Risk reduction and development in a multi-hazard landscape: a case study of Eastern Uganda

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Dissertation

RISK REDUCTION AND DEVELOPMENT IN A MULTI-HAZARD LANDSCAPE: A CASE STUDY OF EASTERN UGANDA

by

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DEDICATION

I would like to dedicate this work to my Uncle Gary, whose support and pride never failed to fill my heart with strength, to my Mom, the most stalwart champion a daughter could ever ask for, my Dad, the inspiration for my aspirations to be another Dr. K Sullivan-Wiley, and to my wonderful Vincent, I cannot imagine a better partner for life. I love you.
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Boston University Graduate School of Arts and Sciences, 2016

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ABSTRACT

Environmental disasters result in the death of tens to hundreds of thousands of people and the loss of US$250-300 billion annually. Vulnerability to environmental disasters stems from both social and biophysical factors. While there is increasing awareness that individual hazards are often found in combination with other environmental or social risks in what can be referred to as multi-hazard landscapes, few studies directly examine how people respond to environmental hazards in a multi-hazard environment and the role that risk reduction and development organizations (DOs) play in that response. In this dissertation, I address this research gap through an investigation of risk perception and management in a multi-hazard environment of eastern Uganda dominated by people relying on subsistence agriculture for their livelihoods. Using a combination of qualitative and quantitative statistical analyses, I investigate how individual farmers and DOs differ in their perception and prioritization of hazards and the factors that influence farmers’ perception of multiple risks and their decisions to adopt best management strategies. Building on this household-level analysis of perception and
action, I also draw on data from community-level focus groups and participatory mapping exercises to relate individual to community vulnerability. Results from these analyses show that the factors that shape farmers’ perception and management of different environmental hazards are not universal. Instead, the predictors of risk perception and adoption of best management practices are unique to particular hazards and management strategies. DOs can play an important role in reducing vulnerability through training and material inputs but need to recognize the heterogeneity of communities in doing so. Results show that communities are heterogeneous with respect to vulnerabilities, motivations, and capacities. DO programs must address these differences to achieve perception and behavior changes on a large scale. Participatory mapping exercises can be useful complements to expert risk assessments as they highlight local capacity and risk prioritizations, which do not always align with those determined by outside experts. While mapping is a promising tool for vulnerability analysis, the aspatial and unmappable components of vulnerability require a combination of methods across many scales and data types in order to be more holistically understood.
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<tr>
<td>BMP</td>
<td>Best Management Practice</td>
</tr>
<tr>
<td>CBO</td>
<td>Community-Based Organization</td>
</tr>
<tr>
<td>CCA</td>
<td>Climate Change Adaptation</td>
</tr>
<tr>
<td>DO</td>
<td>Risk Reduction and Development Organizations</td>
</tr>
<tr>
<td>DRM</td>
<td>Disaster Risk Management</td>
</tr>
<tr>
<td>DRR</td>
<td>Disaster Risk Reduction</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information Systems</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning Systems</td>
</tr>
<tr>
<td>IFRC</td>
<td>International Federation of the Red Cross and Red Crescent Societies</td>
</tr>
<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
</tr>
<tr>
<td>MDPR</td>
<td>Ministry of Disaster Preparedness and Refugees (Uganda)</td>
</tr>
<tr>
<td>MFA</td>
<td>Mbale Farmers Association</td>
</tr>
<tr>
<td>MWE</td>
<td>Ministry of Water and Environment (Uganda)</td>
</tr>
<tr>
<td>NAADS</td>
<td>Uganda National Agricultural Advisory Service</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-Government Organization</td>
</tr>
<tr>
<td>NRE</td>
<td>Uganda Ministry of Natural Resources and the Environment</td>
</tr>
<tr>
<td>NUSAF</td>
<td>Northern Uganda Social Action Fund</td>
</tr>
<tr>
<td>OPM</td>
<td>Office of the Prime Minister (Uganda)</td>
</tr>
<tr>
<td>PGIS</td>
<td>Participatory Geographic Information Systems</td>
</tr>
<tr>
<td>SACCO</td>
<td>Savings and Credit Cooperative</td>
</tr>
<tr>
<td>TACC</td>
<td>Territorial Approaches to Climate Change</td>
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UBOS.................................................................Uganda Bureau of Statistics
UGX.................................................................Ugandan Shillings
URCS.................................................................Uganda Red Cross Society
CHAPTER ONE: Introduction

1.1 Background and rationale

Vulnerability is a concept central to some of the most urgent and complex challenges faced by humanity today. Adger (2006) describes vulnerability as “the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt.” This definition reveals three component factors of vulnerability: exposure, susceptibility, and adaptive capacity as well as their embeddedness in a social-ecological system. This description of vulnerability also implies its counterpart: resilience, which in the context of a social-ecological system reflects the magnitude of disturbance (stresses) that the system can absorb before it is pushed to a state outside its normal range of equilibria (Berkes et al., 2003). These two concepts, vulnerability and resilience, can be seen as defining a spectrum along which people fall, both as individuals or groups, with respect to a given stressor or hazard.

An important and cross-disciplinary subset of the work on vulnerability focuses on disaster risk. Due to the complexity and spatial heterogeneity of social-ecological systems, disasters risk is particular to a given context. Over the past decades, a number of frameworks for the studying the links between disaster vulnerability and the vulnerability-resilience spectrum have emerged. One of the most commonly used addresses the composition of disasters as lying at the intersection of hazard events, exposure, and vulnerability (Figure 1). Disasters only occur when each of the three components are realized together, i.e. if a flood occurs in a location with no human
population, or in a context where those who are exposed are somehow invulnerable to it, then the event does not become a disaster (Quarantelli, 1998).

Vulnerability is a key component of disaster risk. Turner et al. (2003) provide a more detailed framework for assessing the components of vulnerability and the centrality of the concept to work on development in a changing world. This description of vulnerability demonstrates the interactions of exposure, sensitivity, and resilience (Figure 2).

Figure 1 Model of disaster risk as the intersection of hazard events, exposure, and vulnerability, with feedback loops among disaster risk and the social and environmental systems (adapted from IPCC, 2012)
This framework addresses components that can be characterized as the who, what, where, when, and how of vulnerability. Work on the “who”, “where”, and “when” of vulnerability focuses on the characteristics of exposure to hazards, in identifying the potential vulnerable components of the population and the characteristics of the stressors that have the potential to cause them damage (Blaikie et al., 1994; Cutter et al., 2000; Adger, 2006), their spatial heterogeneity (e.g., Cutter and Finch, 2008; McCall, 2008; Shi and Kasperson, 2015), and their variability and trends through time (e.g., Smith, 2013; IPCC, 2014b). Other work addresses identifying what are the conditions of the human and environmental components of the system that make them sensitive to the stressor,
and lead to negative impacts and outcomes (Adger et al., 2005). Finally, vulnerability studies examine how people cope with stressors, respond to disasters, and protect themselves through adaptive policies and DRR activities, building their resilience through time (e.g., Folke et al., 2002; Tompkins, 2005; Eakin et al., 2010; Lindell and Perry, 2012).

Though much of the work described above reflects intensive and technical analyses of singular components of vulnerability, research on risk connects multiple components. Risk represents the uncertainty embedded in each component of the vulnerability framework; exposure is a direct risk calculus, multiplying likelihood and severity to calculate probable losses across an exposed population. Resilience, too, involves additional risks and uncertainties. Responses to hazards during and after exposure, and protective measures taken before an event are all decisions that are based in uncertainty and all entail a cost; a cost with uncertain outcomes defines a risk. The ways in which people perceive the risks associated with both exposure to stressors and the responses to those stressors affects their coping and response decisions and thus, their resilience and vulnerability.

Research on the relationship between risk perception and resilience draws heavily from case studies in the industrialized world (e.g., Slovic et al., 1979; Grothmann and Reusswig, 2006; Wachinger et al., 2013) and related to catastrophic hazards (e.g., Nathan, 2008; Martin et al., 2009; Buchecker et al., 2013). In the past decades, there has been increasing attention to the concept of overlapping risks in multi-hazard environments (Cutter et al., 2000; O’Brien et al., 2012; UNISDR, 2015). Attention to
such multi-hazard landscapes is especially salient in the developing world where capacity to address risk is already low (Tschakert, 2007). Work that addresses risk perception and action in a multi-hazard landscape, however, is both rare and increasingly relevant in the context of growing exposure to risk associated with climate change and ongoing population growth rates in much of the developing world.

### 1.2 Thesis Overview

My dissertation research builds on these fields by examining risk in a multi-hazard context to answer the overarching questions: How do smallholder farmers balance the dangers of environmental risk with the demands and limitations of a rural agricultural livelihood, and how is this balance affected by intrinsic factors such as household capacity and extrinsic interactions with development agencies and risk reduction organizations (DOs)?

Using a mixed methods approach that draws on qualitative interviews, quantitative household surveys, and participatory mapping, I investigate the relative roles of DOs, capital endowments, risk perception, and geographic scale in explaining vulnerability in the multi-hazard environment of the Bugisu region of eastern Uganda. I adopt a case study approach due to the complexity of vulnerability, its particularity to an individual context, and the paucity of sufficiently detailed and comprehensive social data available for much of the developing world. Further, the qualitative opportunities provided by a case study allow an in-depth look into the many contextual factors at play in a vulnerable rural environment. Drawing on the frameworks of vulnerability as relating to disasters as outlined in the previous section, my research objectives are to:
• Identify the factors contributing to risk perception on the part of smallholder farmers with specific reference to capital endowments, interactions with DOs, and the adoption of protective actions (Chapter Two).

• Investigate the relationship between risk perception and the adoption of best management strategies (BMPs) on the farm in a multi-hazard area, making specific reference to the trade-offs between risk avoidance and livelihood development and the role that DOs may play in mediating this relationship relative to other explanatory factors (Chapter Three).

• Examine the ways in which vulnerability at the community level is similar to and differs from household vulnerability as expressed through participatory vulnerability mapping exercises (Chapter Four).

Finally, in chapter five I review the primary results of the research chapters, present my contributions to the field of vulnerabilities research, and propose future research directions that will lead to further elucidations for the betterment of the human condition.
CHAPTER TWO: Risk Perception in a Multi-Hazard Environment

2.1 Introduction

Globally, environmental disasters result in the death of tens to hundreds of thousands of people (IFRC, 2014) and the loss of US$250 billion to US$300 billion every year (UNISDR, 2015). In addition to the threat of an individual hazard event, there is increasing awareness that hazards are often found in combination with other threats, both environmental and social and that these threats can interact to exacerbate each other in a multi-hazard landscape (Cutter et al., 2000; O’Brien et al., 2012; UNISDR, 2015). High population growth rates exacerbate threats in multi-hazard environments (Huppert and Sparks, 2006) and the threat of climate change, an additional uncertainty overlaying existing vulnerabilities, further complicates the meteorological component of hazards (IPCC, 2014a). The international community has recognized the interconnectedness of these threats in the adoption of the Sustainable Development Goals and the Sendai Framework for Disaster Risk Reduction in 2015. Both development and risk reduction organizations (DOs) are making substantial efforts to encourage vulnerable populations to adopt protective actions, designing programs that build risk understanding and risk perception to that end (Thomalla et al., 2006; Shaw and Izumi, 2014).

In order to take protective actions against a hazard, people must have some understanding of the risk associated with that hazard and the capacity to act on their concern (Lindell and Perry, 2012). While higher levels of risk perception would be expected to lead to higher rates of protective action, this relationship is not always straightforward. In a phenomenon termed the ‘risk perception paradox’, elevated risk
perception is not always linked to protective action. A lack of motivation, inconsistencies in perceived responsibility for protection and trust in protective agencies, and the perception of limited self-efficacy (i.e., the capacity to undertake protective actions) have each been found to act as intermediaries to prevent the understanding of risk from translating into action (Wachinger et al., 2013). The decision to take, or not take, action can in turn influence risk perception (Brewer et al., 2004). These challenges in translating risk perception to action may be especially critical in multi-hazard environments where people are vulnerable to multiple, overlapping threats, with which they have limited resources to cope.

Hazards are rarely experienced in isolation, yet we know little about how individuals perceive and prioritize multiple hazards at once and how this relates to their use of the protective actions that are frequently particular to an individual threat (Doss et al., 2008). With climate change, multi-hazard environments are likely to intensify or expand into new areas as the ranges of individual hazards change. Examining risk perception in a multi-hazard environment better reflects the reality of vulnerable individuals and allows us to tease out the influence of particular hazard characteristics versus individual characteristics on risk perception. We must also more clearly examine the possible role of DOs in shaping this relationship, through increasing individual risk awareness and enabling protective action.

Much work has been done to identify who perceives risk and why, with early research focusing on investigations of technological risks in the industrialized world (e.g., Wildavsky and Dake, 1990, Boholm, 1998, and Earle, 2010). Those studies that address
environmental or natural hazard risk perception and the role of risk communication are also dominated by studies from the industrialized world (Paton and Johnston, 2001; Bickerstaff, 2004; McCaffrey, 2004; Toman et al., 2006; Paton, 2008; Wachinger et al., 2013). In the past decade, there has been increased attention to the perception of environmental hazards in the developing world including valuable case studies on flooding risk perception (López-Marrero, 2010 in Puerto Rico), landslides (Nathan, 2008 in Bolivia), and volcanoes (Gaillard, 2008 in the Philippines). Gallina et al. (2016) reviewed risk perceptions of single hazards in the context of climate change, including some reference to the developing world. However, each of these studies, as well as review articles, tended to focus on single hazards (e.g., flooding by Kellens et al., 2013). Further, no studies explicitly address the role of DOs in affecting risk perceptions in local communities in a multi-hazard context.

Our work addresses environmental hazard risk perception in a multi-hazard context in the developing world, with specific attention paid to the role of non-regulatory organizations in shaping risk perceptions and their potential to influence protective action. Understanding the factors that shape risk perception and the implications for those on changing action is essential to aid DOs in their work to reduce risks to the most vulnerable populations.

This paper begins with an overview of the literature on risk perception of environmental hazards and an introduction to our study area of the Bugisu region of eastern Uganda. We then present results of hazard ranking and regression analyses for risk perception that show a disconnect between DO and local prioritizations and
perceptions, the difference in factors shaping perception of different hazards, and the role that DOs may play in shaping perception. Finally, we discuss the implications of our study for DO program design and implementation, as well as areas of future research based on this work.

2.2 Background/ theoretical framework

Risk perception is a key component in encouraging protective action in the context of natural hazards (Lindell and Perry, 2012; Wachinger et al., 2013). Risk perception contrasts with “real risk”, or the statistical likelihood of fatality from the hazard, through its reference to a person or population’s interpretation of the hazard and its risk (Sjöberg, 2000). There are three issues implicit in perceived, as opposed to real, risk. First is that, while distinct from real risk, the notion of probability still exists in perceived risk, but instead of reflecting a calculated statistical probability, perceived risk reflects perceived likelihood, which frequently disagrees from statistical probability in meaningful ways through biases such as the availability heuristic (Tversky and Kahneman, 1974; Siegrist and Gutscher, 2006). Secondly, perceived risk comprises uncertainty in event outcomes and the severity of those outcomes for the individual or group interpreting the risk; even the same physical outcome of a hazard can represent different danger to different people depending on their preferences and coping capacities. Finally, there is the social construction of risk that relates to the level of risk society is willing to accept in exchange for the social benefits associated with its cause, a relationship that is influenced by perceptions of the parties responsible for risk mitigation (Kasperson et al., 1988; Bronfman et al., 2009). Much early work in the field focused on
assessing the differences between perceived and real risk (e.g., Lichtenstein et al., 1978; Slovic et al., 1979; Slovic et al., 1980), while later work began investigating the implications of these differences for risk management and risk communication (e.g., Boholm, 1998; Renn, 2008; Wachinger et al., 2013).

A large and mature body of research investigates how people perceive risks associated with technological hazards (e.g., nuclear power, genetically modified organisms). Focusing primarily on hazards relevant in industrialized countries, this body of work shows that risk perception varies with respect to the characteristics of the individual perceiver as well as the characteristics of the hazard itself (Fischhoff et al., 1978; Slovic et al. 1979; Slovic 1986; Wachinger et al., 2013).

Early research identified differences in how expert and non-expert communities perceive risk. While experts generally equate risk with fatality frequency (annual death rates associated with a given hazard), non-experts factor other hazard characteristics such as catastrophic potential and sensationalism into their risk calculus (Lichtenstein et al., 1978; Slovic et al., 1979). Non-experts tend to have a lower perception of risk for some hazards (e.g., motor vehicle accidents) and a higher perception of risk for others (e.g., vaccinations) compared with experts (Slovic et al., 1979). In addition, non-experts tend to rate concern about risks more highly when the hazard is uncontrollable, catastrophic, involuntary, not equitable in its impacts, and not well-understood (Slovic 1986; Boholm, 1998). Familiarity ameliorates non-expert perception of risk. Non-experts consider everyday actions such as driving in a motor vehicle less risky than less familiar actions that are statistically less likely to result in fatalities (Slovic et al., 1979).
Demographic and socioeconomic characteristics related to social vulnerability are also associated with higher risk perceptions of hazards in the industrialized world, a relationship likely to reflect individual self-efficacy, or one’s perceived ability to effect change through protective action (Bandura, 1995; Bickerstaff, 2004—regarding air pollution). Women (Siegrist, 2000—gene technology), older adults (Mayhorn, 2005—environmental), people with lower levels of education (Gyekye and Salminen, 2009—workplace safety), those with children in the household (Turner et al., 1986—earthquakes), those living in poverty (Cutter, 1981—pollution; Nyland, 1993—general; Sjöberg et al., 1996—general), people who are divorced or unemployed (Boholm, 1998), and other characteristics like cultural identity (Rohrmann, 1994) have been shown to be associated with elevated risk perception of both technological and environmental hazards.

People who feel confident in their ability to control or affect their environments (those with high self-efficacy) generally perceive less risk and feel more prepared for hazards, while the converse is true for people who do not feel confident in their ability to affect their environments (those with low self-efficacy) (Bickerstaff, 2004; Martin et al., 2007). Beyond individual vulnerability, the country in which people live also may affect the perceived magnitude of a hazard, but generally not in how hazards rank with reference to each other (Boholm, 1998).

Like technological hazards, the most essential components of environmental hazard risk perception are generally considered to be the perceived probability (likelihood) and the severity of the consequences of the hazard (Lindell and Perry, 2012). These, however, are insufficient to account for variability in risk perceptions. Gender,
age, and educational attainment are often (though not consistently) found to be mediating factors in the perception of the risk of environmental hazards. Women have been found to perceive greater risk than do men, older adults to perceive greater risk than young, and less educated to perceive greater risk than more educated (Flynn et al., 1994; Terpstra and Lindell, 2013; Wachinger et al., 2013), consistent with those trends found in relation to technological and anthropogenic hazards. Other studies of perceptions of individual environmental risks, however, have found weak or non-existent trends with respect to some or all of these socioeconomic characteristics (Plapp and Werner, 2006; Burningham et al., 2008).

Direct personal experience with a hazard has consistently been shown to be important and generally positively associated with risk perception (Plapp and Werner, 2006; Heitz et al., 2009; Miceli et al., 2008; Siegrist and Gutscher, 2006; Grothmnn and Reusswig, 2006; and Terpstra, 2011) and risk aversion (Gloede et al., 2015). The recency, frequency, and severity of a person’s experience can affect the strength of its relationship to risk perception (Lindell and Perry, 2012). Those who have experienced mild forms of a hazard, for example, tend to underestimate subsequent danger, with an attitude that Mileti and O’Brien (1992) describe as “normalization bias”, whereby people interpret the mild impacts of the early experience as the norm and believe that future severe impacts can also be avoided. Baan and Klijn (2004) found that those most experienced with floods were among those least concerned by them, but in this case the effect was mediated through a sense of preparation on the part of the perceiver.
Individual and community risk perceptions are influenced by communication about risks from external expert sources in complex ways (Fischhoff, 1995; Renn, 2008). Much of the work on risk communication emphasizes that, beyond accuracy and relevance of message content, the trust between the non-expert and the expert is important (Renn and Levine, 1991; Fischhoff, 1995; Wachinger et al., 2013). Paton (2008) notes that trust is an especially important component of communication when people are dealing with decisions under conditions of uncertainty, a condition satisfied in all cases of hazard risk. In these cases, trust is used as a proxy in place of complete information, allowing a simplified message to be believed and taken up by the individual without all underlying complexity needing to be understood. In addition to reducing uncertainty, external experts can provide information to people who lack direct experience with a particular hazard. Through risk communication, the expert provides indirect experience to the non-expert, but only when trust between the parties is present (Siegrist and Cvetovich, 2000; Earle, 2010; Wachinger et al., 2013). Trust is influenced by characteristics of the expert, as perceived by the non-expert. A large body of work shows trust as determined by knowledge and expertise, openness and honesty, and concern and care (Kasperson, 1986; Renn and Levine, 1991; Peters et al., 1997; Fisher, 2013). However, this list of characteristics has received some criticism (Cvetkovich and Lofstedt, 2013). Earle (2010) suggests that trust is primarily influenced by perceived morality, interpreted through the “similarity heuristic”, which reflects shared values and priorities of the expert and non-expert. This trust can be undermined by perceived differences in values and priorities, which trigger the non-expert to perceive expert bias.
In some cases, value congruence is more important than even transparency and other factors such as competence in generating trust between parties (Earle and Siegrist, 2006; Pirson and Malhotra, 2008). That said, and all else being equal, people are more willing to accept information from experts they trust (Bickerstaff, 2004).

While this body of research highlights the many factors that influence individual risk perception and the role that trusted organizations can play, we lack an understanding of how individuals perceive risks when faced with multiple hazards. Risk perception studies that simultaneously evaluate the perception of multiple risks are rare and those that do tend to focus on industrialized countries (Lindell and Hwang, 2008; Perry and Lindell, 2008). Lin and colleagues (2008b) is a notable exception in their focus on landslide and flood risk in Taiwan. Given the frequent intersection of multiple hazards with social components of vulnerability in the developing context, a better understanding of how people perceive multiple threats can help resolve conflicting findings about the predictors of risk perception and is important for informing the design of risk reduction programs.

2.3 Study area

Our study area includes ten small communities in the Bududa and Manafwa Districts, Eastern Province, Uganda (Figure 3). These districts border the main commercial and transport hub of Mbale, which connects to other major cities in Uganda by tarmac road.

People are ethnically Bagisu and speak Lugisu dialects and, to varying extents, English. Most have lived in the Mount Elgon region for generations and have close
cultural ties to the region. The population of Bududa is approximately 210,000. Though Manafwa’s population is 66% larger, it is less densely concentrated. The population of Bududa is also growing more quickly, and this rate has increased since 1991, while the growth rate in Manafwa is lower and is decreasing (Table 1).

