REPORT

CLIMATE CHANGE, RAINFALL PATTERNS, LIVELIHOODS AND MIGRATION IN CABRICAN, GUATEMALA

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Climate change, rainfall patterns, livelihoods and migration in Cabricán, Guatemala

Authors: Sergio Ruano and Andrea Milan

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Abbreviations and acronyms

ABM	*Agent-based model*
AR4	*Fourth Assessment Report of the Intergovernmental Panel on Climate Change*
EACH-FOR	*Environmental Change and Forced Migration Scenarios Project*
ECLAC	*Economic Commission for Latin America and the Caribbean*
ENSO	*El Niño Southern Oscillation*
FAO	*Food and Agriculture Organization of the United Nations*
FLACSO	*The Latin American Social Sciences Institute*
GDP	*Gross Domestic Product*
ha	*Hectare*
IARNA	*Institute of Agriculture, Natural Resources and the Environment*
ICIMOD	*International Centre for Integrated Mountain Development*
ICTA	*Guatemalan Institute of Science and Agricultural Technology*
INAB	*Guatemalan National Forest Institute*
INE	*Guatemalan National Statistics Institute*
INSIVUMEH	*Guatemalan National Institute of Seismology, Volcanology, Meteorology, and Hydrology*
IOM	*International Organization for Migration*
IPCC	*Intergovernmental Panel on Climate Change*
kg	*Kilogram*
MARN	*Guatemalan Ministry for Environment and Natural Resources*
MINEDUC	*Guatemalan Ministry of Education*
PECCN	*CARE Poverty, Environment and Climate Change Network*
PRA	*Participatory Research Approaches*
SESAN	*Guatemalan Secretariat of Food and Nutritional Security*
SNET	*Guatemalan National Service of Territorial Studies*
UNDP	*United Nations Development Programme*
UNFCCC	*United Nations Framework Convention on Climate Change*
UNICEF	*United Nations Children's Fund*
UN-SPIDER	*United Nations Platform for Space-based Information for Disaster Management and Emergency Response*
UNU-EHS	*United Nations University Institute for Environment and Human Security*
USAC	*Universidad de San Carlos de Guatemala*
USAID	*United States Agency for International Development*
WFP	*World Food Programme*
WHO	*World Health Organization*

Executive summary

This report is based on the data collected during the Where the Rain Falls (Rainfalls) Project, which was conducted in 2011–2013 by the United Nations University Institute for Environment and Human Security (UNU-EHS) and CARE International). The research team in Guatemala sought to understand the views of inhabitants from four communities belonging to the municipality of Cabricán in order to understand the impact of rainfall variability on their livelihoods, and the way in which rainfall variability, livelihood and food security influence human mobility patterns.

Increasing rainfall variability has a direct impact on local food and livelihood security given that most households depend on rain-fed subsistence agriculture. The population expressed its strong attachment to the communities and its desire to remain there. As a consequence, households only tend to migrate when in situ options are not profitable. In contrast, the migration of just one (or several) household member(s) is commonly used as a risk management strategy usually in combination with other non-migratory strategies.

However, the profitability of in situ diversification (weaving) is decreasing and is associated with decreasing migratory opportunities. In particular, migrating to the United States is becoming dangerous and expensive. These trends expose local populations to the risk of becoming trapped in the near future in a place where they are extremely vulnerable to climate change.

Intensive agriculture aimed at selling vegetables on the local and international markets could be pursued in the area, possibly in combination with economic diversification which would lessen dependency on agricultural production. Finally, promoting local ownership of the production process and access to international markets for textiles should be a priority for local policymakers.

Section 1: Introduction

As early as 1990, the Intergovernmental Panel on Climate Change (IPCC) warned that the greatest single impact of climate change could be on human migration (Tegart and others, 1990). Since then, the number of publications about the relationship between climate change, environmental change and human mobility patterns has increased dramatically (Laczko and Aghazarm, 2009; Warner, 2010; Afifi and Jäger, 2010; Black and others, 2011; Foresight, 2011; Piguet and others, 2011). In contrast, the number of empirical studies is still limited, not only because environmentally induced migration is a relatively new issue, but also because the matter is quite complex and relies on interdisciplinary research (Milan and others, 2011).

The Environmental Change and Forced Migration Scenarios (EACH-FOR) Project took place between 2007 and 2009 and was the first large-scale empirical research project on environmental change and migration. It consisted of 23 case studies in 6 regions of the world (Warner and others, 2009; Jäger and others, 2009). The lessons learned from this project included the importance of isolating independent climatic and environmental variables, developing indicators, improving methods and finding evidence to support policy around climate change, migration and displacement.

In this context, the Where the Rain Falls (Rainfalls) Project, supported by the AXA Group and the John D. and Catherine T. MacArthur Foundation, took an important step towards filling these policy-relevant knowledge gaps. The project aims to improve understanding about how rainfall variability affects food and livelihood security, and how these factors interact with household decisions on mobility and migration among groups of people particularly vulnerable to the impact of climate change.

The Rainfalls Project has two research objectives: 1) to understand how rainfall variability, food and livelihood security and human mobility currently interact; and 2) to understand how these factors might interact in the coming decades as the impact of climate change is becoming more evident.

The eight case study reports from each of the countries in the project (Bangladesh, Ghana, Guatemala, India, Peru, Tanzania, Thailand and Vietnam) focus on the first objective (Rademacher-Schulz and others, 2012; Warner and others, 2012; Warner and Afifi, 2014), while an agent-based model was developed for the second objective (Smith and others, 2008; Smith, 2013). In Guatemala, fieldwork was conducted from August to September 2011 in the western highlands and specifically in four communities from the Cabricán municipality – in El Cerro, Buena Vista, Quiquibaj and El Durazno.

1.1 Guatemala: Population, geography, history and climate

1.1.1 Population

The name Guatemala is derived from the Náhuatl[1] word *quauhtlemallan*, which means "place of many trees" (Luján Muñoz, 1993). The country is located in the Central American Isthmus, with a territory extending over 108,889 km^2 bordering to the north-west with Mexico, to the east with Belize and the Gulf of Honduras, to the south-east with Honduras and El Salvador and to the south with the Pacific Ocean. Guatemala's territory is divided into 22 departments and 333 municipalities, and its capital is Guatemala City located 1,500 metres above sea level.

Guatemala is a multicultural country with a highly diverse population including 23 ethnic groups, each one with its own language and culture. The largest ethnic group is the ladino, who are generally non-indigenous Guatemalans, as well as mestizos and westernized Amerindians, characterized by a Western culture. In total, 43 per cent of the population lives in rural areas, primarily in the central and western highlands (Ruta, 2011). In 2011, the estimated total population of Guatemala was 14,813,763. The indigenous population represented 38 per cent of all Guatemalans, but has been decreasing mainly due to the so-called *ladinización*[2] process (INE, 2010).

In some municipalities of the western highlands (including Cabricán), the entire population is indigenous.

Variable	Indicator
Population growth rate	1.98% annually*
Net migration rate	-2.12/1000 inhabitants*
Child mortality rate	26.02/1000 births*
Total life expectancy	70.88 years*
Life expectancy for men	69.03 years*
Life expectancy for women	72.83 years*
Gross domestic product (GDP) per capita	US$2.869 million**
Total remittances	US$4.127 million**
Prevalence of poverty	51.0%*
Prevalence of extreme poverty	15.2%*

*Table 1: Demographic and economic indicators in Guatemala, 2010. Sources: *INE, 2010; **Bank of Guatemala, 2012.*

1 When Guatemala was conquered by Spain in 1523, conquerors were accompanied by Náhuatl warriors who had previously been forced into submission during the conquest of México.

2 The concept of ladinización comes from the Guatemalan term ladino, which means anyone who is not an indigenous person. It refers to the phenomenon through which members of indigenous societies adopt Western culture and stop being identified culturally as "indigenous."

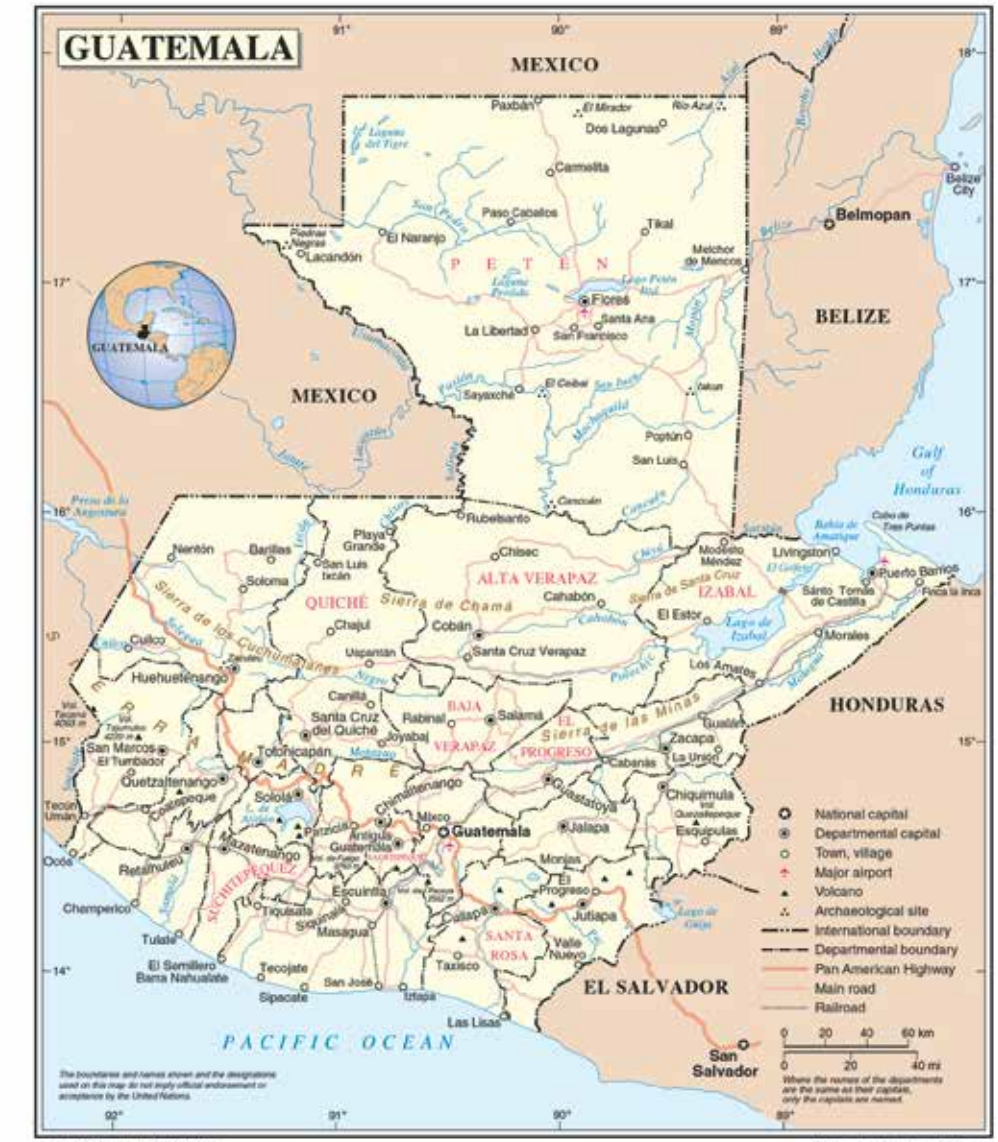

Figure 1: Map of Guatemala.
Source: United Nations (Guatemala, Map No. 3834 Rev.3, May 2004).

