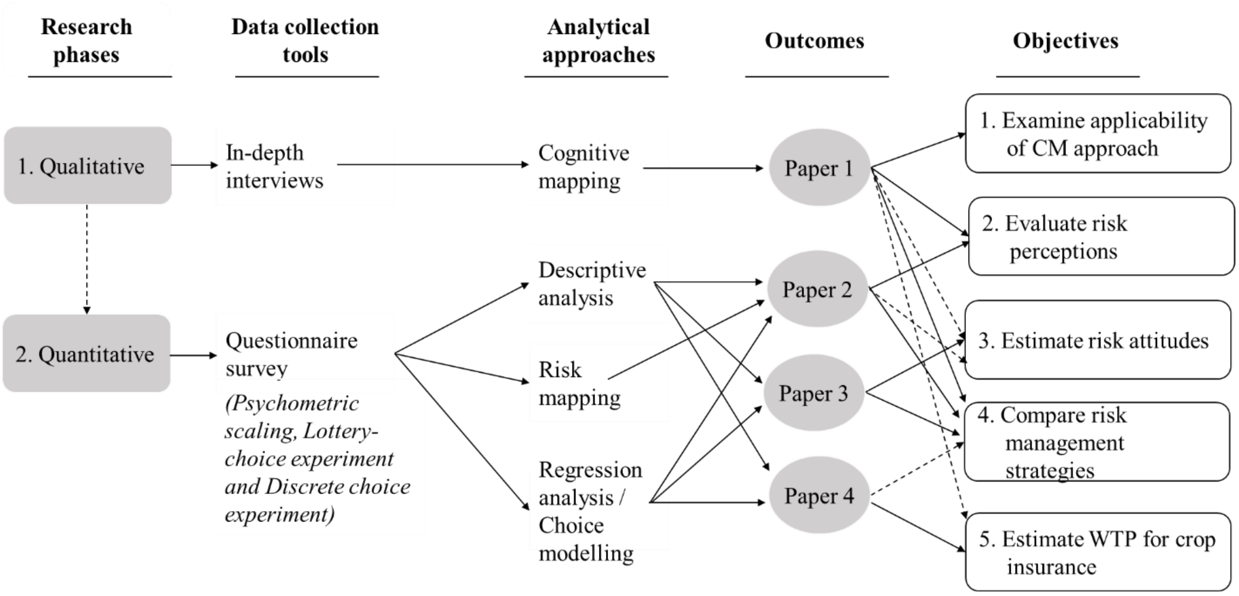

Figure 3.1 Exploratory mixed-methods (qual=>QUAN) research design.

Note: Solid and dotted arrows indicate primary and secondary linkages, respectively, between the elements in the diagram.

3.2 Conceptual framework

The theoretical foundation of this study is underpinned by two major theories from neoclassical economics: psychometric theory (PT) and expected utility theory (EUT). The measurement and analysis of risk perception are based on PT, which assumes that individual perception of risk is subjective and can be explained by psychological or cognitive factors (Sjöberg et al., 2004). Similarly, the measurement and analysis of risk attitude are based on EUT first posited by Bernoulli (1738), which describes the rational human decisions in the presence of risk as the outcomes of their utility-maximising behaviour. Building on this theoretical foundation, we developed a conceptual framework (Figure 3.2) to guide the identification, measurement and analysis of the variables relevant to the research problems. Meraner and Finger (2017) adopted a similar conceptual framework that explains farmers' risk management decisions as a combined function of farmer characteristics (risk perception and risk attitude), farm characteristics and household characteristics.

The research involves measuring three groups of variables and analysing their relationships, as shown in Figure 3.2. The first group includes the variables related to individual characteristics, farm characteristics, objective risk factors, other socio-demographic variables and attributes of crop insurance products. The second group comprises attitudinal variables such as risk perception, risk attitude, risk experience and willingness to pay for crop insurance. The third group includes decision-making variables, such as the choice of risk management strategy, selection of crop varieties and farm mechanisation. The risk management strategies include on-farm strategies such as farm diversification and off-farm strategies such as crop insurance. As discussed in the Literature Review, the relationships between these three groups of variables vary across studies and regions. This thesis examines these relationships in the Nepalese context.

This study hypothesises that the variation in farmer decision-making is associated with individual differences in risk perception and risk attitude. Risk perception and risk attitude are latent constructs that depend on personal characteristics, farm characteristics and socio-demographic factors. Farmer risk perception is also affected by objective risk factors and their past exposure to risks. Similarly, farmers' willingness to pay for crop insurance is explained by the attributes of insurance products and risk attitude. The variables and the relationships portrayed in Figure 3.2 and the theories underpinning such relationships are further elaborated in the relevant papers.

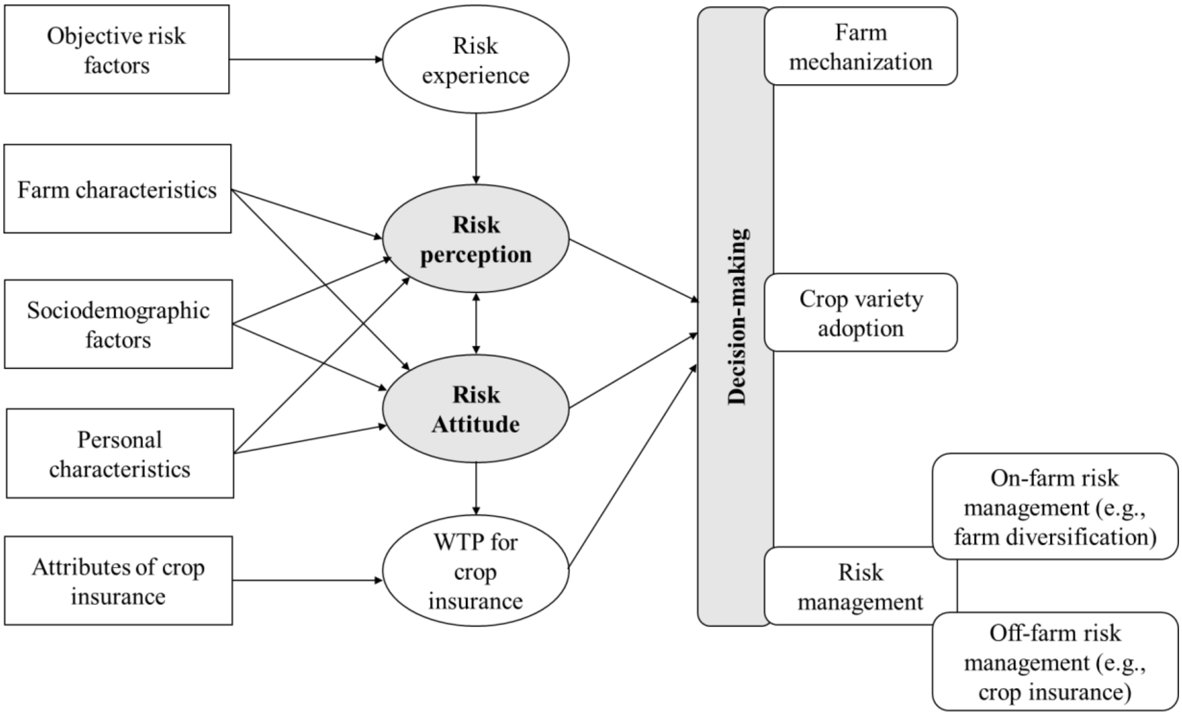

Figure 3.2 Conceptual framework of the study

3.3 Study area

We purposively selected the southern plain of Nepal, also known as Terai, for the study because this region is considered the grain basket sharing more than two-thirds of total crop production in the country from only 23% of the total land area (Joshi et al., 2012; MoALD-Nepal, 2020). Based on the spatial distribution of rainfall, Kansakar et al. (2004) divided Nepal into three major river basins—Koshi, Narayani and Karnali—representing high, medium and low rainfall areas, respectively. Accordingly, we stratified the study area into three clusters—Eastern Terai region (ETR), Mid-Terai region (MTR) and Western Terai region (WTR)—corresponding to low, medium and high rainfall areas (Figure 3.3). Excluding some microclimatic pockets, the amount of annual rainfall gradually decreases from East to West. Accordingly, ETR, MTR and WTR can be considered as high, medium and low vulnerable clusters to flooding risk, respectively, with the opposite gradient for drought risk vulnerability.

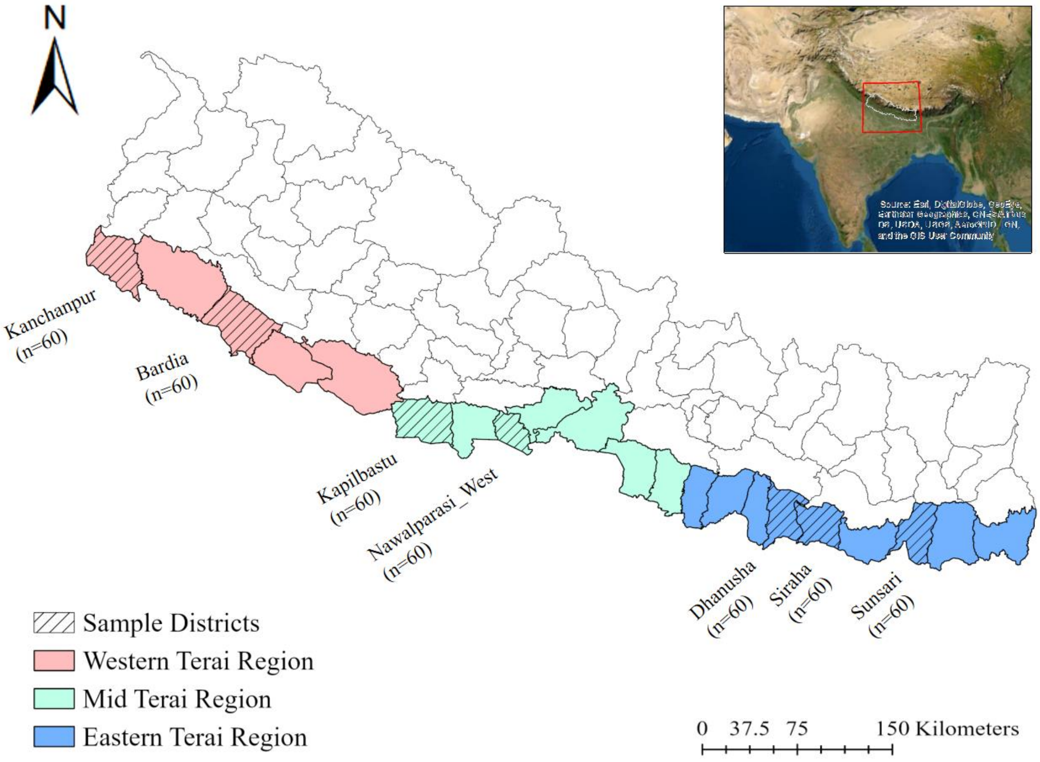

Figure 3.3 Map of Nepal showing study clusters and districts
Note: n indicates sample sizes within districts.

3.4 Sampling design

The study population comprises farmers from the Terai region of Nepal that are mainly involved in rice cultivation. Rice crop is mainly grown during June -October, which coincides with the monsoon in Nepal. Rice is the most crucial crop in Nepal, accounting for more than 50% of the total agricultural area and production (Joshi et al., 2011). It contributes about one-fifth of the total AGDP and provides about one-third of the Nepalese people's total calorie requirements (Tripathi et al., 2019). Despite its importance, rice productivity is threatened by the changing climate and extreme weather events (Rayamajhee et al., 2020).

Farming households and adult members of the selected households actively involved in agricultural-related decision-making and farming activities are the fundamental units of analysis in this study. In the qualitative study, we selected 45 farmers applying the maximum variation sampling technique and the concept of theoretical saturation (see Mark, 2010; Patton, 1990). The sampling design of the qualitative study is discussed in the corresponding paper. Here, we discuss the sampling design of the quantitative study, which is common to the three quantitative papers.

We first calculated the minimum sample size, considering a 95% confidence interval and 5% margin of error (see Moore & McCabe, 2000), to represent the total farming households in the study area. We determined the number of sub-samples within the strata proportionate to the number of farming households (Table 3.1).

Table 3.1 Sample size calculation

Strata	Number of households (CBS-Nepal, 2013)	Targeted sample size
Eastern Terai Region	701 081	182
Mid Terai Region	482 394	125
Western Terai Region	296 035	77
Terai Region	1 479 510	384

We applied the multi-stage stratified random sampling technique to select districts, local units and villages. Considering the sub-sample sizes, we selected two districts from MTR and WTR and three districts from ETR. We selected two local units within each district and one village from each local unit, resulting in 14 villages as final study sites. The choice scenarios in the discrete choice experiment were grouped into six blocks. To ensure at least five participants in each block, we randomly selected 30 respondents in each village. The final sample size for the quantitative study was 420, although the targeted sample size was only 384 (Table 3.2).

Table 3.2 Details of the multi-stage random sampling

Strata1	# Districts	Selected districts	# Local units	Selected local units	# Wards	Selected wards	Selected households
ETR	9	Sunsari	12	Gadhi	6	3	30
				Ramdhuni	9	3 & 4	30
		Siraha	17	Bariyapatti	5	4	30
				Dhangadhimai	14	3	30
		Dhanusha	18	Laxminiya	7	1	30
				Mithila	11	9	30
	Sub-total of ETR						180
MTR	7	Parasi	7	Ramgram	18	16	30
				Sunwal	13	12	30
		Kapilbastu	9	Shibraj	11	10	30
				Suddodan	6	3	30
	Sub-total of MTR						120
WTR	5	Bardiya	8	Badhaiyatal	9	2	30
				Gulariya	12	8	30
		Kanchanpur	9	Bedkot	10	8	30
				Shuklaphanta	12	4	30
	Sub-total of WTR						120
Total							420

3.5 Fieldwork and data collection

The fieldwork was conducted in two phases. The qualitative interviews were undertaken by the researcher from October through December 2017 using an interview guide. The quantitative survey was undertaken from October 2018 through January 2019 using a pre-tested semi-structured questionnaire (Appendix C). We employed and trained six enumerators, who are researchers working at the field stations of the Nepal Agricultural Research Council. We used the Qualtrics application to carry out the quantitative interviews. In cases where the use of tablets was not feasible, paper-based

[1] According to the constitution of Federal Democratic Republic of Nepal promulgated in 2015, the country is divided in to 77 districts grouped into seven provinces. This study area consists of 20 districts situated in the southern plain of Nepal, also known as Terai Region. The districts have various number of local units called municipalities and rural municipalities. The local units have varied number of wards. A ward may consist of one or more villages/settlements.

questionnaires were used. The information of paper-based interviews was entered into the Qualtrics software. The qualitative data were analysed using NVivo 12 and Banxia Decision Explorer software, while the quantitative data were analysed using Stata 16.1 and Microsoft Excel.

The questionnaire was first developed in English and then translated into Nepali. We also employed another researcher from NARC, who did not see the original questionnaire, to back-translate the Nepali questionnaire into English to examine and ensure the linguistic equivalence in translation (see Pena, 2007). Pre-testing of the questionnaire was carried out with five farmers (three men and two women) in the Morang district (non-sample district) to check whether the questions worked as intended and were understood by the targeted respondents. Farmers from Morang have similar socio-economic characteristics to farmers from sample districts. A pilot study of the discrete choice experiment was conducted with the first 50 respondents, which is discussed in Chapter 6.

3.6 Ethical consideration

The study was approved as low-risk research by the UWA human ethics committee following the ethical requirements of the Australian National Statement on Ethical Conduct in Human Research (National Statement) and the policies and procedures of the UWA. There is no formal ethics approval system in Nepal for conducting research of this kind. However, we obtained written consent from all respondents using the project information sheet and participant consent form. All forms of physical and soft copies of information are securely stored at the UWA facilities.

3.7 Basic socio-demographic information

Figure 3.4 presents some of the basic socio-demographic characteristics of the respondents and households. A more detailed description of the respondents and summary statistics of the variables related to the specific topics are presented in the corresponding papers.

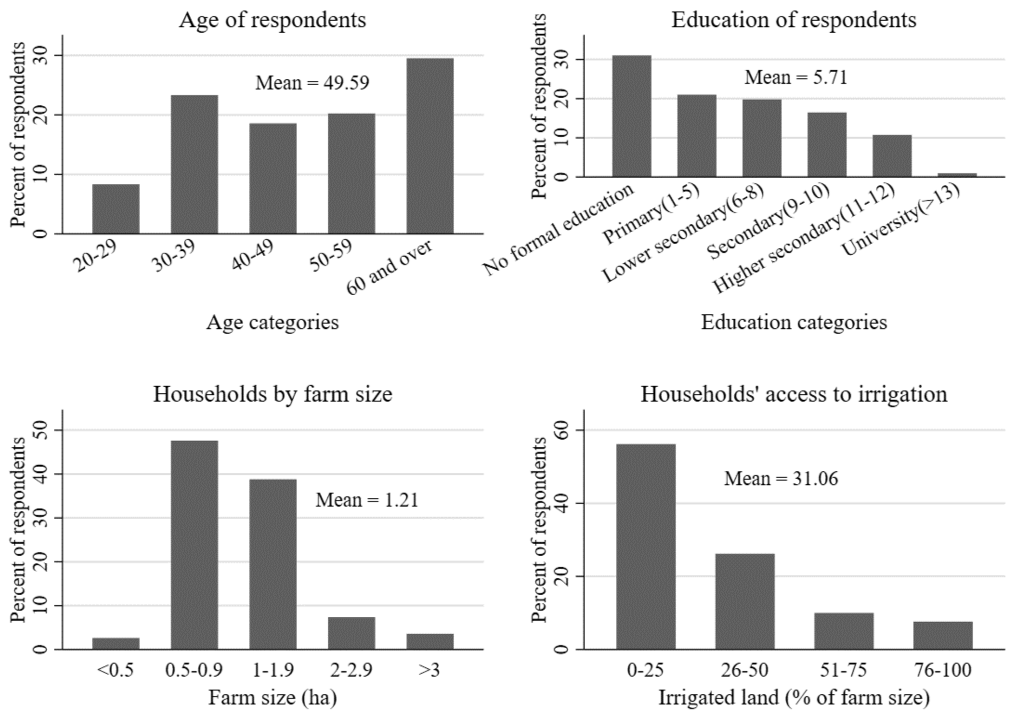

Figure 3.4 Basic socio-demographic characteristics of respondents and households

About 42% of survey respondents were female farmers. The respondents' age ranged from 24–77, with an average age of about 50 years. The 60 and over age category had the most respondents, and the youngest category (20–29 years) the fewest. The respondents had 5.71 years of formal schooling on average, with only a few having university degrees, while the number of respondents with no formal education was highest in all categories. The respondents' educational attainment was lower than those in previous studies involving experimental methods (see Meraner & Finger, 2017; Nielsen et al., 2013; Tanaka et al., 2010). The amount of cultivated land per household was 1.21 ha, with the 0.5 to 0.9 ha category having the highest proportion of households. In all clusters, the farm sizes were larger than the national average (0.66 ha) reported for 2011 (CBS-Nepal, 2017). This inconsistency is mainly because our study population comprises rice farmers from the Terai region, who generally have larger farms than average Nepalese farmers. On average, only one-third of farmland had assured sources of irrigation, which implies that about two-thirds of rice farming in the Terai region of Nepal depends on monsoonal rainfall.

The following four chapters are written as journal papers addressing five research objectives, as shown in Figure 3.1. Although the research objectives are interlinked and the elements of one chapter may be referenced in other chapters, each chapter can be read as a stand-alone paper.

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Chapter 4: Cognitive Mapping of Nepalese Farmers' Risk Perceptions and Management Strategies (Paper 1)

4.1 Abstract

This paper validates the applicability of the cognitive mapping approach for studying risk perception and management strategies in the context of smallholder subsistence farming. We conducted in-depth interviews with 45 farmers from the Terai region of Nepal and used the content analysis method to convert the interview transcripts into individual cognitive maps. Then, we applied centrality analysis, domain analysis and most mentioned constructs techniques to identify the relative importance of various constructs related to farming risks and management strategies. We found that farmer perception of risk is a complex network of interdependencies between sources of uncertainty, risks and management strategies. The quantitative risk mapping approach that requires farmers to disentangle such complexity and assign numerical values to the risks may not elucidate a complete picture of farmers' risk perceptions. Cognitive mapping can complement the quantitative approach in broadening the understanding of risk and communicating the key message to the relevant stakeholders. The results revealed that most of the risks perceived by Nepalese farmers are related to production risk. This finding is consistent with the fact that subsistence smallholders are more exposed to production risks than market risks. Likewise, the farmers' feeling of insufficiency in technical knowledge about modern farming technologies was the main factor leading to their perceptions of risk in adopting such technologies. We also found women farmers were mainly worried about the uncertainty in the supply of basic inputs such as seeds and fertilisers, while males were mainly concerned about access to more advanced elements of farming such as mechanisation services. Apart from this difference, perceptions of climatic risk factors such as the unpredictable onset of monsoon, heavy rainfall and increased temperature were similar between men and women. Similarly, the farmers' low bargaining power, lack of government support and competition with imported goods were major factors leading to market risks. Along with managing risks through on-farm diversification strategies, farmers were willing to buy market-based risk management tools, such as crop insurance. However, most farmers were not aware that crop insurance products were available in the market. Therefore, educating farmers about the concept and benefits of crop insurance is likely to improve its adoption.

Keywords: cognitive mapping, farming risk, Nepal, risk perception, risk management, risk preference

4.2 Introduction

This paper validates the applicability of the cognitive mapping approach for studying risk perceptions and management strategies in the context of smallholder subsistence farming, while the mainstream approach to risk is quantitative. The quantitative methods are based on the psychometric theory (Aven, 2010), which assumes that individual risk perceptions can be measured in terms of various characteristics of risk (Sjöberg et al., 2004; Slovic, 1992; van Winsen et al., 2013). These methods ask respondents to rate their perceptions of various risk characteristics on a scale and derive numerical scores that represent their risk perceptions (Sjöberg, 2000). Although the psychometric theory is compatible with several quantitative methods for carrying out studies and testing the theory, it is not free from criticism. The psychometric theory considers qualitative attributes of risks as intrinsic characteristics of hazards, but researchers argue that risk is a cognitive construct that exists in the perceivers' heads (e.g., Rayner, 1992; Turner & Waynne, 1992). Moreover, psychometric methods involve data aggregation to develop personal risk profiles (Slovic, 1992), but the aggregated score is only part of the risk perception, which may not ideally represent individual stories (Vlek & Stallen, 1981). Realising the limitations of quantitative methods in fully explaining such a pervasive but nuanced aspect of human existence, Smithson (1988) called for alternative approaches to risk that move beyond the reliance on probability theory. Exploring such approaches is one of the major objectives of this paper.

Three other reasons further reinforce our motivation for using a qualitative method. Firstly, alternative methods are required to complement quantitative methods or reach beyond the limits of quantitative representation to enhance the understanding of risk and effectiveness of risk communication. van Winsen et al. (2013) also suggested that qualitative approaches are necessary to address the complexity of the probabilistic quantification of risk, the interconnectedness of seemingly discrete risks, and individual differences in risk perception. Similarly, Sjöberg (2000) suggested that unstructured and soft approaches, such as in-depth interviews, allow follow-up investigation so that respondents can further explain their opinions about risk, which is often ignored in questionnaire methods.

Secondly, qualitative methods are needed due to the qualitative dimensions of risk. Studies have shown that risk perception is largely affected by qualitative factors (e.g., Otway & Winterfeldt, 1982; Vlek & Stallen, 1980, 1981), which are more appropriately investigated through qualitative approaches than statistical computation. According to Slovic (1987), people evaluate risks in terms of qualitative attributes such as voluntary versus involuntary, chronic versus catastrophic, usual versus unusual and known versus unknown. Questions such as how familiar people are with a hazard, how early the undesirable effects of the hazard are realised, and what management options are available to manage the effects are better answered in qualitative terms (Lowrance, 1976; Winterfeldt & Edwards, 1984).

Thirdly, because risk perception is often a socially shared experience of individuals in a community (Rohrmann & Renn, 2000), qualitative approaches are necessary that allow people to verbally explain their opinion on risk (Henrich & McElreath, 2002; Kuznar, 2001; Tucker, 2012). Zinn (2017) also urged the need for qualitative attribution of risk perception to answer how risk-taking is rooted in social institutions and practices and how people question, compromise or deal with social and cultural structures in their daily lives.

Furthermore, several researchers have recommended a combination of quantitative and qualitative approaches to capture a comprehensive picture of risk perceptions (e. g., Sjöberg, 2000; Wright, 2016). Qualitative research helps explore an issue in detail and identify new dimensions, whereas quantitative studies help simplify the picture and identify the important aspects to focus on (Sjöberg, 2000). From this perspective, qualitative approaches are necessary to explore major themes related to farming risks and identify the variables for further investigation, while quantitative approaches are necessary to identify the important aspects of risk and prioritise management actions. A mixed-methods approach is more pertinent than the single method approach for studying farming risks in the context of Nepal, where no systematic research has been done on this topic. Therefore, we used a mixed-methods design to accomplish the research objectives as outlined in the Introduction. The qualitative study established a broad context of the farming risk and identified relevant variables, and the quantitative study identified important aspects of risk for prioritising risk management actions. This paper presents the findings of the qualitative study. The remainder of this paper is organized as follows. First, we clarify the key terms relevant to this paper, followed by a brief discussion on the importance of risk perception studies. Next, we briefly review the qualitative methods used in risk perception studies, with a special focus on the cognitive mapping approach. The methodology section clarifies the sampling approach, interview methods and data analysis techniques. Then, we present the findings and discussion, and conclusion of the study.

4.2.1 Definition of key terms related to risk

The understanding and definition of risk and related terms vary across individuals and decision contexts. Therefore, it is essential to clarify the key terms and constructs relevant to this paper. Although the quantitative measure of risk perception combines the probability of loss exposure and the size of likely loss (Agrawal, 2009), this paper adopts the following qualitative definitions of risk and risk perception. We define risks as undesirable outcomes that farmers foresee in various aspects of their farming. We examine farmers' perceptions of a risk looking at how often they talk about it in the interviews and how connected the risk is with other constructs and management actions in the cognitive maps. We define intrinsic factors as the sources of uncertainty related to the perceiver's characteristics, such as knowledge, attitude, expectation, willingness and behaviour. Likewise, extrinsic factors are sources of uncertainty that originate outside the perceiver, such as climatic factors, farm characteristics and institutional factors. Similarly, risk management refers to the actions taken by farmers ex-ante to reduce the chances of undesirable situations happening or manage the consequences of such outcomes once they occur. We follow Hardaker et al. (2015)'s categorisation of risk into two broad categories: business risk and financial risk. Business risk includes the combined effect of production, market, institutional and personal risk, whereas financial risk includes the risks arising from the methods of financing the business.

4.2.2 The need for studying farmers' risk perception

The importance of studying farmers' risk perception is well recognised in the literature. Information on farmers' risk perception and responses to risk are necessary to understand and predict their behaviour. Risk perception indicates how concerned people are about the uncertainty and likely undesirable outcomes (Slovic, 2000). It also indicates their potential decisions on adopting risk management strategies (Gebrehiwot & van der Veen, 2015). When faced with risk, people often place greater weight on potential negative outcomes than positive outcomes and are willing to avoid the risks (Ghadim & Pannell, 2003; Marra et al., 2003). A high perception of risk results in conservative and prudent behaviour, while a low perception of risk results in less conservative behaviour (Rejda & McNamara, 2014). Farmers' risk perception is also an important indicator of their demand for crop insurance (Gebrehiwot & van der Veen, 2015; Marra et al., 2003).

Farmers' risk perception is not only an indicator of their risk management decisions but also associated with investment, innovation and farm productivity (Ullah et al., 2015). Knowing individual perceptions of risk is essential for understanding their saving and investment behaviour (Weerdt, 2005). Analysis of sources and nature of risks helps farmers choose the best available option (Lomott & Lyskawa, 2014). People tend to invest more in financial opportunities they perceive as less risky (Weber & Hsee, 1998). The question of why large sections of farmers in developing countries do not adopt the most profitable livelihood options available to them persists despite long-running efforts to increase the adoption of modern crop varieties, technologies and farm mechanisation. A study conducted by Liu and Huang (2013) in China found that the perceived uncertainty associated with new technology was the primary factor determining farmer adoption decisions.

Despite the need to study farmers' risk perception, as highlighted above, research is still lacking in the Nepalese context. A comprehensive understanding of how farmers perceive risk and how they deal with risk is necessary to inform future risk management efforts. Hence, this study attempts to overcome the information gap in farming risk management in Nepal, focusing on prevailing risks, sources of risk and risk management practices from farmers' perspectives. Such information will help the government and insurance companies refine policies and risk management products.

4.2.3 Qualitative methods in risk perception research

Researchers have emphasised the need for integrating qualitative approaches into the risk research methodology, as discussed above, but little research has used such an approach thus far. The few studies that have applied qualitative methods to study risk in part or fully are cited below. Even the early psychometric studies included qualitative variables to characterise risk, but their methods were still quantitative (e.g., Fischhoff et al., 1978; Slovic et al., 1980). While Ellis (1998) applied an in-depth, open-ended interview method and constructed influence diagrams or mental models to represent individual risk perception, Lupton and Tulloch (2002) applied the same to examine the role of risk epistemologies and perceptions in people's lives. Similarly, McCarthy (2007) and Meuwissen et al. (2001) conducted in-depth interviews to identify sources of risk. While Ellis (2000) applied the questioning method to develop cognitive models of experts and laypeople about chemical risks on human health, van Winsen et al. (2013) used the Grounded Theory approach to develop cognitive maps of Dutch dairy farmers' risk perception. Likewise, Legesse and Drake (2005) conducted a participatory rural appraisal method to supplement the findings of a quantitative survey. Murray-Prior (1998) also used a qualitative decision model based on Kelly (1955)'s personal construct theory to analyse farmer behaviour. Among these studies, van Winsen et al. (2013) used the qualitative method exclusively to study farmers' risk perception. The scarcity of qualitative methods in risk perception research also motivated us to validate a new method while answering the research questions. Therefore, we used the cognitive mapping approach, which is discussed below.

4.2.4 Cognitive mapping approach

Graphical representation of knowledge, attitude, perceptions, or other information as a set of constructs and interrelationships between the constructs is called cognitive mapping (CM) (Alberto et al., 2017; Novak & Musonda, 1991). CM is qualitative modelling of the functioning of a complex system that represents relevant variables and causal interconnections among these variables (Özesmi & Özesmi, 2004). CM is rooted in Kelly (1955)'s personal construct theory, which suggests that human beings disaggregate the functioning of the world into mental constructs to represent their experiences and understanding of their surroundings. An important postulate of Kelly (1955)'s personal construct theory is that every construct is bipolar in nature. Constructs or concepts and pathways are the major constituents of cognitive maps (Huff & Fletcher, 1990), where the constructs relate to issues, events, various factors and outcomes, and the pathways represent the relationships between the constructs (Goodier & Soetanto, 2013). The constructs bear context-specific meaning depending on the relationship between one another as indicated by the direction of arrows (Farsari et al., 2011). According to van Winsen et al. (2013), there are four essential aspects of the relationship: (1) Meaning: relationship is itself a construct which defines the connection between constructs; (2) Direction: uni-directional or bi-directional; (3) Sign: positive or negative relationship; (4) Strength: the map that depicts the strength of relationships is known as 'fuzzy cognitive map'. However, they suggested that the fourth aspect can be omitted in a pure qualitative cognitive model.

Human perceptions of almost every issue or system can be represented by cognitive maps (Özesmi & Özesmi, 2004). According to Özesmi and Özesmi (2004), CM can be done using physical variables such as rainfall amount or distance to market and abstract concepts such as perceptions or attitudes. Likewise, Wood et al. (2012) suggested CM as an appropriate approach to understand and communicate any complex system. Similarly, while van Winsen et al. (2013) recommended CM as a useful tool for modelling the decision-making process, Eden and Ackermann (2004) recommended it as a decision-making tool in a complex setting. van Winsen et al. (2013) also suggested CM as a bi-directional learning tool between farmers, researchers and policymakers. It can also be used as a participatory policy development tool that enables a deeper understanding of the system (Özesmi, 1999). These suggestions imply that CM can simplify a complex issue into information that is easy to understand.

Several studies in various fields have applied the CM approach for different purposes. For example, while Goodier and Soetanto (2013) constructed cognitive maps to design future scenarios of the UK construction sector, Soetanto et al. (2011) applied CM to identify the skills required by construction industries in the UK. Similarly, while Fernandes et al. (2018) used CM to rank the factors affecting sustainable development in Portuguese urban areas, Farsari et al. (2011) studied mental models of policymakers applying the CM method. Other works that applied CM methods include the improvement of auditing task planning in public organisations (Ackermann & Eden, 2001), empowerment of management team to analyse and manage complexities in the UK Home Office Prison Department (Eden & Ackermann, 2004), exploration of decision-making process in a public sector performance appraisal system (Ahmad & Ali, 2004) and enhancement of citizens' participation in strategic forest management planning process (Hjortsø, 2004).

Although the application of the CM approach seems diversified, the literature related to the application of CM in agricultural studies is relatively scarce. A few studies that have applied CM approaches in the natural resource management sector include: designing ecological management plan (Özesmi & Özesmi, 2004), comparing perceptions of different stakeholders about environmental conflict (Özesmi, 1999); studying Dutch dairy farmers' risk perceptions (van Winsen et al., 2013) and studying local knowledge in agroforestry management (Isaac et al., 2009). According to van Winsen et al. (2013), the advantages of CM are that it allows in-depth investigation of complex issues, it emphasises interdependencies among constructs, it is applicable at the farm level, the results are farmer-driven rather than researcher-driven, and it can depict multiple meanings of risk. Such diversified applicability but scarce adoption of the CM approach in agriculture indicates scope for validating an alternative research method for addressing the complexities in farming risk.

4.3 Methodology

Aligned to the interpretive research philosophy, we followed an inductive approach allowing constructs and the relationships among the constructs to emerge from the data without proposing any *a priori* hypotheses. We collected data using an open-ended conversational interview method without a structured interview guide. However, we applied an outline guide to confine the conversations within the scope of the study. We phrased main thematic questions, follow-up questions and probes during the interview.

4.3.1 Sampling

We purposively selected the Terai region of Nepal for the study as it has the highest share of total agricultural production in the country (see MoALD-Nepal, 2018). We applied the maximum variation sampling technique so that the interviewees sufficiently represented the existing heterogeneity of the population in terms of age, gender, education, economic status, and geographical region (see Patton, 1990). We determined the sample size based on the concept of theoretical saturation (see Mark, 2010). Researchers have suggested varying sample sizes for achieving theoretical saturation in qualitative studies. While Guest et al. (2006) suggested six samples for code saturation and 12 samples for meaning saturation, Hennink et al. (2017) suggested nine interviews for thematic saturation and 16–24 interviews for meaning saturation. In our case, we did not find additional constructs after the 11th interview. However, we continued until the 45th interview to fully understand the meaning of the constructs and the relationships between them. We identified appropriate samples in consultation with the District Agriculture Development Offices and Agricultural Research Stations in the study area. We first contacted the identified samples by phone to get preliminary consent, scheduled the interview and then conducted actual interviews in person to visit their homes from October through December 2017. We audio-recorded the interviews and de-identified the interviewees with pseudonyms wherever they appear.

4.3.2 Data analysis

The preliminary data analysis started with the first interview to examine data saturation and refine the technique for the following interviews. Although actual coding was done later, interviews were transcribed on the same or following day. We transcribed the interviews in the Nepali language and translated them into English for further analysis. We also back-translated the transcripts into Nepali to verify meaning equivalency in translation (see Chen & Boore, 2010). Then, we coded the transcript contents into various themes and sub-themes related to farming risk using NVivo Pro 11. Although we analysed 45 interviews to identify nodes and interpret the relationships among nodes, we purposively selected six interviews for constructing cognitive maps and further analysis. The selection of samples for cognitive mapping was also based on the maximum variation sampling technique, ensuring that the minimum samples represent maximum heterogeneity in terms of socio-economic characteristics (see Table 4.1 and Appendix A). van Winsen et al. (2013) used a similar strategy for constructing cognitive maps. They conducted in-depth interviews with 19 farmers and selected four interviews for constructing cognitive maps to represent the sample. Other researchers have constructed a varied number of cognitive maps, ranging from one to 116, to study different issues (see Özesmi & Özesmi, 2004, p. 58). We have presented only two cognitive maps in the discussion section (Figures 4.1 and 4.2). All six cognitive maps and their explanation are presented in Appendix B1 to B6.

Table 4.1 Characteristics of the sample selected for cognitive mapping

SN	Name	Geographic cluster	Education	Age	Family size	Landholding (ha)
1	Female-1	Eastern Terai region	Secondary	42	6	2.66
2	Female-2	Central Terai region	Illiterate	70	5	3.33
3	Female-3	Western Terai region	Lower secondary	42	4	0.33
4	Male-1	Western Terai region	Adult literacy	47	19	7.50
5	Male-2	Eastern Terai region	Tertiary	53	4	1.00
6	Male-3	Eastern Terai region	Higher secondary	28	6	1.50

4.3.3 Construction of cognitive maps

According to Özesmi and Özesmi (2004), cognitive maps can be constructed in four ways: (1) eliciting information using a questionnaire, (2) analysing written texts, (3) using available data having causal relationships, and (4) conducting interviews with people and asking them to draw maps directly. The questionnaire method involves identifying variables, selecting important ones to include in the map, and defining the relationships among the chosen variables (Roberts, 1976). Text analysis or content analysis involves identifying the concepts, constructs, variables, or factors and relationships between these using the interview transcripts (Özesmi & Özesmi, 2004; Wrightson, 1976). Coding involves identifying causes, effects, constructs, and linkages that may or may not be explicitly mentioned in the text (Özesmi & Özesmi, 2004). The third and fourth methods are applicable in specific conditions. Of these four methods, content analysis is most suitable for the analysis of in-depth interview transcripts.

Researchers have applied different structures for constructing mental models in various fields with somewhat varying objectives and foci. For instance, while Brightman (2003) constructed a mind map focusing on a single construct, the cognitive map of Wood et al. (2012) and causal map of Montibeller and Belton (2006) did not focus on a single construct. Likewise, while Brightman (2003) followed a hierarchical structure to construct a dialogue map, Bostrom et al. (1992) and Carriger and Newman (2012) did not follow an ordered structure in their influence diagrams and concept maps. Similarly, while Brightman (2003) focused on complex relationships to construct a concept map, Montibeller and Belton (2006) and Zhu and Timmermans (2010) focused on causal relationships to construct a causal map and a cognitive map. Also, while Wood et al. (2012) and Zhu and Timmermans (2010) allowed bi-directional relationships and feedback loops in CM, Howard and Matheson (2005) used only uni-directional relationships, not allowing feedback loops in the influence diagram. A bi-directional relationship is the reciprocal causal relationship between constructs, and a loop is the sequential relationship between more than two constructs forming a cycle (van Winsen et al., 2013). Such variation in structures of cognitive models provides the flexibility to apply an appropriate construction method that best suits our context. Accordingly, our approach does not limit the focus to a single construct or follow a hierarchical structure; it focuses on causal relationships and allows bi-directional relationships and feedback loops.

Many software packages are available for CM, including Banxia Decision Explorer (DE), Coogle, Mind Manager, Mind Mapper, and Free Mind. Among them, DE is the most appropriate tool for constructing cognitive maps because it allows better visualisation of several concepts and linkages to collect feedback from the participants and carry out further analysis (Goodier & Soetanto, 2013; Tegarden & Sheetz, 2003). Goodier and Soetanto (2013) also suggest that DE helps depict different types of relationships, such as causal, cognitive, temporal or researcher defined, between various concepts constructed as short phrases. DE contains several tools for analysing the cognitive model, allowing a better understanding of individuals' cognition of the issue under study. Accordingly, we chose DE for this study.

4.3.4 Analytical framework

Graph theory indicators

We compared the cognitive maps based on various graph theory indicators such as number of constructs (N), number of linkages (L), linkage/construct (L/N) ratio, and map density (D). Hage and Harary (1983) defined map density as the ratio of existing connections (L) to maximum possible connections between the constructs. If a construct can have a causal relationship with itself, the maximum possible links is equal to the square of the total number of constructs (N^2). Map density tells us how sparse or connected the map is (Özesmi & Özesmi, 2004). The higher the value of D, the larger the number of causal relationships among variables. High D values also indicate that individuals have more flexibility to adapt to changes (Hage & Harary, 1983). Alternatively, van Winsen et al. (2013) used a slightly different formula, calculating map density as linkage to construct ratio halved (L/2N). We calculated map density using Hage and Harary (1983)'s formula and the L/N ratio, representing a similar characteristic to van Winsen et al. (2013)'s formula.

Domain and centrality analysis

Although DE allows several tools to analyse cognitive maps, domain and centrality analyses are considered more important, revealing the importance of the constructs in terms of the number of linkages (Farsari et al., 2011). According to Eden et al. (1992), the domain score (D) of a construct is calculated as a summation of total in-arrows and out-arrows around the construct. The value of D indicates how connected a construct is to other constructs and the overall strength of all connections (Özesmi & Özesmi, 2004). However, Eden et al. (1992) suggested that domain analysis ignores the wider context of the construct, accounting only for local complexity. They noted that centrality analysis overcomes this shortcoming by extending the same principle to account for the relevant interconnections beyond the immediate domain of the construct. While domain analysis accounts only for immediate linkages, centrality analysis goes beyond immediate linkages, considering all secondary, tertiary and even further connections. According to Eden (2004), the centrality score is calculated as follows:

$$C = \sum_{1}^{n} \frac{L_i}{N_i}$$

where C = centrality score, L_i = number of linkages in the ith layer, N_i = level of the ith layer.

