RAINFALL, FOOD SECURITY AND HUMAN MOBILITY
CASE STUDY: TANZANIA

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REPORT No. 6

November 2012

"Where the Rain Falls" Project
Case study: Tanzania

Results from: Same District, Kilimanjaro Region

Authors: Emma T. Liwenga, Lukas Kwezi and Tamer Afifi

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Abbreviations and acronyms

ADB	*African Development Bank*
ARU	*Ardhi University*
CARE	*Cooperative for Assistance and Relief Everywhere*
CEEST	*Centre for Energy, Environment, Science and Technology*
CRS	*Catholic Relief Services*
DALDO	*District Agriculture and Livestock Development Officer*
GDP	*Gross Domestic Product*
EPMS	*Environmental Protection and Management Services*
GWI	*Global Water Initiative*
HH	*Household*
IFAD	*International Fund for Agricultural Development*
IIED	*International Institute for Environment and Development*
IPCC	*Intergovernmental Panel on Climate Change*
IRA	*Institute of Resource Assessment*
IUCN	*International Union for Conservation of Nature*
NAPA	*National Adaptation Programme of Action*
NEP	*National Environmental Policy*
NGO	*Non-Governmental Organization*
NSGRP	*National Strategy for Growth and Reduction of Poverty*
PBWB	*Pangani Basin Water Board*
PINGO	*Pastoralists Indigenous Non-Governmental Organizations*
PRA	*Participatory Research Approach*
SUA	*Sokoine University of Agriculture*
TAPHGO	*Tanzania Pastoralist, Hunter-Gatherers Organization*
TMA	*Tanzania Meteorological Agency*
TNRF	*Tanzania Natural Resource Forum*
UDSM	*University of Dar es Salaam*
UNU-EHS	*United Nations University Institute for Environment and Human Security*
URT	*The United Republic of Tanzania*
VEO	*Village Executive Officer*
WWF	*World Wide Fund for Nature*

Executive summary

I. Background

Where the rain falls: climate change, hunger and human mobility ("Rainfalls") is a three-year programme of research, adaptation activities, advocacy and education on changing agro-climatic risks, hunger and human mobility. The programme is a partnership between CARE International and the United Nations University Institute for Environment and Human Security (UNU-EHS), with support from the AXA group and John D. and Catherine T. MacArthur Foundation.

The research of the project aims at improving understanding about how rainfall variability affects food and livelihood security, and how these factors interact with household (HH) decisions about mobility/migration among groups of people who are particularly vulnerable to the impacts of climate change. The research focuses on perceived as well as measured changes in rainfall, such as extended dry and wet periods, droughts and floods, erratic rainfall and shifting rainy seasons.

The project's research in Tanzania was conducted in three villages (Bangalala, Ruvu Mferejini and Vudee) in the Same District in the Kilimanjaro Region. Data collection involved the use of both qualitative (Participatory Research Approach (PRA) sessions and expert interviews) and quantitative (structured HH survey questionnaire) methods.

Measured/observed rainfall data were obtained from the Same meteorological station. While the three villages reflect a wide range of agro-climatic conditions in upland and lowland areas of the Pangani Basin, their residents share a high degree of dependence on crop and livestock production for their livelihoods. Local agriculture, in turn, is highly dependent on local rainfall, either directly or via local irrigation systems (including traditional Ndiva), which shows a high degree of variability and unpredictability. Given that livelihoods in the research villages are almost entirely dependent on the local natural resource base, residents are very worried by the degradation of the local environment, brought on by recurrent droughts, lack of enforcement of laws against logging and other destructive practices in critical watersheds, and continuing population growth.

Across the three villages, research participants perceived a number of significant changes in rainfall patterns in the past two to three decades. Most significant were: a shortening of the growing season; increased frequency of dry spells during the rainy season; and more frequent heavy storms. In addition, higher temperatures and stronger winds are seen as exacerbating local water scarcity. While an analysis of 60 years of local rainfall data does not show a statistically significant negative trend in total annual rainfall, it does provide evidence to support a number of negative changes in rainfall patterns over the last 20–30 years (since the early 1980s), including: a decline in the long rainy season *(Masika)* and total annual rainfall; reduced number of rainy days and longer dry spells during the rainy season; and early cessation of rain. The data also provides dramatic examples of the unpredictability of rainfall, with several cases of extremely low annual rainfall followed by years of very high rainfall.

Under the conditions that prevail in the Same District, changes in rainfall patterns translate directly into impacts on crop and livestock production and food security. Water scarcity is the most common problem identified by the residents of this area, and research participants consistently identified drought as the biggest threat to their livelihoods. Given the dearth of alternative local off-farm employment opportunities, migration is a very important risk management strategy for HHs in these villages. While the majority of migrants are male and youths, women now represent one-third of the total. Migration patterns vary across the three villages, but seasonal migrants overall outnumber those migrating for more than six months. While the largest migration flows seem to be rural-rural, nearly one-third of survey respondents identified Dar es Salaam as the most common destination. The elderly and women with young children are most likely to be left behind with less support and more work and can thus be seen as most vulnerable to the negative impacts of rainfall variability on HH food security.

II. The variables

A. Rainfall variability

The Same District is a semi-arid zone in the Pangani River Basin, located in the north-eastern part of Tanzania, characterized by a bimodal rainfall pattern, with the long rainy season (commonly known as *Masika*) occurring from March to May and the short rainy season (commonly known as *Vuli)* occurring from October to December[1]. Over the past 60 years, total annual rainfall has averaged 560 mm.

The project's research revealed a consistent perception in all three villages that rainfall patterns in the Same District have changed in the past two to three decades. The main perceived changes were: (1) increased frequency of dry spells during the rainy season; (2) late onset and earlier cessation of rain (resulting in shorter growing seasons); and (3) increased frequency of heavy storms. For the residents of these communities, these changes result in an overall picture of increasingly erratic rainfall and less predictable seasons. In addition to changes in the timing and distribution of the two rainy seasons (*Masika* and *Vuli*) in the region, residents also noted higher temperatures and stronger winds as factors that exacerbate local water shortages.

1 There are differing opinions on when *Masika* and *Vuli* start and end. The most common perception in the study villages is that *Vuli* runs from October to December and *Masika* runs from March to May. Also, several studies use this interpretation; therefore it has been used across the report.

A careful comparison of community perceptions to 60 years of daily rainfall data reveals a more nuanced picture, but one which still provides significant evidence in support of perceived changes in rainfall patterns in the Same District over the last 10 to 30 years (since early 1980s). An examination of patterns in total annual rainfall over the last six decades (since early 1950s) does not reveal a statistically significant change over the full period, but shows instead a trend of increasing total rainfall during the 1950s to the 1970s, followed by a declining trend over the last three decades (since early 1980s). Strong evidence of the erratic nature of rainfall patterns from year to year can be seen, with extremely dry years (1996 and 2005) followed immediately by extremely wet years; similar patterns can be observed in earlier decades, with extremely low rainfall in 1952 and 1975 and very high rainfall totals in 1957 and 1978. Several other trends can be identified over the last three decades that would explain community perceptions of negative changes in rainfall patterns that have had a serious negative impact on their crop and livestock-based livelihoods: (1) decline in both *Masika* and total annual rainfall over the past two decades (early 1990s); (2) a reduction in the number of rainy days per year from 90 to 71 over the last 20 years, coupled with an increased frequency of dry spells during the rainy seasons; and (3) a pattern of early cessation, and thus shorter growing seasons over the last 20 to 30 years (since early 1980s) is evidenced by declining rainfall totals for April/May (during *Masika*) and December (during *Vuli*). *Taken together, the evidence supports the changing and very unpredictable nature of rainfall in the research area, in which the timing and distribution/intensity of rain can lead to crop failure even in years with "normal" total annual rainfall.*

B. Food and livelihood insecurity

The livelihoods of the residents of Bangalala, Ruvu Mferejini and Vudee are highly dependent on crop and livestock production, which is inherently tenuous in this semi-arid region of

Tanzania. Based on data from the HH survey, the top three economic activities – agriculture, livestock and casual labour – are all very dependent on the natural resource base of the region, and little diversification into non-farm livelihood activities has taken place. Local agriculture, in turn, is highly dependent on local rainfall, either directly or via local irrigation systems (including traditional *Ndiva*).

Food insecurity is a significant and pervasive problem in the Same District and is normally highest during the months from August/September to January/February. Focus group discussions (FGDs) in Bangalala village revealed that only about 5 per cent of HHs were considered "rich" and able to ensure three meals a day for all HH members. By contrast, the middle group (65 per cent of HHs) could only afford two meals a day, while the poorest 30 per cent often struggled to provide one nutritious meal a day. HH survey data revealed that approximately 6.7 per cent of the population is landless, while a further 24.8 per cent owns 0.71 hectares or less. The largest group of HHs (49.1 per cent) has between 0.712 and 1.62 hectares of land, while 19.4 per cent of farmers have more than 1.62 hectares. The average landholding in the area is 1.53 hectares, which supports an average of six HH members.

Livelihood risk rankings conducted in all three villages showed a strong perceived link between rainfall patterns and food insecurity. More than 80 per cent of the HH survey respondents indicated that rainfall variability negatively affected their food production "a lot". Drought, by far, was identified as the major hazard to HH livelihoods, followed by storms/excessive rain and floods. The major impacts of rainfall variability were seen in declining crop production and deteriorated pasture conditions for livestock. FGDs also revealed that significant environmental degradation has occurred in the past two to three decades as a result of the combined impact of recurrent drought and increased population density.

C. Migration

Who is migrating? Based on the data from the HH survey, it is shown that two-thirds of total migrants from the three villages are male; the average age at first migration is less than 25 years, so young men can be seen as most likely to migrate. The elderly and women with young children are least likely to migrate, although it is noteworthy that women represent one-third of total migrants. The numbers of married and single migrants were almost the same, while the average level of education of migrants varies significantly across the villages, from less than four years in Ruvu Mferejini to more than 8.5 years in Vudee. When breaking down the migrant numbers into landless, small, medium and large farmers, it was found that medium farmers migrate the most, followed by the large and small farmers in that order, and the landless have migrated the least, perhaps because they can least afford the costs and/or have no means of support during migration.

What type of migration? Migration from the research villages is overwhelmingly internal, with very few (mostly Maasai pastoralists) moving across international borders (to Kenya). Economic migrants outnumber educational migrants by two-to-one. While a slight majority (53.4 per cent) of first trips are seasonal (less than six months) with return, the pattern varies widely across the three villages. Temporal migrants represent a clear majority in Vudee (69 per cent) and almost 50 per cent in Bangalala. Only in Ruvu Mferejini, where there is a significant pastoralist population, were seasonal migrants a clear majority (66.3 per cent).

When do people migrate? For pastoralists, migration would normally occur during the dry season (June–September), but can begin in May or June if the *Masika* rains fail. For farmers, one or more successive crop failures can prompt out-migration to locations with more favourable weather conditions or the availability of casual work.

Why do people migrate? The results of the HH survey indicate strong links between unpredictable and changing weather patterns and the decision to migrate. The top three factors affecting HH migration decisions, all directly related to rainfall, were: (1) increased drought frequency; (2) longer drought periods; and (3) water shortage. Of the next four most commonly given reasons, two are related to the availability of basic services (health and education), while one each related to rainfall (floods) and land (insufficient land for farming). Given the high level of dependence on agriculture, and the limited access to irrigation facilities and off-farm employment opportunities in the district, inadequate or untimely rainfall often translates directly into crop failure and food insecurity. Under such circumstances, out-migration is one of the few available livelihood options for poor HHs with able-bodied members of working age.

Where do people migrate to and what do they do? The majority of migrants appear to move to other rural areas with more favourable weather conditions, where they can engage in the farming and livestock-keeping activities with which they are most familiar, or find work as casual labourers. Most migrate to destinations in the Kilimanjaro Region and neighbouring parts of north-eastern Tanzania. Among the frequently mentioned during FGDs were Moshi, Morogoro, Kabuku, Simanjiro, Makanya and Kiteto. It is important to note, however, that the results of the HH survey showed that the single most common destination for migrants is the capital city Dar es Salaam (32 per cent), where they seek work as labourers in markets/retail, construction, and other services (e.g. as security guards). Out-migration from the Same District should thus be seen as a mix of rural-rural and rural-urban. FGDs with youths suggest that they see little future in agriculture and may be more inclined to seek their fortunes in urban areas, despite the hardships encountered there by migrants with limited education and financial resources.

III. Vulnerability, coping and adaptation

A. Vulnerable groups

Groups that are less mobile and those that have fewer assets to exchange for food are more vulnerable to the negative impact of climate change on food security. In general, although women constitute one-third of migrants and some women interviewed have migrated on their own without family (which is accepted culturally in the region of study), they are more likely to be left behind to care for small children and less likely to be able to source paid labour outside the home. In such cases, an increased workload on the farm falls to women to make up for the absence of male HH members. In the case of flooding, Maasai women are also responsible for the construction of new houses when families are forced to move to higher ground. While men who migrate are clearly also subject to the hardships of travel and poor working and living conditions, it is the women who are left behind to care for young children and the elderly and ensure that they have enough food. Under such circumstances, the elderly may suffer from inadequate care and children's education may be disrupted due to inadequate financial resources or competing demands (farm work or caring for younger children) on the time of older children. Young people, on the whole, are most mobile and able to take advantage of casual labour opportunities and/or migrate to locations with more favourable weather conditions or job prospects.

B. Coping and adaptation

The results of the HH survey revealed that the most frequently (all the time or pretty often) utilized coping strategies to deal with recent episodes of food insecurity were: (1) limiting portion sizes (i.e. reduction in size of meals); (2) borrowing food from family or neighbours; (3) utilizing less expensive food; and (4) reducing the number of meals taken per day. In FGDs, residents of the three research villages reported utilizing many of the short-term coping strategies seen elsewhere in response to changes in rainfall that

affect food security status and livelihood strategies. Those most commonly reported include: (1) changes in HH food consumption (fewer meals per day or even going an entire day without eating, elimination of more expensive foods such as fish, or eating lighter meals); (2) changes in economic activity, including those with negative long-term consequences (casual labour for others in the local community, cutting timber, collecting firewood, burning charcoal and reducing cultivated areas to match available water); (3) sale of assets (most often livestock though sometimes other productive assets such as beehives, but almost never land); (4) seeking help from others (including government relief food, assistance from non-governmental organizations (NGOs), and borrowing money from friends and family). For wealthier HHs, other coping strategies are available, given their larger asset base, including food purchases, food storage for future use and moving livestock to better pastures elsewhere. For the majority of poor and very poor HHs, coping normally involves reduced (quantity and quality) food intake, borrowing food or money or seeking relief assistance. In extreme cases, families can be forced to resort to begging, and some men abandon their families.

In addition to these short-term – and sometimes damaging – coping strategies, residents of the three research villages also reported either already beginning to employ longer-term adaptation strategies or needing help to do so. At least three broad categories of longer-term adaptation strategies can be seen: (1) improved integrated natural/water resources management (better protection of water sources, including enforcement of bans on logging, agriculture and mining in such areas, tree-planting, expansion of traditional irrigation systems, improved water management in modern irrigation schemes to reduce problem of salinization, and development of new water resources, including boreholes fitted with windmills); (2) introduction of more productive and sustainable agricultural systems and practices (improved livestock varieties to increase milk production per animal, switching to more drought-resistant crops such as lablab, sorghum or cassava, adoption of shorter-term crops or varieties, especially of the staple crop maize, more use of terracing in hillside agriculture, more inter-cropping); and (3) increased diversification of livelihoods (more diverse agricultural production to include livestock, tree crops, vegetables and legumes, more small business/trading and other non-agricultural activities, and promotion of increased savings and access to loans through the village savings and loan associations (VSLA) promoted by CARE and referred to locally as Tuji Komboe). Finally, for some families it is clear that permanent out-migration and subsequent remittances have been an important part of diversifying their livelihood strategies and reducing the risk inherent in largely rain-fed agriculture. This strategy appeared to be most successful for those families where one or more children were able to attain a sufficient level of education to obtain regular, stable employment, usually in urban areas.

IV. Research analysis and conclusions

The study answers the research question "under which circumstances do HHs use human mobility as an adaptation strategy in response to rainfall variability and food security" by listing the following key points:

- → When farmers base their agricultural production entirely on rainfall, the latter being erratic encourages them to move to irrigated agriculture by leaving their land (even if not for the long-term), in order to have more regular and reliable crop/food production.

- → As the population grows rapidly, this leads to conflict over natural resources, especially water which is a limited resource in the first place, given the erratic rainfall, droughts, seasonal shifts, shorter seasons and dry spells.

- → When rain variability has a negative impact on food availability, pasture for livestock and income generation, all these factors together force people to head to other places to seek alternative livelihoods.

- → When floods occur, people move from the lowlands to higher elevations, and vice versa when droughts occur or when the rain is erratic.

- → The more severe the problems related to rainfall variability, the more people are willing to leave for new livelihood possibilities. However, the most vulnerable people are not always able to do so. Where alternative activities and livelihood options are available in their home villages, the majority of people prefer to stay.

- → Gender plays a role in the migration decision/process. It is mostly the young men who migrate. Once they settle, they sometimes ask their wives/families to follow them to their destination. However, when this has negative implications on the children's schooling, the families might be left behind. Women heads of HH usually do not migrate, since they need to take care of the children.

- → People migrate when they have animals/livestock on which they depend for nutrition and income, and when they are unable to feed and water them they migrate (for short periods) in search of water and pasture.

- → People migrate when they know that the destinations provide better alternative livelihoods, where more water and pasture is available.

- → They also migrate when they receive support from families, relatives and friends in the places of origin and destination. In their places of origin, migrants need to assure that the family members left behind, especially the elderly and children, are taken care of by friends or extended families. At the destination, friends and relatives help them to find land, jobs and accommodation.

- → The availability of communication/telephone services helps local communities to obtain information on where to migrate and also helps people to stay in touch with their families after migrating.

- → Businessmen and traders who visit the research sites and distribute their products are involved in the migration process as mediators who support the migrants and even offer them job opportunities at the destinations.

Section 1: Introduction

1.1 Background information

Climate change is a global phenomenon and a major challenge to humanity. The evidence indicating significant changes in global climate over the past century has been presented in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (IPCC, 2007b). Climate change is expected to challenge the adaptive capacities of many different communities, and overwhelm some, by interacting with and exacerbating existing problems of food security, water scarcity and the scant protection afforded by marginal lands (Brown, 2007). According to Tacoli (2009), the impact of climate change on population distribution and mobility has attracted growing interest and fuelled heated debate. It is estimated that by 2050 the number of people forced to move primarily because of climate change will range between 200 million (Myers, 2005) and 1 billion (Christian Aid, 2007). It has been pointed out that most probably extreme weather events (storms, floods, droughts) and changes in mean temperatures, precipitation and sea level rise will in many cases contribute to increasing levels of mobility. However, inherent difficulties are noted in predicting with precision how climate change will impact on population distribution and movement.

Limited evidence suggests that, in certain circumstances, environmental hazards and/or climate change do alter migration patterns typically observed in developing countries. The reasons why it is difficult to prove such a correlation are twofold: first, data are generally unavailable and, second, the decision to migrate is based on multiple factors and it is difficult to filter out the environmental factors as a single reason for migration. However, migration reflects a failure to adapt to changes in the physical environment and migrants are a relatively undifferentiated group presenting similar emergency responses and moving to random destinations (Tacoli, 2009). Better information is important to formulate appropriate policy responses at the global, local and national levels.

1.2 Goals and objectives of the research

This report presents and discusses the findings of the "Rainfalls" project aiming to contribute to the body of knowledge on how rainfall variability affects food and livelihood security, and how these factors interact with HHs' migration decisions among groups of people particularly vulnerable to the impact of climate change. The findings presented in this report are largely drawn from the research conducted in the Same District–Kilimanjaro Region in the north-eastern part of Tanzania.

The research focuses on perceived as well as measured changes in rainfall, such as extended dry and wet periods, droughts and floods, erratic rainfall and shifting seasons. The research further examines how rainfall variability influences food and livelihood security, focusing especially on crop yields, local food production and food availability, stability of prices and livestock. Earlier definitions presented by the Food and Agricultural Organization of the United Nations (FAO) (1983) expressed the need to fulfil "basic food needs" with "access" to food. Now, however, the issue of preference and all three components of access have been integrated into the definition. According to FAO, "Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. The four pillars of food security are availability, access, utilization and stability"(FAO, 2002). This understanding of food security integrates and refines the conceptual developments by the World Food Summit (1996) and Nobel prize winning Economist Amartya Sen (1981).

People normally develop different strategies to cope with stress and variability related to food and livelihood security. The Rainfalls project is further interested in understanding why people react differently to stress caused by changing weather patterns and food insecurity. One of the mechanisms used by people experiencing this stress is human mobility, for example different forms of migration or displacement. Therefore, this research project explores to what extent changing weather patterns influence people's decisions to leave their homes.

The "Rainfalls" project has three objectives: (1) to understand how rainfall variability, food and livelihood security, and migration interact today; (2) to understand how these factors might interact in coming decades as the impacts of climate change begin to be felt more strongly; and (3) to work with communities in identifying ways to manage and cope with rainfall variability, food and livelihood insecurity, and migration.

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

1. Under what circumstances do HHs 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 security have the potential to become a significant driver of human mobility in particular regions of the world in the next two to three decades?

3. In the context of climate change, what combination of policies can increase the likelihood that human mobility remains a matter of choice among a broader range of measures to manage risks associated with changing climatic conditions, rather than "merely" a survival strategy after other pathways have been exhausted? The project will explore such policy alternatives in vulnerable areas of the world.

This Report fulfils the first objective and therefore answers the first research question. The second and third research questions go beyond this publication and will be answered respectively through an agent-based model/mapping and a community-based exercise.

1.3 Tanzania: country profile

This section describes the background information regarding the location of the country, population, demographic data, history, political situation, environmental issues, economic situation and migration patterns.

1.3.1 Location and population

The United Republic of Tanzania (URT) is located in Eastern Africa between longitude 29o and 41o east, latitude 1o and 12o south (see Figure 1). The URT has an area of about 945,000 km^2. It is a union of two countries: the former Republic of Tanganyika and the former People's Republic of Zanzibar, which on 26 April 1964 merged to form the URT. The country shares international boundaries with eight countries: Kenya and Uganda in the north, Burundi, Democratic Republic of Congo and Rwanda in the west, Mozambique and Malawi in the south, Zambia in the south-west and a long coastline of the Indian Ocean, which connects the country with the Comoros Islands, Seychelles, Madagascar, Mauritius and Asian countries.

The current population of Tanzania is approximately 42 million, with a growth rate of 2.9 per cent. The population is projected to double in the next 25 years (by 2037). Tanzania's population is characterized as having a youthful age structure, with over 78 per cent under the age of 35, and 77 per cent living in rural areas (see Figure 2). The Tanzanian society and culture are shaped by the variable topography and ecology, with pockets of extreme isolation and inaccessibility. There are numerous tribes and local dialects, but Kiswahili is the most widely spoken language throughout the country.

Figure 1: Map of Africa showing location of Tanzania. Source: Rossow (2012).