1.1.2 Geography

The country is crossed from west to east by a mountainous chain of volcanic origin called the Sierra Madre with altitudes reaching between 1,000 and 4,220 metres above sea level (deGuate.com, 2007). Moreover, its territory is characterized by lakes and rivers which drain towards both the Pacific Ocean and the Caribbean Sea.

Guatemala possesses huge potential for hydroelectric power and irrigation systems for agriculture: more than 93 billion cubic metres of water are available annually, equating to more than 7,000 cubic metres per person. However, in 2006, Guatemala only used 34 per cent of those resources and just 15 per cent of that for the generation of power (IARNA, 2009a).

1.1.3 History

The history of Guatemala spans several thousand years, with the country having been populated by different groups dating before the Spanish conquest. The Maya, mainly settled in the modern-day Petén region, constituted the most important pre-Columbian civilization. Mayan history began during the so-called Pre-classic Period from about 1500 B.C., rising to prominence around 250 A.D. in what is known as the Classic Period. This civilization's development lasted more than 3,000 years until the Spanish arrived in 1523 (Encarta Encyclopedia, 2000; Lost Civilizations, 2010).

Over the next three centuries, the indigenous population was confined to the so-called "indigenous towns" in order to provide service, primarily labour, to the Spanish population. The conquerors confiscated a large portion of indigenous land.

Guatemala, along with Costa Rica, El Salvador, Honduras and Nicaragua, gained independence from Spain in 1821. After independence, a series of military rulers led Guatemala until the end of 1944, when the October Revolution resulted in the overthrow of the dictatorship (Luján Muñoz, 1993).

After the revolution, Guatemala held national elections. Democracy was in place until the 1954 coup d'état. History moved on, and a series of imposed military governments or governments comprised of individuals who used fraud as a stepping stone to gain office ruled the country. Early in the 1960s, a bloody conflict between a leftist guerrilla movement and the army began, which lasted for more than 30 years. Guatemala returned to democracy in 1996 through the negotiation of a peace deal between the military and the guerrilla movement.

1.1.4 Climate

Guatemala is located within the tropical zone of the Northern hemisphere and its wide variety in terms of altitudes results in diverse environmental conditions. According to the Holdridge classification, Guatemala has approximately 360 microclimates and 14 life zones (Holdridge, 1967). Biotemperature and rainfall vary in relatively small areas of land because of the steep topography (FAO, 2009a).

Mean yearly temperatures at sea level are 27° C for the Pacific Ocean and 28.2° C for the Caribbean Sea. Starting at sea level, these increase by 1° C per 166 m of altitude, according to Thornwaite's medium thermal gradient for Guatemala. Maximum temperatures inland may vary from 40° C to 42° C, while minimum temperatures drop to below 0° C in areas 2,000 m above sea level (FAO, 2009a).

Guatemala has two weather seasons: the dry season (summer) and the rainy season (winter). Annual rainfall is mostly concentrated in the period from May to October (with a short dry period in July or August called canícula). The rainfall range in the country varies between 400 mm to more than 6,000 mm per year. In extreme zones, such as those found in the eastern part of the country, rain only falls on 45–60 days per year, while meteorological stations in the northern areas report around 200 days of rain each year. In short, Guatemala is characterized by warm tropical weather that changes extensively depending on the altitude. Seasonal tempera-

tures are scarcely different from each other; hence, Guatemala is known as the "Land of Eternal Spring" (INSIVUMEH, 2010).

The trade winds are the main factor explaining the origin and distribution of the country's rainfall. Trade winds regularly reach the continent from the east–north-eastern area because they originate in the North Atlantic anticyclonic cell after a long journey on the warm waters of the Caribbean Sea where temperatures fall between 25° C and 28° C (INSIVUMEH, 2010).

In the central and western high-altitude areas (such as Cabricán), the rainy season starts in June and lasts until October. The season is characterized by its clear skies before and after heavy rains, which generally occur during the afternoon due to convective rainfall (Foëhn effect), which warms the air while moving through the mountain chains. In contrast, in the Atlantic plains, humidity is generated because the Atlantic coast is exposed to the trade winds (FAO, 2009a).

1.2 Outline of the report

Section II presents a review of relevant publications on livelihood and climate variability, climate variability and climate change, and migration trends in Guatemala. Section III explains the research objectives and methodology applied to gather primary data, and includes a discussion on the research limitations. Section IV describes the case study area and its selection process. The next three sections examine the variables of interest for this study in the research area, both according to scientific data and the perceptions of the population: section V addresses rainfall patterns and rainfall variability, section VI analyses livelihoods and food security, with a specific sub-section on gender dynamics and the views of youth, and section VII focuses on human mobility patterns. Section VIII provides an analysis of the results of this research, looking at the interaction between rainfall variability, food and livelihood security and human mobility in particular. Finally, section IX summarizes the main conclusions of this study and section X outlines the implications for policymakers.

Section 2: Literature review

This section presents a summary of selected publications on climate variability and climate change, livelihood and climate variability and internal and cross-border migration.

2.1 Climate variability and climate change in Guatemala

The second working group for the IPCC's Fourth Assessment Report (AR4) collected and analysed the scientific literature on the impact, adaptation and vulnerability to climate change in Latin America. The report showed that climate variability and extreme events have severely affected the Latin America region in recent years (Magrin and others, 2007).

Climate change is a central economic problem for Latin America and the Caribbean; Guatemala "has a considerable challenge to adapt to climate change while redoubling efforts to reduce poverty, inequality and socio-economic and environmental vulnerability" (ECLAC, 2010, p. 1).

The adaptive capacity of human systems in Latin America is low, particularly regarding extreme climate events, while vulnerability is high. With respect to the main crops of Guatemala, the possible impact of climate change on maize is uncertain, while rice and bean harvests are likely to decrease under all scenarios (ECLAC, 2010, p. 1).

The National Weather Service of the United States defines El Niño as "above-average sea-surface temperatures that periodically develop across the east-central equatorial Pacific. It represents the warm phase of the [El Niño-Southern Oscillation (ENSO) cycle], and is sometimes referred to as a Pacific warm episode. La Niña refers to the periodic cooling of sea-surface temperatures across the east-central equatorial Pacific.

It represents the cold phase of the ENSO cycle, and is sometimes referred to as a Pacific cold episode" (undated).

ENSO is the dominant mode of climate variability in Latin America, and carries the largest socio-economic impact of any natural phenomenon (Magrin and others, 2007). El Niño has a relevant impact on temperatures and precipitation patterns which can either have a positive or negative influence on agricultural production (FAO, 2009b).

The El Niño phenomenon directly affects Guatemala. A study by Pedreros and other (2010) examined the effects of El Niño on rainfall patterns at regional scales and specifically quantified its effects on agricultural water balances in Guatemala. Their results corroborate previous work showing that there is a negative relationship between El Niño and annual rainfall, primarily affecting the Pacific coast of Guatemala and mainly during the months of August and September. The authors also conclude that these rainfall variations influence long-term (May–October) maize growth and they could affect the start of the short-term postrera season (August –October) by extending the canícula.

As shown in Table 2, 40–60 years ago, there were 3 Niños; in the subsequent 20-year period, there were 5; and, then, 6 have occurred over the last 20 years. The El Niño effect alters the period and behaviour of canículas, and causes delays in the onset of the rainy season mostly during dryer years. It also affects the intensity of rainfalls: in one year under the effect of El Niño, it rained up to 70 mm in one hour.[3] The last Niño effect (2009–2010) was marked by many days of intense rain which affected water availability that summer in a negative way: soils became over-saturated leading to more run-off and a reduction in filtration.

Guatemala is among the most vulnerable countries to extreme weather events in Latin America: according to the 2012 Global Climate Risk Index, Guatemala was the second most affected country in the world in terms of the impact of extreme weather events in 2010, and the twelfth most affected in the 20-year period from 1991 to 2010 (Harmeling, 2011). Guatemala is also listed as the nineteenth most vulnerable country to climate change worldwide in the 2011 Climate Change Vulnerability Index (Maplecroft, 2010). In both cases, most countries which precede Guatemala in the rankings are situated in Asia and Africa.

Period	Number of ENSOs	Years of occurrence
1951–1970	3	1951, 1957–58, 1965
1971–1990	5	1972–73, 1976–77, 1979, 1982–83, 1987–88
1991–2010	6	1990–91, 1993, 1994–95, 1997–98, 2007, 2009–10

Table 2: Frequency of El Niño (ENSO) phenomena (1950–2010). Sources: WHO, 1999; SNET, 2010.

Several social, economic and environmental factors explain why Guatemala as a country is vulnerable to environmental and climate change. The majority of the rural population lives in marginal and isolated areas; for instance, it is estimated that 60 per cent of the communities in the western highlands are located in steep areas and at least one third of them are at high risk of natural disasters. Most of the rural population depends on agriculture for subsistence, yet they also rely on crop systems, which are grown on marginal and vulnerable lands due to the lack of alternatives in better-suited zones (IARNA, 2005; IARNA 2009b).

3 Interviews with experts Edwin Castellanos, PhD (5 September 2011, Guatemala City); Pedro Pineda, MSc. and Carlos Rosito, MSc. (interviewed jointly on 8 September 2011, Guatemala City)

The first studies on vulnerability to climate change in Guatemala were conducted in late 2001, under the framework of the First National Communication on Climate Change, which concluded that Guatemala was vulnerable in the following areas: 1) human health, 2) forest resources, 3) water and 4) agriculture (grain production). The communication described climatic, socioeconomic and environmental scenarios for the period between 1961 and 1990 to determine crop vulnerability to climate change and to quantify the possible impact on the quantity and quality of production (MARN, 2001).

Guatemala is located between two great continental masses and two oceans in the inter-tropical convergence zone. As a result, it suffers from events with a hydrometeorological origin, such as droughts, hurricanes[4], intense rains and storms; the consequences of such events include floods and landslides (IARNA, 2005).

In the western highlands at altitudes between 1,800 and 3,200 metres above sea level, hydrometeorological events such as frost directly affect the production of maize, beans, broad beans and potatoes.

From the late 1990s, four extreme precipitation events have affected Guatemala: Hurricane Mitch in 1998, Tropical Storm Stan in 2005, Tropical Storm Agatha in 2010 and Tropical Depression 12-E in 2011. The large amount and high intensity of rain that fell during these events caused serious damage, the most regrettable of them being the loss of hundreds of human lives.

The department of Quetzaltenango, where the research area is located, was one of the most seriously affected by these extreme precipitation events.