The individual cognitive maps can be compared based on D and C values. For instance, Soetanto et al. (2011) ranked the constructs according to the D and C scores. They found eight of the top ten constructs common across domain and centrality analyses, which they considered for further detailed analysis.

Other analyses

Following Özesmi and Özesmi (2004), we compared the cognitive maps based on the most mentioned constructs and construct types. We ranked the constructs based on the frequency of their appearance in the maps. Such ranking indicates the importance of a construct and assumes that people tend to talk more about the aspects they consider more important. We can also classify the constructs into major types such as transmitter/receiver/ordinary or cause/effects and rank them by domain or centrality score (Özesmi & Özesmi, 2004). For instance, van Winsen et al. (2013) classified the constructs into four categories: ‘causes’, ‘effects’, ‘values at stake’, and ‘risk management’. Accordingly, we reduced the interview transcripts to various constructs and established the relationships between them through textual analysis using NVivo. Then, we classified the constructs into four categories, namely ‘intrinsic factors’, ‘extrinsic factors’, ‘perceived risk’, and ‘risk management’. Intrinsic factors relate to farmers’ inherent characteristics such as education, farming motivation and knowledge, whereas extrinsic factors relate to farm characteristics such as irrigation availability, input availability, policies and market access. Perceived risks are the constructs related to the consequences of uncertainty caused by various factors. Both intrinsic and extrinsic factors are the causes or sources that lead to risks. Risk management constructs are the options that farmers have in place to act upon various factors and perceived risks. We differentiated four types of constructs in terms of colour and font style (see Figures 4.1 and 4.2).

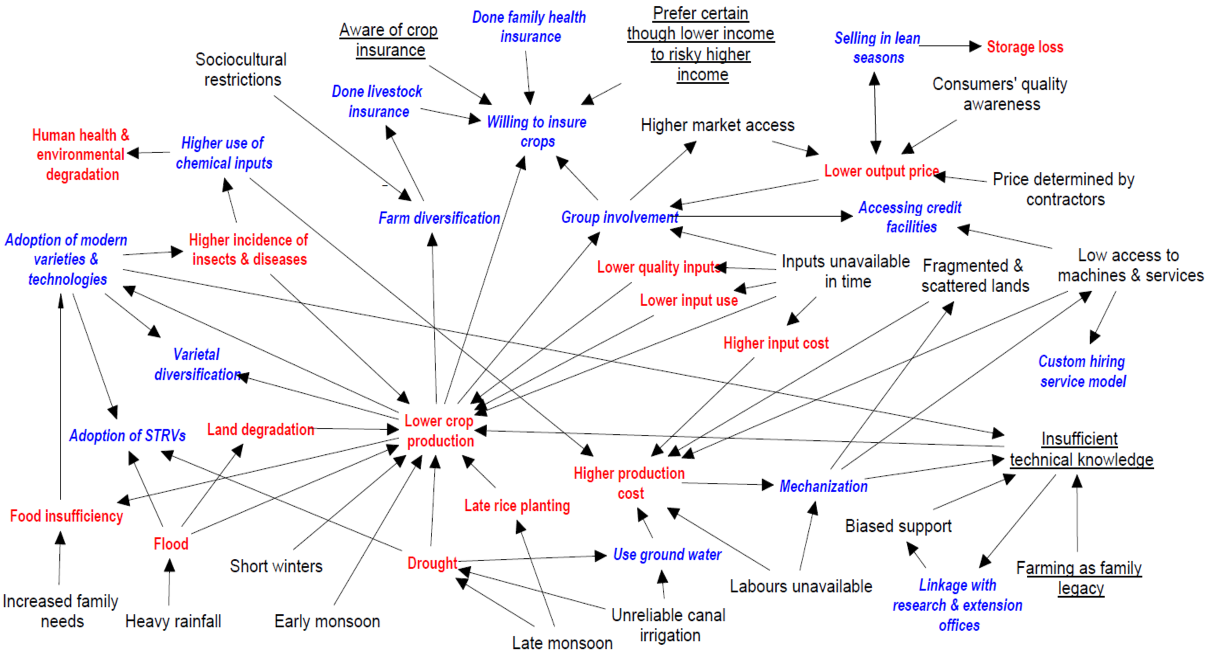

Figure 4.1 Cognitive map of female-1

(Legend: Extrinsic factor = regular; <u>intrinsic factor = underlined</u>, **perceived risk = bold red** and ***risk management = italicised bold blue***)

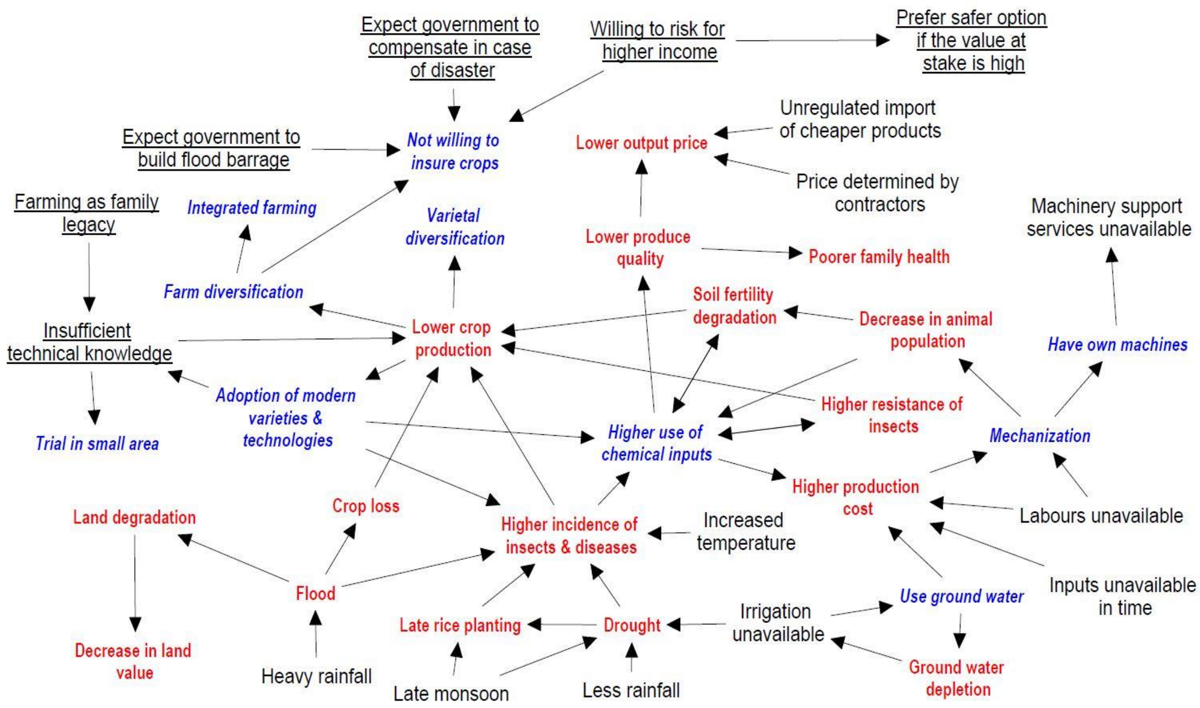

Figure 4.2 Cognitive map of male-1

(Legend: Extrinsic factor = regular; <u>intrinsic factor = underlined</u>, **perceived risk = bold red** and ***risk management = italicised bold blue***)

4.4 Findings and discussion

4.4.1 Graph theory indicators

Considering the whole map, the number of constructs (N) ranged from 34 to 48 across individual cognitive maps, with a mean of 42 and 12% coefficient of variation (Table 4.2). Such low variation in N across maps indicates similar perceptions of the complexity of farming risks among farmers. van Winsen et al. (2013) also interpreted N ranging from 25 to 37 to indicate a similar understanding of the complexity of farming risks. Other studies have reported N ranging from 14 to 59 (see Özesmi & Özesmi, 2004, p. 58). Similarly, considering all four categories of constructs, the extrinsic factor, risk management, and perceived risk categories had similar N while the intrinsic factor category had the smallest N (Table 4.2). This finding suggests that farmers' focus is more strongly on extrinsic circumstances than intrinsic factors as the sources of risk. Similarly, they give similar emphasis on risk and risk management. In van Winsen et al. (2013)'s case, farmers showed the strongest emphasis on the causes of risks. Our interpretation of N is based on the idea that people are likely to talk more about the issue they consider more complex (Eden, 2004), which results in a higher N on a map. Similarly, among various aspects of an issue, people tend to talk more about the aspects they think are more important (Soetanto et al., 2011). From this perspective, the size of a map indicates the perception of the overall complexity of an issue, while the partitioning of such complexity into various aspects helps to identify the focus of the perceiver.

In the above discussion, we only considered the number of constructs to understand perceived complexity in farming risks. The map density (D) and link/concept ratio (L/N) help extend our understanding of the issue by considering relationships between the constructs. D ranged from 0.029 to 0.035 with a mean of 0.032 and 6% coefficient of variation (Table 4.2). Researchers have reported varied map densities (see Özesmi & Özesmi, 2004, pp. 60, 61). According to Isaac et al. (2009), a small variation in map density indicates similar perceptions regarding the issue's complexity. Likewise, the average ratio of links to the constructs was 1.33, and higher than one in each case (Table 4.2). According to Georgiou (2009), the L/N ratio should be ideally around 1.2. They argued that the inexperience of the mapper results in a higher L/N ratio. However, various researchers reported L/C values ranging from 1.20 to 2.07 (see Özesmi & Özesmi, 2004, p. 60). More than one link per construct simply implies that one outcome is the consequence of more than one cause, or one cause is leading to more than one consequence. According to van Winsen et al. (2013), a higher value for the L/C ratio indicates that farmers perceive more than one cause of the risk and aim to achieve more than one goal with a single intervention. Such complexity suggests that isolating and assigning the probability to a particular risk and quantifying the consequences, as required in the conventional risk mapping exercise, is not easy for farmers. Moreover, low variation in these graph theory indicators across samples also indicates that the diversity in the sample characteristics in terms of geographical region, age, education, family size and landholding size did not produce an observable difference on the complexity of the cognitive maps related to farmers' risk perception.

Table 4.2 Graph theory indicators from the cognitive maps

Sample	Constructs (#)					Links	Density	L/N
	Extrinsic factor	Intrinsic factor	Perceived risk	Risk management	Total (N)	(L)	($D=L/N^2$)	
Female-1	15	4	14	15	48	71	0.031	1.48
Female-2	12	6	10	9	37	43	0.031	1.16
Female-3	11	6	6	11	34	41	0.035	1.21
Male-1	10	6	16	10	42	57	0.032	1.36
Male-2	14	4	13	15	46	69	0.033	1.50
Male-3	13	5	12	14	44	57	0.029	1.30
Mean	12.50	5.17	11.83	12.33	41.83	56.33	0.03	1.33
CV	13.66	17.37	26.91	19.68	11.74	20.36	5.81	9.52

4.4.2 Domain analysis

Altogether, the dominant construct belonged to the perceived risk category in all maps, except for the Male-1, whose map had the dominant construct under the risk management category. The risk of ‘lower crop production’ was the dominant construct within the perceived risk category in all maps (Table 4.3). This implies that the farmers are most concerned about production risks because they perceive that many factors lead to production risk, and most of their efforts were towards managing production risks. We can relate this finding to the fact that Nepali smallholder farmers—who generally practice subsistence farming systems and consume much of what they produce—are more exposed to production risks than price risks.

Similarly, within the intrinsic factor category, the dominant construct was ‘insufficient technical knowledge’ in all maps (Table 4.3). This finding implies that farmers perceive that their technical knowledge about modern farming practices is the most important intrinsic factor leading to ‘lower crop production’. For instance, Female-1 mentioned that *“Although I know that I should adopt new varieties and technologies for better crop production to meet the increased need of my family, I am not sure whether these would really give better yield because I don’t have enough technical knowledge about cultivation practices of such modern varieties. I have been farming with the knowledge that was passed on to me by my elders”.* Likewise, Male-2 mentioned that *“I am keen to use machines. However, I am afraid that mechanisation would increase my dependency on others because I don’t have sufficient technical knowledge about machine operations”.*

Uncertainty in the timely availability of inputs such as seeds, fertilisers and agrochemicals, which poses lower crop production risk, was the dominant extrinsic factor in all women farmers’ minds. According to Female-1, *“If fertiliser and seeds are not available in time, I am likely to suffer in three ways. Firstly, I will have to pay a higher price to purchase these inputs, which will increase the cost of production. Secondly, I will have to buy lower quality inputs available in illegal supply chains. And thirdly, I will have to reduce the seed and fertiliser dose. In both the second and third situations, the crop production is likely to decrease”*.

Female-2 also mentioned that “if seeds and fertiliser are not available in time, the production cost is likely to increase because such inputs become more expensive”. On the contrary, Female-3 mentioned that “because of uncertainty in the availability of fertilisers, I started raising livestock and started adopting organic farming practices”. In contrast, for male farmers, low access to machines and services and unavailability of irrigation were the dominant extrinsic factors, both leading to low crop production. This finding suggests that women farmers are more worried about the uncertainty in the supply of primary inputs such as seeds, fertilisers and agrochemicals, while male farmers are more concerned about access to more advanced elements of farming such as machines, mechanisation services and irrigation. We can relate this difference to the gender-specific division of roles in farming. For instance, tillage, threshing, marketing and overall resource management are the responsibilities of men, while women usually carry out seeding, transplanting, weeding, harvesting and cleaning activities.

Adopting modern varieties and technologies was the dominant construct within risk management strategy in half of the maps, while Male-1, Female-3 and Male-3 had different dominant constructs within this category. For Male-1, higher use of chemical inputs was the dominant risk management strategy. Although Female-3 did not perceive the likelihood of any disastrous hazards in her crop production, she was willing to insure her crop against production risks for the following reasons: (i) she was aware of the concept of insurance, (ii) she had insured her livestock, (iii) she had health insurance for her family, and (iv) she preferred a lower but certain income to a risky but higher income. In contrast, although Male-3 was aware of crop insurance, he was unwilling to insure crops because he had little trust in insurance companies. He had seen other farmers having difficulties getting insurance payouts in the past. Moreover, he expressed a willingness to bear some risk if risk-taking entails some chances of higher income. Apart from his bad experience with insurance companies, his risk preference might have decreased his willingness to insure crops.

Table 4.3 Dominant constructs in the cognitive maps

Sample	Construct category			
	Intrinsic factor	Extrinsic factor	Perceived risk	Risk management
Female-1	Insufficient technical knowledge (6)	Uncertainty in timely input availability (5)	Lower crop production (17)	Adoption of modern varieties and technologies (6)
Female-2	Insufficient technical knowledge (6)	Uncertainty in timely input availability (5)	Lower crop production (8)	Adoption of modern varieties and technologies (6)
Female-3	Insufficient technical knowledge (6)	Uncertainty in timely input availability (4)	Lower crop production (10)	Willing to insure crops (7)
Male-1	Insufficient technical knowledge (4)	Irrigation unavailable (3)	Lower crop production (8)	Higher use of chemical inputs (9)
Male-2	Insufficient technical knowledge (3)	Low access to machines and services (3)	Lower crop production (12)	Adoption of modern varieties and technologies (9)

Male-3	Insufficient technical knowledge (5)	Low access to machines and services (3)	Lower crop production (11)	Not willing to insure crops (9)

Note: Figures in parentheses indicate domain scores

4.4.3 Centrality analysis

The centrality analysis of the cognitive maps produced slightly different results from the domain analysis. Considering all four categories of constructs, the most central construct in each map belonged to the perceived risk category (Table 4.4). The risk of lower crop production was the most central construct in each map except for Male-1's map, where the most central construct was the higher incidences of insects and diseases leading to the risk of lower crop production. Although the perception of the most central intrinsic factor leading to farming risks was insufficient technical knowledge in each case, the perception of extrinsic factors varied greatly. Female-1, Female-3 and Male-2 perceived uncertainty in timely availability of inputs as the most central extrinsic source farming risk, whereas Female-2 and Male-3 perceived low access to machines and services as the most central source of farming risks. Similarly, Male-1 perceived increased temperature as the most central extrinsic source of farming risk.

The most important risk management strategy also varied greatly. Female-1 perceived that group involvement had helped her manage farming risks, while Female-2 and Male-1 thought that higher use of chemical inputs helped them reduce the risk of product failure due to insects and diseases. Similarly, while Female-3 was willing to insure crops as the most useful risk management strategy, Male-3 was unwilling to insure crops because he did not trust insurance companies. For Male-2, the adoption of modern varieties and technologies was the most central risk management strategy against farming risks. Although the above analysis showed varied results, we could not establish any pattern in these results corresponding to the variation in sample characteristics. Based on this finding, we could not find any association of farmers' geographical location, age, education, family size or landholding size with their perceptions of risk, risk factors or choice of management option.

Table 4.4 Central constructs in the cognitive maps

Name	Construct category			
	Intrinsic factor	Extrinsic factor	Perceived risk	Risk management
Female-1	Insufficient technical knowledge (21 from 42 c)	Uncertainty in timely input availability (20 from 44 c)	Lower crop production (29 from 45 c)	Group involvement (22 from 44 c)
Female-2	Farming as family legacy (7 from 16 c)	Low access to machines and services (8 from 18 c)	Lower crop production (13 from 20 c)	Higher use of chemical inputs (12 from 27 c)
Female-3	Insufficient technical knowledge (15 from 29 c)	Uncertainty in timely input availability (14 from 30 c)	Lower crop production (15 from 23 c)	Willing to insure crops (14 from 25 c)
Male-1	Insufficient technical knowledge (10 from 20 c)	Increased temperature (8 from 21 c)	Higher incidences and insects and diseases (18 from 33 c)	Higher use of chemical inputs (17 from 33 c)
Male-2	Insufficient technical knowledge (19 from 41 c)	Uncertainty in timely input availability (18 from 41 c)	Lower crop production (24 from 41 c)	Adoption of modern varieties and technologies (22 from 41 c)
Male-3	Insufficient technical knowledge (16 from 34 c)	Low access to machines and services (12 from 28 c)	Lower crop production (23 from 38 c)	Not willing to insure crops (20 from 39 c)

Note: Figures in parentheses indicate centrality scores from the number of constructs.

4.4.4 Most mentioned constructs

We calculated the repeat index for each construct by dividing the number of farmers mentioning it by the total number of farmers—six in our case. We used this index to rank the importance of the constructs, assuming that the more people agree on an idea, the more important the idea is. van Winsen et al. (2013) also used the number of farmers mentioning a construct to rate its importance. The constructs with a repeat index ≥0.5, meaning at least half of the farmers mentioned it, are discussed below. Like other results discussed earlier, we could not attribute the variation in most mentioned constructs to differences in sample characteristics. This finding gives us more strength to conclude that age, education, gender, family size, landholding size and decision-maker's geographical location do not affect their perception of risk, risk factors or management decisions.

As shown in Table 4.5, insufficient technical knowledge is the most important intrinsic risk factor because all farmers mentioned it. Similarly, most farmers were involved in the farming occupation only to continue the family legacy, which means they were less motivated by its economic prospect. Such motivation might have negative implications not only in dealing with risk but also in overall farm efficiency.

Within the extrinsic risk category, all farmers perceived that uncertainty in the timely availability of farm inputs (e.g., fertilisers, chemicals, and labour) is the primary factor leading to farming risks. Low access to farm machines and farm mechanisation services were also perceived as important factors leading to farming risks. Low access to mechanisation services was mainly due to the high initial cost of farm machines and unavailability of custom hiring services. Similarly, the uncertain onset of monsoon, often late, is an important source of drought risk. Such risk perception is magnified by the unavailability of canal irrigation systems and the high cost of pumping groundwater to irrigate crops. Other important sources of climatic risk include heavy rainfall and increased temperature. Apart from the factors that impart uncertainty in farm production, farmers also face many factors that lead to unpredictability in the market. Farmers possess less bargaining power in the market because they sell their produce to meet their cash needs, and they think that the government does not intervene in the market in their favour. In such situations, farmers are left with no option other than accepting whatever price the contractors offer for their produce. All farmers perceived such a price determination system as the major source of price risk in the farm business. Moreover, farmers often need to compete with the unregulated import of cheaper products, a major source of market risk in the Terai region.

Drought, higher incidence of insects and diseases, higher production cost, lower crop production and lower output price were the major risks perceived by all farmers. Similarly, while most farmers perceived flood, higher input costs, delayed rice planting and soil fertility degradation as major farming risks, half of them perceived human health and environmental degradation and storage loss as the major risks. From their ranking of risks, it is again clear that farmers are more concerned about production risks.

For instance, Female-1 mentioned that "To address the issue of food and income insufficiency, I adopted modern crop varieties and technologies. Since I didn't have enough technical knowledge of such technologies, I knew that I could have no production at all. However, I was fortunate not to have seen so happening, but, at the same time, I found modern crop varieties more susceptible to insects and diseases. I used more fertilisers, pesticides, and fungicides to manage insects and diseases even if I knew that such chemicals are harmful to health and the environment. The use of chemicals also increased my cost of production. As I continued using a higher dose of chemicals and fertilisers, I found my soil less productive year after year".

In the above example, Female-1 adopted modern crop varieties and technologies to reduce the risk of food and income insufficiency. However, it triggered an intrinsic factor, i.e., insufficient technical knowledge, which might lead to production risk, consequently affecting her objective of fighting food and income insufficiency. The adoption of modern crop varieties also increased the risk of insects and diseases, leading to production risk. Moreover, the higher use of chemical inputs to overcome production risk due to insects and diseases triggered her perception of human health and environmental risk and higher production costs. Furthermore, she also perceived that the chemicals negatively affect soil fertility, ultimately leading to production risk. This example shows that farmers do not perceive farming risks as independent items but as a network of causes and effects having multi-faceted relationships. Such a complex network implies that, sometimes, a cause may induce other causes, an effect may trigger other causes, or an effect leads to other effects. It also shows how farmers trade-off between risks and benefits attached to their decisions.

Farm diversification and mechanisation were the most important risk management strategies followed by all farmers. Likewise, most farmers perceived the increasing use of chemical inputs and groundwater as major risk management strategies. Similarly, farmers said they manage risks by accessing credit facilities, adopting modern varieties and technologies, getting involved in a group, selling farm produce in lean seasons, and diversifying crop varieties. As part of the interview, we asked the farmers to choose between a certain amount and a lottery resulting in the expected value slightly higher than a certain amount. Of the four farmers who chose a certain amount, implying risk aversion, three were willing to buy crop insurance. This finding suggests that farmers' risk aversion translates into their willingness to insure crops. However, only one farmer had already purchased crop insurance, and only half of the farmers were aware of it. Such a low level of awareness partly explains the low adoption of crop insurance. Moreover, farmers' risk preference (Male-3) and their choice for other management options such as group involvement (Male-3) and expectation for government support in case of hazards (Male-1) were also important factors leading to the reluctance of farmers to adopt crop insurance. This result suggests that farmers' willingness to insure crops is affected by their risk attitude and availability of other management options.

Table 4.5 Most mentioned constructs in the cognitive maps

Category	Constructs	Repeat index
Intrinsic factor	Insufficient technical knowledge	1.00
	Farming as a family legacy	0.83
	Preference for a certain lower income to risky higher income	0.67
	Aware of crop insurance	0.50
Extrinsic factor	Uncertainty in timely availability of inputs	1.00
	Uncertainty in labour availability	1.00
	Price determination by contractors	1.00
	Late monsoon	0.83
	Uncertainty in irrigation availability	0.67
	Low access to machines and services	0.67
	Heavy rainfall	0.50
	Increased temperature	0.50
	Unregulated import of cheaper products	0.50
Perceived risk	Drought	1.00
	Higher incidence of insects and diseases	1.00
	Higher production cost	1.00
	Lower crop production	1.00
	Lower output price	1.00
	Flood	0.67
	Higher input cost	0.67
	Delayed rice planting	0.67
	Soil fertility degradation	0.67
	Human health and environmental degradation	0.50
	Storage loss	0.50
Risk management	Farm diversification	1.00
	Mechanisation	1.00
	Higher use of chemical inputs	0.83
	Use groundwater	0.83
	Accessing credit facilities	0.67
	Adoption of modern varieties and technologies	0.67
	Group involvement	0.67
	Selling in lean seasons	0.67
	Varietal diversification	0.67
	Willing to insure crops	0.50

4.4.5 Reflection on the cognitive mapping approach

CM helped us reduce a complex topic such as farming risk—implicit in the long open-ended conversational interviews—into explicit networks of constructs. We could replace thousands of words with a simple picture to explain the story succinctly. It allowed us to explain farmers' understanding of risk and management decisions using various map dimensions, offering semi-quantitative flavours in qualitative research. It also helped us analyse the effect of individual heterogeneity on the perceptions of risk and management decisions. Moreover, CM is a flexible tool that can be adapted to a variety of contexts. In addition to its applicability as a research method, it can also serve as a communication tool because of its power in presenting a complex topic using a simple picture that is easy to understand for a wide range of audiences. Because there is no specific start or end point to read the map, readers can choose their construct of interest and follow relevant links to interpret the idea. Furthermore, the CM approach can be an appropriate tool for recording, analysing, and reporting focus group discussions, presentations and dialogues. We also see the opportunity for further exploring the potential of the CM approach. In our study, the interviewees were not essentially aware of the approach. Future research may consider a participatory approach for map construction. Alternatively, such mapping exercises can be tested in a group setting.

4.5 Conclusion

This study has shown that farmers do not perceive various risks as discrete elements. Farmers do not even consider it worthwhile to differentiate the various notions of risk such as risk factors, uncertainty and risk. They often understand these constructs as synonyms of threats or challenges to their farming occupation. Their cognition of risk is a complex network of bi-directional causal relationships between sources of uncertainty, risks and management strategies. The multiple linkages between the constructs indicate that farmers perceive more than one cause of a risk, and they aim to meet more than one goal while responding to the risks. This tendency informs us that risk management products, such as multi-peril crop insurance that target multiple risks, will create more demand than those targeting a single risk. Such complexity also indicates that conventional risk mapping is challenging because it is difficult for farmers to quantify the probability and consequences of one element out of such entanglement. We found that cognitive mapping can complement the quantitative methods to dissect such complexity into tangible parts and communicate the key message to a wide range of audiences.

Among the various risks perceived by farmers, the majority belonged to the production risk category. This finding is consistent with the fact that smallholder subsistence farmers, who consume much of what they produce, are more exposed to production risks than market risks. Similarly, farmer perception of a gap between their existing knowledge and the knowledge required to adopt new crop varieties or technologies was the primary factor determining their perception of production uncertainty associated with adopting such varieties or technologies. Such risk factors may explain the low rate of varietal and technological adoption. The results also showed that men and women had different perceptions of extrinsic sources of farming risks. For instance, while women farmers were worried about the uncertainty in the supply of basic inputs, males were worried about access to more advanced elements of farming. We can relate such differences to gender-differentiated roles in farming. However, the perceptions of other climatic risk factors such as the uncertain onset of monsoon leading to drought, heavy rainfall leading to flooding, and increased temperature leading to low crop production were common to all samples.

Apart from the factors that lead to production risks, traders' monopolistic role in determining the price of farm produce, lack of government support in the market, and unregulated import of cheaper goods were the primary sources of market risk perceived by farmers. The government's role seems pivotal in protecting farmers against such risks. Announcing minimum support prices for major commodities before the start of the growing season could help farmers maximise expected returns considering all potential investment options. Similarly, policy adjustment aimed at regulating imports also falls within the scope of the government's responsibility. Moreover, the promotion of cooperative marketing systems may increase farmers' bargaining power in the market.

Farm diversification, mechanisation, adoption of modern varieties and technologies, application of more chemical inputs, and groundwater use were the major strategies targeted against production risks. Likewise, participating in farmer groups, accessing credit facilities and income diversification were the farmers' major strategies for dealing with financial risk. Similarly, although selling farm produce in lean seasons was the major strategy against price risk, it was constrained by two main factors. Firstly, smallholders need cash immediately to purchase inputs for the next crop. Secondly, it exposes them to further risks such as storage loss and price risk in the lean seasons. In addition to these informal strategies, farmers were willing to buy formal risk management products such as crop insurance. Moreover, farmer awareness of potential risk management options and their risk attitude are linked to their willingness to purchase crop insurance. However, because risk aversion is an intrinsic characteristic of farmers, educating them about the concept and benefits of crop insurance is likely to create more demand for it. Furthermore, understanding the complexity of farming risks was similar irrespective of wealth, age, education, family size and geographical location of the decision-maker. Such homogeneous perception of risk suggests that a risk management intervention or product may have wide acceptability.

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Chapter 5: A Psychometric Analysis of Farmers' Perceptions of Risks, Uncertainties and Management Strategies in Nepal (Paper 2)

5.1 Abstract

Risk perceptions indicate how worried people are about risks and affect their decisions to manage potential adverse outcomes. We conducted a psychometric analysis of farmers' perceptions of risks, uncertainties and management strategies using a questionnaire survey with 420 randomly selected farmers from Nepal's Terai region. The results showed that farmers were most concerned about the risks associated with labour supply, followed by the price of farm outputs and drought. Traders' dominant role in price determination of farm outputs was the primary source of market risks. The Farmers' drought risk perception was associated with drought experience, family size, rice productivity, migrant family, age and access to infrastructure and services. Likewise, their flood risk perception was correlated to flood experience, rice productivity, farm size, migrant family, and joint family system. We also found significant spatial variation in farmers' risk perceptions. These relationships suggest that farmers' risk perception is a combined function of objective risk factors, personal characteristics and farm characteristics. Although farmers considered drought risk more severe than flood risk, their perceptions of the two risks were uncorrelated. This finding suggests that risk management support programs that consider drought and flood as mutually exclusive risks are not likely to meet a proportion of farmers' needs. We also found that drought and flood were not ideally insurable risks, which implies a wide gap between an actuarially fair premium and the farmers' willingness to pay. In such a case, the government may need to provide a high subsidy to improve the adoption of crop insurance. Although crop insurance adoption has recently gained momentum, farmers rated the applicability and effectiveness of on-farm diversification strategies higher than those of crop insurance. Therefore, a holistic risk management approach should be applied involving the right combination of on-farm tools and market-based tools. Improving farmers' access to modern farming technologies such as climate-smart crop varieties and training them on the use of such technologies can increase the effectiveness of on-farm diversification strategies. In addition, establishing a weather forecasting service, irrigation development and promoting drought-tolerant crop varieties may be effective strategies to mitigate drought risk.

Keywords: agriculture, Nepal, psychometric paradigm, risk perception, uncertainties

5.2 Introduction

Understanding how farming communities perceive risk is a common interest of researchers, policymakers and risk management actors. Knowing how worried the farmers are about risks helps predict their potential response to policy interventions and willingness to adopt the risk mitigation measures. The effectiveness of agricultural development programs will be improved if farmers' risk perceptions and the factors causing variation in the individual judgement of risk are accounted for (Legesse & Drake, 2005). The success of climate change adaptation policies relies on a shared understanding of the causes of climate change and associated risks between policymakers and farmers (Patt & Schroter, 2008). Farmers are unlikely to support climate change adaptation initiatives that require them to take individual action unless they perceive that it poses considerable risks to their farming and livelihoods (Ahsan & Brandt, 2014).

Several studies have analysed farmers' risk perceptions and decision-making to deal with these risks. However, the causal relationships between risk perception, risk attitude and risk responses are inconsistent across studies. For example, Weber et al. (2002) reported that the variation in risk responses was due to the difference in risk perceptions. Similarly, Sitkin and Pablo (1992) found the effect of various factors on risk response to be mediated by risk perception and risk attitude. Petrolia (2016) also found that the nature of risk perception confounded the effect of risk attitude on choice behaviour. In contrast, van Winsen et al. (2016) found that risk responses were not affected by risk perception but by risk attitude.

Authors also have contrasting views on the effect of risk perception on willingness to reduce risk. For instance, while Lin et al. (2008) found higher risk perception associated with higher willingness to invest in mitigating risk in Taiwan, Sjöberg (2000) argued that it is simplistic to assume that higher risk perception indicates higher demand for risk mitigation. Moreover, human behaviour is so diverse and inconsistent that no single model can accurately predict all outcomes (Hardaker & Lien, 2010). Individuals differ in their perceptions even for a well-known risk (van Winsen et al., 2016) because the judgement of the probability and impact of an unfavourable event is highly individualised (Gebreegziabher & Tadesse, 2013). Furthermore, perceived and objective risks are often incongruent, indicating that the nature of risk affects individual perceptions and reactions to the risks variably (Linda & Nicole, 2004). These facts signify that a context-specific understanding of how farmers perceive and deal with risk seems pivotal for informing policymaking related to farm risk management. This paper comprehensively answers what farming risks the Nepalese farmers are most concerned about, what sources of uncertainty they perceive in farming, what factors influence their risk perceptions and what risk management strategies they consider are important.

5.2.1 Risk

Risk is a pervasive feature of human existence as the future is inherently uncertain, yet there is no single universal definition of risk. Variability of outcomes and the possibility of loss are two common elements across all definitions of risk. For a risk to exist, there must always be at least two possible outcomes, and we do not know for sure how often such outcomes will occur (Vaughan & Vaughan, 2008). An additional commonality across all notions of risk is that uncertainty always relates to a future state of the world (see Sjöberg, 2000). Although risk, uncertainty and ambiguity are often used interchangeably in day-to-day life, academia defines these as distinct notions. Risk is defined as a situation where the probabilities of outcomes can be estimated with some accuracy, while uncertainty refers to a situation where such probabilities are unknown (Hardaker et al., 2015; Rejda & McNamara, 2014). In contrast, Barham et al. (2014) used uncertainty as a broad term that includes both risk and ambiguity. They referred to risk when the probability distribution of random outcomes was known and ambiguity when such distribution was unknown. Furthermore, when risk is measured in terms of variance of outcomes, it can be divided into downside risk and upside potential. The downside risk measures the distribution of outcomes below the mean or expected level, while upside potential, also called upside risk, refers to the right-hand side variability of the outcomes (see Grootveld & Hallerbach, 1999). In this paper, risk refers to undesirable outcomes in farming when farmers have personal estimates of probability and potential loss associated with it, and uncertainty as the situation where they have a vague idea of unfavourable outcomes with no estimate of probability or likely loss.

5.2.2 Risk perception

Risk perception is an individual's judgement on the characteristics of risk (Agrawal, 2009). Perceiving a risk involves estimating the probabilities and undesirable consequences (Sjoberg et al., 2004). In mathematical terms, risk perception is the product of subjective probability and magnitude of negative impacts of an outcome (MacCrimmon & Wehrung, 1986; Patt & Schroter, 2008). Risk perception is a more reliable indicator of human behaviour than objective risk because decision-making is influenced more by what they think will happen than by what really happens (Howarth, 1988). Farmers' decision-making depends on their intuitive estimates of risk, and they can express it when asked (Sherrick et al., 2004).

There are two approaches to probability estimation: frequentism and subjectivism (Hardaker & Lien, 2010). The frequentists consider probability as the limit of a relative frequency estimated based on an infinite number of observations, called objective probability. In contrast, the subjectivists view probability as a degree of belief by rational agents, also called personal probability. In line with the approaches to probability estimation, risk is also viewed from two perspectives. Objective risk, also called the degree of risk, refers to the relative variation of actual loss from expected loss. Subjective risk, also called perceived risk, refers to the personal expectation of loss (Rejda & McNamara, 2014).

The idea of objective risk is relevant to corporate and institutional decision-making contexts. However, in personal decision-making spaces, such as farming, individual perception of risk is more important than objective risk—this paper analyses subjective risks in farming from the farmer perspective.

5.2.3 Factors affecting risk perception

Extensive efforts have been made to relate farmers' risk perception with their age (Fonta et al., 2015; van Winsen et al., 2016), gender (Boholm, 1998; Lupton & Tulloch, 2002), education (Gebrehiwot & van der Veen, 2015; Ginder et al., 2009), wealth (Ginder et al., 2009; Lefebvre et al., 2014), farm size (Lucas & Pabuayon, 2011; van Winsen et al., 2016), access to infrastructure (Legesse & Drake, 2005) and family size (Fonta et al., 2015; Lefebvre et al., 2014). However, the relationships between risk perception and these variables are not consistent across studies. Consequently, the literature lacks explicit theoretical models that explain the heterogeneity in individuals' risk perceptions. Researchers also disagree on the relationship between risk experience and risk perception. For instance, while van Winsen et al. (2016) found a positive effect of past risk exposure on risk perception, Slovic (1987) argued that familiarity with risk decreases risk perception because people feel they have more control over the risks when they become more familiar with them.

The diverging findings of the studies conducted in other regions suggest that the relationship between the same factors and risk perceptions may vary across geography and socio-demographic conditions. Therefore, one of the objectives of this study is to test the findings of earlier studies in the Nepalese context. Moreover, Nepalese agriculture has some unique features that have not been linked with farmers' risk perceptions in other regions. For instance, land tenancy is an important aspect of Nepalese agriculture because many farmers are part-tenants (MoALD-Nepal, 2014), and landlords usually make the key farming decisions. Therefore, tenant farmers may have different risk perceptions than owner-cultivators. Likewise, the Government of Nepal has promoted two flood-tolerant and six drought-tolerant rice varieties (SQCC-Nepal, 2019) to reduce production risks due to floods and droughts. Farmer awareness and access to these climate-resilient crop varieties affect their risk perception. Similarly, both governmental and non-governmental agricultural extension programs are implemented through farmer groups. Farmer involvement in groups might affect their risk perception because such groups can create risk awareness while also being a risk management agency. Further, we examined the association of rice productivity and households' migration status with their risk perception. Figure 5.1 shows 16 hypotheses tested in this study. The dependent variables include the measures of farmers' drought and flood risk perceptions. Similarly, the explanatory variables include those reported to have varied effects on risk perception by earlier studies and those not studied elsewhere before (indicated by shaded boxes).

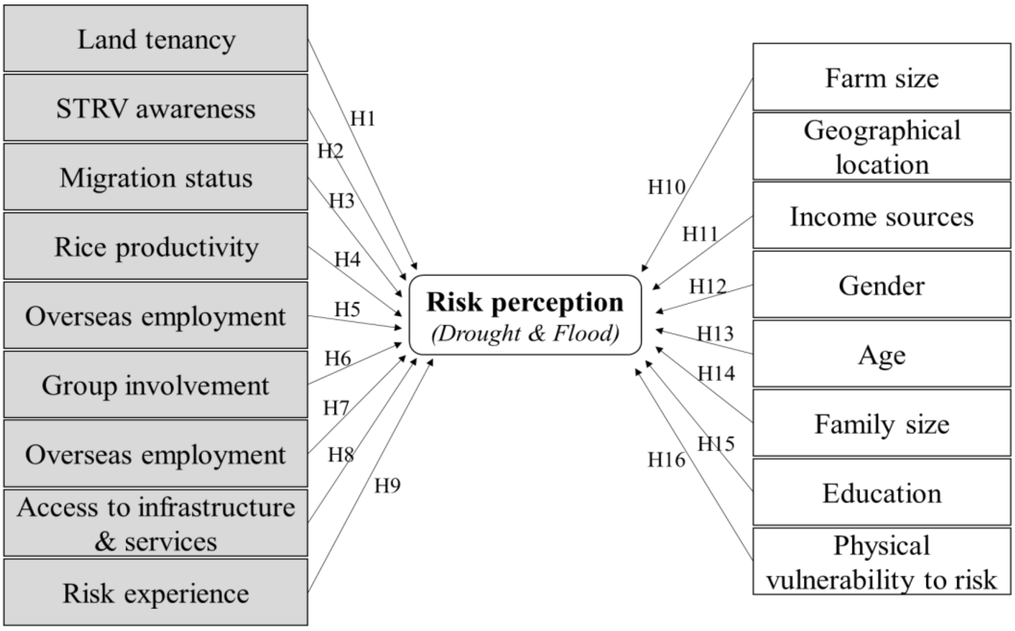

Figure 5.1 Hypothesized relationships between various factors and risk perception

Note: Shaded boxes include the variables not studied before elsewhere.

5.2.4 Risk management strategies

Risk management involves identifying potential loss exposures of a firm and applying the most appropriate strategy to deal with such exposures (Rejda & McNamara, 2014). It also involves deciding to take (or not to take) action (Hoag, 2009). Moreover, risk management itself is a risky undertaking because whether the loss will happen or not is uncertain. In farming, the sources of uncertainty, risk, and risk management action form a complicated network of relationships that a risk management strategy may become a risk factor itself (van Winsen et al., 2013). For instance, farmers may decide to grow a drought-tolerant rice variety to reduce the risk of yield loss due to drought. However, this decision involves a risk of forfeiting higher yields that a regular water-intensive variety could yield if rainfall occurs normally. Furthermore, risk management always involves a cost, either as a direct cost such as the insurance premium or indirect cost such as giving up the potential gain (Hoag, 2009). Therefore, a good risk management strategy seeks a balance between accepting risk or acting against it.