Figure 3 Uganda shaded elevation map with Bududa and Manafwa districts highlighted and surveys villages shown

<table>
<thead>
<tr>
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<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bududa</td>
<td>211,683</td>
<td>5.7</td>
<td>844.0</td>
<td>15.4/13.9</td>
<td>96.8%</td>
<td>4.52 (higher)</td>
</tr>
<tr>
<td>Manafwa</td>
<td>352,864</td>
<td>4.8</td>
<td>586.1</td>
<td>22.0/22.4</td>
<td>93.5%</td>
<td>2.46 (lower)</td>
</tr>
</tbody>
</table>

Table 1District background information. Demographic and socioeconomic information for Bududa and Managwa districts, Uganda (UBOS, 2014)
People in the region are vulnerable due to poverty and population pressures as well as multiple environmental hazards. The region is characterized by steep slopes, river valleys, and is dominated by loose, volcanic soils. Rainfall is distributed across two rainy seasons with average annual rainfalls of 1000-1800 mm (Manafwa) and 1400-2200 mm (Bududa) (NEMA, 2010). Available land is scarce and land scarcity has pushed cultivation onto the steepest slopes of Mount Elgon, the extinct volcano that defines the region. Together these factors result in a landscape at risk for chronic soil loss due to erosion, severe landslides, mudslides, and flooding along the Manafwa River, which runs through both districts. In 2010, the leading disaster relief organization in the region, the Uganda Red Cross Society, responded to 11 landslides in the Bugisu region and in a period of about 15 years 98 landslides occurred in Bududa alone (Claessens, 2007), with one catastrophic landslide in 2010 killing well over 300 people and displacing many more (URCS, 2010). Landslides and related hazards have increased in recent years (Mugagga et al., 2012) and represent only a few of the hazards facing the study region. Other hazards include drought, deforestation, and the proliferation of pests and diseases.

Numerous non-governmental, private sector, and government organizations are active in these districts. These DOs aim to reduce smallholder vulnerability to environmental hazards directly and/or to engage in other development activities that can indirectly reduce hazard risk. Some risk reduction agencies, like the Red Cross Society and the Ugandan Department of Natural Resources and the Environment, address environmental hazards through training programs to reduce risk levels through disaster preparedness and improved land management training. Others, like Technoserve, Send-
A-Cow, and the Uganda national agricultural advisory service (NAADS) address risk indirectly through livelihoods development and income generation programs. The confluence of multiple hazards (Shi and Kasperson, 2015), social vulnerability (UNDP, 2013), and the presence of a number of risk reduction and development organizations makes the Bugisu region a compelling site to investigate the factors at play in shaping risk perception in a multi-hazard environment.

2.4 Methods

To investigate the role of DO programs and other factors on risk perception we used a mixed methods approach that combines data collected through semi-structured interviews with DO personnel, surveys of farming households across ten villages in the Bugisu region, and focus groups with individuals from the study villages.

2.4.1 Interviews with DO Program Managers

We conducted 40 semi-structured interviews with staff at DOs to identify the range of DO programs involved in risk communication and to characterize the ways in which they prioritize and communicate those risks. Interviews were conducted with personnel from organizations that: (1) have a consistent local presence in Bududa or Manafwa districts, (2) implement programs intended to reduce farmer risk from any hazard, and (3) target either land management or environmental education as a key node of program design. The interviews varied in the specific questions asked but all queried:

- risks facing smallholder farmers,
- benefits farmers accrue from their land and environment,
• the design and implementation characteristics, and evaluation techniques for programs, and
• relationships with other organizations.

Interview data was transcribed and coded using NVivo 10 qualitative analysis software (QSR International Pty Ltd. Version 10, 2012). Information from the interviews was used to understand DO practices and informed the development of the household survey.

2.4.2 Household survey

A household survey conducted in 10 study villages collected data on individual risk perceptions, the use of risk management and other best management strategies, engagement with DO programs, and a variety of demographic and socioeconomic variables (Table 2).

The survey was pre-tested with three smallholder farmers in each district, with minor modifications made as necessary to survey questions to ensure clarity, and administered in ten villages – five in Bududa and five in Manafwa. Eight of the villages (the “program” villages) were selected because they were identified as the targets of programs administered by one of the regional development and disaster risk reduction organizations (DOs). The remaining two “control” villages were selected because they have similar social and environmental conditions but have not been a part of any development or disaster risk reduction program beyond outreach by NAADS, the government extension program that operates in all villages across Uganda.
Risk Perception Index (RPI)  

A single index value to represent three component variables (perceived likelihood of experience, perceived severity of outcomes, and holistic concern about the issue) collected in the survey for each of 8 environmental hazards and 4 social issues (Environmental: landslide, soil erosion, flood, drought, hailstorm, pests and diseases, climate change, and deforestation; Social: corruption, market prices, the sale of counterfeit seeds, and overpopulation).

Derived for each individual and each hazard based on responses on a 5-point scale from 0-4 (0=no likelihood, not severe, and no concern; 3= definite likelihood; 4= unknown likelihood, extremely severe, and extreme concern).

\[ RPI_{i,j} = \left( \frac{L_{i,j} \times S_{i,j}}{3} + C_{i,j} \right) / 2 \]

Mean RPI deviance  

Derived measure of general risk perception of an individual relative to the average perception of the sample population.

\[ RPI \text{ deviance}_{i,h} = \frac{\sum_{j=a}^{g} (RPI_{i,j} - \overline{RPI})}{7} \]

Derived for each individual (i) for each environmental hazard(h) as the average difference between that individual’s RPI value and the mean population RPI value for all other environmental hazards (a-g) (e.g., in the OLS regression for landslide RPI, the mean RPI deviance for the individual would take into account only RPI values for soil erosion, floods, drought, hailstorms, climate change, deforestation, and pests & diseases).

Demographic variables  

- Income (continuous; log adjusted, in 2013 USD);
- Farm acreage (continuous; in hectares);
- Respondent sex (binary; 0=female, 1=male);
- Children in household (binary; 0= no school-aged children in household, 1= presence of school-aged children in household);
- Uphill land (binary; 0= no portion of cultivated land is on the slopes of the mountain; 1= some portion of cultivated land is on the slopes of the mountain);
- Fragmented land (binary; 0= all owned land is contiguous; 1= land is in at least two pieces);
- Income sources, including off-farm income and income from coffee (binary)

Engagement with organizations  

Categorical variable comparing (1) those with no engagement to (2) those who engaged with an organization other than the Red Cross and (3) those who engaged with the Red Cross

Hazard experience  

- Occurrence of hazard in village in the recent past (binary; 0=hazard was not experienced; 1=hazard was experienced)

Derived from focus group responses; experience of a hazard in the village was used as a proxy for experience of that hazard by individuals living in the village.

Table 2 Household survey data. Data collected directly or derived from the household survey and the focus groups and used in regression analysis.
In each village, surveyed households were randomly selected from a comprehensive list obtained from the local elected chairperson. The average number of households in each of nine villages was 80 (range 41 to 118), with one outlier village containing 358 households. In control villages and villages where organizations aim to reach the entire village, 55 households were selected randomly from the master list to be approached for participation in the survey. In villages in which organizations target only a sub-population of the village, surveyed households included 10 households identified as beneficiaries by program managers and a random selection of 45 additional households to ensure that the sample included at least 10 beneficiary households. Only heads-of-households or their spouses responded to the survey.

Surveyed farms in Bududa and Manafwa (n=426) averaged 0.7 ha with a mean household size of just over 6 people, with 15% of households reporting household sizes of 10 or more (see Table 3 for more detailed information). Surveyed households were an average of 3.5 km from the nearest market and the mean annual incomes of surveyed households was 650 USD (values reported in Ugandan shillings and converted to USD based on the exchange rate of mid-September 2013). We surveyed an average of 54% of households in each village. Of these, 75% reported male heads-of-household, though only 49% of survey respondents were male.

2.4.3 Focus groups

To gain insight into risk perception from the level of the community, one focus group was held in each study village. Focus group participants included a randomly
selected subset of survey respondents who had indicated a willingness to participate in additional discussion beyond the survey. During focus group discussions, information was elicited about which hazards were currently or historically experienced in the village.

<table>
<thead>
<tr>
<th>Village</th>
<th>DO active in village</th>
<th>HH in sample (%)</th>
<th>Farm size (ha)</th>
<th>HH size (total)</th>
<th>Annual income (USD)*</th>
<th>Respondents male (%)</th>
<th>HOH male (%)</th>
<th>HH with uphill land (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bududa</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bunasaba</td>
<td>Environment Office</td>
<td>51%</td>
<td>0.73±0.63</td>
<td>6.4 ± 3.1</td>
<td>354 ± 501</td>
<td>3.74±1.93</td>
<td>91.6</td>
<td>100</td>
</tr>
<tr>
<td>Buwabusera</td>
<td>Mbale Farmers Assn</td>
<td>83%</td>
<td>0.48±0.37</td>
<td>5.7 ± 2.7</td>
<td>528 ± 1315</td>
<td>2.32±0.81</td>
<td>72.7</td>
<td>44.9</td>
</tr>
<tr>
<td>Bushibuya</td>
<td>Coffee A Cup Coop.</td>
<td>100%</td>
<td>0.86±0.68</td>
<td>6.7 ± 3.3</td>
<td>381 ± 436</td>
<td>5.40±4.72</td>
<td>75.4</td>
<td>87.3</td>
</tr>
<tr>
<td>Bunamutunyi</td>
<td>(control)</td>
<td>40%</td>
<td>0.63±0.63</td>
<td>4.8 ± 2.8</td>
<td>233 ± 345</td>
<td>3.57±1.58</td>
<td>67.4</td>
<td>51.1</td>
</tr>
<tr>
<td>Bunamalise</td>
<td>Red Cross I</td>
<td>88%</td>
<td>0.46±0.23</td>
<td>5.3 ± 2.5</td>
<td>301 ± 343</td>
<td>9.26±3.17</td>
<td>80</td>
<td>75</td>
</tr>
<tr>
<td><strong>Manafwa</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shiruku</td>
<td>Send-A-Cow</td>
<td>34%</td>
<td>0.60±0.53</td>
<td>7.4 ± 3.7</td>
<td>709 ± 933</td>
<td>0.56±0.30</td>
<td>54.8</td>
<td>53.1</td>
</tr>
<tr>
<td>Bumwangu</td>
<td>Technoserve</td>
<td>11%</td>
<td>0.84±0.74</td>
<td>6.4 ± 4.0</td>
<td>774 ± 846</td>
<td>1.06±0.61</td>
<td>75</td>
<td>35</td>
</tr>
<tr>
<td>Buwangota</td>
<td>Spark Microgrants</td>
<td>41%</td>
<td>1.00±0.94</td>
<td>6.4 ± 2.7</td>
<td>1513 ± 1544</td>
<td>3.37±1.45</td>
<td>81.4</td>
<td>95.3</td>
</tr>
<tr>
<td>Bunokomola</td>
<td>Red Cross II</td>
<td>43%</td>
<td>0.68±0.48</td>
<td>6.1 ± 3.4</td>
<td>1019 ± 893</td>
<td>3.42±2.31</td>
<td>64.1</td>
<td>78</td>
</tr>
<tr>
<td>Silumbusa</td>
<td>(control)</td>
<td>50%</td>
<td>0.63±0.33</td>
<td>6.3 ± 2.2</td>
<td>949 ± 874</td>
<td>1.50±0.68</td>
<td>81.6</td>
<td>31.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>54%</td>
<td>0.70±0.62</td>
<td>6.1 ± 3.1</td>
<td>652 ± 959</td>
<td>3.50 ± 3.26</td>
<td>74.6</td>
<td>65.9</td>
</tr>
</tbody>
</table>

Table 3 Background information for study villages. Demographic and economic means and standard deviations of the surveyed population of ten target villages in Bududa and Manafwa districts

* Exchange rate of 1 USD = 2588 Ugandan shillings based on daily rate from mid-September 2013.

2.4.4 Data analysis

Data from the survey, interviews, and focus groups were analyzed in multiple ways. To assess multiple dimensions of risk across the survey population and to compare the prioritization of concern between farmers and DO program managers, we constructed several indices: the risk perception index (RPI), which represents individual risk perception, and the incidence (I), importance (P), and severity (S) index of each hazard, which reflect the ranking of hazards across households and study villages. The indices are based on survey responses that rank the hazards of most concern and rate each hazard
on three risk perception components (Table 2). We then utilized multiple regression analyses to examine the variables that are predictive of an individual farmers’ perception of risk, using the RPI as the dependent variable of analysis.

2.5. Results and interpretation

Eight environmental hazards and four social issues were considered in this study and are listed in Table 2. The results focus on three issues: (i) the relative importance of environmental hazards and social issues to farmers and DOs, (ii) the relative importance of predictor factors in shaping farmer risk perceptions for a subset of four environmental hazards, and (iii) the role of risk communication and DO engagement in risk perceptions.

2.5.1 Hazard indices across the study population

The indices used to analyze the rankings of hazards across the study population – incidence ($I$), importance ($P$), and severity ($S$) – are based on methods from Smith et al. (2000), Tschakert (2007) and López-Marrero and Yarnal (2010).

The incidence index ($I$) represents the proportion of participants that named a specific hazard in their ranking of the top three hazards of concern. This is based on but differs slightly from the rankings used in Tschakert (2007) as the survey in this study constrained the total number of ranked hazards to a maximum of three. Values range from 0 (ranked by no one) to 1 (ranked by everyone) and are reported as percentages.

Across the survey population, the hazards and issues with the highest incidence were environmental rather than social (Figure 4). More than 50% of respondents named
hailstorms in their top three hazards of most concern, followed by soil erosion (49%) and pests and diseases (46%).

Rankings generally reflected our expectations across most villages based on geographical features. Concerns about soil erosion and hailstorms were ubiquitous while flooding and landslides were more localized. However, given the high level of concern about landslides by the Ugandan government and national and international DOs, it is notable that only 25% of respondents ranked this hazard. Even in Bushibuya, the entirety of which is located in a steep slope prone to mass movement events, concern about landslides was not ubiquitous. Fifteen percent of respondents in Bushibuya did not rank landslides in their top three concerns. These differences are even more pronounced between villages. In three villages (Shiruku, Bumwangu, and Sirumbusa), there were no respondents who ranked landslides as the primary hazard of concern and, in two of these (Shiruku and Sirumbusa), landslides were never listed. While this latter result reflects our expectations, given the relatively flat topography of these two villages, the low ranking overall is surprising and contrasts to the picture painted by DOs.¹

Market price fluctuation is the only social issue with an incidence index value of more than 10%. Climate change, deforestation, and overpopulation, issues frequently

¹ The eight remaining villages contain terrain hilly enough for landslide risk. Between 45% and 100% of households within these villages have at least some portion of their land on the slope, indicating that they retain at least some exposure to a mass movement event.
discussed as issues of concern by DO personnel, ranked among the lowest for farmers, with incidence index values of only 3-4%.

The importance index ($P$) represents how highly each issue was ranked by respondents, to get some measure of its relative position to other ranked issues in the population. The importance index was calculated for each issue by:

$$P_{i,j} = 1 - \frac{(r-1)}{(n-1)}$$

(1)

where $P_{i,j}$ is the importance value for a given hazard $j$ for a given individual $i$, $r$ is the rank individual that hazard as it relates to $n$, the total number of hazards named by the individual. The index ranges from 0 (lowest importance) to 1 (highest importance). A mean value of $P$ was calculated for the subset of participants who identified a particular hazard (López-Marrero and Yarnal, 2010).

Landslides\(^2\) are the most important hazard for farmers as measured by this index, with a $P$ value of 0.675, demonstrating that, while they are not of ubiquitous concern across the population, they are an important concern where they are ranked (Figure 4). Soil erosion and hailstorms are the next most important hazards that also have incidence values over 10\%, scoring 0.594 and 0.582 importance index values respectively. Both hailstorms and soil erosion are ubiquitous throughout the study districts.

\(^2\) The importance index value ($P$) for Theft was greater than that of Landslides, but only two respondents ranked this threat, so that while it is of great importance to a very few, it is not discussed further in the context of the other hazards of broader concern.
Figure 4 Plot of the incidence index (I) against the importance index (P) for each environmental hazard or social issue ranked by a survey respondent. Program expert agreement on issue significance is indicated by the shading of each point. Ignorance and over-cultivation were ranked by more than 50% of experts, but were never ranked by farmers and thus do not appear on this chart.

Finally, the severity index \((V)\) provides information on how dangerous people perceive these issues to be. It was calculated as the mean value of perceived severity for a given hazard for the subset of participants who ranked that particular hazard in their top three. \(V\) values range from 0 (least severe) to 4 (most severe). This index value varied little among issues, from a low of \(2.30 \pm 0.81\) (drought) to \(2.87 \pm 0.52\) (hailstorms). When calculated for all respondents, including but not limited to those that ranked the issue, variation increased, ranging from \(1.90 \pm 1.33\) (landslides) to \(2.83 \pm 0.55\) (the sale of counterfeit seeds). This indicates that perceived severity is closely tied to ranking decisions.
In interviews, DO program managers were asked to speak to the issues of most concern in the region. In contrast to farmer rankings, DO program managers emphasized landslides as the most important environmental hazard and many social issues like overpopulation and ignorance, over other environmental hazards. While more than 75% of managers cited landslides and overpopulation as posing the greatest risk to farmers, only one mentioned hailstorms (Figure 4). Pests and diseases, along with soil erosion and flooding occupied much of the concern of both farmers and DO personnel.

2.5.2 Risk perception index for individuals

Based on a more complex index created by Leiserowitz (2006) as a holistic measure of risk perception, the risk perception index (RPI) is derived for each individual based on his or her perceived likelihood, perceived severity, and holistic concern for each hazard.

\[ RPI_{i,j} = \left( \frac{L_{i,j} \cdot S_{i,j}}{3} + C_{i,j} \right) / 2 \]  \hspace{1cm} (2)

Where \( RPI_{i,j} \) is the risk perception index rating for respondent \( i \) for hazard \( j \) calculated as a simple mean of stated holistic concern \( C \) and perceived “real risk” from that hazard, calculated as expected losses: perceived severity \( S \), multiplied by perceived likelihood \( L \). \( RPI \) is continuous, varies from 0 (no risk) to 4 (extreme risk), and represents a single metric describing an individual’s perceived risk for a given hazard. RPI ranges vary by hazard (Figure 5), with mean RPI values ranged from 1.54 (landslides) to 2.70 (hailstorms). One-way analysis of variance (ANOVA) tests indicate
that these differences are significant across villages at the $p < 0.05$ level for all hazards except for perceived risk from deforestation.

Figure 5 Box plots for all environmental hazards queried in the household survey, with boxes containing the central 50% of respondents, squares marking the median, and whiskers extending to 1.5 the interquartile range of the nearest quartile (Tukey, 1977). Across all hazards, the 75th percentile RPI value of 2.625 reflects likelihood, severity, and concern all rated of 3 out of 4, the most common rating.

2.5.3. Factors influencing risk perception (landslide, flood, soil erosion, and hailstorm)

A series of ordinary least squares regressions were performed to predict farmers’ risk perception (RPI). Variables included socioeconomic variables, geographic factors, respondent RPI deviation (indicating the general level of worry of individual respondents), respondent experience to the hazard either directly or indirectly, and respondent’s general tendency to perceive environmental risk (Table 2).
No single set of independent variables consistently explains the Risk Perception Index (RPI) for all hazards across the population. Though RPI ratings did vary across hazards and among people, this variability was small compared with the magnitude of variability in the independent variables. We highlight the results from a subset of four regression analyses to discuss these results, focusing on two of the hazards of most concern to farmers (soil erosion and hailstorms), and two hazards of most concern to development and risk reduction organizations in the region (landslides and floods).³

Across all four of our target hazards, the models were significant at the p < 0.001 level and reasonable adjusted R-squared values ranging from a low of 0.2976 for hailstorms to 0.4946 for landslides (Table 4). No single set of independent variables was significant across all four hazards. Counter to results from other studies, the presence of school-aged children in the home (Perry and Lindell 1990) is not significant for any hazard, while gender (Lindell and Perry, 2012; Wachinger et al., 2013) and other household characteristics are significant for some hazards but not others. Similar to other work, our study shows that hazard experience is significantly related to heightened risk perception when experienced indirectly through others in the same village (experience: landslides and flooding), and through communication with DOs (engagement: marginally

³ BMP adoption is sometimes a predictor of risk perception (Lindell and Perry, 2011), but is not included in these regressions due to concerns about endogeneity. The potential simultaneity of the effect of RPI and BMP adoption on each other was investigated through parallel regression analysis, which found no significant difference in the models (APPENDIX II).
significant for flooding) (Wachinger et al., 2013). Soil erosion, which is ubiquitous across the region, is an exception to this tendency, while interaction with DOs has a marginally significant and slightly dampening effect on risk perception of hailstorms.

<table>
<thead>
<tr>
<th></th>
<th>Landslide RPI</th>
<th>Soil erosion RPI</th>
<th>Flood RPI</th>
<th>Hailstorm RPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of obs</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
</tr>
<tr>
<td>p-value (model)</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>Adj R-squared</td>
<td>0.4946</td>
<td>0.4332</td>
<td>0.3556</td>
<td>0.2976</td>
</tr>
<tr>
<td>Income (log-adjusted, 2013 USD)</td>
<td>-0.073 0.100</td>
<td>-0.022 0.499</td>
<td>-0.054 0.237</td>
<td>-0.010 0.721</td>
</tr>
<tr>
<td>Income from coffee</td>
<td><strong>0.655 0.000</strong></td>
<td><strong>0.248 0.018</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-farm income</td>
<td>0.098 0.637</td>
<td>-0.060 0.696</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acreage (ha)</td>
<td>0.129 0.262</td>
<td>-0.005 0.953</td>
<td>0.177 0.136</td>
<td>0.031 0.656</td>
</tr>
<tr>
<td>Hilly land</td>
<td><strong>0.384 0.002</strong></td>
<td>-0.029 0.747</td>
<td>-0.584 0.000</td>
<td>0.036 0.626</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>-0.217 0.107</td>
<td>0.050 0.612</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children in household</td>
<td>-0.293 0.056</td>
<td>0.102 0.367</td>
<td>0.105 0.499</td>
<td>0.022 0.814</td>
</tr>
<tr>
<td>Gender (0=female, 1=male)</td>
<td>0.128 0.246</td>
<td>-0.190 0.020</td>
<td>0.155 0.170</td>
<td>0.027 0.689</td>
</tr>
<tr>
<td>RPI deviation</td>
<td><strong>1.169 0.000</strong></td>
<td><strong>0.892 0.000</strong></td>
<td><strong>0.932 0.000</strong></td>
<td><strong>0.503 0.000</strong></td>
</tr>
<tr>
<td>Engagement (baseline: none)</td>
<td>0.491 0.000</td>
<td>n/a</td>
<td>0.288 0.042</td>
<td>n/a</td>
</tr>
<tr>
<td>Other DO</td>
<td>0.068 0.610</td>
<td>0.049 0.616</td>
<td>0.078 0.562</td>
<td>-0.148 0.065</td>
</tr>
<tr>
<td>Red Cross</td>
<td>0.175 0.374</td>
<td>0.045 0.752</td>
<td>0.307 0.113</td>
<td>-0.191 0.100</td>
</tr>
<tr>
<td>Experience</td>
<td><strong>0.491 0.000</strong></td>
<td>n/a</td>
<td><strong>0.288 0.042</strong></td>
<td>n/a</td>
</tr>
<tr>
<td>constant</td>
<td><strong>1.295 0.000</strong></td>
<td><strong>2.305 0.000</strong></td>
<td><strong>1.800 0.000</strong></td>
<td><strong>2.852 0.000</strong></td>
</tr>
</tbody>
</table>

Table 4 Ordinary least squares (OLS) regression results. Results for four target hazard RPI values. All models are very significant (p<0.001). In bold are those variables that were significant (p<0.05). Experience was not included as a variable for soil erosion or hailstorms because ≥90% of villages reported these hazards as occurring in their communities. Only the most salient protective land management action was assessed for each landslide, soil erosion, and flooding, but none was assessed for hailstorms as the authors are aware of no protective action advocated for this hazard.