Event	Year	Casualties	No. of affected people
Hurricane Mitch	1998	268	749 533
Tropical Storm Stan	2005	1 500 (3 000 disappeared)	3 500 000
Tropical Storm Agatha storm	2010	156	400 000
Tropical Depression 12-E	2011	30	478 030

Table 3: Social costs from recent extreme precipitation events in Guatemala. Sources: USAC, 1999; UNICEF, 2005; Noticias.com, 2010; and CONRED, 2011.

4 The word hurricane comes from the Mayan term *hurakan*, which is the name of the god who creates storms (Rankeen.com, 2011; Pilos.net, 2011).

Event	Year and month	Mean monthly precipitation for the 10 preceding years	Monthly precipitation when the event took place	% increase in precipitation
Hurricane Mitch	November 1998	1988–1997 16.3 mm	157.9 mm	869%
Tropical Storm Stan	October 2005	1995–2004 110.9 mm	290.1 mm	162%
Tropical Storm Agatha	May 2010	2000–2009 156.2 mm	395.9 mm	153%
Tropical Depression 12-E	October 2011	2006–2010 110.7 mm	278.8 mm	152%

Table 4: Increase in precipitation for Quetzaltenango. Source: INSIVUMEH, Labor Ovalle meteorological station (2012).

Before Hurricane Mitch in 1998, the previous rainfall-related extreme event affecting the Quetzaltenango area was only Hurricane Fifi, which hit the region in 1974. Between 1998 and 2001 however, Guatemala experienced four extreme events (SNET, 2002). Daily amounts of rainfall during extreme events are also increasing. For instance, at San José Port on the Pacific coast of Guatemala, 450 mm of rain fell in single day during Hurricane Mitch (1998).[5]

2.2 Livelihood and climate variability in Guatemala

The 2011 report on human development, published by the United Nations Development Programme (UNDP), shows a medium human development index (0.574) for Guatemala; this value is the second lowest among Latin American countries and ranks 133rd in the world (UNDP, 2011a). Guatemala has the highest percentage of malnourished children in Latin America at 45.6 per cent; furthermore, this percentage is even higher among indigenous children (62.5 per cent) (MINEDUC-SESAN, 2009). In 2005, only 35.1 per cent of the total population was economically active, in rural areas the percentage was 39.4 (Ruta, 2011).

In Guatemala, the agricultural sector alone represents about one eighth of GDP, two-fifths of exports and half of the workforce. Aside from the direct impact of climate variables on agricultural production, the land rent for Guatemalan households is sensitive to climate: a marginal increase in the average temperature of

5 Interview with Dr. Edwin Castellanos, PhD (5 September 2011, Guatemala City).

just 1° C reduces the monthly rent of land by about US$6 per hectare. Similarly, a 10-mm increase in the annual accumulated rainfall leads to an increase in the land rent of US$2 per hectare (ECLAC, 2010).

Climatic variability is already lowering Guatemalan production levels, where yields and incomes are decreasing. Unless adaptive measures are taken, these losses might become more substantial in the near future (ECLAC, 2010, p. 1). Rural Guatemalans are often vulnarable and have few resources to endure bad seasons, or more generally, to cope with climate variability (ECLAC, 2010, p. 4).

A recent publication by the Ministry of Agriculture of Guatemala illustrates how climatic variability – in particular, the substantial rainfall increase during the last few years – has affected yields for 15 of the 27 crops it examined. The study indicates that at least 56,128 farmed hectares were directly impacted in 2011, affecting 86,599 farming families. Maize was among the most affected crop, with average yields decreasing from 2.58 to 1.99 tons per hectare, a 30 per cent reduction (Trejo, 2012).

Castellanos and Guerra emphasized that "temperature variation and rainfall can surpass, year after year, the autochthonous capacity of agricultural workers to adapt, which is nothing more than a trial and error exercise for the modification of the conditions and sowing and harvesting times in the face of a variable environment" (Castellanos and Guerra, 2009, p. 32).

Changes in the climate caused by El Niño are affecting Guatemalans and their ability to rely on a regular harvest. El Niño has led to reduced rainfalls in the dry corridor in Guatemala, affecting agricultural production and limiting harvests. As a result of dry spells, more than 2,000 children under the age of 5 have died due to malnutrition. The El Niño event of 2009–2010 caused agricultural losses totalling US$70 million in Costa Rica, El Salvador, Guatemala, Nicaragua and Panama (WFP, 2010).

UNICEF (2011) confirmed the gravity of the situation in Guatemala in 2010. Irregular rains and unusually high temperatures have negatively affected crop production. As a result, the European Commission (2010) provided €1.3 million for relief programmes in Guatemala and its neighbouring countries. Severe droughts linked to El Niño affected Guatemala, particularly those regions along its borders with Honduras and El Salvador.

Deforestation has direct negative consequences on the soil of Guatemala's mountainous regions, including the area of Cabricán. The degradation of soils caused by rainfall-induced erosion is exacerbated by the farming systems along hillside regions. The higher the intensity of the rain, the higher the rate of soil erosion, which, in turn, leads to a decrease in soil fertility, farming productivity and food availability (Castellanos and Guerra, 2009).

Most soil in Cabricán is suitable for forest vocations and is highly susceptible to erosion because of its physical and chemical characteristics. While producing their staple food, farmers tend to leave the soil exposed leading to its gradual deterioration and the problem is exacerbated by the high demand for wood and firewood. As a result, an important part of the soil of Cabricán is already degraded (CARE, 2010). The increase in rainfall intensity further increases soil erosion; as a direct result, the soil becomes less productive (FAO, 2005).

Studies of climate sensitivity of both maize and beans, which are the most important crops in Cabricán, indicate that one the one hand current levels of annual precipitation are already above the optimal level. On the other hand the temperature has not reached the ideal for maize, while the sensitivity study carried out for beans indicates that the optimum temperature had been reached (ECLAC, 2010).

2.3 Migration

Since Cabricán is located in a mountainous region, this subsection provides a short review of the migratory trends both in Guatemala and in mountainous areas worldwide.

2.3.1 Trends in Guatemala

Human mobility in Guatemala has been documented since the so-called liberal revolution in 1871, when coffee production became an important export crop often at the expense of indigenous lands. Since then, the indigenous population from the highlands has constituted the main source of labour in coffee fields. In addition to coffee, migrants travelled to the south-west of the country where other traditional crops for export are produced, including cotton (in the past), sugar cane, rubber, tropical fruits and others.

Poverty, a lack of economic opportunities, illiteracy, social exclusion, social and ethic discrimination and the agrarian relationship between small and large landholders have been the main socioeconomic factors causing migration within Guatemala in the twentieth century (Caballeros, 2006). Moreover, the main driver of migration during the 1960s, 1970s and 1980s was the internal armed conflict. It is estimated that about 1 million people were internally displaced and an estimated 400,000 people migrated to Belize, Costa Rica, El Salvador, Honduras, México and the United States during the 36 years of conflict (Beristain, 1998).

About 1.6 million Guatemalans are living abroad, 97 per cent of them in the United States. Most of these migrants are family heads of households that have left their children behind (UN, 2011). Outmigration and remittances are very important for the Guatemalan economy: in 2008, annual remittances (US$4.5 billion) constituted 10 per cent of GDP (Carletto and others, 2011). In 2008, approximately 30 per cent of the population in Guatemala received remittances (44 per cent of them in urban areas and 56 per cent in rural areas). Most of these remittances reach the poorest areas of the country and they come from young people who live in the United States. It is estimated that 70 per cent of all Guatemalans living in the United States do not possess the necessary legal immigration documents (International Organization for Migration (IOM), 2008).

Migration is an important strategy for reducing household vulnerability, and, in some cases, it enables households to accumulate assets. In many cases, however, the poorest and most vulnerable cannot move, even if they would like to, because of their lack of financial means (IOM, 2008, p. 29).

In Guatemala, migration from rural areas disproportionately affects men and youth, even though an increasing number of women are migrating. Two main hindrances to mobility for women are their limited language skills and their role within the household (taking care of children). Approximately one third of rural indigenous women are monolingual in their local language; however, language barriers for rural women are declining statistically over time as access to schooling increases for the younger generations (USAID, 2009).

An important element shaping international outmigration patterns among Guatemalans is the increasingly stringent immigration laws of the United States. In December 2005 and March 2006, under the framework of immigration reform, the United States Congress authorized a significant increase in the border patrol force, the incorporation of the National Guard into immigration control and the construction of a wall along the border between the United States and México (Agencia Pulsar, 2011).

Quetzaltenango, where the research area is located, is one of the departments with the strongest migratory tradition. According to a survey by IOM carried out in 2005, inhabitants in this department received over US$165 million in remittances.

In Quetzaltenango, as well as in the rest of the country, most of those were received by the wealthiest families (Adams, 2004).

2.3.2 Mountain regions

Migration behaviour in the mountain regions is influenced by a combination of environmental (floods, flash floods, landslides, droughts and land degradation) and non-environmental (economic, demographic, social and political) factors. Unfortunately, despite the relevance of environmental and socio-economic peculiarities of the mountainous areas, studies concentrating on migration from such regions in the developing world are rare (Kollmair and Banerjee, 2011, p. 4).

Migration (of one or more household members as well as of the whole household) is one of the most common strategies to manage livelihood risks in mountain regions worldwide. Human mobility is often combined with other livelihood strategies (Kreutzmann, 2012; Afifi and others, 2014; Milan and Ho, 2014). Environmental drivers such as scarce rainfall and the availability of land directly influence migration decisions in households dependent on farming or natural resource–based employment. This type of migration is usually temporary, seasonal and internal (rural–rural) (Kollmair and Banerjee, 2011).

Moreover, social networks are a powerful predictor of long-distance outmigration from mountainous areas. The gender division of labour affects migration patterns, and women tend to move for longer time periods than men. Non-environmental factors are of critical importance in understanding the diversity of migration and mobility patterns and are especially important in developing appropriate policy responses (ICIMOD, 2011, p. 11).

In this context, climate change acts as an additional stressor which can multiply existing development deficits and may limit mountain inhabitants' inherent capacity to cope and adapt (UNDP, 2010).

Section 3: Methodology

This section is divided into three parts: the first describes the research objectives; the second briefly discusses the methodology; and the third presents some limitations of this study.

3.1 Research objectives

The Rainfalls Project has two objectives:

1. To understand how rainfall variability, food and livelihood security and migration interact today; and
2. To understand how these factors might interact in the coming decades as the impact of climate change begins to be felt more strongly.

The project investigates the following two questions (related to the research objectives above):

1. Under what circumstances do households use migration as a risk management strategy in relation to increasing rainfall variability and food insecurity?
2. Under what scenarios do rainfall variability and food insecurity have the potential to become significant drivers of human mobility in specific regions of the world in the next two to three decades?

Fieldwork was undertaken for eight case studies across three major regions (Latin America, Africa and Asia) in order to address the first objective of the Rainfalls Project (Warner and others, 2012; Warner and Afifi, 2014). Case studies were aimed at gathering primary and secondary data about the circumstances under which households use migration as a risk management strategy in

relation to rainfall patterns and food security. The second objective was pursued through the development of an agent-based model (ABM) of migration (Smith, 2014).

This report presents the findings of field research in four Mam communities located in the Cabricán municipality in the department of Quetzaltenango in the western highlands of Guatemala.