Although the strategies to deal with risk are as diverse as the risks in farming (Hoag, 2009), the common purpose of all strategies is to stabilise income and maintain sustainable growth of the farming sector (Lomott & Lyskawa, 2014). Depending on availability, applicability and affordability, farmers can use one or more tools to manage risk (Gurenko & Mahul, 2004; Mahul & Stutley, 2010). In developing countries like Nepal, where the agricultural insurance market is underdeveloped, farmers generally depend on self-insurance and disaster relief payments to deal with farming risks (Mahul & Stutley, 2010). Self-insurance is a set of individual actions practised by farmers to reduce their risk exposure (OECD, 2009). Farm diversification, development of irrigation facilities, engaging in off-farm income opportunities, and monetary savings are some of the traditional strategies practised by farmers to mitigate the potential negative consequences of risk (Alan & Hendrik, 2011). However, traditional strategies do not absorb a large share of weather risks, leading to humanitarian calamities in the case of major production shocks (Barnett & Mahul, 2007). Recently, low-premium agricultural insurance has become a popular tool for protecting poor farmers against the negative consequences of weather-related risks in developing countries (FAO, 2014). A sound risk management policy should ensure coherence between farmers' traditional strategies and market solutions, avoiding the potential conflict of interests between farmers, government, and private insurance companies in the risk market (OECD, 2009). Such policymaking requires a good understanding of farmers' perceptions of the applicability and efficacy of the potential risk management alternatives. This paper also assesses the diversity in farmers' risk management strategies and ranks them by their importance from the farmers' perspectives.

5.3 Methodology

The psychometric theory is the dominant theory in risk perception research, which assumes that individuals perceive risks subjectively, and their perception is affected by cognitive or psychological factors (Sjöberg et al., 2004). The theories, methods, and findings of risk perception studies based on psychometric theory have been so popular that they constitute what is known as the 'psychometric paradigm' (Slovic, 1993). Moreover, the early study that used the psychometric method (Fischhoff et al., 1978) has been replicated many times in diverse contexts; most of which have confirmed the original two-factor model—dread and novelty—to account for risk perception (Sjöberg et al., 2004). Therefore, psychometric methods are considered highly robust in measuring risk perception.

The psychometric theory assumes that the semantical classification of hazards, mental representation of information, and probability estimation are done through interdependent cognitive activities (Boholm, 1998). More specifically, the psychometric theory is built on the following major assumptions:

- Individual perception of risk is subjective and can be measured in terms of various characteristics of risk (Sjöberg et al., 2004; Slovic, 1992; van Winsen et al., 2013).

- Risks can be classified; individuals understand risk well and can discretely quantify and compare them (van Winsen et al., 2013).

- Risk perception is influenced by psychological, social, cultural, and institutional factors, and properly designed studies can estimate such influences to explain individual variation in risk perception (Slovic, 1992).

5.3.1 Psychometric methods

Psychometric methods involve psychological scaling of various risk characteristics and multivariate analysis techniques to represent risk perception in quantitative terms (Slovic, 1987). Risk perception is assessed by asking respondents to rate the probability and potential loss associated with the risk on a given scale (Baird et al., 2009; Goszczynska et al., 1991; Mary et al., 2003; Sjöberg et al., 2000; Slovic, 1987; Smith et al., 2000; Stoffle et al., 1991). Ranking different risks based on a composite index that constitutes individuals' subjective probability and magnitude of impact is also known as 'risk mapping' (van Winsen et al., 2013). According to Sjöberg et al. (2004), adopting a psychometric method to a specific domain involves:

- Listing various sources of risk
- Developing scaling questions that characterise the risk in terms of probability and impact
- Surveying respondents to elicit their responses to the questions
- Carrying out descriptive and multivariate analysis of the data to calculate risk perceptions and identifying the factors that explain the variation in respondents' judgement and perception.

We adapted the methods to elicit farmers' risk perceptions from three studies, i.e., van Winsen et al. (2016), Greiner et al. (2009), and Meraner and Finger (2017). Both van Winsen et al. (2016) and Meraner and Finger (2017) used five-point Likert scale questions to elicit the probability and impact of different risks and descriptive approaches to analyse the data. Although Greiner et al. (2009) used a slightly different risk assessment matrix to elicit risk perception, their analytical approach is similar to the other two studies. The number of response categories is an important consideration in designing Likert-scaling questions to reduce cognitive burden and response bias. Sjöberg (2000) suggested that five or seven categories are generally preferable in categorical scales. Accordingly, we used five-point scales to elicit farmers' responses to the psychometric questions. The questionnaire used in the survey is presented in Appendix C.

5.3.2 Description of the study tools and data analysis techniques

We asked the farmers to rate their agreement on various statements representing the sources of uncertainty or risk factors in their farming on a five-category scale (0 meaning strongly disagree to 1 meaning strongly agree). We ranked these sources of uncertainty based on the average scores across samples. Likewise, we developed a list of unfavourable outcomes related to farming and asked the farmers how likely they think the given outcomes would happen next year (0 meaning not likely at all to 1 meaning certain). We also asked them how much loss they think they would suffer if the outcomes occurred (0 meaning not at all to 1 meaning complete loss). We calculated the risk perception scores for each respondent for all risks as a product of their ratings on likelihood and potential loss and ranked the risks based on average risk perception scores across samples. Using the same list of unfavourable outcomes, we also asked the farmers to rate how often they faced the outcomes in the past ten years (0 meaning never to 1 meaning every year) and the loss they suffered when it happened (0 meaning not at all to 1 meaning complete loss). We calculated the risk experience score as a product of their ratings of frequency and loss associated with the given risk item. We also carried out a correlation test between risk perception and risk experience scores for each risk. To identify the factors affecting risk perception, we estimated two Tobit models using the measures of farmer perception of drought and flood risk as dependent variables and various socio-demographic and individual-specific variables as explanatory variables.

Similarly, we developed a list of on-farm and off-farm risk management strategies and asked the respondents to rate how often they used the given strategy in the past ten years (0 meaning never to 1 meaning every year) and how effective the strategy was when they used it (0 meaning not at all to 1 meaning highly effective). We calculated important scores of each strategy for all samples and ranked the strategies based on average scores over samples. The categories of five-point scale were coded as 0, 0.25, 0.5, 0.75 and 1.

5.3.3 Tobit Model specification

The dependent variable in the present study is risk perception which has been constructed as the product of the two variables representing probability and impact of the risk. Both variables were measured in a five-point scale coded as 0, 0.25, 0.5, 0.75 and 1. Therefore, the risk perception variable has ten values ranging from 0 to 1. Given that the variable has been generated multiplying two underlying values, we have treated it as a continuous variable. However, the ordinary least square model produces biased estimates in the presence of such a limited dependent variable (see Peter et al., 2000). The Tobit model using maximum likelihood estimation is the appropriate model to analyse censored continuous variables (see Tobin, 1958), restricting the predicted values within the limit specified by the censoring values.

The Tobit model for the latent dependent variable (y^*), which is only partially observed, is given by:

$$y_i^* = \beta_0 + \beta_1 x'_{1i} + \beta_2 x'_{2i} + \cdots + \beta_n x'_{ni} + \varepsilon'_i, \quad \varepsilon_i = N(0, \sigma^2)$$

where $x'_1 \ldots . x'_n$ are explanatory variables. The error term ε_i is assumed to be normally distributed with mean 0 and variance σ^2. We specified a lower limit (L) = 0 and an upper limit (U) = 1. The partially observed latent variable y^* determines the value of the observed dependent variable (y). The observed dependent variable y is defined as:

$$y = \begin{cases} L \ if \ y^* < L \\ U \ if \ y^* > U \\ y^* if \ \mathrm{L} < y^* < \mathrm{U} \end{cases}$$

or

$$y = \max(y^*, L) \ and \ \min\,(y^*, U)$$

The estimated parameters represent the marginal effects of x variables on y^* which will be attenuated when the point of evaluation lies close to the limits. The marginal effects of x variables on the expected value of y are complicated by the censoring at the lower and upper limits. In the results that follow Tobit estimation, we have reported the marginal effects of x variables on y*. The x variables include those shown in Figure 5.1.

5.3.4 Sampling and data collection

The study involves 420 randomly selected farmers from the Terai region of Nepal. The study area is divided into three regions—Eastern Terai region (ETR), Mid-Terai region (MTR), and Western Terai region (WTR)—based on the amount of annual precipitation. We used a face-to-face survey using a pre-tested semi-structured questionnaire. The details of sampling design and survey implementation are presented in Chapter 3 (Methodology).

5.4 Findings and discussion

5.4.1 Sample characteristics

Table 5.1 presents the summary statistics of the socio-demographic variables relevant to the subsequent analyses of farmers' risk perceptions. We also examined the association of these socio-demographic variables with the geographical location using Pearson's chi-square test (for categorical variables) and simple linear regression for continuous variables. The tests were significant for migration status, family type, family size, cultivated area, tenancy, income sources, off-farm employment, overseas employment, rice productivity and group involvement. We will examine the influence of such regional variation in explanatory variables on farmers' risk perceptions later.

The study region has a mixed population of endogenous communities that migrated from hilly areas. About one-third of the respondents represented migrant households. More than two-thirds of the sample households had a joint family system. Major typologies of Nepali farmers include owner-cultivator, who cultivate own land; part-tenant, who cultivate rented land in addition to their own; and landless-tenant, who cultivate only rented land (Sugden & Gurung, 2012). Most of the respondents were owner-cultivators, with about one-fifth representing part-tenant farmers. About 54% of sample households had at least one family member in off-farm employment, with 29% of households having overseas employment. The average rice productivity reported by the respondents was 3.55 Mt/ha, which is slightly lower than the national average reported for 2018, i.e., 3.76 Mt/ha (MoALD-Nepal, 2020). About two-thirds of the respondents were aware of at least one stress-tolerant rice variety (STRV).

Table 5.1 Descriptive statistics

Variable	Description	ETR	MTR	WTR	All
Female	% Respondents	44.44	35.00	44.17	41.67
Age	Years	51.29 (12.81)	47.52 (15.21)	49.12 (15.80)	49.59 (14.47)
Education	Years of schooling	5.44 (4.40)	5.93 (4.29)	5.86 (4.55)	5.70 (4.41)
Immigrant family***	% Households	34.44	15.83	51.67	34.05
Joint family***	% Households	35.56	64.17	36.67	44.05
Family size***	Number	6.06 (2.04)	6.53 (2.46)	4.93 (1.38)	5.87 (2.10)
Farm size***	Ha	0.90 (0.35)	1.25 (0.46)	1.62 (1.17)	1.21 (0.77)
Part-tenant***	% Respondents	22.78	28.33	10	20.71
Income sources***	Number	1.92 (0.59)	1.78 (0.64)	1.58 (0.63)	1.78 (0.63)
Off-farm employment***	% Households	61.67	54.17	41.67	53.81
Overseas employment***	% Households	38.33	30.83	13.33	29.05
Infrastructure/ service access index	Index: 0 - 1	0.60 (0.19)	0.59 (0.23)	0.61 (0.25)	0.60 (0.22)
Rice productivity***	Mt/Ha	3.76 (1.10)	3.51 (1.11)	3.27 (0.93)	3.55 (1.07)
Group involvement***	% Respondents	66.11	83.33	75.83	73.81
Aware of STRV	% Respondents	62.78	71.67	71.67	67.86
Drought risk perception	Score 0 - 1	0.59 (0.26)	0.59 (0.27)	0.58 (0.25)	0.59 (0.26)
Flood risk perception	Score 0 - 1	0.17 (0.19)	0.21 (0.23)	0.19 (0.19)	0.19 (0.20)
N		180	120	120	420

*Note: figures in parentheses indicate SD; asterisks indicate statistical significance of regional differences at * p<0.05, ** p<0.01 and *** p<0.001.*

5.4.2 Risk mapping

We present the psychometric analysis of farmers' perceptions of risk and uncertainties in various aspects of farming.

5.4.2.1 Sources of uncertainty

We asked the respondents to rate their agreement with 54 statements on a five-point scale (0 meaning 'fully disagree' to 1 meaning 'fully agree'), considering the relevancy of these statements to their farming conditions. These statements represent the sources of uncertainty or risk factors. Table 5.2 presents the ordered list of the top ten risk factors based on average scaling scores over samples (see Appendix H for the complete list). The median values of more than half of the risk factors were greater than or equal to 0.75. This result implies that farmers have high perceptions of uncertainties in farming, in general.

Farmers perceived the traders' dominant role in determining the price of farm outputs as the most important source of uncertainty leading to market risks. Mainly during the crop harvesting months, there are many farmers who want to sell their produce and few traders who want to buy them. Consequently, farmers have low bargaining power and are less likely to fetch a reasonable price for their produce. Similarly, they perceived the increase in the number of drought days as the second most important source of risk. The uncertainty about the incidence of drought in the forthcoming crop season affects farmers' decision-making related to crop selection, variety selection and planting time. For instance, a farmer may be uncertain whether to grow a drought-tolerant crop variety with low potential yield or a water-intensive variety with higher yield potential in the absence of a clear idea about the likelihood of drought. In addition to posing a threat of production losses, sometimes complete losses, drought may also increase production costs if farmers need to pay for irrigation. The top ten risk factors also include unavailability of labour in peak seasons, insufficient government support in the market, increased overseas migration of male youth, increased insect and disease infestation, lack of access to irrigation, and unstable government support and subsidy. When labour demand exceeds supply, the wage rate is likely to increase, leading to the risk of increased production costs. Insufficient external support in the market—for infrastructure development, policy intervention or price support—may increase uncertainties about farmer access to markets and potential price. In addition to causing labour shortages, increased outmigration of male youth has resulted in the feminisation of agriculture, creating challenges and opportunities for the Nepali farming sector (see Bhawana & Race, 2020; Gartaula et al., 2010; Spangler & Christie, 2019). Increased insect and disease infestation may affect farmers' decision-making related to the selection of crop variety, planting time and input use. The lack of irrigation access also affects farmers' decisions on crop variety selection and planting time in the context of uncertain rainfall. If farmers are uncertain about the continuity of government support and subsidies in the coming seasons, their financial plan will likely be affected.

We implemented factor analysis to examine the possibility of reducing 54 risk factors into fewer latent constructs. However, the analysis suggested a 21-factor model (eigenvalue > 1), which only explained 60% of the variation in the farmer ratings of the risk factors, with no meaningful factor loadings. Therefore, we thematically ascribed the factors into one or more of five categories of farming risks (production, market, institutional, personal and financial) suggested by Hardaker et al. (2015) and

Komarek et al. (2020). Greiner et al. (2009) also followed a similar strategy to attribute risk factors into risk categories after failing to achieve reliable results through factor analysis. We also indicated drought or flood to the relevant statements ascribed in the production risk category, considering these statements as the factors leading to drought or flood risks. We constructed separate indices to represent farmer vulnerability to drought and flood risks using these statements, which we discuss in the next paragraph.

Table 5.2 Sources of uncertainty/risk factors in farming

Rank	Risk factors	Risk category	Scale rating		
			Mean	SD	P50
1	Traders determine price of output	Market	0.86	0.18	1.00
2	Number of drought days has increased	Production (drought)	0.85	0.18	1.00
3	Rainfall has been more erratic than before	Production (drought, flood)	0.85	0.20	1.00
4	Labour is not sufficiently available when needed	Production, market	0.85	0.19	0.75
5	Government support in the market is not sufficient	Market, institutional	0.84	0.19	0.75
6	Outmigration of male youth has increased	Production, market	0.84	0.20	0.75
7	Onset of monsoon has delayed	Production (drought)	0.84	0.18	0.75
8	Insect and disease infestations has increased	Production	0.83	0.19	0.75
9	I do not have access to reliable irrigation	Production (drought)	0.81	0.22	0.75
10	Government support and subsidies are not stable	Institutional, financial	0.77	0.22	0.75

Note: Figures in parentheses indicate SD.

5.4.2.2 Vulnerabilities to drought and flood risks

From the list of risk factors discussed earlier (see Appendix H), we extracted seven statements related to drought risk, five statements related to flood risk, and one statement related to both. We calculated the drought vulnerability index (DVI) and flood vulnerability index (FVI), averaging the scale scores of the respective statements (Table 5.3). We used these indices as explanatory variables in the models of farmers' risk perceptions. The paired t-test suggests that farmer vulnerability to drought is higher than for flood (H_0: DVI = FVI; P= 0.000). We also conducted a one-way ANOVA test to examine whether the vulnerabilities to drought and flood risk were associated with geographical location. The test produced non-significant results for both indices, suggesting that the farmers' perceptions of objective factors leading to drought and flood risks are similar across study regions.

Table 5.3 Vulnerabilities to drought and flood risk

Rank	Statements	Scale rating	
		Mean	SD
1	The number of drought days has increased	0.85	0.18
2	Rainfall has become more erratic than before	0.85	0.20
3	The onset of monsoon has delayed	0.84	0.18
4	I do not have access to reliable irrigation	0.81	0.22
5	The groundwater table is deepening	0.73	0.24
6	Natural water sources have dried up	0.72	0.23
7	I am at the tail-end of the irrigation system	0.39	0.28
8	Most of my farmlands are upland	0.35	0.28
	DVI	0.69	0.10
1	Rainfall has become more erratic than before	0.85	0.20
2	Rainfall intensity has increased	0.68	0.25
3	Total rainfall has increased	0.48	0.24
4	Most of my farmlands are low lying	0.40	0.29
5	Unplanned physical development has blocked natural drainage channels	0.40	0.29
6	My farmlands are close to a river	0.27	0.24
	FVI	0.51	0.11

5.4.2.3 Risk experience and perceptions

We presented the farmers with 34 risks items and asked them to rate how often they had experienced these risks in the past ten years (0 meaning 'never' to 1 meaning 'each year') and the magnitude of the negative impact on their income due to these risks when it occurred (0 meaning 'not at all' to 1 meaning 'complete loss'). Similarly, we asked them to rate the likelihood of the same risks next year (0 meaning 'not at all likely' to 1 meaning 'certain') and the potential impact on their income due to the risks (0 meaning 'not at all' to 1 meaning 'complete loss'). The scales used in all cases had five categories coded as 0, 0.25, 0.5, 0.75 and 1. We calculated experience scores as the product of frequency and impact ratings and perception scores as the product of likelihood and potential impact ratings for all risk items. Figure 5.1 presents the average risk experience and perception scores of each risk over samples sorted in ascending order by risk perception score.

The risk associated with the shortage of farm labour was ranked highest, followed by the risk of lower prices for farm produce and drought. The risks associated with increased production cost, insect infestation, high input price, subsidy cut, disease and delay in rice planting were among the top ten risks. Drought was perceived as the third most important risk, while the flood was much lower in the risk perception ranking. This disparity is consistent with differences in vulnerabilities to drought and flood risk, as discussed earlier. The numbers within brackets adjacent to each risk item indicate the correlation coefficients between risk experience and perception, and the asterisks indicate the significance of the correlation. The correlations were significant, and the coefficients were more than 0.5 for each pair. This finding has important methodological implications. The self-reported scaling method is prone to various response biases. Speculating about the future state of the world is cognitively more demanding for farmers and likely to incorporate more response biases than reporting what they experienced in the past. Therefore, researchers should consider using the measure of risk experience as a proxy of risk perception, especially when the respondents have low education status and less informed risk perceptions.

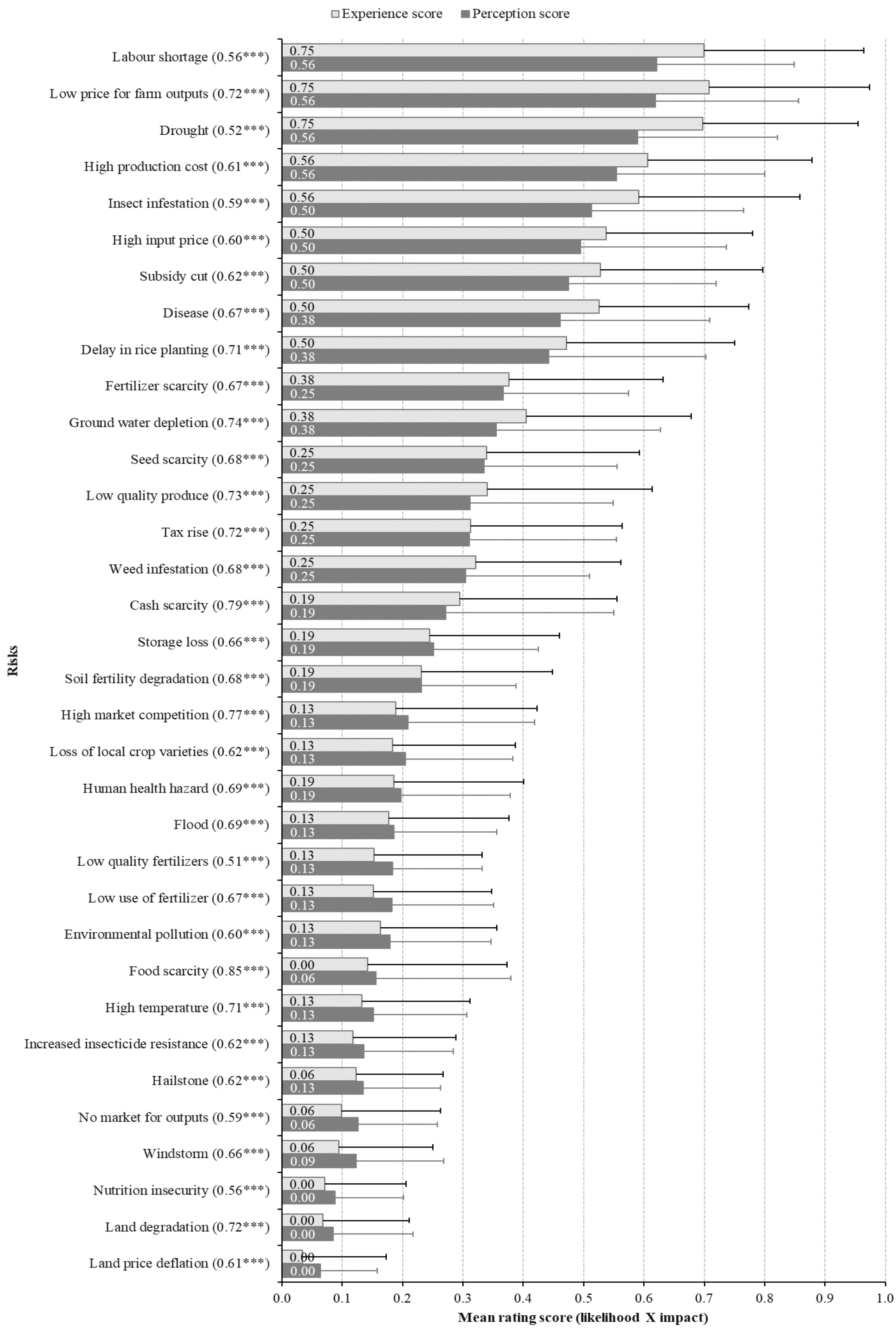

Figure 5.2 Farmers' experience and perception of risks

*Note: Risks are sorted by mean rating score; error bars show SD; figures within the bars indicate median rating score; figures within the parentheses indicate the correlation coefficient between risk experience and perception; asterisks indicate statistical significance at * p<0.05, ** p<0.01 and *** p<0.001.*

5.4.2.4 Relationship between farmers' perceptions of drought and flood risk

In Nepal, rice is mainly transplanted in June-July and harvested in October-November. The rice-growing season coincides with the Monsoon, which receives more than 80% of the annual rainfall (Dahal et al., 2016). Although drought and flood do not occur simultaneously because the objective factors leading to these hazards are counteractive, a rice crop may face both drought and flood at different stages of growth. We analysed the correlation between farmers' perceptions and experiences of drought and flood risks. As shown in Table 5.4, farmers' risk perceptions are highly correlated with their risk experience for both drought and flood. Their experiences of the two risks are also slightly negatively correlated. However, their perceptions of the two risks are uncorrelated. Since farmer behaviour depends on what they perceive will happen more than what they experienced (Howarth, 1988), these findings imply that a risk management support program assuming flood and drought as mutually exclusive risks will not likely meet the needs of a proportion of farmers. Therefore, farmers' risk perceptions need to be assessed within each context to improve the effectiveness of risk management interventions.

Table 5.4 Correlation between farmers' perceptions of drought and flood risk

	Drought perception	Drought experience	Flood perception
Drought experience	0.52***		
Flood perception	–0.08	–0.08	
Flood experience	–0.11	–0.11*	0.70***

*Note: Asterisks indicate statistical significance at * p<0.05, ** p<0.01 and *** p<0.001.*

5.4.2.5 Insurability of drought and flood risks

The insurability of rice crops against drought and flood depends on the nature of crop losses due to these hazards. Floods cause immediate physical damage, while losses due to droughts are realized slowly over time. Horizontal risk transfer, such as insurance, is an ideal strategy for mitigating low-frequency high-impact risk (Rejda & McNamara, 2014). We examined the insurability of drought and flood risks by analysing farmers' perceptions of the probabilities and impacts of these risks in relation to the rice crop. The farmers considered drought more severe than flood, both in terms of probability and potential loss (Figures 5.2 and 5.3). This finding has important implications for the insurance market. As shown in Figure 5.3, both drought and flood are not ideally suitable for risk transfer strategy. Farmer willingness to pay for flood risk may be much lower than an economical rate for insurance providers. Similarly, the premium for drought insurance may be high given that farmers have high perceptions of the likelihood and impact of the risk. In such cases, the government may need to substantially subsidise the premium to increase the adoption of crop insurance.

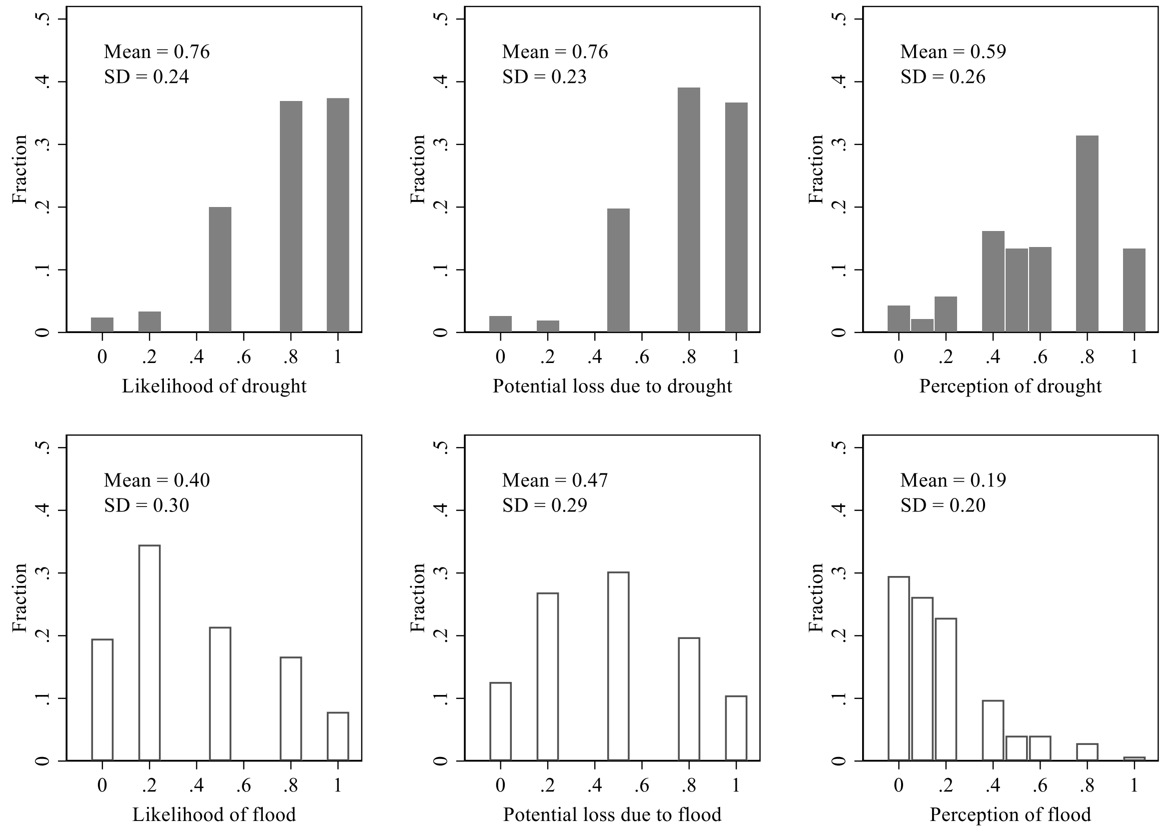

Figure 5.3 Farmers' perceptions of probabilities and losses of drought and flood risks

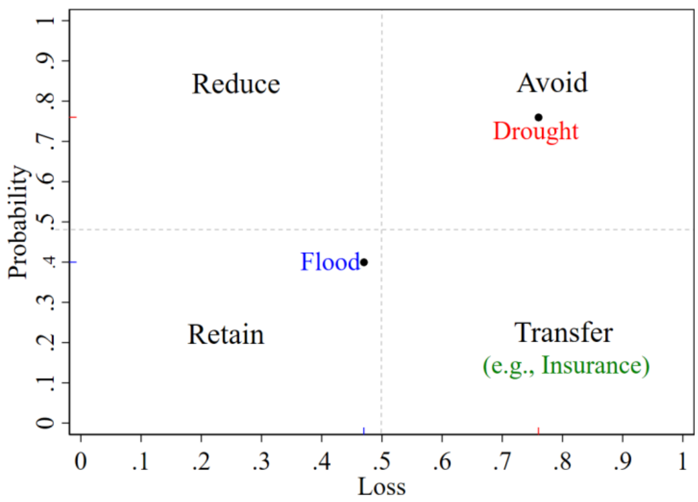

Figure 5.4 Insurability of drought and flood risk

5.4.3 Factors associated with risk perceptions

Of the various risks presented in Figure 5.1, we modelled farmers' perceptions of drought and flood risk because they are major weather-related risks in farming (see section 1.2). We estimated the Tobit model to identify the factors associated with farmers' risk perceptions. To account for the spatial correlation in the observations, we have reported robust standard errors clustered by study regions. We also estimated Ordered Logit and Fractional Probit models to check the robustness of Tobit estimates.

Table 5.5 shows the estimates of Tobit, Ordered Logit and Fractional Probit models of farmers' perceptions of drought and flood risks. The consistent results across different models indicate that Tobit estimates are robust. In addition, the highest Log-Likelihood and Pseudo-R^2 values for the Tobit model suggest that it is a preferable model among the three. The following discussion is based on the Tobit model estimates.

The perception of drought risk is positively associated with drought experience, family size, rice productivity and migrant family, while the same is negatively associated with age and access to infrastructure and services. Similarly, the perception of flood risk is positively correlated to flood experience, rice productivity, farm size, and migrant family, while it is negatively correlated to the joint family system. Mid-Terai and Western-Terai farmers have lower perceptions of drought risk and higher perceptions of flood risk than Eastern-Terai farmers.

The risk experience variable was generated by multiplying the frequency and impact of an unfavourable event in the last ten years as assessed by the farmers. Due to the unavailability of information on the prevalence of drought and flood events in the study region, we assumed the risk experience measure as a proxy for objective risk. The strong positive correlation between risk perception and experience for both risks indicates that the risk perception is shaped by objective risk, to a great extent. Che et al. (2020) also found a positive recency effect on risk perception, which implies that a recent experience of a bad outcome increases the perceived threat of the same outcome happening in the future.

The Terai region of Nepal has a mixed population of indigenous communities and migrant communities from hilly areas. The migrant communities often live in more marginal areas than the indigenous communities. We can link this to the positive correlation between risk perception and migrant household dummy. Contrary to the hypothesized relationship, the models show a positive correlation between rice productivity and perceptions of both risks, which requires further exploration. One reason underlying this relationship may be that the farmers with higher efficiency consider farming as the primary income source and are more concerned about the potential threats to their business than less efficient farmers who resort to off-farm opportunities for livelihood and are less worried about farming.

The respondents with a joint family system have higher flood risk perceptions than those belonging to the nuclear family. Similarly, the farmers cultivating larger areas are likely to have higher flood risk perceptions than the smaller farmers. The farmers who cultivate larger areas have a higher physical vulnerability to loss exposure compared to those cultivating smaller areas. Moreover, the increased dependency of the larger farmers on farming might have resulted in higher risk perceptions than the smaller farmers. Gebrehiwot and van der Veen (2015) also reported a positive effect of the scale of farming on risk perception (cf. Santeramo et al., 2016).

A farmer's drought risk perception increases with the increase in family size (cf. Legesse & Drake, 2005). Since farming is the primary source of income for most respondents, increased family size increases their responsibility of producing more food. Such a burden may amplify their perception of drought, which is a major risk for their farming. In contrast, the feeling of better control over a risk due to experience in handling it may be why older farmers have a lower perception of drought risk than younger farmers. This result supports the findings of earlier studies (e.g., Fonta et al., 2015; Gebrehiwot & van der Veen, 2015; van Winsen et al., 2016) that reported a positive association of age with risk perception (cf. Cohn et al., 1995).

Similarly, farmers' access to infrastructures and services, such as all-weather roads, post-harvest storage and processing facilities, input and output markets, agricultural research and extension agencies, credit providers and insurance companies, is likely to decrease their perceptions of drought risk. Increased access to such facilities may increase farmers' feeling of control over the risks, consequently decreasing their risk perception. However, this result contradicts Legesse and Drake (2005), who reported a positive association of risk perception with access to information and infrastructure.

Farmers' risk perceptions are not associated with other variables, such as gender, education, tenancy status, income sources, overseas employment, group involvement STRV awareness, and indices representing vulnerabilities to drought and flood. As discussed earlier (Chapter 2), studies conducted in other regions have reported varied effects of these variables on farmers' risk perceptions. These findings can aid in identifying specific target groups and designing appropriate agricultural development and risk management programs to help them uplift their living livelihoods.

Table 5.5 Factors associated with farmers' risk perceptions

Explanatory variables		Drought risk perception			Flood risk perception		
		Tobit	Ordered Logit	Frac. Probit	Tobit	Ordered Logit	Frac. Probit
Region	MTR (vs ETR)	–0.03*	–0.26***	–0.09***	0.04***	0.33***	0.15***
		(0.01)	(0.04)	(0.03)	(0.01)	(0.09)	(0.03)
	WTR (vs ETR)	–0.05*	–0.27**	–0.10**	0.02*	0.10	0.09*
		(0.02)	(0.10)	(0.04)	(0.01)	(0.08)	(0.04)

Age (years)	–0.00*	–0.02***	–0.00**	0.00	–0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
Drought experience	0.68***	5.46***	1.62***			
	(0.06)	(0.56)	(0.14)			
Flood experience				0.99***	9.76***	2.88***
				(0.05)	(0.89)	(0.07)
Family size	0.02**	0.19**	0.06**	–0.01	–0.13	–0.02
	(0.01)	(0.06)	(0.02)	(0.01)	(0.07)	(0.03)
Rice productivity (mt/ha)	0.02***	0.11***	0.04**	0.02***	0.27***	0.07**
	(0.00)	(0.03)	(0.01)	(0.01)	(0.05)	(0.02)
Migrant family (vs	0.05**	0.48***	0.14***	0.02*	0.26**	0.05*
indigenous)	(0.02)	(0.09)	(0.03)	(0.01)	(0.09)	(0.03)
Joint family (vs nuclear)	–0.05	–0.32	–0.09	–0.03***	–0.27***	–0.07
	(0.04)	(0.19)	(0.09)	(0.01)	(0.04)	(0.05)
Infrastructure & service	–0.16*	–1.13***	–0.38**	–0.01	–0.28	–0.09
index	(0.08)	(0.22)	(0.15)	(0.03)	(0.30)	(0.10)
Farm size (ha)	0.01	0.01	0.02	0.04***	0.47***	0.09**
	(0.03)	(0.20)	(0.06)	(0.01)	(0.08)	(0.03)
Education (years)	–0.00	–0.04***	–0.01	0.00	–0.01	0.01
	(0.00)	(0.01)	(0.01)	(0.00)	(0.03)	(0.01)
Female	–0.05	–0.33	–0.14	0.01	0.15	0.04
	(0.04)	(0.31)	(0.10)	(0.02)	(0.30)	(0.04)
Part–tenant farmer	–0.00	0.09	0.01	0.02	–0.07	0.07
(vs owner cultivator)	(0.01)	(0.06)	(0.01)	(0.04)	(0.27)	(0.11)
STRV awareness	0.00	0.00	0.01	0.06	0.53	0.22*
	(0.04)	(0.26)	(0.11)	(0.03)	(0.35)	(0.10)
Income sources	–0.00	–0.07	0.00	0.02	0.25	0.05
	(0.03)	(0.22)	(0.08)	(0.02)	(0.21)	(0.05)
Overseas employment	0.00	0.08	–0.01	0.04	0.36	0.14
	(0.03)	(0.14)	(0.07)	(0.03)	(0.33)	(0.09)
Group involvement	–0.01	0.02	–0.03	0.00	0.12	0.03
	(0.09)	(0.57)	(0.20)	(0.03)	(0.40)	(0.10)
Drought vulnerability	–0.06	–0.36	–0.20			
index	(0.11)	(0.77)	(0.24)			
Flood vulnerability index				0.03	0.44	0.13
				(0.12)	(1.28)	(0.36)

Constant	0.24		–0.62	–0.24*		–2.20***
	(0.20)		(0.40)	(0.11)		(0.27)
Observations	420	420	420	420	420	420
Pseudo R2	0.44	0.11	0.07	0.93	0.16	0.13
LL (Null model)	–172.18	–789.15	–284.46	–144.37	–838.72	–201.76
LL (Full model)	–97.21	–699.25	–265.52	–10.08	–701.49	–175.16

*Note: Figures in parentheses indicate robust SE clustered by study regions; asterisks indicate statistical significance at * p<0.05, ** p<0.01 and *** p<0.00.*

5.4.4 Risk management strategies

We assessed the importance of a diverse range of risk management options from farmers' perspectives. We asked farmers to rate the applicability and efficacy of the options and calculated importance scores as a product of their ratings on these two constructs. The applicability component represents how often farmers applied the given option in the past (0 meaning 'never applied' to 1 meaning 'always applied'), and the efficacy component represents the effectiveness of the option in overcoming crop or income loss (0 meaning 'not effective at all' to 1 meaning 'extremely effective'). Figure 5.4 presents the ordered bar chart of the risk management options by importance score.

Crop diversification, crop varietal diversification and integrated farming were the top–ranked risk management strategies. Farmers also considered participating in farmer groups as an important risk management strategy. Such self–help groups function as an avenue for technological capacity building, input supply, risk awareness, saving and microcredit, and marketing. Other strategies such as testing new technology or crop variety in a smaller area and take upscaling decisions based on the results, observing the performance of new technology in fellow farmers' farms first, growing modern crop varieties and technologies, consulting fellow farmers for advice, maintaining cash saving and diversifying income sources were among the list of top 10 risk management options. Most options that ranked higher belong to on–farm risk management strategies, while modern market–based tools such as crop insurance and forward contracts were considered less important. Farmer awareness and access to such market–based options are crucial factors to consider before prioritising risk management strategies. The responses to follow–up questions revealed that 27% of respondents were not aware of any form of insurance, only 50% said they had access to at least one of the six insurances (crop, livestock, life, health, vehicle, and house), 40% had purchased at least one of these insurances, 18% had purchased livestock insurance, and 10% had purchased crop insurance. These figures suggest that farmers do not have adequate awareness and access to farm insurance products.

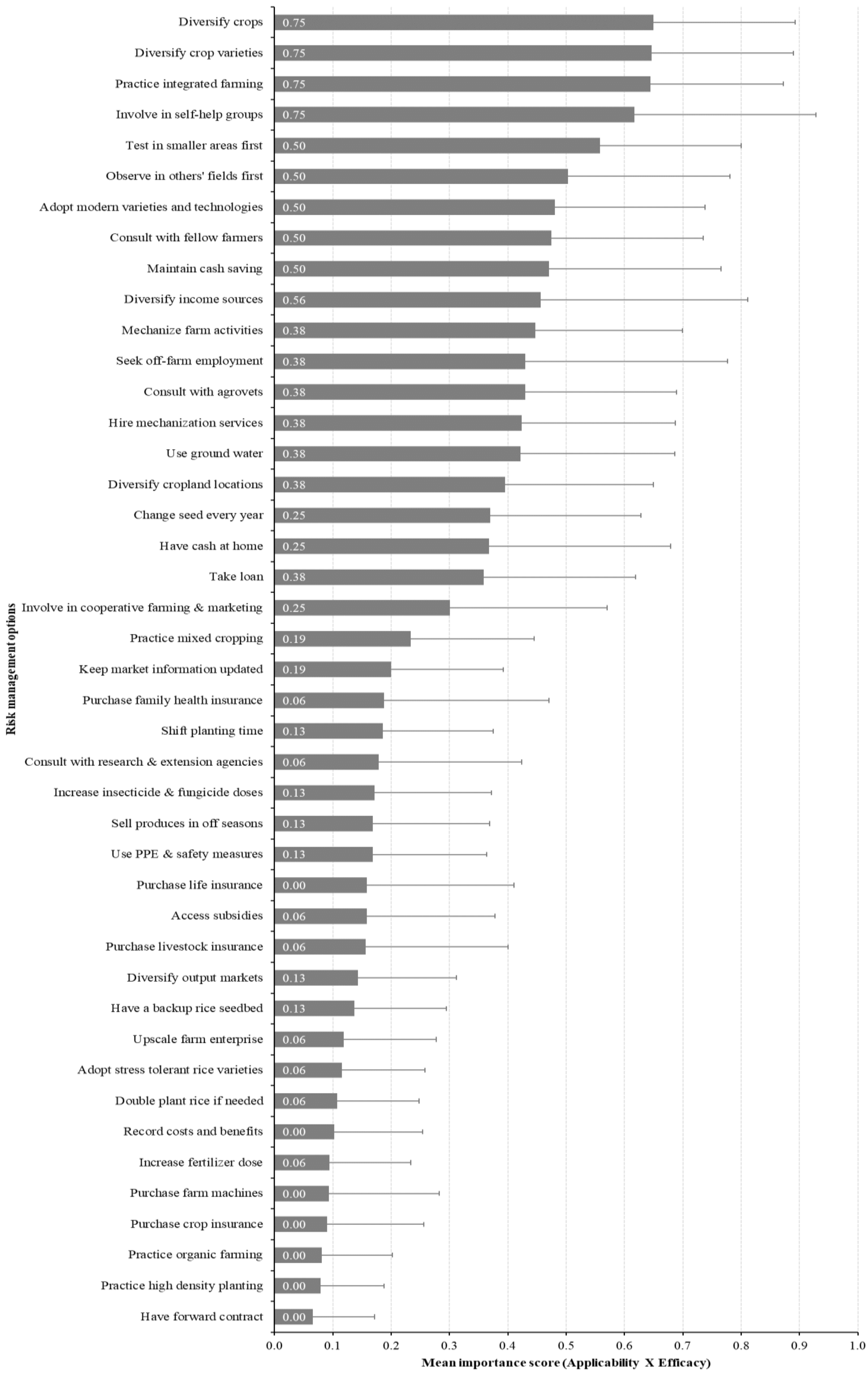

Figure 5.5 Importance of risk management options

Note: Options are sorted by mean importance scores; error bars show SD; figures within the bars indicate median rating scores.