Though hazard experience was an important predictor, the most powerful predictor of RPI across all four hazards was the tendency for an individual to perceive more or less risk from environmental hazards in general, relative to other individuals (RPI deviation). Those who worried more for one hazard also tended to do so for others. Both the significance (p<0.001 for all hazards) and magnitude of this effect were strong, with a 1-point increase in RPI deviation corresponding to an effect more than twice as
strong as the effect of experience for both landslides and flooding. For all hazards, RPI deviation reflected the largest magnitude effect behind the constant, and in the case of landslides its effect was greater than the constant.

There is significant baseline concern across our study sample for each hazard, indicated by the regression constant. This is consistent with the focus group data indicating that these hazards are ubiquitous across the region. For all hazards, baseline concern was both highly significant (p<0.001) and had the highest coefficient value, ranging from 1.295 for landslides to 2.852 for hailstorms.

For landslides, in addition to the three broadly significant factors, the only additional factors of significance are the cultivation of land on the sloped hillside and having income from coffee (Table 4). The relationship between slope cultivation and landslide RPI is significant (p=0.002) and is also positive (0.384), an effect comparable in magnitude to the relationship between RPI and landslide experience. Those who grew and sold coffee also perceived higher risk of landslide (p<0.001), an effect even stronger than experience in determining risk perception.

In the case of soil erosion and only soil erosion among the hazards evaluated here does gender play a role in risk perception. Women perceive greater risk of soil erosion than do men (p=0.020). Though the magnitude of this effect is much less than the relative effects of both baseline risk perception and the individual effect of RPI deviation, men perceive less risk than women in the case of soil erosion. For no other hazard was gender even marginally significant. As with landslides, perceived risk of soil erosion was also positively associated with coffee incomes (p=0.018), with a similar magnitude of effect.
as that of gender on risk perception. Those who have invested in the cultivation of coffee are more concerned than others about soil erosion and landslides.

For flooding, beyond the effects of baseline concern, RPI deviation, and experience, the presence of off-farm income and certain farm characteristics also play a role in risk perception. Having non-farm income through family members or non-agricultural employment has an attenuating effect on flood risk perception. Those who were employed in paid labor activities such as teaching, transport, and business ownership in addition to farming showed a lower perceived risk of flooding than their neighbors who had no off-farm income (p=0.023). Farm characteristics are also significant contributors to flooding risk perception. Those who farmed on the hillier slopes perceived lower flooding risk (coefficient=-0.584, p<0.001), while those with fragmented land perceived higher flooding risk (coefficient=0.424; p=0.002). Land fragmentation is very common in Bududa and Manafwa and frequently represents farmer use of more marginal lands used for food production. As mentioned above, those who have experienced a flood (p=0.042) also perceive more risk from floods.

In the case of hailstorms, baseline risk perception and RPI deviation are the only significant factors in individual risk perception. No addition individual, household, or farm characteristics play a role in the extent to which individuals perceive hailstorm risk. Interestingly, interaction with DOs has a marginally significant attenuating effect on hailstorm risk perception (p= 0.065 for DOs other than the Red Cross). While this effect is slight in magnitude compared to baseline concern and RPI deviation, it is nonetheless interesting in that the direction of the relationship (attenuated risk perception) is different
for hailstorms than for the other three hazards (heightened risk perception with DO engagement). In fact, using only RPI deviation and DO interaction as independent variables, the adjusted $R^2$ value for hailstorm RPI increases to 0.3067, indicating that socio-economic factors contribute little to the development of the perceived risk of hailstorms.

### 2.5.4. The role of DOs

Engagement with DOs other than the Ugandan Red Cross Society (URCS) is negatively correlated and marginally significant ($p<0.1$) with respect to farmer risk perception of hailstorms. Beyond the existence of a relationship, it is also important to further understand the significance of the interaction between DOs and people. Trust has often been shown to be an important factor in relationships between DOs and individuals they work with, and that this trust can be assessed by components such as perceived similarity and perceived morality (Earle, 2010). To investigate this relationship, we collected information on farmers’ opinions regarding the intentions of the organization as well as the frequency and recency of their interactions (Table 5). A one-way ANOVA reveals no significant difference of farmers’ perceptions of organizational goodwill based on the organization under question. This was largely due to low variability in perceptions of goodwill in our sample. Farmers responded that they perceived the DOs with which they worked as having the farmer’s best interests as a priority in 90% of cases. While this low variability makes goodwill a poor candidate for inclusion in a regression analysis, we
do see that it varies in our sample with other measures of organizational engagement, such as the frequency and recency of engagement.

<table>
<thead>
<tr>
<th>Survey question</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goodwill: Do you feel that this organization has your well-being as its primary goal?</td>
<td>Binary; 0 = no; 1 = yes</td>
</tr>
<tr>
<td>Recency: When was the last time you met with a representative of this organization?</td>
<td>Categorical; 1 = this month; 2 = this season; 3 = this year; 4 = more than one year ago</td>
</tr>
<tr>
<td>Frequency: Over the course of your interaction with this organization, how often did you have contact with the representative?</td>
<td>Categorical; 1 = Only once; 2 = annually; 3 = multiple times per year; 4 = monthly or more</td>
</tr>
</tbody>
</table>

Table 5 Descriptions of factors assessed in conjunction with DO engagement.

A correlation matrix, Sidak-adjusted to prevent spurious correlations, reveals that there is a strong and significant relationship among recency and frequency of interaction and perceived goodwill of the DO. Recency and frequency are related the most significantly (p < 0.001), with those who tend to meet more frequently with a given DO also having met with them more recently. This is a relationship that corresponds well with ongoing relationships farmers have with DOs, as opposed to those they may have had only in the past (where recency of engagement would be unrelated to the frequency of engagement). Even given the limited variability in goodwill, farmers in our sample were more likely to ascribe goodwill to an organization that met with them both more frequently (p=0.008) and more recently (p=0.042), indicating that the farmer’s perception of the organization is tied, at least in part, to the characteristics of the interaction with that organization.

Trust has also been shown to be related to the similarity heuristic, or a person’s perception of how similar an organization is to him or her. While we did not query similarity directly, our comparison of risk rankings from the farmers differ significantly
from the implied prioritizations of the DOs in our study, indicating that there are
differences between the framing of risk by these two groups. This difference may have
implications for the long-term relationship between farmers and DOs with respect to the
similarity heuristic and trust.

2.6. Discussion

Smallholder farmer understanding of risk, and the translation of that knowledge
into protective action, is essential for successful vulnerability reduction. Yet, how these
perceptions are influenced by DO programs and how this relates to action in a multi-
hazard environment is poorly understood. Our findings demonstrate that the factors
shaping smallholder risk perception vary among hazards within the same study
population and shows that characteristics of both hazards and individuals shape risk
perception. The regression analysis also reveals an unexpected relationship between risk
perception, self-efficacy, and protective action. These findings suggest that DOs can and
do play a role in affecting both risk perception and the capacity of smallholders to
respond to environmental threats, and point to the need for additional research about the
mechanisms through which DOs most successfully work with individuals in a multi-
hazard environment.

2.6.1. Hazard and individual characteristics both shape risk perception

Previous research on the predictors of risk perception for individual
environmental hazards has found conflicting results regarding the importance of socio-
economic and other individual characteristics (Wachinger et al., 2013). However, it is
unclear if these inconsistencies are due to the characteristics of the hazards and/or differences among study populations. Our examination of risk perception of multiple hazards for a single population shows that the characteristics of the hazards themselves are likely to explain some of this variation. Our regression analysis demonstrates that risk perception drivers vary by hazard and are shaped by both hazard and smallholder characteristics. Factors such as off-farm income and gender, generally associated with capacity, socioeconomic status, and self-efficacy, are important only for some hazards. Off-farm income is negatively associated with risk perception of flooding, while gender-differentiated risk perception is only a factor when considering the chronic stressor of soil erosion, but not for more acute hazards like landslides or flooding (Table 4). Similarly, the cultivation of coffee is associated with heightened risk perception of landslides and soil erosion. Coffee is the most common export crop in Bugisu, and one of the few crops grown by Bagisu farmers for sale outside local markets (Mugagga et al, 2012). While investment in coffee production is one of the foremost income-generating activities (IGAs) pursued by the Bagisu, our results indicate it may also increase farmers’ risk perception.

Experience of landslides and flooding increases risk perception, the two hazards of our study that are spatially heterogeneous. This builds on other work that has demonstrated the importance of experience in heightening risk perception (Siegrist and Gutscher, 2006; Grothmnn and Reusswig, 2006; and Terpstra, 2011) even in the case of indirect experience (Wachinger et al., 2013). Measures of experience are moot in other cases, like hailstorms and soil erosion, which are ubiquitous throughout the region, and
commonly experienced. In a multi-hazard environment, chronic and ubiquitous hazards must not be forgotten, however, in the shadow of catastrophic, but less broadly experienced hazards.

Some smallholders tend to perceive higher risks than others, regardless of hazard. Though our study did not investigate why some smallholders are more prone to worry than others, we suggest three likely explanations for this tendency toward generally elevated risk perception. First, that some people, regardless of underlying susceptibility to hazards, are more likely to perceive greater risk than are their neighbors, and that this tendency is not based solely on gender or socioeconomic status, but rather reflects individual risk aversion (Wossen et al., 2015). Secondly, that some people, as a result of where they live or farm, are at greater risk from a great number of hazards compared to counterparts who are geographically susceptible to fewer (i.e. there is spatial heterogeneity of hazards within a multi-hazard environment). Lastly, it could reflect a compounding effect of multiple hazards, whereby initial susceptibility to one hazard may lead to increased vulnerability to other hazards, either because of compounded environmental susceptibility or double exposure to environmental and social risk (Cutter and Finch, 2008; O’Brien and Leichenko, 2000). This overlapping susceptibility to multiple is reflected in the significant baseline concern for all hazards in our sample, as reflected in the regression constant (Table 4) and in the focus group data indicating that many hazards are present in each village, though the set of hazards varies.
2.6.2. Differences between smallholders and DOs

Our analysis illustrated both heterogeneity in the perception of risks among the smallholder population and differences in the levels of concern between the smallholder and DO communities. DOs generally focus training efforts on hazards that are within their capacity to affect (e.g., soil erosion through improved land management; ignorance through training), though they acknowledge heavy rains as an important hazard, without a direct protective measure. Hailstorms, in contrast, are the most common concern ranked by smallholders. While these differences likely reflect differences in underlying framings of concern, they may also lead farmers to perceive dissimilarity between themselves and the DOs.

Though our research was not designed to tease out the long-term implications of these differences, our data lead us to posit two competing hypotheses regarding the impact of shared prioritization on long-term trust. First, there may be no relationship; the difference in priorities may be readily understood and accepted by both groups. This hypothesis is supported by the high rates of DO goodwill reported by smallholders. The alternative hypothesis contends that the difference in priorities has the potential to weaken the trust at the foundation of the DO-smallholder relationship, making DO success more difficult over time. The importance of trust in facilitating success has been much discussed in the literature, and within this, the importance of the similarity heuristic has garnered much support (Boholm 1998; Bickerstaff, 2004; Earle, 2010). This hypothesis is also supported by anecdotal evidence of dissatisfaction and perceptions of a lack of understanding on the part of DOs for what smallholders really need. One
community member in Bududa, when asked about the help received from a local DO after a recent mudslide, said “They don’t give us what we need. After a disaster we get food- ok- but really the problem is education and the people cannot afford school fees [for their children]. We need help for education, for the next generation”. The differences in prioritization of hazards, or even recognition of important hazards, could present a long-term challenge to these relationships. Our research suggests that trust, goodwill, two-way communication, and perceived similarity may not relate in straightforward ways in a complex environment at the intersection of risk reduction and development interests. Further research that includes long-term and/or ethnographic studies that assess how trust relationships evolve over time at the intersection of these fields would add insight into if and how differences such as these impact trust and would provide practical insights to inform program design in vulnerable communities.

2.6.3. Self-efficacy and the ability to take protective action

The regression analysis also illuminates an unexpected relationship between risk perception, self-efficacy, and protective action, with implications for the role of DOs. Previous research has found that the perception of limited self-efficacy and associated low levels of protective action are linked to elevated risk perception (Bickerstaff, 2004; Martin et al., 2007; Wachinger et al., 2013). In contrast, our regression results demonstrate that the use of protective measures, where applicable, is positively associated with risk perception: those that perceive more risk are more likely to adopt protective measures. This relationship is significant for the use of trenches for flooding,
even taking into account factors usually associated with vulnerability and low self-efficacy expectancy (income, gender, capital assets like land). If low self-efficacy were driving heightened risk perceptions, we would expect to see a negative relationship between risk perception and protective action because those who were most fearful would also be those who felt unable to act. The positive association between these two, however, indicates that heightened risk perception is not primarily driven by feelings of helplessness. While capacity metrics are still related to risk perception, as mentioned above, they are not preventing people from taking protective action.

This result may indicate success on the part of DOs, which frequently provide both information and the means to act (through trainings, material resources, or both). The majority of smallholders who have adopted contour hedgerows (59%) and trenches (54%), credit DOs with having provided the information necessary to implement the protective action and 72% of DO beneficiaries received a farming tool (hoe, panga, or bucket), while 64% received seeds or seedlings. Most interactions involved the transfer of both information and material benefit. Furthermore, farmers report high levels of satisfaction with the efficacy of contour hedgerows (89% say they work) and trenches (90%). By providing knowledge and material benefits in combination, DOs may be demonstrating their contribution to increasing the self-efficacy expectancy of stallholders as well as their understanding of hazards so that they can take appropriate protective action. This is discussed in more depth in Chapter Three.
CHAPTER THREE: The role of risk reduction and agricultural development programs in the voluntary adoption of best management practices in the Bugisu region of Uganda

3.1 Introduction

The adoption of agricultural best management practices (BMPs) is a central goal of development efforts toward reducing the vulnerability of communities to natural hazards (Benson et al., 2001; IEG-World Bank, 2006). With increasing population pressures and changing weather patterns associated with climate change, the urgency of addressing vulnerability at the local scale is increasing across the developing world (UNEP, 2014). Improving agricultural management is of particular interest in addressing the economic, environmental, and social challenges of sustainable development in some of the poorest areas of the world (Pender et al., 2006). Voluntary adoption of agricultural BMPs, however, remains stubbornly low in many regions (Richards et al., 2014; Tey et al., 2014).

Many BMPs are promoted by both the agricultural development and disaster risk reduction communities and adoption may be motivated by either benefit seeking or risk avoidance. In the development sector, BMPs are used to increase agricultural productivity to bolster both household income and food security, two targets of the 2015 Sustainable Development Goals (Garnett et al., 2013; sustainabledevelopment.un.org). Many disaster relief agencies have recently been shifting their focus from disaster relief to disaster risk reduction, finding it more humanitarian and cost-effective (White et al., 2001; Shreve and Kelman, 2014). Efforts focusing on the risk reduction motivation of
BMP adoption emphasize the importance of land management or “ecological engineering” efforts to stabilize slopes, buffer coastal and riparian systems, and build fertility into soils (ProAct, 2008; Mercer, 2004; Stokes et al., 2014).

Though many of the target BMPs for risk reduction and agricultural development overlap, we understand little about how farmers balance risk avoidance and benefit seeking motivations in their voluntary adoption of BMPs. Moreover, we know little about how the interplay of multiple hazards or goals influence the adoption of particular BMPs from among many management strategies. Much of the existing research examines single hazards or BMPs (e.g. Gaillard, 2007 for volcanoes; Tey and Brindal, 2012 for precision agriculture technologies; Rufat et al., 2015 for floods). While this has provided useful insights regarding adoption constraints, important BMP characteristics, and psychological factors of interest, it does not provide insight into how farmers may be balancing the trade-offs of adoption in the context of daily life. While some studies tackle multiple hazards with richer complexity (e.g. Harvatt et al., 2011), more knowledge of how these trade-offs are perceived and how multiple BMPs are addressed within the same population and with respect to multiple hazards simultaneously is needed.

In this paper, we argue that agricultural development and risk reduction organizations (DOs) play an important role in shaping voluntary adoption of BMPs and that this effect is strongest when DO programs emphasize the co-benefits of BMPs and when the messaging is combined with inputs that reduce material constraints. Understanding the influence of DO messaging and program design on adoption in the context of multiple and overlapping risks could allow risk reduction and agricultural...
development institutions to identify and capitalize on their common aims to achieve greater efficiency and effectiveness in program implementation and to address vulnerabilities in their target communities.

In the next section, we provide a review of the literature on BMP adoption for risk reduction, agricultural development, and the relationship between these fields in the recent past. We address gaps in these literatures through an examination of the role of DOs and other socio-economic and physical factors in influencing adoption of multiple BMPs. We explore this in a case study of disaster risk reduction and agricultural development in the Bugisu sub-region of eastern Uganda. We conclude by discussing the contributions of the case study to relevant theory, as well its practical implications and limitations, and avenues of future research.

3.2 Factors influencing the adoption of BMPs

3.2.1 BMP adoption for risk reduction

BMPs are promoted to manage soil and water dynamics in order to reduce local risk of natural hazards. Such approaches are increasingly relevant due to the expected changes in the frequency and severity of extreme weather events associated with climate change (IPCC, 2014a). Conservation agriculture (CA) and sustainable land management (SLM) strategies, such as mulching, crop rotation, terracing, and grassed waterways, aim to reduce the likelihood or severity of hazards (Black et al., 2013; Marquis, 2015). BMPs associated with risk reduction are used to reduce land surface hazards and to buffer soil fertility without the need to resort to external inputs (Magdoff, 2007).
Evidence suggests that, when adopted correctly and maintained, these strategies can reduce risks. After Hurricane Mitch, farmers who practiced SLM and increased their on-farm vegetation complexity, suffered fewer losses, had reduced landslide effects on their own property, and contributed to lower landslide occurrence on a landscape scale (Holt-Giménez, 2002; Philpott et al., 2008). Tengö and Belfrage (2004) found that intercropping helped in water conservation and regulated pest outbreaks, and interspersing crops with trees results in mitigated risk of windstorms and excessive precipitation; as well as to provide protection from soil moisture losses, soil erosion, and water runoff (Wallace et al., 1999; Stigter et al., 2002; Lin et al., 2008). Agroforestry BMPs have also been shown to mitigate fluctuations of temperature and humidity that can be harmful to crops (Beer et al., 1998; Klein et al., 2003). These results indicate that certain ecologically-motivated land and crop management techniques may well buffer against hazards for small-scale farmers. However, despite the recognized role of ecosystems in DRR, adoption of such ecosystem-based approaches has been slow and realized generally at a small scale (Renaud et al., 2013).

Some concerns exist about the efficacy of some BMPs for risk reduction. Cammeraat et al., 2005 and Sidle et al., 2006 find that poorly designed terracing can decrease slope stability, thereby increasing risk of landslides and soil erosion. Contour terracing cannot prevent impacts from being realized on farmland when a landslide begins farther up the slope, though it does reduce the likelihood of a landslide beginning on the terraced land (Sivanpillai and Thurow, 2008). Further, some risk reduction techniques such as intercropping for pest management, have also shown inconsistent
results (Beer et al., 1998). However, taken together, results indicate that the agricultural practices associated with CA and SLM offer the greatest potential for risk reduction, especially under conditions of future climate change (Lin et al., 2008a).

In the context of risk reduction, research on BMP adoption has identified risk perception, access to material resources, and the use of local knowledge and experience as important factors driving behavioral responses for disaster risk reduction (Burton et al., 1993; Wisner et al., 2004; Gaillard and Mercer, 2012). Belief in the efficacy of the particular BMP in addressing the risk also enhances adoption likelihood, reflecting individual’s response to reassurance that their actions may reduce the probability of hazard occurrence (Maddux and Rogers, 1983). Barriers to adoption have been identified as a perceived lack of responsibility, insufficient individual material or economic capacity, and the combination of high perceived threat with low perceived self-efficacy (Martin et al., 2009; López-Marrero and Tschakert, 2011; Bubeck et al., 2013; McCaffrey et al., 2013). However, the relationships among these factors and their relative importance in the context of overlapping hazards are not well understood as most studies of BMPs for risk reduction focus on a single hazard (e.g., Gaillard, 2007 for volcanoes; Neale and Weir, 2015 review of floods and wildfire; Rufat et al., 2015 for floods).

### 3.2.2 BMP adoption for agricultural productivity

BMPs are also associated with gains in agricultural productivity, an outcome thought to contribute to improvements in economic, social, and environmental well-being. Motivated by the assumption that traditional or conventional agricultural practices
are neither environmentally nor economically optimal, programs that promote conservation agriculture (CA) and other sustainable agriculture practices (SAPs) like agroforestry aim to achieve sustainable agricultural intensification through the harnessing of ecosystems services and improving soil fertility (Kassam et al., 2009; Tey and Brindal, 2012; Tey et al., 2014). Though they differ in the precise combination of recommended BMPs, interventions for SAPs tend to encourage some changes in input management (e.g. limited fertilizer and pesticide treatments, organic manure, integrated pest management), crop management (e.g. intercropping, mulching or cover crop maintenance, crop rotation, agroforestry), and land management (contours, trenches, low or no tillage) (Tey et al., 2014).

A rich body of research examines the factors that facilitate and constrain the adoption of BMPs associated with SAPs. Within the agricultural economics literature, many studies have used logistical regression models to examine the correlation of BMP adoption with a variety of socio-economic, biophysical, and external factors. In their meta-analysis of 31 such studies of BMP adoption for CA, Knowler and Bradshaw (2007) find that no single set among these factors universally explains BMP adoption.