3.2 Research methodology

Four research methods were applied to this case study: a household survey; participatory research approach (PRA) workshops and focus group discussions; expert interviews at the local and national levels; and rapid rural appraisal techniques (which were not considered in the original research protocol, but were implemented as a supplemental tool).

For more detailed information on the methodology, please refer to the research protocol for the project which includes the full household survey, a description and guidelines for using the PRA methods implemented for this project and the guiding questions for semi-structured expert interviews (Rademacher-Schulz and other, 2012).

3.2.1 Household survey

Community	No. of households (total)	%	No. of samples (sample size)
1. El Cerro (baseline community)	404	55	74
2. Buena Vista	219	30	39
3. El Durazno	31	4	5
4. Quiquibaj	80	11	18
Total	734	100	136

Table 5: Household survey sample size. Source: Own data, household survey.

The research team applied a two-stage random sampling technique. In the first stage, each sector of each village was assigned a percentage of surveys corresponding to its percentage of the total population. In the second phase, within each sector, households were selected randomly (Milan and Ruano, 2014).

Characteristics	Surveyed villages					
	El Cerro	El Durazno	Buena Vista	Quiquibaj	Total	%
Households interviewed	74	5	39	18	136	100
Female headed households						
Female interviewees (#)	10	0	4	1	15	11
Average age of the interviewees	38	3	14	8	63	46
Household size (average)	35.26	33	39.1	41.1	37.04	--
Average years of schooling of household head	6.92	7.4	6.9	5.8	6.79	--
Average years of schooling of household members aged 14+	3.25	1	2.81	3.65	3.12	--
Average monthly income in US$ per capita	3.98	4.83	2.58	3.09	3.57	--
Average farm land holding (ha)	18.20	14.60	11.41	16.11	15.71	--
Households with migrants	0.54	0.88	0.51	0.53	0.54	--
Households below the poverty line:	23	0	6	3	32	24
<US$1 per capita per day	34	2	23	14	73	87
US$1–US$2 per capita per day	7	0	1	3	11	13
Number of landless households (#)						
Households in various land categories	3	1	0	0	4	3
Small farmer (<0.44 ha)	48	1	25	14	88	69
Medium farmer (0.44–1 ha)	17	2	11	2	32	25
Large farmer (>1 ha)	3	1	2	2	8	6

Table 6: Key characteristics of the surveyed households.
Source: Own data, household survey.[6]

6 Variables such as income and farm size included missing values; the calculated percentage does not include the missing values.

As shown in Table 6, the characteristics of the population in the research area are relatively homogenous. With the exception of El Durazno, inhabitants in the communities reported similar levels of schooling. The high proportion of households living below the poverty line supports the assumption that most people are extremely poor, despite the fact that 38 per cent of the interviewees did not answer the question on income.[7]

Since the vast majority of households make a living from agriculture, one of the primary factors explaining the high prevalence of poverty is the size of the landholdings: 96 per cent of households own less than 1 hectare of land, and the average size is around 0.5 hectare in three out of the four villages.[8] Landholdings of this size cannot allow families to produce beyond a subsistence level nor do they allow for the diversification of agricultural production.

3.2.2 Participatory research approach (PRA) workshops and focus group discussions

Participatory research approach (PRA) workshops and focus group discussions were employed in all communities. A total of 36 PRA sessions were held and a total of 298 individuals took part in them. Among the participants, 163 (55 per cent) were women and 135 (45 per cent) were men.

All of the PRA techniques presented in the project protocol were applied in the El Cerro community and some were replicated in the satellite communities (Rademacher-Schulz and others, 2012). All of the techniques were not replicated across all communities for several reasons: because of time limitations, because the four communities were deemed very similar in terms of their food production systems as well as the problems they faced and livelihood strategies; and, finally, given the small population of the community it would not have been possible to organize multiple focus groups without inviting the same people more than once.

Please refer to Annex I for additional details on the PRA workshops held in each community and their timing.

3.2.3 Expert interviews

Expert interviews were carried out at three geographic and institutional levels: the local level (Cabricán); the regional level (Quetzaltenango); and the national level (Guatemala City). A total of seventeen experts were interviewed:

- Three local experts including the leader of one of the study communities (Buena Vista) and two people working in Cabricán;
- In the city of Quetzaltenango, six people from different organizations, most of whom took part in the regional roundtable on climate change; and
- In Guatemala City, eight experts who work in different organizations on topics related to the main focus of this study. These interviews were conducted after the fieldwork stage had been finalized.

Please refer to Annex II for additional details on the list of interviews held at the local, regional and national levels and their timing.

3.2.4 Rapid rural appraisal

The rapid rural appraisal is a participatory research method that was originally developed between 1974 and 1975 by the Institute of Agricultural Science and Technology (ICTA) in Guatemala with the name of sondeo (Ruano, 1989). It was subsequently identified generically in different places around the world as "rapid rural appraisal", and includes other names and variations.

7 Researchers were advised not to insist on an answer to this question since it is a sensitive topic.

8 As shown in Table 5, El Durazno only consists of 31 households. As a result, the team only completed 5 surveys there.

This method was applied before the primary phase of fieldwork in order for the team to familiarize itself with the study area. The half-day activity consisted of open-ended interviews with El Cerro community members (both male and female) regarding the study topic during the first visit to the community on 3 August 2011.

3.3 Research limitations

This study was only conducted in the area of origin of migrants. This limits an understanding of the migratory process which is always based on factors related both to the origin and destination areas.

The research team faced several limitations during fieldwork. This case study was conducted earlier than others, because UNU-EHS and CARE International agreed to finalize fieldwork in the country before the national elections were held in mid-September. In addition, time was very limited considering the size of the team.

Data are missing mostly at the local level related to the climate and particularly regarding rainfall. Unfortunately, as mentioned by one of the interviewed experts, there are no climatologists in Guatemala.

In terms of the results of the case study, the year before the research took place was characterized by heavy rainfall and a substantial portion of the maize harvest was lost. The population sampled for this study likely had a heightened awareness of rainfall and livelihood issues. It is also likely that individuals had more vivid memories of the heavy rainfall events, thus rendering drought events, as less significant, although they are also important in the long run.

Furthermore, a few years before fieldwork took placr, the government conducted interviews on migration in order to decide who complied with the necessary requirements to receive government support. Those who claimed to have relatives in the United States were not granted access to the programme; as a consequence, the team faced reluctance among the study population to mention any migrants in their families. It is likely that the number of migrants reported in this survey is underestimated. The same kind of distortion is likely to have lead to an underestimation of the importance of logging, which, although considered illegal, is practiced in the communities.

Finally, two of the five sectors of Quiquibaj were not included in the household survey because of extreme difficulty in accessing them. This meant that eight surveys which were supposed to have been completed there were subsequently randomly redistributed among the other three sectors of Quiquibaj.

Section 4: Introduction to the case study area

In this section, we present the criteria used to select the research area and general information on Cabricán.

4.1 Criteria for selection

The research area was selected by CARE and UNU-EHS using the following criteria (Milan and Ruano, 2014):

- Background information related to variation in the rainy seasons and rainfall variability;
- Population highly vulnerable to rainfall variability (prevalence of rain-fed agricultural activities);
- Highly mountainous area for which the farming zones are primarily located in areas where the soil is best for forest vocations and which is highly susceptible to erosion and degradation;
- High percentage of people living in conditions of poverty or extreme poverty; and
- Previous evidence of seasonal and permanent migration.

4.2 Description of survey site

The research took place in four communities: El Cerro, El Durazno, Quiquibaj and Buena Vista. These communities all belong to the municipality of Cabricán.

Figure 2: Location of the research area. Source: Authors own.

San Cristóbal Cabricán (original name) was founded in 1664 as part of the neighbouring municipality of San Juan Ostuncalco. According to oral tradition, its name comes from a two-headed snake, which in the Mam language is known as *kabekan*. Cabricán officially became a municipality in 1825. The entire population of the research area belongs to the Mam ethnic group, and its mother tongue is also Mam (Juarroz, 2004).

The municipality is located at 2,625 metres above sea level, covers an area of 60 km^2 and is characterized by cold weather with well-defined rainy and dry seasons. Frosts begin in October and end in March when the temperature can drop to 0° C or less (Juarroz, 2004).

Community	Number of inhabitants
1. El Cerro	2,424
2. El Durazno	186
3. Quiquibaj	480
4. Buena Vista	1,314
Total	4,404

Table 7: Estimated population of the research communities. Source: Authors' estimates based on data provided by municipal mayor's office.

As of 2011, Cabricán had an estimated 25,085 inhabitants which were distributed across 6 *aldeas* (villages) and 27 *caseríos* (hamlets). Among the population, 52 per cent were female and 60 per cent were located in rural areas (INE, 2010). The demographic trend is towards a population increase: in 1994, its population totalled 14,881, but is expected to reach 30,000 by 2020 (INE, 1996; INE, 2010).

In total, 84 per cent of the population of Cabricán is poor and the human development index for 2002 was 0.635[9], up from 0.510 in 1994 (UNDP, 2011b). The municipality is highly vulnerable to chronic malnutrition: in fact, 70 per cent of its school children face height retardation (Ministerio de Educación and SESAN, 2009).

The vast majority of this population depends on agriculture as the main economic activity, in particular rain-fed subsistence agriculture based on annual basic crops including maize, beans, broad beans and squash. However, Cabricán's soil potential is for perennial crops, such as forests or pasturelands. This suggests that annual crops face serious limitations and soil requires intensive soil conservation practices. This is a typical smallholdings zone, where approximately 94 per cent of the parcels measure less than 0.7 hectares (see Table 5) and most extend to just a few *cuerdas*[10] (Ministerio de Educación and SESAN, 2009). These characteristics are primarily the result of the broken topography of the area, as well as the prevailing soil types which are volcanic in origin. When not protected by forest, they are highly susceptible to erosion and land- and mudslides.[11]

Until 2001, seasonal migration to the southern or Pacific coast was a common strategy in order to obtain cash. Migration to the United States was an incipient phenomenon at that time, but the most common destination for migrants is now the United States (CARE, 2010).

9 This corresponds to a medium human development index. The national average for Guatemala is 0.7.

10 A cuerda is a local measurement, which is a fraction of a manzana (0.7 ha). One cuerda measures 21 m by 21 m or 441 m2.

11 Interview with Luis López, PhD (7 September 2011, Guatemala City).

Section 5: Rainfall Patterns and Rainfall Variability

This section summarizes the analysis of information collected through the household survey, PRAs and expert interviews and is supported by data from the Labor Ovalle Meteorological Station located in Quetzaltenango, 27 km from the study area. Both experts and the population from the study area have observed important changes in rainfall patterns over the last few decades.

Sub-section 5.1 presents rainfall data, while 5.2 discusses the perception of the population on changes in rainfall patterns.