5.5 Conclusion

Information on farmers' risk perception is essential for understanding and predicting their behaviour in the face of risk and uncertainty. Farmers' risk perception indicates their risk management decisions and is associated with their investment, innovation, and farm productivity. Therefore, knowing the sources of risk and drivers of farmers' risk perception is imperative in designing effective risk management products and support programs. Risk perception is a latent construct that constitutes an individual's estimation of the probability and severity of unfavourable outcomes. Because of the subjective nature of such estimates, risk perception is a highly individual–specific variable. While this topic has been studied for a long time, whether the variation in risk perception is due to individual characteristics or objective risk factors persists because the literature reports contrasting findings across regions. We conducted a psychometric study of farmers' perception of risk and uncertainties and the factors affecting risk perception using a questionnaire survey with the key decision-makers from 420 randomly selected households in Nepal's Terai region.

The results showed that farmers generally have high perceptions of risk in farming. The farmers perceived traders' dominant role in determining the price of farm outputs as the most important source of price risk. This result is consistent with the finding of our earlier qualitative study (see Chapter 4). However, while the qualitative study suggested farmers' insufficient technical knowledge as the most important source of production risk, the psychometric analysis suggested increased number of drought days as the most important source of production risk. In the absence of information on the incidence of drought in the coming season, farmers face crop selection, variety selection, and planting time uncertainties. Drought also increases the irrigation requirement, which increases production costs. Farmers perceived the risk associated with the shortage of farm labour as the most important risk, followed by the risk of lower prices for farm produce and drought. Farmer vulnerability to and perception of drought risk were considerably higher than that of flood risk throughout the study area. The earlier qualitative study also suggested that the farmers were more concerned about drought than flood. Farmers perceived drought as a higher likelihood, higher–impact risk than flood risk. Insurance providers may charge higher premiums for insuring such risks, and the government may need to increase subsidies to improve the adoption of such products by poor farmers.

Moreover, farmer perceptions of drought and flood risk were not correlated, and some respondents had high perceptions of both risks. This finding implies that flood and drought are not mutually exclusive risks. Therefore, farmers' risk perceptions should be considered when designing risk management products and support programs. Moreover, farmers' risk experience and perceptions were positively correlated. Researchers may consider using risk experience as a proxy for risk perception to minimise response biases if the respondents have low education and less informed risk perception.

The Tobit regression suggested that farmer perception of drought risk is associated with their age, family size, migration status, access to infrastructure and services, and rice productivity. Similarly, the farmer perception of flood risk correlates to farm size, migration status, rice productivity and joint family system. Risk experience and risk perception are strongly correlated, implying that risk perception is significantly shaped by objective risk factors. Non-significant correlation between gender and risk perception supports the findings of our earlier qualitative study that found similar perceptions of climatic risks between men and women (see Chapter 4). We also found a significant regional variation in farmers' risk perceptions, which has practical implications in identifying targets groups for agricultural development programs. If farmers' perceptions of risk and uncertainty and the associated factors are accounted for, the effectiveness of agriculture extension programs and risk management interventions will be improved.

Crop diversification, crop varietal diversification and integrated farming were the most important risk management strategies from farmers' perspectives. The earlier qualitative study also suggested crop varietal diversification, including modern crop varieties, as the most important strategy to manage production risk. Improving farmers' access to modern farming technologies, developing and promoting climate-smart crop varieties and training them on the use of such technologies can help improve the effectiveness of on-farm diversification strategies in managing production risks. Weather forecasting service, irrigation development and promotion of drought-tolerant crop varieties may be effective strategies to mitigate drought risk. Improving farmers' skills for on-farm and off-farm jobs may help them diversify income opportunities and better manage livelihood risks.

Farmers considered on-farm risk management strategies more important than the modern market–based tools, such as crop insurance. Their preference for on-farm risk management options was mainly due to inadequate awareness of and access to farm insurance products. Therefore, in addition to improving farmers' capacity for on-farm risk management, agriculture extension program and insurance companies should consider educating farmers about the concept and benefits of insurance. Since there is no one–size–fits–all strategy for managing farming risks, a holistic risk management approach should be applied involving a wise combination of on-farm tools and market–based tools.

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Chapter 6: Linkages Between Farmers' Risk Attitudes, Sociodemographic Factors and the Choice of Risk Management Strategies in Nepal (Paper 3)

6.1 Abstract

Risk attitude indicates an individual's willingness to trade–off potential income for certainty. Farmers' risk attitude is an important indicator of their demand for risk management products. We elicited the risk attitudes of 409 randomly selected farmers from the Terai region of Nepal using an incentivised monetary lottery–choice experiment. We then examined the relationships between various sociodemographic variables, farmers' risk attitudes and their risk management decisions. We found that farmers were risk-averse in general, but to varying degrees. Farmers' risk aversion increased as we moved from East to West, the direction in which the duration and amount of monsoonal rainfall decrease. Similarly, farmers' numeracy skills and landholding size had a positive association with their risk aversion. Contrary to the prevalent stereotyping that women are more risk-averse than males, we found the opposite result. We also found that farmers' decisions on farm mechanisation, monetary saving, involvement in groups and cooperatives, production diversification, use of stress-tolerant rice varieties, and adopting insurance products were associated with their risk attitudes. Information on farmers' risk attitudes, factors explaining the heterogeneity in their risk attitudes, and how this heterogeneity reflects in their decision–making can aid the development of policy interventions, agriculture extension programs and risk management products.

Keywords: agriculture, lottery–choice experiment, Nepal, risk attitude, risk aversion, risk management

6.2 Introduction

Analysing farmers' risk attitudes is an ongoing research agenda in agricultural economics. This paper measures farmers' risk attitudes using a monetary lottery choice experiment and analyses the association of such a measure of risk attitude with farm characteristics, sociodemographic characteristics and farmers' risk management decisions. The motivation underlying this work is the potential role of risk attitude on farmers' choice of risk management strategies, including crop insurance. The theory of absolute risk aversion suggests that people are risk-averse, and their aversion is negatively correlated with wealth or income (Pratt, 1964). The theoretical model of farm innovation and technology adoption includes risk attitude as a key variable (Feder, 1980; Feder et al., 1985). The decreasing marginal utility of wealth (Pratt, 1964) generally implies that poorer farmers are more risk-averse and less likely to adopt new farming technologies that increase risk. However, documentary evidence suggests that the degree of risk aversion and its effect on decision–making vary across individuals and decision contexts despite these well-known theories. Therefore, context-specific analysis of farmers' risk attitudes is essential for informing policy development related to farming risk management.

Risk aversion is not merely an emotional attribute representing people's dislike of risk but also an indicator of their willingness to sacrifice some income to eliminate risk (Ert & Haruvy, 2017; Hardaker et al., 2015; Ye & Wang, 2013). Risk attitude reflects what level of hazard, threat, or monetary loss individuals are willing to accept (Ye & Wang, 2013). According to Hardaker et al. (2015), risk management should be viewed as an integral part of the overall decision–making process, which involves balancing risks against potential benefits. Risk attitude is a crucial factor determining how farmers attain such balance (Saqib et al., 2016). For instance, a risk–the averse farmer is more inclined to reduce income variation than maximise profit (Binici et al., 2003). More specifically, farmers' risk aversion implies their tendency to compromise higher returns for certainty.

The importance of studying farmers' risk attitudes has been well established within the literature (see Lusk & Coble, 2005; Pennings & Garcia, 2001; Petrolia, 2016). Knowing farmers' risk attitudes, the factors that explain the heterogeneity in their risk attitudes, and how such heterogeneity reflects in their decision–making is essential for developing policy interventions, agriculture extension programs and risk management products. Such studies are even more important for developing countries where farmers are mostly poor, vulnerable to the negative consequences of farming risks, and less resilient to shocks without external support (Ye & Wang, 2013). Accounting for the needs, preferences, and risk-taking behaviours of the potential target group is necessary when designing risk management support interventions to improve their acceptability (Flaten et al., 2005; Santeramo et al., 2016).

Moreover, the agriculture sector offers a unique case study of risk attitudes for many reasons. First, the sources of uncertainty in farming are numerous, including production (weather, disease), market (price, input, output), finance (interest), personal (death, sickness), and institutional (policy) factors (Bard & Barry, 2001). Second, the sources of uncertainty are continuously growing due to the changing climate and increasing market competition (Sulewski & Kłoczko-Gajewska, 2014). Third, the portfolio of farming risk management strategies is large and growing (Meraner & Finger, 2017). For instance, income diversification, cutting expenditure, selling assets, and migration are some of the strategies practised by farmers to cope with the consequences of risk (Ashraf & Routray, 2013). Similarly, production diversification, storing produce for future sale, adopting less risky farming practices, engaging in off-farm employment, saving cash instead of investing for capital gain, and purchasing insurance are some of the managerial tendencies consistent with risk aversion (Binici et al., 2003). Fourth, many risks in farming are covariate, meaning a risk affects many households in a community at a time, and such risks cannot be managed through local insurance or credit arrangements (Barrett, 2011). Lastly, the effects of such covariate risk are systemic, which may extend beyond farming households, affecting all other actors in the agricultural value chains, including consumers.

The literature has extensively covered the relationships between various personal and socio-economic factors, risk attitudes, and risk management behaviours, but the findings are not consistent across regions. For instance, researchers have reported varied relationships between farmers' risk attitudes and factors, such as age (Nielsen et al., 2013; Ullah et al., 2015; van Winsen et al., 2016), gender (Brick et al., 2012; Harrison et al., 2007; Holt & Laury, 2002), wealth (Binswanger, 1980; Cohen & Einav, 2007; Dohmen et al., 2011), farm size (Lucas & Pabuayon, 2011; Velandia et al., 2009), and family size (Binswanger, 1980; Lucas & Pabuayon, 2011). Similarly, researchers have reported varied relationships between measures of farmers' risk aversion and risk management decisions, such as farm diversification (Chavas & Holt, 1996; Engle Warnick et al., 2011), adoption of modern technologies (Engle Warnick et al., 2011; Marra et al., 2003), and uptake of insurance (Hellerstein et al., 2013). These contrasting findings suggest that the effect of different factors on farmer risk attitude may vary across geographical locations and socio-demographic settings. Moreover, farmers' decision–making process when choosing a risk management strategy is dynamic (Meraner & Finger, 2017), necessitating more research. Therefore, a region-specific study of farmers' risk attitudes is necessary to understand and predict their behaviours.

Information on farmers' risk attitudes and the role of risk attitude in decision making is limited in Nepalese agriculture. A literature search related to this topic revealed only five published works in Nepal, which are cited below. First, Hamal and Anderson (1982) analysed the risk attitudes of rice farmers from two Terai districts. They found that farmers were risk-averse in general, and their risk aversion was negatively correlated with wealth. They also identified farmers' risk aversion as a limiting factor in the adoption of modern farming technologies. Second, Sharma (2016) elicited the risk attitudes of coffee producers from two mid-hill districts using a lottery–choice experiment and reported similar results to Hamal and Anderson (1982). Moreover, Sharma (2016) found that farmers' risk aversion affected labour allocation but did not affect land allocation for coffee farming. Third, Mishra et al. (2020) used the Bayesian method to investigate the effect of contact farming on production risk, technical efficiency and risk attitude of tomato, ginger, lentil and paddy farmers. They found contract farming an effective method to reduce production risk, increase technical efficiency and support the modernization of agriculture. They also found contract farmers more risk-averse than independent farmers. Fourth, Mohan (2020) studied the effect of risk aversion on tea certification to an agricultural standard. They used a lottery game adapted from Binswanger (1980) and Eckel and Grossman (2008) to elicit farmers' risk attitudes. They reported a positive correlation between risk aversion and farmers' propensity to get their tea certified. Fifth, Begho (2021) investigated the effect of risk attitude on the adoption of rice varieties. They used a single choice list procedure to measure farmers' risk attitudes, which is similar to Mohan (2020)'s lottery game. Begho (2021) found a negative correlation between risk aversion and the propensity to adopt new rice varieties.

Although the abovementioned studies answered some important questions about farmers' risk attitudes, none of them investigated the relationships between risk aversion and the choice of risk management strategy. Moreover, their findings represent small geographical areas and specific samples. This paper examines Nepali farmers' risk attitudes more comprehensively, involving a larger sample size and representing a wider geographic area than the earlier studies. Further, this paper investigates the association of risk attitude with sociodemographic factors and risk management decisions, such as crop insurance purchase.

6.3 Methodology

Risk attitude is studied within the framework of the expected utility theory (EUT), originally proposed by Bernoulli (1738). The EUT assumes that humans are *homo–economicus*, and their decisions conform with von Neumann and Morgenstern (1944)'s expected utility axioms and are stable over space and time (Becker, 1976). Assuming that farmers are rational decision–making agents, who maximise expected utility while choosing between available alternatives, we adapted a lottery–choice instrument to measure their risk attitudes. Moreover, we adapted a conceptual model similar to that of Meraner and Finger (2017), which hypothesises that farmers' decision–making is a function of their risk attitudes, while their risk attitude depends on various individual, farm and socio–economic characteristics. Our model of farmers' risk management decisions also includes farmers' risk perceptions measured using a psychometric scaling method (see Chapter 5 for details). The study involves measuring three distinct groups of variables: (1) farmers' risk attitudes; (2) individual, socio–economic, and demographic attributes of farmers and households; (3) measures of risk management strategies. Here, we discuss the methods for measuring the variables included in the conceptual model and analysing the relationships between them.

6.3.1 Measuring risk attitudes

Researchers have developed several methods to elicit individual risk attitudes. Field and lab experiments are the most prevalent risk attitude elicitation methods, involving hypothetical (e.g., Asravor, 2019; Kahneman & Tversky, 1979; Menapace et al., 2016), real monetary payoff (e.g., Brick et al., 2012; Dohmen et al., 2011; Hellerstein et al., 2013; Hermann & Mußhoff, 2017; Meraner & Finger, 2017) or a combination of both (e.g., Binswanger, 1980; Holt & Laury, 2002; Morgenstern et al., 2014; Nielsen et al., 2013) choice scenarios. Such methods are also called lottery–choice experiment (LCE) or multiple price list (MPL) methods because they ask respondents to choose between a series of options that vary in payoff and risk level (Charness et al., 2013). Such a design produces sufficient data points to fit a smoother utility curve and estimates parameters with more precision. An important assumption across these methods is that an individual has a constant relative risk aversion coefficient, which is indicated by the shape of the utility curve (Pennings & Garcia, 2001). MPL methods have the advantage of reflecting participant's inherent choice (Hermann & Mußhoff, 2017), allowing calculation of utility function parameters such as the risk aversion coefficient (Charness et al., 2013), and providing incentive-compatible designs (Charness et al., 2013; Hermann & Mußhoff, 2017).

Although Binswanger (1980), who was the first to use MPL, conducted an incentivised money lottery–choice experiment to elicit risk preference in a rural Indian farming context (Charness et al., 2013), variants of the MPL method proliferated after Holt and Laury (2002) published their seminal work. According to Anderson and Mellor (2009), Holt and Laury (2002)'s instrument is the 'Gold Standard' in risk attitude elicitation research. Different MPL instruments are developed mainly by allowing the payoff amount, probabilities, or both to vary across choice scenarios (e.g., Brick et al., 2012; Eckel & Grossman, 2008; Hellerstein et al., 2013; Holt & Laury, 2002; Jacobson & Petrie, 2009). Usually, participants in such experimental studies are university students who have higher numeracy skills and cognitive ability. Since Nepalese farmers have a low level of education and are less familiar with such experimental procedures, we searched for the simplest experimental instrument, which is easy for less-educated respondents to understand and make an informed choice.

6.3.2 Lottery–choice experiment instrument

Table 6.1 presents the LCE instrument adapted from Brick et al. (2012), which was also used by Jianjun et al. (2015) and Jin et al. (2017). This is the simplest experimental instrument available within the literature that allows estimation of the utility function parameters. Brick et al. (2012)'s instrument had eight decision rows, had less–linearly decreasing certain amounts, and did not include a certain zero amount against the lottery, restricting the respondents from making extremely risk-averse choices. Therefore, we added three decision rows, including a Zero value in the certain amount column to cover the full range of possible choices and made the decline in certain amount perfectly linear. In this way, the experiment involved 11 choice scenarios, each asking the respondents to choose between a coin–toss lottery and a certain amount. We scaled up the monetary values of Brick et al. (2012)'s instrument by 10 to maintain the attractiveness of the choice options in terms of Nepali Rupees (NPR). The expected value of the lottery was NPR 100, with NPR 200 and zero as two equally likely outcomes. The lottery was constant throughout 11 scenarios, while the certain amounts gradually decreased from NPR 200 to zero.

Table 6.1 Lottery–choice instrument used in the study

Choice scenarios	Certain amount (C)	Lottery amount (L)	
		Head (L1)	Tail (L2)
1	200	200	0
2	180	200	0
3	160	200	0
4	140	200	0
5	120	200	0
6	100	200	0
7	80	200	0
8	60	200	0
9	40	200	0
10	20	200	0
11	0	200	0

Note: Amounts in NPR; instrument adapted from Brick et al. (2012)

Payoff scale

The respondents' motivation to state true preference in the experiment is affected by the payoff size of the lottery (Holt & Laury, 2002) and whether the experiment is hypothetical or involves an actual payment (Tanaka et al., 2010; Wik et al., 2004; Yesuf & Bluffstone, 2009). Risk aversion parameters are underestimated when the experiment is hypothetical or involves low payoff scales (Holt & Laury, 2002). If an experiment involves actual payment lotteries and attractive payoff scales, then inconsistent responses will decrease, and respondents are more likely to participate (Camerer, 2003; Camerer & Hogarth, 1999). Accordingly, the present research involved real monetary payments with 100 NPR as the expected payoff (200 NPR as the favourable payoff) of the lottery, which is slightly above the hourly wage rate in the locality. The payoff scales in the experiments of Holt and Laury (2002) and Nielsen et al. (2013) were also equivalent to the respondents' opportunity cost. In addition to the money the respondents won in the experiment, we paid NPR 100 to all respondents for participating in the experiment.

6.3.3 Measures of risk aversion

The Arrow–Pratt measures of absolute risk aversion (ARA) and relative risk aversion (RRA) are the most popular measures of risk aversion, introduced by Pratt (1964) and Arrow (1965). Depending on how the risk aversion function changes for increasing wealth, these measures can be categorised into increasing, decreasing, and constant absolute or relative risk aversion (Hardaker et al., 2015). Several studies (e.g., Brick et al., 2012; Eckel & Grossman, 2008; Hermann & Mußhoff, 2017; Meraner & Finger, 2017; Nielsen et al., 2013) considered constant relative risk aversion (CRRA), which implies that relative utilities of risky options are unaffected if all payoffs are scaled by a positive constant (Hardaker et al., 2015). The CRRA also means decreasing ARA. We derived a formula for calculating the CRRA coefficient (CRRA indicates the coefficient hereafter) using the following utility function:

$$u(x) = \frac{x^{1-r}}{1-r} \dots\dots\dots Equation\ 6.1$$

where x is monetary value, and r is CRRA. According to Hardaker et al. (2015), this utility function is preferred over other functions because it is consistent with CRRA.

For a respondent to be indifferent between the lottery and a certain amount, expected utilities of both should be equal, i.e.,

$$U(C) = U(L)$$

or

$$\frac{C^{1-r}}{1-r} = \frac{L_1{}^{1-r}}{1-r} \times p + \frac{L_2{}^{1-r}}{1-r} \times (1-p)$$

here C is a certain amount, and L_1 and L_2 are the lottery outcomes with probabilities p and 1–p, respectively. In our case, L_2 is 0, and p and 1–p are equal. Therefore, the above equation reduces to:

$$\frac{C^{1-r}}{1-r} = \frac{L_1{}^{1-r}}{1-r} \times p$$

or

$$C^{1-r} = L_1{}^{1-r} \times p$$

Taking logs of both sides,

$$(1-r)\ln C = (1-r)\ln L_1 + \ln p$$

or

$$(1-r)\ln C - (1-r)\ln L_1 = \ln p$$

or

$$(1-r)\,(\ln C - \ln L_1) = \ln p$$

or

$$(1 - r) = \frac{\ln p}{(\ln C - \ln L_1)}$$

or

$$r = 1 - \frac{\ln p}{(\ln C - \ln L_1)} \ldots \ldots \ldots Equation\ 6.2$$

Table 6.2 details the CRRA calculation and classification of respondents into risk attitude classes. If one can identify the values of L_1 and C to which a respondent is indifferent, one can infer the implied value of CRRA. The C value that makes a respondent indifferent to C and L is called the certainty equivalent (CE) of L. The primary purpose of the experiment is to ascertain the CE of the given L for each respondent and assign them the corresponding CRRA. However, asking respondents to choose the row on which they are indifferent to C and L is less practical than asking their preference between C and L for each row. Therefore, we asked respondents to choose between C and L in each row and identify the row on which they switched from C to L. For example, if a respondent chooses C up to the fourth row and switches to L in the fifth, the indifference point must have occurred anywhere between the fourth and fifth rows (C = 139 to 121). We considered the midpoint of the C values of the switching row and the previous row as CE for simplicity. We calculated CRRA values for each row using the values of CE and L in Equation 6.2. A zero value of CRRA means risk neutrality, while negative and positive values mean risk preference and risk aversion, respectively. Eleven choices may lead to 12 switching behaviours, including a never switching decision. Accordingly, we classified respondents into 12 risk attitude classes based on the CRRA values. However, choosing L even when C is equal to the highest possible gain from L and not choosing L even when C is equal to zero are behaviours inconsistent with the expected utility theory. Therefore, we excluded respondents in the 1^{st} and 12^{th} rows from the analysis.

Table 6.2 CRRA calculation and risk attitude classification

Card no.	Certain amount (C)	Lottery amount (L)		CE of L if switched to L on this row	CRRA if switched to L on this row	Risk attitude class
		Head (L1)	Tail (L2)			
1	200	200	0		–∞	Infinitely risk–preferring
2	180	200	0	190	–12.51	Extremely risk–preferring
3	160	200	0	170	–3.27	Highly risk–preferring
4	140	200	0	150	–1.41	Moderately risk–preferring
5	120	200	0	130	–0.61	Slightly risk–preferring
6	100	200	0	110	–0.16	Risk–preferring to neutral
7	80	200	0	90	0.13	Risk–neutral to averse
8	60	200	0	70	0.34	Moderately risk–averse
9	40	200	0	50	0.50	Highly risk–averse
10	20	200	0	30	0.63	Extremely risk–averse
11	0	200	0	10	0.77	Extremely to infinitely risk–averse
#	Those who never switched to L				∞	Infinitely risk–averse

Note: Amounts in NPR

6.3.4 Validity and reliability of the LCE instrument

Framing and presenting choice problems are crucial considerations in choice experiments. If the respondents do not clearly understand the choice task, they may exhibit noisy preferences (Charness et al., 2013). The preferences are inconsistent with the EUT axioms when the respondents do not choose strictly dominated options (Barham et al., 2014) or make more than one switching point (Barham et al., 2014; Jacobson & Petrie, 2009). According to Andersen et al. (2006), the standard MPL format is likely to tempt respondents towards the middle of the list. Dave et al. (2010) analysed noise–reliability trade-offs between MPL instruments with different degrees of complexity and concluded in favour of the simpler instrument, especially when the respondents have low numeracy skills.

Overcoming hypothetical bias and improving the external validity of the experimental measures of risk attitude are ongoing concerns of researchers. Some of the techniques that have been found effective in motivating the subjects to state true preferences include displaying outcome probabilities graphically (see Meraner & Finger, 2017; Wakker et al., 1994), using real–payment lottery games, increasing the potential incentives from the lottery games (see Holt & Laury, 2002), framing the choice problems in real-life decision contexts (see Hellerstein et al., 2013; Kimball et al., 2008; Menapace et al., 2016; Meuwissen et al., 2001) and using virtual reality to mimic real-life settings (see Fiore et al., 2009). However, some researchers have reported contrasting effects of these techniques on the external validity of the risk attitude measures. For example, while Harrison and List (2004) found contextualized framing of choice tasks improved task comprehension by the subjects, Rommel et al. (2016) reported that framing choice questions in familiar contexts negatively affected the task comprehension by the subjects. Meraner and Finger (2017) also reported that a standard monetary MPL is as efficient as a contextualized choice experiment in measuring risk attitude. In what follows, we discuss the strategies that we adopted to address these issues.

We presented graphic choice cards reflecting the choice scenarios so that farmers better understand decision problems (see Appendix G). Like the ordered MPL design followed by various researchers (e.g., Binswanger, 1980; Eckel & Grossman, 2002, 2008; such as Holt & Laury, 2002), we sorted choice scenarios by descending value of a certain amount. As Jacobson and Petrie (2009) did, we presented the choice cards one–by–one in the sequence of first to eleventh. This strategy helped minimise middle response bias, ensuring that the respondents did not have an exact reference for previous or subsequent choice scenarios while making decisions. Following various studies (e.g., Hellerstein et al., 2013; Liu, 2013; Tanaka et al., 2010), we informed the respondents beforehand that, upon completing the task, they would be asked to randomly draw one ball from a bag containing 11 numbered balls and the matching choice card would be chosen for actual payment based on the decision they had already made on that card. Charness et al. (2013) suggested that if the respondents know that all choices are equally likely to be selected for actual payment, they will be motivated to maximise the expected utility from each decision. Following Nielsen et al. (2013), we allowed the respondents to revisit their choices when they finished the choice tasks. As a result of these strategies, only 11 (2.61%) respondents made inconsistent choices in our experiment.

6.3.5 Experiment implementation

The experiment involved 420 randomly selected farmers from the Terai region of Nepal, divided into three regions (see Chapter 3 for details of sampling design). Excluding 11 respondents whose choice behaviours were inconsistent with EUT, the final sample size for risk attitude analysis was 409. The LCE was combined with a questionnaire survey to measure factors that might affect farmers' risk attitudes and adoption of various risk management practices. Along with the variables that had ambiguous effects on risk attitudes in other regions, as reviewed earlier, we included additional variables that are important in the Nepali context. Here, we briefly define the variables included in the questionnaire and various indices derived for the analysis.

6.3.5.1 Factors that might affect risk attitude

We categorised the factors that might affect farmers' risk attitude into farmers' characteristics and socio-economic factors. Farmers' characteristics included variables related to their inherent attributes such as age, education, gender and their perceptions of flood and drought risk in farming. In addition to farmers' education, we included a numeracy score in the model (see Appendix C for a description of the numeracy test used in the survey). Education is expected to correlate with farmers' risk literacy and ability to evaluate expected payoffs from the risky prospects. In addition to the respondent's gender, we used the gender equality index of respondent households in the analysis. We assessed gender participation in five household decisions, eight farming activities, and six farming decisions in terms of male–only (0), female–only (0), or both (1). We calculated the gender equality index averaging the responses to these 19 items. A GEI value close to one means equal gender participation in farming activities and decision–making, whereas lower values indicate gender disparity. Moreover, we assessed farmer perception of drought and flood risk in farming using the psychometric method, as discussed in Chapter 5. Although the Nepali farming system is vulnerable to many risks, drought and flood are the most prominent climatic risks.

Socio–economic factors included family type, family size, dependency ratio, migration status, income sufficiency, sources of income, whether agriculture was the primary source of income, and whether agriculture was the only source of income. The terai region of Nepal has a mixed population of indigenous communities and migrated communities from hilly areas. Therefore, we included whether the household had migrated or was indigenous to examine the effect of migration status on risk attitude. Similarly, we used farm size (area cultivated by the farmer in the previous year) as a proxy for their wealth. We also included the proportion of irrigated land to farm size to see the effect of irrigation availability on risk attitude. The model also included the access to infrastructure and services index. We asked farmers whether they have access to nine infrastructures and services and created nine dummy variables to represent their responses. We calculated the access to infrastructure and service index as an average of the nine dummy variables. Additionally, we used rice productivity reported by the farmers as a proxy for farm technical efficiency.

6.3.5.2 Numeracy test

The reliability of the experimental measure of risk attitude depends on how well the respondents understand the choice task. Rommel et al. (2016) reported a positive correlation between respondents' numeracy skills and task comprehension. Results from studies that do not consider respondents' cognitive ability are biased because such ability is associated with risk attitude (Barham et al., 2014). For instance, while three authors found a negative relationship between cognitive ability and risk aversion (Benjamin et al., 2013; Dohmen et al., 2010; Frederick, 2005), Sherman (1974) reported similar results for ambiguity aversion. To account for the respondents' cognitive ability, various authors embedded a probability-based numeracy skill test with the experiment (e.g., Hermann & Mußhoff, 2017; Meraner & Finger, 2017). We also assessed farmers' numeracy skills using a numeracy test adapted from BBC's probability quiz level A intended for adults (see Appendix C for test questions). Moreover, we asked respondents to self–assess their comprehension of the choice task on a five-point scale and used it in the model of their risk attitude.

6.3.5.3 Risk management strategies that might be affected by risk attitude

We categorised farmers' risk management strategies into non–farm and on-farm strategies. Non–farm risk management strategies included income diversification, loan use in farming, monetary saving, group involvement and adoption of crop insurance. On-farm risk management strategies included farm mechanisation, production diversification, sale diversification, crop varietal diversification, and adoption of stress-tolerant rice varieties (STRVs). The selection of variables to represent farmers' risk management strategies was informed by our earlier qualitative study (Chapter 4) and psychometric scaling of risk management strategies (Chapter 5).

We created separate dummies to represent loan use in farming, monetary saving, group involvement and crop insurance purchase. According to SQCC-Nepal (2019), six drought–tolerant (Sukhadhan 1 to 6), three submergence–tolerant (Swarna Sub–1, Shamba Mahasuri Sub–1 and Cheharang Sub–1), and two multi-stress-tolerant (Bahuguni 1 & 2) rice varieties have been released for cultivation. We created a dummy variable to represent whether the respondent used any of these STRVs.

We constructed separate indices to represent some risk management strategies as continuous variables. We asked the respondents whether they used 16 farm machines and mechanised nine farming activities. The list of farming activities and machines was developed in consultation with local researchers and farmers. Then, we calculated the farm mechanisation index averaging the 25 binary responses (1 = yes and 0 = no). Similarly, we asked the respondents whether they grow/raise 13 crop/livestock commodities. We calculated the production diversity index as the sum of these 13 binary responses divided by land area cultivated by the respondents in the previous season. We also calculated the sale diversity index, similar to the production diversity index. Likewise, we constructed the rice varietal diversity index as a ratio of rice varieties grown to the total area cultivated (ha) by respondents in the previous season. We also calculated the income diversity index, dividing the income sources by the highest value of income sources within the sample.

6.3.6 Econometric models

6.3.6.1 Factors affecting risk attitude

The effects of various factors on risk attitude were examined by estimating the OLS model as follows:

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_k x_{ik} + \varepsilon_i \ldots\ldots\ldots Equation\ 6.3$$

where y_i is CRRA for the i^{th} respondent (i=1, …, n), n is sample size, x represents independent variables that might affect risk attitude as discussed earlier, k represents the number of x variables, β_0 is the intercept, $\beta_1, \ldots, \beta_k$ are parameters to be estimated, and ε_i is the error term.

6.3.6.2 Relationships between risk attitude and the application of risk management strategies

Farmers may need to apply more than one risk management strategy simultaneously to deal with farming risks. Considering that many risk management strategies are not mutually exclusive, the decision to apply one strategy may affect the decision to apply other strategies. Univariate models of such decisions exclude useful economic information on the interdependence of simultaneous adoption decisions (Kassie, 2013). Models that do not account for the synergies and trade-offs between different alternatives produce biased estimates (Greene, 2012). Multivariate models account for potential complementarities (positive correlations) and substitutability (negative correlations) among choice options, allowing for correlation in error terms across dependent variables (Mittal & Mehar, 2016). Moreover, the Multivariate Probit model offers a higher estimation efficiency compared to the Multinomial Logit when there is simultaneity in decision–making (see Gillespie et al., 2004). Therefore, we estimated a Multivariate Probit model using the simulated maximum likelihood method to examine the effect of farmers' risk attitude (CRRA), drought risk perception (Drought RP), and flood risk perception (Flood RP) on the adoption of risk management strategies measured as binary variables. The following J–equation Multivariate Probit model adapted from Mittal and Mehar (2016) and Cappellari and Jenkins (2003) was used to examine the effect of explanatory variables on the dependent variables:

$$Y_{ij}^{*} = X_{ij}'\beta_j + \varepsilon_{ij} \dots \dots \dots Equation\ 6.4$$

$$y_{ij} = 1\ if\ y_{ij}^{*} > 0\ and\ 0\ otherwise$$

Where Y_{ij}^{*} $(j = 1, \dots, 6)$ represent six risk management strategies available to the i^th^ farmer (i=1, …,n), n is sample size, X_{ij}' is a k×1 vector of observed variables that affect the adoption of risk management strategies, β_j is a k ×1 vector of parameters to be estimated, and ε_{ij} is the unobserved error term which may be correlated across j. The y_{ij} represents outcomes for J different adoption decisions happening simultaneously. The dependent variables include loan use in farming, monetary saving, STRV use, crop insurance, off-farm employment and group involvement. Similarly, the independent variables include CRRA, drought risk perception and flood risk perception. We also estimated individual logit models of all risk management decisions as robustness checks.

We also estimated six OLS models to examine the association of farmers' risk attitude, drought risk perception and flood risk perception with the risk management strategies that were measured as continuous variables. The functional form of the OLS model has been already presented in Equation 6.3. The dependent variables, in this case, include farm mechanization, number of groups involved, production diversity index, rice varietal diversity index, sale diversification index and income diversification index (these indices have been described in Chapter 5). To account for the potential heteroscedasticity, we have reported robust standard errors.

6.4 Findings and discussion

6.4.1 Summary statistics

This section presents the summary statistics of the variables included in the analyses of farmers' risk attitudes. Some of these variables are described in Chapters 3 and 4. Therefore, we only discuss the variables not discussed elsewhere. We also examined whether these variables are associated with the study regions using the chi-square test for categorical variables and linear regression for continuous variables. As indicated by the asterisks, many variables vary across regions.

The sample households have a high dependency on agriculture for their livelihoods. As shown in Table 6.3, agriculture is the first income source of more than two–thirds of households and the only income source of about one–third of households. The dependency on agriculture increases from East to West. The average irrigated area is only one–third of total farmland, and the irrigated area decreases from East to West, consistent with the categorisation of the study area to represent low, medium and high vulnerability to drought risk based on rainfall amount. In addition to education, we also used a measure of farmers' numeracy skills and self–assessed comprehension of the experimental task in the model of their risk attitude.

The overall mean of CRRA was slightly negative, indicating risk-neutral to risk–preferring attitudes towards the lottery. The mean CRRA for ETR, MTR, and WTR were negative (risk preference), nearly zero (risk neutrality), and positive (risk aversion), respectively. However, positive median values of CRRA for all regions indicate that farmers were generally risk-averse. The pattern of regional variation in CRRA indicates that farmers' risk aversion increases from East to West.

Table 6.3 Summary statistics by region

Variable	Description	ETR	MTR	WTR	All
Female	% Respondents	44.69	35	47.27	42.54
Farming experience	Years	25.99	23.85	25.35	25.19
		(12.29)	(13.7)	(14.4)	(13.3)
Family size***		6.04	6.53	4.85	5.86
		(2.02)	(2.46)	(1.31)	(2.10)
Joint family***	% Households	35.20	64.17	34.55	43.52
Dependency ratio	Not–earning/earning	0.72	0.59	0.59	0.65
	family members	(0.71)	(0.45)	(0.59)	(0.61)
Immigrant HHs***	% Households	34.64	15.83	51.82	33.74
Landholding***	ha	1.06	1.19	2.09	1.37
		(0.41)	(0.36)	(1.11)	(0.79)
Irrigation***	% Of land cultivated	39.97	26.13	23.09	31.37
		(29.58)	(16.8)	(17.8)	(24.6)
Gender equality index		0.39	0.33	0.46	0.39
		(0.34)	(0.42)	(0.42)	(0.39)
Income sources***	Number	1.92	1.78	1.57	1.79
		(0.59)	(0.64)	(0.63)	(0.63)
Agriculture as the only income source***	% Households	21.79	32.5	50	32.52
Agriculture as the first income source***	% Households	65.92	75	89.09	74.82
Income diversity index***		0.48	0.45	0.39	0.45
		(0.15)	(0.16)	(0.16)	(0.16)
Off–farm income**	% Households	61.45	54.17	40.91	53.79
Income sufficiency**	% Households				
Income deficit HHs		26.82	26.67	8.18	21.76
Income sufficient HHs		49.72	48.33	58.18	51.59
Income surplus HHs		23.46	25.00	33.64	26.65
Loan for agriculture***	% Households	43.58	17.5	9.09	26.65
Have monetary saving**	% Households	66.48	64.17	82.73	70.17
Involvement in group**	% Households	65.92	83.33	73.64	73.11
Number of groups involved*	Number	1.09	1.32	1.45	1.25
		(1.06)	(1.05)	(1.19)	(1.10)

Infrastructure/ services access index		0.24 (0.11)	0.20 (0.11)	0.22 (0.13)	0.22 (0.12)
Farm mechanisation index***		0.30 (0.10)	0.37 (0.12)	0.35 (0.14)	0.33 (0.12)
Rice productivity***	Mt/ha	3.76 (1.10)	3.51 (1.11)	3.26 (0.95)	3.56 (1.08)
Production diversity index***		9.34 (4.93)	5.98 (2.57)	5.70 (3.05)	7.38 (4.25)
Sale diversity index***		4.94 (3.48)	3.43 (2.08)	3.23 (2.15)	4.04 (2.90)
Rice varietal diversity index***		4.11 (1.78)	3.37 (0.92)	3.08 (1.15)	3.61 (1.48)
Used STRVs	% Respondents	31.28	43.33	31.82	34.96
Crop insurance adoption	% Respondents	8.38	10	8.18	8.8
Drought risk perception	0–1	0.59 (0.26)	0.59 (0.27)	0.58 (0.25)	0.59 (0.26)
Flood risk perception	0–1	0.17 (0.19)	0.21 (0.23)	0.19 (0.18)	0.18 (0.20)
Numeracy score	0–5	2.89 (1.56)	2.57 (1.39)	2.60 (1.46)	2.72 (1.49)
Experiment comprehension	0–1	3.77 (0.98)	3.69 (1.07)	3.75 (1.10)	3.74 (1.04)
CRRA***	Mean	–0.29 (0.93)	0.03 (0.70)	0.19 (0.53)	–0.06 (0.80)
	Median	–0.16	0.34	0.34	0.13
N		179	120	110	409

*Note: Figures in parentheses indicate SD; asterisks indicate significance of regional differences at * p<0.05, ** p<0.01 and *** p<0.001.*

6.4.2 Risk attitude analysis

In the LCE, a respondent made 11 decisions whether to play the lottery (L) or accept a certain amount (C). We expanded the dataset into 11 rows for each respondent keeping 11 values of C (0 to 200), and created a dummy variable called ‘certain–choice’ (1 if C was chosen or 0 otherwise). This expansion resulted in 4499 observations, or 11 times the sample size (409). Then we estimated logistic regression using ‘certain–choice’ as the dependent variable and C as the independent variable. As expected, the probability of choosing C over L increases as the value of C increases (Table 6.4).

Table 6.4 Logistic regression of ‘certain–choice’ on the certain LCE amount

Independent variable	Odds ratio	SE
Certain amount	1.04***	0.00
Constant	0.01***	0.00
Log–likelihood	–1363.07	
LR chi2(1)	3455.33***	
Pseudo R^2	0.56	
Observations	4499	

*Note: Asterisks indicate statistical significance at * p<0.05, ** p<0.01 and *** p<0.001.*

We predicted the probabilities of choosing C over L in the experiment using logistic regression estimates. We also separated these probabilities by study region. Figure 6.1 shows the overall and region-wise probabilities of choosing different values of C over L. The dotted line shows the theoretical probabilities of choosing C over L by a risk-neutral decision-maker (DM), which is a reference line for evaluating predicted probabilities. A risk-neutral DM is an expected value maximiser who is indifferent between C and L when C is equal to the expected value of L. The value of C corresponding to 0.5 provability of choosing C over L is the certainty equivalent (CE) of L. The CE for the risk-neutral DM is 100 NPR in our case, and the average CE for the respondents is about 87.79 NPR. This finding suggests that the farmers were risk-averse in general. We also observed regional variation in farmers’ risk attitudes. Although the CE for ETR respondents indicates a risk-neutral attitude, the same for MTR and WTR indicate risk aversion. Moreover, the graph shows that farmers’ risk aversion increased from East to West.