1.3.2 History and political situation

Tanzania went through colonial times, first under the Germans, and then, following the Berlin Conference of 1884/85 and after World War I, under the British as a mandate territory, and later a trusteeship under United Nations until 1961. Zanzibar got its independence in December 1963, which was followed by the revolution on 12 January 1964. Tanzania adopted the policy of socialism in 1967 as its blueprint in nation-building, and Pan-Africanism and non-alignment as its foreign policy. Beginning in the mid-1980s and throughout the 1990s, Tanzania undertook market-oriented economic policy reforms, including liberalization of internal and external trade, privatization of state-owned

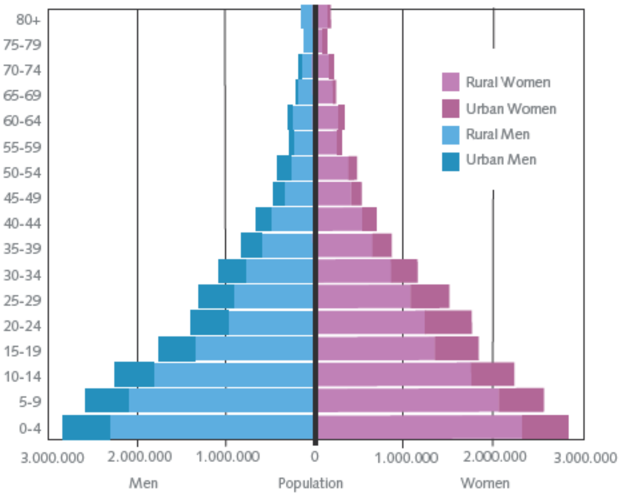

Figure 2: Population of the United Republic of Tanzania.
Source: Population and Housing Census (2002).

enterprises and various sector policy reforms. These radical economic reforms were not based on an internal strategy, but rather administered jointly by the World Bank and International Monetary Fund. By the end of the 1990s, the country moved in the direction of poverty-reducing strategies and adopted the global Millennium Declaration containing the Millennium Development Goals (MDGs) in 2000.

The Government of the URT is a unitary republic consisting of Mainland Tanzania and the Zanzibar Revolutionary Government. It is based on multiparty parliamentary democracy. All state authority in the United Republic is exercised and controlled by the Government of the URT and the Revolutionary Government of Zanzibar. In the context of the present study, the scope of the study is restricted to Mainland Tanzania.

In May 1992, Tanzania transitioned from a single-party rule under the Revolutionary Party to a multi-party system, and in October 1995 elections for the president and members of parliament were conducted for the first time under this multi-party system. His Excellency, Benjamin William Mkapa, became the first president under this system. Tanzania is said to be one of the most politically stable countries in Africa.

Since the introduction of the multi-party system, the political and social situation has remained stable under the leadership of the governing/ruling Chama Cha Mapinduzi, Revolutionary Party (CCM). In 2000, President Benjamin William Mkapa was re-elected, and in 2005 the former Minister of Foreign Affairs and International Cooperation, His Excellency, President Jakaya Mrisho Kikwete, was inaugurated as the new president to date.

1.3.3 Environmental issues

Tanzania's long-term economic growth is dependent on natural resources, that is, wildlife, forestry, fisheries, mining, land and water resources. The National Environmental Policy (NEP) identifies six major problems that require urgent attention: (1) loss of wildlife habitats and biodiversity; (2) deforestation; (3) land degradation; (4) deterioration of aquatic systems; (5) lack of accessible, good quality water; and (6) environmental pollution. Further, the Government of Tanzania admits, in this policy, that the country needs to adopt environmentally sustainable natural resource management practices in order to ensure that long-term sustainable economic growth is achieved (NEP, 1997). It can, therefore, be concluded that the country's long-term economic growth is dependent upon, among other factors, coherent natural resource management.

One of the biggest environmental challenges of the 21st century is climate change. Climate change is poised to undermine national efforts to attain the MDGs and places poverty reduction efforts in jeopardy. The loss of human, natural, financial, social and physical capital, caused by the adverse impacts of climate change, especially severe droughts and floods, among many other disasters, are of great concern to Tanzania. The impact of climate change on various sectors became the driving force for the preparation of the inaugural Tanzania National Adaptation Programme of Action (NAPA) in 2007.

1.3.4 The economy

The economy of Tanzania depends heavily on agriculture, which accounts for one-third of the Gross Domestic Product (GDP), and employs about three-quarters of Tanzania's labour force (AfDB, 2012). Rain-fed agriculture is still the backbone of the Tanzanian economy and accounts. Currently, the agriculture sector accounts for nearly half of the GDP of the Tanzania economy and employs nearly 80 per cent of the workforce in the country (Tanzania Invest, 2012). About 95 per cent of Tanzanians involved in the agricultural sector subsist on landholdings of less than two hectares (ha) and sustain their livelihoods through rain-fed subsistence agriculture. Tanzania's per capita income is $410, with an average life expectancy of 52 years.

The majority of rural HHs are plagued by either chronic or transitory food insecurity, compounded by poor infrastructure, limited market access, credits and extension services. Approximately 98 per cent of rural Tanzanian women classified as economically active are engaged in agriculture. Time use studies consistently show that women spend more hours per day than men in both productive and domestic activities. Despite women's deeper involvement and contribution to farming activities, women continue to be excluded from decision-making and are disadvantaged in terms of access to economic assets (e.g., land), information, education and social services.

Taking advantage of one of the most stable political systems in the region, Tanzania has seen its GDP grow regularly for several years. However, this noteworthy growth in GDP did not trickle down to the majority poor sufficiently to allow realization of a considerable reduction in the incidence of poverty (percentage of the population below the food and basic needs poverty lines) (The Economic Survey, 2004). Table 1 shows the trends in the incidence of poverty (food and basic needs) in Mainland Tanzania for 2000/01 and 2007.

		Dar es Salaam	Other urban areas	Rural	Overall
Food	2000/01	7.5	13.2	20.4	18.7
	2007	7.4	12.9	18.4	16.6
Basic needs	2000/01	17.6	25.8	38.7	35.7
	2007	16.4	24.1	37.6	33.6

Table 1: Trends in incidence of poverty in Mainland Tanzania, 2000/01 and 2007. Source: HBS (2007).

Accordingly, Tanzania remains classified by the World Bank and the International Monetary Fund as a low-income country, and it is hampered by structural issues and a strong dependency on international aid. Increased productivity within the agricultural sector is crucial for achieving the 6–8 per cent annual growth rate targeted in the National Strategy for Growth and Reduction of Poverty (NSGRP) and is vital in ensuring food security and poverty alleviation.

Due to climate change, the frequency and severity of droughts, floods and storms are projected to increase globally (IPCC, 2007b), and this is likely to affect the country's agricultural production, food security and GDP. The impact that climate variability has on predominantly rain-fed agrarian economies is clearly demonstrated by Tanzania, where GDP closely tracks variations in rainfall (Van Aalst et al., 2007). About half of Tanzania's GDP comes from agricultural production (including livestock), the majority of which is rain-fed and highly vulnerable to droughts and floods. Both farmers and pastoralists are highly dependent on the climate for their livelihoods. Figure 3 accordingly shows rainfall variability and GDP growth and draws the similarities in the trends of both variables.

1.3.5 Migration patterns

Migration is a process of moving, either across an international border or within a state. It is a population movement, encompassing any kind of movement of people, whatever the distance, composition and causes, and includes migration of refugees, displaced persons, uprooted people and economic migrants (Perruchoud, 2004). Migration is a process that has existed since time immemorial. However, it is only in the last three decades (since early 1980s) that migration has become an issue of growing concern to the international community (Mwalimu, 2004). Various patterns of migration (rural-urban, urban-urban and rural-rural) are observed in the country; these patterns are caused by either pull or push factors.

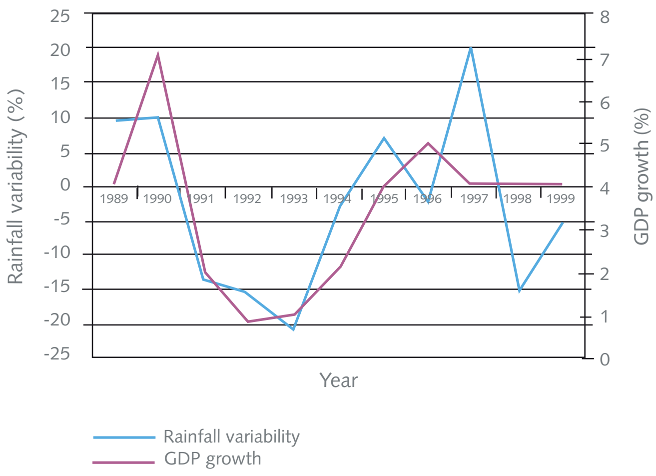

Figure 3: Rainfall variability vs. GDP growth in Tanzania. Source: World Bank (2006).

Despite the fact that the majority of the population (77 per cent of all Tanzanians) still lives in rural areas, the urban population has been growing at a rapid rate of more than 5 per cent per annum over the past three decades. This rapid growth has been caused mainly by rural-urban migration than any other factor (URT, 2006). The increase in rural-urban migration has led to an increasing rate of urbanization, especially in major urban centres including Dar es Salaam, Mbeya, Mwanza, Arusha and Zanzibar.

Rural-rural migration also contributes to the regional and district level variations in terms of population pressure over resources. Experience from the semi-arid zone of central Tanzania indicates that rural-rural migration is a way of coping with food insecurity as a result of adverse conditions (Liwenga, 2003).

Historically, the Pangani Basin, in which the "Rainfalls" project sites are located, was one of the main areas of development in the country, with large plantations of coffee, sisal and sugarcane; and it was thus one of the core areas for in-migration. According to Mbonile (2002), the area is now among the leading regions of out-migration in the country. A number of factors, such as population pressure associated with rapid urbanization, contributed to the observed trends. In the 19th century, population pressure started to build up in the highlands of the Pangani Basin, resulting in population mobility and migration due to land shortage. The main direction of rural-rural migration in this area was from highland to lowland areas that are ecologically fragile. Most people migrated from highlands to lowlands due to the favourable areas for settlement and irrigation farming. Out-migration is also associated with environmental factors. Maasai from the Pangani Basin, accompanied by large herds of livestock, migrate to other parts of the country, for example wetland areas (Mbonile, 2002).

1.4 Organization of the report

This report is organized into 10 sections. Section 1 introduces the study and provides background information on the case study country. Section 2 presents the literature review based on the key thematic areas of the research. The research methodology and limitations are presented in Section 3. Section 4 introduces the research sites and communities. Sections 5, 6 and 7 present and discuss the results based on the key findings of the study: Section 5 discusses the rainfall patterns/variability; Section 6 discusses livelihood issues with a particular focus on food security, and also links this to climatic conditions; and Section 7 presents migration patterns in the study areas, and links this to climatic conditions and food security aspects. Section 8 presents a synthesis of research findings based on expert interviews, PRA sessions and HH surveys. Section 9 presents the conclusions; and finally Section 10 highlights some reflections for policymakers.

Section 2: Literature review

This section provides a synthesis of the literature reviewed on the key thematic areas of this study covering Africa, and Tanzania in particular, while at the same time providing some insight into the situation in the study area. Specifically, the section gives an overview of climate change and associated impacts. It further highlights the link between climate change and food security, and the relationship between climate change and migration.

2.1 Overview of climate change

According to the IPCC (2001), Africa is "highly vulnerable" to the impacts of climate change "because of factors such as widespread poverty, recurrent droughts, inequitable land distribution, and over-dependence on rain-fed agriculture". Historical data shows that the continent is already undergoing climate change. Temperatures rose by 0.7 °C during the 20^{th} century, and changes in rainfall patterns saw reduced precipitation in the Sahel and a net increase across the eastern central regions. Current projections are unanimous in agreeing that these trends – increasing temperatures and changing rainfall patterns – will continue. Indeed, temperatures are due to rise by a further 0.2 to 0.5 °C *per decade*, and the impact on the hydrological cycles is likely to cause reduced rainfall in south-east Africa (and possibly the Sahel), and more precipitation in those parts of East Africa which have historically been "wetter" (IPCC, 2001: 489, 494). These changes have serious implications for water resources, food security, the productivity of natural resources, spread of diseases and desertification (IPCC, 2001). In East Africa, climate change will likely be directly felt in terms of higher temperatures and changes in the timing and quality of rain. The most iconic indication of climate change is, arguably, the glacial retreat being observed on Mount Kilimanjaro (Agrawala et al., 2003).

Particular to Tanzania, climatic projections show that annual temperatures may rise by 2.2 °C by 2100, with somewhat higher increases (2.6 °C) over June, July and August, and lower values (1.9 °C) for December, January and February, with greater warming for the cooler months (June to August) compared to the warmer months (December to February) (Bezabih et al., 2010). According to meteorological data, monthly temperatures over the last 30 years (since early 1980s) are already showing an upward trend (URT, 2007).

Annual precipitation over the whole country is projected to increase by 10 per cent by 2100, although seasonal declines of 6 per cent are projected for June, July and August, and increases of 16.7 per cent for December, January and February (Agrawala et al., 2003). Given variations in altitude, topography, vegetation and coastal proximity, changes in rainfall patterns and temperature are expected to vary considerably from one part of the country to another (Agrawala et al., 2003). For instance, rainfall is expected to continue to decrease in inner and dryland regions, while coastal areas of Tanzania such as Dar es Salaam are predicted to receive increased rainfall during the rainy season. Some areas of northern Tanzania are likely to get wetter (between 5 per cent and 45 per cent wetter), whilst others, especially in the south, will probably experience severe reductions in rainfall (up to 10 per cent) (Paavola, 2003).

According to future projections, the timing of rain will become less predictable and its intensity more volatile (Agrawala et al., 2003). Seasonal variations will become accentuated, with a 6 per cent decline in rainfall between June and August (traditionally the 'dry' season), and a 16.7 per cent increase between December and February (Agrawala et al., 2003). Significant regional variations will also occur. Areas with a 'bimodal' rainfall pattern, that is, two rainy seasons (long rains March–May and short rains October–December), can expect to receive 5 to 45 per cent more rain during both seasons. This applies to north-east, north-west and northern regions including the Kilimanjaro Region. Areas with a 'unimodal' rainfall pattern on the other hand, characterized by one main rainy season (December to April), will see reduced precipitation of between 10 and 15 per cent. This will occur in central, western, southern, south-western and eastern Tanzania.

Extreme events are likely to pose the greatest climate change threat to livelihoods of local communities in Tanzania. These events are likely to take the form of drought, flooding and tropical storms, which are expected to become more frequent, intense and unpredictable (IPCC, 2003). Extreme weather *conditions*, such as the recent drought, and specific events, such as the El Niño episode of 1997/98, highlight the country's vulnerability to current climatic hazards. The El Niño event, for example, led to drought and flooding, and triggered a national food emergency, with severe food shortages, 'skyrocketing' food prices, increases in power rationing as well as extensive food, cattle and cash crop losses (US National Drought Mitigation Center, 1998). It was reported that villagers walked up to 50 km to collect emergency aid rations (ibid.). Meanwhile, flooding damaged human settlements, infrastructure, property and livelihoods, and was associated with the spread of malaria, cholera and diarrhoea (URT, 2003).

2.2 Climate change and food security

Over 95 per cent of Africa's agriculture is rain-fed (Van Aalst et al., 2007). Accordingly, agricultural production in many African countries is predicted to become severely compromised by climate variability and change. The area suitable for agriculture, the length of growing seasons, and yield potential, particularly along the margins of semi-arid and arid areas, are all expected to decrease. This will adversely affect food security and exacerbate malnutrition on the continent. In some countries, yields from rain-fed agriculture could be reduced by up to 50 per cent by 2020 (IPCC, 2007a).

Projected climate change is expected to significantly impact food production in the central, western and south-western highlands in Tanzania. Regional predictions suggest that Tanzania may lose 10 per cent of its grain production by 2080 (Parry et al., 1999), triggering food insecurity, reduced incomes, and increasing poverty. Tanzania's NAPA report (NAPA, 2007) indicates that with an increase in temperature, reduced rainfall and change in rainfall patterns, maize yield in Tanzania will decrease by 33 per cent, but regionally the decrease will vary from 10 to 13 per cent in the southern highlands, and up to 84 per cent in central regions. However, people in the north-eastern highlands will need to take advantage of the projected slight rainfall increase to enhance their agricultural activities.

Changing climatic conditions and more frequent extreme events are likely to pose a threat to food and livelihood security, water supply and human health (Charles and Twena, 2006). Given the importance of agriculture to the Tanzanian economy, and the fact that this sector is dominated by rain-fed agriculture, climate change consequences for the sector and general livelihood of people are likely to be significantly adverse. While uncertainties in climate change and impact projections pose a challenge for anticipatory adaptation in any country, Tanzania's case has several specific characteristics that might suggest the need for a differentiated adaptation strategy. Some discernible trends in climate and attendant impacts are already underway in Tanzania. Such impacts – as is the case in the Kilimanjaro ecosystem – argue for more immediate adaptation responses as opposed to a "wait and see" strategy (Agrawala et al., 2003).

Tanzania's main economic activity is agriculture, which employs about 80 per cent of the total population and is vulnerable to climate change. The adverse impacts of climate change in agricultural sectors include reduced crop yields due to drought and floods, and reduced water availability for both crops and livestock. The shifting of seasonal rainfall, one of the predicted outcomes of climate change, may bring too much rain when it is not required and lead to damage to plants. In addition, dramatically rising temperature trends, responsible for increased evapotranspiration in the soil, may keep crops from maturing due to insufficient moisture in the soil, thus leading to food shortages (Levira, 2009).

Climate change is also expected to have a direct impact on livestock production through reduced water and forage. In addition, increased atmospheric CO_2 levels will result in changes in plant species and create favourable conditions for snails, bloodsucking insects such as ticks, and other pests that will increase incidences of trypanosomiasis, liver flukes and outbreaks of army worms (Mwandosya et al., 1998). Furthermore, seasonality of rainfall, increased water scarcity and overstocking of livestock will further shrink rangelands, which are already overloaded in semi-arid areas, and create serious conflicts between farmers and livestock keepers. This will add to the already existing encroachment of agricultural activities in pastoral areas.

According to URT (1998), in the Kilimanjaro Region, agricultural land occupies a total area of 643,300 ha, 333,640 ha of which is under cultivation (51.8 per cent). This is 22 per cent of the total area of the region. Out of this, 15 per cent is under cultivation settlements. More than 70 per cent of the agricultural land is held by smallholders, while the remaining 30 per cent is cultivated by both public and private corporations. In the Kilimanjaro Region, and particularly in the Same District, various factors have contributed to migration. Climate change is likely to have impacted on many people's livelihoods and this has resulted in different adaptation strategies, with migration being one of the alternatives to cope with the changing climate.

In the Same District, a trend of increasing environmental deterioration and destruction, due to land degradation and ineffective enforcement of relevant laws, has reduced soil fertility. Crop yield per unit area is very low, and there is significant run-off during the rainy season, causing erosion in the highlands and floods in

the lowlands (URT, 2009). The problems exist and persist due to a lack of community land ownership and responsiveness, resulting in an accelerated rate of soil erosion, land degradation, charcoal burning, brick burning using tree logs, and uncontrolled grazing, which are all contributing factors to deforestation.

Food shortages are rampant in the Same District. According to the Global Water Initiative (GWI, 2009) Tanzania Programme Baseline Survey results from five wards, 86 per cent of HHs reported food shortages in a 12-month recall period, with up to 50 per cent of HHs not having sufficient food for eight months or more in a year. HHs in Ruvu and Mwembe reported even longer periods without sufficient food (nine and ten months respectively). Weather-related risks, especially insufficient rain and drought, which contribute to poor harvests, were the leading reasons for insufficient food for at least 90 per cent of HHs in Hedaru, Makanya, Mwembe and Same.

2.3 Climate change and migration patterns

Migration is one of the oldest coping strategies for dealing with environmental change. People have been moving in response to changes in their environment, often seasonally, for centuries. Throughout the millennia people have moved temporarily or permanently during periods of drought and other environmental change (Kolmannskog, 2008). For nomadic people and pastoralists such movement is an integral part of their livelihood. However, it is only in the last 20 years or so (since early 1990s) that the international community has begun to slowly recognize the wider links and implications that a changing climate and environment has on human mobility (Laczko and Aghazarm, 2009).

Within the past two to three decades there has been an upsurge of interest in the likely impact of climate change on population movements. Estimates have suggested that between 25 million and 1 billion people could be displaced by climate change over the next 40 years (Laczko and Aghazarm, 2009). The climate is changing, and global emissions of greenhouse gases continue to increase. The recent IPCC report describes these processes in detail, and in the blunt words of an IPCC spokesperson, "if we continue where we are heading, we are in deep trouble". In fact, many of the world's poorest are already in deep trouble as a result of climate change (IPCC, 2007b).

Migration has long been of interest to policymakers, and it has recently become a prominent topic in debates on the impact of climate change. Frequently cited figures estimate that, by 2050, the number of people displaced primarily because of environmental degradation linked to climate change could be as high as 200 million (Myers, 2005; Stern Review Team, 2006). At the same time, policies that build on existing strategies to support adaptation to climate change are among the most likely to succeed. There is growing evidence suggesting that mobility, along with income diversification, is an important strategy to reduce vulnerability to environmental and non-environmental risks, including economic shocks and social marginalization (Tacoli, 2009).

Tanzania, like other developing countries, is seriously impacted by climate change and climate variability. Many sectors are impacted by climate change, and this has resulted in many publications, such as Mwandosya, Nyenzi and Luhanga (1998), assessing the vulnerability and adaptation to climate change impacts in Tanzania. Longer dry seasons are already driving farmers to migrate to locations with better moisture conditions and higher soil fertility.

While local coping strategies may be able to deal with such shocks in the short-term, they are unlikely to be able to cope with more frequent and severe climate events. Indeed, selling assets such as livestock and HH goods as a coping mechanism can leave HHs more vulnerable to both poverty and climate change in the long-run (Orindi and Murray, 2005). This could explain the need for farmers and livestock keepers to migrate to areas that can support their livelihood activities.

Section 3: Methodology

This section provides a brief description of the way the study was carried out in order to address the research objectives and key research questions. In particular, the present section provides information about the study design, study areas and criteria for site selection, data collection and analysis methods, and the sampling procedure employed in drawing the representative HHs from the study areas.

3.1 Research design and approach

This study used a cross-sectional research design to capture information from three different sites. Data collection was accordingly undertaken in three villages that were selected following a preliminary survey based on research criteria. Data collection involved both qualitative (PRA sessions and expert interviews) and quantitative means (structured HH questionnaire). Measured/observed rainfall data were collected from the Same meteorological station.

The goal of this policy-oriented research is to study and understand the interrelations between rainfall variability, food/livelihood security and human mobility among people particularly vulnerable to the impacts of climate change (see Rademacher-Schulz et al., 2012, for a general methodological overview).

The "Rainfalls" project is a significant second generation approach to help fill some specific policy relevant knowledge gaps after previous research investigated the complex relationships between environmental factors and migration (e.g., Afifi, 2011; Afifi and Jäger, 2010; Afifi and Warner, 2008; Foresight, 2011; Milan et al., 2011; Piguet, 2008, 2010; Renaud et al., 2007, 2011; Stal and Warner, 2009; Warner, 2010, 2011; Warner and Laczko, 2008; Warner et al., 2009).