5.1. Rainfall patterns

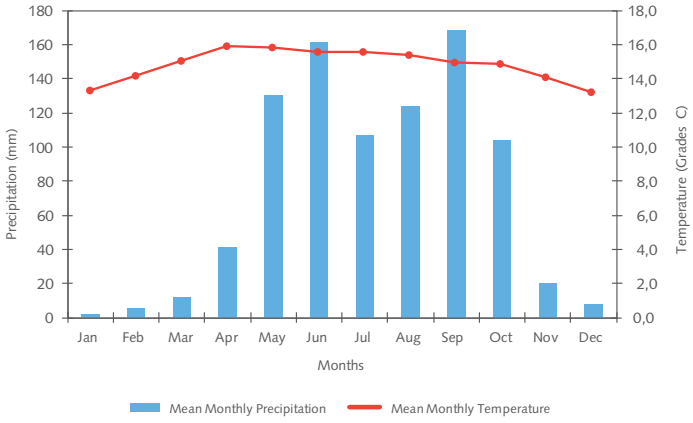

Figure 3: Mean monthly rainfall and monthly temperatures in the study area, 1977–2011. Source: Authors' own based on data from INSIVUMEH, Labor Ovalle meteorological station, Quetzaltenango (2012).

Figure 3 shows that rainfall patterns in the research area, similar to those found in the rest of the country, are bimodal with peaks in June and September, the latter being the month with the highest amount of precipitation. In terms of the temperature, Cabricán is characterized by relatively cold weather with minor fluctuations of around 3° C over a 35-year period.

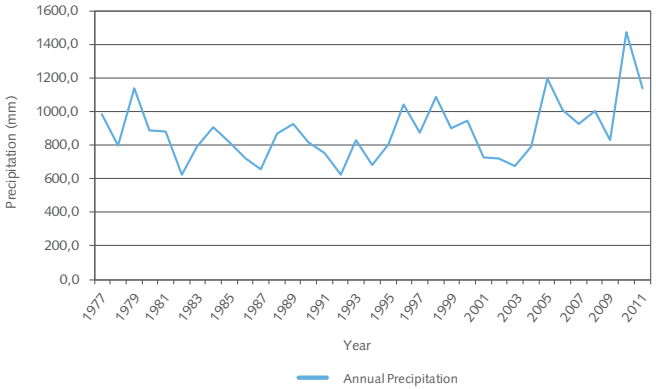

Figure 4: Annual rainfall (mm) for the study area, 1977–2011. Source: Authors' own based on data from INSIVUMEH, Labor Ovalle meteorological station, Quetzaltenango (2012).

Figure 4 shows the annual rainfall trends for the period 1977 through 2011, which is characterized by an initial decrease from 1977 to 1993, followed by an increase from 1994 to 1998, a second decrease from 1999 to 2003 and another increase from 2004 continuing to the present. The area received the highest amounts of annual rainfall in 2010 and 2011.

The minimum temperature of the area is quite frequently near or below zero from November to February when frost usually appears. Both experts and PRA participants pointed out that, two or three decades ago, frost usually occurred at the end and at the beginning of each year.

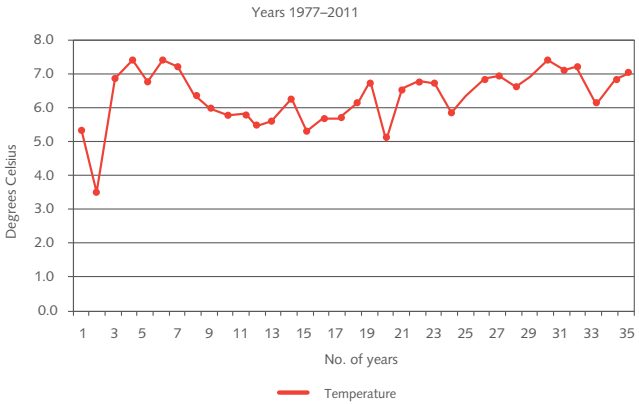

Figure 5: Average annual minimum temperature in the study area. Source: Authors' own based on data from INSIVUMEH, Labor Ovalle meteorological station, Quetzaltenango (2012).

In recent years, this phenomenon has changed, and now frost occurs in March and April, which did not happen in the past.

Unfortunately, no in-depth study on the impact of El Niño in the research area is available.

5.2 Perceptions of precipitation changes

5.2.1 Rainfall variability

Participants in the PRA sessions on livelihood risk ranking mentioned heavy rain and, consequently, the humidity of the soil, crop diseases, damage to roads and landslides as well as a lack of water for domestic use as the main threats to their livelihoods. Both men and women participating in the PRA sessions on rainfall and its impacts emphasized that rainfall variability has increased over time.

Both men and women also highlighted changes in hail, which is now less predictable and more intense.

Changes in rainfall are also perceived as being related to seasonality and frequency, making it impossible for farmers to predict what is going to happen. This conclusion was a finding from the PRA sessions when facilitators emphasized that the team was not only asking about the most recent years but was also interested in longer term trends.

	More drought / dry spells?	More flooding?	More heavy rain?	More extreme weather events?
Yes, a lot more	47	44	51	51
Yes, more	20	9	40	37
Same as before	8	5	10	15
No, less than before	13	12	0	6
Did not exist at all	18	37	8	0
Not applicable	2	2	2	2
Don't know	0	0	0	0
No response	28	27	25	25
Total	136	136	136	136

Table 8: Perception of climatic changes over the last 10–20 years (absolute number of respondents). Source: Author's own, household survey.

In the household survey, even though the questions were about long-term trends, the most frequent explanations of the changes mentioned by respondents were "heavier rain" and "more extreme weather events". Few respondents mentioned shorter rainy seasons. As noted above, this could be explained by the heavy rains which destroyed the maize crops in the year prior to the fieldwork reported here.

To summarize, 74 per cent of the survey respondents reported that there have been climatic changes, with the increase in rainfall intensity being the most relevant and of primary concern. Among respondents, 50 per cent thought that drought/dry spells were more common now than 30 years ago (or 20 years ago, in the case of people who did not live in the community or were not old enough to remember), 39 per cent mentioned more floods, 68 per cent noted heavier rain and 65 per cent noted a greater frequency of extreme weather events. The percentages for respondents answering that the same climatic factors did not exist at all 30 years ago were 13 per cent, 27 per cent, 7 per cent and 0, respectively.

A vast majority of respondents believe that climatic conditions have changed for the worse. In fact, the number of people who stated that climatic events are the same or better than before constitutes less than one-fifth of the respondents: only 16 per cent for drought/dry spells, 13 per cent for floods, 7 per cent in the case of heavy rain and 16 per cent for extreme weather events.

5.2.2 Floods

The survey data shown in Table 8 highlights that, among the climatic changes recognized by communities in the study area, floods are of least concern despite the fact that 39 per cent of respondents perceived changes in this phenomenon.

During PRA discussions, women ranked landslides as the third most important risk to their livelihood, while men ranked it second. Among men, the primary risk was identified as the death of animals, while for women the highest ranked risk was diseases affecting trees, crop diseases, particularly those affecting maize and wheat, ranked second.

PRA participants reported that there have been cases where families had to leave their homes due to landslides. They also stated that, during Tropical Storm Agatha in 2010, inhabitants from the study area remained isolated for several days since the only road was blocked. This affected their livelihood in multiple ways including limiting their access to the market, hospital and other services which are only available in the town centre of Cabricán.

5.2.3 Drought and seasonal shifts

In the research area, droughts are directly associated with two main events:

1. The scarcity of water suitable for human consumption during the driest period of the year (March–April) when many water sources either completely dry up or substantially decrease; and

2. The canícula (a dry period during the rainy season). According to PRA participants and experts, canículas have become extremely unpredictable events which directly affect crop systems.

The irregularity of canícula was mentioned during several PRA sessions. Canículas previously started by mid-July. Recently, they occur at unexpected times and sometimes last for longer periods than normal, which can have devastating effects on crops.

Information from the household survey described in Table 9 shows broad consensus on three main changes related to the timing of rainfall[12]:

- The rainy season has become shorter;
- The frequency and intensity of rain has increased; and
- Dry spells last longer.

Rainfall change	Yes
Longer rainy seasons	12
Shorter rainy seasons	42
More rains at unexpected moments	42
Longer dry spells	32
Shorter dry spells	11
More dry spells at unexpected moments	13
Others	0

Table 9: Perception of changes in rainfall over the last 10–20 years (absolute values). Source: Author's own, household survey.

Qualitative data collected during PRA sessions is supported by these figures (see Table 9). Elderly individuals stated that, up to 30 years ago, the rainy season would start in March and end in October–November. Gradually this period has shortened, whereby in the last decade the rainy season sometimes starts in May or June and ends around October.

PRA participants added that rain was previously more frequent but less intense during each rainfall event. As a result of the shorter rainy season, the dry season[13] has become longer.

12 Survey respondents were allowed to give more than one answer in terms of changes they perceived in rainfall patterns. Because of this, the number of responses shown in Table 9 is larger than the actual sample size.

13 As mentioned earlier, Guatemala is a tropical country with just two main seasons, rainy and dry. The former is called "winter" and the latter "summer."

Section 6: Livelihood and Food Security

The study area is characterized by a high prevalence of illiteracy, disease and malnutrition, as well as a lack of basic services and few economic and social opportunities.

Historically, livelihoods have been based on a subsistence economy with farming (mostly oriented towards the production of food staples) as the main activity. Agricultural production is not irrigated due to the lack of sources of water. As a consequence, all farming systems are rain-fed and completely dependent on weather conditions, in particular, rainfall.

This section presents the most important findings on livelihoods and food security based on the household survey and the PRAs. Sub-section 6.1 describes the sources of livelihood, 6.2 analyses food security and 6.3 focuses on gender issues and the ideas of the youth.

6.1. Sources of livelihoods

6.1.1 Economic Livelihoods

Exactly three-fifths of the survey respondents provided their income[14]: 88 per cent declared an income of less than US$1 per capita, while only 12 per cent earned between US$1 and US$2. None of the participants indicated that they earned more than US$2 per capita per day.

14 The research team did not insist on an answer to the question since income can be a sensitive topic to discuss.

	Landless	Small farmer (<0.44 ha)	Medium farmer (0.44–1 ha)	Large farmer (>1 ha)	Total
Poor (<US$1 per capita)	4	80	21	4	109
Average (US$1–US$2 per capita)	0	8	11	4	23
Above the poverty line	0	0	0	0	0
Total	4	88	32	8	132

Table 10: Landholdings and income groups.
Source: Author's own, household survey.

Table 10 shows the relationship between income and landholdings. All landless families, 91 per cent of the small farmers, 66 per cent of the medium farmers and 50 per cent of the large farmers earned less than US$1 per capita per day. Regardless of the size of the landholding and the ownership of assets (see Table 11), everyone in the community earns less than or equal to US$2 per capita per day.

In total, only 17 assets were mentioned (see Table 11) from a sample of 1,000 individuals, 600 of which were above 15 years of age (INE, 2010). Thus, the ownership of assets is not widespread, which is in accordance with previous findings on the high levels of poverty in the research area.

The primary element differentiating households in Cabricán is related to housing conditions. There is a clear distinction between old and new houses which have been built thanks to remittances from one or more persons living in the United States.