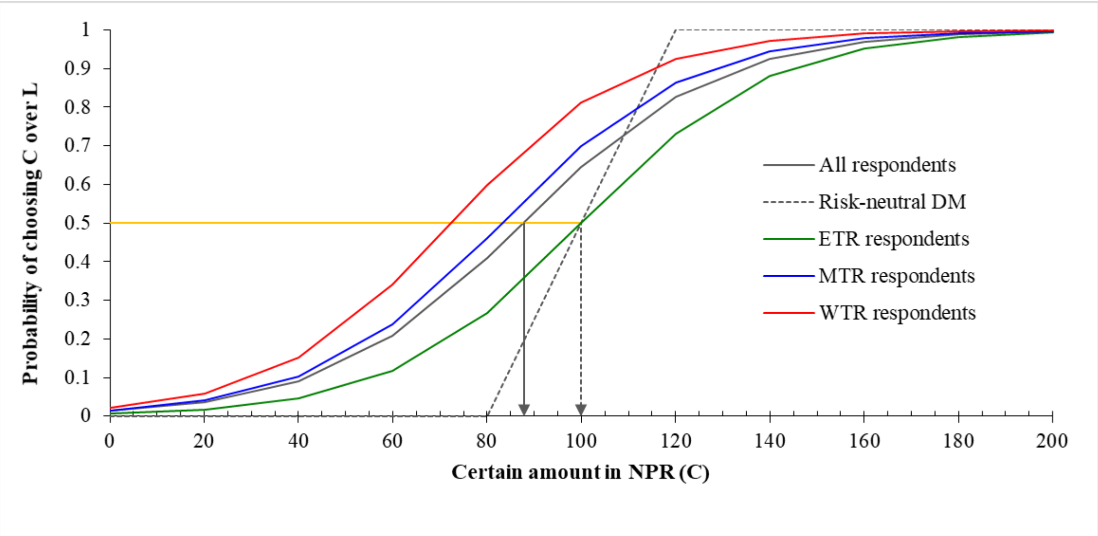

Figure 6.1 Risk attitude analysis using a lottery–choice experiment

Note: Arrows indicate CE.

6.4.2.1 Constant relative risk aversion coefficient (CRRA)

Table 6.5 presents the summary statistics of CRRA derived from the utility function elicited through LCE. We also examined whether CRRA is associated with study regions using regression analysis considering robust standard errors[2]. A highly significant result implies that farmers' risk attitudes varied across study regions.

Table 6.5 Description of risk attitude measures

Variables		ETR	MTR	WTR	All
CRRA***	Mean	–0.29 (0.93)	0.03 (0.70)	0.19 (0.53)	–0.06 (0.80)
	Median	–0.16	0.34	0.34	0.13

*Note: Figures in parentheses indicate SD; asterisks indicate the significance of the regional difference at * p<0.05, ** p<0.01 and *** p<0.001.*

6.4.2.2 Classification of respondents by risk attitude

Table 6.6 shows the region-wise distribution of respondents into various risk attitude classes based on CRRA values, as discussed in the Methodology section. About half of the respondents belonged to the three classes grouped in the risk-averse category. Similarly, while 29% of respondents belonged to two classes grouped as the risk-neutral category, the remainder (22%) belonged to three classes grouped as the risk–preferring category. The proportion of respondents in risk aversion classes was highest in WTR (74%), followed by MTR (56%) and ETR (35%).

Table 6.6 Distribution of respondents by risk attitude class

Risk attitude class	ETR	MTR	WTR	All
Highly risk–preferring	10 (5.59)	2 (1.67)	0 (0.00)	12 (2.93)
Moderately risk–preferring	20 (11.10)	9 (7.50)	7 (6.36)	36 (8.80)
Slightly risk–preferring	23 (12.85)	10(8.33)	7 (6.36)	40 (9.78)
Sub–total of risk–preferring category	53 (29.61)	21 (17.50)	14 (12.72)	88 (21.51)
Risk–preferring to neutral	37 (20.67)	19 (15.83)	9 (8.18)	65 (15.89)
Risk–neutral to averse	27 (15.08)	13 (10.83)	13 (11.82)	53 (12.96)
Sub–total of risk–neutral category	64 (35.75)	32 (26.66)	22 (20.00)	118 (28.85)
Moderately risk–averse	33 (18.44)	31 (25.83)	24 (21.82)	88 (21.52)
Highly risk–averse	27 (15.08)	25 (20.83)	35 (31.82)	87 (21.27)
Extremely risk–averse	2 (1.12)	11 (9.17)	15 (13.64)	28 (6.85)
Sub–total of risk–averse category	62 (34.64)	67 (55.83)	74 (67.28)	203 (49.64)

[2] One-way ANOVA and Kruskal-Wallis H test produced similar results, indicating that the regression analysis results are robust.

Total	179	120	110	409

Note: Figures in parentheses indicate column percentage.

The CRRA discussed in this paper is a measure of farmers' risk attitudes when evaluating the monetary lottery used in the experiment. An important assumption of this study is that the measure of risk attitude derived from an incentivised LCE is sufficiently correlated with risk attitude when evaluating real-life risks, such as those in farming. The reliability of the experimental instrument is a critical factor for determining this correlation. If a lottery involves the risk of losing life with some possibilities, every individual will have a risk-averse attitude. Similarly, if the risk is trivial with some possibility of gain, most individuals will prefer to take the risk. However, such instruments do not yield variable data so that individuals can be compared based on their risk attitudes. The heterogeneity in respondents' choice behaviours suggests that the experimental instrument and payoff scale used in our study were appropriate to produce a reliable measure of risk attitude.

6.4.3 Factors associated with risk attitude

Table 6.7 presents the results of the OLS estimation using CRRA as a dependent variable. Although the initial model included many independent variables, we eliminated variables with a variance inflation factor (VIF) greater than or equal to 10 to overcome the multicollinearity issue. The mean VIF of the final model was 1.78, with none of the variables with a VIF greater than four. We have reported robust standard errors to account for the heteroscedasticity, as suggested by the Breusch–Pagan/Cook–Weisberg tests. Further, we have adjusted the standard errors by clustering to account for potential correlation in observations within study districts (see Wooldridge et al., 2017).

The regression results show that farmers' risk aversion is correlated with geographical location. Among the three regions, the farmers from WTR were most risk-averse, followed by those from MTR. As shown in Table 6.3, the proportion of households with agriculture as the only source of income and agriculture as the first source of income increased from east to west. Likewise, the proportion of irrigated land and the amount of annual rainfall decreased in the same direction. These results lead us to conclude that the households' dependency on agriculture for livelihoods increases the farmers' preference for certainty. Moreover, the overall physical and human development indicators decreased from East to West. The increase in farmers' risk aversion with decreasing physical and human development and rainfall implies that less resourceful or underdeveloped contexts make farmers more risk-averse.

Our finding on the relationship between gender and risk attitude is unusual because most previous studies reported either positive (e.g., Brick et al., 2012; Croson & Gneezy, 2009; Eckel & Grossman, 2002, 2008; Hermann & Mußhoff, 2017; Nielsen et al., 2013; Weber et al., 2002; Ye & Wang, 2013) or non–significant (e.g., Harrison et al., 2007; Schubert et al., 1999) effects of being female on the level of risk aversion. Generally, males are the decision-makers in Nepalese households. A female acquires a decision–making role only if a family does not have an adult male. The female respondents in the study were active decision-makers in their families. Such an acquired status for decision–making might have made them less risk-averse than they would have been otherwise. Further research involving non–decision–making women is needed to ascertain whether Nepali women are more risk-taking than men. Nevertheless, farmers' risk attitudes were unaffected by the levels of gender equality in household decision–making and farming activities.

The farming experiences of the respondents, a linear function of their age, had a negative association with their risk aversion. With more experience in farming and dealing with risks, farmers might have developed better ideas to maximise expected benefits by taking some risks. However, this finding contradicts those of Iqbal et al. (2016) and Ullah et al. (2015), who reported positive correlations between farming experiences and risk aversion. Considering the land as a proxy for wealth, the positive correlation between farm size and risk aversion is consistent with the classical theory of ARA and findings of others (e.g., Iqbal et al., 2016; Lucas & Pabuayon, 2011; Ullah et al., 2015). However, some studies reported a negative relationship between farm size and risk aversion (e.g., Feder, 1980; Velandia et al., 2009). The positive correlation between risk aversion and numeracy (numeracy and education were positively correlated) suggests that individuals tend to avoid risk as they become more able to calculate risks. However, earlier studies reported negative relationships between numeracy and risk aversion (e.g., Benjamin et al., 2013; Dohmen et al., 2010; Frederick, 2005) while the correlation between education and risk aversion varied across studies (see Harrison et al., 2007; Hartog et al., 2002; Nielsen et al., 2013; Tanaka et al., 2010).

Although farmers had higher perceptions of drought risk than flood risk (see Table 6.3), their risk attitudes were correlated only with their flood risk perception. The differential associations of flood and drought risk perceptions with risk attitude are not surprising because these risks affect farm production in different ways. Most flood-related hazards are catastrophic, while the drought effects are not realised as immediately as flood effects. The experience of immediate loss of property and crops due to floods might have influenced farmers with higher flood risk perceptions to become more risk-averse. Earlier studies reported ambiguous relationships between farmers' risk perceptions and risk attitudes. For instance, Ullah et al. (2015) reported a positive correlation between risk perception and risk aversion, while van Winsen et al. (2016) found these variables uncorrelated. Moreover, the other variables included in the model had non–significant association with risk attitude, which is also noteworthy because other studies reported varying results for most of these variables.

Table 6.7 Estimates of OLS regression model of farmers' risk attitude

Dependent variable: CRRA			Coef.	Robust SE
Region (Base ETR)	MTR		0.19*	0.05
	WTR		0.23**	0.05
Female			−0.36*	0.10
Age (Years)			−0.02*	0.01
Family size			−0.02	0.02
Farm size (Ha)			0.23*	0.06
Numeracy score (0−5)			0.07*	0.03
Flood risk perception			0.28*	0.09
Joint family			0.12	0.08
Dependency ratio (Earning/ non–earning members)			0.03	0.08
Migrant household (Base: indigenous)			−0.03	0.14
Irrigation (% of farm size)			0.00	0.00
Agriculture as first income source			0.03	0.10
Agriculture as only income source			−0.05	0.10
Income sufficiency (Base deficit)		Sufficient	0.03	0.13
		Surplus	−0.01	0.08
Gender equality index			0.11	0.17
Infrastructure/ service access index			−0.34	0.39
Rice productivity (Mt/Ha)			−0.02	0.03
Choice task comprehension			0.03	0.18
Drought risk perception			−0.03	0.10
Constant			0.44	0.48
R2			0.30	
N			409	

*Note: Asterisks indicate statistical significance at * p<0.05, ** p<0.01 and *** p<0.001; SEs are adjusted for seven clusters in study districts to account for potential spatial correlation in observations.*

6.4.4 Association of risk attitude and risk perceptions with risk management decisions

As shown in Table 6.8, both Drought RP and Flood RP were not related to the adoption of risk management strategies except for the positive correlation between Drought RP and loan use in farming. But CRRA was positively associated with monetary saving, STRV use, adoption of crop insurance and group involvement, but non–significant for loan use in farming and off-farm employment. Earlier studies that reported varied effects of risk aversion and risk perception on risk management decisions are noteworthy in this context. For instance, while Sherrick et al. (2003) reported a higher likelihood of crop insurance use for a higher perception of yield risk, van Winsen et al. (2016) concluded that the propensity to implement risk management strategy is not affected by risk perception but by risk attitude. Likewise, while Meraner and Finger (2017) found a positive effect of risk aversion on the adoption of risk management strategies, several studies (e.g., Hellerstein et al., 2013; Just et al., 1999; Menapace et al., 2016) reported a negative effect of risk aversion on insurance uptake.

Drought is the most important weather-related risk in the study area. Farmers who are more worried about drought might take a loan to cope with the associated negative consequences. The positive association between risk aversion and monetary saving might be because farmers who dislike risk prefer more financial liquidity to manage the likely undesirable outcomes. The adoption of flood and drought-tolerant rice varieties is gaining momentum in Nepal. Risk-averse farmers might consider such varieties as appropriate options for minimising production uncertainty. The positive association of risk aversion with the adoption of crop insurance was consistent with the general expectation. Farmers with a high dislike of risk are expected to be more willing to pay for certainty. Similarly, involvement in farmer groups is an important risk management strategy. Farmer groups can be important platforms for local innovations and information exchange, helping farmers better manage their farms. Such groups and cooperatives can also help farmers manage credit risks by providing microcredit facilities and price risk by increasing their bargaining power in the market. Increased awareness about the availability and benefits of formal risk management strategies (e.g., crop insurance) through information sharing also increases the demand for such strategies.

We also examined the robustness of multivariate probit results estimating individual logit models of all risk management strategies using the same independent variables. The estimates are almost identical to those of the Multivariate Probit model except for the significant positive association between Flood RP and STRV use in the individual logit model (see Appendix I). The consistency in the results across the two models confirms that the estimates of the multivariate probit model are robust and unbiased.

Table 6.8 Estimates of Multivariate Probit models of farmers' risk management strategies

Model	Loan use in farming	Monetary saving	STRV use	Crop insurance	Off-farm employment	Group involvement
CRRA	–0.06	**0.21****	**0.24****	**0.93****	–0.01	**0.45*****
	(0.08)	**(0.08)**	**(0.09)**	**(0.28)**	(0.08)	(0.08)
Drought RP	**0.53***	–0.28	0.23	–0.27	–0.22	–0.20
	(0.26)	(0.26)	(0.25)	(0.34)	(0.25)	(0.27)
Flood RP	–0.56	–0.02	**0.60**	–0.08	0.03	0.43
	(0.35)	(0.33)	**(0.32)**	(0.46)	(0.32)	(0.36)

Constant	**–0.85*** (0.19)**	**0.72*** (0.18)**	**–0.62*** (0.17)**	**–1.36*** (0.24)**	0.22 (0.17)	**0.72*** (0.19)**
Log–likelihood						–1299.56
Wald $chi^2(18)$						72.41**
Draws						500
Observations						409

*Note: Figures in parentheses indicate SE; LR test of rho21 = rho31 =…= rho65 = 0: $chi^2(15)$ = 99.01***; asterisks indicate statistical significance at * p<0.05, ** p<0.01, and *** p<0.001; the bold figures indicate that the coefficients are also significant in individual logit models.*

Pairwise correlation coefficients between the residuals of most of the risk management strategies in the Multivariate Probit model are significant (Table 6.9). This result implies that the error terms in the risk management decision equations are correlated and justifies the use of the Multivariate Probit model instead of independent binary models (Mittal & Mehar, 2016). The positive correlation indicates a complementarity, and the negative correlation indicates substitutability between the risk management strategies. We expected a negative correlation between crop insurance purchase and STRV use because STRVs minimize production loss due to climatic stresses, decreasing farmers' demand for crop insurance. However, the model suggests that crop insurance purchase and STRV use are the most significant complementary strategies. The positive correlation between these variables might be because the insurance companies and extension agencies encourage farmers to grow STRVs to minimize the insurance claim and subsidy burden. Moreover, farmers' awareness of such technologies might be associated with their awareness of crop insurance programs resulting in higher adoption of both. Further, the model suggests that off-farm employment and monetary saving are substitutable strategies to some degree. Farmers who have off-farm employment might have considered maintaining monetary reserves less important as a risk management strategy.

Table 6.9 Correlation between the adoption of risk management strategies (multivariate probit)

	Loan use in farming	Monetary saving	STRV use	Crop insurance	Off-farm employment
Monetary saving	–0.11 (0.09)				
STRV use	0.18* (0.08)	0.23** (0.08)			
Crop insurance	0.34** (0.11)	0.39** (0.13)	0.56*** (0.09)		
Off-farm employment	0.29*** (0.08)	–0.21** (0.08)	–0.12 (0.08)	0.00 (0.11)	

Group involvement	0.34*** (0.09)	–0.04 (0.09)	0.31*** (0.08)	0.10 (0.14)	0.15 (0.08)

*Note: Figures in parentheses indicate SE; asterisks indicate statistical significance at * p<0.05, ** p<0.01 and *** p<0.001.*

As shown in Table 6.10, none of the risk management measures was associated with farmers' risk perceptions. However, CRRA was positively associated with farm mechanisation and the number of groups involved. This association was negative for production diversification and rice varietal diversification. Sale diversification and income diversification were not associated with any explanatory variables included in the model.

Table 6.10 Estimates of OLS models of farmers' risk management strategies

Model	Farm Mechanisation index	Number of groups involved	Production diversity index	Rice varietal diversity index	Sale diversity index	Income diversity index
CRRA	0.02**	0.48***	–1.40***	–0.33***	–0.35	–0.02
	(0.01)	(0.07)	(0.31)	(0.09)	(0.22)	(0.01)
Drought RP	–0.02	–0.25	0.29	–0.18	0.14	0.00
	(0.02)	(0.21)	(0.73)	(0.25)	(0.61)	(0.03)
Flood RP	0.01	0.23	0.52	–0.18	0.80	0.02
	(0.03)	(0.27)	(0.89)	(0.29)	(0.64)	(0.04)
Constant	0.34***	1.39***	7.02***	3.73***	3.79***	0.44***
	(0.02)	(0.14)	(0.48)	(0.16)	(0.41)	(0.02)
F	4.76	19.10	7.05	4.53	1.23	1.16
R2	0.03	0.13	0.07	0.03	0.01	0.01
Observations	409	409	409	409	409	409

*Note: Figures in parentheses indicate Robust SE; asterisks indicate statistical significance at * p<0.05, ** p<0.01 and *** p<0.001.*

As discussed earlier, the Multivariate Probit model suggested a positive association between risk aversion and farmers' involvement in the group. The OLS models reinforce this finding, suggesting that the increase in farmers' risk aversion increases their tendency to be involved in more groups. Similarly, mechanisation of farm activities is a major risk management strategy adopted by farmers. Due to increasing youth outmigration and the higher opportunity cost of labour in industrial sectors, agriculture is facing increasing uncertainty in labour supply, especially during peak seasons. Changing climatic patterns have been limiting farmers to follow the usual crop calendars. For instance, uncertainty in the onset of monsoon is a major manifestation of climate change in Nepal, which interferes with farmers' timing for rice seeding and transplantation. Grain quality risk associated with unexpected rainfall during crop harvest is an emerging weather risk in farming. Provided that access to machines and mechanisation services are not constraints, increased risk aversion was associated with increasing machine use for farming activities to overcome these risks. Moreover, the use of machines for cleaning, grading and packaging operations also subsides market risks adding value to farm produce.

The negative association of risk aversion with the production and rice varietal diversification is counterintuitive because a risk-averse farmer is expected to adopt a more diversified production system. Engle Warnick et al. (2011) also reported a negative correlation between risk aversion and crop varietal diversification. However, the number of commodities or crop varieties a farmer grows depends on farm size and irrigation facilities. To account for the effect of farm size on production diversification, we constructed an index dividing the number of crops grown by farm size. The availability of irrigation and production diversity index decrease from the East towards the West (see Table 3), while farmers' risk aversion increases in the opposite direction (see Table 4). This discrepancy explains the negative relationship of risk–aversion with production diversification and rice varietal diversification.

6.5 Conclusion

This study used an incentivized monetary-lottery choice experiment to elicit farmers' utility function. Using the risk aversion coefficient derived from the utility function as a measure of risk attitude, this study reinforces some existing theories while establishing new relationships between various personal and socio-economic factors, farmers' risk attitudes and their choice of risk management strategies in the Nepali context. In general, farmers showed a risk-averse attitude to the lottery game, and their risk aversion increased from East to West. Although the current rate of crop insurance adoption is low, the findings that farmers were risk-averse and risk aversion was positively correlated with insurance adoption indicate the potential for expansion of the existing agricultural insurance market. Information on spatial variation in farmers' risk attitudes can be useful for insurance companies to identify target groups, assess region-specific demand, diversify insurance products, set appropriate premium prices to minimise adverse selection, and design promotional programs.

The negative correlation between female and risk aversion does not support the prevalent stereotyping about gender that females are more risk–averse than males. We suspect that the acquired decision–making status of female respondents could make them less risk–averse than males, who are the default decision–makers in Nepali households. Although further research is required to clarify such a surprising finding, it suggests that policies and programs should not assume that women are more risk–averse than men. Similarly, policies and programs that aim at improving farmers' adoption of modern farming technologies and risk management products may consider the findings that larger farmers are more risk–averse than smaller ones, and risk aversion decreases with increasing farming experience.

Similarly, increased risk aversion with increasing numeracy skills may be due to individuals' better ability to calculate risk. Since increasing the formal education level of farmers is not practical in a short timeframe, insurance companies are likely to benefit if they invest in training farmers on probability calculations and risk management through insurance. Such skills may increase farmers' willingness to adopt insurance products through increased risk aversion. However, further research is needed to compare the effectiveness of numeracy training and conventional awareness campaign or advertisement in creating demand for risk management products. We also found that farmers' risk aversion was positively associated with monetary saving, STRV use, adoption of crop insurance and group involvement. These findings can aid both insurance companies and extension agencies in designing risk management products and support programs.

Further, while answering specific questions related to farmers' risk attitudes and farming risk management in Nepal, we have developed a simplified MPL, which is less cognitively demanding than the existing instruments and suitable for eliciting risk attitudes even when the respondents have low levels of formal education. A small number of inconsistent responses and the significant correlation between CRRA and the adoption of risk management strategies suggest that the instrument used in the experiment was reliable. Future research may adapt our instrument to elicit the risk attitudes of individuals in various sectors.

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Chapter 7: Farmers' Willingness to Pay for Crop Insurance in Nepal (Paper 4)

7.1 Abstract

The Government of Nepal started crop and livestock insurance programs in 2013, employing a public-private partnership model. Despite a 75% subsidy for the premium, farmers' participation in the crop insurance program has been negligible thus far. The available crop insurance product mainly draws on a feasibility study that only looked at supply-side issues. Information on farmers' risk attitudes, preferences, and willingness to pay (WTP) for crop insurance is lacking for Nepal. We estimated farmers' WTP for crop insurance using a discrete choice experiment (DCE) with 420 randomly selected farmers. The DCE involved hypothetical insurance products defined by various levels of risk coverage, deductible, premium price and insurance type. The study also involved an incentivised monetary lottery–choice experiment (LCE) for eliciting farmers' risk attitudes, together with a socio-demographic survey. We estimated a Mixed Logit model with correlated random parameters to analyse farmers' choices in the experiment. The results showed that premium price and deductible had negative effects on the utility of crop insurance, while sum insured had a positive effect. Similarly, farmers' risk aversion had a negative effect on the utility of the status–quo, implying that more risk-averse farmers were more willing to pay for insurance. While the mean coefficient for insurance type suggested that farmers were indifferent between loss-based insurance and rainfall–index insurance, significant standard deviations for all coefficients suggested considerable preference heterogeneity among farmers for crop insurance attributes, indicating a potential for diversifying crop insurance products. Among the attributes considered in the experiment, the sum insured had the dominant effect on the utility of insurance. Farmers' WTP for the existing crop insurance product is almost equal to the current subsidised premium, which indicates that the low uptake of crop insurance in Nepal is not related to price.

Keywords: crop insurance, discrete choice experiment, Nepal, rice farmers, risk attitude, rainfall–index insurance, willingness to pay

7.2 Introduction

This paper analyses farmers' preferences for various characteristics of crop insurance, which has emerged as a popular ex-ante risk management tool in farming, especially for weather-related risks. The tripling of global premium turnover from USD 10.2 billion in 2006 to 30.7 billion in 2017 implies that the agricultural insurance market is growing rapidly (see Hohl, 2019). A study conducted by Mahul and Stutley (2010) found that more than 108 (50%) countries across the world had some form of agricultural insurance program at the time of the study. Crop insurance is the largest component of the agricultural insurance industry, contributing about 90% of the total agricultural insurance premium in 2017 (Hohl, 2019). Increasing global food demand and price, increasing production risks due to climate change, and governments' preferences for insurance over disaster loss payments are the reasons for the rapid growth of the agricultural insurance market, especially in developing countries (FAO, 2011).

The main purpose of agricultural insurance is to pool farming risks and protect farmers against production losses, thereby stabilising their income. The major benefits of agricultural insurance include increased production, increased income, smoothened consumption, and reduction in loss disparity (Zhao et al., 2016). Crop insurance encourages farmers to expand crop areas and pursue high–risk, high–return farming options, which may require investing in advanced technologies and productive inputs (FAO, 2014). A properly designed insurance program stimulates economic growth and protects farmers from falling into the poverty trap by addressing credit constraints, the major reason for the chronic underinvestment problem in developing countries (Barnett et al., 2008). Credit institutions are more willing to fund insured farmers as they are less likely to default on the loans (FAO, 2014). Agricultural insurance can also be an important tool for assisting the process of climate change adaptation (Falco et al., 2014; Garrido & Zilberman, 2008).

Despite a large body of literature showing the significant benefits of crop insurance (see Carter et al., 2015; Elabed & Carter, 2015; Karlan et al., 2014), the viability of agricultural insurance markets is often limited by the low demand for it (FAO, 2011). Unlike other goods, for which the demand is shaped by the present utility of goods against the price paid, insurance provides an uncertain or stochastic utility that accrues only in the future states of the world (Carter et al., 2015). Poor farmers are often doubtful of insurance, which requires advanced payment for managing a risk that may or may not happen (Dercon & Kirchberger, 2008). Perceived demand for agricultural insurance can be overestimated if it does not account for other risk management options practised by farmers (Mahul & Stutley, 2010). A systematic study is needed to know whether agricultural insurance is an appropriate or cost-effective risk management tool in a given context because it is not a 'silver bullet' for risk management and climate adaptation (FAO, 2011).

A large public intervention in the form of premium subsidies is the most common feature of agricultural insurance markets worldwide (Mahul & Stutley, 2010). Since the demand for agricultural insurance is relatively price–inelastic, such subsidies are required to increase farmer participation (Keith & Barry, 2013). The transformation of public-funded insurance programs into public-private partnership (PPP) programs and the emergence of index-based insurance products, especially targeting smallholder farmers, are some of the major developments in the agricultural insurance industry in recent years (Hohl, 2019). The PPP model of the agricultural insurance market features the farmers as buyers, private companies as suppliers, and the government as the premium subsidy and reinsurance protection provider (FAO, 2011). Knowing buyers' preferences and willingness to pay (WTP) for insurance products is fundamental for insurance companies and the government in such a multi-stakeholder market.

Setting appropriate premium rates and subsidy level is the primary problem in establishing a viable agricultural insurance market. Premium rates set without information on farmers' WTP result in 'adverse selection' and 'moral hazards' (Liesivaara & Myyrä, 2014), leading to market failure (Arias & Covarrubias, 2006; Quiggin et al., 1993). Estimates of WTP can be used to project the change in demand and profitability of a product or service in response to the price change (Breidert et al., 2006). Companies can maximise their profit by adopting a harmonised pricing mechanism that acknowledges the consumers' WTP (Beredugo & Etuk, 2014). Therefore, companies need to make pricing decisions with an understanding of the likely response of potential consumers.

Although some form of farm insurance program existed in Nepal as early as 1987 (see Bagazonzya et al., 2009; Bhushan et al., 2016), the Government of Nepal formally initiated crop and livestock insurance programs in 2013 employing a PPP model. The Ministry of Agriculture and Livestock Development provided a 50% subsidy in the insurance premium until the second year, which was increased to 75% afterward. Although the value of sum insured increased from 55 million NPR in 2013 to 9000 million in 2017 (MoALD-Nepal, 2020a), the adoption of agricultural insurance in Nepal remains the lowest among Asian countries (Bhushan et al., 2016). Bhushan et al. (2016) pointed out that farmers' ability to pay is a major constraint to the adoption of crop insurance in Nepal. In addition to affordability, the uptake of crop insurance products largely depends on farmers' WTP (Santeramo et al., 2016). This paper analyses the demand-supply incongruency in the insurance market in light of farmers' risk attitudes and WTP for various insurance product attributes.

The Nepali agricultural insurance market is in its infancy, requiring evidence-based product improvement and implementation mechanisms to increase uptake by farmers. The existing crop insurance program was mainly based on a feasibility study conducted by Bagazonzya et al. (2009). The scope of their study was limited to reviewing international practices, assessing farming risks and identifying operational and institutional mechanisms to implement the insurance program. Little is known about demand-side issues, such as farmers' preference and WTP for crop insurance. Few studies conducted in Nepal related to crop insurance are cited below. Poudel et al. (2016) estimated actuarially fair premium rates of rainfall-index insurance in Nepal using production and rainfall data, Budhathoki et al. (2020) analysed farmers' perceptions of heat, cold and flood risks and identified crop insurance as one of the intended risk management strategies. However, both of these studies did not account for farmers' willingness to pay for crop insurance. Although Budhathoki et al. (2019) looked at farmers' WTP for insuring rice and wheat crops, they only covered a small geographic area and used a contingent valuation method (CVM), which does not offer insight into farmers' preferences and trade-off behaviours across crop insurance attributes. The present research evaluates farmers' risk attitudes, estimates their WTP for crop insurance, compares the importance of various characteristics of crop insurance products, and examines the effect of risk aversion on WTP.

This research investigates the relevance of crop insurance against drought risk in rice farming. Among weather-related risks, drought has received the most attention from farmers, policymakers and researchers. The growing emphasis on drought risk and its management is underpinned by an increasing incidence and severity of drought due to climate change (IPCC, 2014). Drought has detrimental effects on ecosystems and agricultural production, results in socio-economic costs for farming households, and jeopardises the macroeconomic objectives of food security, poverty reduction, and environmental protection (Dar et al., 2020; Hill et al., 2019; Kyle et al., 2016; Pandey et al., 2007; Ward et al., 2020a). The effect of drought is more detrimental on rice crops than other crops, which is the staple food for more than half of the global population (Dar et al., 2020) and most of the Nepali population. About two–thirds of the total rice area in Nepal has some form of irrigation facility (MoALD-Nepal, 2020b); the remaining rice crop area depends on monsoonal rainfall and is therefore prone to severe drought. The high dependency on rainfall indicates a high vulnerability of rice crops to drought. Our earlier findings (Chapters 4 and 5)—that farmers' perceptions of drought risk were highest among weather-related risks—also reinforced our motivation to explore more effective options to deal with drought risk in farming.

This study considers two major types of crop insurance—loss-based insurance (LBI) and rainfall-index insurance (RII)—as potential alternatives to mitigate weather-related risks in rice farming. LBI is traditional yield insurance that involves the insurance company paying a specified indemnity amount to the insured party if the yield loss exceeds an agreed threshold level (Diersen et al., 2015). Despite being an easy risk management instrument, the uptake of LBI is low worldwide, with just a few exceptions where governments have massively subsidised the insurance premium (FAO, 2011). High chances of moral hazard and adverse selection are two major disadvantages of LBI products (Diersen et al., 2015). Moreover, most weather-related risks are systemic, or loss exposures of individual farms are correlated, limiting the insurability of such risks (Adeyinka et al., 2016). Weather–index insurance (WII) products have emerged as more effective and equitable insurance tools than LBI in managing such risks (Jesús & Shingo, 2011). WII involves an index constructed using one or more weather variables as an indicator of production loss. A reference value is derived based on the historical average of the weather parameter, and a deficit or excess on the reference value recorded during a specified period is used to determine indemnification (Barnett et al., 2008). RII is the most popular WII for use against rainfall deficit or drought (FAO, 2011).

WII was first introduced into India in 2003 (FAO, 2011). Since then, it has received attention in the South Asia region as an innovative solution to deal with farming risks. Many pilot projects of WII are being carried out in the region targeting smallholder farmers (Hill et al., 2019). A rainfall–based WII was initiated for apple crops in the Jumla district of Nepal by the Sakchyam project and Shikhar Insurance company in 2016 (Sakchyam, 2016). The Ministry of Agriculture and Livestock Development (MoALD), donors (e.g., World Bank), and private insurance companies have shown interest in introducing similar insurances for other crops. Recent studies conducted in India (e.g., Ward & Makhija, 2018; Ward et al., 2020a) and Bangladesh (e.g., Ward et al., 2020b) have shown higher demand for WII than other types of risk management products. In contrast, another study conducted by Akter et al. (2017) in Bangladesh found most farmers insurance averse, while those who were willing to buy insurance preferred standard insurance over WII. The present research answers whether Nepali farmers prefer WII over LBI.

7.2.1 Attributes of crop insurance

The premium price is the most important attribute of an insurance product, which is supposed to negatively affect its demand. However, the relationship between premium price and demand for crop insurance is not univocal. For example, while Ginder et al. (2009) identified premium price as the most important determinant of farmers' insurance product choice, Serra et al. (2003) found a price–inelastic demand for crop insurance. Serra et al. (2003) concluded that premium subsidy alone could not increase farmers' participation in a crop insurance program. In contrast, Garrido and Zilberman (2008) found a positive correlation between premium subsidy and insurance adoption. These contrasting results suggest that other factors confound the relationship between price and demand for crop insurance. Moreover, the demand for crop insurance is affected by risk level, expected risk coverage, availability of alternative risk management tools, and characteristics of the insurance contract (Ginder et al., 2009). For instance, Babcock and Hart (2005) concluded that increasing risk coverage increases the demand for crop insurance. Likewise, Ramsey (2020) found a positive correlation between expected return to insurance and adoption rate. In general, increasing the level of risk coverage implies a higher premium. Furthermore, deductible is another essential feature of a co-insurance contract that directly affects the premium price. In the case of crop insurance, deductible serves as a trigger for indemnification. The present research considers premium price, deductible, risk coverage level and insurance product type as major characteristics of crop insurance products that determine farmers' demand. The discrete choice model examines the hull hypothesis that these attributes do not affect the utility of crop insurance.

7.2.2 Risk aversion and demand for insurance

Risk aversion implies a preference for certainty over uncertainty, even when the uncertain outcome offers a higher expected value. Although most economic theories assume humans as risk-averse agents, individuals have varying degrees of risk aversion to the same risk (Binswanger, 1980; Edgardo & Alain de, 1977). Nevertheless, a rational agent, who maximises the expected utility, is willing to pay for insurance if the premium is actuarially fair (Elabed & Carter, 2015). However, Daniel (2016) found a negative effect of risk aversion on demand for insurance at higher risk aversion levels but a positive effect at lower risk aversion levels. They argued that the counterintuitive relationship between risk aversion and demand for insurance might be due to the imperfect risk coverage provided by the insurance. This finding implies that the effect of risk aversion on WTP is confounded by the characteristics of the insurance. In an earlier study (Chapter 6), we derived a constant relative risk aversion coefficient (CRRA) for each respondent using an incentivised monetary lottery–choice experiment. The discrete choice model also examines another null hypothesis that the CRRA does not affect the utility of crop insurance.

7.3 Methodology

The methods for evaluating WTP are classified into two major categories: revealed preference (RP) and stated preference (SP) (Abbeam et al., 2014; Baker & Ruting, 2014; Breidert et al., 2006). RP methods are used to analyse actual purchase data, whereas SP methods analyse consumers' intention to purchase (Breidert et al., 2006; Louviere et al., 2010). While RP methods more accurately estimate consumers' WTPs, SP methods are suitable for products or services that are not already available in the market (Lancsar & Louviere, 2008; Liesivaara & Myyrä, 2014). In the Nepalese farming sector, insurance products are not diversified, and the level of adoption is very low, so we used an SP method involving hypothetical insurance products.

The contingent valuation method (CVM) and choice modelling are two SP methods widely used in evaluating farmers' WTP for crop insurance (e.g., Abbeam et al., 2014; Okoffo et al., 2016; Taneja et al., 2014). CVM directly asks respondents to state their WTP for a given good or service (Carson, 2012). CVM is a linear approach that ignores trade-offs between mutually competitive attributes of the good or service being valued (Venkatram, 2004). Rather than the consumers stating a price that they are willing to pay for a good or service, it is easier for them to answer if a given price is acceptable or not (Brown et al., 1996). In indirect surveys, consumers are presented with various products with systematically varied prices and asked if they would purchase the products at a given price or not (Marbeau, 1987). Breidert et al. (2006) also argued that when consumers are presented with product alternatives and respective prices, it is cognitively easier for them to rank the alternatives based on their preferences. In such surveys, the consumers are free to choose between different scenarios according to the weightage they attach to price or other attributes (Cameron & James, 1987). Discrete choice experiment (DCE), which uses an indirect survey to measure consumers' WTP, is the most popular choice modelling method. DCEs help simulate real market situations and estimate more accurate WTPs than other methods (Breidert et al., 2006). Therefore, we used DCE to measure farmers' WTP for crop insurance.

7.3.1 Analytical approach

The theoretical framework of DCE comprises three important theories from classical economics that explain consumer behaviour. The first is expected utility maximisation, or rational choice theory (RCT), which has its major roots in Bernoulli (1738)'s logarithmic utility function and von Neumann and Morgenstern (1944)'s four axioms of perfect rationality. The RCT assumes that consumers can assign utilities to each of the available alternatives and have a stable preference for the one that provides the highest utility, subject to their affordability (Amaya-Amaya et al., 2008). The second is Lancaster (1966)'s characteristics demand theory, which states that consumers buy a good not for the good itself but for its attributes. In the experiment, respondents face choice problems between alternatives defined by varying levels of attributes, allowing researchers to model the impact of change in levels of the attribute on the demand for a good (Hauber et al., 2016). Changing the levels of attributes affects the total utility of the options, which can result in a discrete switch between the alternatives based on the most beneficial combination of attributes (Amaya-Amaya et al., 2008). The third is McFadden (2001)'s random utility theory (RUT), originally proposed by Thurstone (1994) in psychology and introduced into economics by Marschak (1960). Among these theories, RUT provides a major analytical basis to the DCE, which we discuss below.

RUT assumes that individual choice behaviour has a stochastic or random component. People can discriminate between choice alternatives by their cognitive judgement of the indirect utilities. However, because such cognitive utilities are hidden inside decision–makers' heads and cannot be measured directly, the analyst can separate the utilities into two additive parts: a deterministic component (observable) and a random component (unobservable) (Amaya-Amaya et al., 2008). In mathematical terms, the latent utility (U_{nj}) obtained by an individual (*n*) from choosing j alternative (*j = 1, …, J*) can be represented by the sum of observable component (V_{nj}) and the unobservable component (ε_{nj}).

$$U_{nj} = V_{nj} + \varepsilon_{nj} \; \dots\dots\dots\dots\dots\dots \textit{Equation } 7.1$$

The deterministic component (V_{nj}), also called representative utility, can be modelled as a linear function of observed attributes of alternative (x'_{nj}) and decision–maker's characteristics (z'_n).

$$V_{nj} = \beta x'_{nj} + \gamma_i z'_n \dots\dots\dots\dots\dots\dots \textit{Equation } 7.2$$

Where β and γ represent parameter vectors of X and Z, respectively.

The random component represents unmeasured variation in preferences, which can be due to unobserved variables affecting choice, individual taste variation, and measurement errors (Manski, 1977). Different assumptions about the distribution of unobserved ε_{nj} results in different discrete choice models (Hole, 2007).

7.3.2 Choice models

Multinomial Logit (MNL) and Conditional Logit (CL) are two popular models for analysing discrete choice. MNL is used to model choice as the function of decision–makers' characteristics, while CL explains choice as the function of alternative–specific characteristics (Saul & Greg, 1988). If we assume that random terms are independently and identically distributed (IID) type I extreme value, the choice probability that a respondent (*n*) choses *j*th alternative is given by the Conditional Logit model (Equation 7.3).

$$P_{nj} = \frac{\exp\,(\sigma_n V_{nj})}{\sum_{j=1}^{J} \exp\,(\sigma_n V_{nj})} \ldots\ldots\ldots\ldots\ldots\ldots Equation\ 7.3$$

Both MNL and CL are valid only when random component of the utility is IID across alternatives, which is often unlikely. Moreover, both models do not account for individual preference heterogeneity, assuming constant coefficients of the explanatory variables across decision-makers. Alternatively, Mixed Logit (ML), also called Random Parameters Logit (RPL), allows the coefficients of alternative–specific variables to vary across decision-makers and estimates means and standard deviations of the coefficients. Means of the coefficients are average marginal utilities of the variables, while standard deviations provide insight into the distribution of such utilities across individuals or individual taste variation. Moreover, the random parameters of different attributes are likely to be correlated, so ML with correlated normal distribution of random coefficients ('correlated ML' hereafter) can be used to account for such correlations.

$$P_{nj}(\beta_n) = \int \frac{\exp\,(\beta_n'\, X_{nj})}{\sum_{k=1}^{K} \exp\,(\beta_n' X_{nk})} f(\beta/\theta)d\beta \ldots\ldots\ldots\ldots\ldots\ldots Equation\ 7.4$$

Where β' representants individual-specific parameter with $f(\beta/\theta)d\beta$ density function.

7.3.2.1 Willingness to pay (WTP)

We estimated WTPs for attributes and different bundles of attributes representing insurance policies using Equations 7.5 and 7.6, respectively. WTP for an attribute is simply the ratio of the attribute–specific coefficient to the coefficient for premium, with the sign reversed. Similarly, WTP for an insurance policy is the ratio of the sum of products of values and coefficients for all variables included in the utility model excluding premium to the coefficient for premium, again with the sign reversed.

$$WTP_{attribute} = -\frac{\beta'_{attribute}}{\beta'_{premium}} \ldots\ldots\ldots\ldots\ldots\ldots Equation\ 7.5$$

$$WTP_{Policy} = -\frac{\sum \beta' * attribute}{\beta'_{premium}} \ldots\ldots\ldots\ldots\ldots\ldots Equation\ 7.6$$

7.3.2.2 Market share

In the correlated ML model, we defined the status–quo option as having zero utility. The alternative–specific constant (ASC) was defined as 0 for the status–quo option and 1 for the insurance policy. Considering these, we calculated market shares of various policies with different combinations of the attributes using Equation 7.7. The market share shows how the insurance policies would perform in the market if they existed. If a policy is priced exactly at WTP, the market share would be 0.5 or 50% of farmers would buy it.

$$\text{Market share} = \frac{e^{\sum \beta' x}}{1 + e^{\sum \beta' x}} \ldots\ldots\ldots\ldots\ldots\ldots Equation\ 7.7$$

7.3.3 Experimental design

The DCE involved different crop insurance contracts as choice alternatives (Table 7.1). The crop insurance contract covers production risk in rice crop for one season. The rice crop is grown during June – October in Nepal. Both drought and flood may occur at any stage of crop growth depending on the distribution of monsoon during the crop period.