By integrating perspectives from multiple disciplines, BMP adoption has been linked to institutional support and participation in farmers’ groups, as well as by access to high quality training and information, a set of factors that become more important as the complexity of the BMP increases (Tey et al., 2014). In their review paper, Pannell et al. (2006) found that not only did access to this information matter, but trust in and proximity to the source of the information were also significant predictors of adoption. In
contrast, they find that adoption may be constrained by low financial resource availability and encouraged by financial and land wealth, though the relationship between income and adoption may not be linear.

The characteristics of the target BMP also influence adoption rates. The likelihood of adoption increases as BMPs are recognized as having comparative advantage, especially with regard to producing short-term productivity gains, having low cost of implementation, and being compatible with current practices (Pannell et al., 2006). Conversely, the low comparative advantage or perceived incompatibility of a BMP with current practices were barriers to adoption (Reimer et al., 2012). The barrier to adoption of CA BMPs most commonly cited by farmers in another study was capacity, especially with respect to access to extension services and income (Baumgart-Getz et al., 2012).

3.2.3 Combined risk-benefit framework

The key role of knowledge in facilitating hazard management (White et al., 2001) and the adoption of agricultural BMPs (Baumgart-Getz et al., 2012) suggests that DOs have the potential to influence BMP adoption in both arenas independently and, combined, even more so (Alcántara-Ayala, 2015). Historically, risk reduction and economic development have been treated as separate issues in the literature and in practice (IEG-World Bank, 2006; Schipper and Pelling, 2006). This gap in cooperative effort may stem from stakeholder distrust or misperception of shared interests (Gaillard and Mercer, 2012). Recent partnerships such as the Partners for Resilience, which brings
together risk reduction agencies with traditional development agencies, demonstrate complementarity of these approaches and have achieved some success in promoting solutions in developing countries (Girot, 2014). We currently lack knowledge about the relative efficacy of risk reduction vs. agricultural development interventions for promoting BMP adoption and/or how combined approaches can shape adoption.

In this paper, we address gaps in our understanding of the role of DOs BMP adoption in a set of communities subject to overlapping risk reduction and development interventions. In doing so, we add a richer understanding of the uptake of BMPs in a developing context by simultaneously looking at multiple risks and multiple BMPs to plum the relative importance of risk characteristics versus BMP characteristics in driving adoption.

3.3 Study Area

The study districts, Bududa and Manafwa, of the Bugisu sub-region of Eastern Uganda are discussed in depth in Chapter Two (Table 1). The confluence of multiple hazards (Shi and Kasperson, 2015), social vulnerability (UNDP, 2013), and the presence of a number of DRR and development organizations makes Bududa and Manafwa compelling sites to investigate BMP adoption. The area is dominated by small-scale crop agriculture (staple crops are maize, beans, and bananas) supplemented with on-site animal husbandry, predominantly dairy cows and chickens.

Most development and risk reduction organizations active in the greater Bugisu area promote a common set of land and agricultural BMPs with a few points of divergence (e.g. the use of mineral, as opposed to organic, fertilizer). The most
commonly recommended BMPs include digging and planting contour hedgerows, planting trees, digging trenches, and intercropping (Table 6). These BMPs are the focus of our analysis.

<table>
<thead>
<tr>
<th>Description</th>
<th>Risks addressed</th>
<th>Production Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contour hedgerows</td>
<td>deep ditches are dug and their soil piled uphill and planted with trees or, more commonly, grasses that may later be used as fodder or mulch</td>
<td>Soil erosion, Landslides (indirectly), Water runoff/ floods</td>
</tr>
<tr>
<td>Tree-planting</td>
<td>Planting of seedlings of native and non-native trees</td>
<td>Soil erosion, Landslides</td>
</tr>
<tr>
<td>Trenches</td>
<td>Ditches (channels) are dug to provide a path for water to run through during rainstorms, often ending in a pit</td>
<td>Water speed/ Flooding, Drought, Soil erosion, Landslides</td>
</tr>
<tr>
<td>Intercropping</td>
<td>Planting more than one type of crop, interspersed on the same plot at the same time</td>
<td>Soil erosion (ground cover crops)</td>
</tr>
</tbody>
</table>

Table 6 Best management practices (BMP) descriptions, risk reduction and agricultural production targets, and the organizations and programs that promote them in the study area.

3.4 Methods

Our analysis simultaneously assesses the factors that shape the adoption of four BMPs across the Bugisu sub-region (Table 7). To investigate how farmer motivations, socio-economic factors, engagement with DOs, and the risk or benefit framing influences BMP adoption, we combine qualitative data collected through interviews with
development organizations and quantitative household data collected through a household survey in ten villages in the region (Table 2).

3.4.1 Organization interviews

We conducted 40 semi-structured interviews with program managers between 2012 and 2013. The interviews varied in the specific questions asked but all queried (a) the organization’s perspective on the risks facing farmers in the region, (b) the goal and approach of programs administered by the organization, and (c) the BMPs recommended by the organization. This data was used to build an understanding of the operation of DOs in the study area, to select villages and organizations for further study, and to inform the design of the household survey.

Interview respondents included program managers at over 20 organizations that have a consistent local presence in Bugisu, implement programs for risk reduction or agricultural development, and target either land management or environmental education as a key node of their programs and interventions.

Initial organizations and respondents were identified through database searches and contacts at the Uganda Red Cross Society. Additional contacts were identified through snowball sampling, whereby initial respondents were asked to recommend other potential participants. By the end of these interviews, no relevant organizations were suggested that were not already accounted for.
<table>
<thead>
<tr>
<th>Organization</th>
<th>Broad goal</th>
<th>Associated village</th>
<th>Approach</th>
<th>BMPs promoted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee-A-Cup</td>
<td>Agricultural</td>
<td>Bushibuya</td>
<td>Educates and provides market support for coffee growing and selling.</td>
<td>Contouring</td>
</tr>
<tr>
<td></td>
<td>development</td>
<td></td>
<td></td>
<td>Tree-planting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Trenching</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Intercropping</td>
</tr>
<tr>
<td>District Environment Office</td>
<td>Risk reduction</td>
<td>Bunasaba</td>
<td>Boost the adoption of planted contours for reduced landslide and soil</td>
<td>Contouring</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>erosion in a particular village.</td>
<td>Tree-planting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Trenching</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Intercropping</td>
</tr>
<tr>
<td>Mbale Farmers Association</td>
<td>Agricultural</td>
<td>Buwabusera</td>
<td>Links village farmer groups to materials, programs, and trainings at</td>
<td>Contouring</td>
</tr>
<tr>
<td></td>
<td>development</td>
<td></td>
<td>higher levels.</td>
<td>Tree-planting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Trenching</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Intercropping</td>
</tr>
<tr>
<td>National Agricultural Advisory</td>
<td>Agricultural</td>
<td>All</td>
<td>Provides training and materials for agricultural development and</td>
<td>Contouring</td>
</tr>
<tr>
<td>Service (NAADS)</td>
<td>development</td>
<td></td>
<td>modernization</td>
<td>Tree-planting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Trenching</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Intercropping</td>
</tr>
<tr>
<td>Red Cross</td>
<td>Risk reduction</td>
<td>Bushibuya, &amp;</td>
<td>Provides training on flood, landslide, and soil erosion mitigation.</td>
<td>Tree-planting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bunakomola</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Send-A-Cow</td>
<td>Agricultural</td>
<td>Shiruku</td>
<td>Educates people on animal husbandry and other on-farm income-generating</td>
<td>(other)</td>
</tr>
<tr>
<td></td>
<td>development</td>
<td></td>
<td>activities</td>
<td></td>
</tr>
<tr>
<td>Spark Microgrants</td>
<td>Risk reduction</td>
<td>Buwangota</td>
<td>Finances and mentors community-driven projects related to health and</td>
<td>(other)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>development</td>
<td></td>
</tr>
<tr>
<td>Technoserve</td>
<td>Agricultural</td>
<td>Bumwangu</td>
<td>Educates people on growing and marketing passion fruit</td>
<td>(other)</td>
</tr>
<tr>
<td></td>
<td>development</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7 Target organizations. Organizations whose programs were assessed in the target villages, with information on the goal and target BMPs of the organizations, as well as the total percentage of our 423 households reached by the organization.

3.4.2 Village selection

Based on our interviews, we identified seven organizations for further study and used insights from these organizations to select the ten study villages (Table 7). Each of the focal organizations targets on-farm land management practices and has a strong
presence on the ground in study districts. To select study villages, we asked each organization to identify a village that represents the “best case scenario” of their program implementation. By including only those best case scenarios, we focus on a ‘successful’ example where influence of DO is likely to be highest. Eight study villages were selected in this way (two villages are associated with the Red Cross). Two additional villages that did not have active interventions were selected as controls. In addition to the seven focal organizations, the government agricultural extension service (NAADS) is active in all villages studied.

3.4.3 Household Survey

We collected data on farmers’ adoption of BMPs, risk perceptions, interactions with DOs, and household demographics through a household survey (Table 8). Survey data was collected in 2013 from the ten study villages (Table 7; n = 423; coverage from 11-100% in each village).

In each village, households were selected from a comprehensive list obtained from the elected village chairperson. In villages in which DOs target only a sub-population of the village, the sample was stratified to include 10 households program managers identified as recipients of DO services and a random selection of 45 households. The stratification ensured that the sample included households that have worked with the focal organizations. In all other villages, 55 households were selected randomly from the master list.
Table 8 Description of key explanatory variables in the logistic regressions

<table>
<thead>
<tr>
<th>Explanatory variable</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
</table>
| Risk perception index (RPI) | a combination of three individual survey response variables (perceived likelihood, perceived severity, and general concern of the hazard) | \[ R_{i,j} = \frac{1}{2} \left( \left( \frac{\alpha_{i,j} \ast \beta_{i,j}}{3} \right) + \delta_{i,j} \right) \]

For a given hazard \( i \) for respondent \( j \) RPI is the mean of the respondent’s stated concern \( \delta \) and their calculated concern. Calculated concern scales perceived severity \( \beta \) by stated likelihood \( \alpha \) expressed as a probability; \( \alpha, \beta, \) and \( \delta \) on a scale from 0 - 3.

| Farmland characteristics | Ownership of land, cultivation of any land on the hillside (sloped) areas, and farmland fragmented into more than one contiguous piece | 1 = owned land, 0 = leased; 1 = cultivated on the hillside, 0= valley/flat land only 1 = land fragmented; 0 = single contiguous holding |
| Household assets | Total acreage, log of income, total number of adults (18 years and over) in household | Given values and their log transformed values in the case of income |
| Village | Village in which household was located | Ten villages numbered 1-10; categorical variable |
| BMP training | For those who received training from a DO that runs programs actively advocating the particular BMP | 1 had exposure to training; 0 no training |

3.4.4 Statistical methods

Statistical analyses were performed on survey data to investigate the links between the adoption of BMPs, risk perception, and household demographics, and to assess the degree to which these variables are linked to smallholder farmers' relationships with development and risk reduction programs. Student’s two-sided t-tests were performed to determine if BMP adoption rates differed among beneficiaries and non-beneficiaries within villages and in the broader study sample. To account for a representative set of effect variables on the rates of adoption, we ran a series of multivariate regressions against the adoption of our target BMPs. Four binary variables
were generated to represent adoption of the four target BMPs by survey respondents. These were used as dependent variables in a series of multivariate logistic regressions (logit models), along with eleven explanatory variables expected to influence BMP adoption decisions.

To interpret the results, we calculated the odds ratio value for each explanatory variable. The odds ratio indicates the change in the likelihood of adoption based on a unit change in the explanatory variable, holding all other variables constant. Odds ratios greater than one indicate that increases in the explanatory variable correspond to a higher likelihood of adoption, while odds ratios between zero and one indicate that as the explanatory variable increases, the likelihood of adoption decreases. The eleven explanatory variables in the logistic regressions include an index of risk perception, household capital resources, farmland characteristics, a categorical variable for the village of residence, and a binary variable indicating that the respondent received training on the target BMP.

To avoid issues with multicollinearity and to partially address concerns of the endogeneity of household variables with DO engagement, a correlation matrix among all explanatory variables was generated and examined for high correlations (APPENDIX III). All correlation coefficients were less than 0.4, while values of 0.8 or more are associated with problems of collinearity (Field, 2009). While this does not preclude any influence of endogeneity, it does indicate that the effect of any endogeneity is not likely to be large. To make sure that the effects of these correlating variables are not wholly endogenous to the effect of DO engagement, they are both included in all analyses of
BMP adoption that also include DO engagement as a predictive variable. In that way, the results more closely reflect the additional effect of DO engagement above and beyond the effect of those endogenous variables that may initially contribute to DO engagement.

Individual logistic regressions were initially run for each of the four target BMPs using all eleven explanatory variables, varying the risk perception index for all hazards thought to be addressed by the BMP, resulting in ten logit model runs. Variables that were non-significant in all regression analyses were removed from subsequent models, while all explanatory variables that were significant in at least one regression were included in all subsequent logit models for each BMP. An overview of these variables is provided in Table 8. Ownership of the cultivated land (as opposed to leasing or renting) was excluded as an explanatory variable as 411 respondents out of 423 were owners, representing 97% of the sample.

3.5 Results

Across our study sample, farmers adopted the four target BMPs at relatively high rates ranging from a low of 58% for trenches (n=232) to a high of 71% for intercropping (n=276), with contouring (61%, n=242) and tree-planting (68%, n=264) in between. Overall, 84% of respondents reported using at least one of the target BMPs, with 20% having adopted all and only 14% adopting only one.

3.5.1 The influence of DOs and risk vs. benefits motivations for adopting BMPs

Overall, 69% of surveyed households self-identified as a DO beneficiary (i.e. a household that has received training or materials from a named organization). The largest
beneficiary group, 45% of surveyed households, comprised those who had received training or material inputs from the Uganda National Agricultural Advisory Extension Service, NAADS. The smallest beneficiary cohort were beneficiaries of the local coffee cooperative, Coffee-A-Cup, and comprised 9 households or 2% of the sample (Table 7). Beyond this, there was also a great deal of overlap in this sample, with 39% of beneficiaries having interacted with 2 or more organizations of interest.

DO activities were not always associated with significantly different adoption rates (Table 9). We assessed the relationship between BMP adoption and engagement with DOs that actively promote those BMPs in particular villages. BMP adoption rates were compared between self-identified beneficiaries of organizations that promoted the BMP, and non-beneficiaries within the same village. In the case of NAADS, all villages were included in the analysis. Beneficiaries had higher rates of adoption in two of five cases for contouring, in two of the seven cases for tree planting, and in one of three cases where trenches were promoted. Engagement with organizations was not a significant predictor of intercropping in any village. Significant differences were only found for a single BMP per DO, regardless of how many BMPs that organization promoted.

Some organizations, like NAADS, focus almost entirely on the benefit motivations of BMP adoptions, reflecting their mission “to increase farmers’ access to information, knowledge and technology for profitable agricultural production”. Others, like the Red Cross, are primarily driven to mitigate risks in their target populations. To assess which motivational base produced the stronger effect, we identified a sub-population of adopters that received training from both benefits-focused and risks-
focused organizations. For this subpopulation, those who adopted contours and trenches were motivated by risk-aversion in 69% and 59% of cases respectively, while risk-aversion only motivated 17% of tree planters and none who intercropped, a group who was motivated entirely by benefit-seeking. These differences in motivation indicate that adoption may have less to do with the specific message of the DO and more to do with the characteristics of the BMP itself, though benefit-seeking is the more common motivator overall.

<table>
<thead>
<tr>
<th>Village</th>
<th>Beneficiary %</th>
<th>Contour</th>
<th>Tree</th>
<th>Trench</th>
<th>Intercrop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Cross</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bushibuya</td>
<td>31%</td>
<td>+ (0.06)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shiruku</td>
<td>28%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAADS</td>
<td></td>
<td></td>
<td></td>
<td>+ (0.01)</td>
<td></td>
</tr>
<tr>
<td>District</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environment Office</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bunasaba</td>
<td>19%</td>
<td>+ (0.06)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bumwangu</td>
<td>15%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mbale Farmers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buwabusera</td>
<td>43%</td>
<td>+ (0.06)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coffee-A-Cup</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bushibuya</td>
<td>11%</td>
<td>+ (0.04)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Send-A-Cow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shiruku</td>
<td>41%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spark Microgrants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buwangota</td>
<td>51%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technoserve</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bumwangu</td>
<td>41%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9 T-test results for BMP adoption and beneficiary status. Results of a two-sided Student's t-test of differences in mean adoption of a given BMP within the village based on groupings by beneficiary status of focal DOs. P-values reported only in cases of significance (p < 0.1) Gray shading indicates BMPs not actively promoted by DO. Note: Send-A-Cow, Spark Microgrants, and Technoserve all have programs in the area but do not actively promote the BMPs examined in this study.

DOs also differ in their use of material inputs in combination with training, which affects uptake rates. NAADS provides both training and material inputs, with 63% of NAADS beneficiaries having received farm goods such as hoes, spades, and seeds in addition to training for contours. A similar pattern is reflected for the 263 adopters of trees, for which NAADS provided 51% of its trainees with additional material inputs. This trend of training associated with material assistance holds true for the other organizations analyzed (District Environment Office, Red Cross, Mbale Farmers...
Association, and Coffee-A-Cup). Those adopters who credit these organizations for their training also report having received agricultural inputs from their trainers 14% to 100% of the time, depending on the BMP and DO considered.

3.5.2 The relative importance of DOs, risk perception, and other socio-economic factors on BMP adoption

To understand the interaction of DO activities, risk perception, and other socio-economic factors in shaping BMP adoption, we conducted a series of multivariate logistic regressions. We find that no single factor consistently drives adoption across all BMPs, though meaningful patterns are present.

<table>
<thead>
<tr>
<th>Explanatory variable</th>
<th>Odds Ratio</th>
<th>Std. Err.</th>
<th>[95% Conf. Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landslide RPI</td>
<td>1.451</td>
<td>0.220</td>
<td>1.077</td>
</tr>
<tr>
<td>Farm acreage</td>
<td>0.889</td>
<td>0.272</td>
<td>0.488</td>
</tr>
<tr>
<td>Log income</td>
<td>1.071</td>
<td>0.126</td>
<td>0.851</td>
</tr>
<tr>
<td># adults</td>
<td>1.253</td>
<td>0.118</td>
<td>1.043</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>1.287</td>
<td>0.417</td>
<td>0.681</td>
</tr>
<tr>
<td>Sloped land</td>
<td>1.386</td>
<td>0.450</td>
<td>0.733</td>
</tr>
<tr>
<td>Village</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bunasaba</td>
<td>1.000</td>
<td></td>
<td>(empty)</td>
</tr>
<tr>
<td>Buwabusera</td>
<td>1.715</td>
<td>0.890</td>
<td>0.620</td>
</tr>
<tr>
<td>Bushibuya</td>
<td>2.136</td>
<td>1.414</td>
<td>0.584</td>
</tr>
<tr>
<td>Bunamutunyi (control)</td>
<td>2.403</td>
<td>1.330</td>
<td>0.812</td>
</tr>
<tr>
<td>Bunamalishe</td>
<td>13.839</td>
<td>10.737</td>
<td>3.025</td>
</tr>
<tr>
<td>Shiruku</td>
<td>0.837</td>
<td>0.513</td>
<td>0.252</td>
</tr>
<tr>
<td>Bumwangu</td>
<td>0.502</td>
<td>0.295</td>
<td>0.159</td>
</tr>
<tr>
<td>Buwangota</td>
<td>0.734</td>
<td>0.504</td>
<td>0.191</td>
</tr>
<tr>
<td>Bunakomola</td>
<td>0.949</td>
<td>0.669</td>
<td>0.238</td>
</tr>
<tr>
<td>Sirumbusa (control)</td>
<td>1.000</td>
<td></td>
<td>(omitted)</td>
</tr>
<tr>
<td>Contour training</td>
<td>1.847</td>
<td>0.560</td>
<td>1.020</td>
</tr>
<tr>
<td>Constant</td>
<td>0.089</td>
<td>0.071</td>
<td>0.019</td>
</tr>
</tbody>
</table>

M-Z $R^2$ = 0.307 ***

Table 10 Logit results for contour adoption. Complete model predicting the adoption of contours when considering landslide risk (n=272). * p-value < .05, ** p-value < .01, *** p-value < .001.
### Table 11 Logit results for tree-planting. Complete model predicting the adoption of trees when considering landslide risk (n=279). * p-value < .05, ** p-value < .01, *** p-value < .001.

<table>
<thead>
<tr>
<th>Explanatory variable</th>
<th>Odds Ratio</th>
<th>Std. Err.</th>
<th>[95% Conf. Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landslide RPI</td>
<td>0.966</td>
<td>0.146</td>
<td>0.718</td>
</tr>
<tr>
<td>Farm acreage</td>
<td>1.903</td>
<td>0.745</td>
<td>0.884</td>
</tr>
<tr>
<td>Log income</td>
<td>1.549***</td>
<td>0.193</td>
<td>1.213</td>
</tr>
<tr>
<td># adults</td>
<td>1.070</td>
<td>0.095</td>
<td>0.900</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>1.652</td>
<td>0.518</td>
<td>0.893</td>
</tr>
<tr>
<td>Sloped land</td>
<td>1.356</td>
<td>0.476</td>
<td>0.682</td>
</tr>
<tr>
<td>Village</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bunasaba</td>
<td>10.445**</td>
<td>7.512</td>
<td>2.551</td>
</tr>
<tr>
<td>Buwabusera</td>
<td>2.055</td>
<td>1.095</td>
<td>0.723</td>
</tr>
<tr>
<td>Bushibuya</td>
<td>3.327</td>
<td>2.252</td>
<td>0.883</td>
</tr>
<tr>
<td>Bunamutunyi (control)</td>
<td>3.419*</td>
<td>1.950</td>
<td>1.118</td>
</tr>
<tr>
<td>Bunamalishe</td>
<td>5.507*</td>
<td>3.631</td>
<td>1.512</td>
</tr>
<tr>
<td>Shiruku</td>
<td>8.571**</td>
<td>5.780</td>
<td>2.286</td>
</tr>
<tr>
<td>Bumwengu</td>
<td>3.806*</td>
<td>2.166</td>
<td>1.247</td>
</tr>
<tr>
<td>Buwangota</td>
<td>1.096</td>
<td>0.769</td>
<td>0.277</td>
</tr>
<tr>
<td>Bunakomola</td>
<td>1.000</td>
<td>(empty)</td>
<td></td>
</tr>
<tr>
<td>Shirumbusa (control)</td>
<td>1.000</td>
<td>(omitted)</td>
<td></td>
</tr>
<tr>
<td>Tree training</td>
<td>1.388</td>
<td>0.425</td>
<td>0.761</td>
</tr>
<tr>
<td>Constant</td>
<td>0.013***</td>
<td>0.011</td>
<td>0.002</td>
</tr>
</tbody>
</table>

M-Z R² = 0.290 ***

### Table 12 Logit results for the use of trenches. Complete model predicting the adoption of trenches when considering flood risk (n=309). * p-value < .05, ** p-value < .01, *** p-value < .001.