Asset owned	Number
Pick-up truck	2
Motorcycle	2
Bicycle	12
Tractor[15]	1
Total	17

Table 11: Asset ownership.
Source: Author's own, household survey

15 Tractors cannot be used for agricultural purposes in the area because the region is extremely hilly.

In total, 94 per cent of the respondents mentioned at least one activity which was most important for their household, while only 59 per cent mentioned at least two important activities. Nevertheless, PRA sessions and informal discussions with locals revealed that more than 59 per cent of the population was working in both agriculture and weaving.

Agriculture is the most important economic activity for 66 per cent of the households surveyed, weaving is the most important activity for 22 per cent, while 5 per cent mentioned other activities and sources of income, such as public employment, working in a lime cave, working in construction, selling livestock, being *jornalero* (employed on a daily basis) and remittances. A further 7 per cent did not reply.

In total, 41 per cent of the respondents did not mention a secondary economic activity, 30 per cent mentioned weaving, 14 per cent mentioned agriculture, 7 per cent mentioned *jornalero*, 3 per cent ran a small business (*negocio*), 2 per cent worked in a lime cave and 3 per cent specified another activity (such as construction work, remittances, wood collecting and livestock-related activities).

6.1.2 Production systems

Through PRA sessions, researchers found that the typical agricultural production subsystem is called *milpa*, or maize field, which is practiced by all of the families. *Milpa* is a combination of maize (main crop), beans, *piloy* (a legume similar to and larger than beans), lima beans and *ayote* (a variety of squash known as *cucurbiaceae*). Maize is the only crop that follows a defined spatial order while the other crops are sowed randomly. In addition to this subsystem, in certain cases, temperate deciduous fruits such as apples, apricots and plums are also produced for household consumption or sale.

Subsistence agriculture is of vital importance to households in Cabricán. PRA participants unanimously stated that all households whose main activity is agricultural depend on rainfall for their crops since there is no irrigation system. In the household survey, 98 per cent of the respondents stated that they only produce food for household consumption, while only 2 per cent said that they also produced food for the market.[16]

Most PRA participants stated that, approximately three decades ago, the average yields in a normal year were approximately as follows: 6,400 lbs of maize per *manzana*, which is equivalent to 2,880 kg/ha; 120 kg/ha for beans; 100 kg/ha for lima beans; and between 12 and 15 units of *ayote* per hectare.

Over the last few years, the average yields have decreased by about half. In 2010, a year characterized by excess rain due to Tropical Storm Agatha, yields were 60–70 per cent less than the average. Participants also mentioned that the climatic situation has had direct negative consequences on the production of fruits, wheat and potatoes, as well as small and large livestock since less fodder is available for feeding them.

In response, local farmers have developed a diversification and food security strategy that has two main objectives: to produce the highest yield of different foods on a limited piece of land and to cope with climate variation, in particular, rainfall variability and frost.

Agricultural diversification in the study area is not limited to the production of several crops, but is also implemented through the production of more than one genotype of each crop. For example, four varieties of maize are sowed: white, yellow, red and black. Black, white and red beans are grown and three varieties of *piloy* (yellow, red and black) are also common. Moreover, there are two varieties of lima beans (small and large) and three kinds of ayote.

16 The percentages indicate only valid responses. However, 31 out of 136 respondents did not respond to this question.

This genotype diversification strategy has two main objectives. First, it allows for dietary diversification. Second, and most importantly, in terms of food security, it helps to cope with climate variability, specifically related to rainfall variability and frost.

For instance, during a "normal" rainy year, white and yellow maize would produce the highest yields. In a year with a shortage of rainfall, black maize would have a better yield. In a year with an excess of moisture, red maize would perform best. Black maize is also the most resistant to frost and grows best in soil with a low fertility even though its yield potential is lower. This same strategy applies to other crops as well. *Piloy*, for example, has a lower yield than beans, but is more resistant to excess moisture. Among the three bean genotypes, black has the highest yield potential, but is less tolerant to heavy rainfall and frost. Lima beans and *ayote* follow a similar pattern, with each genotype responding differently to varying rainfall and temperature patterns.

In relation to soil fertility, farmers have relied on chemical fertilizers for several years. However, because of the increase in oil prices, the price of petrochemical-based fertilizers has also increased. As a result, such products are now unaffordable for many households (although they are extensively subsidized by the Guatemalan government). As an alternative strategy, many farmers are looking for (or actually developing) an organic fertilization process. For their strategy to be successful, they would need technical assistance as well as improved crop seeds.

In all households where this is economically feasible, livestock is produced as a diversification strategy. In fact, all survey respondents mentioned owning livestock, but only one mentioned the selling of livestock as an important activity for his household.

The production of poultry is very common, this mostly includes hens, chickens, turkeys and ducks. Pigs and sheep are also common, although not among the poorest households. Large livestock is produced to a lesser degree and is common among families who have more extensive resources in terms of capital or land. Common species include cattle, which are also the primary means of transportation, and pack animals such as horses, mules and donkeys.

Until the late 1980s and early 1990s, the main source of work other than agriculture was the production of lime stock. In 1989, there were 68 lime stock ovens in Cabricán. At present, only 10 of them remain and migration to the southern coast is not as common. Since the late 1990s, weaving has become the primary non-agricultural diversification activity. Indeed, it is now the most common non-agricultural economic diversification activity, with 34 per cent of households listing it as their second most important activity.

For several decades, one of the most important centres for weaving was Salcajá, situated near Quetzaltenango. However, approximately 20 years ago, most of its inhabitants began migrating to the United States, as a result weaving almost disappeared. In response, one of the largest textile traders from Salcajá started looking for alternative labour sources to keep up with textile production. In Cabricán, he found a population that demanded opportunities for diversifying their economic activity and moved his production there.

All of the households that are involved in this activity do so under an oral contract, working for a patrón (owner) who lives in Salcajá. The *patrón* provides them with equipment, tools and materials (thread, etc.) as part of the commitment and in exchange s/he buys the final product.

However, the increasing number of people in Cabricán who work in weaving is pushing local incomes down. In PRA sessions, respondents reported that the earnings of households working in this sector have decreased significantly. Some time ago, owners demanded between four and five cortes (standard cut required by textile traders) per week, while today they tend to request only

one or two per week. Researchers estimated that the payments that families involved in weaving receive correspond to approximately 10 per cent of the final selling price on the market.

When agricultural diversification does not work and resources cannot be generated from textiles, the first option in most households for earning money is to sell small or large livestock. Depending on the need, the first option is poultry followed by pigs. When this is not an option for the household, men try to sell their labour within the community or in a neighbouring town.

Alternatively, members of a household will try to obtain an "informal" loan from a relative, friend or neighbour in that order. Families with relatives who work in the United States, Quetzaltenango or Guatemala City will ask for a remittance. When none of these strategies work, individuals will resort to eating wild herbs collected from the forest. Another strategy adopted by the population is to reduce food intake or (very seldom) to decrease the number of meals to two per day. In extreme situations, individuals mill *olote*[17] and mix it with water or some *atol*[18].

6.2. Food security

Cabricán is located in a relatively isolated mountainous area in Guatemala's western highlands. Given the prevalence of rain-fed subsistence agriculture, the relationship between rainfall and food security is mostly related to food production. Food insecurity constitutes a problem for most households: 78 per cent of respondents reported having suffered food shortages at least once in the last 10 years, while only 16 per cent had not (an additional 6 per cent did not respond to the question).

A factor that deeply affects the population during times of crisis is the market dynamic of maize. It is precisely when production is poor and people need to buy maize that its price tends to increase. Maize is the main staple in the region and diseases that affect other crops increase dependence on the production of maize.

For every plant, soil fertility is vital. This factor has been seriously affected by rainfall variability and increases in the price of fertilizers. Participants in the PRA sessions explained that, many years ago, organic manure was used as a fertilizer. A few decades ago, chemicals were introduced and people stopped using manure for a considerable period of time. Currently, farmers use a combination of chemicals and manure.

Landless families, who only represent 3 per cent of the total, have very few options to ensure their food security. They depend on selling their labour to obtain cash, and periods of major food shortages generally coincide with a lower demand for labour. However, they are often beneficiaries of governmental subsidy programmes.

In Cabricán, the first harvests begin in October when it is possible to harvest the first elotes (green maize). Major food shortages are most likely occur between June and October, since this is the period when people run out of the milpa harvested during the previous November.

Household survey results correspond to those from PRA sessions, during which people agreed that the highest food insecurity period is from May or June through to November. However, respondents to the household survey expressed a wider range of opinions on the highest food insecurity period, with some respondents including April, March and December and others mentioning a shorter period.

Survey results also show that when households did not have enough food or money to buy food in the last 10 years, 46 per cent of them modified their food production to increase output,

17 Olote is the central part of maize. Once the grain is removed, it is generally used as fuel for cooking.

18 Atol is a Mesoamerican indigenous beverage usually prepared using smashed maize and water.

20 per cent sold assets, 18 per cent reduced food consumption, 12 per cent reduced their expenditures and 10 per cent diversified their activities, very few respondents mentioned other coping strategies.[19] In particular, migration was only mentioned by 3 per cent of the respondents. This confirms what PRA participants stated. Even during times of food scarcity, people want to remain in their communities and only leave when no other option is exists.

According to the outcomes from PRA sessions, modifying food production requires the application of improved production technologies based on better soil and crop management. Participants believe there are three important areas which would lead to increased food crop productivity: soil conservation, soil fertility and improved seeds.

Analysis of a PRA session held with a group of women focused on those institutions that support households during times of food insecurity. The results showed that governmental programmes such as Mi Familia Progresa and Bolsa Solidaria (solidarity bag), as well as one's family and the local church, were the most important sources of support. Mi Familia Progresa is a programme through which the government offers economic support and a solidarity bag containing food items (combining the main staples with other foods of high nutritional value) to the poorest households. Participants added that not all families can benefit from these programmes.

Other institutions that help during times of food insecurity include schools, informal moneylenders and the local municipal office for women. Participants also mentioned a governmental school feeding programme, which generally consists of a nutritional beverage supplemented by bread, cookies or a maize-based snack.

In addition to food shortages, cultural and educational factors worsen food insecurity. For centuries, the diet in the region's communities has been based on maize, which makes shifting away from it difficult. Families, particularly mothers, need to be better advised regarding the benefits of a more balanced diet as well as how to use other locally available vegetables and crops.

In fact, the rate of malnourishment among children in Cabricán is considerably high (69.8 per cent compared with the Guatemalan average of 45.6 per cent). In San Carlos Sija, a neighbouring municipality, the rate of child malnutrition is 41.7 per cent (MINEDUC-SESAN, 2009). In San Carlos Sija, food consumption is much more diversified and wheat, potatoes, local vegetables, eggs, milk and meat are widely consumed.

6.3 Gender dynamics and youth

PRA sessions provided interesting insights on the gender dynamics as well as the perceptions of the younger generation. Similar to the rest of the country, the research area is marked by a mainly chauvinistic society, where gender relationships are evidently unequal and women bear most of the disadvantages. Alcoholism is an aggravating factor. It is a daily trigger for intrafamily violence and other negative consequences including the misuse of very limited household financial resources. Additionally, it is evident that the level of participation among women in community decision-making is insufficient or non-existent.