3.2 Data collection methods

Data collection methods involved a literature review, expert interviews, PRA methods and HH surveys. Data collection involved detailed fieldwork in all study villages – base camp village (Bangalala) and satellite villages (Vudee and Ruvu Mferejini). The different methods used in data collection are described below.

3.2.1 Expert interviews

A semi-structured questionnaire was used during discussion with various experts along with the key thematic areas of the study (see Annex I). The key questions addressed the following thematic areas: perceptions on rainfall patterns and variability; livelihood issues and food security, including coping strategies for food insecurity; migration patterns; and the interplay between rainfall variability, food security and migration. The experts ranged from national ministries, international organizations/NGOs, academic institutions, the Pangani Basin Water Office Kilimanjaro Region Officials, the Same District Officials, and civil society organizations. The various institutions were selected based on the link with research focused at various levels (local, regional and national) and previous research or related working experience in the study area.

3.2.2 Participatory Research Approach sessions

A variety of PRA techniques were used to collect relevant information for the study, including: resource mapping; wealth ranking; transect walks; livelihood risk assessment; timeline; mobility maps; impact diagrams; seasonality; Venn diagrams; and FGDs. Prior to detailed fieldwork, pre-testing of the first five techniques was carried out in a separate village (Ruvu Darajani). This is a neighbouring village of Ruvu Mferejini, one of the satellite villages. The selection of participants for the PRA sessions was guided by what each tool focused on. The PRA sessions involved elders, farmers, livestock keepers, non-farmers, women, men and youths. Each session had six or seven local community members, two facilitators and a note taker. Annex II provides a detailed description of PRA sessions conducted for all three study villages.

During the main fieldwork, PRA sessions were conducted by two research teams in a parallel manner in both the base camp and satellite villages. The process involved introduction of the research team and group members, followed by an outline of the objectives of the research. The facilitator then explained the aims of each tool prior to the beginning of the exercise, while the note taker assisted by making a record of the process and the findings. The outputs were shared with the group members for verification and then photographed for documentation. At the end of the exercises, the PRA notes were shared, compiled and then discussed by the research team for further synthesis. The data was synthesized and presented back to local communities as a way of confirming the findings obtained (triangulation).

3.2.3 Household level surveys

3.2.3.1 Survey design

Data collection at the HH level was based on a cross-sectional design survey of HHs in which the required data was collected at one point in time from the selected sample of respondents in the three villages. The desired target population for the survey was all HHs in the study villages. Accordingly, the sampling unit for the survey was a HH[2]. All HHs (both male and female head of) were eligible for sampling to constitute the sample for the HH level surveys in the "Rainfalls" project for the Tanzania case study.

2 Defined as a group of people who are generally but not necessarily relatives, who live under the same roof and normally eat together, including individuals who live for part of the year or the entire year elsewhere either without having established their own family with spouse and/or children in that other place or having established their own family with spouse and/or children in that other place but are still contributing to the income of the HH.

3.2.3.2 Sampling procedure

The intention of the study was to have a random and representative sample. To achieve this goal, the survey utilized a probability sampling procedure in which each HH in the study villages was given a non-zero chance of inclusion in the sample. As mentioned, the reporting unit was the HH; therefore, the study assumed that HHs within the study villages were heterogeneous in terms of the variables of interest (e.g., impacts of changing rainfall on food security and migration). Accordingly, in order to have a representative sample, taking into account likely existing social classes or wealth categories within the study villages, a stratified random sampling procedure was employed. To implement the procedure, the wealth rank based on local perception criteria of wealth ranking was used as a stratification factor in the survey. That is, in each village, HHs were categorized as lowest, middle or highest. Because an up-to-date list of HHs for each village was unavailable, a door-to-door listing of HHs and associated wealth ranking was done. Wealth ranking was carried out by a group of people who had details about the HHs. In each village, the procedure Survey Select in SAS system software was used to select the representative HHs using wealth ranking as the stratification factor. In all strata considered, sample HHs were selected by a simple random sampling procedure to constitute the desired total sample size for the respective village.

3.2.3.3 Sample size

The research team aimed at completing a total of 150 HH questionnaires to obtain sufficient information to draw valid conclusions from the sample for the population of interest. However, since in many practical situations it is not likely that all required reporting units are available or willing to provide information for the study (non-response), an additional 30 HHs were included in the study, resulting in a total of 180 sampled HHs for the Tanzania case study. Of the total sampled HHs, 60 (about 33 per cent) were female head of HHs, while the remaining 120 (approximately 67 per cent) were male head of HHs. In many cases, the study populations (e.g., villages) of interest often contained a different number of units, that is, they were of unequal sizes. Accordingly, a sample of HHs selected from each village to constitute the overall sample size for the study was proportionate to the number of HHs in the respective village. Therefore, the three villages contributed 38 per cent (Ruvu Mferejini), 37 per cent (Bangalala) and 25 per cent (Vudee), that is, $_{rm}$=68, n_b=67, and n_v=45 respectively (see Annex III for details.)

3.2.3.4 Data collection

As is the case in the other "Rainfalls" country case studies, data collection in the HH surveys was carried out through face-to-face interviews using a structured questionnaire consisting of both closed and open-ended questions formulated to capture information in the three areas of major focus (climate change, hunger and human mobility) of the study.

3.2.3.5 Administration of questionnaire

The interviews were conducted by five trained research assistants (two men and three women) who were recruited based on several criteria, including previous experience in data collection and educational backgrounds. Prior to commencement of the fieldwork in the study villages, the team that participated in the pre-testing of the questionnaire took part in a two-day training workshop, which provided the team with more understanding of the questions in the questionnaire. Consistent with previous country case studies, respondents for the HH surveys were heads of HH or his/her spouse or a delegate from among the HH members. Sampled HHs were identified with the help of Village Executive Officers (VEOs), Village Chairmen (VCs) or his/her representative such as hamlet/sub-village heads in the respective villages. In order to avoid missing a lot of people in their respective

HHs at the time of the first visit to the HH, in certain sub-villages, especially in Vudee, the VEO informed in advance the heads of randomly selected HHs about the date and time that the research team was scheduled to visit his/her sub-village for interviews.

The objective of the survey was made clear to the respondent through a consent seeking statement, which was read out at the first contact with each respondent. Preceding the interview in each selected HH, respondents who freely chose to participate in the survey signed a consent form. The interviews were conducted in *Swahili*, thus the interview technique adopted in the survey was to read the questions as verbally as possible. In a few exceptional cases (wherever the respondent was not fluent enough in *Swahili*) a translator fluent in the respondent's local language was used to translate the questions into *Swahili*. However, in order to ensure reliable responses, great care was taken not to change the meaning of the question. Where the respondent was temporarily unavailable to participate in the study, up to three callbacks were made (preferably at a time when there was a good chance of meeting the respondent for interview same day of first visit or next day's visit to the village). Likewise, attempts were made to persuade the respondent who, for various reasons, was unwilling to be interviewed. No replacements of either unavailable or disinclined respondents were made.

Data collection took place for two weeks (3–20 February 2012) and yielded a sample of 165 completed questionnaires, resulting in an overall response rate of about 91.7 per cent. That is, of the total 180 sampled HHs, 15 (about 8.3 per cent) did not provide responses in the survey. The non-response rate was due to: 1) entire HH members moved permanently to another village: 5 HHs (33 per cent); 2) entire HH absent for extended period of time or no competent respondent at home at time of visit: 8 HHs (53 per cent); 3) respondent refused to be interviewed: 1 (7 per cent); and address not a dwelling: 1 (7 per cent).

Thus, the number of HHs interviewed/questionnaires analysed was 63 (out of 572) for Ruvu Mferejini, 59 (out of 562) for Bangalala and 43 (out of 373) for Vudee, which represents about 11 per cent, 10.5 per cent and 11.5 per cent of the total village population size, respectively.

3.2.3.6 Data quality

In order to ensure that the data was of acceptable quality to meet the anticipated goal of the "Rainfalls" study, the data collection team in collaboration with an international researcher held daily debriefing sessions to assess challenges experienced in the field, and plausible solutions were given accordingly.

3.3 Pre-testing and validation

Prior to conducting detailed fieldwork, the Tanzania research team pre-tested the data collection tools in the field. The researchers were divided into two teams; one team was responsible for conducting PRAs and another team for conducting HH surveys. The testing of the research tools was carried out in Ruvu Darajani (a village with similar characteristics to those considered in the study but not included among the three villages for the main survey). A summary of the pre-testing process is described below.

3.3.1 Pre-testing of PRA tools

The PRA team consisted of six researchers. The team went through a training session on the tools as outlined in the Research Protocol document (see Rademacher-Schulz et al., 2012). One day was spent in understanding the tools and planning for pre-testing. The next day was used in the field for pre-testing the tools with two separate groups, each comprising of 6 to 7 villagers as key informants. The group comprised of youths, elderly, men and women. The aims of pre-testing were to familiarize with the methods and tools, to make an appraisal of time needed to conduct the PRA sessions, to make an assessment of understandability of questions in the PRA tools and steps to be undertaken, to assess the appropriateness of questions in terms of socio-cultural norms and lifestyles, and to note the strengths and weaknesses of some of the tools to be used in the field survey.

Pre-testing PRA tools with the first group involved six villagers. The PRA tools that were pre-tested included: resource mapping; wealth ranking; problem or livelihood risk assessment; and transect walks. The research team decided to first use resource mapping since there were no satellite images present. The resource mapping helped in understanding the spatial dimension of the village and the associated resources. The resource map was prepared in a participatory way. This was followed by a discussion of criteria determining wealth in the village and whether there were any patterns of settlements based on socio-economic groups. The team later brainstormed with the group members regarding the key problems affecting their livelihoods. After agreeing on the problems, these were put in a matrix and pair-wise ranked and scored. Lastly, the group conducted a transect walk to areas of particular interest to the group. The research team further conducted a pre-testing of timeline and mobility maps with another group of seven villagers, comprised of youth, elderly, men and women.

Experience from pre-testing PRA tools indicated that each tool required approximately one to two hours. The process involved introduction of the research team and group members, followed by an explanation of the objectives of the research. The facilitator then explained the aims of each tool prior to the beginning of the exercise, and the note taker assisted by making a record of the process and the findings. The outputs were shared with the group members for verification and then photographed for documentation.

3.3.2 Pre-testing of household questionnaire

Prior to implementation of the main data collection from the sampled HHs, the questionnaire was subjected to pre-testing on a randomly selected sample of 10 HHs in Ruvu Darajani. Key issues looked at during the pre-testing of the HH survey questionnaire in the context of Tanzania were: appraisal of time needed to conduct the HH survey; assessment of understandability of the questions; testing the effects of question formulation (appropriateness of questions in terms of socio-cultural norms, lifestyles, etc.); assessment of cultural appropriateness; and establishment of an exhaustive list of response codes (to minimize the code 'other'). Prior to conducting the pre-testing of the questionnaire, a one-day intensive training was conducted in which a question-by-question review was carried out to ensure a common understanding of each question among all participants (interviewers).

With regard to the time needed to conduct the HH survey, it was concluded, based on the sampled HHs, that on average one HH interview could last at least 60 to 110 minutes or more, depending on the level of the respondent's understanding and whether or not a translator was used. Regarding understandability of the questions, with the exception of question 731, in which respondents were unable to tell what the specified distances (km) exactly represent, all other questions were easily and correctly understood by the respondents. In the case of this particular question, it was suggested that a local facilitator with a better understanding of distance (in km) be used to associate the specified distances with specific points (equivalent) known to the respondent. Concerning the appropriateness of questions in terms of socio-cultural norms, lifestyles, etc., none of the questions were considered inappropriate. Also, almost all questions were found to be exhaustive in terms of the response code.

3.4 Data analysis

The data collected from the HH surveys was entered in Epidata entry mask. Because of time restrictions, data entry was carried out on a daily basis, primarily in the evening after the fieldwork. Every interviewer entered his/her own questionnaires that were completed in the field on that particular day. Whenever it was not possible to complete data entry after the fieldwork, interviewers entered the data either on Saturday and/or Sunday of the same week. Data entry was supervised closely by an international researcher trained in data entry for the "Rainfalls" project.

After entry in the data entry mask, the collected data from the HH surveys was further cleaned, processed and analysed mainly descriptively by a UNU-EHS expert who carried out analysis of the project data in the other case study countries. This was done to facilitate comparability of the results across case study countries and make easier the process of integrating research results from individual participating countries into the global report of the "Rainfalls" project (Warner et al., 2012).

The data collected from the PRA sessions were compiled and synthesized focusing on three sub-themes: perceptions of climate change; food security issues/livelihood strategies; and migration patterns. The information was summarized in flip charts and presented to communities during feedback sessions for triangulating and validating the key findings related to the study. During these sessions local communities were also given opportunities to provide suggestions on how to improve their livelihood conditions in the context of the observed climatic changes and the associated livelihood risks.

Furthermore, exploratory and trend analysis of rainfall data (1950–2011) from the Same meteorological station, located at an altitude of 882 m, was completed to triangulate findings from PRAs, HH surveys and expert interviews to actual measured met-data for comparative purposes.

3.5 Research limitations

Like many research studies, there are some practical limitations that deserve mentioning in this section. However, it should be noted that the limitations presented in this section neither invalidate the research findings nor attempt to question the reliability of the research methods employed in the study. They are instead highlighted to make the reader aware of the existence of these limitations so that s/he can take them into consideration when interpreting the results of the study.

The first and intrinsic limitation of the research is associated with the (cross-sectional) design of the study. Compared to longitudinal studies, cross-sectional study designs do not capture the required information from the respondents to reflect the dynamic or changing pattern of the outcome variables of interest in the study. In the present study, as mentioned, no follow- up of the respondents to record observations over a given period of time was done, but information was collected from the selected respondents only at one point in time. In this situation, the responses on some key aspects of the study (e.g., rainfall variability) were largely dependent on the respondent's ability to recall past events.

The second limitation is concerned with the time allotted to complete the research activities/field visits (both HH level surveys and PRA sessions) and expert interviews. Due to time constraints, there was overlapping of other activities, for example expert interviews, which needed more time in terms of finding key respondents. Moreover, although not observed in the pre-testing of the questionnaire, during the main HH surveys it was noted that, for reasons beyond the scope of the interviewer (e.g., respondent's general level of understanding of various issues of interest in the study), some interviews took more time than the pre-determined time for interviews. In such cases, the respondents seemed impatient and thus wanted the interview to be completed quickly, which necessitated the interviewers not probing very much on the remaining items of the questionnaire. Associated with this was the problem of finding heads of HHs, so the researchers sometimes had to make a second or third appointment.

The third limitation is related to the generalization of the study findings across the eight agro-ecological zones which currently exist in Tanzania, and which exhibit significant variations. Because this study was limited to the north-eastern zone, the study findings were therefore possibly limited to only that agro-ecological zone of Tanzania.

The fourth limitation is associated with translating the questionnaire items from the original (English) formulation to *Swahili*, the main language of communication in Tanzania. Although efforts were made to ensure that the original meanings of the questionnaire items were maintained, it is possible that in some items (one-to-one) matching of the meanings between the original and the translated versions was not attained.

The fifth limitation of the study is concerned with the (simple random) sampling mechanism employed to select the representative HHs. In the HH surveys, representative HHs were selected on a random basis. Therefore, some respondents/heads of HHs and their spouses were relatively young and thus not well positioned (age-wise) to describe in an informative way past events such as rainfall variability, to permit meaningful interpretation of findings. Likewise, people who had been living in districts outside Same (the study district) but moved to the Same district within the past few (one to three) years, also had little information about past events related to the district under consideration in the Tanzania case study. Furthermore, the wealth-ranking factor used to stratify HHs in the study villages prior to implementing the simple random sampling procedure was based on local perceptions of wealth. It is likely that some people would be in different wealth categories from the ones in which they were placed. This might have either increased or decreased the probability of inclusion of some HHs for contribution to each stratum, as the overall sample size for each village was proportional to the size of the stratum.

The sixth limitation of the study is related to the use of the rainfall data from the Same meteorological station (1950–2010). The data used in the analysis largely represents the trend in rainfall pattern and distribution in the Same District as a whole and may not necessarily truly reflect actual patterns specifically occurring in the study villages. To be more precise, observed rainfall data specifically for Bangalala, Vudee and Ruvu Mferejini could have been used, if it were available, and this would have led to specific conclusions regarding rainfall patterns in the selected villages[3]. Also, it should be noted that the period of analysis (1950–2010) might not necessarily be representative for drawing conclusions on climate change and climate vulnerability in the Same District. Having a longer time series of data analysis (80 to 100 years) could be more useful to confirm the observed trends with confidence. Furthermore, it should be noted that climate change and climate vulnerability are not only measured by changing rainfall patterns; there are other climatic factors which may contribute to climate change and vulnerability which were not considered during this study.

3 The rainfall data analysis in the three villages could not be undertaken due to a lack of data representing the period of analysis on a village scale.

Section 4: Introduction to the case study area

4.1 Site selection: criteria for selection

The "Rainfalls" research team selected the study area based on the core research criteria that the proposed sites should be typical of major ecosystems and livelihoods. These included factors such as median levels of poverty, different agro-climatic zones and food insecurity (i.e. should not be extreme or marginal samples) and observation of migration patterns. Accordingly, the research team selected Bangalala village as a Base Camp and Ruvu Mferejini and Vudee as Satellite Villages. The characteristics of the selected villages are summarized in Table 2; this information was obtained before the actual research started.

Furthermore, the study villages were selected to complement previous studies and the ongoing work of the Global Water Initiative (GWI) programme – a partnership between CARE, Catholic Relief Services (CRS) and the International Union for Conservation of Nature (IUCN) – which addresses, among others, issues related to climate change in the study areas, particularly with regard to building the resilience of communities to adapt, cope and recover from water-related shock, such as droughts and floods. The presence and experience of GWI in the study area made it possible to further address some practical matters, for example logistics, travel, accommodation and collaboration from local government authorities in the study area.

Bangalala	Vudee	Ruvu Mferejini
The village is located in a semi-arid area comprising of farmers and livestock keepers; rain-fed agriculture is a dominant activity. The main challenge with socio-economic activities in this village is the shortage of rain, which leads to low crop production, poor areas for grazing and insufficient water for livestock during the dry season. The village is increasingly experiencing recurrent drought which results in male migration, leaving behind women and children. The village is about 25 km from Same town, where the research team was situated. There were reported cases of migration of farmers and other migrants; 2003 was reported as a year with strong wind patterns, 2006 as a good year and 2008 as a bad year with droughts.	The village is located at the highlands of Bangalala and it is mountainous. The weather patterns of the village have started changing. The main change experienced is the rainfall pattern. Since farming is the main economic activity, changes in rain patterns have been felt more. Reported cases of changing rainfall intensity, erratic rainfall patterns and crop failure due to failing rainy seasons. Reported cases of seasonal migration, some people left due to the droughts in 2005 in Vudee and therefore it was decided to apply some PRAs in this village, although this was originally not planned.	The village is located in the lowland areas of the Pare mountains. Livelihood activities comprise of farming, including both rain-fed and irrigated agriculture; livestock keeping (pastoralists); and, to a small extent, fishing. The village has a history of floods in 1998 and droughts, which impact on their key livelihood activities and food security. The seasons are less predictable and rainfall increasingly erratic/sporadic over the last 10–15 years (since mid-1990s). The village was reported to be dynamic with a history of various mobility patterns, including out-migration and in-migration associated with climatic factors.

Table 2: Characteristics of the selected study villages.
Source: Field survey (2011).

4.2 Description of the research sites

The study villages Bangalala, Vudee and Ruvu Mferejini are located in the south Pare Mountains, which form part of the Pangani River Basin. The study villages are similar to other rural areas in the semi-arid Sub Saharan Africa (SSA) in that they have experienced a series of dramatic changes over the past two to three decades with regard to agro-climatic conditions (Enfors and Gordon, 2007). The map in Annex VI shows the research sites.

The climate is semi-arid to dry sub-humid, and the rainfall pattern is bimodal with a "short" rainy season occurring anytime between October and December (*Vuli*). The "long" season *(Masika)* occurs between March and May. In terms of rainfall distribution, the highlands (Vudee) receive generally more rainfall than the mid and lower parts (Bangalala and Ruvu Mferejini respectively). The annual average precipitation ranges from 500 mm in the lowlands to about 1,000 mm in the highlands, but the rainfall is highly variable both between and within years and the variability has increased over the past two to three decades (Enfors and Gordon, 2007). The annual rainfall received is split over two agricultural seasons, which is an indication that there is hardly enough water to support the common food crops such as maize and beans (Mutiro et al., 2006). The rainfall is of short duration and high intensity, which has a rapid run-off response, but only for short periods. This run-off, if not harvested, drains into the river networks and alluvial aquifers (Mul et al., 2007) before occasionally reaching the main rivers.

In the highlands, small-scale farming, which is non-mechanized and involves few external inputs, is the principal food and income source. Farmers grow maize for subsistence, with harvests averaging just above 1 ton/ha (FAO, 2008), and vegetables as cash crops. In these areas agriculture is practiced throughout the year, supported by an indigenous supplemental irrigation system (the *Ndiva* system). At mid-elevations, farming is confined to the rainy seasons despite *Ndiva* irrigation. In the lowland areas (Ruvu Mferejini), rainfall is too low for crop production and farming is supported by local irrigation systems. Livestock keeping constitutes an important additional livelihood source here. Farmers in the three villages perceive lack of water as a major constraint to crop production. Despite a significant expansion of cultivated areas over the two to three decades, relatively large areas of bush still remain. The bush land supplies farmers with a range of provisioning ecosystem services, such as fodder for livestock, firewood and construction materials. This resource base is likely to be degraded in the case of over-dependence on such resources.

4.3 Socio-demographic profile of surveyed communities

The socio-economic profile of the HHs interviewed is presented in Table 3. The findings indicate that the average HH size was 6.08. Most of the farmers had a farm size ranging from 0.712 to 1.62 hectares, followed by those with small farms (0.004 to 0.71 hectares) and lastly those with large farms (equal to or more than 1.624 hectares)[4]. The average farm size was 1.53 hectares. The average monthly income was Tanzanian Shillings (Tsh) 11,214.8. Out of 165 HHs, 38 were female head of HH, and the total number of female interviewees was 37. As to migration, more than half of the HHs interviewed had at least one migrant, and the total number of migrants within all the HHs interviewed was 204, 84 of whom (41 per cent) were in Ruvu Mferejini.

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4 To define land categories, 25, 50 and 75 percentiles were used and the corresponding land sizes were 0.71, 1.01 and 1.62 hectares, respectively.