<table>
<thead>
<tr>
<th>Explanatory variable</th>
<th>Odds Ratio</th>
<th>Std. Err.</th>
<th>[95% Conf. Interval]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood RPI</td>
<td>1.916***</td>
<td>0.276</td>
<td>1.445</td>
</tr>
<tr>
<td>Farm acreage</td>
<td>0.860</td>
<td>0.254</td>
<td>0.483</td>
</tr>
<tr>
<td>Log income</td>
<td>0.905</td>
<td>0.106</td>
<td>0.719</td>
</tr>
<tr>
<td># adults</td>
<td>1.251*</td>
<td>0.117</td>
<td>1.041</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>2.034*</td>
<td>0.659</td>
<td>1.078</td>
</tr>
<tr>
<td>Sloped land</td>
<td>0.277***</td>
<td>0.098</td>
<td>0.138</td>
</tr>
<tr>
<td>Village</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bunasaba</td>
<td>11.631**</td>
<td>8.372</td>
<td>2.837</td>
</tr>
<tr>
<td>Buwabusera</td>
<td>1.486</td>
<td>0.802</td>
<td>0.516</td>
</tr>
<tr>
<td>Bushibuya</td>
<td>1.099</td>
<td>0.643</td>
<td>0.349</td>
</tr>
<tr>
<td>Bunamutunyi (control)</td>
<td>1.886</td>
<td>1.113</td>
<td>0.593</td>
</tr>
<tr>
<td>Bunamalishe</td>
<td>8.817**</td>
<td>6.365</td>
<td>2.142</td>
</tr>
<tr>
<td>Shiruku</td>
<td>1.533</td>
<td>0.966</td>
<td>0.446</td>
</tr>
<tr>
<td>Bumwengu</td>
<td>3.455*</td>
<td>2.062</td>
<td>1.072</td>
</tr>
<tr>
<td>Buwangota</td>
<td>4.559*</td>
<td>2.803</td>
<td>1.366</td>
</tr>
<tr>
<td>Bunakomola</td>
<td>3.919*</td>
<td>2.450</td>
<td>1.151</td>
</tr>
<tr>
<td>Shirumbusa (control)</td>
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<td>(omitted)</td>
<td></td>
</tr>
<tr>
<td>Trench training</td>
<td>1.611</td>
<td>0.471</td>
<td>0.908</td>
</tr>
<tr>
<td>Constant</td>
<td>0.191*</td>
<td>0.160</td>
<td>0.037</td>
</tr>
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</table>

M-Z R² = 0.352 ***
Table 13 Logit results for the use of intercropping. Complete model predicting the adoption of intercropping when considering soil erosion risk (n=262). * p-value < .05, ** p-value < .01, *** p-value < .001.

<table>
<thead>
<tr>
<th>Explanatory variable</th>
<th>Odds Ratio</th>
<th>Std. Err.</th>
<th>[95% Conf. Interval]</th>
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<tbody>
<tr>
<td>Soil erosion RPI</td>
<td>0.676(p=0.058)</td>
<td>0.139</td>
<td>0.451</td>
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<tr>
<td>Farm acreage</td>
<td>1.502</td>
<td>0.556</td>
<td>0.727</td>
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<tr>
<td>Log income</td>
<td>1.769***</td>
<td>0.246</td>
<td>1.347</td>
</tr>
<tr>
<td># adults</td>
<td>0.858</td>
<td>0.085</td>
<td>0.706</td>
</tr>
<tr>
<td>Fragmentation</td>
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<td>0.190</td>
<td>0.228</td>
</tr>
<tr>
<td>Sloped land</td>
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<td>0.376</td>
<td>0.458</td>
</tr>
<tr>
<td>Village</td>
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<td></td>
<td>(empty)</td>
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<tr>
<td>Buwabusera</td>
<td>1.709</td>
<td>1.102</td>
<td>0.483</td>
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<td>Bushibuya</td>
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</tr>
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<td>0.559</td>
</tr>
<tr>
<td>Bunamalisehe</td>
<td>6.184(p=0.053)</td>
<td>5.828</td>
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</tr>
<tr>
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<td>Bumwangu</td>
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<td>Buwangota</td>
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<td>0.513</td>
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<tr>
<td>Bunakomola</td>
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<td>14.608</td>
<td>1.333</td>
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<tr>
<td>Sirumbusa (control)</td>
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<td>(omitted)</td>
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<tr>
<td>Intercropping training</td>
<td>1.257</td>
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</tr>
<tr>
<td>Constant</td>
<td>0.332</td>
<td>0.323</td>
<td>0.049</td>
</tr>
</tbody>
</table>

M-Z R² = 0.339 ***

3.5.3 Adoption of contour hedgerows

Table 10 shows the results of the logistic regression analysis for the adoption of contour hedgerows. Overall, the model is very significant (p < 0.001) and has a McKelvey-Zavoina pseudo-R² of 0.307, which while not directly analogous to the R² of an ordinary least square result, has been found to be the most comparable in its indication of model fit (Hagle and Mitchell, 1992). Using a 5% cutoff for significance we find that risk perception of landslides, total number of adults in the household, the village of residence, and exposure to training on contours contribute significantly to explaining contour adoption. The odds ratio of Landslide RPI indicates that those who perceive higher risk of landslide are much more likely to use contours than are their less concerned neighbors (p=0.014). With each 1-point increase in the RPI, which varies from 0 to 4, the
odds of the farmer adopting contours increase by 45%. This indicates that a person’s perception of landslide threat does influence their decision to adopt a strategy intended to reduce hazard likelihood over time.

Greater access to labor resources, as indicated by the number of adults in the household, is also associated positively with adoption rates. With each additional adult, the odds of households adopting contours increases by 25%. This demonstrates the importance of labor capital in BMP adoption.

Village of residence was significant in only one case—for Bunamalishe, where the odds of adoption were nearly 14 times that of the reference village, Silumbusa (Table 10). Bunaalishe is one of the hilliest villages in our sample, a characteristic associated with landslides, soil erosion, and flooding that contours combat. Even accounting for hilly terrain and landslide risk perception directly, as is done in this model however, changing a farmer’s village of residence can increase adoption likelihood, indicating that some factor other than the topography of the village is driving its residents to adopt contour hedgerows as a BMP.

3.5.4 Adoption of tree-planting

Table 11 shows the results of the logistic regression analysis for the adoption of tree-planting when considered in the context of landslide risk perception. Overall, the model is very significant (p < 0.001) and has a McKelvey-Zavoina pseudo-$R^2$ of 0.290, a reasonable outcome in a behavioral context. Using the same 5% level for accepting
significance, income is the single most important factors influencing adoption, along with village of residence.

Income was significantly correlated with the adoption of tree-planting. A 10% increase in income corresponds to a 55% increase in the odds of tree-planting. Investment in trees is closely related to household income. In fact, using only log-adjusted income as an explanatory variable, over 70% of the variability in investment in tree-planting is explained (p < 0.001). This result might reasonably be expected, given that the use of trees is associated with not only higher yields of the same crops, but trees are also generally found in conjunction with higher value products (e.g. coffee and timber).

Village of residence was also a significant factor in this model in the case of five of the ten villages (Table 11). Given the many and varied benefits associated with the planting of trees in both the reduction of risks on hillsides and along waterways as well as in the production of market goods (Table 6), the difference in adoption rates among villages might be accounted for in any number of ways.

3.5.5 Adoption of trenches

Table 12 shows the results of the logistic regression analysis for the adoption of trenches when considered in the context of flood risk perception. Overall, the model is very significant (p < 0.001) and has a McKelvey-Zavoina pseudo-$R^2$ of 0.309, representing good power in a behavioral context. Using the same level for accepting significance (p < 0.05), we find that risk perception plays a very important role in adoption. With respect to capital assets, only labor is significant, while both of the
included farm land characteristics, land fragmentation and cultivation on the slope, are also significant. Again, we find that village of residence plays an important role in adoption.

A greater perceived risk of flooding, as reflected in higher flood RPI values, corresponds with a significant and greatly increased likelihood of trench adoption, with a one unit increase in perceived risk resulting in a 92% increase in the odds of adoption. This tendency is offset for households farming on the slopes of Mount Elgon, whose odds of adopting trenches are one nearly one quarter of those who are not on the slopes, even keeping flood risk perception constant. This indicates that valley dwellers are more likely to adopt trenches, which corresponds to the cultivation of lowlands and floodplains. Interestingly, the odds of adopting trenches by those who cultivate multiple non-contiguous parcels (those with fragmented land) is over two times higher than those with a single, continuous parcel. Household resources were also important. Labor availability, as represented by number of adults in the household, plays an important role in determining trench adoption, though material resources such as income and acreage are not significant.

3.5.6 Adoption of intercropping

Table 13 shows the results of the logistic regression analysis for the adoption of trenches when considered in the context of flood risk perception. Like the previous model, the model for intercropping is very significant (p < 0.001) and has a McKelvey-Zavoina pseudo-\(R^2\) of 0.339, a good model for a behavioral variable. Using a 5%
significance cutoff (p < 0.05), we find that log-adjusted income and certain villages correspond with higher rates of intercropping adoption, while both perceived risk of soil erosion is marginally significantly and negatively associated with adoption.

Intercropping is positively associated with log-adjusted stated income, with a 10% increase in income corresponding to a 77% increase in the odds of adoption (p<0.001). Risk perception, so important in driving adoption in the case of trenches and contours, was nearly significantly (p=0.058) and inversely related to adoption. Intercropping is unlikely to be the tool of choice in reducing risk to soil erosion. In two villages, Bushibuya and Bunakomola, the odds of residents adopting intercropping were 5 and 13 times higher than the reference village of Silumbusa, indicating that, all other factors being equal, the residents of some villages are more likely to adopt than their neighbors in another town.

3.5.7 Comparison

There was no single factor, beyond the importance of some villages, which was significant in determining the adoption of all BMPs in this study. There are, though, patterns that link BMPs together, pairing land management BMPs (contours and trenches) and crop management BMPs (tree-planting and intercropping). Labor resources and risk perception are important for contouring and trench-digging, the more labor-intensive strategies of our sample. Labor resources may act as a capital constraint for these strategies. This is reflected in the responses of non-adopters to the question “why is it that you don’t use this strategy?” A lack of time and energy played a much greater role
for these than it did for either tree-planting or intercropping (Figure 6). The next most common constraint was motivation, which aligns well with the substantial and significant role that risk perception plays as a motivating factor in the adoption of land management BMPs. This lack of motivation could also be explained in part by the existence of alternatives for contouring and trenches. Of the 26 respondents who lacked motivation for contouring, 19 (73%) adopted an alternative strategy that met one or more of the benefit targets sought from contours. In the case of trenches, of the 47 non-adopters citing a lack of motivation, 42 (89%) pursued alternative strategies. In both cases, a similar motivational profile also occurs. For both trenches and contours, the stated primary motivations for adoption were soil conservation and soil fertility, representing 55% and 70% of adopters respectively. These motivations reflect a mitigated risk of soil erosion. Reduction of landslide and flooding risk motivated 12% of trench and 4% of contour adopters.

For tree-planting and intercropping, the crop management BMPs, neither labor resources nor risk perception played a significant role in explaining adoption rates. Instead, material resources in the form of income ranked among the most important factors. For both of these high-income strategies, benefit-seeking, as opposed to risk avoidance plays a more important role in determining adoption, and may also be reflected in the outcomes of adoption. A common intercropping technique, in fact, is in the combination of banana and coffee, the latter being one of the premier commodity and export crops in the region (Mugagga et al., 2012). Trees are often also planted with coffee to provide shade. Tree-planting is the only BMP we studied for which material resources,
rather than knowledge resources, were the greatest barrier to adoption, with 59% of non-users falling into this category.

For all other BMPs, the principal factor constraining adoption was a lack of knowledge. Farmers cited this lack, claiming that they “hadn’t been informed [of]”, “didn’t understand”, or “didn’t have the knowledge to use” the BMP. This category of responses accounted for between 35% (tree-planting) to over 60% (intercropping) of responses. As with land management BMPs, crop management practices also showed a distinct motivational profile. Trees and intercropping were both motivated by direct increases in income (11% and 14%), and material gains either through crop productivity (66% of intercropping adopters) or timber and firewood harvesting (36% tree-planting adopters). In addition to these benefit-seeking motivations, there were a small number of adopters who were motivated by risk avoidance. For 12% of those who planted trees, reducing risks of flooding, landslides, drought, or windstorms was of primary importance. Fewer than 6% of intercroppers were motivated by risk reduction.

Village of residence, all else being equal, still had a significant and in some cases substantial difference to the odds of a farmer adopting any of our target BMPs, with differences in adoption rates significantly different among villages, a result reflected in a separate ANOVA of adoption rates by village. Since topography and risk perception are accounted for by other explanatory variables included in the models, as are an individual household’s capital resources, some other characteristic of each village must have its own independent role in influencing adoption within its borders.
3.6 Discussion

3.6.1 Adoption influenced by risk perception, knowledge, and material constraints

We find that BMP adoption is influenced by both risk-avoidance and benefit-seeking motivations, as well as material constraints, though the balance of these factors differs depending on the BMP. For contours and trenches, labor constraints and risk avoidance play important roles; while tree-planting and intercropping are more closely tied with income as both a motivator and constraint. Our findings support past work in demonstrating that there is not one set of predictors that consistently or universally explain adoption, even when considering a BMP in response to a particular risk (Knowler
and Bradshaw, 2007). Further, these results contribute to the body of evidence that risk perception is an important factor in adopting risk management strategies (Burton et al., 1993).

Risk perception alone does not determine adoption and cannot be assessed in isolation from other constraints. Knowledge of the nature, target, and implementation of the BMP can constrain adoption across all BMPs, even (and in some cases even more so) for farmers who have worked with DOs (Figure 6). This may be an indication of imperfect information being less beneficial than no information. Those who had received training, but did not adopt, more often cited insufficient knowledge as a barrier than did those who had received no training. While risk perception, motivation, and knowledge facilitate BMP adoption, the availability of resources can constrain adoption. These constraints occur at the household level, and may be exacerbated by social dynamics, factors that are in danger of being overlooked by interventions that emphasize non-contextualized knowledge transfer (Vanclay, 2004; Bezner Kerr, 2012). As has been found in other studies, our work supports the conclusion that, while the material costs of implementing land management and agroforestry strategies may seem low, especially when compared with commercial inputs, their costs of implementation are still too high for many vulnerable households to take on without assistance.

3.6.2 The role of DOs in BMP adoption: motivation, capacity building, and credibility

Our analysis indicates that the role of DOs in adoption is to motivate potential adopters by connecting BMPs to their livelihood goals, to empower motivated farmers
through training and material inputs, and to harness the power of co-benefits through targeted messaging.

Overall, we found that benefit seeking is a more frequent motivator of BMP adoption than risk avoidance, though the strength of this relationship varies by BMP. For crop management BMPs, benefit-seeking was consistently dominant, while the motivations were more evenly split when considering land management BMPs. This is reflected in the statistical relationship between the RPI and contour and trench adoption, as well as in adopters’ survey responses on adoption motivation. While risk avoidance and benefit accrual are co-benefits of each of our target BMPs, these motivations are differentially prioritized depending on the BMP.

As expected, adopters’ perceptions of the efficacy of these measures is high, though low perceptions of self-efficacy in implementation is a principle constraint on non-adopters (Maddux and Rogers, 1983). This indicates that while DOs may be achieving their goal of motivating farmers and linking a BMP to a desired outcome, there is still work to be done in building farmer belief in their knowledge and skill to implement each practice effectively. Responses to open-ended questions on the survey suggest that DOs can increase their effectiveness by combining training with material inputs is linked with adoption, reflecting the importance of resource access in reducing vulnerability (Wisner et al., 2004). Taken together with the frequencies with which material constraints were the barriers to adoption, it is clear that information from DOs is translated to action in a context of material resource availability.
This analysis indicates, too, that DOs may increase diffusion opportunities by targeting BMP advocacy to those farmers that do not actively seek DO training. This is especially true in cases where an organization is associated with a particular motivation that may not resonate with a subset of the population (e.g. risk avoidance). Since benefits appear to be more powerful motivators overall, risk reduction DOs should not rely on benefits-seeking farmers to seek out their services. Instead it may be more efficient to seek out non-adopters within target communities, and link what might be old ideas with ‘new’ benefits. All of the BMPs assessed here are associated with co-benefits. Populations of potential adopters who are not convinced by one motivation may be motivated by another. DOs may be able to harness the power of co-benefits to reach these populations.

3.6.3 Future Research needs

Results from this study raise additional questions related to BMP adoption in its relationship to income, quality of adoption, and a more detailed understanding of its relationship with risk perception.

Though income has a clear association with adoption of crop management BMPs, the direction of the relationship is unclear. While farmers with higher incomes may be in a position to invest in BMPs, they may also increase their income potential through the benefits derived from adoption. The relationship may also be associated with an untested third variable, in this case, growing coffee as a market crop, a practice generally associated with higher incomes. A longitudinal analysis that follows non-adopters
through a period of intervention and assesses baseline and outcome material assets, crop choices, and BMP adoption would be better positioned to address this issue of causality, and the potential feedback relationship between adoption and income.

The quality of BMP adoption also merits further inquiry. As in other studies, we treated BMP adoption as a dichotomous variable. However, BMP adoption falls along a spectrum ranging from no adoption to adoption that was both spatially complete and of high initial and maintained quality (e.g. Figure 7). BMP quality is relevant for those concerned with the environmental and economic outcomes of BMP adoption, but is seldom addressed directly (Baumgartz-Getz et al., 2012). When translating adoption into ecological, environmental, and risk reduction effect, the quality of adoption must be taken into account.

Figure 7 A sample of implemented strategies that were all considered by farmers to be contours, but which demonstrate marked variability in vegetative content, planted upper bounds, depth, and maintenance.

Finally, previous research suggests that the relationship between risk perception and protective actions is complex and multi-directional (Lindell and Perry, 2011). Though risk perception clearly plays a role in the adoption of at least the more labor-intensive BMPs, its relationship to both DO engagement and BMP adoption is not fully
addressed here. In this study, risk perception is taken as an independent variable, but the complex relationship between risk perception and risk management raises endogeneity concerns as predictor variables such as income, gender, and engagement with DOs can influence both risk perception (RPI) and management decisions (BMP adoption). Though the potential simultaneity of RPI and BMP adoption is addressed in Chapter 2, and the potential endogeneity of socioeconomic factors in DO engagement is partially addressed through the correlation analysis described in section 3.4.4, further work should use a combination of qualitative ethnographic and quantitative longitudinal analysis to tease apart the differential effects of socioeconomic and demographic characteristics on both DO engagement and BMP adoption.
CHAPTER FOUR: Mapping vulnerability: limitations and opportunities of participatory community mapping

4.1 Introduction

The impacts of global climate change on the populations and ecosystems of sub-Saharan Africa are expected to be severe. Heavy rainfall and extremely wet days are very likely to increase over the coming decades over much of East Africa (SREX, 2012), while extreme events related to the frequency and intensity of rainfall already result in severe losses of life and property for the communities in this region (IFRC, 2015; Munich Re, 2016). In Uganda alone, mass movement and flooding events related to high intensity rainfall resulted in the deaths of 705 people between 1990 and 2015 (EM-DAT, 2016).

The challenges accruing due to climate change and meteorological events interact with and build upon other types of vulnerability. Beyond their direct impacts on life and property, acute environmental hazards are a threat to development as they affect essential economic infrastructure by interrupting transport and communication lines, reduce household labor availability due to morbidity and mortality increases, and deplete economic savings that are redirected toward recovery (World Bank, 2003; Shreve and Kelman, 2014). In addition to acute shocks, related stresses like soil erosion, depleted soil fertility, and contamination, threaten and weaken livelihoods more chronically (Pender et al., 2006).

Hazard shocks and stresses, and their relationship to climate change and development are recognized by the international communities dedicated to assisting affected populations. The development community, through its declaration of the
Sustainable Development Goals, seeks to address disasters through building resilience, reducing exposure, and implementing resilient agricultural practices that increase productivity, maintain ecosystem health, and strengthen opportunities for climate change adaptation (UN, 2015). The intergovernmental panel on climate change (IPCC) acknowledges the role of economic development in increasing community response to climate change through adaptation efforts, while also recognizing the significant effect of anthropogenic climate change on hazard distribution in space, frequency, intensity, and duration (IPCC, 2014b). The hazards and DRR communities recognize the importance of development in providing coping capacity to at-risk populations (Schipper and Pelling, 2006).

Over the past decades, there has been increasing integration between DRR, development, and adaptation communities (Thomalla et al, 2006, Eakin and Luers, 2006). This has been followed with calls for further integration and a more holistic vision and assessment of vulnerability to natural hazards, across space and looking forward in time as communities respond, cope, and adapt to threats with all of the tools and approaches available (van Aalst et al., 2008).

Mapping offers a suite of tools for examining and visualizing vulnerability and assisting with the integration of development, adaptation, and resilience (O’Brien et al., 2004; McCall, 2008; van Aalst et al., 2008). Top-down large scale risk mapping and community-based participatory risk mapping have evolved over the past decades as useful tools with which to examine how vulnerability is distributed in space (Berz et al., 2001; IFAD, 2009). Top-down mapping excels at demonstrating large scale distribution
of hazards as well as rare and unprecedented hazards, but falls short in its capacity to represent DRR and adaptation activities on the ground at any meaningful scale (Frazier et al., 2009). It also falls short in its ability to represent small scale variability in vulnerability due to data limitations on the social components of vulnerability. In response to these challenges, and to give voice to the often underrepresented knowledge and viewpoints of vulnerable communities, community-based and participatory vulnerability evaluations arose (Wisner, 2006).

A variety of participatory tools seek to harness the power of local knowledge and action to better understand and address vulnerability where it is found (van Aalst et al., 2008). These efforts tend to be limited to single-hazard or primary-hazard assessments (e.g. Krishnamurthy et al., 2011; Cadag and Gaillard, 2012), and target a particular set of policies to address them (e.g., Piccolella 2013; Gaillard and Pangilinan, 2010). Few are designed to look at the spatial relationship between existing risk reduction and adaptation strategies (e.g., Valdivia et al., 2010).