The division of labour within the family is very well defined: men are responsible for most agricultural activities, while women take care of livestock and the household. Both men and women are engaged in textile-related work. Women are very careful in managing the portion of income they are allowed to control, which can be generated from livestock (most often), textiles or remittances.

19 Multiple responses were possible.

Local problems are perceived differently among groups of men and women. Men place higher importance on everything related to productivity, whereas women highlight reproductive issues (e.g., health, family and, in particular, children) without leaving productivity aside.

When it comes to strategies to deal with problems related to rainfall, men have a more optimistic view than women. Men think it is feasible to address part of this issue, which they associate with agricultural production. Both groups think it is very hard to find alternative economic options or employment opportunities.

The local youth tend to feel a shared responsibility for climate change and are developing an awareness which will help them take corrective measures for the future. During their focus group discussions on rainfall variability, food security and migration, boys focused more on developing production or professional skills, while girls highlighted the importance of reproductive knowledge.

Young people also value savings and the wise management of resources as a way to fulfil their ambitions and achieve their goals. To do so, they believe it is necessary to study and have a better education, as well as engage in jobs and activities that go beyond subsistence farming.

Section 7: Migration and human mobility pattern

Historically, human mobility in the study area has always been common and predates the memory of most PRA and survey participants. Elderly men and women recalled that, since they were children, many people from the region migrated to look for income earning opportunities.

Origin	Number	%
Born in the research area	476	96
In-migrants from other communities in Cabricán	16	3
In-migrants from outside Cabricán	6	1
Total	498	100

Table 12: Place of birth. Source: Author's own, household survey

People born outside the four study communities represent a very low proportion of the total population, with the majority of them coming from neighbouring communities and moving because of

marriage. The primary reason for the very low rate of in-migration is that environmental, economic and social conditions and opportunities are not favourable for attracting outsiders.

In terms of outmigration, survey data shows that 25 per cent of the households have experienced migration (22 per cent experienced international migration and 3 per cent experienced internal migration). As mentioned in section V, this data is likely to be an underestimation of the real figures, since individuals tended to deny having a household member abroad.

PRA sessions revealed that in the past several decades seasonal migration was quite common, mostly to the southern coastline where cotton fields were historically located and where rubber, fruit, sugar cane and other export crops are still grown. Migration to the midlands above the coastline was also frequent among those who wanted to work on coffee plantations.

At present, this seasonal agricultural labour market is seriously restricted, since cotton fields have now been replaced by sugar cane, which requires less labour. Moreover, these farms tend to have a group of full-time labourers. This is also the case for coffee plantations and other crops. Nowadays, most migrants go to the United States.

Typical migrants are young men, 78 per cent of whom are married or in a consensual union, with nearly two years more schooling than the average population. The typical migrant has most likely moved for economic reasons, and migrates for a period of six months or more. Information collected through PRA sessions indicates that most migrants contribute to the local economy in general and to their families in particular through remittances.

Non-seasonal migration mostly flows in the direction of the United States, with New York the most common destination followed by New Jersey and Virginia. During PRA sessions, Los Angeles was also listed as an important destination. As stated above, the main reason behind migration is the search for employment opportunities since the migrant's communities of origin offer so few. A strong reason for choosing a particular destination is the availability of a network.

Destination	No.	%
Guatemala City	3	9
Huehuetenango (neighbouring department)	1	3
Southern coastline	3	9
United States (unspecified / unknown city)	11	31
Los Angeles (USA)	1	3
New York (USA)	9	26
New Jersey (USA)	2	6
Virginia (USA)	2	6
Not specified	3	9
Total	35	100

Table 13: Migrant destinations. Source: Author's own, household survey.

In fact, among surveyed households, 72 per cent of migrants moved to the United States, significantly fewer migrated seasonally to the coastline or to Huehuetenango and Guatemala City. These figures support the statements made by PRA participants indicating that the United States is the most important destination.

Migration to the United States from Cabricán began in 1990, with Don Mario Pérez who is said to have "paved the way" for all other migrants. Since then, migrants who come back for holidays (normally for the *feria*, the most important local holiday) share their experiences and knowledge with potential migrants from the community. Participants in the PRA session on migration estimated that, at present, there are at least 50 individuals from El Cerro living and working in the United States. Among those, 40 per cent were estimated to be women.

PRA participants also revealed that, in the last five or six years, migration to the United States has decreased significantly. One of the main reasons for this trend is the high price paid to the travel assistant, referred to as the *coyote*. In 2011, the cost of the trip fluctuated between 45,000 and 50,000 Quetzales (approximately US$6,000), which is an extremely high price considering the resources locally available.

This decrease in migration to the United States is also influenced by the increased rigidity of its immigration laws following the terrorist attack on the World Trade Centre (2001) (Facundo, 2010). The high risk to one's personal safety while travelling through Mexico, especially in terms of the threats of abuse, crime, human trafficking and drug dealing, also play a role. Moreover, communities perceive that there is a significant reduction in the employment opportunities available in the United States.

To cover the cost of the trip, migrants have generally requested mortgage loans from banks using the deeds to their land or house as collateral. During the first four to five years, most of the generated income sent through remittances is often used to repay the debt. Unfortunately, survey data on remittances are not conclusive. In many cases, people answered that they did not receive remittances, but it was evident to the interviewer from the overall conditions of the house that the household had very likely received remittances (or, at least, may have benefited from them in the past).

An interesting outcome of the PRA sessions was that, despite the difficult life conditions in Cabricán, people are quite attached to their community of origin and would definitely prefer to remain in the area if at all possible. Most migrants to the United States plan to return once they have saved enough money to ensure a better future. However, those migrating to Guatemala City (primarily as construction workers or in textile factories) have less of an opportunity to save capital or send remittances.

Potential migrants are primarily driven by economic considerations and sufficient rainfall is crucial for their economic situation, which is mostly dependent on rain-fed agricultural production.

Section 8: Research Analysis

This section pulls together the key facts and pieces of evidence from sections V through VII and analyses additional findings related to the interaction between the three variables of interest: rainfall variability, livelihood and food security and migration. In particular, the analysis here aims to understand under what circumstances households use migration as a risk management strategy in relation to increasing rainfall variability and food insecurity.

Less frequent but heavier rains were the most widely cited changes in rainfall. Moreover, floods and droughts were frequently mentioned, as well as a shortening of the rainy season. Increases in the intensity of rain affect the maize harvest, as well as all other crops and livestock.

Moreover, excess moisture favours the proliferation of diseases, particularly fungi that affect beans, lima beans, wheat and potatoes, all of which are highly susceptible. Many families are no longer able to produce the two latter crops. In the case of potatoes, the problem is related to a fungal infection known as *tizón tardío* (known in the scientific community as phytophthora infestans). Moreover, all varieties of wheat are susceptible to rust (also known as Puccinia) and fusariosis.[20]

During a PRA session held with men and women in El Cerro and Buena Vista, participants constructed a diagram of the impact of rainfall variability on their livelihoods.

In El Cerro, men agreed that the most important impact of damaging rains is the resulting reduction in food production. This reduction triggers several problems: a lack of money to buy food, a lack of job opportunities, an increase in the costs related to agricultural production, a reduction in the amount of food consumed, a diminishing return from animal productivity and a reduction in any opportunities related to livestock production and sale.

Rainfall is also less predictable than in the past. In recent winters, it would rain intensely for one day and then stop raining for a week. This change directly affects crop production and livestock subsystems.

Rather than discussing the impact of rainfall variability, women in El Cerro focused initially on excessive rains and later addressed the lack of rain. According to them, the impacts of excessive rain include landslides, a loss of crops, human and animal diseases, a lack of money to buy food and medicines, damage to homes, forced migration of people affected (or threatened) by landslides, an increase in the price of maize and excessive sludge. Participants emphasized that the lack of rain causes water shortages during summer. When this happens, wells dry up and insufficient water is available for domestic consumption.

Survey respondents were explicitly asked whether changes in rainfall had affected their food production: 68 per cent responded "yes, a lot", 29 per cent "yes, but only a little", and 1 per cent stated that rainfall does not affect their food production (with a further 2 per cent not providing an answer). In particular, 87 per cent mentioned a decrease in crop production, 8 per cent mentioned a decrease in crop production together with one or more additional effects (e.g., a decline in the production of fodder, a decline in pasturelands and a water shortage for animals), while 2 per cent did not answer and 1 per cent mentioned an increase in crop production.

Another perceived impact of changing rainfall is on the availability of mushrooms. Older respondents mentioned during PRA sessions (and informal discussions) that, up to 20–30 years ago, mushrooms were not even sold on the market. Everyone could gather them for free. Currently, there are fewer mushrooms and as a consequence they are sold on the market.

20 Personal communication with Dr. Fernando Aldana, scientist from Instituto de Ciencia y Tecnología Agrícolas (ICTA).

Participants in PRA sessions also emphasized the impact of droughts, which, during the growing season, affect the availability of water for human consumption as well as for crops. For the former, with the support of a local NGO, many households are installing water reservoirs to collect rainwater during the rainy season. In relation to the latter, farmers have been adapting by planting more drought tolerant crop varieties such as local maize and bean germplasm.

Communities reported that, in the past, frosts generally appeared at the end and beginning of the year (from November to February) when most annual crops were under cultivation. Frost is now less predictable and can appear during critical moments of the growing season. During PRA sessions, farmers reported that they are forced to plant varieties of maize, beans and lima beans which are more tolerant to frost.

Another relevant climatic event for the area is hail. Nowadays, its occurrence is highly unpredictable, whereas, in the past, it used to take place only during the peak of the rainy season (July and September). Hail can now fall at any time during the rainy season, particularly affecting crops when it occurs during the initial stages of the crop cycle. Farmers could not describe any strategy to cope with this particular climatic event.

PRA and survey data reveal the attachment of people in Cabricán to their communities and their strong willingness to remain there. An important result of this case study is that migration from Cabricán is driven by livelihood risks in the communities of origin (which are often related to damaging rains) more than by the "pull" factors associated with a particular destination.

The results of this case study provide some conclusions related to the primary research question: under what circumstances do households use migration as a risk management strategy in relation to increasing rainfall variability and food insecurity?

In the long term, the most common *in situ* risk management strategies were related to agricultural (e.g., introducing different crops in combination with planting different genotypes of the same crops) and non-agricultural economic diversification (i.e., mostly weaving). During times of food shortages, often a consequence of damaging rains, the first strategies households implement are either selling livestock or borrowing money from a relative or friend (or a combination of the two). Individuals only tend to migrate when these options are not feasible.

Households expressed their preference for risk management strategies that allow them to remain in their community of origin; as a result, the entire household only migrates when in situ options are not profitable. However, *in situ* and migration strategies are often combined. It is often the case that one or more household members moves, while the remainder of the household stays in the community and diversifies its sources of livelihood there. Migrants remain strongly attached to their household and community of origin.

Preference aside, neither migration to the coastline nor to the United States is as easy or as profitable as it once was. This limits limits the potential use of migration as a risk management strategy. Moreover, migration can only be used as a risk management strategy by those households that can afford it. The prevalence of poverty in Cabricán is very high and the cost of migration to the United States is unaffordable for the most vulnerable households, unless they are offered a loan.