Socio-economic indicators	Ruvu Mferejini	Bangalala	Vudee	Total
HHs interviewed	63	59	43	165
Female heads of HH	12	15	11	38 (23%)
Female interviewees	37	37	22	96 (58%)
Average age of the interviewees*	41.05	50.39	52.42	47.39
HH size (average)	5.84	6.56	5.79	6.08
Average years of schooling of head of HH	3.76	5.56	6.65	5.16
Average years of schooling of HH members aged 14+	4.03	6.86	7.45	6.06
Average monthly income/cap** International (1.25 US$/cap/day)	13,091.86	9,943.43	10,500	11,214.8
Landholdings:***				
Number of landless HH	5	3	3	11 (7%)
Small farmers (0.004 to 0.71 hectares)	10	16	15	41 (25%)
Medium farmers (0.712 to 1.62 hectares)	34	29	18	81 (49%)
Large farmers (≥1.624 hectares)	14	11	7	32 (19%)
Average farm landholding (hectares)	2.11	1.26	1.03	1.53
HHs with migrants	37	31	21	89 (54%)
Total migrants	84	84	36	204
Percentage of migrants per village	41%	41%	18%	100%

* *The age of one interviewee was missing.*

** *Income values for 22 houses were provided in local currency. Also, 10 houses specified '0' as money available for disposal per month.*

*** *Three HHs did not specify the size of their land in numbers, but the interviewer has recorded the category as described by the interviewees (small, medium and large).*

Table 3: Socio-economic profile of surveyed households.
Source: Household survey (2012).

Section 5: Rainfall variability

This section discusses research outcomes on rainfall patterns/variability, based on PRA sessions, expert interviews, HH surveys and analysis of climatic data. The section focuses on climatic issues, particularly events related to rainfall in the past 30 years (floods, droughts, seasonal shifts, etc.). Climate variability refers to a *deviation from the long-term meteorological average* over a certain period of time, for example a specific month, season or year (IPCC, 2001). A stronger than normal monsoon, a more intense drought period, or wet spells in a desert area are examples of climate variations. Although variability is an inherent characteristic of climate, variability and extremes may be exacerbated as a result of global warming (IPCC, 2001).

5.1 Community perceptions on rainfall variability

This section discusses research outcomes regarding rainfall patterns/variability, particularly events related to rainfall in the past 30 years (floods, droughts, seasonal shifts, etc. since early 1980s). It describes community perceptions of rainfall variability (onset and cessation of rain, knowledge of extreme events and the impact of rainfall variability on food security) and makes a comparison between the perceptions and actual rainfall data.

5.1.1 Communities' perceptions of rainfall variability across villages

The findings from expert interviews, FGDs and HH interviews in the three research villages (Bangalala, Ruvu Mferejini and Vudee) yielded largely consistent descriptions of perceived changes in rainfall patterns over the past two to three decades, despite the varying agro-ecological conditions of the sites, particularly in relation to elevation and average annual rainfall. The discussion below summarizes communities' perceptions of rainfall variability and their implications on food security.

5.1.2 Onset and cessation of rain

Change in the onset of rain and the predictability of rain was reported relatively consistently by communities in all three villages despite the differences in agro-ecological conditions. Perceptions in Bangalala indicated that, during both rainy seasons, there are variations in the onset of rainfall, most of the time experiencing late onset and early cessation. It was further reported that sometimes the rainy season is dominated by prolonged dry periods, even when rain would normally be expected. In addition to changing rainfall patterns, communities also reported a tendency of higher temperatures and stronger winds. These are most common and severe during January and February, in-between the two main rainy seasons. These conditions exacerbate the reported problem of water shortage by increasing evaporation from the *Ndiva*. The pattern of increasing winds that was reported in Bangalala was attributed to the lack of trees/forest cover. There were some claims that temperatures were getting warmer across the village.

The PRA findings based on the seasonal calendar indicated that the onset and cessation of rain was more predictable in the past than in the last 10 to 15 years (since mid-1990s); it is more difficult now to be precise about the date of onset of the seasons. There are two major rainy seasons, namely long *(Masika)* and short *(Vuli)*. *Masika* started in February until mid-May, with more rain falling in March and April and less in May. *Vuli* started in September until December. In the past, each rainy season normally provided enough rain to support crops grown in each season. However, in the past 10 to 15 years (since mid-1990s), the seasons have become very unpredictable. The rainfall pattern is erratic; *Vuli* has become more and more unreliable because of failing seasons. *Masika* has also become unpredictable and one cannot tell when it starts or ends; the *Masika* rain may start later or earlier but last for a short period of time and become more intense. In Ruvu Mferejini, where the *Masika* crop is the most important, villagers in the PRA session reported that the season is "shorter now, and that rains often start later and then stop early".

Similarly, in Bangalala and Vudee, the PRA sessions established that changes have occurred regarding rainfall patterns. The main changes included late onset, early cessation and heavy storms with large amounts of rain in a short period of time. The community members explained that they really do not understand what is happening because the season can start well but suddenly the rain will stop even before crops are mature. It was further reported that heat has increased in the upland area compared to the past, which used to be cold. Furthermore, they explained that they are experiencing strong winds which destroy crops before pollination.

Generally, the findings from expert interviews with NGOs within the study region indicated that there is great variability in rainfall amount, onset and cessation, and more frequent prolonged drought periods. Even in areas where rainfall has not declined, temperatures have been so high that there is an increase in evaporation and the water sources also dry up easily. It was, however, indicted that within these drought-prone areas there are pockets with an increase in rainfall, for example in Emborate, 100 km from Arusha (in the Simanjiro District). From the PRA session this appeared to be one of the key destinations for migrants from all the study villages.

Experts from the Tanzania Meteorological Agency (TMA) reported that they have not observed significant changes in the amount of annual/seasonal rainfall. What they have observed is varying dates for the onset of rain, reduced length of growing seasons and early cessation of rain, and increased length of dry spells even in the growing seasons. According to them, this has been observed since the mid-1980s. According to the HH survey, the findings show that the majority of the respondents interviewed (more than 84 per cent) indicated that there are longer dry spells (see Table 4), which also concurs with observations from the PRA sessions. In addition, about 68 per cent of HHs interviewed complained about shorter rainy seasons, which is also in line with the PRA outcomes as well as the expert statements.

Rainfall change	Yes	% of total HHs (165)
Longer rainy seasons	1	0.6
Shorter rainy seasons	112	68
More rains	17	10
Longer dry spells	139	84
Shorter dry spells	0	0
More dry spells	1	0.6
Others	8	5

Table 4: Perceptions of rainfall variability.
Source: Household survey (2012).

During expert interviews with researchers from the University of Dar es Salaam, with vast experience in working in the Pangani River Basin, it was commented that "the research region is becoming drier now due to frequent droughts. This has been more pronounced particularly in the past 20 years in both highlands and lowlands – but much significant in the lowlands and the leeward side".

They further explained that, currently, the seasons can no longer be clearly defined. "The rainfall has become unpredictable." It was further explained that 20 years ago (early 1990s) the dry/cool season *(kipupwe) – ilikuwa na manyunyu* – was accompanied by fog and mist, but that now *kipupwe* is very dry. The key changes reported are that the seasons are not very distinct; rain may come too early or late. Again the most affected are the *Vuli* rains. This observation concurs with the findings from the PRA sessions, where the unreliability of *Vuli* rainfall has significantly affected the agricultural production system in Vudee.

5.1.3 Extreme events

According to the IPCC, an extreme weather event is an event that is rare within its statistical reference distribution at a particular place (IPCC, 2001). Of the two extremes of variability in rainfall, that is, drought and floods, the former constitutes the most significant threat to rain-fed agriculture, which is critical to rural livelihoods across SSA. All the extreme weather events have had severe impacts on people's livelihoods, especially on agriculture and food security.

When asked to recall specific events in the histories of the villages using the Timeline PRA tool, local communities identified a number of major episodes of drought fairly consistently across the three villages (see Table 5). These include: (1) 1960/61, when the Government of Tanzania distributed yellow maize donated by the US Government as relief food; (2) 1973–1976, experienced in all research villages but with variation in specific years; (3) 1995–1997, similar to experience in the mid-1970s; and (4) 2005–2007, cited by residents of Ruvu Mferejini in the PRA session as the worst drought in recent memory. The worst droughts were the ones that significantly disrupted their livelihood system in terms of crop and livestock production and resulted in people migrating to other locations.

Interestingly, there is little consensus on the experience of drought in the 1980s, despite the occurrence of a national drought-induced food security crisis in the mid-1980s. Residents of Vudee identified 1980 and 1984 as drought years. Residents of Bangalala mentioned 1989 as a year for bad rain in terms of drought conditions, but they also described the decade as a whole as one of "neither very good nor very bad rains". According to one farmer in Bangalala, over the last 50 years, residents

Year	Type of extreme event	Highland Vudee	Middle Bangalala	Lowland Ruvu Mferejini
1961	Severe drought	✓	✓	
1965	Drought		✓	
1971/72	Drought		✓	
1972/73	Drought		✓	
1973/74	Severe drought	✓	✓	✓
1974/75	Severe drought		✓	
1977/78	Good rain		✓	
1980	Good rain		✓	
1983/84	Drought	✓	✓	
1993/94	Inadequate rain		✓	
1996	Drought	✓	✓	✓
1997/98	Heavy rain (El Niño) floods	✓	✓	✓
2000	Outbreak of diseases		✓	
2003	Good rain		✓	
2005	Drought		✓	
2006/07	Drought	✓	✓	
2011	Strong winds		✓	

Table 5: Timeline of major climatic events (1961–2011).
Source: Field survey (2012).

of the research villages in the Same District recall at least one severe drought in each decade, sometimes of multiple-year duration.

From the timeline exercise, farmers were able to map out bad years and good years in terms of climate and associated impacts as indicated in Table 5. It was reported that bad years in terms of climate have been increasing because land is becoming bare due to increased human activities, particularly involving the exploitation of forest products leading to deforestation. Bad years identified included the following years: 1961, 1965, 1974, 1996, 1999/2000, and 2006 to date. With regard to the impact of bad years on people, crops and livestock, it was reported that everyone was negatively impacted but the magnitude varied. For example, poor and elderly people, women and children were significantly affected. Some women were affected because men migrated to other locations, thereby leaving their families behind.

On the other hand, it was reported that good years in terms of climate are becoming less because nowadays there is frequent drought (low rainfall). Men reported that sometimes it rains too much and for a prolonged period such that it becomes more difficult to manage crops or undertake field operations (weeding, etc.), again resulting in low crop yields. Good years identified were 1977, 1980, 1997/98 and 2003. The good years were characterized by adequate harvests, good income and also the fact that people do not migrate.

Bangalala appears to have noted the largest number of extreme events in terms of drought, despite the villages being located within the same district. This could be explained by fewer livelihood options, especially due to limited irrigation potential when compared to Ruvu Mferejini. It was reported during the PRA sessions that the existing traditional irrigation system was not sufficient to cater for the majority of the HHs in the community and that the available water could only last for a shorter duration of about a month or so in periods of extreme drought.

5.2 Statistical analysis of Same meteorological station rainfall data (1950–2010)

Exploratory and trend analysis of Same meteorological station monthly rainfall data covering the period 1950 to 2010 was carried out. The primary objective of the analysis was to understand whether there was a trend (increasing or decreasing) in the amount of rainfall over time in statistical terms. Specifically, the analysis aimed at providing an understanding of the evolution of rainfall both within and between seasons across years within the specified reference period (1950 to 2010). The descriptive statistics of monthly rainfall data from the Same meteorological station (and distribution across the seasons) are provided in Annex IV.

5.2.1 Rainfall patterns

The analysis of rainfall data shows that the distribution of rainfall in the Same District is bimodal in nature (see Table 6). As discussed earlier, the first rainy season *(Vuli)* begins in October and continues to December with a peak in November, while the second season *(Masika)* normally begins in March and ends in May with a peak in April[5] (see Figures 4 and 5.) January and February represent a transitional dry spell period from *Vuli* to *Masika*. Each of the two rainy seasons is characterized by less rainfall at the onset of the season and ends with slightly more rainfall compared to that observed at the beginning of the season, but less than that in subsequent months. The period from June to September is generally a dry season (locally known as *Kiangazi*). Figure 6 further confirms the bimodal nature of rainfall distribution in Same when the data are disaggregated by decade from the 1950s to 2000s. However, the data illustrates that the observed amount of rainfall in the *Masika* shows a declining trend in the past two decades (1990s and 2000s), with April recording lower amounts of rainfall than in the past four decades (since early 1970s).

5 The period of each rainy season lasts on average between three and four months.

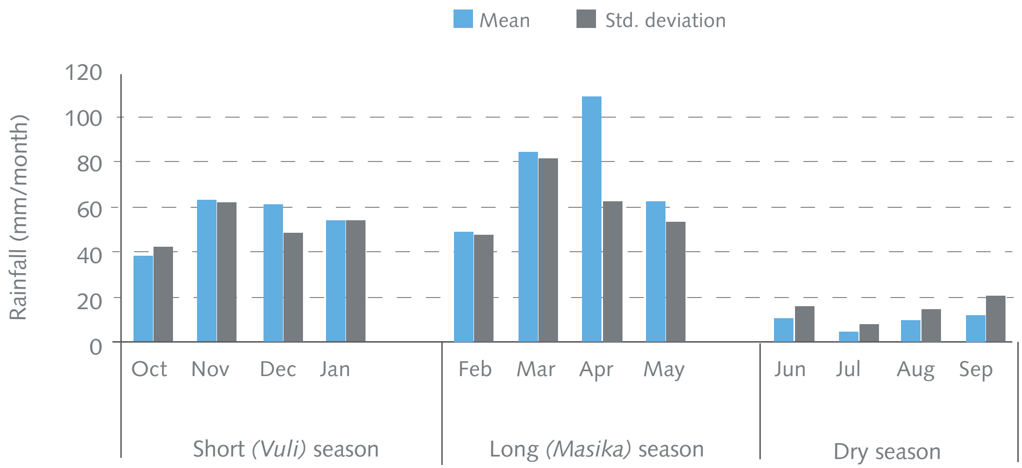


Figure 4: Rainfall seasons in Same (1950–2010).
Source: Designed by authors, based on data provided by TMA (2012).

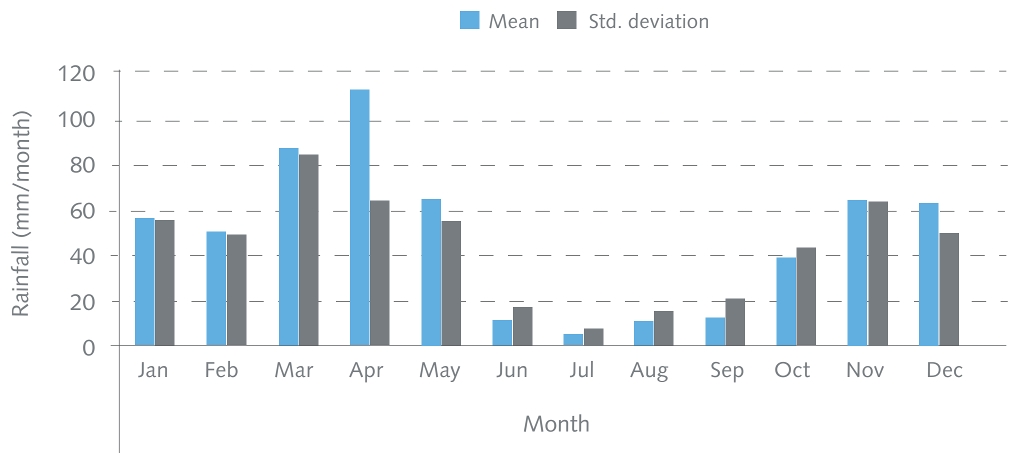


Figure 5: Monthly rainfall in Same (1950–2010) (bar chart).
Source: Designed by authors, based on data provided by TMA (2012).

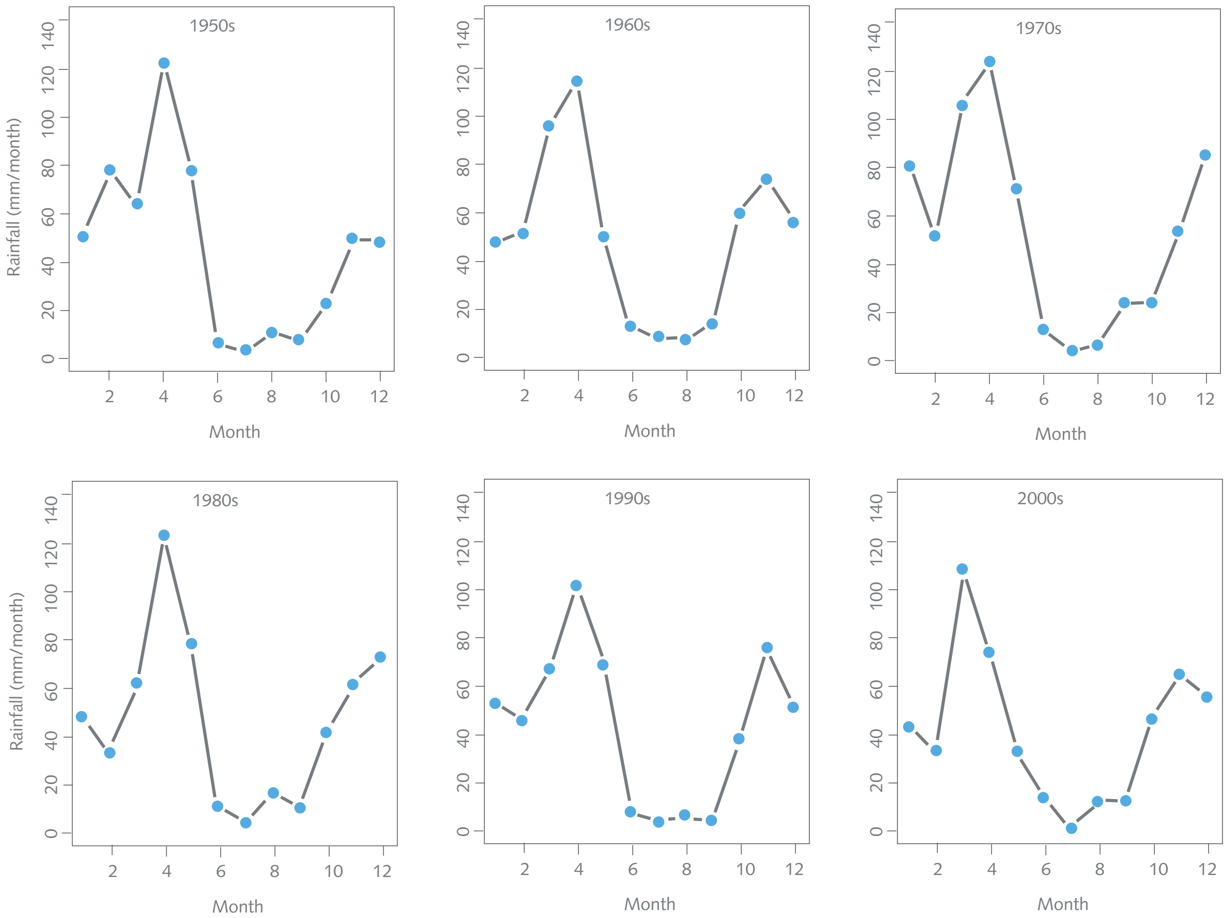


Figure 6: Monthly rainfall in Same (1950–2010) (graphs). Source: Designed by authors, based on data provided by TMA (2012).

Vuli rains			Dry spell		*Masika* rains			Kiangazi			
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep

Table 6: Bimodal rainfall calendar.
Source: PRA sessions and household survey (2012).

5.2.2 Extreme incidences of rainfall

The five extreme lowest incidences of rainfall (in ascending order of magnitude) in the area occurred in 2005, 1993, 1952, 1996 and 1975. In these years, the corresponding amounts of rainfall (mm/annum) were 265.30, 302.40, 314.04, 318.30 and 320.10 respectively. Conversely, the five extreme highest amounts of rainfall (mm/annum) were 919.84, 967.50, 975.20, 1019.20, and 1074.00, which occurred in 1957, 1968, 1997, 2006 and 1978 respectively. Of particular interest in these observations is the amount of rainfall portrayed between 2005 and 2006 and between 1996 and 1997. Whereas 2005 was observed to be among the first five extreme lowest amounts of rainfall, 2006 recorded among the top five highest annual amount of rainfall. Similarly, while 1996 recorded an annual amount of rainfall that is among the extreme lowest values, 1997 recorded an annual amount of rainfall that is among the extreme highest values. A fairly comparable prototype of evolution of rainfall in the area involves 1952 (extreme lowest) and 1957 (extreme highest), and 1975 (extreme lowest) and 1978 (extreme highest). The pattern of extreme values observed in the data presents evidence of the evolution of rainfall over time that is largely in line with what was obtained from the PRA sessions.

5.2.3 Mean annual and seasonal rainfall

Summary statistics in Table 7 reveal that between the 1950s and 1970s the average annual amount of rainfall was increasing at a decreasing rate. It increased by about 11 percentage points between the 1950s (539.82 mm/annum) and 1960s (596.92 mm/annum) and at a rate of 6 percentage points between the 1960s and 1970s (631.09 mm/annum). Overall, between the 1950s and 1970s, average annual rainfall increased by roughly 17 percentage points. A similar trend is also observed in the *Vuli* season in which the mean amount of rainfall was increasing until the 1970s, and then decreased consistently and steadily until the 2000s. Findings from FGDs also reflect this, with the impacts on agricultural production being more pronounced in Vudee village. In contrast, for *Masika*, the mean amount of rainfall decreased between the 1950s and 1960s then increased in the 1970s, and again decreased afterward. Figure 7 provides a graphical display of the mean evolution of annual and seasonal amount of rainfall over time.

Year	Annual rainfall (mm/annum) Mean	SD	Min.	Max.	*Vuli* (mm/season) Mean	SD	Min.	Max.
1950s	539.8	207.9	314.0	919.8	169.8	119.6	49.4	403.4
1960s	596.9	156.7	454.0	967.5	239.4	116.7	95.8	441.9
1970s	631.1	239.4	320.1	1074.	240.1	145.9	80.3	511.0
1980s	559.8	123.0	376.5	768.1	222.4	87.3	133.7	399.5
1990s	531.1	228.2	302.40	975.2	219.9	157.5	54.5	602.3
2000s	505.5	222.1	265.30	1019.20	212.5	140.6	71.9	476.0

Year	*Masika* (mm/season) Mean	SD	Min.	Max.
1950s	341.5	121.8	204.5	546.4
1960s	312.4	166.4	133.9	647.1
1970s	348.1	134.8	165.1	552.8
1980s	295.6	69.1	230.7	415.3
1990s	286.1	117.9	153.1	585.9
2000s	250.1	147.9	76.1	549.5

Table 7: Mean, standard deviation, minimum and maximum values of rainfall in Same (1950s–2000s). Source: Designed by authors, based on data provided by TMA (2012).