This paper draws on fieldwork conducted in eastern Uganda to examine the use of participatory mapping approaches to assess the relationship of risk reduction and adaptation management strategies in a set of communities susceptible to multiple environmental and social stressors. Our work takes a critical look at the opportunities available through the participatory mapping methodology, and also highlights some of the limitations of mapping due to social and physical context. Our discussion of lessons learned is motivated from both the mapping exercises and the process of map production and has broad implications for community vulnerability assessments. We show that not
all risk and management phenomena are best summarized spatially and, perhaps more importantly, there may be taboos about mapping certain phenomena that may be better addressed with aspatial analyses. We discuss this “unmappability” of some risks and strategies, the social construct of hazard, and the non-binary character of factors as either risk or benefit. This paper concludes with recommendations for improvements in subsequent participatory mapping efforts and a discussion of best practices to better understand vulnerability through space.

4.2 Background

Vulnerability is comprised of both social and environmental components (Adger, 2006). In one of the most commonly cited frameworks for vulnerability, Turner and colleagues (2003) include disaster risk as a component of vulnerability, along with exposure, sensitivity, and resilience (Figure 2). A complementary framework for disaster risk, and one of the most commonly cited in the vulnerability literature relating to climate change, frames disaster risk as the product of environment, exposure, and vulnerability (Figure 1, Birkmann et al., 2013). The key element of these frameworks is in their recognition of the interplay between the social human system and the biophysical environment in which it is situated and on which it acts.

The spatial distribution of exposure to hazards and variable nature of vulnerability in space has been an area of interest across the development, hazards, and climate change sectors for decades (White, 1945; Lewis, 1990; DeLong and Eichengreen, 1991). Over this time, a number of tools have been developed, which can collectively be called vulnerability maps, through which academic communities, governments, and risk
reduction organizations seek to understand the relationship between vulnerability and space so that appropriate policies and actions can be taken. To show vulnerability, maps should take into account all its salient features, including exposure to the hazard, sensitivity to its impacts, and the coping capacity/resilience of the sensitive populations (Turner et al., 2003).

Some of the earliest and still ongoing efforts to map vulnerability come out of the scientific hazard and risk mapping communities, which tend to focus on mapping disaster risk areas at the intersection of hazard likelihood and human exposure in order to identify and prioritize places for intervention and action (Figure 1; Berz et al., 2001; Shi and Kasperson, 2015). Disaster risk for such maps is generally modeled “top-down” using combinations of geospatial data sets (e.g. satellite images, terrain and elevation models, soil classification maps, and other geographic information systems (GIS) layers) combined with information on past hazard events (Clarke et al., 2006; Claessens et al., 2007; Prasuhn et al., 2013; Torkashvand et al., 2014). The predominant focus of these top-down maps is on the models underlying hazard event probability estimation, though this is subject to data constraints related to past hazard events (Castellanos Abella and Van Westen, 2007). As data becomes more available, both with respect to our monitoring of actual events and the availability of increasingly long archives of high resolution satellite imagery, these models improve. Especially with respect to rare or unprecedented events, a category of hazards likely to increase with climate change, top-down hazard maps are an incredibly valuable tool (Mercer et al., 2007).
Yet these top-down disaster risk maps remain limited when it comes to incorporating the social element of vulnerability. Exposure, sensitivity, and resilience are less well-developed in the top-down maps largely as the result of data limitations. While large scale data related to biophysical characteristics discernible by satellite imagery are available over relatively fine spatial resolutions, social data is not to the same standard. As a result, incorporating exposure has been addressed in many risk maps by simply combining a population density map with a hazard probability map (Nadim et al., 2006; Castellanos Anella and Van Westen, 2007; Jaedicke et al., 2013). In places where comprehensive, reliable census data is available at a fine spatial resolution, as in Europe or the United States, this may be sufficient to map exposure. In developing countries, however, the low reliability of population data limits disaster risk maps from being able to map exposure with a high degree of certainty. Sensitivity and coping capacity or resilience mapping at this level is even more problematic with respect to data limitations (Castellanos Abella and Van Westen, 2007, with notable exceptions for soil erosion mapping using RUSLE, e.g., Prasannakumar et al., 2012; Prasuhn et al., 2013).

As top-down models expand efforts to include social data, increasing attention is being paid to the contributions achievable through bottom-up community-based efforts at vulnerability mapping. People play a significant role in shaping hazard probability, intensity, duration, and impact through disaster risk reduction (DRR) and disaster risk management (DRM) activities that shape sensitivity and through coping strategies, and adaptive responses (Burton et al., 1993). Interest in assessing DRR and DRM from a community standpoint has long been of interest to disaster relief agencies like the Red
Cross, while adaptive strategies are increasingly recognized as integral to reducing future vulnerability to climate change impacts (van Aalst et al., 2008, Mercer et al., 2010; Cadag and Gaillard, 2012). There is tremendous and increasingly recognized opportunity for vulnerability assessment at the community level to gain more holistic insights into the reality of vulnerability on the ground (Wisner, 2006). Though not all efforts to understand vulnerability from the bottom-up standpoint include a spatial component, participatory risk mapping has risen in prominence over the past decades as an important tool in holistic vulnerability assessment (McCall, 2008; Mercer et al., 2010).

Efforts in participatory mapping efforts generally target a single or primary hazard of interest to outside organizations (e.g. Krishnamurthy et al., 2011; Cadag and Gaillard, 2012), are designed to address a particular set of policies, both for top-down and bottom-up DRR and DRM (e.g., Piccolella 2013; Gaillard and Pangilinan, 2010), and draw on existing risk reduction and adaptation strategies to do this (e.g., Valdivia et al., 2010). People in the developing world have always adapted to the changes in their environments that threaten their lives and livelihoods (Kelman et al, 2009). Most participatory mapping efforts focus on identifying and improving the coping, evacuation, and recovery strategies of communities. In agricultural locations prone to multiple hazards, however, land management strategies are among the most basic DRR tools available for addressing a hazard before it occurs. Strategies like terracing, planting contour hedgerows, planting trees along riverbanks and at the tops of steep slopes, digging trenches to guide water downhill, and toward storage areas are all pursued as risk reduction strategies, but are rarely included in such risk and capacity mapping efforts.
(notable exceptions include Mercer et al., 2008; Valdivia et al., 2010). By including such strategies on the map, they can be understood in the context of risk and hazard perception, and thus related to holistic vulnerability.

The case study presented here extends these studies of participatory vulnerability mapping to include land management strategies adopted for use in reducing risk likelihood, and the relationship these strategies have with vulnerability in a multi-hazard environment.

4.3 Study site

This study draws on focus groups and participatory mapping exercises conducted in 2014 in the Bugisu region of eastern Uganda, on Mount Elgon, an area noted for its landslide and flooding risk potential. The focus groups and mapping exercises provide information about farmers’ experience and perception of particular risks and the distribution of hazards, capacities, and existing management strategies in their communities. The economy of the East African highlands is dominated by small-scale agriculturalists whose livelihoods depend on an increasingly unpredictable climate in order to be productive. Though coffee and tea are important export crops in Bugisu, most crops in the region are destined for household consumption or a local market. Access to finance, savings opportunities, and insurance are also scarce, so that the options for near and long-term coping are difficult from a financial standpoint (Pender et al., 2006). Due to this lack of institutional support, the threats that small-scale farmers face are most often addressed through direct efforts to reduce risk likelihood through DRR and reduce risk impacts through coping strategies. Common threats in the East African highlands
include not only catastrophic risks associated with landslides and floods, but also more chronic and widespread threats as hailstorms, windstorms, soil erosion, and heavy rainfall (Shi and Kasperson, 2015).

Disaster relief and risk reduction activities in Bududa and Manafwa are primarily accomplished through the Uganda Red Cross Society (URCS) as the local partner of the International Federation of the Red Cross and Red Crescent Societies (IFRC), the Office of the Prime Minister (OPM), and the Ministry of Disaster Preparedness and Refugees (MDPR). Toward the overarching goal of vulnerability reduction through economic development, a number of additional organizations focus in agricultural and livelihoods development in the predominantly agricultural Bugisu region. These include organizations like the Uganda National Agricultural Advisory Service (NAADS), Technoserve, Send-A-Cow Uganda, Heifer International, local cooperative Coffee-A-Cup, the regional farmers’ consortium Mbale Farmers Association, and the Northern Uganda Social Action Fund (NUSAF). Additional organizations such as Territorial Approaches for Climate Change (TACC) and the Ministry of Water and Environment (MWE) target environmental restoration as a combined disaster mitigation and adaptation strategy.

This paper focuses on ten villages located in the Bugisu region of eastern Uganda in the Bududa and Manafwa districts (Figure 3). The villages all face multiple biophysical and social stressors though each village has different vulnerabilities, capacities, and relationships with an array of government and non-government agencies for DRR, climate change adaptation (CCA), and development. The study villages were
selected because of their relationships with particular DOs in the region. NAADs officers work in all of the study villages and eight of the villages have additional relationships with other DOs in the region (Table 1; see Chapter Two for a more thorough description).

4.4 Methods

The data reported here was gathered as part of a larger research project investigating risk perception and management in a multi-hazard environment, which included interviews with DOs from 2012 and 2013, a household survey in 2013, focus groups in 2014, and participatory mapping exercises also in 2014 (see Chapters 2 and 3 for a detailed description of the larger study).

4.4.1 Vulnerability and capacity focus groups

To gain insight into risk perception at the community level, we conducted vulnerability and capacity focus groups in each of ten villages across Bududa and Manafwa, adjacent districts in the Bugisu region.

One focus group was held in each study village. Focus group participants included a subset of respondents to an earlier survey who had indicated a willingness to participate in additional discussion beyond the survey, and an effort was made to include focal program beneficiaries and non-beneficiaries in each group. Through an interpreter hired through the district Red Cross branch, focus group participants were asked to discuss hazards that are currently or were historically experienced in the village, their frequency and recent experience, as well as what capacities the village had to address the hazards, including infrastructure, common resources, markets, water sources, and other
benefits. These prompts were open ended and encouraged participants to describe as many hazards, risks, or related issues with little guidance from the researchers except through clarification questions and prompts to elaborate on the timing of named risks. Focus groups were audio recorded and transcribed for qualitative analysis. Discussion points were also written on posters during the focus groups so that participants could see, discuss, and approve the output, and refer to the focus group discussion in the subsequent mapping sessions.

4.4.2 Participatory mapping exercises

We conducted eighteen participatory mapping exercises with farmers from the focus group discussions to identify the spatial extent of risks in the community, the location of community capacities and benefits, the extent of coping and adaptive management strategies, and the availability of development, DRR, and aid agencies within the village. In each of the eight villages that have relationships with a particular DO (beyond NAADS), two participatory mapping exercises were conducted following a single focus group. These groups were differentiated based on participants’ self-identification as beneficiaries of the target organization of that village (beneficiary status was defined as the respondent reporting having received training or material good from the organization). For each of these villages there was one participatory mapping exercise conducted with non-beneficiaries and another with beneficiaries of the village target organization. In the two villages without additional DO relationships beyond NAADS, only one mapping exercise was conducted.
Following Cadag and Gaillard (2012), mapping exercises combined stone maps, sketch maps, and were supplemented by GPS mapping. Participants in each mapping exercise were asked to cooperatively develop a stone map on the ground, using local objects, to represent the village boundary and main features. To this map were then added village risks and capacities, based on those that had been identified in the previous focus group discussion. Once participants agreed on the stone map, a group representative (elected by the group) transferred the stone map to a sketch map, approved by the group through consensus. Lastly, a copy of the base map was traced and participants were asked to mark on it the management and coping strategies used to address their named risks, and to list those organizations or groups in the village that provided any help in risk reduction, development, or management, even if these could not be represented spatially on the map.
4.4.3 GPS mapping of hazards on private property

To complement community assessments of risk, specific locations of hazards were identified on private property by ten village members in each study village. Global positioning system (GPS) locations were recorded at each of these sites, along with the hazard identified and digital photographs of the landscape along with any management efforts in use to address the hazard.
Figure 9 Sketch maps of village features, risks, capacities, and management activities for Bumwangu, Manafwa district.

4.5 Results

Combining data from the focus groups, participatory mapping exercises, and GPS mapping efforts, allows us to assess the value and the limitations of each component of the vulnerability analysis at the village level. We used a combination of qualitative and spatial analysis to analyze the sketch maps. Qualitative analysis of the sketch maps allows us to compare the relationship between perceived risk extents and the use of risk reduction land management strategies both across and within villages. Qualitative analysis of GPS mapping points allows us to visualize local risk perceptions in the context of the local landscape and existing management strategies (Figure 10).
Through the focus groups, participants identified forty-eight unique environmental and social risks (Table 14). Soil erosion and pests and diseases were listed in every village, and hailstorms and windstorms in nine of ten. While many of the remaining risks were only named in one or two focus groups, at least half of the villages listed landslides or mudslides, flooding, drought, heavy rains, lightning strikes, water contamination, deforestation, land fragmentation associated with population growth, hunger or food insecurity, poverty, and human diseases.
<table>
<thead>
<tr>
<th>Environmental</th>
<th>Social</th>
<th>Mixed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meteorological</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flood (8)</td>
<td>Economic</td>
<td>Changes in seasons from climate change (1)</td>
</tr>
<tr>
<td>Water seepage (3)</td>
<td>Market prices fluctuate (1)</td>
<td></td>
</tr>
<tr>
<td>Heavy rain (8)</td>
<td>No market available (1)</td>
<td></td>
</tr>
<tr>
<td>Drought (7)</td>
<td>Theft (2)</td>
<td></td>
</tr>
<tr>
<td>Hailstorm (9)</td>
<td>Poor transportation after rains (2)</td>
<td></td>
</tr>
<tr>
<td>Windstorm (9)</td>
<td>Overcultivation / low soil fertility (2)</td>
<td></td>
</tr>
<tr>
<td>Lightning strike (5)</td>
<td>Low medical access (high mortality rate) (2)</td>
<td></td>
</tr>
<tr>
<td><strong>Geomorphic</strong></td>
<td>Hunger/ food insecurity (6)</td>
<td></td>
</tr>
<tr>
<td>Soil erosion (10)</td>
<td>Water scarcity (potable water)</td>
<td></td>
</tr>
<tr>
<td>Landslide/ mudslide (6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Falling rocks (2)</td>
<td>Other</td>
<td></td>
</tr>
<tr>
<td><strong>Biological</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crop pests &amp; diseases (10)</td>
<td>Overpopulation/ land fragmentation (7)</td>
<td></td>
</tr>
<tr>
<td>Banana bacterial wilt</td>
<td>Poverty (7)</td>
<td></td>
</tr>
<tr>
<td>Banana weevil</td>
<td>Poor nutrition (1)</td>
<td></td>
</tr>
<tr>
<td>Cassava mosaic</td>
<td>Reduced education (1)</td>
<td></td>
</tr>
<tr>
<td>Coffee insect pests</td>
<td>Language barriers (especially for elderly) (1)</td>
<td></td>
</tr>
<tr>
<td>Moles</td>
<td>Human sacrifice &amp; witchcraft (1)</td>
<td></td>
</tr>
<tr>
<td>Termites</td>
<td>Too many different churches (1)</td>
<td></td>
</tr>
<tr>
<td>Animal diseases</td>
<td>High fertility rate &amp; young marriage (1)</td>
<td></td>
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<tr>
<td>Ticks</td>
<td></td>
<td></td>
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<tr>
<td>Foot &amp; mouth disease</td>
<td></td>
<td></td>
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<tr>
<td>Skin ailments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mastitis</td>
<td></td>
<td></td>
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<tr>
<td>Human diseases (7)</td>
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<tr>
<td>Malaria</td>
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<tr>
<td>Cholera</td>
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<tr>
<td>Typhoid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HIV/AIDS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ailments (e.g. hernia)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steep topography (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil compression (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil infertility (6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 14 Environmental, social, and hybrid risks named in focus groups. Number of villages reporting the risk in parentheses.

Capacities showed similar heterogeneity between villages while management strategies were more consistent. Across all villages, transportation routes including roads that could support local minibus taxis, motorcycle taxis, and foot traffic were consistently
listed as benefits to the community. Villages also showed churches, schools, village health worker and pharmacy locations, improved water sources (protected springs or boreholes), and local markets (trading centers), when they were present in the community, though this varied widely among villages. Forests and trees were the item of least consensus both within and across villages with respect to their inclusion as a public benefit and/or a management strategy. Commonly, villages addressed soil erosion with the use of contour hedgerows, addressed overland flooding and water pooling by digging trenches to guide the water downhill. Some management was more specific to the village. Elephant grass and trees planted along riverbanks was seen as a management strategy to reduce risk from riparian flooding in one village, while in another village, participants were proud of efforts by villagers to practice zero-graze husbandry to prevent cows from starting rock slides from the tops of hills. One of the groups in one village addressed communication avenues within the village when asked to discuss and depict capacities-indicating where information was provided to people. These management strategies were placed on the maps, overlain with risk sources and capacities to illuminate relationships among these factors of vulnerability.

Participatory community risk maps allow us the opportunity to compare bottom-up perceptions of vulnerability with top-down efforts. These comparisons reveal that the scale of perception, the complexity of vulnerability, and the distribution and identification of risk differ between the two types of risk maps. Private landholders perceived risks on their lands that were considered low or non-existent risks on top-down maps, and in turn listed risks that rarely appear in any top-down risk map. For example,
in addition to, or sometimes instead of landslide risk, community members identified rocky slopes, exposed rock, and steep slopes as risks or sources of vulnerability in themselves. Through mapping it became clear that these hazards overlapped with, but were not synonymous to, landslides. Being attentive to these differences is important as they may indicate departures from or additions to the information available from top-down risk maps, a factor that is reinforced when we compare the risk maps produced by communities with risk maps produced remotely.

Though quantitative geospatial analysis is not possible between our sketch maps and top-down risk maps depicting some of the same risks, a qualitative comparison reveals that village level perception of risk is much more finely resolved than low resolution hazard maps (the scales of risk differ), and can differ from high resolution top-down maps in the specific locations of risk identification (the extents of risk differ) (Figure 11). This may indicate a tradeoff between precision and accuracy in the construction of top-down risk maps.
Building on previous work on the value of participatory mapping and community-based vulnerability assessment, we discuss five lessons learned through the participatory vulnerability mapping process. Broadly, different groups within the same village agreed on the distribution of risks, but in some cases differed in their recognition of capacities and management, indicating that it matters who is doing the mapping when vulnerability is being assessed. Risks varied among villages, while management strategies remained largely consistent, though the emphasis on particular strategies varied by village. Finally, there are aspects of risk and adaptation that are unmappable, either because they are aspatial or because they are socially unmappable. While the former indicates the need for mixed data sources, the latter provides its own insights into vulnerability. The contextual and aspatial material needs to be elicited and understood alongside the map.
4.6 Lessons Learned and Discussion

Since the purpose of this mapping exercise was to investigate perceptions of vulnerabilities and how they are addressed, our lessons pertain to this aspect of vulnerability analysis, distinct from other efforts at risk mapping as a way to explicitly advance risk awareness and preparedness in the area (Gaillard and Pangilinan, 2010; Cadag and Gaillard, 2012; Henly-Shepard et al., 2015).

4.5.1 Differentiation of risk based on cause and effects

Root causes of hazard (e.g. rainfall intensity, seismic activity) can be mapped and modeled remotely, but people experience hazards in different ways and their responses are tied to this experience. While the disaster and development communities recognize that a single hazard can produce cascades of impact, these effects are rarely mapped as separate hazards. Community members, however, may perceive them as such. In our exercises and focus groups, community members were encouraged to describe and include all threats and their interconnections. As a result, participants differentiated risks by root cause and experiential effects, a level of nuance not often found within the single-risk focus of many participatory risk maps (e.g., Cadag and Gaillard, 2012; Fuller et al., 2014). Hazards that are typically treated as singular risks in many mapping exercises were differentiated into a source for multiple risks in our study. These multiple risks from different source hazards could then be mapped simultaneously and discussed in relation to each other, both temporally and spatially. This level of differentiation and relation is
important because of its implications for correctly identifying vulnerable persons and for identifying the most appropriate strategies to reduce vulnerability.

Single root hazards like heavy rains were identified as a threat in themselves and also differentiated by participants into multiple experienced risks like soil erosion, soil fertility loss, river overflow, flash flooding along steep slopes, footpaths and roads becoming dangerous or impassable, and infrastructural damage to homes, outbuildings, and bridges. River overflow was further differentiated into its effects on crop and material damage, contamination of water sources, and in one village with the threat of snakes being transported down from higher up in the forested uplands of the mountain. Flooding was also associated with water logging in the soils, which is associated with increased rates of mosquito-borne illnesses like malaria.

This issue is central to the purpose of mapping vulnerability—identifying vulnerable people so that action may be taken to reduce that vulnerability. Top-down models rely on meteorological and geological data to drive hazard likelihood models. If a multiplicity of interrelated risks is narrowed to only one or two (e.g. flooding from high rainfall), we run the risk of misidentifying some individuals, households, or groups as not vulnerable to the threat of high rainfall, as areas that are threatened by non-flooding impacts of heavy rain are not addressed. Incomplete identification of vulnerability can then lead to a misallocation of effort to address it through DRM and DRR.
Participants also mapped risks as overlapping in time and space, with focus groups specifying the timing of hazard events and the sketch maps depicting their spatial distribution (Figure 12). Though the prevalence of multi-hazard environments is recognized in the literature and in the top-down risk mapping community, most bottom-up participatory mapping efforts focus on a single hazard and how to address it.

This is true not only for those catastrophic hazards that are commonly addressed in the literature (e.g. floods, landslides, earthquakes, volcanoes), but also those more chronic stresses like soil fertility loss, soil erosion, water seepage, pest prevalence, and water contamination. This is important because people experience these risks in the loss
of capacity (health, income, physical assets), and these losses can affect individual coping
and adaptive capacity in the event of a subsequent hazard (Turner et al., 2003).

Understanding how hazard events are experienced as risk to vulnerable
populations is also an important piece to understanding how people are likely to respond
to the risk. “Effect” risks are more intimately tied to DRR strategies because they are the
product of the meteorological or geophysical event at its intersection with social action.

The focus group output indicates the temporal overlap of many risks during the
rainy seasons, with a separate set during the dry seasons. Awareness of these overlaps can
also aid in the identification of efficient management strategies. Soil erosion and water
rushing over the ground both result from heavy rains are can both be addressed by
planting contour hedgerows, especially if they are combined with a water pit at one end,
where water can gather and slowly infiltrate over time.

Flooding, one of the more commonly mapped risks, is a multi-faceted and
interconnected hazard in Bugisu. Participants noted flooding as a risk during focus
groups and, during the mapping exercise, they differentiated among different ways that
flooding manifests as risk within the village. Flooding was seen to manifest as water
rushing over steep slopes, which causes the clay soil footpaths to become extremely
slippery and dangerous for children, while the rushing water also washes soil and crops
away. While river bank flooding is readily mapped using remotely sensed imagery,
digital elevation models, and models of rainfall intensity, these direct and indirect
manifestations of flooding, their spatial distribution in the landscape, and how people are
made vulnerable to them, is not possible. This last requires conversation with people familiar with the landscape.