The choice alternatives are defined by insurance product types, sum insured, deductible and premium price. We used two types of crop insurance products, namely loss-based insurance (LBI) and rainfall-index insurance (RII). LBI covers production loss due to various reasons, including floods, drought, insects and diseases. LBI requires field assessment of production loss for determining indemnification. In contrast, the RII indemnifies the insurers irrespective of production loss based on the rainfall recorded during a specified period. A rainfall record of 1000 mm during June – September has been set as the normal rainfall. The deficit amount below the normal level will indicate the indemnification amount. The RII also involves a trigger (15% rainfall deficit in this study) for policy activation. The 15% trigger implies that the indemnification is not activated above 850 mm rainfall during the crop period. The details of payment schedule have been presented in Appendix D and E.

Insurance contracts were also differentiated by two levels of the sum insured: NPR 60000 NPR and 90000 NPR per hectare, which are equivalent to potential income and cost of cultivation from one hectare of land, respectively. Further, the choice alternatives were also defined by three levels of deductibles (15%, 20% and 25%) and five levels of premium price (NPR 250, 500, 750, 1000, 1250 and 1500 per hectare.

Table 7.1 Summary of attributes and levels included in the DCE

SN	Attributes	Unit	Levels					
A1	Insurance type		Loss–based insurance			Rainfall–index insurance		
A2	Premium	NPR/ha	250	500	750	1000	1250	1500
A3	Sum insured	NPR/ha	60000	90000				
A4	Deductible	% of sum insured	15	20	25			

We used Ngene software to generate a D–efficient design with 24 choice scenarios (Appendix F). We blocked the choice scenarios into six groups, each with four choice scenarios. That is, each farmer faced four choice scenarios in the experiment. The choice card also involved a status–quo option. Respondents were asked to choose the best and worst options from three, which allowed a full profile ranking of the options. We developed graphic choice cards representing the choice scenarios and presented the cards to the respondents randomly to eliminate potential ordering bias (Figure 7.1).

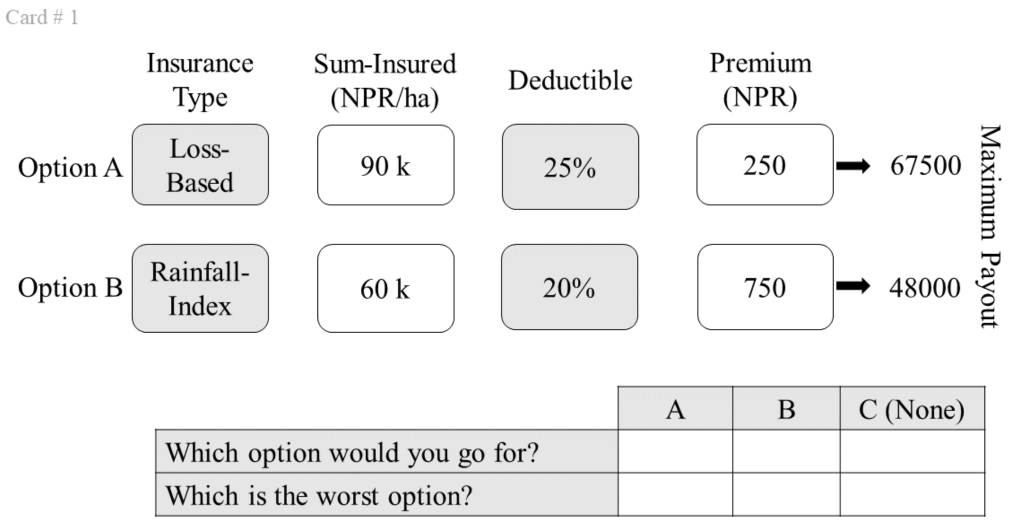

Figure 7.1 An example of the choice cards used in the DCE

7.3.4 Survey implementation

This paper considers crop insurance, particularly rainfall–index insurance, as an option for mitigating drought risk in rice farming and estimates farmers' willingness to pay for it. More than two–thirds of the rice area in Nepal is rainfed (Bagazonzya et al., 2009), which makes them vulnerable to drought. We conducted the DCE with the decision-makers from 420 randomly selected rice farming households in the Terai region of Nepal from October 2018 through February 2019. The study area was divided into three geographic regions—Eastern Terai region (ETR), Mid–Terai region (MTR), and Western Terai region (WTR)—representing high, medium and low rainfall areas, respectively. From 2001 to

2012, the average annual rainfall records for ETR, MTR and WTR were 1926 mm, 1819 mm and 1642 mm, respectively (CBS-Nepal, 2014). We used a multi-stage random sampling technique to select up to 14 villages from seven districts and randomly selected 30 farmers from each village, ensuring five respondents in each of six experimental blocks for a total sample size of 420. See Chapter 3 (Methodology) for a more detailed description of the sampling design.

Supplementary data were collected through a questionnaire survey that included an incentivised monetary lottery–choice experiment (LCE) to elicit the respondents' risk attitudes. We conducted face–to–face interviews and experiments with the respondents visiting their homes. The purpose of the study and the concepts related to crop insurance and experiments were thoroughly explained to the respondents. A clear explanation of attributes, levels, and payout structures (see Appendix D, E and I) was provided to the participants before presenting the choice cards, and they could ask questions when needed. The principal researcher trained the enumerators to minimise interviewer bias. Similarly, to minimise hypothetical bias, the respondents were reminded repeatedly about the general tendency to overstate WTP and urged to make honest decisions. We also assured the respondents that the information would remain anonymous to minimise social desirability bias. In addition to the opportunity of winning up to NPR 200 the LCE, we provided the respondents with NPR 100 for their participation in the study. We conducted a pre-testing survey with five farmers to examine whether the questionnaire and DCE tools elicited the information we needed and the respondents could complete the tasks. We also conducted a pilot survey with 60 respondents and checked the consistency of the data with the analytical models. We completed the main survey using the same experimental design as the pilot survey did not suggest any change.

7.4 Findings and discussion

7.4.1 Sample description

Table 7.2 presents some socio-economic and attitudinal characteristics of the respondents by clusters relevant to the context of risk management decisions. Although we conducted the experiment with 420 respondents, we eliminated 11 (2.61%) who made inconsistent choices in the lottery–choice experiment. The inconsistent choices refer to decisions that are not consistent with the expected utility axioms, i.e., not choosing a strictly dominating option and switching across risky and certain options more than once. Moreover, 39 (9.48%) of the remaining respondents chose the status–quo option in all four choice cards. Among these respondents, 24 mentioned that the insurance premiums were higher than their WTP, 13 mentioned that they did not want any insurance at all, and two mentioned that the sums insured were not attractive for them. We kept the respondents mentioning the first and third reasons because such information still has economic meaning. We considered the respondents who did not want any insurance at all as protesters (see Jourdain & Vivithkeyoonvong, 2017) and excluded them from the analysis, reducing our effective sample size to 396.

The participants' education level is an important indicator of the reliability of the information collected through complex experimental studies, such as DCEs. The respondents had nearly six years of formal education, which is lower than the participants' educational attainment in DCEs conducted in other regions. In addition to formal education, farmers also develop numeracy skills through informal and non–formal education. To test such skills, we included five probability-based quizzes in the survey (Appendix C). The average score in the quizzes was 2.75, indicating that the farmers answered more than half the questions correctly. Moreover, we asked the respondents to self–assess their comprehension of the experimental tasks on a five-point scale. The average task comprehension score across samples was 0.69, indicating that the participants understood the experimental tasks and made informed decisions in the experiment.

Table 7.2 Basic characteristics of the samples

Variable	Description	ETR	MTR	WTR	All
Sample size		172	117	107	396
Female	% Respondents	43.02	33.33	46.73	41.16
Formal education	Years	5.60 (4.36)	6.09 (4.22)	5.56 (4.43)	5.73 (4.35)
Numeracy score	0–5	2.95 (1.54)	2.56 (1.40)	2.63 (1.45)	2.75 (1.49)
Experiment comprehension	0–1 (scale)	0.70 (0.24)	0.67 (0.27)	0.68 (0.28)	0.69 (0.26)
Flood risk perception	0–1 (score)	0.17 (0.19)	0.21 (0.23)	0.19 (0.18)	0.19 (0.20)
Drought risk perception	0–1 (score)	0.59 (0.26)	0.59 (0.27)	0.58 (0.25)	0.59 (0.26)
CRRA		–0.32 (1.02)	0.03 (0.74)	0.21 (0.51)	–0.07 (0.86)
Group involvement	% Households	67.44	85.47	74.77	74.75
STRVs use	% Households	30.81	43.59	32.71	35.1
Insurance adoption (Any)	% Households	38.95	42.74	39.25	40.15
Crop insurance adoption	% Households	8.72	10.26	8.41	9.09

Note: Figures in parentheses indicate SD. Insurance adoption shows the percentage of respondent households who had purchased any of six insurance products, namely crop, livestock, health, life, vehicle and house.

7.4.2 Choice modelling

We started our analysis by estimating CL and checked for any inconsistencies in the data. Then, we estimated ML followed by correlated ML. The sign and significance of the coefficients of explanatory variables are consistent across these models, indicating the robustness of the findings (see Table 7.3). We calculated WTP and market shares using the correlated ML estimates, which allows for examining individual preference heterogeneity. Another important benefit of using correlated ML is that it accounts for all sources of correlation, including those arising from factors not included in the model, which is called scale heterogeneity (Hess & Train, 2017). We used CL estimates to carry out dominance analysis for examining the relative importance of crop insurance attributes because the algorithm is not compatible with ML specifications.

7.4.2.1 Correlated Mixed Logit estimation

Following Hole (2007), we implemented the maximum simulated likelihood algorithm to estimate the correlated ML model in Stata 16. We first estimated uncorrelated ML and used those estimates as starting values for the correlated ML estimation. The model included premium, sum insured, deductible and rainfall–index dummy as the independent variables. Similarly, we included a no status–quo dummy variable (NoSQ) to represent whether the choice corresponds to either insurance type. We also included the interaction term of NoSQ dummy and CRRA (NoSQ*CRRA) to examine the effect of risk aversion on choice. NoSQ*CRRA was specified as a fixed parameter variable, where the remaining variables were specified as random parameter variables. Table 7.3 shows the results of both CL and ML estimations. In what follows, we only discuss ML estimates.

As expected, the mean coefficients for premium and deductible were negative, while that of sum insured was positive. The mean coefficient of the rainfall–index dummy was non–significant, indicating farmers' indifference between insurance types for the same level of risk coverage. Similarly, the positive coefficient of CRRA*NoSQ implies that the utility of crop insurance increases with increasing risk aversion. The non–significant coefficient of NoSQ dummy suggests that the farmers do not derive higher utility just by changing from the status–quo to having an insurance. However, the significant standard deviations of NoSQ and rainfall–index dummy together imply that some farmers derive higher utility by changing from status–quo to having an insurance irrespective of insurance type, while some farmers do so only when the product type is rainfall–index insurance.

A likelihood–ratio test rejected the null hypothesis that all standard deviations are jointly equal to zero, which implies that the respondents have a heterogeneous preference for crop insurance attributes. Since the coefficients of the standard deviation are significant for all variables, preference heterogeneity exists for all attributes. These tests justify the use of the correlated ML to model farmers' choices.

Table 7.3 Estimates of the Correlated ML and CL models of farmers' choice

Attributes	Correlated ML		CL	
Mean	Coef.	SE	Coef.	Robust SE
CRRA*NoSQ	3.432***	0.517	1.766***	0.204
Premium (NPR)	–0.011***	0.002	–0.004***	0.000
Deductible (%)	–0.228***	0.059	–0.072***	0.017
Sum insured ('000, NPR/ha)	0.239***	0.040	0.100***	0.005
Rainfall–index dummy	0.253	0.370	0.256	0.125
NoSQ dummy	–3.678	2.120	–2.500***	0.547
SD				
Premium (NPR)	0.006***	0.001		
Deductible (%)	0.185**	0.074		
Sum insured ('000, NPR/ha)	0.133***	0.026		
Rainfall–index dummy	1.242*	0.513		
NoSQ dummy	10.397***	3.204		
Log–likelihood		–688.669	Log pseudo–likelihood	–817.825
Observations		4752	Observations	4752
LR $chi^2(15)$		258.310***	Wald $chi^2(6)$	631.440***
			Pseudo R^2	0.530

*Note: Asterisks indicate statistical significance at * $p<0.05$, ** $p<0.01$ and *** $p<0.001$. We have reported three decimal places because some estimates are too small.*

7.4.2.2 Individual preference heterogeneity

Figure 7.2 shows the distribution of the random parameters estimated by correlated ML, indicating individual preference heterogeneity or taste variation. Almost all respondents had positive coefficients for sum insured and negative coefficients for deductible and premium, indicating that farmers dislike premium price and deducible and like insurance coverage. About 31% of respondents had positive coefficients for the NoSQ dummy, implying that about one–third of farmers prefer crop insurance to status–quo irrespective of product type. Similarly, 52% of respondents had positive coefficients for rainfall–index dummy, indicating that more than half of farmers prefer rainfall–index insurance to loss-based insurance. The heterogeneous preferences of the farmers for the attributes of crop insurance suggest scope for diversifying crop insurance products.

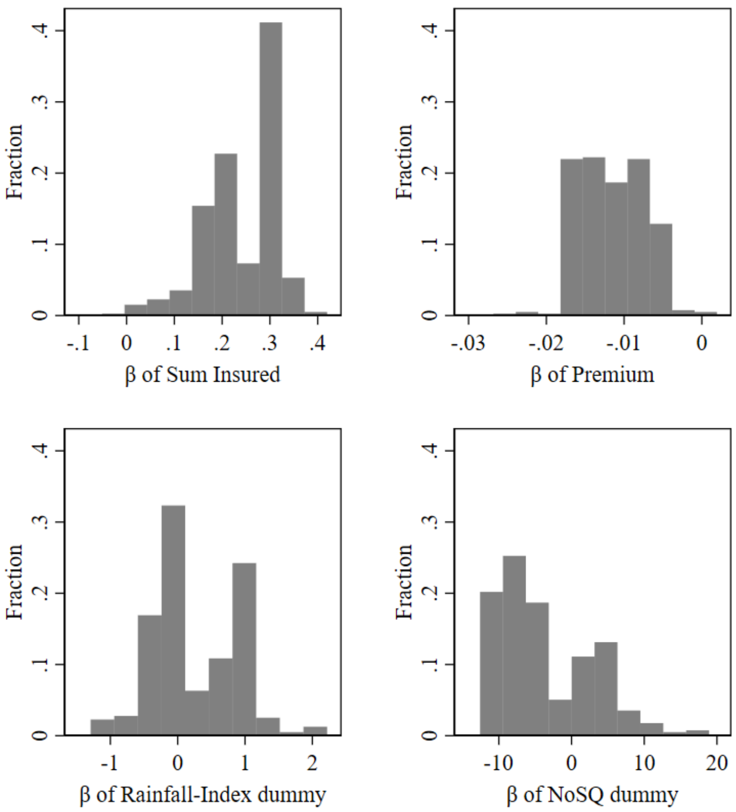

Figure 7.2 Distribution of random parameter estimates in the correlated ML model

7.4.2.3 WTP for attributes

We calculated farmers' WTP for various attributes that define the choice alternatives using random parameter estimates of correlated ML model for individuals. The WTP for an attribute is the ratio of its coefficient to the coefficient of the premium. Table 7.4 shows the summary statistics of the WTP estimates for various attributes used in the experiment, while the kernel density plots in Figure 7.3 show their distribution across individuals. The distribution of WTP estimates corresponds to the distribution of random parameter estimates in the correlated ML model. The WTP estimates for deductible were mostly negative, and sum insured and CRRA*NoSQ were mostly positive. This finding indicates that farmers prefer higher insurance coverage and lower deductible, and their WTP for crop insurance increases as their risk aversion increases. The WTP estimates for rainfall–index insurance and NoSQ dummies were positive for 52% and 31% of respondents, respectively. Based on these figures, we can conclude that about one–third of farmers are willing to pay to change from status–quo to either insurance type, while about half of the farmers are willing to pay only for rainfall–index insurance. These results are somewhat consistent with the findings of previous studies. For instance, Zhao et al. (2016) found that increasing the risk coverage up to a level equivalent to potential income encouraged farmers to adopt crop insurance even when they had to pay higher premiums.

Similarly, the Rain and Hail Society (2013), cited in Zhao et al. (2016), reported high participation of farmers in high–premium insurance programs in the USA, indicating the effectiveness of high–premium, high–indemnity insurance in managing farming risks.

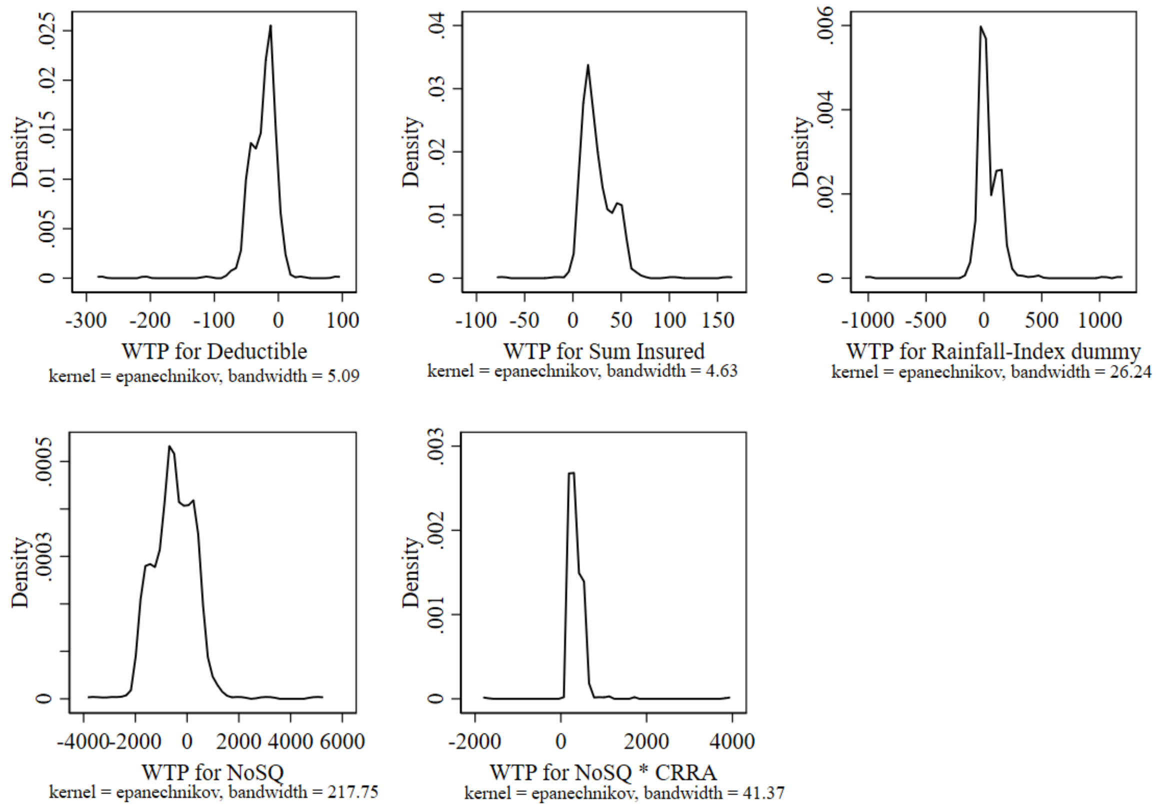

Figure 7.3 Distribution of WTP estimates for crop insurance attributes

Table 7.4 Summary of WTP estimates for crop insurance attributes

Variable	Observations	Mean	SD	Min	Max
Deductible	396	–21	23	–227	210
Sum insured	396	25	18	–69	139
Rainfall–index dummy	396	24	223	–3555	1486
NoSQ	396	–562	805	–3874	2955
CRRA*NoSQ	396	332	363	–5147	3528

7.4.2.4 Relative importance of crop insurance attributes

Knowing the relative importance of the insurance attributes allows predicting market shares of competing insurance products and provides guidance for configuring new products targeting specific producer groups (Sherrick et al., 2004). We carried out dominance analysis using the CL estimates to examine the relative importance of the crop insurance attributes. The dominance analysis partitions the contributions of all variables to the overall fit statistic, i.e., R–square in this case, and ranks the variables by such statistics. Standardised dominance statistics are the ratios of dominance statistics to the overall fit statistic. The ranking scores indicate that farmers are willing to trade off an attribute with a lower score for other attributes with higher scores.

As shown in Table 7.5, the sum insured had the leading effect on the utility of crop insurance, followed by premium and NoSQ dummy. The rainfall–index dummy had the lowest dominance statistics, followed by the deductible. In general, farmers would prefer lower premium products to higher premium products. However, their preference depends on the government's subsidies and the level of risk covered by the insurance. The dominance analysis confirms our earlier finding that farmers are willing to pay a higher premium if the risk coverage level is increased (see Section 7.4.2.3). The farmers' preferences for product types (differentiated by loss estimation methods) and deductible (indicating the level of risk-sharing between insurance companies and farmers) were lower compared to risk coverage level and premium. A study conducted by Sherrick et al. (2004) is noteworthy in this context. They found that US corn and soybean farmers' preference for flexibility in deciding the area under crop insurance dominated risk coverage level and insurance product type. Utilizing these findings will allow better tailoring of crop insurance products to farmers' preferences.

Table 7.5 Dominance analysis using conditional logistic regression

Dependent variable: Choice dummy	Dominance statistics	Standardised dominance statistics	Ranking
Sum insured	0.21	0.38	1
Premium	0.17	0.32	2
NoSQ dummy	0.05	0.09	4
CRRA*NoSQ	0.08	0.15	3
Deductible	0.03	0.05	5
Rainfall–index dummy	0.00	0.00	6
Overall fit statistic	0.53		
Observations	4752		

7.4.2.5 WTP for insurance policies

Table 7.6 shows the distribution of WTPs for 12 different insurance policies constructed using various combinations of attributes. The first row shows a mean WTP of NPR 1362/ha for the most preferred insurance policy, which offers the highest level of insurance coverage. The second last row shows that a mean WTP of NPR 380/ha for the least preferred insurance policy. The last row represents the existing insurance policy in the market, with a mean WTP of NPR 758/ha, which is almost equal to the current premium price after subsidy (NPR 750/ha). This finding supports the conclusion of Budhathoki et al. (2019) that the low adoption of crop insurance in Nepal is not related to price.

Table 7.6 WTP estimates for various insurance policy combinations

Policy				WTP (NPR/ha)			
Sum insured (NPR/ha)	Deductible (%)	Insurance type	Observations	Mean	SD	Min	Max
90000	15	Rainfall–index	396	1362	995	–9632	7905
		Loss–based	396	1338	812	–6076	6419
	20	Rainfall–index	396	1254	885	–8583	6768
		Loss–based	396	1231	706	–5028	5281
	25	Rainfall–index	396	1147	778	–7535	5630
		Loss–based	396	396	1123	603	–3979
60000	15	Rainfall–index	396	619	620	–7969	3730
		Loss–based	396	595	465	–4414	2243
	20	Rainfall–index	396	511	536	–6921	2592
		Loss–based	396	487	403	–3365	1356
	25	Rainfall–index	396	404	465	–5872	1455
		Loss–based	396	380	370	–2317	1224
60000 (existing)	10	Loss–based	396	758	547	–775	5796

7.4.2.6 Market share

We calculated the potential market share of various insurance product combinations using correlated ML estimates. Figure 7.4 shows the market share of the insurance product combinations mentioned in Table 7.6 at various premium levels (12 insurance products). The existing insurance product features loss-based insurance with NPR 60000/ha sum insured and 10% deductible, priced at NPR 750 (after 75% subsidy). Market share was highest for the rainfall-index insurance product with NPR 90000/ha sum insured and 15% deductible, and lowest for the loss-based insurance product with NPR 60000/ha sum insured and 20% deductible, at all premium rates. The predicted market share of the existing product at the existing premium price was 53%, which is inconsistent with the existing crop adoption within the sample (9%). Therefore, the market share predicted by the model is inconsistent with the existing adoption of crop insurance in the market.

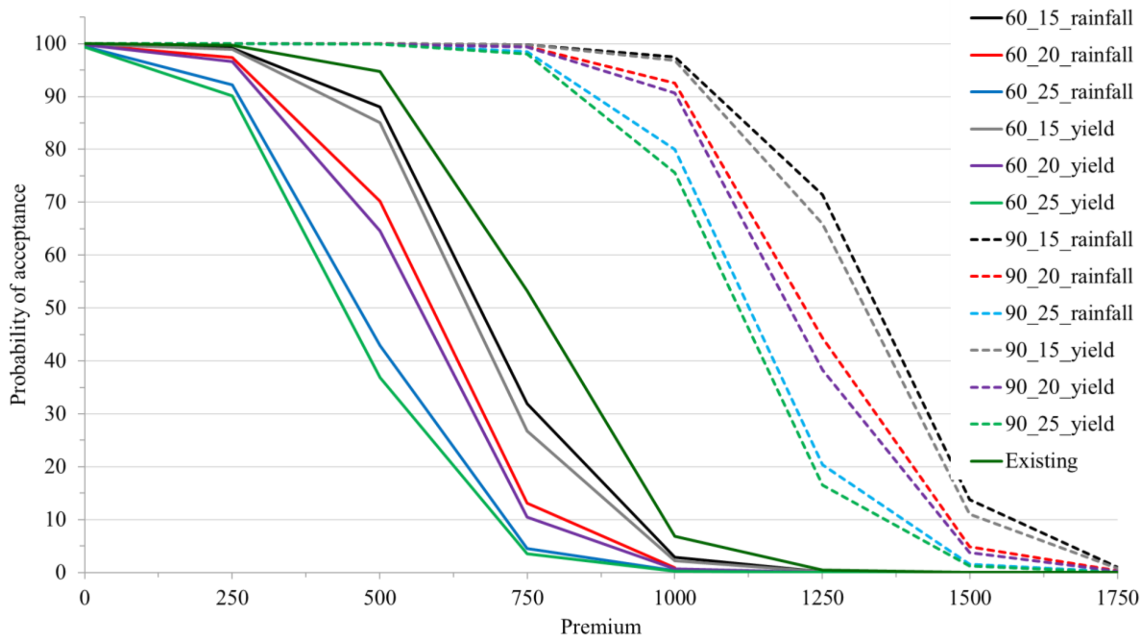

Figure 7.4 Market share of different crop insurance policy combinations

To explain the potential overestimation of WTP, we asked open-ended follow–up questions to the respondents who stated their WTP in at least one choice scenario but had not yet bought a crop insurance product. Of 281 such respondents, 36% said they did not know about the availability of insurance (Table 7.7). Such lack of awareness of the insurance explains the overestimation of WTPs as indicated by the market shares. All the other reasons mentioned by the farmers were not related to the premium rate either. Moreover, the crop insurance adoption rate within the sample is the current adoption, which does not indicate their future intention to adopt. A recent study conducted by Budhathoki et al. (2019) in the same population found that 84% of farmers were interested in buying area-based crop insurance and willing to pay USD 42.42/ha/season, which is three times more than the current premium price. These facts lead us to conclude that the market share predicted by the choice model was not overestimated.

Table 7.7 Reasons for not buying crop insurance

Reasons	Frequency	Per cent
Companies are unreliable	21	7.47
I didn't like just cost compensation	25	8.90
I didn't understand its concept well before	14	4.98
Existing product is too complex	12	4.27
No facilitation	42	14.95
Others haven't done it	36	12.81
Process is cumbersome	29	10.32

I was unaware about insurance	102	36.30
Total	281	100

7.5 Conclusion

This study offers a broad perspective on the scope of crop insurance products relative to other available options for mitigating drought risk in rice farming. Nepali farmers are willing to pay for crop insurance if the products are tailored to what they value. The results of the choice models suggest that the demand for crop insurance depends on premium, deductible and risk coverage levels. Some farmers also prefer rainfall–index insurance, which overcomes the issue of loss estimation. Moreover, farmers' WTP for crop insurance increases as they become more risk-averse. The dominance analysis showed that the risk coverage level is the most preferred, and the insurance product type (based on the loss estimation method) is the least preferred attribute of crop insurance products. The findings on the relative importance of the insurance attributes will be useful in predicting market shares of competing insurance products and customising new products to farmers' preferences. Another important finding of the study is that farmers have heterogeneous preferences for crop insurance attributes, indicating the scope for diversifying the products according to their tastes. The main reason for the low adoption of crop insurance is not due to high premiums but due to the lack of awareness of its availability in the market. Therefore, in addition to designing insurance products according to farmers' preferences, creating awareness of crop insurance availability and benefits is crucial for improving its adoption.

The weather conditions vary significantly across study sites, resulting in heterogeneous rainfall–yield models. However, due to practical reasons, we used a single hypothetical rainfall index that might have incorporated a large basis risk. Supplying such a single-index insurance product with a large basis risk throughout the country may lead to market failure. Crop varietal diversity, specifically the adoption of drought-tolerant rice varieties, may also significantly affect rainfall–yield models. Therefore, developing reliable indices by considering the rainfall-yield models based on location-specific data is essential for minimizing the basis risk associated with rainfall–index insurance. Loss–based insurance products should also be customized based on site-specific information on farmers' needs, preferences and WTP to minimize adverse selection and moral hazard in the insurance market.

Farmers' needs and preferences indicate that crop insurance can be an important aid for accelerating the process of agricultural modernization in Nepal. However, it should not be considered a panacea that can overcome all risks in farming. Moreover, as Mahul and Stutley (2010) suggested, crop insurance does not operate in isolation and should not replace essential agricultural supports, such as timely input supply, extension services and output marketing facilities. OECD (2009) also recommended adopting a holistic approach for managing farm risks, with insurance as a component of the comprehensive risk management framework. We support these suggestions and recommend improving risk management policy and products according to farmers' needs and preferences.

We evaluated the crop insurance policies based on single-season risk coverage. However, several authors have suggested temporal diversification of insurance contracts, such as offering multi-year insurance, as a potential measure for addressing systemic risks in farming. Such multi-year contracts can be diversified by adopting different pricing mechanisms, e.g., static (constant premium rate) or dynamic (premium rate adjusted based on claims), and indemnification schemes (based on annual loss or losses during a specified period). Calum and Megan (2012) suggested that non–weather indices, such as the normalised difference vegetation index, can be used to predict yield loss more accurately than the weather index. Farmers' might also be interested in risk management products other than yield insurance, such as revenue insurance. Future research could evaluate farmers' WTP for these alternatives.

7.6 References

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Chapter 8: Summary and Conclusion

This chapter concludes the thesis by presenting a summary of the research, key findings, significance of the study, policy recommendations, limitations of the study and suggestions for future research.

8.1 Research overview

Understanding the dynamics of farmers' decision–making in the face of risk and uncertainty is an ongoing research agenda for behavioural scientists and policymakers. Risk perception and risk attitude are the key variables of farmers' decision–making models that align with the theory of expected utility maximisation. These variables are indicators of farmers' risk management decisions and are associated with investment, innovation, and overall performance of the farming sector. Knowing what risks concern farmers the most, their risk profile, and their strategies for dealing with risk are essential for designing effective risk management policies and products. While the body of literature on risk and decision–making is quite extensive, no universal theory explains the relationships between individual characteristics, socio-demographic factors, risk perception, risk attitude and response to risk. Studies conducted in other parts of the world have reported contrasting relationships between these variables. To address the paucity of significant studies investigating these variables in the Nepalese context, we analysed the relationships between farmers' risk perceptions, risk attitudes and risk management decisions. More specifically, the study assessed farmers' risk perceptions, estimated their risk attitudes, assessed existing risk management strategies, and estimated their willingness to pay for crop insurance.

We used a sequential mixed–methods (qual=>QUAN) research design within the framework of the rational decision–making model, which assumes that individuals can evaluate their economic options and choose the one that maximises the present value of expected earnings. The qualitative study involved in-depth interviews with 45 farmers from the Terai region of Nepal and content analysis of interview transcripts, followed by cognitive mapping of the relationships between various themes and sub-themes emerging from the data. The qualitative study established a broad context of farming risk in Nepal, particularly assessing perceived risks, risk factors, risk attitudes and risk management strategies. It helped us identify variables and develop survey instruments for the subsequent quantitative studies involving a questionnaire survey of 420 randomly selected farmers from the same region. The survey contained psychometric scaling questions to elicit farmers' perceptions of risk and management strategies, incentivised lottery–choice experiments to elicit their risk attitudes, and discrete choice experiments to measure their willingness to pay for crop insurance.

8.2 Key findings

This section summarises key findings of the study, addressing five research objectives as below.

Objective 1: Examine the applicability of the cognitive mapping approach for studying risk perceptions

Analysis of the cognitive maps indicated that farmers' risk perception is a complex network of reciprocal relationships between sources of uncertainty, risks and management strategies. The multiple linkages between the constructs indicate that farmers perceive more than one cause of risk and aim to meet more than one goal while responding to the risks. Such complexity indicates that the psychometric risk mapping, which requires farmers to quantify the probability and consequences of one element out of the entanglement, may not elucidate a complete picture of farmers' risk perceptions. We found cognitive mapping as an appropriate tool to reduce long open-ended conversational interviews into explicit networks of constructs. Domain analysis, centrality analysis and the most mentioned constructs techniques allowed us to explain farmers' understanding of risk and management decisions, offering semi-quantitative flavours in qualitative research. In addition to its applicability as a research method, cognitive mapping can also serve as a communication tool because of its power in presenting a complex topic using a simple diagram. Furthermore, cognitive mapping can be an appropriate tool for recording, analysing, and reporting focus group discussions, presentations and dialogues.

Objective 2: Evaluate farmers' risk perceptions and identify the factors influencing drought and flood risk perceptions

The findings of the qualitative and quantitative studies mostly converge for prevalent risks, farmers' risk perceptions, risk attitudes and management strategies. Both methods revealed that farmers were more concerned about production risks than market risks. The study showed that farmers' insufficient technical knowledge and uncertain labour supply were the primary sources of production risk, while farmers' low bargaining power was the most important source of market risks. The study also revealed that men and women farmers had similar perceptions of climatic risk factors, with drought being the most critical weather risk, followed by flood. However, perceptions of uncertainties about input supply varied across genders. For example, women farmers were most concerned about the uncertainty in the availability of basic inputs, such as seeds and fertiliser, while male farmers were most worried about the uncertainty in their access to farm machines and irrigation. We can relate the different risk perceptions of men and women to gender-differentiated roles in farming. Further, the Tobit model estimates suggested that farmers' perception of drought risk was associated with their age, family size, migration status, access to infrastructure and services, and rice productivity. Similarly, their perception of flood risk was associated with farm size, migration status, rice productivity and joint family system. We also found significant spatial variation in farmers' perceptions of both risks. Moreover, their risk perception and past exposure to risk were highly correlated. These findings suggest that the variation in farmers' risk perception is linked to differences in objective risk factors, socio-demographic factors, and farm characteristics.

Objective 3: Estimate farmers' risk attitudes and identify factors associated with risk attitude

In the qualitative study, most farmers preferred a certain low–income option to a risky high–income option. The results of the lottery–choice experiment also revealed that farmers are risk-averse in general, and their risk aversion is associated with their gender, farm size, farming experience, numeracy skills and flood risk perception. The results also showed that farmers' risk aversion increases from East to West, the direction in which the amount of rainfall decreases. Likewise, farmers' risk aversion is linked to various farming and risk management decisions, such as farm mechanisation, farm diversification, crop varietal diversification, group involvement, monetary saving, use of stress-tolerant rice varieties, and purchase of crop insurance. However, these decisions are not associated with farmers' risk perception. These findings lead us to conclude that risk attitude has a more significant influence on farmers' decision–making than risk perception.

Objective 4: Compare farmers' risk management strategies in terms of applicability and efficacy

Farmers considered diversification, such as crop diversification, crop varietal diversification and integrated farming, as the most important strategy for managing production risks in their farming. From farmers' perspectives, on-farm risk management strategies are more important than market-based risk management strategies such as crop insurance. About one–third of respondents were not aware of the availability of crop insurance in the market, and more than two–thirds of respondents were not aware of the concepts and benefits of crop insurance. Their lack of knowledge might be why they preferred on-farm risk management strategies over crop insurance.

Objective 5: Estimate farmers' willingness to pay for crop insurance

The discrete choice experiment of hypothetical crop insurance products revealed that farmers are willing to buy crop insurance if the insurance products are tailored to their needs and preferences. Premium, deductible and risk coverage levels are major determinants of farmer demand for crop insurance. Almost half of the respondents stated a higher willingness to pay for rainfall–index insurance than loss-based insurance, presumably because the index eliminates the tedious loss estimation process for determining indemnification, a major drawback of loss–based insurance. The dominance analysis showed that sum insured is the most preferred attribute of crop insurance, which implies that farmers are willing to pay higher if the risk coverage level is increased. We also found that farmer willingness to pay for crop insurance increases as their risk aversion increases. These findings suggest that there is scope to expand the crop insurance market in Nepal.

8.3 Significance of the study and policy implications

This thesis contributes to the growing body of literature on the relationships between socio-demographic factors, risk perception, risk attitude and decision–making in the Nepalese farming context. The study makes two significant methodological contributions. First, it has validated the cognitive mapping technique as an effective tool for studying farmers' risk perception, which can be a complementary method to the conventional psychometric scaling method for enhancing the understanding of farming risks. Second, we have adapted a simple and easy–to–implement experimental tool (multiple price list) for measuring risk attitudes in the farming context of developing countries where respondents often have low formal education. Moreover, the study answered some important questions about the prevalent farming risks in Nepal, sources of uncertainty, farmers' risk perceptions and attitudes, and risk management strategies, which have practical implications for policy development and risk management product design. Potential beneficiaries of this study include farmers, agricultural researchers, extension workers, students, insurance providers and policymakers. Key recommendations emerging from this study are summarized as follows.

- The study showed considerable heterogeneity in farmers' risk vulnerabilities, risk perceptions, risk attitudes, choice of risk management strategy, and WTP for crop insurance. Such heterogeneity implies that a one–size–fits–all agricultural insurance product is likely to suffer from moral hazards and adverse selection arising from information asymmetry between farmers and insurance providers. Proper identification of target groups and customising insurance products according to potential clients' risk perceptions, risk tolerances and WTP may help minimise such issues in the market.

- Sources of uncertainty in farming are so diverse that insurance alone cannot address all risks. For example, the risk associated with labour shortage is not insurable, despite being the most important risk identified in the farmers' risk perception study. In addition to expressing their willingness to pay for crop insurance, the farmers also emphasised the need for applying on-farm risk management strategies. Therefore, the government should formulate a holistic risk management policy that fosters the balanced use of on-farm risk management strategies and market–based alternatives. Along with subsidising the premium price to overcome the potential gap between farmers' WTP and profitable premium rates for insurance providers, the government should focus on capacity–building interventions to improve farmer resilience to risk and self–insurance capacity. Moreover, agricultural insurance should be implemented with adequate extension support, input supply and output marketing arrangements.

- Improving farmers' access to modern farming technologies, developing and promoting climate-smart crop varieties and training farmers on the use of such technologies can be helpful in increasing the effectiveness of on-farm diversification strategies in managing production risks. Weather forecasting service, irrigation development and promotion of drought-tolerant crop varieties may be some of the effective strategies to mitigate drought risk. Improving farmers' skills for on-farm and off-farm jobs may help them diversify income opportunities and better manage livelihood risks.

- The low adoption of crop insurance is mainly due to two reasons not related to insurance costs or subsidy deficits.

    - First, most farmers were unaware of the availability of such risk management tools in the market. They did not know about the concepts and benefits of insurance. Therefore, facilitating a linkage between farmers and insurance companies is needed to increase farmer awareness of the crop insurance program. Employing insurance agents in rural areas may increase farmer awareness and access to insurance products. Agricultural extension programs also need to increase farmer training programs to educate them about the concepts and benefits of crop insurance.

    - Second, the insurance market is not diversified, and the existing insurance product does not meet farmers' needs and preferences. Farmers are willing to pay more than the existing premium for insurance if the risk coverage level increases. Moreover, considerable preference heterogeneity exists among farmers regarding crop insurance attributes. Therefore, offering diversified insurance products with varying risk coverage levels and product types allows farmers to select the best product based on their needs and preferences.

- The qualitative study showed that farmers perceive risk as complex networks of multiple connections between sources of risks, their tendency to avoid risks, and decisions made to deal with them. In-depth interviews and cognitive mapping can be useful for disentangling such complexity and gaining comprehensive insight into the numerical measures of risk perception.

- This study considered the case of the Nepalese farming context, which is characterized by the prevalence of smallholder subsistence farmers, inadequate infrastructure and facilities, and high vulnerability to climate change. Researchers, policymakers, and insurance providers from other developing countries with similar farming contexts may benefit from the findings and methodological approaches adopted in this study.

8.4 Limitations of the study and future research directions

This research suffered several practical constraints that limited the generalizability of the outputs to a wider context. The following points highlight the limitations of this study and offer suggestions for future research.