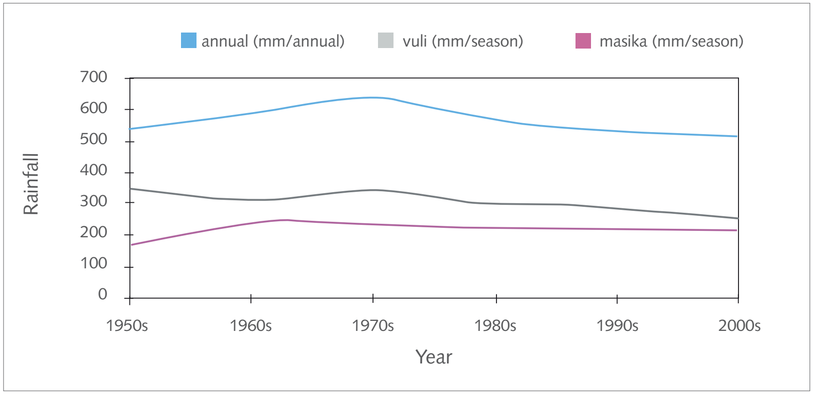
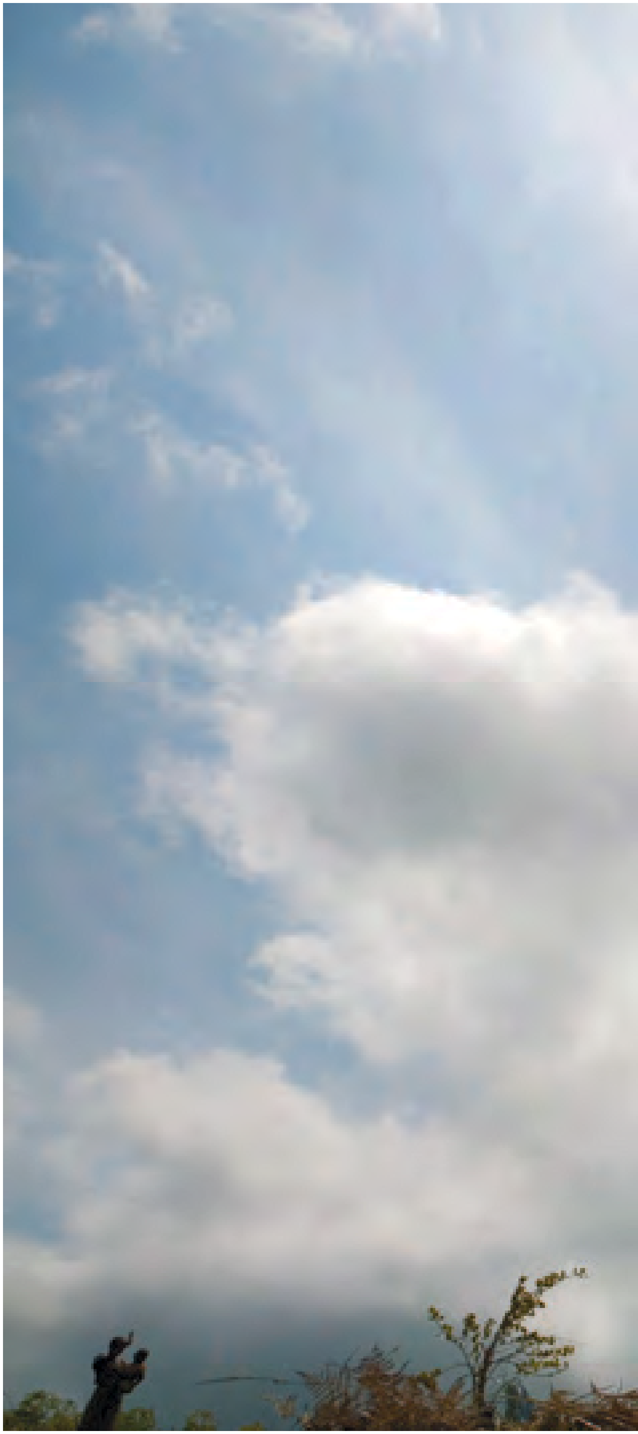


Figure 7: Smoothed annual and seasonal trends of rainfall in Same (1950s–2000s). Source: Designed by authors, based on data provided by TMA (2012).

As seen in Figure 7, the gap between *Vuli* and *Masika* in terms of mean rainfall was much wider (172.00 mm/season) during the 1950s, narrowed in the 1960s (73.00 mm/season), increased in the 1970s (108.05 mm/season), and then started to narrow down gradually until it reached 37.65 mm/season in the 2000s. In general, the period 1971–1979 was characterized by a larger amount of rainfall compared to all other periods. Despite the higher rainfall during this period, villagers reported having experienced drought, especially in 1974/75, which implies that poor rainfall distribution could explain the observed situation.

In general, the analysis of rainfall patterns from the Same meteorological station for the period 1950–2010 reveals a decreasing mean in the total annual rainfall and a decrease in the amount of rainfall in the Masika over the past two decades (1990s–2000s). The declining trend of the total annual rainfall would imply that the *Masika* season largely dominates the overall annual rainfall pattern in the Same District.



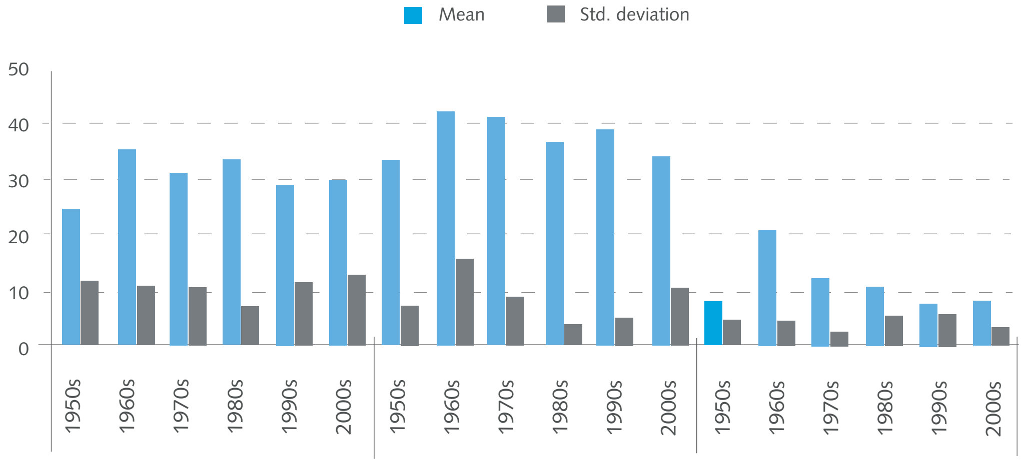


Figure 8: Number of rain days per season (1950s–2000s). Source: Designed by authors, based on data provided by TMA (2012).

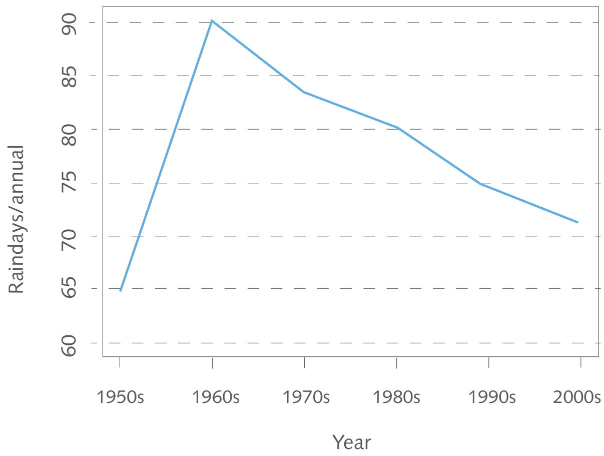


Figure 9: Number of rain days per annum (1950s–2000s). Source: Designed by authors, based on data provided by TMA (2012).

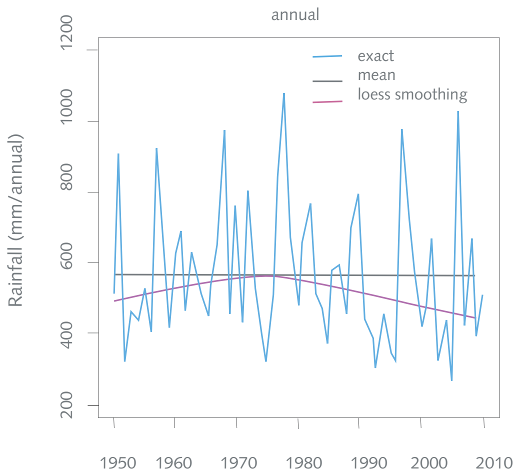


Figure 10: Evolution profile of annual rainfall (1950–2010). Source: Designed by authors, based on data provided by TMA (2012).

5.2.4 Number of rain days

Although the period 1970–1979 was generally observed to have the highest average (631.09 mm/annum) amount of rainfall, it had a slightly lower number of rain days across seasons compared to the period 1960-1969, which had an annual average rainfall of 596.92 mm. The difference is more pronounced in the short *(Vuli)* and dry seasons than in the long *(Masika)* season. Figure 8 shows the rain days per season. The number of rain days per year increased from about 65 days in the 1950s to 90 days in the 1960s, but thereafter declined to 71 days in the 2000s (see Figure 9).

In general, the analysis shows a progressive decline in the number of rainy days per annum with a pronounced reduced number of rainy days in Masika noticed in the past 20 years (1990s–2000s). An increasing trend in the dry spells during dry seasons in the past 20 years is also visible and *Vuli* rains being highly variable with a relatively stable pattern.

5.2.5 Trend test

Figure 10 demonstrates that the annual amount of rainfall oscillates about the mean value with no apparent trend of increase or decrease. However, the LOESS smoothing function shows existence of a general increase from 1950 to the mid-1970s; afterwards a general decline is demonstrated. Nonetheless, results from the Mann-Kendall's trend test (see Table 8) fail to reject the null hypothesis of no trend in the series at the 5 per cent level of significance.

Non-seasonal Mann-Kendall test

Kendall's tau	-0.016
S	-4318.000
Var(S)	43645604.667
p-value (Two-tailed)	0.513
Alpha	0.05

Seasonal Mann-Kendall test / Period = 12

Kendall's tau	-0.026
S'	-578.000
p-value (Two-tailed)	0.299
Alpha	0.05

Table 8: Non-seasonal and seasonal Mann-Kendall test for trend. Source: Designed by authors, based on data provided by TMA (2012).

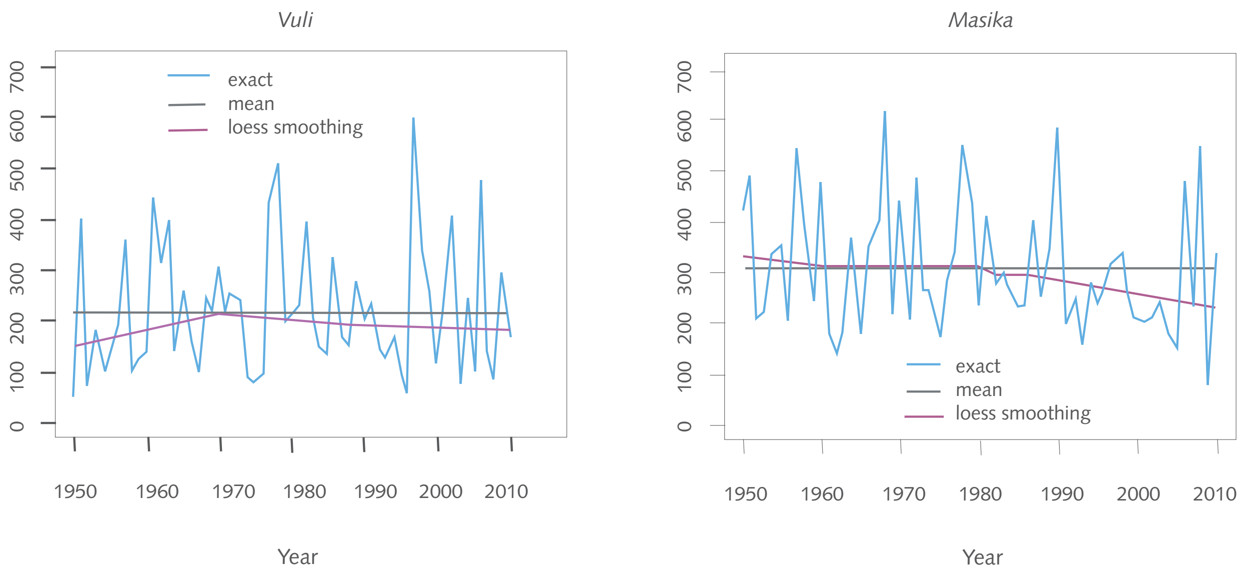


Figure 11: Evolution profile of rainfall amount per season (1950–2010). Source: Designed by authors, based on data provided by TMA (2012).

In order to gain more insight into possible differences between the short *(Vuli)* and long *(Masika)* seasons over time, we plotted separate profiles of evolution of rainfall for each season. Figure 11 also presents no evidence of overall increasing or decreasing trend, with relatively more stable evolution in the short *Vuli* rainfall season than in the long *Masika* rainfall season.

In general, the analysis shows that there are no statistically significant trends in the cumulative Vuli and Masika seasons, and annual rainfall records. A visual analysis, however, suggests an increasing trend in the total seasonal rainfall in the Vuli season, with a declining trend in the Masika season over the past 20 years (1990–2010).

5.3 Comparisons of community perceptions to actual rainfall data

Daily rainfall data from 1950 through to 2010 was obtained from the meteorological station in Same, which is in the lowlands of the Same District and roughly comparable to conditions at two of the research sites (Bangalala and Ruvu Mferejini). The availability of this data offers great potential for rainfall trend analysis, as well as comparison with community perceptions.

5.3.1 Changes in amount of rainfall

Using total annual and seasonal rainfall figures and comparing across decades, there is some basis for community perceptions of declining rainfall totals, particularly over the 10 to 30 year time-frame on which they were based. Mean annual rainfall during 1950–2010 was 560 mm/annum. Of this total, an average 76 per cent fell during the seven months of the year considered part of the normal *Masika* and *Vuli* rainy seasons. Interestingly, while this percentage ranged from a maximum of 97 per cent in 1992, a year of poor rainfall, to 53 per cent in 1998, an El Niño year, decadal averages were consistently narrow, ranging from 73-79 per cent from the 1950s through to the 2000s.

Decadal rainfall rose from 540 mm/annum in the 1950s to a peak of 631 mm/annum in the 1970s, but then fell in each successive decade to a low of 505 mm/annum in the 2000s. The total rainfall in the decade beginning 2000 was 10 per cent below the 60-year average and nearly 20 per cent below the peak experienced in the 1970s.

From the PRA discussions in Bangalala it was noted that water was in abundance in the 1980s and 1990s, attributed to good rainfall, relatively good environment and a smaller population. In the 1960s and 1970s, water availability was reported to be average because the area received moderate rainfall with periods of drought in-between. Water availability was reported to be scarce, almost diminishing, in the period between 2000 and 2011. This period was characterized by prolonged dry spells, failing seasons, cultivation close to water sources, population increase and increased wind and heat, as reported by the community.

In Ruvu Mferejini, it was reported that water is usually available in the irrigation canal[6] depending on rainfall availability upstream in the Pangani River Basin (Kikuletwa and Ruvu catchments); the community members reported decreasing water levels over the years. Reasons given for this observation include less rainfall in the catchment areas, increased temperatures that led to increased evapotranspiration on water bodies, and the poor management of the canal.

5.3.2 Changes in total rainfall during long *(Masika)* rains

Using the same data, there is also evidence to support community perceptions of declines in the total amount of rain during the *Masika* cropping period (March–May). Over the 60-year period beginning in 1950, the mean annual *Masika* rain was 258 mm. Values over the period fluctuated significantly, with the lowest *Masika* rain (51 mm) occurring in 2009, and the highest annual total (550 mm) occurring in 1968. Rainfall during these months was below average in the 1950s and 1960s but grew significantly in the 1970s to peak at 288 mm/annum. Since then, decadal totals fell steadily to a low of 218 mm/annum in the 2000s. The 2000s are remembered in the research villages for poor harvests, due to the communities' experience with *Masika* rainfall, which were at or above the 60-year average in only two of the ten years (2006 and 2008).

During the six-year period from 2000 to 2005, Masika rain, on which villages such as Bangalala and Ruvu Mferejini depend heavily, averaged only 165 mm/annum, roughly 36 per cent below the 60-year mean.

6 The main canal in the Naururu irrigation canal, which is fed by water, diverted from the main Pangani River.

5.3.3 Changes in total rainfall during short *(Vuli)* rains

Meteorological data provides less support for community perceptions of declining rainfall during the *Vuli* cropping season. Total rainfall during September through to December averaged 174 mm/annum over the period 1950–2010. *Vuli* rainfall showed an even wider range of values, with the lowest recorded (20 mm) occurring in 1996, while the highest seasonal rainfall (596 mm) occurred just one year later in 1997 as part of the 1998 El Niño event. The 1950s saw very low *Vuli* rainfall, averaging only 128 mm/annum, followed by a dramatic increase to a peak of 206 mm/annum in the 1960s. The perception of declining rainfall could be explained by the erratic nature and poor distribution of rainfall as well as the pressure of a growing population on water availability.

In the four decades since the 1960s, the decadal average has fluctuated around the long-term mean, ranging from 171 mm/annum in the 1990s to 185 mm/annum in the 1980s. While rainfall data from the Same meteorological station does not seem to support the claim that the *Vuli* season is "disappearing", it does show a high degree of variability from year to year. Over the last two decades (1990s and 2000s), *Vuli* rain equalled or exceeded the 60-year average only six times, while annual totals were less than 100 mm/annum in seven years. Many years of below average *Vuli* rainfall were offset in the decadal totals for the 1990–2009 period by two very large *Vuli* rains (1997, the beginning of the El Niño event, and 2006, when totals were 598 and 499 mm/annum respectively). The rainfall data also shows the El Niño event, even though it does not show up clearly in the annual total of 975 mm/annum (only the third highest on record after 1978 with 1,074 mm/annum, and 2006 with 1,019 mm/annum). Instead, *Vuli* rainfall of 598 mm in September–December 2007 was followed by unusually high rainfall of 330 mm in January–February 2008, giving a six-month total of 928 mm.

5.3.4 Delayed onset and early cessation of *Masika* rains

Using monthly rainfall totals for March as a proxy for the onset of *Masika* rainfall, there is limited evidence to support the perceptions of recent delays. While March rainfall was indeed below the long-term average of 85 mm/annum, at 62 and 68 mm/annum respectively in the 1980s and 1990s, the decadal average for March in the 2000s was above the mean at 108 mm/annum. By contrast, there is more evidence of a recent trend toward early cessation of *Masika* rainfall, with the average monthly totals for April and May during the 2000s falling well short of long-term averages (80 vs. 110 mm/annum and 36 vs. 63 mm/annum). Further analysis is required to understand better intraseasonal variations in rainfall.

5.3.5 Delayed onset and early cessation of *Vuli* rainfall

Using the combined rainfall of September and October as a proxy for the onset of *Vuli* rainfall, there is no apparent trend toward delayed onset. Indeed, over the last four decades (since early 1970s), average rainfall during these months has been near or above the long-term average of 50 mm/annum. With regard to earlier cessation of *Vuli* rainfall, using December rainfall totals as a proxy, there is some evidence to support a declining trend over the last four decades. December rains peaked in the 1970s at 85 mm/annum, well above the long-term average of 50 mm/annum, and then declined to 67 mm/annum in the 1980s and 55 mm/annum in both the 1990s and 2000s, representing a 27 per cent decline.

5.3.6 Occurrence of major droughts

An examination of the meteorological data from the Same station also provides evidence to support the occurrence of at least one major drought in the district in each of the last five decades (1960s onwards):

1. The drought of the early 1960s is a consequence of the poor 1960 *Vuli* rainfall (63 mm), followed by a failure of the 1961 *Masika* rainfall (81 mm); the *Masika* of 1962 was also poor. Although total annual rainfall in 1960–1962 was not particularly low (and indeed above the long-term average in both 1960 and 1961), the failure of the *Masika* rainfall would have had an even bigger impact at that time before irrigation was introduced into the lowlands of the Pangani River basin.

2. The drought of the mid-1970s shows up clearly in the five consecutive years of well-below average *Masika* rainfall from 1973 through to 1977, the impact of which was compounded by two consecutive poor *Vuli* rainfalls (1974/75).

3. Like community perceptions, the evidence for drought in the 1980s is mixed, although *Masika* rainfall in the five years from 1982 to 1986 totalled just 217 mm/annum, or nearly 16 per cent less than the long-term average.

4. The mid-1990s show several years of well-below average rainfall, although not coinciding precisely with community memories of drought in 1996/97. From 1993 to 1996, only 1994 was normal, with 459 mm/annum rainfall. *Masika* rainfall in 1993, 1995 and 1996 averaged only 170 mm/annum (34 per cent below the long-term average), while *Vuli* rainfall for the same years averaged only 52 mm/annum (70 per cent below the long-term average).

5. Rainfall records for the 2000s show below average rainfall through much of the first half of the decade. *Masika* was below average from 2000 to 2005, falling 36 per cent short of the long-term average. *Vuli* fluctuated widely in the same decade, ranging from 63 mm/annum to 499 mm/annum; in both 2003 and 2005, bad *Vuli* rainfall coincided with bad *Masika* rainfall. Also, 2009 was another bad year, with an almost complete failure (51 mm) of *Masika* rainfall, following poor *Vuli* rainfall (93 mm) in the preceding year.

5.4 Summary of key findings

Regarding changes in rainfall, based on HH surveys, the perceptions of local communities include: an increase in experience of prolonged dry spells; erratic rainfall; late onset and early cessation; and higher temperatures and winds resulting in increased evaporation and hence a negative impact on agricultural production. Similar observations were obtained from PRA sessions and expert interviews. Most of the changes were reported to have occurred in the last three decades (since early 1980s) but more pronounced within the last two decades.

From the analysis of meteorological data, the actual changes indicate periods of rainfall increase and decrease across decades. When a comparison of the perceptions and actual data is made, it is seen that statistics in some cases show increases in annual rainfall even in periods where communities have experienced drought. This can imply that annual rainfall data does not reflect its distribution; a lot of rainfall could be falling in a few days and then disappear during critical periods of plant growth, with the result being crop failure. However, there is a match of meteorological data and local perceptions in terms of years with extreme climatic events. Nevertheless, the analysis of rainfall data from the Same meteorological station (1950–2010) reveals the following key trends worth mentioning:

- The observed extreme events (high rainfall events – floods and low rainfall events-drought) from the local meteorological data largely match with the community perceptions. For example, there is a fairly comparable prototype evolution of rainfall in the area involving the years 1952 (extreme lowest) and 1957 (extreme highest), and 1975 (extreme lowest) and 1978 (extreme highest). The pattern of extreme values observed in the data present evidence of the evolution of rainfall over time, and most of these observations are in line with what was obtained from the PRA sessions.

- There is a decreasing mean in the total annual rainfall and a decrease in the amount of rainfall in the *Masika* over the past two decades (1990s–2000s). The declining trend of the total annual rainfall would imply that the *Masika* seasons largely dominate the overall annual rainfall pattern.

- There is a progressive decline in the number of rainy days per annum with a pronounced reduced number of rainy days in *Masika* noticed in the past 20 years (1990s–2000s). An increasing trend in the dry spells during dry seasons in the past 20 years is also visible and *Vuli* rainfall being highly variable with a relatively stable pattern.

- There are no statistically significant trends in the cumulative short season *(Vuli)*, long season *(Masika)* and annual rainfall records. A visual analysis, however, suggests an increasing trend in the total seasonal rainfall in *Vuli* with a declining trend in *Masika* in the past 20 years.