Until now, potential migrants have found formal and informal ways to obtain a loan to finance their trip. Borrowers know that migrants are usually able to repay such a debt. Given the decreasing demand for labour in the United States, it is not clear whether credit will still be offered to potential migrants in the future. Thus, an increasing number of people might find themselves forced to leave due to adverse climatic conditions, yet unable to do so because of the lack of financial means available to them.

Section 9: Conclusions

This case study was carried out in four rural communities in the western highlands of Guatemala. The study was aimed at investigating the relationship between changing weather patterns, livelihood and food security and human mobility.

The research team found a direct negative impact of rainfall variability on food security. Most households base their livelihood on rain-fed subsistence agriculture. Outmigration from Cabricán is mostly driven by "push" factors from the community of origin, including conditions related to one's livelihood and food security. In-migration is quantitatively negligible and mostly related to family reunions.

At present, no long-term risk management strategy seems to be sustainable for the communities. On the one hand, income from weaving – the primary *in situ* complementary activity to rain-fed agriculture – is decreasing. On the other hand, the most common and profitable migration destination in recent years – the United States – is becoming too risky and expensive.

These alarming trends reveal that, unless action is taken, El Cerro, El Durazno, Quiquibaj and Buena Vista do not have a clear and sustainable development pathway for the future.

Section 10: Reflections for Policymakers

Cabricán is the thirty-fourth most vulnerable municipality to chronic malnutrition in Guatemala, and the second most vulnerable in the department of Quetzaltenango (MINEDUC and SESAN, 2009). As consequence of this vulnerability, Cabricán is one of the 166 municipalities which were prioritized for the government's *Plan hambre cero* or "zero hunger plan". The effectiveness of this programme will be crucial for the communities so that they may follow a path towards sustainable development in the coming years.

The plan was signed in February 2012 and has four main objectives to be achieved by 2015:

1. Reducing the prevalence of chronic malnutrition in children under 5 years of age by 10 per cent;
2. Preventing and reducing mortality related to acute malnutrition in children under 5 years of age;
3. Fighting hunger and promoting food security; and
4. Preventing and responding to food and nutrition emergencies.

In Guatemala, there are institutionalized efforts underway to address the consequences of climate change, such as the national (and three regional) climate change roundtables, which involve all of the key stakeholders. These roundtables have already allowed the Guatemalan Parliament to approve important legislation on climate change.

However, both the zero hunger plan and the climate change roundtables are still at the very initial phases of implementation, and require reinforcement in order to create the corresponding legal and institutional platforms that allow for the effective implementation of actions to address climate change–related issues.

With respect to the possible future adaptation of maize to climate change, which is the most important crop for Cabricán, the first national communication to the United Nations Framework Convention on Climate Change (UNFCCC) suggested the following priorities (MARN, 2001):

1. More and better functioning organization for maize producers (e.g., collective purchase of inputs and services to reduce costs and to access formal credit markets);
2. More efficient marketing of maize in order to improve profits for producers;
3. Investment in technology to improve maize yields through the introduction of new varieties, accompanied by training and technical assistance; and
4. Provision of financial products that meet the needs of producers and marketers of maize.

Geographic location, physiography, marginality and poverty of rural populations and a lack of practical preventive and corrective measures make Cabricán a municipality that is highly vulnerable to climate change in general and to rainfall variability in particular. It is crucial to immediately begin with processes that promote economic diversification (non-farm rural employment, in particular) and better water management and storage practices in order to lower dependency on rain-fed agriculture as a means of subsistence. These actions need to be promoted by local as well as national policymakers as part of the design for new, long-term rural development in the region.

At the local level, individuals with entrepreneurial vision and ambition have expressed their willingness and motivation to become entrepreneurs and to produce for one or more export markets.

Several years ago, there was an attempt to export textiles to Europe and the United States. However, payments from trade intermediaries were delayed so much that communities were not satisfied with the process, and it was not repeated. Thus, policies promoting effective access to international markets for locally produced textiles should be a priority.

IARNA (2008) found that 70 per cent of the areas designated for horticulture in Guatemala lie less than 2.5 km away from a paved road and/or within less than 1 km from a dirt road. The study emphasized the importance of the availability of adequate roads in order to easily access national and international markets. Accordingly, policies promoting the export of locally produced products could only work if combined with improvements to the roadway infrastructure in the region.

In Cabricán, livestock is used to produce basic products such as milk and eggs and as insurance against leaner times. Because of the high liquidity of livestock, individuals use animals as an asset that can be sold at anytime. However, the production of dairy products such as cheese could open up further opportunities for the communities.

Additionally, the area is suitable for the development of many products, such as already existing fruit trees, vegetables and medicinal plants. Intensive agriculture aimed at selling vegetables on the market should also be pursued. Intensive production could be performed in very small areas using so-called macro- and micro-tunnels, which are relatively cheap. This should be combined with higher organizational and technical assistance, as well as better access to credit and markets.

The development or adaptation of improved crop varieties that are more resistant to diseases, such as beans, lima beans and wheat, are already playing an important role in the communities. This strategy should also be implemented for potatoes and integrated under a soil conservation strategy to ensure that sustainable practices are adopted.

During the 1970s and 1980s, CARE, in association with the Peace Corps programme and the National Forestry Institute (INAB), implemented a project called Food for Work in Cabricán. The project successfully promoted soil conservation in the community and similar projects could be replicated on a larger scale.

Communities can count on forests, and the local population has solid knowledge about how to manage them. The development of a timber industry aimed at producing items such as doorframes, window frames and toys is another option for new economic opportunities in the region. Such an industry, under sustainable forest management plans, could have a positive effect in terms of increasing the forested area while reducing the negative consequences of timber mining, such as landslides and soil erosion.

Annex I: Participatory Research Approach sessions by community

PRA session	Session number (from the first to the last session, in chronological order)[21]			
	El Cerro	El Durazno	Quiquibaj	Buena Vista
Transect walk (only team and facilitator)	1	2	3	
Map of threats (men)	5			29
Map of threats (women)	6			30
Livelihood risk ranking (men)	7			31
Livelihood risk ranking (women)	8			32
Timeline (men)	9			
Trend analysis (men)	10			
Trend analysis (women)	11			
Mobility map (mixed)	12			
Mobility map (women)	13			
Seasonal calendar (mixed)	14			
Seasonal calendar (women)	15			

PRA session	Session number (from the first to the last session, in chronological order)[21]			
	El Cerro	El Durazno	Quiquibaj	Buena Vista
Food security Venn diagram (women)	16			
Impact diagram (men)	17			33
Impact diagram (women)	18			34
Classification of adaptation strategies (men)	19			35
Classification of adaptation strategies (women)	20			36
Focus group discussion on rainfall variability, food security and migration (young men)	21			
Focus group discussion on rainfall variability, food security and migration (men)		25	27	
Focus group discussion on rainfall variability, food security and migration (young women)	22			
Focus group discussion on rainfall variability, food security and migration (women)		26	28	
Focus group discussion on future strategies (young men)	23			
Focus group discussion on future strategies (young women)	24			

20 In most cases, when the same session was held with men and women from the same community, it was carried out in parallel sessions.

Annex II:
List of experts interviewed

In Cabricán:

Institution	Name	Title	Date
Municipal Forestry Bureau Cabricán	Tránsito López	Officer	22 August 2011
Office for Women Cabricán	Norma Ramírez	Officer	22 August 2011
Municipality of Cabricán	Rolando Ramírez	City Council Member	30 August 2011

In Quetzaltenango:

Institution	Name	Title	Date
Rain Forest Alliance	Hilda Rivera	Climate Change Consultant	1 September 2011
Instituto Nacional de Bosques (INAB)	Mynor Pérez Alfonso Loarca	Regional Director, Quetzaltenango Member of the Climate Change Roundtable, Quetzaltenango	1 September 2011 1 September 2011
Helvetas	Pedro López and Marta Julia Tax	Coordinator and Assistant to the ProBosque Project	2 September 2011
CARE	Roberto Chuc	Manager of the MiBosque Project	2 September 2011

In Guatemala City:

Institution	Name	Title	Date
Universidad del Valle	Edwin Castellanos	Co-Director, Centro de Estudios Ambientales y de Biodiversidad	5 September 2011
Facultad Latinoamericana de Ciencias Sociales (FLACSO)	Claudia Donis and Sergio Dionisio	Researchers	5 September 2011
Ministry for Agriculture, Livestock and Nutrition	Luis López	Chief Executive, Department of Vegetable	7 September 2011
Universidad Landivar	Pedro Pineda and Carlos Rosito	Principal Investigators of the Institute of Agriculture, Natural Resources and Environment (IARNA)	8 September 2011
Ministry for Environment and Natural Resources	Carlos Mansilla	Director of the Climate Change Unit	9 September 2011
Instituto Privado de Investigación sobre Cambio Climático	Alex Guerra	Director	12 September 2011

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WHERE the RAIN FALLS

The Where the Rain Falls Project investigates how changes in rainfall interact with societies. The project provides a more nuanced understanding of the links between changing rainfall patterns, food and livelihood security, as well as migration in eight case study countries:

Bangladesh: Kurigram District, Rangpur Division
Ghana: Nadowli District, Upper West Region
Guatemala: Cabricán Municipality, Quetzaltenango Department
India: Janjgir-Champa District, Chhattisgarh state
Peru: Huancayo District, Junín Region
Tanzania: Same District, Kilimanjaro Region
Thailand: Thung Hua Chang District, Northern Thailand
Viet Nam: Dong Thap Province, Thap Muoi District.

Changing weather patterns are already causing weather extremes, including droughts and flooding, leading to food insecurity and displacement of people. Research results will help climate change policy and its implementation with important practical aspects to tackle poverty, protecting the most vulnerable people.

The full project findings – a research protocol, eight case study reports and a synthesis report for policymakers – are available at *www.wheretherainfalls.org*.

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The United Nations University Institute for Environment and Human Security (UNU-EHS) undertakes field-based empirical research on climate change and human society. This research contributes to policy processes (especially the United Nations Framework Convention on Climate Change (UNFCCC) climate negotiations) and practice (particularly climate risk management, adaptation, and loss & damage).

UNU-EHS is recognized internationally for its focus on empirical methods and fieldwork in areas of origin of migrants. Research undertaken by UNU-EHS has contributed to introduction of climate change and human mobility in international agreements such as the Cancun Adaptation Framework (paragraph 14(f)) and the Doha Climate Gateway Decision on Loss and Damage (paragraph 7a(vi)). This research has also been present in other intergovernmental fora like the Global Forum on Migration and Development (GMFD), and has contributed to the Intergovernmental Panel on Climate Change (IPCC) assessment report process.

UNU-EHS collaborates in research and research-to-policy processes with partners like the Nansen Initiative, the International Organization for Migration (IOM) and Office of the United Nations High Commissioner for Refugees (UNHCR), and academics and practitioners worldwide. This work is conducted primarily with scholars of human mobility, international finance institutions, the United Nations (UN) System and delegates to UN policy processes.