- We divided the study area into three broad regions based on the average amount of annual rainfall. However, considerable microclimatic diversity exists across and within the regions. Aggregated risk perception scores may not represent the variability in farmers' risk vulnerability and perception due to climatic variability. The development of risk management products and support programs based on site-specific assessments of farmers' risk perceptions is likely to improve the acceptability of such interventions.

- The expected payoff level in the lottery-choice experiment was equivalent to the average opportunity cost of the farmers for one hour. The risk could have been too small to stimulate the actual risk attitudes of some farmers. Therefore, the coefficient of risk aversion derived from the experiment has limited generalizability to other risky prospects with higher values at stake. Future researchers could increase the payoff scale or use various payoff scales to elicit more accurate measures of risk attitude.

- The discrete choice experiment used a single rainfall–index for the whole study area due to practical reasons. Such a single index might entail a higher basis risk, given the microclimatic diversity in the study area. If companies want to develop rainfall–index insurance products, they should develop site-specific indices based on local rainfall–yield models to minimise the basis risk.

- The study used cross-sectional data to analyse farmers' risk perceptions and risk attitudes. However, these variables may vary for an individual over time. Future researchers may consider applying a longitudinal approach to study such variables.

- Due to the unavailability of historical data on the frequency and severity of drought and flood in the study sites, we used the measure of farmers' risk experience as a proxy of objective risk. The risk experience variable was constructed by multiplying farmers' ratings of the frequency and average crop loss associated with a risk in the past ten years. Future research may estimate objective risks and compare the objective risks with farmers' risk perceptions.

- In general, crop insurance contracts are made for a single season, which only allows for the spatial transfer of risk. Offering multi-year insurance contracts that allow for the spatiotemporal transfer of risk could be one measure for addressing the catastrophic nature of weather-related risks. Future researchers may evaluate farmers' WTP for such insurance contracts.

- Researchers have suggested innovative solutions, such as a bonus-malus system or premium discounting system based on loss experience, to improve the actuarial soundness of the crop insurance market. Future research could consider investigating the feasibility of integrating such innovations into the Nepalese crop insurance program.

- This study focussed on crop insurance as a major strategy to mitigate the weather–related risks in rice farming in the Terai region of Nepal. Future research may analyse farming risks and applicability of insurance by geographical regions (Mountain, Hills and Terai), crop, livestock types and income groups.

- This thesis has comprehensively mapped prevalent risks in the Nepalese farming sector. However, due to resource and time constraints, the risk management component of the thesis disproportionately focuses on weather-related risks in rice farming, especially drought. Further research is necessary covering other crops and risks to support the development of a holistic agricultural risk management framework.

- This study used insurance adoption as a dichotomous variable to account for whether respondents had an ongoing insurance contract at the time of the survey. However, adoption has various levels, including continuous adoption, intermittent adoption, dis–adoption and non–adoption. Future researchers may consider measuring adoption as a continuous or ordinal variable.

Chapter 9: Appendices

Appendix A. Description of samples involved in the qualitative study

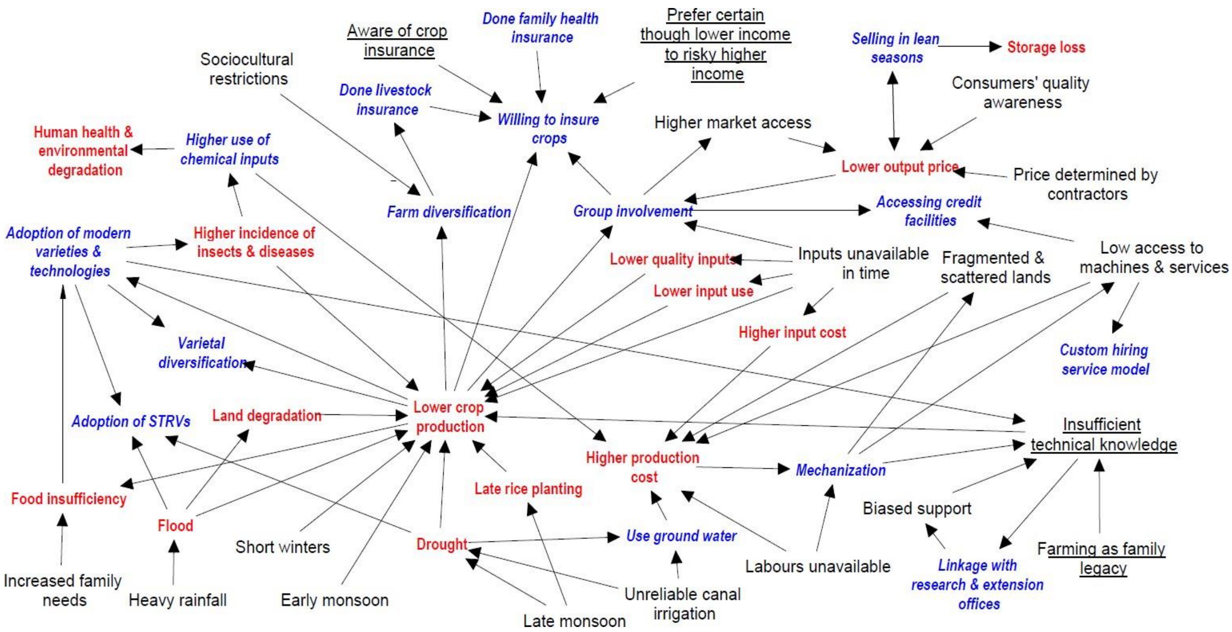
SN	Farmer	Region	Education	Age	Family size	Farm size (ha)	Insurance awareness	Insurance adoption		
								Crop	Livestock	Other
1	Female–1	ETR	Sec.	42	6	2.66	Yes	Yes	Yes	Yes
2	Male	ETR	Sec.	46	6	2.00	Yes	No	No	Yes
3	Male	ETR	Sec.	32	5	4.66	No	No	No	Yes
4	Female	ETR	Sec.	45	5	3.33	Yes	No	No	No
5	Male–2	ETR	Tert.	53	4	1.00	Yes	Yes	No	Yes
6	Male	ETR	HS	64	7	1.50	Yes	No	No	Yes
7	Male	ETR	HS	40	11	2.00	Yes	No	Yes	No
8	Male	ETR	Sec.	35	5	4.66	Yes	No	No	No
9	Female	ETR	Prim.	40	5	1.00	No	No	No	No
10	Female	ETR	Sec.	39	4	0.75	Yes	No	Yes	Yes
11	Male	ETR	LS	42	15	0.75	Yes	No	No	Yes
12	Male–3	ETR	HS	28	6	1.50	Yes	No	No	Yes
13	Male	ETR	LS	48	13	1.80	Yes	No	No	No
14	Male	ETR	Prim.	50	10	1.08	Yes	No	No	Yes
15	Male	ETR	HS	36	8	3.33	Yes	No	No	Yes
16	Male–1	WTR	AL	47	20	7.50	No	No	No	No
17	Male	WTR	Prim.	53	16	2.00	Yes	No	No	No
18	Male	WTR	LS	34	14	2.50	Yes	No	No	No
19	Male	WTR	LS	43	5	1.50	Yes	No	No	No
20	Male	WTR	AL	68	19	1.00	Yes	No	Yes	Yes
21	Female–3	WTR	LS	42	3	0.33	Yes	No	Yes	Yes
22	Male	WTR	LS	54	8	1.00	Yes	No	Yes	No
23	Male	WTR	LS	46	4	1.83	Yes	No	No	No
24	Male	WTR	LS	58	13	4.00	No	No	No	No
25	Male	WTR	Sec.	54	4	6.66	Yes	No	No	Yes
26	Male	WTR	Sec.	50	9	2.66	Yes	Yes	No	No
27	Male	WTR	AL	54	6	3.33	No	No	No	Yes
28	Male	WTR	Illit.	49	4	1.33	Yes	No	No	Yes
29	Male	WTR	AL	45	14	2.66	Yes	No	No	Yes
30	Male	WTR	LS	46	11	6.00	Yes	No	No	No

31	Female	WTR	AL	48	18	4.00	Yes	No	No	No
32	Female	CTR	AL	40	4	0.66	No	No	No	No
33	Male	CTR	LS	46	4	2.66	No	No	No	Yes
34	Male	CTR	Sec	55	6	1.00	Yes	No	No	Yes
35	Female	CTR	AL	45	4	1.00	Yes	No	Yes	No
36	Female	CTR	AL	32	18	3.33	Yes	No	Yes	No
37	Female	CTR	LS	53	13	3.33	Yes	No	No	No
38	Female	CTR	HS	34	8	1.33	Yes	No	No	No
39	Female	CTR	LS	36	5	2.00	No	No	No	Yes
40	Female–3	CTR	Illit.	70	5	3.33	No	No	No	No
41	Female	CTR	Sec.	36	6	4.00	Yes	No	No	No
42	Female	CTR	LL	45	8	0.33	Yes	No	No	No
43	Male	CTR	HS	50	5	1.00	Yes	No	No	No
44	Female	CTR	Prim.	46	5	0.76	No	No	No	Yes
45	Female	CTR	AL	49	7	0.66	No	No	No	Yes
Max			Tert.	70	20	7.50	Yes	Yes	Yes	Yes
Min			Illit.	28	3	0.33	No	No	No	No

Note: ETR = Eastern Terai region, CTR = Central Terai Region, WTR = Western Terai region; shaded rows indicate samples selected for cognitive mapping; Education: Illit. = Illiterate, AL = Adult literacy, Prim. = Primary, Sec. = Secondary, HS = Higher Secondary, Tert. = Tertiary.

Appendix B. Cognitive maps of the samples analysed in the qualitative study with explanation

Appendix B.1 Cognitive map of Female–1



(Legend: regular, <u>intrinsic factor: underlined</u>, **perceived risk: bold red** and ***risk management: italicisedbold blue***)

Female–1 is a 42–year–old farmer from the Sunsari district of the Eastern Terai region. She completed high school level education. She heads a six–membered family that solely depends on farming from 2.66 ha of land for their livelihood.

She got into farming as a family legacy because she never came across any other employment option. She learned basic farming practices seeing her elders do it. As the family grew up, production from the same piece of land did not meet the family's food, fibre, and other requirements. To cope with this insufficiency, she looked for opportunities to increase farm production. She adopted modern, short–duration and high–yielding crop varieties and farming technologies to produce more from the same piece of land. She found these modern crop varieties and technologies riskier than local crop varieties and conventional practices because they needed to increase their technical knowledge. She sought assistance from the agricultural research station and District Agriculture Development Office to deal with this risk. She also found modern crop varieties more susceptible to insects and diseases than local varieties. She applies more pesticides, fertilisers and other chemicals to increase production from the high–yielding varieties, which she knows are harmful to humans and the environment. Moreover, the increased use of chemical inputs increased the costs of production.

Compared to ten years before, the climatic patterns have changed considerably and hampered farming practices. In particular, variation in rainfall pattern in terms of timing of monsoonal onset and seasonal rainfall distribution has made it more difficult for her to synchronise the farming calendar with rainfall, as her farming system is rainfed. The most prominent risk posed by erratic rainfall is flooding. High–intensity rainfall can inundate her newly planted rice fields for more than a week, washing the rice plants away, reducing rice production. This year was a high–flooded year, and she lost half of her rice plants to flooding. She assumes that floods come twice in five years and reduce her rice production by half. The negative effect of the flood is not limited to one season but also affects soil fertility as it silts the cropland and makes it less fertile, affecting crop productivity in following seasons. To overcome some of the flood risks, she plans to grow the flood–tolerant rice varieties that she tested this year on a small piece of land.

Her farming depends on monsoonal rainfall. If the monsoon does not occur as expected in terms of onset timing and seasonal distribution, the rice faces drought, which is another major risk to rice production. If the onset of monsoon is delayed, rice transplantation is delayed, reducing crop production. Similarly, if the monsoon is not evenly distributed between June and August, the rice crop will face flood and drought intermittently. Despite the nearby irrigation canal, the water supply is unreliable. She said that the canal does not supply water when she needs it most. To cope with drought, she relies on pumped groundwater, which she thinks is not as good as rainfall in terms of quality and increases production costs. Early monsoon is one of the features of erratic rainfall, which she thinks is a good thing for both spring and main season rice production. However, early monsoon usually coincides with the winter crop harvest, significantly reducing the quality of produce. She considers drought as the major climatic risk to her rice production, followed by flood.

She thinks that winters have increasingly shortened compared to ten years ago. The early blow of western air terminates the winter season early, forcing the wheat crop to start flowering. The forced flowering reduces the vegetative growth period of wheat and other winter crops, significantly reducing production.

She thinks that uncertainty related to the timely availability of inputs such as seeds, fertilisers, herbicides, and other agrochemicals poses two risks in her farming: (1) increases the chance of reduced crop production, and (2) a short supply of inputs, increases input prices, which increases production costs. She thinks that even if the inputs are available, their quality is uncertain as she has received contaminated inputs in the past. Moreover, she does not have enough knowledge to check input quality, which negatively affects crop production.

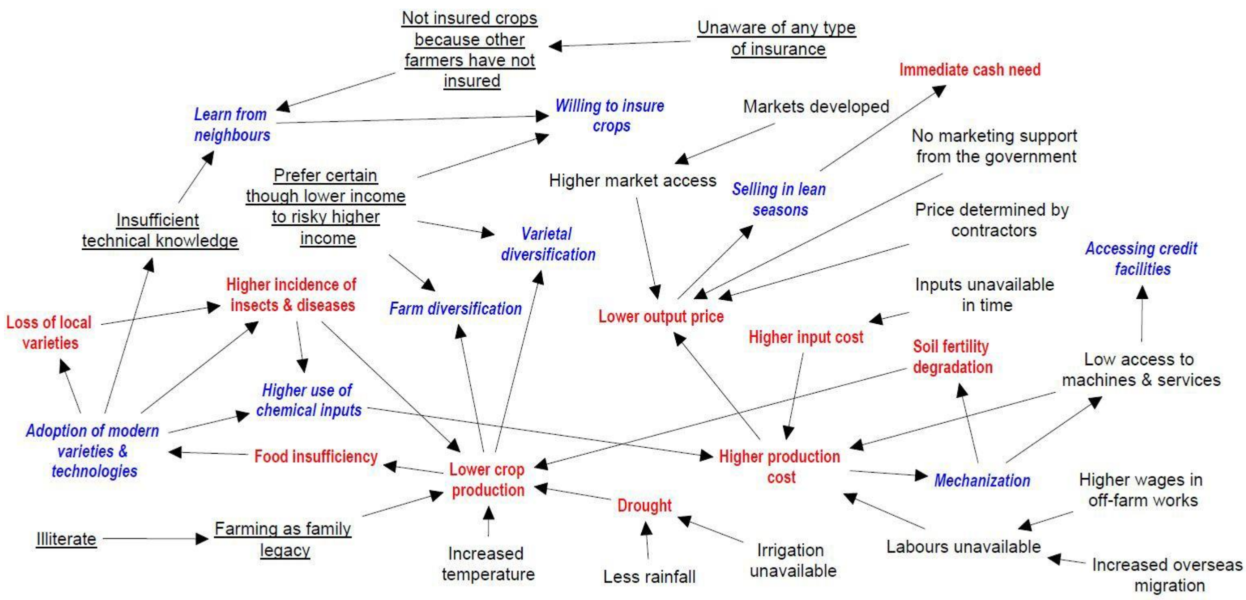
Due to the increase in overseas youth migration for employment and higher opportunity cost of labourers in the off–farm sector, labour availability has declined. In addition to posing uncertainty for the crop acreage decisions, this labour shortage has increased production costs. To deal with the risk of higher production costs and labour unavailability, she uses machines to carry out various farming activities, such as land preparation, planting, harvesting and threshing. However, mechanisation is not a risk–free panacea. The most limiting factor for farm mechanisation is that she does not have enough capital to purchase machines. While mechanisation services are available in villages through the custom hiring service provision model, demand for these services increase during peak seasons. She is associated with an agriculture production cooperative, which has bought farm machinery and provided services to other members. She owns a zero–tilled seed drill, which she purchased using a loan from a farmer group. As a novice user of farm machinery, she often questions the production success from machinery and her technical knowledge associated with machinery operations. She is also uncertain about the economics of farm mechanisation because she suspects that her land is not suitable for mechanisation as it is fragmented into small pieces and scattered in many locations.

The increasing population has increased market access tremendously in the past ten years; the risk of not selling produce at the market is minimal. However, increasing production and competition in the market have led to price stagnation over the same period because the price determination system does not allow for farmers to bargain their prices; price determination is the sole power of a small number of contractors. Moreover, consumers have become more conscious about produce quality. If farmers do not maintain the quality of their produce, they must accept a lower price. In years with low crop yield, the price increases slightly; hence, she prefers selling rice in the lean seasons. However, there is a risk of loss due to insects and rodents in storage.

Uncertainty of crop yield is the major risk to her farming. She does not have any other options to meet the family’s requirements if farm production fails. To cope with the possible failure of a component commodity, she has adopted an integrated farming system that incorporates both horizontal diversity (several crops in a season) and spatial diversity (crop rotation). She also grows several varieties within a single crop according to land type and maturity duration that fits into the crop rotation plan. She thinks that varietal diversification minimises the risk of full crop failure, even if one variety fails for some reason. Moreover, her farming system integrates several livestock components, including goats, pigs and poultry, to minimise the risks associated with fertiliser unavailability. Nevertheless, she struggled for a few years to convince the elders when she wanted to add pigs into her farming system, as they did not allow her to raise pigs due to cultural restrictions.

She heard about crop insurance for safeguarding against production risks and bought it for her rice crop. She also insured eight pigs for NPR 20000 each, paying only NPR 250 for the insurance premium. She also has family health insurance, paying NPR 500 per year for health benefits up to NPR 25000 per year. She has a reasonable understanding of the concepts of risk, insurance and premium. She thinks that the insurance premiums for the pig and health insurance programs are negligible compared to risks. She feels that the premium for crop insurance is not too high, and she is ready to insure her rice production against failures due to flood, drought, insects and diseases. When she was asked to choose between a certain NPR 2000 and a lottery with the chance of winning 5000 NPR or nothing with equal probabilities, she preferred the certain outcome, although the lottery had a higher expected value. She added that she is happier with lower but guaranteed income than higher risky income. This attitude confirms that she is risk–averse, which is consistent with her willingness to insure her rice crops.

Appendix B.2 Cognitive map of the oldest and least educated sample (Female–2)



(Legend: regular, <u>intrinsic factor: underlined</u>, **perceived risk: bold red** and ***risk management: italicisedbold blue***)

Female–2 is a 70–year–old farmer from the Parasi district of the Central Terai region. She is illiterate and heads a five–membered family that depends on farming from 3.33 ha of land for their livelihood.

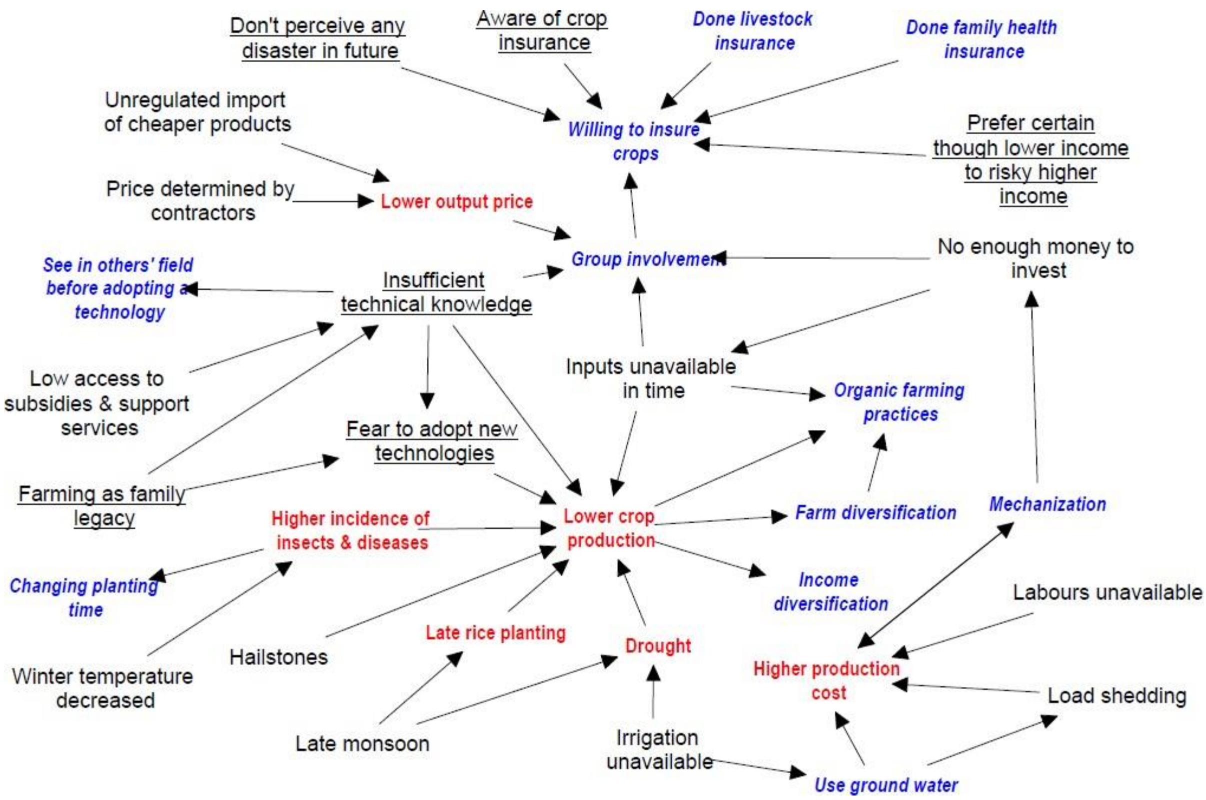
Being illiterate and having no other job opportunities, she got into farming as the only option for her livelihood. She used to practice a traditional way of farming which had low crop production. Compared to the past, she thinks that the temperature has risen. She thinks that rainfall has become more erratic, creating drought, but she has not experienced any serious flood events of note. As she does not have access to irrigation facilities, drought hampers her crop production almost every year. If crop production is low, her family must go through food insufficiency, as she does not have any other source of income. To cope with food insufficiency, she has adopted modern crop varieties and technologies, expecting better yields. However, modern varieties and technologies are not free from risk. She thinks that modern crop varieties require higher applications of fertiliser, which increase production costs. She feels that adopting modern crop varieties has extinguished the local crop varieties that can tolerate insects and diseases. Modern varieties are more susceptible to insects and diseases, increasing the risk of lower crop production. The cultivation of modern crop varieties and technologies requires new knowledge to increase yields. She thinks if she does not acquire appropriate knowledge, even the modern varieties will not produce higher yields. As she does not have any linkage with agencies that provide technical training, she relies solely on fellow farmers to learn. In addition to adopting modern crop varieties and technologies, she has diversified her farm in terms of the number of crops and the number of varieties within a crop to cope with crop production risk. She thinks that if one crop fails to produce for some reason, the same reason might not apply to other crops. Similarly, if one variety of rice fails because of some reason, other varieties might do well.

She thinks that labour unavailability and higher input costs, such as seed, fertilisers, and chemicals, are the major challenges to her farming. She feels that increasing overseas migration and higher wage rates in off–farm sectors are the major reasons for labour unavailability. She thinks that farm mechanisation would be the most appropriate tool for coping with the risk of higher production costs due to higher input costs and labour unavailability. However, she has little access to farm machines and services because she cannot afford them. She does not have access to formal credit institutions and relies on neighbours for credit for farm mechanisation. In addition to the economic aspects of farm mechanisation, she thinks that machine operations degrade soil fertility. She feels that traditional tillage practices would make the soil more fertile.

In her early days, there was no tradition of selling agricultural produce. There was no market, but nowadays, she can sell whatever and whenever she likes. In addition to the risk of low crop production, the chance of not getting a reasonable price for farm produce is always there. The traders determine the price of the farm produce, and there is always a risk that they might not offer a reasonable price. The government does not support price determination or guarantee profitable prices for farm produce. Selling farm produce in lean seasons is one option for minimising low output price risk. However, as she does not have any other income source, she must sell the produce immediately after harvest as she needs cash to meet household needs and purchase inputs for next season’s crops.

She is not willing to insure crops, as she is unaware that it exists or any other insurance for that matter. She believes that crop insurance is not necessary because fellow farmers would have done it already. This attitude shows her dependency on fellow farmers for important farming decisions. Her unwillingness for crop insurance might also be due to her reliance on on–farm diversification and varietal diversification to minimise crop production risk.

Appendix B.3 Cognitive map of smallest holding sample, also representative of nuclear family samples (Female–3)



(Legend: regular, <u>intrinsic factor: underlined</u>, **perceived risk: bold red** and ***risk management: italicisedbold blue***)

Female–3, 42, is the smallest landholding sample from the Bardiya district of Western Terai region andrepresents nuclear families. She owns 0.33 ha of land to sustain a three–membered family.

Having no other options for livelihood, she adopted farming as a family legacy. As she is farming from her own experience and knowledge inherited from elders, she thinks that her farming knowledge is insufficient to adopt modern farming technologies. For this reason, she fears adopting new farming technologies. She also feels that she has low access to government subsidies and support programs, which would have increased her technical know–how. Neighbours are the major source of information regarding farming practices. She adopts only the technologies that she observes doing better in fellow farmers' fields. Moreover, she is associated with a farmer group, which has increased her access to new technical knowledge and support services. With this much farming knowledge and status of technology adoption, she often fears whether crop production from her little piece of land would be sufficient to sustain her small family.

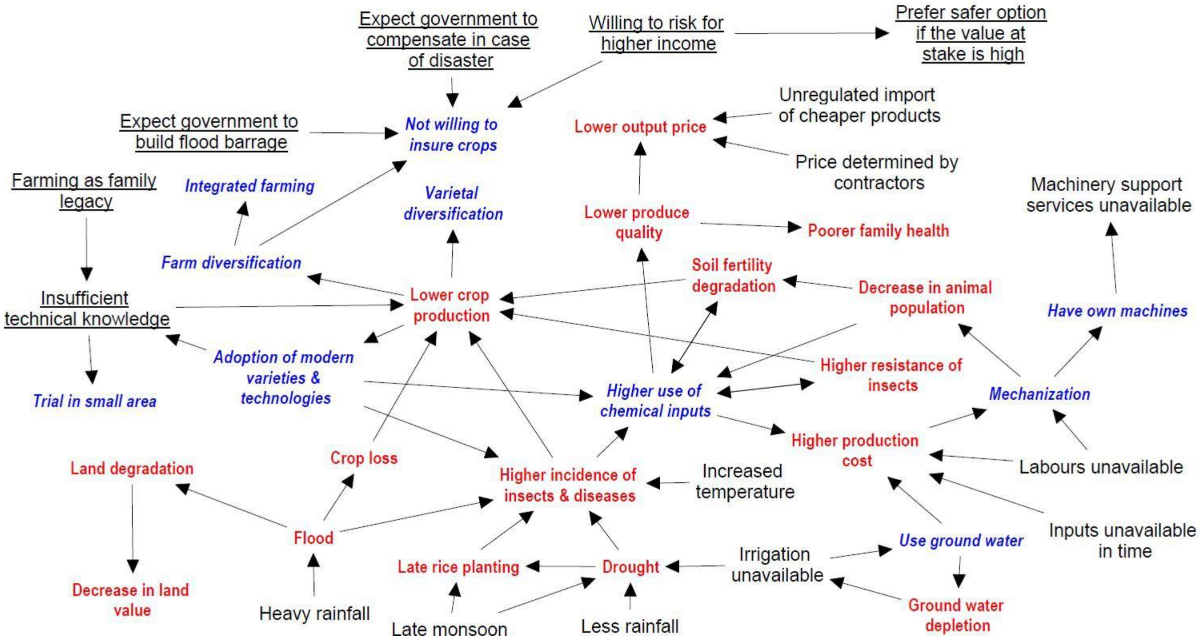
Since she adopted the farming occupation, she has experienced many changes in climatic patterns. She feels that winter temperatures have decreased, the onset of monsoon has delayed, and the incidence of hailstones has increased. The decrease in winter temperatures has increased the incidence of insects and diseases that has reduced crop production. She has managed the risks associated with increased insects and diseases by changing the crop planting time. Late–onset monsoon leads to late rice planting, ultimately decreasing crop production. It is also a major cause of drought stress to crops, reducing production because she does not have access to irrigation facilities. She does have a groundwater pumping facility installed, but she thinks that such irrigation increases production costs. She also feels that uncertainty in the load shedding schedule makes timely pumping uncertain.

Uncertainty in the availability and price of labour and farm inputs are major challenges in her farming that make farm planning difficult. To tackle the uncertainty in labour availability, she has mechanised some of the labour–intensive farming activities, such as land preparation, threshing, etc. However, she does not have access to appropriate machinery services for other activities, such as planting, weeding and harvesting. Because she cannot afford the costly machines, she relies on service providers for machinery use, but their availability at the time she needs them is uncertain. To manage the risks associated with fertiliser unavailability, she has adopted organic farming practices using farmyard manure. The farmer group she is associated with has also increased her timely access to farm inputs and machinery services. She has adopted an integrated farming system that involves crop, vegetable and livestock components, which has helped her reduce the risk of production failure. Such an integrated farming system has also enabled her to adopt organic farming practices. She has diversified her income sources by engaging in crop farming, vegetable farming, dairy business, potato seed production and goat farming. She believes that she can easily cope with one component's failure by putting more effort into other components.

She has seen tremendous development in the agricultural market in terms of access and infrastructure. However, the price for farm produce is not sufficient to cover production costs. She thinks that farmers do not have any role in determining the price of farm produce; it is all in traders' hands. The price of farm produce in the Nepalese market has also decreased due to the unregulated import of cheaper produce from Indian markets. She thinks that the cooperative she is associated with is helping her get a better price in the market.

She prefers a certain income option to risky high–income options. She has family health insurance and insured her buffaloes. The cooperative she is associated with helped her understand the insurance programs' benefits and facilitated the insurance process. She has heard about crop insurance but does not have it because she does not know much about it. She is willing to insure her crops though she does not perceive a higher likelihood of any disaster to her crop production. She thinks that such things are highly uncertain and wants certainty of a specified income by paying a small premium.

Appendix B.4 Cognitive map of the sample with the largest landholding and joint family system (Male–1)



(Legend: regular, intrinsic factor: underlined, **perceived risk: bold red** and ***risk management: italicisedbold blue***)

Male–1, 47, from the Bardiya district of the Western Terai region, is the largest landholder among the samples. He heads 20 members of joint families earning bread and butter from 7.5 ha of land.

Having no other employment options to follow, he got into farming as a family legacy using the knowledge his father passed onto him. For this reason, he thinks that his farming knowledge is low and the major reason for low crop production. To overcome the risk of low crop production, he is keen to adopt modern crop varieties and farming technologies. He suspects that modern varieties and technologies would not produce more than he currently does with his current knowledge level. Before he adopts a new crop variety or technology, he minimises the risk of production failure by testing it in a small area in the first year. He also thinks that modern varieties and technologies require more chemical inputs, resulting in higher production costs. The higher use of chemical inputs is also due to the higher susceptibility of modern varieties and technologies to insects and diseases. He thinks that higher use of chemical inputs degrades soil fertility, leading to higher use of chemical inputs, creating a vicious circle of low fertility–chemical input use and increased insect resistance against chemicals, leading to further chemical use in the future. Similarly, higher use of chemical inputs is associated with lower produce quality, fetching lower prices in the market. Lower produce quality is also correlated with poorer family health.

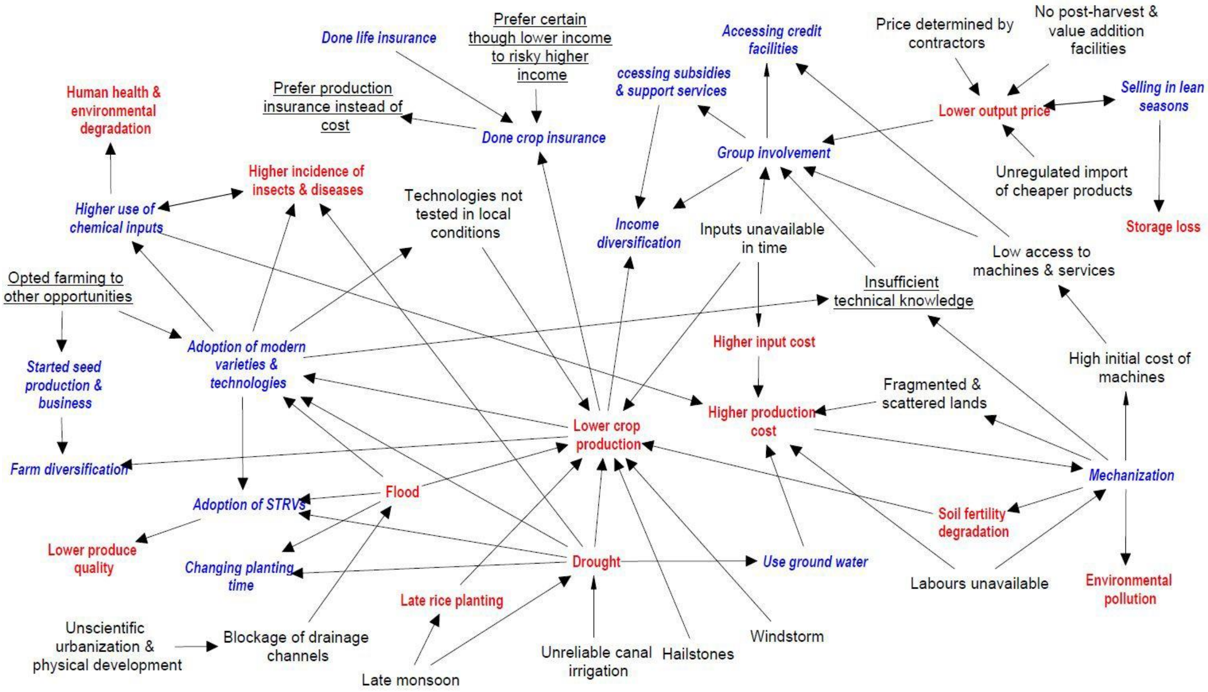
Since his childhood, he has seen many changes in climatic patterns. Rainfall has become more erratic. Sometimes, it rains heavily, creating floods. However, the amount of precipitation has decreased in general, making drought the most critical challenge for farming, particularly as he does not have access to irrigation facilities. The use of pumped water requires high initial capital investment and higher operational costs, resulting in higher production costs. Late–onset monsoon has become usual inrecent years, delaying rice planting. He thinks that a higher incidence of insects and diseases is the major risk associated with the late planting of rice. He feels that all other climatic hazards, such as drought, floods, and high temperature, increase insect and disease incidence. Additionally, flood hazards are associated with direct crop losses, decreasing crop production and increasing land degradation. He thinks that land degradation and physical vulnerability to climatic hazards are associated with the price risk of land and property.

Unavailability of quality inputs in time and labour shortage are other major challenges in farming. If labourers and inputs are not easily available when needed, they must pay more to secure them, resulting in higher total production costs. To overcome the labour shortage challenge, he thinks that mechanisation is the most appropriate solution. He owns some farm machinery. However, machinery support services and spare parts are not available in local markets, so the proper and uninterrupted functioning of such machinery is uncertain. He also thinks that increasing farm mechanisation has decreased the soil animal population, negatively affecting soil fertility and environmental balance.

On top of many challenges that threaten farm production, he has seen that farmers are always uncertain about how much their farm produce will fetch in the market. He is not satisfied with the price of farm produce he received in the past few years, always being very low and not sufficient to cover production costs. Farmers do not have any hand in price determination and must accept the price the contractors offer. The government does not support farmers by guaranteeing a minimum support price for farm produce. Lower prices in nearby Indian markets negatively impact the prices in Nepalese markets. The government has not protected Nepali farmers from the illegal import of cheap farm produce from India.

He is willing to take a risk if he can expect higher income at some level. However, if the value at stake is high, he prefers safer but lower income to risky higher income. He is not aware of the concept of insurance. He is not willing to pay a premium price to insure his crops. He expects the government to compensate farmers in the case of disaster in their farm production. He also expects the government to construct a flood barrage instead of spending money on crop insurance programs. Though he sees many challenges in his farming, he does not think that crop insurance is worth it. To manage production risks, he prefers to diversify his farm, adopt a varietal diversification strategy, and adopt an integrated farming system that includes livestock components.

Appendix B.5 Cognitive map of the most educated sample (Male–2)



(Legend: regular, intrinsic factor: underlined, **perceived risk: bold red** and ***risk management: italicisedbold blue***)

Male–2, 53, is the most educated sample from the Sunsari district of the Eastern Terai region, having completed a master's degree. In addition to running a cooperative, he cultivates 1 ha of land to sustain a four–member family.

When he completed his master's degree, he analysed available employment options and decided to get into farming. He was aware that agriculture is not free from risk, and it is risky if he did not do it differently from the other farmers. He is always keen to learn about new farming technologies and modern crop varieties. He formed an agricultural cooperative organising fellow farmers, which collectively produces and sells crop seeds.

Since he can remember, he has witnessed many changes in the environment and climate. He thinks flood and drought hazards have increased rapidly in the past decade, posing a production risk. He feels that unscientific urbanisation and ill–planned physical development, which have blocked natural water channels, are more important for increased flooding than heavy rainfall. In recent years, the onset of monsoon has been delayed, forcing farmers to plant rice later than usual. As he does not have access to reliable canal irrigation, delayed monsoon causes drought stress to plants. He has been managing the risks associated with flood and drought by changing the planting time, growing stress–tolerant rice varieties (STRVs), and adopting modern farming technologies. He finds that the STRVs have lower grain quality, fetching lower prices in the market. He irrigates his crops by pumping groundwater to overcome the drought risks, but he thinks that the pumped irrigation increases production costs more than canal irrigation. He also feels that hailstones and windstorms have increased in recent years.

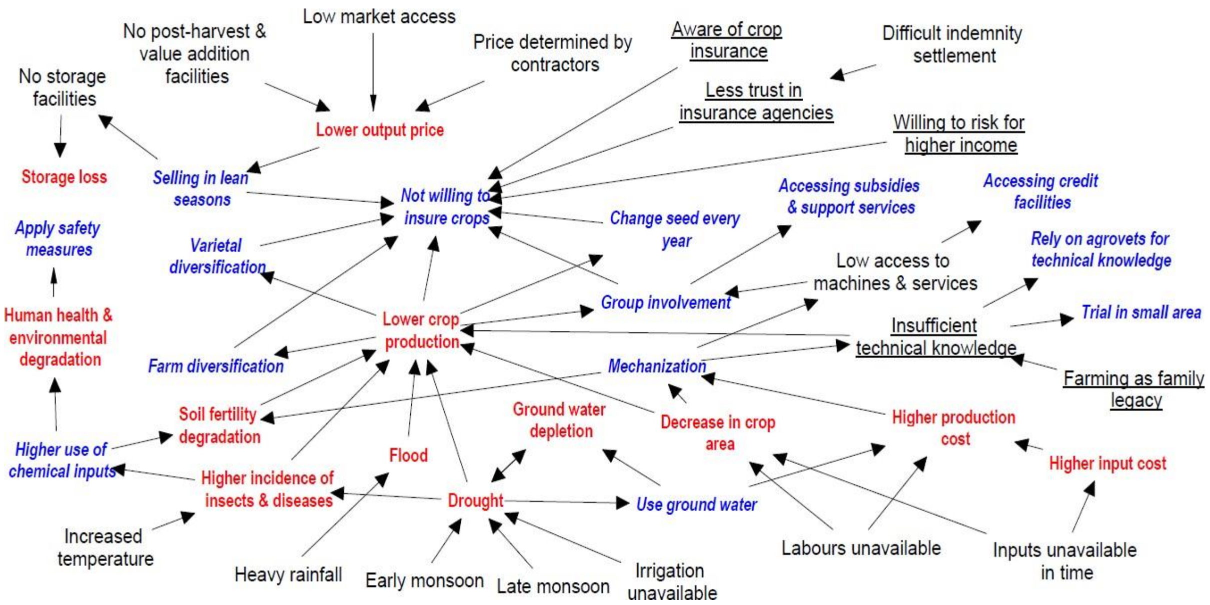
He thinks that farm diversification, in terms of the number of crops grown, the number of varieties of a crop grown, and the inclusion of livestock components in the farming system, has helped him manage the risk of complete production failure. He has adopted modern crop varieties and technologies because he thinks these have higher productivity than local varieties and conventional practices, but they are not free from risk. He feels that there is a risk of farmers' existing knowledge not being sufficient to apply these modern technologies efficiently. He also thinks that these new varieties were developed elsewhere and not tested under local conditions, posing a risk of production failure. In addition, these varieties require more chemical inputs to increase production and minimise insects and diseases. He thinks that higher chemical input use is directly related to higher production costs. Moreover, he thinks that the increasing use of chemical inputs poses tremendous threats to human health and the environment.

The increasing shortage of farm labourers and the unavailability of agricultural inputs, such as seed, fertilisers, and chemicals, are other major threats to their farming. These result in higher production costs because the shortage of these inputs results in higher input prices and labour wages. He thinks that farm mechanisation is the most appropriate arrangement for managing risks associated with a labour shortage, and he is using machines for many farm operations. However, in their context, farm mechanisation is constrained by many factors. Smallholding, fragmented land, scattered holdings and poorly developed land are major hurdles limiting the technical feasibility and economic advantages of farm mechanisation. Similarly, limited access to machines and machinery services due to the high initial capital investment to purchase them is a major hurdle for farm mechanisation. In a far corner of this mind, he feels that environmental pollution and soil fertility degradation are some long–term negative impacts of farm mechanisation.