Section 6: Livelihood and food security

This section discusses research outcomes on livelihood and food security patterns in the base camp (Bangalala) and satellite villages (Vudee and Ruvu Mferejini). A livelihood is defined as consisting of capabilities, assets and activities required to make a living (Chambers and Conway, 1992). Accordingly, HH livelihood security is defined as adequate sustainable access to income and resources to meet basic needs. A livelihood can be made by a range of on-farm and off-farm activities, which together provide a variety of procurement strategies for cash and food. According to Chambers and Conway, a livelihood is sustainable when it can: cope with and recover from stress and shocks; maintain its capability and assets; and provide sustainable livelihood options for the next generation. On the other hand, food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 1983). The four pillars of food security are availability, access, utilization and stability.

The section presents and discusses the study findings with respect to livelihood and food security, and also explores the link with rainfall variability. The section starts by highlighting the population characteristics, livelihood activities and existing socio-economic groups in the research villages. The section further discusses the temporal analysis of livelihood trends and related activities, the implications of climate variability on livelihoods, food security trends as compared to seasonal shifts, coping with extreme events, gender implications, and expectations for the future.

Plate 1: Resource map for Bangalala. Source: PRA sessions (2012).

6.1 Available resources

Bangalala village is limited in terms of natural resources, particularly forests that are the source of firewood and charcoal. Firewood collection is mainly done by women for HH use, and men are mainly involved in the charcoal business. The village has traditional water collection reservoirs for future use, which are known as *Ndiva* (see Plate 2). The village is in a semi-arid area that receives limited rainfall. Water from *Ndiva* helps in irrigating crops when the rain ceases. There is an appointed committee, composed of farmers from the village, which deals with water distribution in the canal.

Villagers were asked to indicate the existing resources in the surveyed villages. Plate 1 presents the resource map for Bangalala.The map also indicates the distribution of these t raditional water collection reservoirs, which were also visited during the transect walk in relation to Bangalala. During this transect walk it was noted that the reservoirs had dried out, and it was reported that the villagers manage to store water to support irrigation for a few months following early cessation of rainfall. *Ndiva* were also found in Vudee (smaller ones), and these helped with irrigating crop fields.

Ruvu Mferejini is demarcated into areas for farmland, settlements and grazing, but still no maps have been prepared to display the plan. The majority of inhabitants depend on both subsistence and large-scale irrigation farming. Residents can farm at any time of the year without regard for rainfall due to their access to the Pangani River. They normally grow onions, tomatoes, ngwasha, maize, rice, sugar cane, eggplant, cucumber, papaya and other vegetables.

6.2 Population and livelihood activities

The major ethnic group in Bangalala and Vudee is the *Pare.* In Ruvu Mferejini, there exists a mixture of ethnic groups, including pastoral communities, particularly the *Maasai*, who reside in this area because of water availability from the Pangani River for their livestock. A number of socio-economic activities are undertaken by the community in the study area. The major farm-related activities reported across the three villages included crop and livestock production. Crop production entails mainly annual crops for both food and income generation. Major food crops produced include maize, lablab, cowpeas, beans, sweet potatoes and onions. Lablab, beans and vegetables are the main cash crops.
From the PRA findings, it was noted that both men and women are involved in crop farming, but when it comes to selling vegetables at the market, women are mainly involved. Men are mainly involved in livestock grazing and taking care of cattle, including selling animals in Makanya Ward. From the findings of the HH surveys, it was noted that there have been only slight changes in the types of activities undertaken by residents when a comparison is made between activities undertaken 10 years ago and recently. The information presented in Table 9 includes all three key activities mentioned by each HH.

Table 9 also indicates that there has been a positive change in people's engagement in agricultural production activities and farming, from 55.68 per cent to 66.66 per cent. It was also interesting to note that the percentage of people engaged in keeping and raising livestock also increased from 26.96 per cent to 55.75 per cent. Apparently, the findings indicate an increase in involvement in casual labouring and daily labour, from 10.31 per cent to 17.54 per cent. This could imply an increase in hardship, which could be related to climatic factors. To support this observation, the findings further indicate an increase in people's dependence on remittances, which increased from 1.21 per cent to 5.45 per cent.

Apart from farm-based livelihoods, members of the community during PRA sessions reported also being involved, in a very limited way, in a number of non-farm income generating activities resulting from various socio-economic constraints and environmental problems. The major non-farm activities reported in Bangalala village, for instance, included charcoal burning, food vendors, bee keeping and collecting honey in the forest, and also fuel wood collection. Charcoal making and fuel wood collection were reported to be undertaken by men and women respectively, for the purpose of income generation and use at home as a source of fuel. The HH survey findings presented in Table 9 highlight some of these non-farm activities. We see that except for agricultural/farming activities, keeping livestock and casual/daily labour, the changes in the numbers of HHs who use these activities as a source of income were very slight over the past 10 years (since early 2000s). This indicates that people did not diversify their livelihood over this period and remained dependent mainly on their agricultural activities. Community members also reported an increase in the number of small shops in the village for the purpose of generating income and also as an alternative source of income for some community members.

Plate 2: Traditional water reservoir (Ndiva) in Bangalala village.
Source: Lukas Kwezi (2012).

HH income source	Count – present	%	Count – 10 years ago	%	Change (%)
Agriculture/farming	143	86.66	92	55.68	30.91
Business	5	3.03	5	3.03	0.00
Carpenter	3	1.82	2	1.21	0.61
Casual labourer/daily labour	29	17.54	17	10.31	2.43
Charcoal making	1	0.61	1	0.61	0.00
Chicken raiser	1	0.61	1	0.61	0.00
Construction	2	1.21	1	0.61	0.61
Firewood	6	3.64	4	2.42	1.21
Informal work	1	0.61	0	0.00	0.61
Livestock keeping/raising	92	55.75	61	36.96	18.79
Pension	3	1.82	0	0.00	1.82
Remittances	9	5.45	2	1.21	4.24
Selling fire-dried bricks	1	0.61	5	3.03	-2.42
Selling fruit and chicken	1	0.61	0	0.00	0.61
Small business	6	3.64	7	4.24	-0.61
Teacher	1	0.61	1	0.61	0.00
Trader	0		1	0.61	-0.61
Salaried job	0		1	0.61	-0.61

Table 9: Main economic activities at present and in the past 10 years (2000s). Source: Household survey (2012).

6.3 Livelihood problems

During the PRA sessions, focusing on analysis of livelihood risks, villagers were able to outline a number of problems constraining their livelihoods. Among the most important constraints cited was water: there is less water both for irrigation and HH use. *Ndiva* depends on cited was water: there is less water both for irrigation and HH use. *Ndiva* depends on rainfall, when there is no rain, *Ndiva* is not functioning; this was reported particularly in Bangalala. Other problems across villages included poor performance of schools, market problems, drought and poverty due to lack of capital. Other problems mentioned included lack of energy (electricity), animal diseases, inadequate availability of agricultural inputs, diseases – particularly cholera, malaria and eye diseases – and lack of entrepreneurial skills. In relation to severity assessment, drought was identified as the number one problem posing a great risk to their livelihoods.

In terms of ranking the severity of these problems, all four PRA groups in Bangalala ranked rainfall variability, particularly drought, as the number one problem. The discussions focused on the severity of the problems, coping strategies and suggestions for prevention. In FGDs with farmers it was reported that lack of enough rainfall has a negative impact on crop production, contributes to livestock deaths, water scarcity, poor income and migration. The coping strategies reported by farmers included migration, strengthening *Ndiva*, terrace farming and selling livestock. Prevention measures reported by farmers included stopping cultivation on river banks, stopping deforestation, practicing terrace farming, strengthening *Ndiva*, participatory conservation of forests, stopping forest fires and using selective cutting of trees for making charcoal.

Findings from FGDs with non-farmers further ranked drought as the key problem in terms of severity. The reasons associated with such ranking include the fact that drought results in poor crop production, livestock deaths, outbreak of diseases and migration (individuals, family and livestock). The non-farmer group further explained that during migration children have to stop school in cases where the families migrate to a place without schools. The highlighted coping strategies included casual labour (collecting stones), small-scale businesses (fish from *Nyumba ya Mungu* dam), making charcoal (men) and sale of livestock in Makanya and Hedaru. Preventability measures included planting trees, stopping cultivation on water sources, stopping deforestation, terrace cultivation and use of other environmentally friendly farming practices. Ellis provides a definition of coping: "coping strategies are invoked following a decline in normal sources of food and these are regarded as involuntary response to disaster and unanticipated failure in major sources of survival" (2000). As applied in this study, coping strategies encompass short-term, unplanned and deliberate risk aversion strategies in adjusting to food crises; whereas adaptation refers to long-term livelihood adjustments to food crises.

FGDs with women further indicated that drought was the key problem and again ranked as number one in terms of severity. The explanations provided included that drought implies not enough rainfall, which results in poor crop production, lack of enough food, death of individuals and livestock, and water sources drying up. Coping strategies reported included working as casual labourers (e.g., collecting stones), small-scale businesses, for example buying fish from *Nyumba ya Mungu* dam and selling them in local markets, making charcoal – particularly by men – and selling livestock in Makanya and Hedaru. Women reported that drought and its impacts could be prevented by planting trees, stopping cultivation on water sources, stopping deforestation and enabling terrace cultivation and environmental farming.

Drought also ranked high in terms of severity during FGDs with vulnerable groups and was likewise expressed during expert interviews and HH surveys. During FGDs, members provided various explanations for such ranking, such as crops drying out, poor crop production, strong winds, forest destruction and water sources drying up. The coping strategies reported were being dependent on government aid, women reliance on art work (e.g., selling rope from sisal), dependence on *Ndiva*, migration to Kabuku and Ruvu for agricultural work, and sale of *Mselee* (a local tree used as a vegetable) in Gonja. Preventive measures outlined included tree planting, terrace cultivation, conservation of water sources and planting drought-tolerant crops.

Climate variability causes short and long-term changes that result in water deficits manifesting as agricultural and hydrological droughts. In the PRA sessions, drought was identified as a major threat to HH livelihoods and food security across all three research villages, even if it manifests itself or is described somewhat differently in each community. Similarly, the HH survey data indicated drought as the major climatic factor affecting their livelihoods. Table 10 presents the responses with regard to HHs affected by natural hazards in the past five years. A majority (94 per cent) of HHs indicated having been affected by drought.

Findings obtained from Ruvu Mferejini village during FGDs revealed that famine was the key problem across all FGD groups. Farmers explained the problem in terms of failing rainfall, shifting seasons, dry spells, drought and floods. In coping with rainfall variability, particularly drought, villagers through FGDs reported using a number of coping strategies, including reducing the number of cattle in the dry season by selling them, making arrangements with farmers to graze animals on harvested farms, migrating to areas with better pastures and water, decrease cultivated hectares, abstract more water from the irrigation canals by deepening the smaller canals, use of improved seed variety (Stukamaize variety)/early maturing varieties, use of farrows on farms to increase efficiency in irrigation, and use of agricultural waste to cover the soil and conserve moisture. Among the coping strategies highlighted by vulnerable groups were working as paid labourers to obtain income for food, asking for food, aid from the government, buying less food and reducing the number of meals per day.

HHs affected by natural hazards	Count	Percentage (%) of total number of HHs (165)
Flood	40	24.2
Storm/wind/excessive rain	48	29.1
Drought	155	94
Landslide	8	4.8
Mudflow	3	1.8
Others	7	4.2
Never affected	8	4.8
NA	2	1.2

Table 10: Households affected by natural hazards. Source: Household survey (2012).

The findings imply that rainfall variability (increase in drought incidences, seasonal shifts and prolonged dry spells) was perceived to be the most significant livelihood threat across different groups of residents in Bangalala and Ruvu Mferejini. The coping strategies were diverse, but all touched upon migration as one of the key impacts of rainfall variability, particularly drought, and also reported this as a way of coping with such calamities. Responses with regard to rainfall variability and its impact on crop production and food security are presented in Tables 11 and 12, respectively.

Does rainfall variability affect food production?	Count	%
Yes, a lot	134	87.0
Yes, but only little	10	6.5
No, it does not affect us	6	3.9
NA	4	2.6
Total	154*	

* The 11 landless HHs are not included.

Table 11: The impact of rainfall variability on food production. Source: Household survey (2012).

How rainfall variability affects food security	Count
Decline in crop production	142
Increase in crop production	3
Decline in fodder production	11
Increase in fodder production	0
Decline in pasture plants	47
Increase in pasture plants	0
Water shortage for animals	27
More water for animals	0
Less fish production	0
More fish production	0
Others	1

Table 12: Different impacts of rainfall variability on food production. Source: Household survey (2012).

During expert interviews, it was further reported that the key foodstuff mostly bought from the market is maize, since farming maize is constrained by drought. It was accordingly explained that its price is determined by supply and demand, which are linked to climatic conditions in terms of how they have influenced agricultural production. Prices of products vary according to the seasons; for instance, during the rainy season, demand for maize is low and the supply of maize is less. As such, the price of maize can go up to 60,000 Tsh/100 kg. In May–August, just after harvest, the price goes down to 25,000 Tsh per bag. From August to December, the price goes up to 90,000 Tsh per bag due to the scarcity of maize.

With regard to livestock production, discussion with experts revealed how these prices could change. For instance, from February to July/early August is the best time for selling livestock; one cow could be sold for between Tsh 400,000 and 1 million Tsh. In terms of exchange, one cow could be exchanged for between 9 and 20 bags of maize. However, from September to November/December, the price of cattle goes down to 150,000 Tsh, while at the same time the price of maize has gone up to about 90,000 Tsh per bag. Under extreme climatic conditions, the terms of exchange become so poor that one cow can be exchanged for only one bag of maize. It was, however, explained that the price

Does rainfall variability affect HH economy?	Count	% total number of HHs (165)
Yes, a lot	136	82.4
Yes, but only little	15	9.1
No, it does not affect us	12	7.3
N/A	2	1.2
Total	165	

Table 13: The impact of rainfall variability on income. Source: Household survey (2012).

How does rainfall variability affect the HH income?	Count	% total number of HHs (165)
Decreasing income due to declining yields	135	82
Decreasing income due to declining animal production	45	27
Increasing food prices in the market	41	25
Substitute market products	7	4
Less sales of fish due to shallow rivers/canals	0	0
Others	1	0.6

Table 14: How rainfall variability affects income. Source: Household survey (2012).

changes also depend on the levels of the previous harvest and thus the rainfall patterns in the previous season. Furthermore, it was commented that most of the "livestock keepers do not sell cattle in good time (they normally sell them under harsh conditions – when the animals are in very poor conditions)". At the same time they cannot store maize for a long time due to storage problems related to pests. This implies that they have double the suffering under extreme drought conditions.

From the PRA sessions conducted in all three villages, community members reported that food production has decreased over the years despite the availability of water sources through Ndiva and the irrigation canals in Bangalala and Ruvu Mferejini. It was accordingly reported that failing rains largely contribute to declining agricultural production due to negatively affecting irrigation opportunities. Based on these conditions, access to food (buying from markets) was crucial in determining food security. As such, local markets in all three villages play an important role in regulating food security. Tables 13 and 14 indicate how rainfall variability has impacted on income. Table 13 shows that the majority of the HHs (82.4 per cent) sense a huge impact of rainfall variability on the HH economy, and Table 14 reflects that 82 per cent of the total sample HHs have particularly suffered from decreasing income due to declining yields.

6.4 Socio-economic group differentiation

Three major social-economic groupings were identified by the communities in Bangalala village, based on their own perceptions. The major criteria used included: (1) amount of livestock a person owns (cattle, goats or sheep); (2) the size of farmland a person owns and uses; (3) food security (amount of food and sustainability); (4) number and type of house(s) a person has; (5) number and types of assets a person has (car, milling machine, radio, ox plough, etc.); and (6) amount of money a person has at the time, involvement in business, etc. The outcome of wealth ranking is as indicated in Table 15.

During PRA sessions participants explained that there are inter-relationships between the groups highlighted in Table 15 in terms of assisting each other in livestock keeping, whereby the rich distribute their animals to the poor, who take care of them and obtain a litre of milk a day in return. This practice is locally known as *Mbidhio*. They also have a local arrangement for renting farms

	Rich (Vadhuri)	Middle (Venakeba)	Poor (Vakiva)
Proportion of population	5%	65%	30%
Group characteristics	Can have three meals a day; some have cars (for family use and business), a good house, milling machines, cattle 100 and above, farmland 4.05 ha and above and they can irrigate; good education (college and university); good income; and capable of paying school fees for their children.	Can afford two meals a day; they are not sure of their income, they sell labour to the rich; they have farms in areas with no irrigation potential, farmland 0.405 to 0.81 ha, cattle 1–5; house with iron roof but not finished.	Can only afford one meal a day (sometimes they are not sure of the meal); education (primary school level); low income. They are not sure of income-generating activities; they mainly sell labour to the rich (farm preparation activities, taking care of farms, cattle grazing). They do not have farms (mainly rent), they help the rich in keeping cattle/livestock (milk).

Table 15: Socio-economic groups in Bangalala village.
Source: PRA sessions (2012).

under specific agreements. Another interrelationship reported was of the poor selling labour to other groups, which is locally termed *Vandima.* This social network might explain the fact that the majority of the population in Bangalala belongs to the middle group, with the poor making up 30 per cent of the total population.

6.5 Temporal analysis of livelihood-related trends

FGDs during PRA sessions established various trends with regard to livelihood-related resources, activities and practices. Resources include forests/vegetation cover, water, livestock, agriculture, yields and migration. With regard to vegetation cover, a trend line analysis made during PRA sessions indicated that in the 1960s Bangalala had many forests/vegetation cover Over time, the vegetation cover started to decrease. The main reason for the change was highlighted to be drought, which has directly and negatively affected the growth pattern of some vegetation, leading to environmental degradation. The latter was also reported to be associated with an increase in population growth, and also due to increasing dependence on forest products for different livelihood activities. Population growth has consequently resulted in a lack of enough land for agricultural activities. This situation also led young generations to search for new land elsewhere or within the village and to be more involved in such activities as charcoal making, which results in deforestation.

It was further narrated that over the past 20 years (since the early 1990s), people took good care of the forests, and there were by-laws which governed resource use and a good interaction between upstream and downstream communities. No one was allowed to cut fresh trees, and if caught cutting fresh trees they would be punished severely. Currently, there is little enforcement of these by-laws. Forest degradation in the area is also accelerated by urbanization and the increasing demand for wood and charcoal as the main source of fuel. Moreover, in years of drought, people do shift from farming as the major source of income to engaging themselves in the charcoal business, which puts more pressure on forest resources.

A trend analysis was also conducted on water resources. Accordingly, it was established that the availability of water in the villages coincides with the availability of rain (confirmed by rainfall data). In other words, rainfall (not stored water resources) is the major source of water for all three study villages – Bangalala, Vudee and Ruvu Mferejini. It was explained that despite the presence of several water springs in the area, there was a water shortage when they experience drought due to the fact that these springs need to be recharged by rainfall.

One other interesting element that emerges from this trend analysis is the confirmation of the links between rain, the availability of water and its positive impact on livestock and food production.

The findings also show that seasonality affects the food security of local communities. Analysis of HH survey data regarding seasonality indicated that there are months of the year when HHs regularly do not have enough food from own production (see Table 16). The findings show that the percentage of HHs experiencing food shortages (up to six months) between September and February is higher than compared to HHs experiencing food shortages for the rest of the year. The same applies to the disaggregated HHs in terms of land ownership; for the four categories presented in Table 16, the percentage of HHs suffering from food shortages during September–February each year in relation to the total number of HHs corresponding to each category, is higher compared to the other six months of the year. This somehow corresponds with the months they indicated they do not have enough money to buy food, though the majority reported December and February as the months without income. The HHs accordingly reported that during this time they go to Simanjiro for farming, while others work as casual labourers.

Month	Absolute no. of landless HHs (% of total landless HHs – 11)	Absolute no. of small farm HHs (% of total small farm HHs – 41)	Absolute no. of medium farm HHs (% of total medium farm HHs – 81)	Absolute no. of large farm HHs (% of total large farm HHs – 32)	Total	Ratio to total no. of HHs (%)
January	7 (64)	18 (44)	37 (46)	16 (50)	78	47
February	5 (45)	14 (34)	29 (36)	13 (41)	61	37
March	5 (45)	13 (32)	19 (23)	13 (41)	50	30
April	4 (36)	14 (34)	10 (12)	7 (22)	35	21
May	1 (9)	6 (15)	13 (16)	6 (19)	26	16
June	1 (9)	7 (17)	13 (16)	6 (19)	27	16
July	2 (18)	5 (12)	22 (27)	8 (25)	37	22
August	5 (45)	8 (20)	35 (43)	11 (34)	59	36
September	4 (36)	11 (27)	41 (51)	15 (47)	71	43
October	4 (36)	14 (34)	46 (57)	16 (50)	80	48
November	4 (36)	13 (32)	38 (47)	19 (59)	74	45
December	5 (45)	17 (41)	38 (47)	19 (59)	79	48

Table 16: Months of food shortage from own production. Source: Household survey (2012).

Plate 3: Seasonality of rainfall availability, food production and migration in Ruvu Mferejini. Source: PRA sessions (2012).

The assessment of seasonal calendars provided an understanding of food seasonality and availability as well as changes that have occurred. Discussions with community members during PRA sessions indicated that the seasons were more predictable in the past; it was easy to be precise about the date of onset of the seasons. Again, there are two major seasons, *Masika* and *Vuli,* and currently across Bangalala, Vudee and Ruvu Mferejini, *Masika* starts around mid-March until mid-May, with more of the rain falling in March and April and less in May. *Vuli* starts in November to December in Bangalala; and September to December in Vudee and Ruvu Mferejini. Farmers reported during FGDs that in the past each rainy season provided enough rain to support crops grown during that season.

With regard to food availability, the analysis from PRA sessions shows that food production is available immediately after the season, but was available for a longer period in the past than at present. In Bangalala, for instance, food was available from June to September (after *Masika*), and from February to April. In Vudee, the food availability season is from January to June and people there depend primarily on *Vuli* rain for agricultural production. In Ruvu Mferejini, food used to be available throughout the year (see Plate 4) thanks to the abundant availability of irrigation water, but recently, food is becoming less available due to a significant reduction of water in the irrigation canals. Nevertheless, people reported that the food produced in Ruvu Mferejini (as a result of irrigation) is mainly sold outside the villages to agribusinesses, resulting in recurrent food shortages in the village. Many people involved in irrigated agriculture are seasonal migrant farmers from outside who deliberately produce for business purposes outside the village.

6.6 Coping strategies in extreme climatic events

6.6.1 Short-term strategies

The PRA findings established that communities in the study area have diverse ways of coping with extreme events related to climate change and variability. This is due to the fact that climatic changes have affected their key crops and livestock activities as explained in the previous sections. Drought, inadequate rain and too much rain all lead to reduced crop yields. Cattle were particularly susceptible to drought and inadequate rain, due to a shortage of pasture and water. Discussion on coping strategies based on the wealth groups identified in Ruvu Mferejini and Bangalala established that coping strategies of the wealthy included: buying food; storing food for future use; advanced planning; and alternative arrangements such as migrating with livestock to new pastures. The coping strategies of the middle and poor groups included: livelihood diversification, such as casual labour for payment in food or cash, selling firewood sales, making charcoal, water collection and sale, brick-making, petty trade (e.g., selling soap, and food vending), collecting and selling wild vegetables, and having to send their children for labouring opportunities; changing their food intake, for example eating more wild edible products or reducing the number of meals or food types they consume; selling small livestock assets; begging from others in the community and government food aid; borrowing food from wealthier HHs; and some men abandon their families. Similar observations were obtained from the HH survey as presented in Table 17.