Simply mapping the hazards that are passed down from, and comparable to, top-down risk mapping efforts (flood, landslide, soil erosion), does not represent the full range of environmental threat to communities, nor does it represent the full range of challenges over which people may be able to exert control through risk reduction efforts. By recognizing that hazards are differentiated into their components based on how they are experienced by the community, DOs and other agencies can be better prepared to identify coping and management strategies currently in use and with the potential for use.

4.5.2 Community heterogeneity

The communities of our study villages are not homogeneous with respect to their risks, capacities, or management decisions. Not only is this heterogeneity spatial, with risks differing based on underlying terrain and management, but also psychological and socio-economic, with the perceptions of risk and capacity and true material capacity differing based on who within the village is doing the mapping (Agrawal and Gibson, 1999; Alesina and La Ferrara, 2000; Costa and Kahn, 2002). Communities must be examined in the context of vulnerability by addressing the variety of interests and actors within politically defined communities. By acknowledging this heterogeneity in the separation of mapping groups, new insights into how perceptions and capacities differ among these groups can be brought to light.
Beneficiaries and non-beneficiaries in our study villages differed with respect to their socioeconomic profiles (Table 15). The maps they produce are likewise distinct.

<table>
<thead>
<tr>
<th>Income (USD)</th>
<th>Farm size (acres) **</th>
<th>Slope cultivation (%) **</th>
<th>Land fragmented (%)</th>
<th>Distance to market (km) **</th>
<th>People in household ***</th>
<th>Adults in household **</th>
<th>Head of household male (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beneficiaries</td>
<td>697.3</td>
<td>1.9</td>
<td>71%</td>
<td>71%</td>
<td>3.8</td>
<td>6.6</td>
<td>2.9</td>
</tr>
<tr>
<td>Non-beneficiaries</td>
<td>557.6</td>
<td>1.4</td>
<td>56%</td>
<td>65%</td>
<td>2.7</td>
<td>5.2</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Table 15 Socioeconomic characteristics of beneficiaries and non-beneficiaries in study villages. Mean values or percentages reported with t-test results for significance of difference between the groups. Slope cultivation indicates that at least some portion of the household’s cultivated land is on sloping, hilly land; land fragmentation indicates that the household cultivates more than one parcel of non-contiguous land. *** p<0.001, ** p<0.01

Efforts to understand community behavior must be based in the understanding that communities have internal differences and that external actors relate to these in different ways (Agrawal and Gibson, 1999). Community relations with external organizations are an important point of consideration in community heterogeneity. The two mapping groups in each village, separated based on their involvement with a focal DRR or development organization, provided unique insights into the ways in which subsets of populations within the same village may perceive differences in risks and capacities.

Across all villages, there were differences in the resources claimed by beneficiary and non-beneficiary groups and in the risk reduction actions described. For example, in Buwabusera, the beneficiaries of Mbale Farmers Association (MFA) listed, in addition to MFA, the Bukigayi Dairy Farmers Association, Buwabusera Women’s Group, and Send-A-Cow Uganda. Non-beneficiaries listed no organization activity in the village. The MFA reaches out to its beneficiaries by engaging with existing local community based
organizations (CBOs), while a part of the Send-A-Cow model is to encourage gender equality through female empowerment and livelihood development through dairy sales. The inclusion of a women’s group, a dairy farmers group, and Send-A-Cow on a map created by MFA beneficiaries may demonstrate the ways in which access to one resource is the gateway to further access.

This trend was not singular to Buwabusera. In six of the eight villages where participants were separated into groups based on beneficiary status, beneficiaries described a more extensive list of organizational resources than non-beneficiaries. In two of these cases even the focal organization of the village (URCS and Coffee-A-Cup) was unrecognized by non-beneficiaries, though both the Red Cross and Coffee-A-Cup intend for their services to be available to all community members. In the remaining four villages, beneficiaries listed additional organizations beyond the focal organization, which were not recognized by non-beneficiaries.

Risk and management descriptions also varied based on mapping group. Individual risks varied slightly in their distribution and level of detail on each map, and in three cases landslide risk was only shown on one of the two group maps, though this was not consistent to either beneficiaries or non-beneficiaries. In Bunakomola, a village targeted by the Red Cross, non-beneficiaries showed landslide risk on an area of the map occupied by beneficiary property, while beneficiaries referred to the same area as simply “rocky ground”. In another village, participants noted a connection between areas of exposed rock, or “rocky ground”, and landslides, indicating that the same physical attribute of exposed rocks can be interpreted as different risks depending on the group.
Management strategies also differed between village maps, mostly with respect to the role of forests and trees and in the level of detail included for other management strategies. In four of the eight split group villages, forests as a community resource were differentiated from trees planted as a risk reduction strategy. The distribution, descriptions, and targets of strategies also differed slightly between groups and among villages, but villages consistently named soil bands and contours, trenches, elephant grass plantings, and tree plantings as strategies to combat soil erosion, flooding, windstorms, and soil fertility losses. Only one solution was recommended to combat pests, and this only by the beneficiary group of Bumwangu, who included notes on using urine, ash, and red pepper as a homemade pesticide. Such heterogeneity in capacity and action across and within villages has serious implications for DO program activity. Single community training programs, material offerings, and interactions may bypass subsets of the population with no awareness of the DO and little capacity to reach out or act independently.

4.5.3 The non-binary distinction of risk and capacity

Participants in focus groups and mapping exercises identified some components of the landscape as both sources of benefit or capacity and as elements of elevated risk. This result highlights the potential for further investigation into the benefits of diversified livelihood strategies, though our data are unable to address them directly. Many of the dual risk-benefit components identified by participants were associated with investments in income diversification on the part of the farmer. This relationship between risk and
benefit may have implications for the diversification strategy and the extent to which the level of investment in diversification relates to real risk reduction as opposed to merely the appearance of it.

Infrastructure, livestock, community footpaths, and trees—all are considered capacities and sources of benefit to the community, and all were also associated with elevated, or novel, risks to well-being. Livestock rearing, especially dairy cows, represent an important income generating livelihood component for many farmers in Bugisu, with 21% of farmers selling milk to supplement their income. The prevalence of cow diseases is high, however, and veterinary care sparsely available and costly (personal communications with district veterinarian and entomologist). Trees provide a similar example. While tree-planting is adopted for reasons ranging from the economic (use of timber for home use or sale) to the environmental (wind breaks, soil stability, and microclimate improvement), planting trees is an investment and theft a concern, especially the theft of limbs and trunks for timber. The issue is that savings are spent as investment in these strategies, but through that investment, farmers are exposed to additional risks. Investments are not backed by insurance policies, so if loss occurs, that loss is complete.

The strength of diversification lies in increasing the number of disasters that would have to strike to result in complete loss. For farmers in this region, however, a single source hazard (like heavy rains) can result in multiple experienced hazards like increases in pest or disease prevalence that can impact crop and livestock health (Rosenzweig et al., 2001; Hii et al., 2011), soil fertility losses that reduce crop yields
(Rosenzweig et al., 2001), increases in incidence of cholera and malaria that can reduce household labor resources (Craig et al., 1999; Fernández et al., 2009), and flooding that can cause physical damage to structures and crops. Rather than diversifying risk, some investments may be increasing exposure to the same risk.

Insurance against loss in our study villages, as in so many others throughout the developing world, is frequently pursued through investment in diversification as an overarching strategy, even at the expense of personal material well-being (Blaikie et al., 1994; Ribot, 1995; Turner et al., 2003). This poses a challenge when farmers diversify into a strategy that exposes the farmer to more of the same risk.

Mapping and focus group discussions can each contribute to this understanding. Though our study is not able to directly assess the potential tradeoffs between levels of diversification, it highlights that this issue is one that may be productively explored through the methodology. A flexible and open inclusion of all risks can highlight components of the village system that are risk and capacity both, depending on circumstance, and which are pursued as risk diversification strategies. Though the map product is not required to glean this understanding, the process of map production, focusing on separating out risks and capacities, elicits this insight into the non-binary nature of landscape components as only one or the other.

4.5.4 Aspatial and unmappable factors and the importance of multiple methodologies

Components of vulnerability may be unmappable due to either sociocultural factors or the aspatial nature of the component (Cacciapaglia et al., 2012; Cadag and
Sociocultural unmappability and aspatial components of vulnerability are both challenges to be considered in our thinking about the role of maps in vulnerability analysis and how they can be overcome through the inclusion of additional methodologies.

In our study, property boundaries and certain private land management decisions were unmappable because of social pressures that stymied communication efforts. Participants in the mapping groups emphasized that land management decisions were up to the particular household and were outside the purview of public opinion, and therefore public “sight”, especially in cases where seeing a lack of good management could be perceived as criticism. In places where “good” management was ubiquitous, however, community members were comfortable describing and mapping these efforts, showing sugarcane, elephant grass, and trees planted along river systems, and trees planted in reforestation efforts at higher elevations.

Property boundaries were also socially unmappable in two of the study villages. In Bunasaba this reluctance was related to ongoing explorations in the area for mineral deposits causing villagers to be concerned that putting their properties on the map would bring legal trouble. In this case, the difficulty was overcome through building trust and rapport between researchers and community members. Further reticence related to land boundaries along rivers and streams, where erosion and silt accumulation regularly shrank or grew properties, and to contended land boundaries related to deeding versus usufruct rights. The challenge of property rights and the formal recognition thereof is not
singular to mapping exercises and is well documented in the vulnerability literature (Watts and Bohle, 1993; Blaikie et al, 1994; Kelly and Adger, 2000).

Finally, there are also many hazards and capacities that are not spatially discrete and therefore difficult to map at the village level. This can be frustrating for participants if aspatial components appear unrepresented in the final map. Participants approached aspatial risks differently in our mapping groups, with some opting to demonstrate hazard ubiquity by scattering sand, ash, or other small markers across the stone map, and translating this as dots on the sketch map, while other groups listed ubiquitous or aspatial hazards as a part of the map key. Aspatial or ubiquitous risks in the study villages included hailstorms, lightning strikes, corruption, and theft. DO activities were sometimes spatialized through marking the homes or offices of DO contacts or representatives, or prominent beneficiaries, though more often DO activities were noted in a separate key. The final sketch maps alone cannot fully represent these hazards and capacities independent of additional data and context.

In improving our understanding of vulnerability, it is not enough even to combine top-down and bottom-up representations of risk and capacity, but to include an aspatial context that includes those components of the vulnerability system that cannot be mapped. Cadag and Gaillard (2012) mention the importance of including a larger array of tools beyond participatory mapping to enable a more holistic understanding of vulnerability and capacity.

By combining focus groups, participatory mapping exercises, and GPS risk points we are able to combine the spatial and aspatial (or unmappable) sources and responses to
risk in vulnerable communities. The contextual and aspatial material needs to be elicited and understood alongside the map. The use of statistically robust analyses at the household level from surveys and interviews can also help to elucidate vulnerability and aid in communicating results to DRR and development agencies in a way that interfaces more readily with their existing structures and which they are more likely to credit.

4.7 Conclusions

Conscientious use of participatory vulnerability and resilience mapping can facilitate a more holistic understanding of current adaptation and future risk reduction potential of vulnerable communities. When used in combination with qualitative group discussions and spatially explicit quantitative household data, participatory mapping can also relate current vulnerability to individual decision-making and to the efforts of DRR and development organizations. Beyond the benefit provided by their data production, the process of producing these maps is likewise an important benefit for communities (Henly-Shepard et al., 2015). Our case study of the Bugisu region of Uganda builds on this work on the spatial aspects of vulnerability, the inclusion of aspatial factors in mapping, and community-based assessments of vulnerability and capacity by examining community perceptions of risk and risk reduction through a combination of qualitative and spatial methods. Our findings show that the sources, manifestations, and impacts of hazard events are perceived as risks by those who experience them, that both risk and risk management are spatially heterogeneous and relate to information and resource access, that facets and characteristics of the community can be characterized by a duality as capacity and risk source, the importance of including ongoing risk reduction land
management strategies in studies on DRR and DRM, and that the aspatial and unmappable aspects of vulnerability can still be understood by combining participatory mapping with additional methods.

DRR and development organizations are well placed to make good use of such participatory efforts in their pursuit of increasing resilience. Increasing resilience may take the shape of diversification, as has been advocated and adopted so frequently (Turner et al., 2003). Further research is required to determine the extent to which thresholds exist such that below that level of investment, the diversification represents more risk to overall household well-being than is being offset by the investment. These studies should take into account material investments in on-farm endeavors such as animal rearing vis-à-vis expected losses from pests and diseases and investments in physical infrastructure and agricultural extensification vis-à-vis expected losses from meteorological storms and mass movement events. In addition, further research is needed in understanding the ways in which communities can and do share management responsibility in the shared ecosystem service of risk reduction. This research should draw on the many investigations of payment for ecosystem services for non-hazard management to see if such systems would be likely to work in the context of private land management for risk reduction. An improved understanding of the ways information, material resources, and motivation flow through a community defined by risk exposure is essential to achieving improved community-level management of disaster risk.

Top-down efforts to map and understand vulnerability contribute significantly to our understanding of the spatial distribution of risk across the globe and across regions.
They have an important additional role to play in acknowledging, incorporating, and disseminating community-derived facets of vulnerability, and in providing communities with risk information for rare and future events about which they are uniquely suited to attest. A more thorough understanding of the contributions of each, and improvements in their integration in global and local assessments of vulnerability is fundamental to the future of resilience.
CHAPTER FIVE: Summary and future directions

5.1 Summary

This dissertation builds on and expands the body of knowledge on vulnerability and resilience in a changing world.

In the second chapter I address how successful implementation of DO programs to reduce vulnerability to hazards, and to promote economic development, requires smallholders to adopt protective actions. Yet protective action relies on the strength of motivation through risk perception, the capacity to act, and the self-assigned responsibility of the smallholder to act (Wachinger et al., 2013). Our study of smallholder farmers in the Bugisu region of Uganda extends past work on risk perception, the risk perception paradox, and the role of DOs in risk management by examining risk perception in a multi-hazard environment. Our findings clearly show that the factors that shape risk perception are specific to particular hazards, that heightened risk perception can sometimes reflect greater understanding and motivation for protective action rather than helplessness, and highlight the challenges associated with DO involvement in the complex relationship between risk perception and protective action in a multi-hazard environment.

DOs have a role to play in facilitating the translation of risk perception to protective action through the provisioning of information and material resources to vulnerable households. In a multi-hazard environment, such actions require a multi-
faceted approach that addresses the material and informational limitations of households and recognizes the overlapping and differently prioritized hazards they face.

In the third chapter I address how motivations and constraints on BMP adoption vary with the characteristics of the particular hazard, with crop management and land management strategies grouping together. Our results indicate that there is no single factor or set of factors that consistently account for adoption of agricultural best management practices, but the patterns that do exist may be used by DOs to improve adoption rates. Programs can increase their effectiveness by targeting BMP training and incentive efforts on those who have received insufficient information and do not consider themselves knowledgeable enough to implement a strategy, even if they have the material capacity and the motivation to do so. DOs may also need to address material constraints, especially in light of the challenge in addressing both crop and management simultaneously, the former relying more heavily on financial resources and the latter on labor and tools like spades, wheelbarrows, and pangas. In the context of training, both risk-avoidance and benefit-seeking motivations influence individual decisions to adopt BMPs, and motivate different BMPs to different extents. To harness both of these motivational draws, DO programs should emphasize the co-benefits of BMP adoption.

In the fourth chapter I address how the use of participatory vulnerability and resilience mapping can facilitate a more holistic understanding of vulnerability at the community level, especially if these methods are used in conjunction with other sources of data. The processes involved in participatory methodologies is an important benefit of the methodology, too, beyond the data production itself. It can provide voice to the
heterogeneous population of communities and produce insights to researchers and community peers alike (Henly-Shepard et al., 2015). Our results show that the sources, manifestations, and impacts of hazard events are perceived differently and distinctly by those who experience them, that both risk and risk management are spatially heterogeneous and relate to information and resource access, and that the binary distinction of risk and benefit is flawed, an observation with potential implications for the risks associated with the pursuit of diversification as a livelihood strategy. Finally, I note that efforts to understand vulnerability through mapping must also investigate the aspatial and unmappable aspects of vulnerability and capacity through the use of additional and complementary participatory tools.

5.1.1. Addressing endogeneity

Two potential sources of endogeneity must be acknowledged in the work presented here. The first stems from the potential simultaneity of risk perception and the adoption of BMPs. The second stems from the mostly non-random selection of beneficiaries of DO programs in our sample, with some beneficiaries self-selecting and others being identified and pursued by the DO. These potential endogeneity challenges require consideration in our assessment.

The potential endogeneity of the risk perception- BMP adoption relationship stems from the proposed feedbacks in the relationship. I partially addressed this endogeneity concern by comparing parallel regressions to predict risk perception that differ only in their inclusion of BMP adoption as a predictive factor. The results of these
regressions indicate that the adoption of protective actions are rarely significant in risk perception and that, even when they are, the direction of the relationship is positive rather than negative. This indicates that heightened risk perception likely drives adoption rather than adoption attenuating risk perception (see section 2.5.3 for further discussion).

The challenge of endogeneity with respect to DO engagement requires a different approach. The potential endogeneity in this case stems from the observation that engagement with DOs is the result of a non-random process, and consequently access to specific information about risks and BMPs is also non-random. Some DOs identify and target beneficiaries through a structured vetting process, while others conduct public meetings attended by a self-selecting local population. Both of these scenarios could result in a DO beneficiary population that is non-random with respect to certain socioeconomic, demographic, or cultural attributes. This could raise concern that farmers’ socioeconomic, demographic, and cultural attributes (factors thought to influence risk perceptions and adoption rates) are endogenous to their exposure to information from DOs (also an influential factor).

Though my work cannot account for this challenge directly, I address it partially by assessing the correlations among DO engagement and the socioeconomic and demographic characteristics that may be endogenous to DO engagement. The correlation matrix indicates that DO engagement is correlated significantly (p<0.05) only with farm acreage and the number of adults in the household, and these with correlation coefficients less than 0.2, far below the threshold of 0.8 generally thought to be problematic with respect to collinearity (Field, 2009). While this does not preclude any influence of
endogeneity, it does indicate that the effect of any endogeneity is not likely to be large, as the relationships between the socioeconomic and demographic variables and DO engagement are neither significant nor large. To make sure that the effects of these correlating variables are not wholly endogenous to the effect of DO engagement, they are both included in all analyses of BMP adoption that also include DO engagement as a predictive variable. In that way, the results more closely reflect the additional effect of DO engagement above and beyond the effect of those endogenous variables that may initially contribute to DO engagement.

To fully address the challenges of potential endogeneity in such a system, further work could use ethnographic methods to investigate the qualitative routes of influence and complement this with a quantitative assessment of the outcomes of three programs implemented in a randomized control trial (to address DO engagement endogeneity) through the period of intervention (to address simultaneity). The first program would provide training solely on local risk characteristics and sources; the second solely on a set of potential protective measures to a variety of risks, and the third would provide training on both risk characteristics and tying this to risk management through the adoption of particular BMPs. The study could then compare adoption of protective strategies across the three groups to test the relative efficacy of risk awareness and risk management trainings on increasing protective action. The longitudinal study should be conducted over the course of the intervention and be careful to account for initial land management and protective action activities to avoid challenges associated with feedbacks between BMP adoption and risk perception.
5.1 Future directions

Although the conclusions drawn in this thesis are specific to the Bugisu region of Uganda and not necessarily applicable to other developing states where smallholder farmers in multi-hazard environments, the methodologies presented and the general conclusions are likely to be applicable more broadly. Further research, however, is required to improve resilience and reduce vulnerability in just such multi-hazard environments under the dual pressures of globalization and climate change (O’Brien and Leichenko, 2000).

First, more research is required on the role of development and risk reduction organizations (DOs) in shaping reducing vulnerability. This research should compare protective action adoption across multiple hazards within a single population, and the ways in which engagement with DOs may be influencing these decisions and prioritizations. A better understanding of how farmers balance and prioritize among protective action is also essential, especially when the recommended protective actions are as varied as the sources of risk. In addition, the nature of trust in long-term DO-farmer relationships and the relative importance of the similarity heuristic in facilitating or eroding trust should be addressed. This research should examine how cycles of engagement, risk perception, action, and risk outcomes develop over time and the influence this development has on the trust between DOs and beneficiaries. Improved understanding of how DO programs in the developing world are engaging with and
influencing risk mitigation in the multi-hazard environments is fundamental for achieving the goal of reduced vulnerability.

Second, more work should be done on the subject of thresholds. It is important that future research into vulnerability take a more holistic view of the economies and capacities constrained and enabled through diversification as a risk management strategy. My results indicate that while many vulnerable people pursue diversification as a risk management strategy or “insurance policy”, the scope and magnitude of their vulnerabilities may actually be enhanced, rather than reduced, below a certain threshold of investment. Further research is required to better understand and quantify these thresholds lest diversification and other efforts to reduce vulnerability in fact increase it.

Related to this are thresholds of self-efficacy and the role they play in shaping the relationship between risk perception and protective action. My results indicate that this relationship is not nearly as straightforward as has been indicated in the past and that while capacity does play a role in adopting protective actions, it does not completely constrain the decision. Further research is required to understand the thresholds of capacity required to take particular actions and the strength of the motivation to do so.

A final threshold relates to the quality of BMP adoption. As in other studies, we treated BMP adoption as a dichotomous variable when in practice BMP adoption falls along a spectrum ranging from no adoption to adoption that was both spatially complete and of high initial and maintained quality (e.g. Figure 7). BMP quality is relevant for those concerned with the environmental and economic outcomes of BMP adoption, but is seldom addressed directly (Baumgartz-Getz et al., 2012). When translating adoption into
ecological, environmental, and risk reduction outcomes, the quality of adoption must be considered.