He thinks that market opportunities have developed tremendously in the past few years. However, he is not satisfied with the price he gets for his farm produce. He thinks that farmers do not have a role in determining the price of their produce, and traders have the sole right. Farmers are obliged to accept whatever price the contractors offer, and the government does not oversee this or implement any policies favouring farmers. The government has failed to regulate the illegal import of cheaper farm produce from India, which is the major reason for the lower prices in Nepalese markets. Selling the produce in lean seasons is one option for getting better prices, but this decision is subject to the availability of an appropriate storage facility. There is a risk of loss in storage due to rodents, insects and diseases, and he does not have access to proper post–harvest processing, storage or other value addition facilities. He thinks that group involvement and cooperative farming has helped him manage the many risks associated with input unavailability, credit unavailability, lack of information about government subsidy and support programs, low access to machines and services, lower price of farm produce in the market, lack of technical know–how about farm mechanisation and modern farming practices, etc. The group has helped him diversify sources of income, which he thinks is important for managing risks associated with low crop production.

He has life insurance for himself and his family members and understands the concept of insurance. He prefers certain income options, despite it offering lower income, to the higher risky income options. For these reasons, he is ready to sacrifice a small amount of his total income to insure his rice crop. However, he does not like the existing crop insurance program. According to him, the current insurance program pays only 80% of the production cost for complete failure, and other things related to the loss assessment are not clear. He thinks that many farmers have not adopted crop insurance programs because the existing product is not what they want. He thinks that if there were multiple crop insurance products in the market, farmers would insure to a specified production level rather than for production costs, even if they have to pay a higher premium than the existing one.

Appendix B.6 Cognitive map of the youngest sample (Male–3)



(Legend: regular, intrinsic factor: underlined, **perceived risk: bold red** and ***risk management: italicisedbold blue***)

Male–3, 28, is the youngest sample from the Dhanusha district of the Eastern Terai region. He is the key earner for a six–member family farming on 1.5 ha of land.

His motivation to get into farming was to follow his family legacy because he could not find any other earning opportunities. While he attained higher secondary level education, he does not have any technical knowledge about modern farming practices. He is relying on whatever knowledge his father passed onto him. If he needs additional technical information, he consults local agrovets when he goes there to purchase farming inputs. Whenever he grows a new crop variety or applies new farming practices, he minimises the risk of failure by testing it on a small area in the first year and expanding it if it has satisfactory results.

Heavy rainfall resulting in flood, early onset of monsoon resulting in drought during the crop season, late onset of monsoon resulting in drought during rice planting, and increased temperature are the major climatic hazards that pose a risk for low crop production. Among these, drought is the most critical risk because he does not have access to irrigation facilities. He can use groundwater for managing drought risks, but the cost of groundwater irrigation is higher than canal irrigation. Increasing the frequency of drought and excessive use of groundwater to manage drought are causing groundwater depletion, posing a threat of more severe drought in the future. He perceives that increased temperature and drought have increased insect and disease incidence, decreasing crop production. To manage these insects and diseases, he relies on the increased use of agrochemicals, which is degrading soil fertility and reducing crop production. He is also aware that these chemicals pose several threats to human health and the environment. When applying chemicals, he tries to minimise health risks by spraying proper doses and using personal safety measures.

In addition to climatic risks, the timely availability of farm labourers and agricultural inputs are major threats that pose risks in his farming. Firstly, if labours and inputs are not available in sufficient quantity, he must reduce the crop area to match the availability, ultimately reducing his total crop production. Secondly, if he wants to cultivate all his land, he has to pay higher costs for labour and inputs that increases production costs. To manage the risk associated with labour unavailability, he uses farm machines to some extent. However, mechanisation is not free from risk. Firstly, he lacks sufficient technical knowledge about machine operations and other farming technologies required for farm mechanisation. Even the agrovets and machinery service providers lack adequate technical knowledge about mechanised farming practices. Secondly, low access to machines and services is another constraint in mechanisation because of higher cash needs. He is managing such cash needs for farm mechanisation by accessing credit facilities. Moreover, his involvement in the farmer group has helped him have easier and cheaper access to credit, machinery and services. Moreover, being involved in the group, he has become aware of subsidies and support services that the government and other agencies provide to farmers. He agrees that mechanisation is an essential solution for improving the labour problem. However, in a far corner of his mind, he feels that farm mechanisation degrades soil fertility more rapidly than conventional farming practices.

Being in a remote rural village, finding markets for farm produce is a big worry for him. Moreover, he becomes frustrated when he thinks of the usual scenario of low crop production and low prices for farm output in markets. He thinks that it is unjust that traders determine the price of the produce that farmers have invested their efforts and money in. Selling the farm produce in lean seasons would help manage the risk of low output prices in peak seasons, but this is limited by the lack of appropriate storage facilities and the risk of storage loss. He does not have access to proper storage and post–harvest value addition facilities to make better money from the farm produce.

He is aware of the farm insurance program being implemented but has not insured his farm against such risks. He is not willing to insure his farm in the future. He is willing to accept some risk in the expectation of higher income. Moreover, he does not trust farm insurance companies because one of his fellow farmers had a tough time settling an indemnity in the past, spending more money than he was paid in the end. Instead of the cumbersome and risky farm insurance, he tries to manage crop production risks by growing more crops and crop varieties and raising animals. He thinks that even if one component completely fails to produce, he can expect better production from other components. Similarly, he changes crop seeds every year, assuming that purchased seeds are superior in quality and can withstand biotic and abiotic stresses more than home–saved seeds.

Appendix C. Household survey questionnaire

Interview date	DD / MM / YYYY
Interview start time	HH / MM AM PM
Interviewer	

Have you understood all the information provided in the participant information form, were given the opportunity to ask questions, signed the participant consent form, and were provided with a copy of both forms?

	Yes		No

Sample identifiers			
i	Study region	1. ETR 2. MTR 3. WTR	
ii	Sample serial no		
iii	Name of the sample farmer		
iv	Phone number		
v	Province		
vi	District		
vii	Municipality/ Rural municipality		
viii	Ward no		
ix	Name of village		

Section A: Personal information of respondent (household head)			
A1	Gender	Male=1, Female=2, Others=3	
A2	Age	Years	
A3	Age you started farming as a decision–maker		
A4	Education	1. Illiterate (cannot read and write) 2. Literate but no formal education 3. Completed primary level 4. Completed secondary level 5. Completed higher secondary level 6. Completed university degree 7. Completed higher degree	
A5	Marital status	1. Married 2. Single, never married	

		3. Single, divorced 4. Single widowed 5. Others	

Section B: Household information			
B1	Family type	1. Nuclear 2. Joint	
B2	How many people livein your household?	1. Adult men (above 18 years) 2. Adult women (above 18 years) 3. Children (below 18 years)	
B3	How many men are earning?		
B4	How many women are earning?		
B5	Are there any persons in your family workingaway from home?	1. Yes → go to B–6 2. No → go to section C	
B6	How many persons are working away?	1. Men in–country 2. Men overseas 3. Women in–country 4. Women overseas	

Section C: Economic characteristics			
C1	Is your family immigrant or indigenous to this place?	1. Immigrant → go to C2 2. Indigenous→ go to C3	
C2	Which year did your family migrate to this place?	Years	
C3	How much land do you own?	Kattha	
C4	How much land have you rented in?	Kattha	
C5	How much land have you rented out?	Kattha	
C6	How much land did you cultivate last year?	Kattha	
C7	What percentage of total land cultivated do you consider is irrigated?	%	
C8	How many parcels of land do you have?		
C9	How much of your land has road access for mechanisation?	% of total holding	
C10	What is the total annual income of your family?	NPR	

C11	What are the sources of your family income?	i. Farming ii. Business iii. Employment (Casual & permanent) iv. Labouring v. Others Total	% of total % of total % of total % of total % of total 100 %
C12	What is the share of different commodities in farm income?	i. Crops ii. Vegetables iii. Fruits iv. Livestock v. Fishery vi. Forestry vii. Others Total	% of total % of total % of total % of total % of total % of total % of total 100%
C13	How sufficient was your own farm production to meet family food requirements last year?	1. 0 – 3 months 2. 3 – 6 months 3. 6 – 9 months 4. 9 – 12 months 5. >12 months	
C14	How sufficient is your family's annual income to meet the family requirements?	1. Deficit 2. Sufficient 3. Surplus	If the answer is '1', go to C14; otherwise, go to Section D
C15	How do you manage your family requirements for deficit months?	1. Spend from saving 2. Take monetary loan 3. Borrowing food grains 4. Selling assets 5. Decrease consumption 6. Others	If the answer is "6", please specify: ____________________

Section D: Village infrastructure and facilities				
SN	Infrastructures and facilities (Consider the nearest one)	i	ii	iii
		Do you have access to these	How much is the distance to? (KM)	Considering all aspects of services or infrastructure, how satisfied are you with these?
		1. Yes 2. No		1. Very satisfied 2. Satisfied 3. Neutral 4. Unsatisfied 5. Very unsatisfied
D1	All–weather road			
D2	Agri–inputs market			
D3	Agri–outputs market			
D4	Agri–technology service centre			
D5	Agri–extension service centre			
D6	Health facilities			
D7	Post–harvest storage			
D8	Post–harvest processing			
D9	Credit institutions			
D10	Insurance companies			
D11	Others (specify) ———————			

Section E: Gender role			i	ii
			Male (%)	Female (%)
E1	Who is involved in following household decisions?	i. Health ii. Education iii. Farming iv. Finance v. Social vi. Others (specify)		
E2	Who is involved in the following farming activities?	i. Cultivation ii. Processing iii. Marketing iv. Others (specify)		

E3	Who is involved in following farming decisions?	i. Crop selection ii. Area selection iii. Marketing iv. Investment v. Saving vi. Others (Specify) -----------------		

Section F: Farm mechanisation						
Do you use machines for the following operations in given crops?						
Yes = 1, No = 0						
SN	Operations	i Rice	ii Wheat	iii Maize	iv Pulses	v Potato
F1	Primary tillage					
F2	Secondary tillage					
F3	Planting					
F4	Chemical spray					
F5	Irrigation					
F6	Weeding					
F7	Harvesting					
F8	Threshing					
F9	Drying					
F10	Grading					
F11	Others (specify)					

Which of the following machines do you use in your farms?				
SN	Machines	i Use	ii Ownership	iii Operations
		(1=Yes; 2=No)	(1=Own; 2=Hired)	(1=Self; 2=Serviced)
F12	Tractor			
F13	Power tiller			
F14	Disc plough			
F15	Cultivator			
F16	Rotavator			
F17	Potato planter			
F18	Rice transplanter			
F19	Zero till seed drill			
F20	Combined harvester			

F21	Reaper			
F22	Thresher			
F23	Drying			
F24	Grading machine			
F25	Laser land leveller			
F26	Pumping set			
F27	Sprayer			
F28	Others (specify)			

Section G: Credit status			
G1	Do you have any ongoing loans?	1. Yes → go to G2 & G3 2. No→ go to G4	
G2	What is the source of the loan?	1. Financial institutions 2. Groups 3. Persons 4. Others	
G3	What is the purpose of the loan?	1. Health 2. Farming 3. Business 4. Foreign employment 5. Household construction 6. Social functions 7. Others (specify)	
G4	If you have taken a loan for farming, has the loan provider made it mandatory to insure the farm?	1. Yes 2. No	
G5	Have you had any savings?	1. Yes→ go to G6 2. No→ go to H1	
G6	Where have you saved your money	1. Financial institutions 2. Groups 3. Persons 4. Others (specify)	

Section H: Capacity building			
H1	Have you participated in any training so far?	1. Yes → go to H2 & H3 2. No→ go to H4	

H2	How many times have you participated in such training		
H3	What was the training that you participated in the highest number of times about?	1. Farming 2. Health and sanitation 3. Group mobilisation 4. Cooperativemanagement 5. Others	
H4	Have you participated in any study tours?	1. Yes→ go to H5 & H6 2. No→ go to I1	
H5	How many times have you participated in such study tours?		
H6	What was the study tour that you participated in the highest number of times about?	1. Farming 2. Health and sanitation 3. Group mobilisation 4. Cooperativemanagement 5. Others	

Section I: Social engagement				
I1	Is any member of your family involved in any of the following social groups or cooperatives?			1. Yes 2. No
	i	Agriculture production–related		
	ii	Agriculture marketing related		
	iii	Post–harvest value addition related		
	iv	Microcredit related		
	v	Income generation related		
	vi	Health and sanitation–related		
I2	Which year did your family first join such a group?			
I3	How many groups are you in a leadership role?			
I4	Is any female member of your family involved in such groups?		1. Yes 2. No	
I5	How helpful do you think these groups arein related issues?		1. Very helpful 2. Helpful 3. Moderatelyhelpful 4. Unhelpful 5. Very unhelpful	

Section J: Farm production status (consider last 12 months)					
SN	Commodity	i	ii	iii	iv
		What was the total area that you grew it?	How much was the total production?	How much was your annual sale?	What was the average unit price
		(local unit)	Kg	Kg	NPR
J1	Rice				
J2	Wheat				
J3	Maize				
J4	Lentil				
J5	Potato				
J6	Mustard				
J7	Other crops				
J8	Vegetables				
J9	Fruits				
J10	Cattle				
J11	Buffalo				
J12	Goat/ sheep				
J13	Pig				
J14	Poultry				
J15	Fishery				
J16	Others (specify):				

Section K: Self–assessment of physical vulnerability to climatic risks		
How much do you agree with the following statements?		
1= Fully agree, 2=Agree, 3=Neutral, 4=Disagree, 5=Fully disagree		
SN	Statement	Rating (1–5)
K1	I don’t have access to the canal irrigation scheme because of the location	
K2	I cannot use groundwater because it is not accessible	
K3	My land is prone to flood risk because it is close to a river	
K4	My land is prone to flood risk because it is low lying	
K5	My land is prone to drought risk because it is upland	
K6	My land is prone to drought risk because it is located at the tail–end of the irrigation system	
K7	My land is prone to hailstone damage because of its location	

K8	My land is prone to windstorm damage because of its location	

Section L: Land tenancy, decision role and distribution of cost, benefit and risk

SN	i	ii	iii	iii	iv	v	vi	vii	viii
	Land tenancy	Cost you share	Rent	Your share in the risk		Decision role			
				Production	Market	Crop selection	Variety selection	Input use	Management
		(0–100%)	1. Fixed 2. % of production	(0–100%)		(0–100%)			
L1	Rented–in								
L2	Rented–out								

Section M: Assessment of risk experience

SN	Please answer considering the following situations in your farming	ii	iii
		How many times did you experience this in the past 10 years?	How severely didit cause yield loss
		1. Always 2. Many times 3. Sometimes 4. Rarely 5. Never	1. Complete 2. Much 3. Medium 4. Low 5. Not at all
M1	Labour shortage		
M2	Low price for farm outputs		
M3	Drought		
M4	High production cost		
M5	Insect infestation		
M6	High input price		
M7	Subsidy cut		
M8	Disease		
M9	Delay in rice planting		
M10	Fertiliser scarcity		

M11	Groundwater depletion		
M12	Seed scarcity		
M13	Low–quality produce		
M14	Tax rise		
M15	Weed infestation		
M16	Cash scarcity		
M17	Storage loss		
M18	Soil fertility degradation		
M19	High market competition		
M20	Loss of local crop varieties		
M21	Human health hazard		
M22	Flood		
M23	Low–quality fertilisers		
M24	Low use of fertiliser		
M25	Environmental pollution		
M26	Food scarcity		
M27	High temperature		
M28	Increased insecticide resistance		
M29	Hailstone		
M30	No market for outputs		
M31	Windstorm		
M32	Nutrition insecurity		
M33	Land degradation		
M34	Land price deflation		

Section N: Assessment of extrinsic sources of risk		
Please rate your agreement on the following statements 1= Fully agree, 2=Agree, 3=Neutral, 4=Disagree, 5=Fully disagree		
SN	Sources	Rating (1–5)
N1	Contractors solely determine the price of output	
N2	Drought days have increased	
N3	The rainfall pattern has been more erratic	
N4	Labour is not available when needed	
N5	The government support in marketing is not sufficient	

N6	Youth overseas migration has increased	
N7	The onset of monsoon has delayed	
N8	Insects and diseases have increased	
N9	Reliable canal irrigation is not available	
N10	Governments' support and subsidies are not consistent	
N11	The initial cost of machines is high	
N12	Government decision on support price is not timely	
N13	The weed problem has increased	
N14	Family needs have diversified and increased	
N15	I have low access to subsidies & support services	
N16	Machines & mechanisation services are not available	
N17	I do not have enough money to invest	
N18	Off–farm sectors are paying higher wages to labours	
N19	Groundwater table has deepened	
N20	Water sources have dried	
N21	Post–harvest & value addition facilities are not unavailable	
N22	Rainfall intensity has increased	
N23	The credit facility is not available	
N24	Seeds, fertilisers and agrochemicals are not available in time	
N25	Machinery support services and spare parts are not available	
N26	My lands are fragmented & scattered in many locations	
N27	Winter has shortened	
N28	Unregulated import of cheaper products creates market distortion	
N29	Overall temperature has increased	
N30	Modern varieties need more inputs	
N31	Storage facilities are not available	
N32	The onset of monsoon has hastened	
N33	Market competition has increased	
N34	Fuel and energy prices have increased	
N35	Technologies are not tested in my local conditions	
N36	Winter temperature has decreased	
N37	Winter temperature has increased	
N38	Windstorm frequency has increased	
N39	The total amount of rainfall has increased	
N40	The electricity supply is irregular	

N41	Crop duration has shortened	
N42	Unplanned physical development has blocked natural drainage channels	
N43	Consumers' quality awareness has increased, and preference is changing	
N44	Insurance companies are not trustworthy	
N45	Sociocultural norms have restricted me to explore new opportunities	
N46	Hailstone frequency has increased	
N47	I have low access to market	

Section O: Assessment of intrinsic sources of risks		
How much do you agree with the following statements? 1= Fully agree, 2=Agree, 3=Neutral, 4=Disagree, 5=Fully disagree		
SN	Statements	Rating (1–5)
O1	I think farming is not a profitable prospect	
O2	I am doing farming because I don’t have money to invest in other sectors	
O3	I am not aware that crop insurance products are available	
O4	I am not aware of the concept and benefits of insurance	
O5	I am doing farming because I don’t have sufficient skills to do other jobs	
O6	I prefer production insurance instead of cost return insurance	
O7	I do not have sufficient technical knowledge about modern farming practices	
O8	My performance in farming is limited because of my education	
O9	I am doing farming only to continue the family legacy	
O10	I am not aware of other farmers who have done crop insurance	
O11	I am afraid to adopt new technologies	
O12	I do not trust insurance companies	

Section P: Assessment of risk perception			
SN	Please answer considering the following situations in your farming	iv	v
		How likely is this to happen next year?	How much wouldbe the loss if it happens?
		1. Certain 2. Much likely 3. Moderately likely 4. Unlikely 5. Not at all likely	1. Complete 2. Much 3. Medium 4. Low 5. Not at all
P1	Labour shortage		

P2	Low price for farm outputs		
P3	Drought		
P4	High production cost		
P5	Insect infestation		
P6	High input price		
P7	Subsidy cut		
P8	Disease		
P9	Delay in rice planting		
P10	Fertiliser scarcity		
P11	Groundwater depletion		
P12	Seed scarcity		
P13	Low–quality produce		
P14	Tax rise		
P15	Weed infestation		
P16	Cash scarcity		
P17	Storage loss		
P18	Soil fertility degradation		
P19	High market competition		
P20	Loss of local crop varieties		
P21	Human health hazard		
P22	Flood		
P23	Low–quality fertilisers		
P24	Low use of fertiliser		
P25	Environmental pollution		
P26	Food scarcity		
P27	High temperature		
P28	Increased insecticide resistance		
P29	Hailstone		
P30	No market for outputs		
P31	Windstorm		
P32	Nutrition insecurity		
P33	Land degradation		
P34	Land price deflation		

Section Q (A): Assessment of risk factors associated with mechanisation		
How much do you agree on the following risks or risk factors that farm mechanisation has caused? 1= Fully agree, 2=Agree, 3=Neutral, 4=Disagree, 5=Fully disagree		
SN	Risk or source of risk	Rating (1–5)
Q1	Job loss of agricultural labours	
Q2	Low quality of farm produce	
Q3	Produce loss during harvesting and threshing	
Q4	Requires high initial investment	
Q5	Uncertainty in machine and service supply	
Q7	No backward linkage with the machine and parts suppliers	
Q8	Soil compaction	
Q9	Loss of beneficial soil organisms	
Q10	Loss of animal population	
Q11	Less opportunity for soil organic matter	
Q12	Soil fertility degradation	
Q13	Requires new and more technical knowledge	
Q14	Higher requirement of chemical inputs (herbicides, fertilisers, pesticides, fungicides)	
Q15	The increased cost of production	
Q16	Unsuitable to my land type and conditions	
Q17	No year–round use	
Q18	Requires immediate cash to pay for custom hiring	
Q19	Environmental pollution	
Section Q (B): Assessment of risk factors associated with the adoption of modern crop variety		
How much do you agree on the following risks or risk factors that modern varieties have caused? 1= Fully agree, 2=Agree, 3=Neutral, 4=Disagree, 5=Fully disagree		
SN	Risk or source of risk	Rating (1–5)
Q20	Loss of local varieties	
Q21	Higher incidence of insect and disease	
Q22	Loss of adaptability to environmental adversities	
Q23	Increased seed dependency	
Q24	Requires more irrigation	
Q25	Increased use of agro–chemicals	
Q26	Loss of soil fertility	
Q27	Requires new technical knowledge	

Q28	The increased cost of production	
Q29	Low taste of food	
Q30	Low quality of produce	
Q31	Human health hazards and environmental pollution	
Q32	Increased production uncertainty	

Section R: Assessment of risk preference (Relative risk aversion)		
How much do you agree with the following statements? 1= Fully agree, 2=Agree, 3=Neutral, 4=Disagree, 5=Fully disagree		
SN	Statement	Rating (1–5)
R1	I am willing to take more risk than other farmers in relation to adopting new technologies	
R2	I am willing to take more risk than other farmers in relation to financial issues	
R3	I am willing to take more risk than other farmers in relation to health issues	
R4	I am willing to take more risk than other farmers in relation to selling produces	
R5	I prefer higher though risky income to low but certain income option	
R6	I am more risk–taker than other farmers in relation to farming	
R7	I am willing to take more risk than others in other life issues	

Section S: Assessment of risk management strategies			
SN	Risk management strategies	i	ii
		Applicability	Contribution in overcoming farming risk
		1. Very irrelevant 2. Irrelevant 3. Neutral 4. Relevant 5. Very relevant	1. Very useless 2. Useless 3. Neutral 4. Useful 5. Very useful
S1	Diversify crops		
S2	Diversify crop varieties		
S3	Practice integrated farming		
S4	Involve in self–help groups		
S5	Test in smaller areas first		

S6	Observe in others' fields first		
S7	Adopt modern varieties and technologies		
S8	Consult with fellow farmers		
S9	Maintain cash saving		
S10	Diversify income sources		
S11	Mechanise farm activities		
S12	Seek off–farm employment		
S13	Consult with agrovets		
S14	Hire mechanisation services		
S15	Use groundwater		
S16	Diversify cropland locations		
S17	Change seed every year		
S18	Have cash at home		
S19	Take loan		
S20	Involve in cooperative farming & marketing		
S21	Practice mixed cropping		
S22	Keep market information updated		
S23	Purchase family health insurance		
S24	Shift planting time		
S25	Consult with research & extension agencies		
S26	Increase insecticide & fungicide doses		
S27	Sell produces in off–seasons		
S28	Use PPE & safety measures		
S29	Purchase life insurance		
S30	Access subsidies		
S31	Purchase livestock insurance		
S32	Diversify output markets		
S33	Have a backup rice seedbed		
S34	Upscale farm enterprise		
S35	Adopt stress–tolerant rice varieties		
S36	Double plant rice if needed		
S37	Record costs and benefits		
S38	Increase fertiliser dose		
S39	Purchase farm machines		
S40	Purchase crop insurance		

S41	Practice organic farming		
S42	Practice high–density planting		
S43	Have forward contract		

Section T: Awareness about technology and support services				
T1	Have you heard of any of the following stress–tolerant rice varieties?	Awareness	Quality awareness	
		Yes→ go to S1b No→ go to S4	1. Flood tolerant 2. Drought tolerant	
	Swarna Sub–1			
	Shambha Mahasuri Sub–1			
	Cheharang Sub–1			
	Sukhadhan 1–6			
T2	Have you used any of these varieties?	Yes → go to K No → go to		
T3	How useful have you found the stress–tolerant crop varieties in managing said risks?	1. Very useful 2. Useful 3. Neutral 4. Less useful 5. Very useless		
T4	Are you aware of the fertiliser cost subsidy?	Yes→ go to S5 No→ go to S6		
T5	Have you claimed fertiliser cost subsidy?	Yes No		
T6	Are you aware of the insurance premium subsidy	Yes→ go to S7 No→ go to T1		
T7	Have you claimed an insurance premium subsidy?	Yes No		

Section U: Farm diversification		
Crop diversification		
SN	Season	Number of crops grown
U1	Kharif	
U2	Rabi	
U3	Zaid	
Varietal diversification		

SN	Crop	i	ii
		Total local varieties	Total modern varieties
U4	Rice		
U5	Wheat		
U6	Maize		
U7	Lentil		
U8	Potato		
U9	Others (specify)————		

Section V: Involvement in insurance			
SN	Have you purchased the following insurance products?	i. Use 1. Yes 2. No	ii. Since which year?
V1	Crop insurance products		
V2	Livestock insurance products		
V3	Health insurance products		
V4	Life insurance products		
V5	Vehicle insurance products		
V6	House insurance products		

Section W: Numeracy test Please put a circle on your answer			
W1	The probability of tossing a coin and getting 'heads' is 1 in 2.	True	False
W2	How many possible outcomes are there when you roll a dice?	One	Six
W3	The probability of rolling a dice and getting the number 3 is one–in–three.	True	False
W4	What is more likely to happen?	Rolling a dice and getting a 6	Tossing a coin and getting 'head'
W5	One hundred people were asked to state their favourite colour. Sixty said blue. This experiment says that the probability of someone choosing blue is 60%.	True	False

Section X: Lottery–Choice Experiment		
Note: Explain the details of the experiment and present 11 choice cards one by one.		
SN	Choice cards	Which option would you go for? (Certain amount–1, Lottery–2)
X1	Choice card 1	
X2	Choice card 2	
X3	Choice card 3	
X4	Choice card 4	
X5	Choice card 5	
X6	Choice card 6	
X7	Choice card 7	
X8	Choice card 8	
X9	Choice card 9	
X10	Choice card 10	
X11	Choice card 11	

Ask the respondent to pick one of the 1–11 marked balls from the bucket. If the farmer has chosen the fixed amount on the selected number card, give them the amount. If the farmer has chosen to play the lottery, play the lottery tossing a coin and pay them according to the result.

X12	What is the number of the ball the respondent picked up?	
X13	What is the outcome from the selected card and the coin toss? 1. Had selected the certain amount 2. Respondent won the lottery 3. Respondent lost the lottery	

Section Y: Discrete Choice Experiment

Explain the experiment, present six choice cards one–by–one in random orders and ask the question only after giving them enough time to ask the questions and making sure that they fully understand the task. Present four cards randomly, one–by–one, allow them to reconsider the choices, if they want and note their preferences on the following table.

Choose the assigned block for the respondent

Y1	DCE Block				
White (1)	Yellow (2)	Blue (3)	Green (4)	Red (5)	Brown (6)
Y2.	Please mention your preference on each of the four cards. Option A = 1, Option B = 2, Option C = 3				

Block	Card	Which would you buy?	Which is the worst option?	Card	Which would you buy?	Which is the worst option?
White (1)	Card 4			Card 17		
	Card 11			Card 19		
Yellow (2)	Card 5			Card 13		
	Card 12			Card 23		
Blue (3)	Card 1			Card 8		
	Card 3			Card 11		
Green (4)	Card 2			Card 7		
	Card 6			Card 20		
Red (5)	Card 14			Card 18		
	Card 15			Card 21		
Brown (6)	Card 9			Card 22		
	Card 16			Card 24		

Y 3: If the respondent has selected the third option (not to buy) in all four cards, ask to explain why?

Y 4: If the respondent has selected the purchase option in any of the cards and has not already boughta crop insurance product, ask why?

Y 5: In the above two exercises, how easy did you find it to understand the exercises?

Very difficult =1, difficult =2, neutral =3, easy =4, very easy =5

Y 6: Would you like to say anything related to the questions covered in this interview?

Thank you very much for your time, valuable information and contribution to this study.

The interview ended at: – –/– –

mm / hh

Appendix D. Loss versus payment schedule of yield–loss insurance

Sum insured (NPR/ha)	60000			90000		
Deductible %	15	20	25	15	20	25
Loss %	Payout amount (NPR)					
0						
15						
20	3000			4500		
25	6000	3000		9000	4500	
30	9000	6000	3000	13500	9000	4500
40	15000	12000	9000	22500	18000	13500
50	21000	18000	15000	31500	27000	22500
60	27000	24000	21000	40500	36000	31500
70	33000	30000	27000	49500	45000	40500
80	39000	36000	33000	58500	54000	49500
90	45000	42000	39000	67500	63000	58500
100	51000	48000	45000	76500	72000	67500

Appendix E. Loss versus payment schedule of rainfall–index insurance

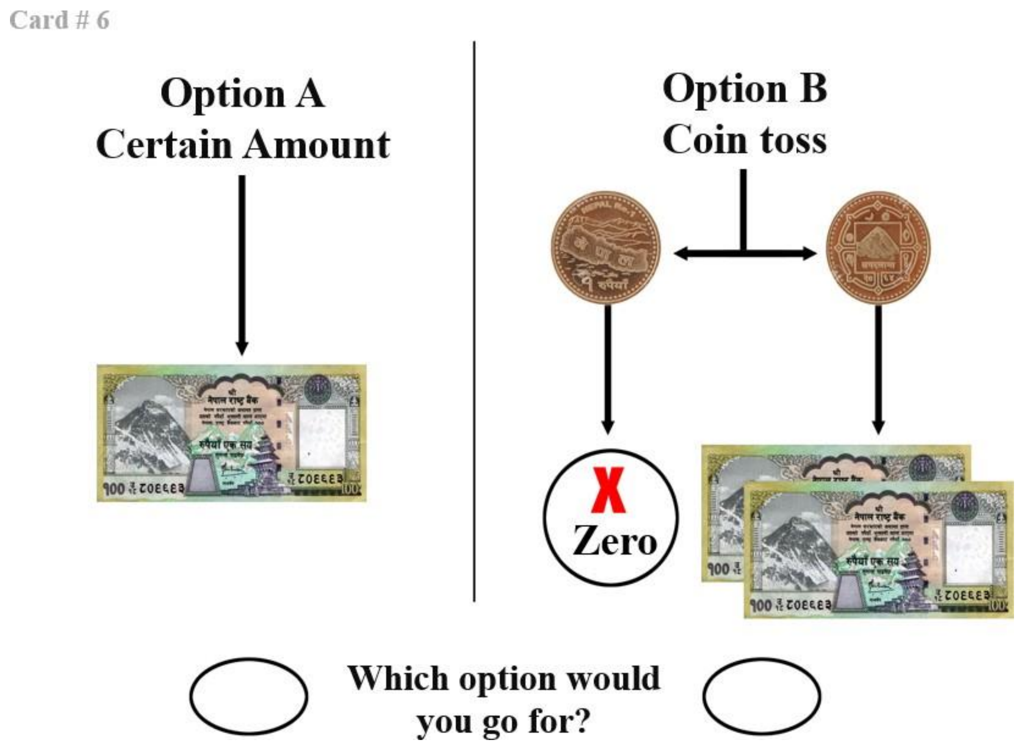
	Sum insured (NPR/ha)	60000			90000		
	Deductible%	15	20	25	15	20	25
Rainfall (mm)	Rainfall deficit%	Payout amount (NPR)					
1000	0						
850	15						
800	20	3000			4500		
750	25	6000	3000		9000	4500	
700	30	9000	6000	3000	13 500	9000	4500
600	40	15000	12000	9000	22500	18000	13500
500	50	21000	18000	15000	31500	27000	22500
400	60	27000	24000	21000	40500	36000	31500
300	70	33000	30000	27000	49500	45000	40500
200	80	39000	36000	33000	58500	54000	49500
100	90	45000	42000	39000	67500	63000	58500
0	100	51000	48000	45000	76500	72000	67500

Appendix F. Choice scenarios (24) defined by various levels of attributes in the discrete choice experiment

Choice situation	Alternative 1				Alternative 2				Block
	Premium	Deductible	Sum insured	Insurance type	Premium	Deductible	Sum insured	Insurance type	
4	750	15	60	0	500	20	90	0	1
11	750	15	60	0	250	25	90	1	1
17	1250	20	90	0	1000	15	60	1	1
19	500	15	60	0	1250	15	90	1	1
5	500	25	90	1	750	20	60	0	2
12	1250	25	60	0	1500	25	90	0	2
13	750	20	90	1	250	25	60	1	2
23	1500	20	90	1	1500	20	60	0	2
1	250	25	90	1	750	20	60	0	3
3	500	15	90	1	250	20	60	1	3
8	1250	25	60	1	1250	25	90	1	3
10	1000	20	60	1	1000	15	90	0	3
2	1250	20	90	0	1500	15	60	0	4
6	250	25	90	1	1250	15	60	0	4
7	1000	20	60	1	500	25	90	0	4
20	250	25	60	0	1250	20	90	1	4
14	250	25	90	0	1000	25	60	1	5
15	250	20	60	0	1000	15	90	0	5
18	1500	20	90	1	1250	20	60	1	5
21	500	15	90	0	750	20	60	1	5
9	750	15	60	1	750	15	90	1	6
16	1000	15	60	0	500	15	90	0	6
22	1000	15	90	0	500	25	60	1	6
24	1500	25	60	1	1000	25	90	0	6

Note: Insurance type 0 = Yield–Loss, 1 = Rainfall–Index

Appendix G. An example of choice cards used in the lottery–choice experiment



Appendix H. Farmers' assessment of sources of uncertainty in farming

Rank	Risk factor	Risk category	Scale rating		
			Mean	SD	P50
1	Price of output is determined by traders	Market	0.86	0.18	1.00
2	Number of drought days has increased	Production (drought)	0.85	0.18	1.00
3	Rainfall has been more erratic than before	Production (drought, flood)	0.85	0.20	1.00
4	Labour is not sufficiently available when needed	Production, market	0.85	0.19	0.75
5	Government support in market is not sufficient	Market, institutional	0.84	0.19	0.75
6	Outmigration of male youth has increased	Production, market	0.84	0.20	0.75
7	Onset of monsoon has delayed	Production (drought)	0.84	0.18	0.75
8	Insect and disease infestations has increased	Production	0.83	0.19	0.75
9	I do not have access to reliable irrigation	Production (drought)	0.81	0.22	0.75
10	Government support and subsidies are not stable	Institutional, financial	0.77	0.22	0.75
11	Mechanisation requires high initial investment	Financial	0.76	0.23	0.75
12	Government's decision on support price is not timely	Market, institutional	0.76	0.23	0.75
13	Weed infestation has increased	Production	0.75	0.21	0.75
14	Family needs have diversified and increased	Market, financial	0.75	0.22	0.75
15	I do not have access to subsidies & support services	Institutional, financial	0.75	0.22	0.75
16	Machines & mechanisation services are not available	Production	0.74	0.23	0.75
17	I do not have enough capital to invest in farming or other business	Financial	0.73	0.22	0.75
18	Off–farm sectors are paying higher wages to labours	Production, market	0.73	0.23	0.75
19	Ground water table is deepening	Production (drought)	0.73	0.24	0.75

20	Natural water sources have dried	Production (drought)	0.72	0.23	0.75
21	Post–harvest & value addition facilities are not available	Market	0.71	0.24	0.75
22	Rainfall intensity has increased	Production (flood)	0.68	0.25	0.75
23	Credit facility is not available	Financial	0.67	0.27	0.75
24	I do not have skills to pursue other employment	Personal	0.65	0.30	0.75
25	Seeds, fertilisers and agrochemicals are not available in time	Production	0.64	0.27	0.75
26	Machinery support services and spare parts are not available	Production, market	0.64	0.27	0.75
27	My farmlands are fragmented & scattered in many locations	Production	0.63	0.29	0.75
28	Winter has shortened	Production	0.61	0.28	0.75
29	Unregulated import of cheaper products creates market distortion	Market	0.60	0.29	0.50
30	I do not have sufficient technical knowledge of farming	Production, personal	0.57	0.25	0.50
31	Overall temperature has increased	Production	0.56	0.28	0.50
32	I am not performing well in farming because I have low education	Personal	0.56	0.32	0.50
33	Modern varieties need more inputs	Production, market	0.55	0.24	0.50
34	Storage facilities are not available	Market	0.55	0.25	0.50
35	I am doing farming just to continue my family legacy	Personal	0.54	0.24	0.50
36	Market competition has increased	Market	0.54	0.24	0.50
37	Fuel and energy prices have increased	Market	0.53	0.24	0.50
38	Technologies are not tested in my farm conditions	Production	0.50	0.26	0.50
39	Winter temperature has decreased	Production	0.50	0.21	0.50
40	Windstorm frequency has increased	Production	0.49	0.23	0.50
41	Total rainfall has increased	Production (flood)	0.48	0.24	0.50
42	Electricity supply is not regular	Production	0.43	0.29	0.50
43	Crop duration has shortened	Production	0.41	0.30	0.50
44	I fear to try new technologies	Personal	0.41	0.28	0.50
45	Most of my farmlands is low lying	Production (flood)	0.40	0.29	0.50

46	Unplanned physical development has blocked natural drainage channels	Production (flood)	0.40	0.29	0.50
47	My farmlands are at the tail–end of irrigation system	Production (drought)	0.39	0.28	0.50
48	Consumers’ quality awareness has increased, and their preferences are changing	Market	0.39	0.29	0.25
49	Insurance companies are not trustworthy	Institutional	0.38	0.28	0.25
50	Most of my farmlands is upland	Production (drought)	0.35	0.28	0.25
51	Sociocultural norms have restricted me to explore new opportunities	Institutional, personal	0.33	0.26	0.25
52	Hailstone frequency has increased	Production	0.30	0.24	0.25
53	I have low access to market	Market	0.28	0.23	0.25
54	My farmlands are close to river	Production (flood)	0.27	0.24	0.25

Appendix I. Estimates of individual logit models of farmers' risk management strategies

Model	Loan use in farming	Monetary saving	STRV use	Crop insurance	Off–farm employment	Group involvement
CRRA	–0.13	0.32*	0.45**	2.36***	–0.01	0.77***
	(–0.14)	(–0.13)	(–0.16)	(–0.69)	(–0.13)	(–0.15)
Drought risk	1.00*	–0.43	0.31	–0.51	–0.35	–0.27
perception	(–0.46)	(–0.43)	(–0.41)	(–0.66)	(–0.39)	(–0.46)
Flood risk	–1.01	–0.05	1.03*	0.23	0.03	0.66
perception	(–0.62)	(–0.56)	(–0.52)	(–0.87)	(–0.5)	(–0.62)
Constant	–1.45***	1.15***	–0.99***	–2.62***	0.35	1.14***
	(–0.33)	(–0.3)	(–0.29)	(–0.53)	(–0.27)	(–0.33)
N	409	409	409	409	409	409
LR Chi2	9.07	7.14	13.65	24.19	0.85	33.53
Pseudo R2	0.02	0.01	0.03	0.10	0.00	0.07
LL (Null model)	–237.12	–249.25	–264.71	–121.85	–282.32	–238.12
LL (Full model)	–232.58	–245.68	–257.89	–109.76	–281.89	–221.36

*Note: Figures in parentheses indicate SE; asterisks indicate statistical significance at * p<0.05, ** p<0.01, and *** p<0.001.*

Appendix J. Explanation of the discrete choice experiment provided to the participants

In the following exercise, I will present you with four cards and ask you to choose one of the three options shown in the cards. The first two options are defined by different characteristics of crop insurance products, while the third is the no purchase option. The crop insurance contract covers production risk in rice crops for one season.

The crop insurance products vary by insurance product types, sum insured, deductible and premium price. You will see two types of crop insurance products, namely loss-based insurance (LBI) and rainfall-index insurance (RII). LBI covers production loss due to various reasons, including floods, drought, insects and diseases. LBI requires field assessment of production loss for determining indemnification. In contrast, the RII indemnifies the insurers irrespective of production loss based on the rainfall recorded during a specified period. A rainfall record of 1000 mm during June – September has been set as the normal rainfall. The deficit amount below the normal level will indicate the indemnification amount. The RII also involves a trigger (15% rainfall deficit in this study) for policy activation. The 15% trigger implies that the indemnification is not activated above 850 mm rainfall during the crop period.

Insurance products are also differentiated by two levels of the sum insured: NPR 60000 NPR and 90000 NPR per hectare, three levels of deductibles (15%, 20% and 25%) and five levels of premium price (NPR 250, 500, 750, 1000, 1250 and 1500 NPR) per hectare. The sum insured indicates the risk coverage level or the amount of insurance payout you would receive in case of crop loss. Insurance payout is calculated based on the crop loss or rainfall deficit percentage. For example, if the crop loss or rainfall deficit is 100%, you will receive 100% of sum insured as the insurance payout. The deductible indicates the amount to be deducted from the insurance payout determined based on the crop loss. For example, if you insure one ha of rice crop for one season specifying the sum insured as NPR 90000 and deductible as 20%, you will only receive an insurance payout of NPR 72000 for 100% crop loss or rainfall deficit. You can see the further details of the indemnification schedule in the following tables (Show them appendices D and E).