Some of the agricultural-based coping strategies within the villages include use of early maturing varieties of their key crops in response to the now shortened rainfall period. Other coping strategies include migrating to other places with potential for both farming activities and livestock keeping. Most farmers reported migrating to Ruvu (for irrigation) and also to distant places such as Kabuku. In Ruvu people are mainly involved in vegetable gardening activities for extra income to improve their livelihoods. It was explained that the pastoralists normally migrate to Gonja and Morogoro where pasture is available; they normally migrate during the dry season. Apparently, youths mainly migrate to urban centres for casual labour and small-scale businesses, rather than opting for agricultural-based coping strategies.

Strategies	General Results % of HHs used each of the strategies	Detailed Results % of HHs (total no. of HHs = 165)						
	At least 4 days out of 7 % > 4 days	All the time 7 days	Pretty often 4-6 days	Once in a while 2-3 days	Hardly 1 day	Never 0 day	NA	No response
Less expensive food	38	42	20	41	5	54	1	2
Borrow food	39	37	27	43	19	38	1	
Limit portion size	45	51	23	36	7	44	3	1
Restrict consumption	20	18	15	36	16	78	1	1
Reduce number of meals	36	37	23	40	14	50	1	
Reduce number of people eating at home	7	8	3	8	10	133	1	2

Table 17: Coping strategies for the past week.
Source: Household survey (2012).

Most of the coping strategies identified were for the short-term and have been seen elsewhere in response to changes in rainfall that affect food security status and livelihood strategies. These short-term strategies can sometimes be damaging and not sufficient in the long-term. Some women in Bangalala, during the PRA session on the impact of drought, illustrated well the vicious circle of the consequences of rainfall diminution and the damage that some coping strategies can cause, as presented in Figure 12.

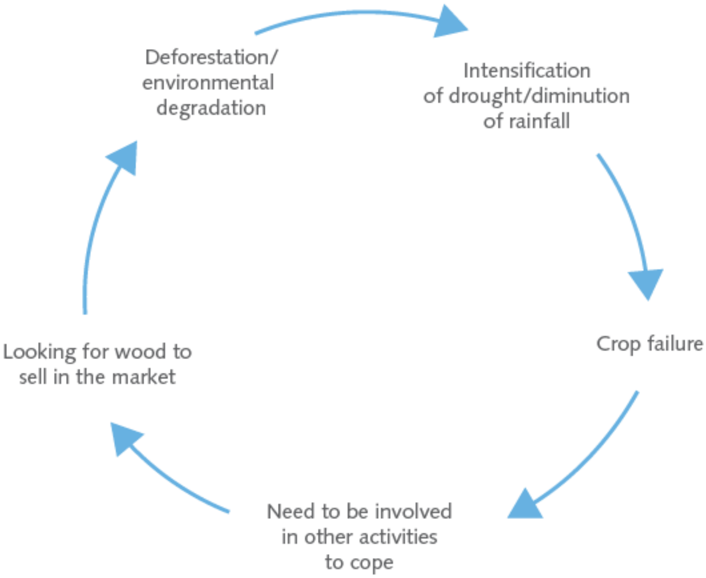


Figure 12: Vicious circle of rainfall diminution and damage caused by some coping strategies. Source: PRA sessions (2012).

This shows the communities' awareness of the clear links between environmental degradation and the likely future impact on rainfall.

6.6.2 Long-term strategies

In addition to these short-term – and sometimes damaging – coping strategies, the communities of the three research villages also reported either already beginning to employ longer-term adaptation strategies or wanting help to do so. At least three broad categories of longer-term adaptation strategies can be seen:

1. Improved integrated natural water resources management, which includes better protection of water sources, enforcement of bans on logging, agriculture and mining in such areas, tree-planting, expansion of traditional irrigation systems, improved water management in modern irrigation schemes to reduce the problem of salinization (in Ruvu Mferejini), and development of new water resources, including boreholes fitted with windmills.

2. Introduction of more productive and sustainable agricultural systems and practices: improved livestock varieties to increase milk production per animal, switching to more drought tolerant crops such as *lablab*, *sorghum*, or *cassava*, adoption of shorter-term crops or varieties, especially of the staple crop maize, more use of terracing in hillside agriculture, and more inter-cropping; and agro-forestry.

3. Increased diversification of livelihoods: more diverse agricultural production to include livestock, tree crops, vegetables and legumes (to encourage nitrogen, which intensifies soil fertility and consequently improves crop productivity); more small business/trading and other non-agricultural activities; and promotion of increased savings and access to loans through the village savings and loan

associations (VSLA)[7] promoted by CARE and referred to locally as *Tujikomboe*. Finally, for some families it was clear that permanent out-migration and subsequent remittances have been an important part of diversifying their livelihood strategies and reducing the risk inherent in largely rain-fed agriculture. This strategy appeared to be most successful for those families where one or more children were able to attain a high enough level of education to obtain regular, stable employment, usually in urban areas.

6.7 Future adaptation and coping strategies

FGDs on future strategies were based on understanding how younger people in the community see their own future, what options they see for themselves in their home community, their attitudes towards migration, and whether they want to migrate (where to), or not; and how they would act in times of further agro-ecological change, or a severe livelihood crisis. The discussions were guided by the major themes of rainfall variability and coping strategies, the status and trend of food security and migration issues.

6.7.1 Rainfall variability and future coping strategies

The youths reported that agriculture appeared to be important to the livelihoods of people in these communities and most non-farm strategies were directly linked to agriculture. As such, rainfall variability has a great influence on agricultural activities and impacts on crop production. The following is the communities' projection of the future climate:

Temperature will continue to increase and thus affect crop growth and yields. Rainfall is likely to be uncertain and decrease in amount thus affecting crop growth and yields. Livestock numbers will become very small due to lack of pasture and water, and farmland will become small due to population increase and very high risk from natural disasters.

In terms of environment, it was reported that the area will become drier and the impact of drought will be enhanced due to deforestation that is ongoing in the villages. Accordingly, they explained that agriculture will no longer be the major economic activity, but studying and being employed will serve their needs. All these trends will accelerate permanent migration so there will be no one left in the village. They further explained that if fewer people become involved in agricultural activities the environment will be conserved and there will be less pressure on the environment.

6.7.2 Future adaptation and coping strategies

According to the FGDs with youths in Bangalala, the future adaptation and coping strategies were categorized into three key areas: agriculture, livestock and non-farm adaptation strategies. Table 18 is a summary of adaptation and coping strategies based on the FGDs. During FGDs, it was found that the youths do not plan to stay in the village and do the same kind of activities that their parents have been doing. The main reason for this is that agriculture is becoming more uncertain and is more of a subsistence activity. For them, staying in the village implied remaining in the poverty circle for the rest of their lives. Doing something else outside the village will help them in having a better life. In future they are planning to undertake some activities also highlighted in Table 18.

7 VSLA is a microfinance methodology that aims to improve poor rural people's access to financial services whereby group members collectively save money and make small loans to each other. VSLA is a highly successful and proven methodology nurtured by CARE and spread to over approximately 300,000 participants throughout Tanzania. This savings-led microfinance methodology provides dynamic investment and credit opportunities for villagers, especially women, who would otherwise be far removed from access to financial services. It also provides a strong community-based organization which CARE is using as a springboard for other development initiatives.

Agricultural strategies	Livestock strategies	Non-farm strategies	Future strategies
Use of drought tolerant crops and varieties. Adapt agronomic practices – e.g. early preparation and faster planting to maximize use of the now shortened rainy season; water saving methods. Crop diversification; both agricultural intensification and diversification were mentioned; better crop storage methods; irrigated agriculture; and improved access to credit and inputs.	Reduced number of animals in order to prevent further environmental degradation. Improved livestock varieties to increase milk production.	Access to credit, through creating savings habits and groups. Petty trade, e.g. small shops selling soap, etc., food vending. Educating one's children as a longer- term strategy. Brewing, crafts, bee-keeping.	Starting crop business in the village by taking crops from other regions such as Tanga and Morogoro and selling them in the village. Getting an education in entrepreneurship skills. Inform people of the opportunities that exist outside the village. Help in development activities in the village (building schools, etc.).

Table 18: Future adaptation and coping strategies.
Source: PRA sessions (2012).

6.7.3 Future migration plans and trends

From discussions with youths it appears that uncertain rainfall and high land pressure suggest that non-farm activities will be key elements of livelihood strategies for many in these communities in the future. Assets that could be exchanged for food, food stocks and the ability and mobility to seek casual labour opportunities elsewhere were identified as key resilience factors. Though a number of livelihood improvement strategies were mentioned during discussions with youths, the preference was to migrate outside the village for various reasons, such as marriage, lack of business opportunities within their villages, hardship due to drought, and lack of employment opportunities.

Future destinations identified for migration included Dar es Salaam (for employment opportunities), Mwanza (some have relatives there), Morogoro (for business and farming opportunities) and Arusha-Kiteto (good agricultural conditions and pasture availability). For married couples, migration of the whole family is an option. The single people said they could just live alone, leaving parents and relatives in the village. Whether to migrate permanently or seasonally depends on the nature of the business they want to do in the future. If the business is to sell grain in the village, migration will be seasonal. But if the reason for migration is to search for employment, then permanent migration will be an option. The details on migration are discussed in Section 7.

6.8 Summary of key findings

The findings under this section establish that climate variability causes short- and long-term changes that result in water deficits manifesting as agricultural and hydrological droughts. In the PRA sessions, drought was identified as a major threat to livelihoods and food security across all three research villages, even if it manifests itself or is described somewhat differently in each community. From the HH survey, the natural hazards that featured most include drought, storm and excessive rain.

The majority have indicated that rainfall variability greatly affects crop production and subsequently affects food security. This is also in accordance with the results obtained from PRA sessions and expert interviews. The findings further show that climate variability affects food security in a number of ways, for example decline in food production, decline in pasture plans and water shortage for animals. The impact diagrams conducted during the PRA sessions also demonstrated such links. It was also established that climate variability greatly affects the income of local communities through declining crop yields, poor animal production and increases in food prices at the markets. Along with rainfall variability, communities reported experiencing seasonal food shortages, which may continue up to six months, particularly from September to February. This implies that the *Masika* and *Vuli* rains do not support adequate food production. During expert interviews it was further mentioned that this period corresponds with the time when they do not have enough income. Under such conditions, some members of HHs are forced to migrate to other areas in both rural and urban locations in search of income-generating activities.

From FGDs with youths, the future adaptation strategies imply increased livelihood diversification. The shift to non-farm activities is associated with increasing rainfall variability and the associated uncertainties in agricultural production. They further indicated that they may be forced to migrate out of their villages to cities in future due to increasing population pressure and land shortages. So, under such circumstances, coupled with increasing climate variability, rural-urban migration is likely to increase.

Section 7: Migration and human mobility patterns

7.1 Type of migration in the study area

The findings from PRA sessions indicated that, in the past, migration happened but was not common and was mainly preceded by droughts. It was further reported that there has been an increase in migration to other places as a way of coping with adverse weather conditions, particularly drought.

In the livelihood risk ranking sessions, drought ranked high because of a lack of rainfall, which results in lack of enough food, water, pasture for livestock and water becomes scarce. Drought also leads to poor income and forces people to migrate to other places in search of food. It was accordingly explained that people do migrate in search of food, and livestock keepers have to migrate in search of pasture and water. In deciding when and where to migrate, people look at the climatic conditions. People migrate permanently or seasonally. If long rains fail, they migrate mainly in May to August or September, because by then whatever has been planted could be harvested and food or money brought home after selling crops.

The migration patterns of communities across the study villages are presented in Table 19. Most of the migration patterns appeared to be seasonal (less than six months) rather than temporal; and most migrations were internal with return migration.

Type of migration (based on first trip)	Ruvu Mferejini	Bangalala	Vudee	Total
Seasonal (≤ 6 months)	53	37	11	101
Temporal (> 6 months)	27	36	25	88
Migration status				
Current internal	35	38	23	96
Returned internal	46	47	13	106
Returned international	3	0	0	3
Gender of migrants				
Male	62	53	23	138
Female	22	32	13	67

Table 19: Types of migration[9] and status.
Source: Household survey (2012).

9 *Seasonal migration* can be defined as yearly recurring migration over periods less than six months a year. *Temporal migration* can be defined as a move from the HH of origin during at least six months a year to a place within the country or abroad with the purpose of working, studying or family reunification, over a distance that forces the concerned person to settle at the destination to spend the nights. Return migration is defined as the return of a once migrated HH member over a sustained period of more than a year. As a consequence of administrating the HH questionnaire (see notes 2. P13), migrants who are no longer contributing to the income of the HH (and so not members of the HH anymore) are excluded from the results.

Land category	Frequency in total numbers	Average no. of migrants per HH	Economic migrants	Educational migrants
Landless	13	1.18	7	4
Small farmer	27	0.65	13	5
Medium farmer	86	1.06	36	19
Large farmer	79	2.46	25	12
Total	205		81	40

Table 20: Types of migrants. Source: Household survey (2012).

Most people migrate to the same areas year after year as long as there is still potential for generating income in the different activities available in the area. Some of the mobility in the study area is associated with rainfall. In Ruvu Mferejini, for instance, during the flooding period, the community moves to the uplands and leaves their lowland area temporarily. From the FGDs during PRA sessions it was reported that most pastoralists shift to Lugoba in the coastal region, and farmers shift to Kabuku in the Tanga region. For example, in 2006/07, villagers in Bangalala experienced a very severe drought and most people migrated to different places. During this period, men established homes where they had migrated to, and then came back to pick up their families. During discussions, it was found that youths do not like agricultural activities; they are normally involved in small-scale businesses, collecting stones and brick-making. Women who are heads of HHs remain at home to take care of the family and do casual work.

From the HH survey, it was found that there are different migration patterns, which can be categorized as economic migrants and educational migrants (see Table 20). The number of economic migrants is twice as large as the number of educational migrants. Since the study mainly covers farmers, cattle herders and pastoralists, it is very likely that climatic factors, including rainfall variability, are a root cause of the migration in this category. It was further reported that mobility patterns are also made easy by communication through businessmen who bring commodities into the markets in the respective villages. When categorizing the migrants into landless, small, medium and large farmers (see Table 20), we find that the average number of migrants per HH is highest among the large farmers, followed by the landless, then the medium and small farmers. The reason behind this finding might be that large farmers possess the most means by which to leave, and their migration might not always be related to food insecurity. However, the landless who do not have sufficient means to migrate might still do so, even if their resources would be loans from others, as in their case migration might be a survival strategy.

	Ruvu Mferejini	Bangalala	Vudee	Total
Average farm landholding (hectares)	2.11	1.26	1.03	1.53
HHs with migrants (count)	37(/63)	31 (/59)	21(/43)	89 (/165)
HHs with migrants (%)	59%	53%	49%	54%
Total migrants	84	84	36	204
Economic migrants (count, first trip)	23	34	14	71
Economic migrants (%, first trip)	27%	40%	39%	35%

Table 21: Total migration across study villages.
Source: Household survey (2012).

	Ruvu Mferejini	Bangalala	Vudee	Total
Gender of migrants				
Male	62	53	23	138 (67%)
Female	22	32	13	67 (33%)
Average age of migrants (first trip)	24.25	26.76	22.42	24.95
Education level of migrants (current)	3.67	6.49	8.58	5.7
Marital status of migrants (current status)				
Single	31	41	20	92
Married	47	36	13	96
Widowed	3	5	2	10
Divorced	0	3	1	4
Separated	3	0	0	3

Table 22: Characteristics of migrants.
Source: Household survey (2012).

A further analysis of migration patterns across villages indicated that across the villages 54 per cent of HHs have experienced migration, but HHs in Ruvu Mferejini and Bangalala are more prone to migrate than HHs in Vudee (see Table 21). Bangalala village was leading in terms of counts for economic migration in the first trip, implying the extent of hardships and limited coping options in this village. The characteristics of the migrants are further presented in Table 22, where it becomes very clear that men dominate; the number of female migrants is half the number of male migrants and one-third of the total migrants.

From the PRA sessions it was observed that decisions to migrate depended on the availability of enough rainfall for crop production and/or water for livestock and irrigation in the migration destinations. It was further noted that farmers go to the same places every year. Pastoralists also go to the same places, but this depends on where the rain will start falling. Analysis of HH survey data shows that migration was associated with a number of factors, as presented in Table 23. Among the very important reasons for migration are an increase in drought frequency (ranked first with a score of 100), longer drought periods (ranked second with a score of 89) and water shortage (ranked third with a score of 81). Pull factors such as better work or living conditions in the city or joining friends are not ranked as important for the majority of people.

Migration also ranked high among the key coping strategies reported across discussion groups. Accordingly, they normally migrate to where there is water, take animals to relatives where the environmental conditions are better, and fetch them later when conditions have improved. Although this was among the key coping strategies by farmers, they were not happy with the option, since the family left behind suffers and migrating with animals is very tough (walk long distances, insecurity, diseases). It was further explained that this disturbs the normal life they are used to. Ways of prevention included increasing water efficiency and improving water governance in the canal, and improving environmental governance.

7.2 Migration patterns

Analysis of seasonal calendars highlighted the link between food insecurity and migration patterns. The PRA findings indicate that, in general, none of the communities in Bangalala and Vudee talked about migrating to distant places in the past, which implies that even people with livestock were not migrating to distant places. It was learned that in the past two to three decades migration has become much more prominent. Villagers linked migration patterns with unpredictable seasons, which according to them was explained by the fact that rainfall has become erratic, with *Vuli* rainfall in particular becoming more unreliable and greatly affecting crop production during that season. They further reported that *Masika* rainfall has also become unpredictable, and it is not possible to tell when it starts or ends. *Masika* rainfall may start later or earlier but last for a shorter period of time and become more intense.

From the PRA sessions in Bangalala, it was learned that if *Masika* rainfall fails, pastoralists migrate to other places; this normally happens from May or June and they come back when it rains again. Otherwise, the normal pastoralists' movements usually occur during the dry season, that is, from August to October. It was further reported that farmers usually go to Kiteto, Ruvu, Kabuku, Moshi and other places if the onset of *Vuli* rainfall is delayed, in order to cultivate crops for that particular season – mostly maize – and come back after harvesting.

In Ruvu Mferejini, it was explained that from September to December livestock keepers migrate to places where water and pasture is available. Some farmers from Ruvu go to Simanjiro to cultivate onions and maize; this is common from February to August. There is also in-migration in the village, with people moving in for irrigation opportunities. People who cultivate in Ruvu come from many different places, and they cultivate cash crops and maize to sell in other places. Some of the maize is stored and taken to other bigger markets in the drier seasons.

Factors that affect HH's migration decision	Very Important	Important	Not Important	No Response	Score*
Increase in drought frequency	44	12	31	1	100
Longer drought periods	39	11	35	3	89
Water shortage	33	15	38	2	81
Insufficient health care services in the village	33	9	43	3	75
Floods	31	13	40	3	75
No land available for farming	33	8	43	4	74
No school for my children available in the village	31	8	45	4	70
No land available for grazing	29	5	48	3	63
Not enough income	24	13	49	2	61
Unreliable harvest	23	14	48	3	60
Decline in animal production for HH consumption	24	11	48	5	59
Poor soil quality and soil degradation	23	11	50	4	57
Decline in crop production for HH consumption	22	13	50	3	57
Shifted seasonal rainfall	20	14	49	5	54
Unemployment	17	14	53	4	48
Not satisfied with my livelihood	17	14	52	5	48
No relatives and friends in the village	20	6	58	4	46
Better job opportunities in the city	18	8	58	4	44
Less crop production for sale	19	5	60	4	43
Conflict over natural resources	18	5	61	4	41
Heavy rainfall events	16	9	59	4	41

Factors that affect HH's migration decision	Very Important	Important	Not Important	No Response	Score*
Work related to my skills is not available	12	16	56	4	40
Poor water quality	15	10	59	4	40
Less animal production for sale	14	9	61	4	37
The quality of life in the city is better	13	9	62	4	35
Storms	9	11	61	5	29
Less financial resources to buy food/staples	9	11	63	5	29
Family reasons (e.g., death of parent)	12	4	69	3	28
"Bright lights" of the city/the city attracts me	10	8	66	4	28
Insect plagues	8	9	67	4	25
Mudflow	10	3	53	18	23
Increasing food prices in the market	7	8	68	5	22
Earthquake	8	4	55	17	20
My friends already live in the city	5	3	76	4	13
I want to build my own life in the city	1	3	79	5	5
Decline in fish production to sell due to shallow rivers/canals	1	2	79	6	4
I want to become independent from my family	1	1	79	7	3
Overfishing	1	1	80	6	3
Decline in fish production to eat due to shallow rivers/canals	1	1	79	6	3
No permission available for fishing?					0

** The score was calculated such that the outcome is 2x Number of 'Very important' response + Number of 'Important' response.*

Table 23: Factors affecting household migration.
Source: Household survey (2012).

The implications of drought were described by the communities' residents as follows: low water levels in the river and irrigation canals; complete crop failure in rain-fed areas; increased incidence of crop diseases; loss of pasture, resulting in livestock disease and death; increased conflict (sometimes fatal) between farmers and herders; movement of livestock to areas with available pasture; movement of farmers to areas with more fertile soil and sufficient rain; general hunger and malnutrition of school children; declining human health and increase in "eruptive diseases"; loss of income (declining livestock prices, crop losses, loss of agricultural input); and declining levels of economic activity (less money for agricultural input, less energy due to poor health, sale of productive assets, etc.). Analysis of HH survey data produced similar observations (see Table 24). The counts indicate that the impact of natural events is experienced most on crop destruction (90 per cent of people), damage to HH property and death of livestock.

Impact of natural events on livelihoods	Count	% of total no. of HHs (165)
House or other property damaged	39	24
Crops affected/destroyed	148	90
Death of livestock	36	22
Loss of livelihood	8	5
Others	8	5
NA	5	3

Table 24: Impact of natural events on livelihoods.
Source: Household survey (2012).

7.3 Migration history

The trend analysis of human mobility indicated that, in the past, migration happened but was not frequent except for Bangalala, where human mobility was recorded to be highest in the 1960s and 1970s. High mobility during these years was associated with strong negative impacts and severity of the droughts on key livelihood activities. As a result of severe drought conditions, government directives were made for people to move closer to water sources in years of drought. Many people migrated to Ruvu Mferejini, where the Naururu irrigation canal was inaugurated in 1975. The PRA findings further show that migration occurred least in the 1980s and 1990s, and this involved more movement of animals than people. In another severe drought before El Niño, people moved their animals to other places with pasture and water.