Finally, my work indicates that future research should be dedicated to a better understanding of the ways in which current risk reduction activities are being used differentially within communities to address heterogeneous risk profiles with heterogeneous household capacities. The role that communication, public interest, public management, and public planning may play in these relationships is of central importance in determining their success. Future research should seek out the current strategies employed within communities to address not only risk reduction on private property, but also how private risk can translate into public action, or at least shared action. Analyses of informational and social networks, and social learning should be used in this endeavor. Heterogeneity of income has a clear association with adoption of crop management BMPs (tree planting and intercropping), but the direction of the relationship is unclear. While higher income farmers may be in a position to invest in BMPs, they may also increase their incomes through the benefits derived from adoption. A longitudinal analysis that follows non-adopters through a period of intervention and assesses baseline and outcome material assets, crop choices, and BMP adoption would be better positioned to address this issue of causality, and the potential feedback relationship between adoption and income. A more thorough understanding of how initial heterogeneity in capacity progresses and transforms through adaptive action and DRR is necessary in furthering our collective effort to reduce vulnerability for all persons at risk.
APPENDIX I Household Survey

Part I: BACKGROUND

1. How many acres do you farm in total? ___________ acres

2. How many plots of land do you farm? ___________ plots

3. How many acres do you farm up the hill/ on the slope? ___________ acres

4. Do you own your land?
   ☐ Yes
   ☐ No

   a. If YES: Do you have a deed to most of your land?
      ☐ Yes
      ☐ No

5. How did you get this land?
   ☐ From a parent
   ☐ Purchased
   ☐ Leased

   a. If LEASED: What is the duration of your lease?
      ___________ years

6. Over the past year, how many of the following animals have you owned or kept on your property?
   ___________ Bee hives
   ___________ Chickens
   ___________ Turkeys
   ___________ Pigs
   ___________ Cows
   ___________ Goats
   ___________ Rabbits
   ___________ Ducks
   ___________ Sheep
   (___________)
   (___________)
   (___________)
7. Please check *all that apply*:

<table>
<thead>
<tr>
<th>In the past year, did you sell or trade:</th>
<th>In the past year, did you get income from:</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Coffee</td>
<td>☐ A job? (please list)</td>
</tr>
<tr>
<td>☐ Fruits</td>
<td>☐ Your own business</td>
</tr>
<tr>
<td>☐ Other crops:</td>
<td>☐ Family sending money</td>
</tr>
<tr>
<td></td>
<td>☐ Other source(s)? (please list):</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Milk</td>
<td></td>
</tr>
<tr>
<td>☐ Eggs</td>
<td></td>
</tr>
<tr>
<td>☐ Honey</td>
<td></td>
</tr>
<tr>
<td>☐ Animals:</td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>☐ Other animal products:</td>
<td></td>
</tr>
</tbody>
</table>

8. In the past year, where did you sell your crops and animals?

- ☐ In the village market
- ☐ In Mbale or Tororo markets
- ☐ To a trader

9. What was your income last year, approximately?

- ☐ $ ___________ UGX

10. How far is the nearest market to here?

- ☐ $ ___________ km

11. Over the past year, how many people are in your household?

- ☐ $ ___________ People
  
  a. How many of these are adults (over 18)?

- ☐ $ ___________ Adults

12. Who is the head of the household?

- ☐ I am (male)
- ☐ I am (female)
- ☐ my wife
- ☐ my husband

13. How many children of your household were in school this past year?

- ☐ $ ___________ Children

14. Over the past year, how much did you spend on education expenses?

- ☐ $ ___________ UGX
Part II: ENVIRONMENTAL PERCEPTIONS

15. **Landslides:**
   a. In your opinion, how likely is it that a landslide will happen on your land in the next 3 years?

   - [ ] 0 (no chance)
   - [ ] 1 (unlikely)
   - [ ] 2 (somewhat likely)
   - [ ] 3 (it will happen)
   - [ ] 4 (I have no idea)

   b. If a landslide occurred on your property, how much would you lose?

   (SKIP IF ANSWERS “no chance” to part a.)

   - [ ] 0 (no loss)
   - [ ] 1 (slight loss)
   - [ ] 2 (some loss)
   - [ ] 3 (much loss)
   - [ ] 4 (lose everything)

   c. How worried are you about landslides?

   - [ ] 0 (no worry)
   - [ ] 1 (slight worry)
   - [ ] 2 (some worry)
   - [ ] 3 (much worry)
   - [ ] 4 (worry every day)

Repeat questions 15 (a-c) for the following issues:

16. Soil erosion
17. Flooding
18. Severe drought
19. Hailstorms
20. Effects of climate change
21. Effects from deforestation
22. Crop or animal pests/ diseases
23. Changes in market prices (uncertain prices)
24. Too little good, available land because of population growth
25. Someone selling bad (fake) seeds
26. Government corruption (any level)
27. Please name the three risks or challenges that you worry about the most, with the worst challenge first:
   a. __________________________________________
   b. __________________________________________
   c. __________________________________________
**PART III: PROGRAM ENGAGEMENT**

Now I’d like to ask you some questions about contact you may have had with people or organizations who gave you training or materials about land and farm management.

28. To the best of your knowledge, what is the extent of your contact with the following groups? Please choose from the following responses

<table>
<thead>
<tr>
<th>NAADS</th>
<th>Never heard of it</th>
<th>No contact</th>
<th>Tried to contact, but no success</th>
<th>They provided me materials/inputs</th>
<th>Did they teach you to use it?</th>
<th>What benefit did it give you?</th>
<th>Provided me training / information</th>
<th>What subject?</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUSAF</td>
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<tr>
<td>MWE</td>
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<tr>
<td>Hunger Project</td>
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<tr>
<td>Uganda Wildlife Authority</td>
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<td>Red Cross</td>
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<td>EPSEDEC</td>
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<tr>
<td>Send-A-Cow</td>
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<td>Heifer International</td>
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<td>TACC</td>
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<tr>
<td>Cooperative (not SACCOS)</td>
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<tr>
<td>CBO (name)</td>
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<tr>
<td>Mbale Farmers Association</td>
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<tr>
<td>Technoserve</td>
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<tr>
<td>Spark Microgrants</td>
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<td></td>
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<tr>
<td>(other):</td>
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</tr>
</tbody>
</table>
For all organizations circled (marked as “They gave me training or information on land management”): which two organization’s trainings have benefited you the most?

a. __________________________________________

b. __________________________________________

ORGANIZATION A:

30. Name of organization: __________________________________________________________

31. Does this organization have a contact person locally? ☐ Yes ☐ No

   a. Does he or she live in this community? ☐ Yes ☐ No

   b. Is this person also a local politician? ☐ Yes ☐ No

32. How often have you had contact with this group?

   ☐ Only once ☐ Once per year

   ☐ Each season (2-3 times per year) ☐ Monthly or more

33. When was the most recent time of contact?

   ☐ This month ☐ This year

   ☐ Last year (2012) ☐ 2011 or earlier

34. Where did they contact you? Check all that apply.

   ☐ On my farm

   ☐ Public meeting locally

   ☐ I went to their office

   ☐ By phone, SMS, letter, radio

35. How did you find out about this training/meeting?

   ☐ Farmer’s group

   ☐ Family, friend, or neighbor told me

   ☐ The local contact person told me

   ☐ They came to my home

   ☐ Media

   ☐ I saw the opportunity myself and approached them
36. What have they trained you about? 
________________________________________________________________________
________________________________________________________________________

37. What has this group given you? Please check all that apply.
☐ Information on farming
☐ Fertilizer or pesticides
☐ Trees seedlings
☐ Seeds
☐ Animals
☐ Money
☐ Tools
☐ Other: ______________________

38. Was the help enough or did you need more?
☐ Enough
☐ I needed more

a. If check “I needed more”:
→ Is there one thing specifically you want from them?
________________________________ (item/ benefit)
→ Sometimes, benefits may be more likely with cost sharing. How much would you be willing to contribute to get this benefit from them?
______________ % total cost
or ____________________ UGX

39. Did you have the opportunity to ask questions or provide feedback to the group?
☐ No
☐ A little bit
☐ Yes

40. Do you think that this organization wants to help you, as its primary goal?
☐ Yes
☐ No

41. Do you think that this organization has the ability (capacity) to help you?
☐ Yes
☐ No
☐ Other: ______________________

42. Repeat questions 30-41 for ORGANIZATION 2.
PART IV: MANAGEMENT

Now I would like to ask you some questions about actions you can take on your farm. These are things like using fertilizer or digging trenches. You may not have heard of the technique I mention and that is fine. Just answer as you are able.

<table>
<thead>
<tr>
<th>43. Do you:</th>
<th>I don’t know it</th>
<th>I don’t use it</th>
<th>I use it</th>
<th>When did you begin?</th>
<th>How much does it cost?</th>
<th>What benefit does it give you?</th>
<th>Does it work? (no, a bit, very well)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use homemade fertilizer</td>
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<td>Use commercial fertilizer</td>
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<tr>
<td>Use homemade pesticides</td>
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<tr>
<td>Use commercial pesticides</td>
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<tr>
<td>Dig drainage trenches</td>
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<tr>
<td>Dig contours with elephant grass</td>
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<td></td>
</tr>
<tr>
<td>Plant trees</td>
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<tr>
<td>Irrigate</td>
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<tr>
<td>Intercropping</td>
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<tr>
<td>Fallow (leave land to rest)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use hybrid seeds</td>
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<tr>
<td>Join a Farmer’s Group:</td>
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<tr>
<td>Join a cooperative:</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
44. Are there other methods that you use?

<table>
<thead>
<tr>
<th>Name of method</th>
<th>Who taught you to do it?</th>
<th>When did you begin?</th>
<th>How much does it cost? (UGX/hours)</th>
<th>What benefit does it give you?</th>
<th>Does it work? (no, a bit, very well)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

45. When you think about your farm, and the way you manage it, what do you think has been the most helpful in your success?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

46. Why?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

We will be scheduling a focus group to do some further research in the next two weeks. Would you be willing to participate in that research?

□ Yes
□ No

a. If Yes, contact 
   #__________________________________________________________________

Thank you!
### APPENDIX II Additional regression analyses

<table>
<thead>
<tr>
<th>Variable</th>
<th>Landslide RPI</th>
<th>Soil erosion RPI</th>
<th>Flood RPI</th>
<th>Hailstorm RPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of obs</td>
<td>187</td>
<td>187</td>
<td>193</td>
<td>205</td>
</tr>
<tr>
<td>p-value (model)</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>Adj R-squared</td>
<td>0.5016</td>
<td>0.4658</td>
<td>0.4008</td>
<td>0.2976</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>variable</th>
<th>coeff.</th>
<th>p-value</th>
<th>coeff.</th>
<th>p-value</th>
<th>coeff.</th>
<th>p-value</th>
<th>coeff.</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income (log-adjusted, 2013 USD)</td>
<td>-0.045</td>
<td>0.370</td>
<td>-0.016</td>
<td>0.654</td>
<td>-0.049</td>
<td>0.289</td>
<td>-0.010</td>
<td>0.721</td>
</tr>
<tr>
<td>Income from coffee</td>
<td>0.592</td>
<td>0.000</td>
<td>0.272</td>
<td>0.015</td>
<td>-0.033</td>
<td>0.822</td>
<td>-0.012</td>
<td>0.884</td>
</tr>
<tr>
<td>Non-farm income</td>
<td>0.091</td>
<td>0.690</td>
<td>0.035</td>
<td>0.831</td>
<td>-0.525</td>
<td>0.016</td>
<td>-0.200</td>
<td>0.111</td>
</tr>
<tr>
<td>Acreage (ha)</td>
<td>0.092</td>
<td>0.500</td>
<td>0.029</td>
<td>0.767</td>
<td>0.218</td>
<td>0.095</td>
<td>0.031</td>
<td>0.656</td>
</tr>
<tr>
<td>Hilly land</td>
<td>0.376</td>
<td>0.007</td>
<td>0.022</td>
<td>0.822</td>
<td>-0.540</td>
<td>0.000</td>
<td>0.036</td>
<td>0.626</td>
</tr>
<tr>
<td>Fragmentation in household</td>
<td>-0.234</td>
<td>0.116</td>
<td>-0.007</td>
<td>0.948</td>
<td>0.373</td>
<td>0.008</td>
<td>0.006</td>
<td>0.941</td>
</tr>
<tr>
<td>Gender (0=female, 1=male)</td>
<td>0.104</td>
<td>0.378</td>
<td>-0.225</td>
<td>0.008</td>
<td>0.106</td>
<td>0.353</td>
<td>0.027</td>
<td>0.689</td>
</tr>
<tr>
<td>RPI deviation (baseline: none)</td>
<td>1.156</td>
<td>0.000</td>
<td>0.933</td>
<td>0.000</td>
<td>0.898</td>
<td>0.000</td>
<td>0.503</td>
<td>0.000</td>
</tr>
<tr>
<td>Engagement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other DO</td>
<td>0.095</td>
<td>0.530</td>
<td>0.077</td>
<td>0.478</td>
<td>0.120</td>
<td>0.401</td>
<td>-0.148</td>
<td>0.065</td>
</tr>
<tr>
<td>Red Cross</td>
<td>0.191</td>
<td>0.376</td>
<td>0.064</td>
<td>0.668</td>
<td>0.351</td>
<td>0.079</td>
<td>-0.191</td>
<td>0.100</td>
</tr>
<tr>
<td>Experience</td>
<td>0.516</td>
<td>0.000</td>
<td>n/a</td>
<td>n/a</td>
<td>0.342</td>
<td>0.019</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Use of DRR strategy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contour</td>
<td>0.197</td>
<td>0.119</td>
<td>0.004</td>
<td>0.966</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Trench</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>0.246</td>
<td>0.047</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>constant</td>
<td>1.090</td>
<td>0.000</td>
<td>2.245</td>
<td>0.000</td>
<td>1.562</td>
<td>0.000</td>
<td>2.852</td>
<td>0.000</td>
</tr>
</tbody>
</table>

The above table shows the results of a series of linear regressions run in parallel with those presented in Chapter 2.
APPENDIX III Correlation table

<table>
<thead>
<tr>
<th>For all models</th>
<th>Contour adoption</th>
<th>Tree adoption</th>
<th>Trench adoption</th>
<th>Intercrop. adoption</th>
<th>Acreage</th>
<th>Income (log)</th>
<th># adults</th>
<th>Fragmented land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acreage</td>
<td>0.1959 *</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income (log)</td>
<td>0.2480 ***</td>
<td>0.3131 ***</td>
<td>0.2922 ***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coffee income</td>
<td>0.1962 *</td>
<td>0.2271 **</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respondent sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children in home</td>
<td>0.2083**</td>
<td>0.2316 ***</td>
<td>0.3175 ***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># adults</td>
<td></td>
<td></td>
<td>0.1848 *</td>
<td>0.2114 **</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fragmented land</td>
<td>0.1992 **</td>
<td>0.2851 ***</td>
<td>0.2579 ***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valley cultivation</td>
<td></td>
<td>0.2408 **</td>
<td>0.2424 **</td>
<td>0.3218 ***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope cultivation</td>
<td>0.2964 ***</td>
<td>0.222 **</td>
<td>0.3099 ***</td>
<td>0.2008 **</td>
<td>0.1826 *</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DO engagement (contours)</td>
<td></td>
<td></td>
<td></td>
<td>0.1746 *</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>DO training (trees)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.1823 *</td>
<td></td>
</tr>
<tr>
<td>DO training (trenches)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DO training (intercrop.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.1927 **</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This table is a correlation matrix for the variables that were common across multiple regressions presented in this dissertation and contained any significant (p<0.05) relationship with any other variable. All results are shown except those among the DO trainings themselves, which were never used in combination; RPI variables because these produced no significant correlation with any socioeconomic, geographic, or DO engagement variable; and columns that contained no additional significant relationships (e.g. coffee income, respondent sex, children in the home, slope cultivation, and valley cultivation) for ease of data presentation and interpretation. None of the correlation coefficients among any of these and the socioeconomic or geographic variables is greater than 0.33, far below the threshold of 0.8 considered at high risk for collinearity (Field, 2009).
BIBLIOGRAPHY


EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.be, Université Catholique de Louvain, Brussels (Belgium)


# CURRICULUM VITAE

<table>
<thead>
<tr>
<th>Mobile: +1 860.933.0995</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kira Sullivan-Wiley</td>
</tr>
<tr>
<td>e-mail: <a href="mailto:kira.s.wiley@gmail.com">kira.s.wiley@gmail.com</a>; <a href="mailto:kswiley@bu.edu">kswiley@bu.edu</a></td>
</tr>
</tbody>
</table>

**Academic Positions**

<table>
<thead>
<tr>
<th>Period</th>
<th>Position</th>
<th>Institution</th>
<th>Supervisor</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept 2011 – present</td>
<td>PhD candidate in Geography and Environment</td>
<td>Boston University, Department of Earth and Environment</td>
<td>Dr. Anne Short</td>
<td>Boston University</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Expected graduation date: September 2016</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun 2015- Aug 2015</td>
<td>Summer Fellow</td>
<td>Frederick S. Pardee Center for the Study of the Longer-Range Future</td>
<td>Dr. Anthony Janetos</td>
<td>Boston University</td>
</tr>
<tr>
<td>Feb 2015- May 2015</td>
<td>Visiting Scholar</td>
<td>Institute of Development Policy and Management, University of Antwerp</td>
<td>Dr. Kristof Titeca</td>
<td>(Instiut voor Ontwikkelingsbeleid en –beheer, Universiteit Antwerpen)</td>
</tr>
</tbody>
</table>

**Research and Field Experience**

<table>
<thead>
<tr>
<th>Period</th>
<th>Location</th>
<th>Institutions</th>
<th>Supervisor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec 2011 – Aug 2016</td>
<td>Boston University and Uganda Red Cross; Co-PI Dr. Anne Short</td>
<td>Co-PI –The roles of information, institutions, and space in disaster risk reduction</td>
<td>Dr. Anne Short</td>
<td>Collect qualitative and quantitative data through interviews and data search (presentations: <em>Landslide Risk in Uganda: The role of vegetation in DRR</em>, <em>Being an A.C.T.I.V.E. community: Strengthening the village for partnerships</em>, <em>The role of targeted programs in risk management: Initial results from Bududa and Manafwa</em>)</td>
</tr>
<tr>
<td>Apr 2012 – Oct 2012</td>
<td>Boston University; PIs: Drs. Anne Short, David Kittredge, and Lucy Hutyra</td>
<td>Research Assistant – Drivers of Conservation along an urban-rural gradient</td>
<td>Dr. Anne Short</td>
<td>Collect qualitative and quantitative data through interviews and data search (presentations: <em>Landslide Risk in Uganda: The role of vegetation in DRR</em>, <em>Being an A.C.T.I.V.E. community: Strengthening the village for partnerships</em>, <em>The role of targeted programs in risk management: Initial results from Bududa and Manafwa</em>)</td>
</tr>
<tr>
<td>March 2010</td>
<td>Environmentally Sustainable Social and Economic Growth (ESSEEG) Miches, Dominican Republic; PI: Dr. James Danoff-Burg</td>
<td>Field Assistant- Avian surveys and tourism feasibility assessment</td>
<td>Dr. James Danoff-Burg</td>
<td>Conduct avian surveys and tourism feasibility assessment (presentations: <em>Landslide Risk in Uganda: The role of vegetation in DRR</em>, <em>Being an A.C.T.I.V.E. community: Strengthening the village for partnerships</em>, <em>The role of targeted programs in risk management: Initial results from Bududa and Manafwa</em>)</td>
</tr>
</tbody>
</table>
May 2004- Aug 2006  UConn Ornithology Lab and Bronx Zoo, Co-PI: Dr. Margaret Rubega

**Co-PI** – Honors Thesis: feeding biology of captive tropical birds
- Individual grant-funded project using high-speed video to describe behavior
- Coordinate with and provide feedback to personnel at the Bronx Zoo

Summer 2004-2006  UConn Ornithology lab and United States Fish and Wildlife Service, Dr. Chris Elphick PI

**Co-PI and Research Assistant:** Nesting behavior of saltmarsh sparrows
- Individual grant-funded project on behavioral biology of saltmarsh birds

**Courses Taught**
World Regional Geography (GE 201- lecturer): Summer 2014
World Regional Geography (GE 201- teaching fellow)
Environmentally Sustainable Development (GE 304- teaching fellow)

**Education**
Boston University, Boston, MA
September 2016 (expected)
Ph.D. Geography

Columbia University, New York, NY
August 2010
M.A. Climate and Society

University of Connecticut, Storrs, CT
May 2006
B.S. Ecology and Evolutionary Biology, minor Molecular and Cell Biology

**Invited Positions**
**Panel:** Pardee Center Symposium on Climate Change Adaptation Strategies, Boston University, Boston, MA.
**Panelist,** October 2015

**Panel:** 1st Year Graduate Student Welcome; Boston University, Boston, MA.
**Panelist,** September 2014

**Course:** Environmentally Sustainable Development (GE/IR304); Boston University, Boston, MA
**Visiting Lecturer,** April 2014, February 2016, March 2016

**Course:** World Regional Geography (GE 201); Boston University, Boston, MA
**Visiting Lecturer,** March 2013, February 2016, March 2016

**Panel:** Climate Conversations: Communicating Climate Across Sectors; Columbia University, NYC, NY
**Panelist,** April 2012
Publications

Oral Presentations


Sullivan-Wiley, K. Farmers, hazards, and the organizations that aim to change them: DRR and development in Eastern Uganda. Department seminar; Earth and Environment, Boston University, Boston, MA, April 2013.


Awards
Graduate- Boston University
   Evelyn L. Pruitt National Fellowship ($8,490); 2015-2016
   Graduate Student Organization Travel Grant to attend IGARSS ($500); 2015
   Pardee Summer Fellowship (10 weeks of funding- $5,000); 2015
   Moorman Simon Civic Fellowship (2 years of funding- $40,000); 2014-2016
   Earth and Environment Outstanding Teaching Fellow Award; May 2014
   Graduate Research Abroad Fellowship ($10,000); 2013
   Dean’s Fellowship ($20,000); 2011-2012
Undergraduate- University of Connecticut
   University Scholar; May 2006
   Award for Outstanding Graduating Senior in EEB; May 2006
Nutmeg Scholar (4 years of funding—$48,000); 2002-2006
University of Connecticut Honors Scholar; May 2006
MBT Travel Award ($350) to attend AOU Conference; August 2005
Summer Undergraduate Research Fellowship ($6,500); 2004, 2005
Phi Beta Kappa; 2005

**Volunteer and Leadership Experience**

**May 2012 – present** Graduate Women in Science and Engineering (GWISE)
*President (’14-’15), Vice President (’13-’14), General Officer (2012-13)*
- generate, monitor, and allocate an annual budget between $16,000-$30,000
- plan, organize, and execute professional development, social, outreach, and mentoring programs and events, numbering more than 40 annually

**Jan 2014 – present** Graduate and Professional Leadership Council (GPLC)
*Founder/ Board Member*
- Work with the Associate Provost for Graduate Affairs to create a forum for policy communication between graduate students and the BU administration

**Sept 2015 – present** Science by the Pint speaker series
*Organizer- 2 events*
- Plan and lead two monthly events featuring a Boston-area scientist and their lab members for a night of science learning and conversation with the public

**Sept 2012 – May 2013** Advocates for Literacy in Environmental Sciences (ALES)
*Blog Administrator*
- Help to found an environmental student organization
- Provide and coordinate contributions to the outreach and education blog

**Dec 2009 – Apr 2010** Earth Day Event Planning Committee
*Committee Officer*
- Coordinate with New York City and E-Day 40 personnel for logistics

**June 2008 – Aug 2009** Harvard University Green Teams
*Ornithology Lab and Office Representative*

**Jan 2003 – June 2006** EcoHusky and the Public Interest Research Group (PIRG)
*Team Member*