The PRA sessions further revealed that there was less movement of people from Bangalala in the 2000s, not because factors that trigger migration were not there, but because people were tired of moving. From the PRAs and also expert interviews it was learned that people from Bangalala sell animals to buy food as their major means of coping in times of food shortage. Ruvu Mferejini had more mobility in the last 15 years because, according to the community members, there has been frequent failure of *Vuli* rainfall and so pastures are supported only by *Masika* rainfall which has become more intense but of shorter duration. It was further explained that there has also been an influx of people into Ruvu Mferejini, which has led to more conflicts over water between farmers and pastoralists and the problem of water management.

In the following case studies, some experiences of farmers in the Bangalala village are shared.

Mrimaoko Ally, a 53-year-old farmer who has been farming for the past 32 years, senses the increase in temperature and the

irregularity of rainfall. The impact of the 2000 drought was severe; there was absolutely no cultivation and his family had to reduce its consumption drastically, to the extent that he and his wife had only one meal and their children only two meals a day.

Mrimaoko Ally:
"Because of the droughts, we cannot sleep anymore. How can I sleep, if I do not know what food will be on my table tomorrow?"

The drought did not only affect water availability but also the soil; before the drought, Mrimaoko's farm had permanent crops, such as banana and sugar cane that no longer exist, as they are unrecoverable. The soil itself lost its fertility, especially as the strong wind blows away the good substance from it. Due to water scarcity, Mrimaoko had to migrate to Kabuku in 1999 in search of food and stayed there for one year. He had to leave his wife and children for the whole year, leaving them to take care of his land.

Yusto Rashidi is 55 years old and has been working in farming since 1980. His main crops are maize, lablab and beans. He mainly relies on rain-fed agriculture. Throughout the years since he started farming, he sensed a gradual decrease in rainfall, which causes crop failure and has huge negative impacts on his and his family's food consumption. In order to overcome this problem, he sometimes has to sell his livestock, which has its negative implications on sustaining his livelihood.

Yusto Rashidi:
"When the rain falls, it prevents us from migrating."

At other times, Yusto works as a carpenter and sells furniture. Therefore, he did not need to migrate in search of better livelihood opportunities. He mentions that once water is available, people do not have a reason to leave, as water is their life and has always been so.

Joyce Jastini, a young female farmer, shared her experience with the research team as well. She mainly plants maize and cotton and confirms that climate has become dry and the rain has become patchy throughout the past two to three decades. She also has experience with migration, as due to the severe drought that hit the country in 1984, her parents migrated to Morogoro when she was a child and took her with them. However, she came back to Bangalala in 1991 after finishing her primary education to look after her grandparents. Moreover, her parents still own a piece of land in Bangalala, which they had asked the grandparents to take care of.

Joyce Jastini:
"When my husband is away, I cannot afford taking care of his land; I only take care of my land, my children and grandparents."

Currently, Joyce plants the land on her own, as her husband migrated to Gonja in 2010 and has been commuting since then.

Rebekka Daniel, a 52-year-old female farmer who specialized in farming since 1986, mentions that there were droughts and rain shortages in 1992, 1994 and 2012. Therefore, her brother migrated to Moshi in 1992 in search of a job, after his income in Bangalala decreased and he could no longer secure a job due to the drought of that year. He took his family with him and is now better off and was able to buy his own house. Rebekka herself has not migrated, but she has visited her brother in Moshi for two weeks, where she asked him to lend her a piece of land so that she can survive and feed her children and mother. However, as part of a government programme, Rebekka received 0.20 hectares after her father passed away. She relies on this piece of land to finance the living expenses for herself, her children and her mother. Her children help with the work, but only when they do not go to school.

Rebekka Daniel: *"Since my husband left long time ago, I take care of my land on my own. As a woman, I am sometimes discriminated and receive unfair prices for my crops. If I had a man beside me, this would have made my life easier."*

Due to the unpredictability of the rainfall, Rebekka has developed coping strategies. She says: *"When the harvest is good, I sell the crop to pay the school fees for my children, and when it is bad, I store the crop for consumption and work for others in their farms."*

7.4 Impact of migration on food security and livelihood

The findings from PRA sessions revealed that migration is associated with various negative and positive implications in the livelihoods of people in the study area, including manpower, food security, income and general livelihood security as explained below.

7.4.1 Seasonal migration and labour availability

From the PRA sessions, it was explained that the major impact of seasonal migration is unavailability of manpower needed in the village for communal work, for example collecting stones for construction in community projects such as schools and hospitals, or cleaning irrigation canals.

7.4.2 Food security and income

It was also reported that migration does not guarantee good income or food security. Everything depends on the harvests and money the migrants are able to secure at particular destinations. For farmers, migration was considered as a way of helping to improve food security but no significant changes are observed in income. For pastoralists, there is insignificant contribution of migration to both food security and income because it is expensive to maintain a scattered family and cattle in transit and at destinations. Shifting to different areas has caused disease infestation in cattle and a lot of money is spent on taking care of the herd instead of sending remittances home. For pastoralists, it is rather a way for cattle to survive than a food security measure. In Ruvu Mferejini, FGDs indicated that pastoralists tend to migrate seasonally from their villages. When they are away, they hire their farms out to people who stay behind or to newcomers in the area; sometimes they hand over their farms to the village leaders to look after their land until they come back. Farmers leave their farms to their families, hire their farms out to newcomers or leave them under fallow for soil nutrient improvement. When farms in the village are hired to newcomers, most of the food produced is sold outside the village, thereby causing food insecurity in that particular village.

7.4.3 Impact of migration on livelihoods

The PRA session established that when migrating to different places, the migrants encounter a number of problems on the way or at their destinations. Some of the issues encountered include harsh working conditions (work environment involves long working hours and little food, especially on the sisal plantations), low wages that do not match the work input (30,000 Tsh/month when working on sisal plantations), death of livestock as it is easy for them to be infected by disease on their way to their destination, loss of livestock (theft and fines if cattle graze in restricted areas), and encountering human diseases such as malaria and amoeba.

7.5 Gender and migration

During PRA sessions, discussions were also held regarding the gender implications of migration. The findings indicate that men are the ones who usually migrate and leave women and children behind (confirmed by HH data – see Table 22). The women are left alone with the families and assume full responsibility for the family with additional farm work that is usually done by the men. The findings from the PRA sessions in Bangalala indicated that people who mainly migrate are men. Women stay at home to take care of the family while their husbands are away. Women are mainly involved in casual labour, small-scale businesses and artwork. Youths are mainly involved in brick making.

Village	Places people migrate to	Distance	Type of migration	Activities in destinations	Relative cost involved (Tsh)
Bangalala	Moshi	150 km	Seasonal	Agriculture, casual labourers	100,000
	Morogoro	400 km	Temporal	Casual labour, employment, agriculture and livestock keeping	500,000
	Makanya	<50 km	Seasonal	Casual labour in Gypsum mining and sisal plantations	30,000
	Ruvu Mferejini	<50 km	Seasonal	Irrigation farming	300,000
	Kabuku	<50 km	Both permanent and seasonal	Agriculture	400,000-500,000
	Lugoba	500 km	Temporal	Livestock keeping	100,000 400,000-
	Same	300/500 km	Seasonal	Small business, casual labour	500,000
	Kiteto	400 km	Seasonal	Agricultural activities	150,000
	Gonja Kihurio	500 km	Seasonal	Rice farming	
	Dar es Salaam		Temporal	Housekeeping, casual labour	200,000
	Kenya	300/500 km	Seasonal	Business (Fiwi)	200,000
Ruvu Mferejini	Morogoro	50/100 km	Temporal	Agriculture, casual labour, livestock keeping	200,000
	Simanjiro	150 km	Temporal	Agriculture, livestock keeping, small business, brick making	200,000
	Dar es Salaam	400 km	Temporal	Employment (in transport, HH sector and as guards) Livestock keeping	200,000

Village	Places people migrate to	Distance	Type of migration	Activities in destinations	Relative cost involved (Tsh)
	Ziwa Jipe		Seasonal	Livestock keeping	200,000
	Tanga		Temporal and seasonal	Agriculture and livestock keeping	200,000
	Kabuku		Temporal	Agriculture and livestock keeping	200,000
	Kisiwani/Mkomazi		Seasonal	Livestock keeping	100,000
	Kenya	300/500 km	Temporal	Livestock keeping and small business	400,000
Vudee	Ruvu Mferejini	50/100 km	Seasonal	Irrigation farming	150,000
	Kabuku		Seasonal	Agriculture	200,000
	Moshi (Uchira)	150 km	Seasonal	Agricultural activities and casual labour	200,000
	Morogoro	400 km	Temporal	Livestock keeping, agriculture, employment and casual labour	300,000
	Ishinde		Seasonal	Agriculture and livestock keeping	50,000

Table 25: Nature of migration, activities at destinations and related costs. Source: PRA sessions (2012).

The expected role of women is to ensure there is food for the family and to look after young children. Hence not being able to travel to source working opportunities was identified as making women and children particularly vulnerable during bad years, that is, during years of extreme droughts and floods that result in the disruption of livelihood systems.

Regarding the impact of migration by gender, there was a long discussion about which group is mostly affected or vulnerable. During the discussion, women said that when men migrate they have to do everything alone; they are left with the children and have to make sure that they have enough food and work on their land. Men disagreed with the fact that the most impacted group are women and explained that men are equally impacted because their living conditions while they are away are harsh and stressful, contrary to women's who have good social networks and help each other during bad years, while the men do not have such support when they are away. When food is estimated for two months, and it lasts for one month, men have to go and search for food again.

These impacts are felt in specific seasons. When rain starts, there is no migration. There is a local saying: "Mkindathama Adha", which means "the one who stops migration has come". Women in Ruvu Mferejini reported to be mostly affected because they carry out men's duties during the migration season. As such, women in the community felt insecure since there is usually not enough food for the family, and families (women and children) are more vulnerable because they have very few resources to run their day-to-day lives (e.g., money for health care, school supplies and other needs). In Ruvu Mferejini, Maasai women appeared to be even more impacted by migration triggered by floods because, when they leave for higher land, the construction of new houses is their responsibility on top of other HH chores.

7.6 Mobility maps

From the PRA sessions, it was noted that the destination of migrants was determined by a number of factors, such as existing support networks. This could be e.g. relatives and friends who inform others of the prevailing environmental factors (rainfall availability, irrigation opportunities, pastures, fertile land). Mobility maps were explored to determine the movement pattern of an individual, a group and the community in the three study villages. The focus was where people go and for what reason. Other aspects of movement, such as the frequency of visits, distances and the importance of places visited were also explored. The results from this exercise are summarized in Table 25, which reflects people's perception of movement patterns and the reasons for them as well as cost implications.

The findings from the PRA sessions in terms of the destination of migrants go to some extent in line with what has been found from the HH survey. Based on the latter, the reported migrants' destinations included Dar es Salaam (32 per cent), Arusha (16 per cent), Rombo (13 per cent), Hedaru (11 per cent), Tanga (10 per cent), Moshi (10 per cent), Ruvu Muungano (10 per cent) and the Same District (10 per cent).

7.7 Migration support systems and networks

The findings obtained from the Venn diagram exercise indicate that institutions, both formal and informal, have played roles in supporting migration networks. However, institutions with direct support for migration are few; these include family, friends and relatives (both in the villages and in places where people migrate to), telephone companies and village government.

Families, friends and relatives in the villages appear to provide support to the members left behind when the head of HH has migrated, and those friends and relatives in destinations provide relevant information needed to move to these places. Telephone companies such as Airtel and Vodacom were reported to have made communication possible between the studied villages and all the different destinations where people migrate to. In Ruvu Mferejini for instance, it was explained that the village government normally provides introductory letters to community members who seek employment (e.g., Maasai guards) in the cities. The rest of the institutions mentioned play an indirect role, for example by providing food aid, financial support, education to the families in the villages or allowing other resources that would have otherwise been committed for other purposes to be used to support the mobility of people to different places and their activities in those places.

7.8 Summary of key findings

The question of whether the primary pattern is rural-urban or rural-rural has major programme and policy implications; hence the need to be clear on this point. The findings indicate that people do migrate as a consequence of the impact of climate variability and particularly drought. This is due to the direct impact of drought on crop and livestock production. Rainfall variability was also reported to be responsible for food insecurity and negatively affecting income levels. The findings further indicate a strong link between drought and the need to migrate in search of sufficient rain and/or water resources for farming, better pastures for livestock and casual employment.

The migration patterns could be temporal or seasonal depending on the extent of the impact of drought. Based on the HH survey, it appears that the majority are seasonal migrants, and most of them return. The decision to migrate depends on social networks, which also determine the migration destinations. From PRA sessions it was reported that most people out-migrate seasonally to nearby places within the same Kilimanjaro Region; and some go to distant places such as Arusha (Simanjiro), Tanga, Morogoro and Dar es Salaam. However, from the HH survey, Dar es Salaam appeared to be the number one destination for migration. This could be related to diverse opportunities in the city. However, for most farmers the pattern of migration is mainly rural-rural; for livestock keepers this can be rural-rural or rural-urban depending on the extent of the impact of drought on animal conditions. In case the conditions of livestock worsen, the livestock keepers are forced to go to cities to generate income. During expert interviews, it was explained that when the pastoralists have generated adequate income they would buy more livestock and return to their home villages.

Section 8: Linking rainfall variability, food security and migration

The research findings in this report have drawn our attention to the rising risks of rainfall variability and change for communities in the Same District located in the semi-arid zone of north-eastern Tanzania. The report has highlighted the associated livelihood constraints, particularly food security, as linked with rainfall variability and the interrelationship with mobility patterns.

8.1 Rainfall patterns and variability

8.1.1 Findings from Participatory Research Approach sessions

The research findings based on PRA sessions, expert interviews and HH interviews indicate that rainfall patterns have changed, and most of the changes have been observed within the past two to three decades (1980–2012). Among the key climatic changes, increase in drought conditions has been reported. The findings further indicate that there is uncertainty in rainfall as reflected in late onset and sometimes early cessation of rain. In addition, rainfall patterns are now described as much more erratic, both from year to year and even between and within individual villages. The findings further show that oftentimes rain comes late and suddenly ends before the normal rainy season. Therefore, the main problem is not solely the amount of rainfall, but also the variability of the distribution during the season.

Regarding rainy seasons, the area used to have two seasons with rainfall that could support agricultural production. Significant seasonal shifts in the traditional *Masika* (March–May) and *Vuli* (September–December) rainy seasons have been observed. A tendency for both seasons to become shorter is reported. *Masika* rainfall, which in the past began as early as February, now does not usually start until at least mid-March and now often end as early as mid-May. The "short" *Vuli* rainfall, which accounts for less of the total average annual rainfall, is described in Ruvu Mferejini as "very undependable" and having almost "disappeared". The onset of *Vuli* is reported as delayed from September to October or even November (the traditional peak rainfall month for the season).

In addition to changing rainfall patterns, the residents of the three research villagers also report a tendency of higher temperatures and stronger winds. Both are most common and severe during January and February, between the two main rainy seasons, and were in evidence when the field research was conducted in February. These conditions exacerbate the reported problems of water shortage by increasing the evaporation of water from the Ndiva.

8.1.2 Findings from household surveys

Regarding changes in rainfall, based on HH surveys, the perception of local communities includes: increase in experience of prolonged dry spells; erratic rainfall; late onset and early cessation; and higher temperatures and winds which result in increased evaporation and hence have a negative impact on agricultural production. Similar observations are obtained from PRA sessions and expert interviews. Most of the changes are reported to have occurred in the last three decades, but are more pronounced within the last two decades (1990–2012).

8.1.3 Findings from the analysis of rainfall data

From analysis of local meteorological data, the actual changes indicate periods of rainfall increase and decrease across decades. When a comparison of the perceptions and actual data is made, it is seen that statistics in some cases revealed increases in annual rainfall, even in periods where communities have experienced drought. This can imply that annual rainfall data does not reflect its distribution, that is, a lot of rain could be falling in a few days and disappear during critical periods of plant growth, resulting in crop failure. However, there is a match of climatic data and local perceptions in terms of years with extreme climatic events. The analysis of rainfall data from the Same meteorological station (1950–2010) reveals the following key trends worth mentioning:

- → The observed extreme events (high rainfall events – floods, and low rainfall events – drought) from the local metrological data largely match with community perceptions. For example, there is a fairly comparable prototype of rainfall evolution in the area involving the years 1952 (extreme lowest) and 1957 (extreme highest), and 1975 (extreme lowest) and 1978 (extreme highest). The pattern of extreme values observed in the data present evidence of the evolution of rainfall over time and most of these observations are in line with what was obtained from the PRA sessions.

- → There is a decreasing mean in the total annual rainfall and a decrease in the amount of rainfall in *Masika* over the past two decades (1990s and 2000s). The declining trend of total annual rainfall would imply that the *Masika* seasons largely dominate the overall annual rainfall pattern.

- → There is a progressive decline in the number of rainy days per annum with a pronounced reduced number of rainy days in *Masika* noticed in the past 20 years. An increasing trend in dry spells during dry seasons in the past 20 years is also visible and *Vuli* rainfall being highly variable with a relatively stable pattern.

- There are no statistically significant trends in the cumulative short season *(Vuli)*, long season *(Masika)* and annual rainfall records. A visual analysis, however, suggests an increasing trend in the total seasonal rainfall during *Vuli*, with a declining trend during *Masika* in the past 20 years.

8.2 Livelihood risk and food security

The findings from PRA sessions and expert interviews further indicate that rainfall variability affects the livelihoods of local communities by negatively affecting HH income. Similarly, the HH survey indicates how rainfall variability affects the incomes of local people. Findings from key experts further indicate that rainfall variability also affects the income of local communities through direct links between drought, poor crop yields and poor performance of animals. It was accordingly reported that maize, the key staple food, is negatively affected by drought and thus the yields decline. During drought periods, livestock productivity also declines due to a lack of adequate feed/pasture and water. Findings from HH interviews show that rainfall variability affects income negatively, mainly due to declining yields, declining animal production, and increasing food prices at the markets.

From PRA sessions, it was accordingly reported that during extreme climatic events, farmers migrate to areas with potential for irrigation farming. Also, livestock keepers have been migrating out of the village on a temporal basis looking for grazing land (livestock feed) and water, but currently have been moving to more distant areas in search of the same. The analysis of the seasonal calendar in Ruvu Mferejini, where most of the people migrate to when faced with food shortages, indicated that habitants of Ruvu Mferejini are always either farming or harvesting because they have the canal for irrigation throughout the year. Different crops are planted in different seasons over the year. They also cultivate during the *Masika* and *Vuli* seasons, if the latter does not fail. Most people with rain-fed farms do not plant in *Vuli*, as it has become very unreliable, frequently failing over the years. Apparently, the migration pattern in Ruvu Mferejini was linked to the availability of water and pasture. Discussions from the PRA sessions indicated that from September to December, livestock keepers migrate to places where water and pasture is available. Apart from livestock keepers, some farmers from Ruvu go to Simanjiro to cultivate onions and maize; this is common from February to August. Migration happens in the same months, specifically for farmers. There is also in-migration in the village, whereby people move in for irrigation opportunities. Many people who cultivate in Ruvu come from many different places, they cultivate cash crops and maize to sell in other places and the latter stored and taken to other bigger markets during the drier seasons.

Regarding vulnerability assessment, there was a general agreement across the villages that women, children, the elderly and the poor are the most vulnerable to rainfall variability, because they are less able to leave and search for casual labouring opportunities in areas where the season has been good, and, in addition, they have fewer assets to sell/exchange for food. Similar observations were noted from the expert interviews. Those less vulnerable to rainfall variability were generally perceived to be: the wealthy; men; and youths. This perception was due to the wealthy having assets they could exchange for food and their better access to relevant information enabling them to know in advance whether the season would be bad or not.

8.3 Migration patterns

The pastoralists are historically very mobile due to the seasonality and availability of resources; they have a tradition of moving to access water, pasture, avoid diseases, etc. The findings show that the frequency and migration distance appears to have increased; and environmental conditions coupled with economic conditions appear to influence these patterns. The extent of mobility depends on how the weather conditions are favourable or unfavourable. With rainfall variability, mobility patterns have increased, so rainfall variability appears to have accelerated mobility patterns. Someone can move from Arusha or Kilimanjaro to Kilindi (in Tanga, located in the coastal area). Findings from expert interviews produced similar observations. However, an expert from WWF commented that "Livestock keepers are the ones migrating temporarily to where the conditions are better during dry seasons, i.e. in places with adequate pasture and water. Farmers do not normally migrate; they ask for relief." It is explained further that farmers can go and produce food somewhere outside their areas. Migration patterns include both rural-rural and urban–rural, with a high proportion of migrants returning to their villages of origin. Migration movements depend on social networks.

FGDs during PRA sessions indicated that the people in Bangalala have also been migrating to different villages/places in search of arable land due to climatic conditions, particularly with respect to drought and rainfall variability. HH survey data, based on responses from HHs that owned agricultural land, provided similar observations that rainfall variability greatly affects food production.

During expert interviews, it was reported that the changing rainfall patterns in the north-eastern zone of Tanzania have implications for HH food production for both livestock keepers as well as farming communities. For livestock keepers, it affects pasture availability, while in farming communities it affects performance of crops. This in general has resulted in food shortages in many HHs. These observations were also noted during PRA sessions and HH surveys. The findings presented in Table 23 indicate how rainfall variability affects food security in ways highlighted above. From the expert interviews it was learned that rainfall variability makes people fail to predict and make proper decisions about the allocation of scarce resources (e.g., when to sell livestock and when to buy enough bags of maize for future use). Rainfall variability further brings increased uncertainty of what livelihood strategies should be undertaken by the HH (e.g., decision to farm or not to). It was accordingly commented by NGOs operating in the zone that "when there is scarcity of rains, there is also shortage of food. There are years when farmers get 100 per cent total crop failure. For livestock keepers they tend to migrate to get enough pasture and water; as a result they move to Tanga and Simanjiro".

8.4 Non-migration

According to expert interviews, the landless and poorest people, despite being among the most affected by extreme climatic events, are often not able to migrate because they do not have the necessary means and information to do so. Moreover, they also have the expectation that the situation will improve. Indeed, those who stay have diversified and have considerable investment in the area.

During FGDs it was further explained that elderly people do not migrate due to their age and ill health. Women who have young children also do not migrate often, since migration is risky for them. With regard to the elderly, it was explained that they have a strong attachment to their homes and resources such as land. They can also be considered as already successful and not prone to taking risks, and thus less likely to see opportunities and rewards in migration. Women and the elderly mostly stay at home within the livestock societies. Families only join when there is success in making a living in areas where other family members have migrated. Children are supposed to go to school, so they do not migrate, and women, the elderly and children are less likely to be able to find employment.

Another limiting factor that was reported why people do not migrate was the issue of land. It was accordingly explained that, whenever someone with land shifts, there is the possibility of the land being taken by others.

> "Drought is at the centre of the migration problem."
>
> Research participant in Bangalala

8.5 Interplay of rainfall variability, food security and migration

The PRA findings further indicate a strong link between drought and the need to migrate in search of sufficient rain and/or water resources for farming, better pastures for livestock, or casual employment. In Ruvu Mferejini, research participants reported that "water shortage" is their biggest problem, while the residents of Vudee singled out the severe drought of 1996/97 as being the biggest problem they had faced in their recent memories. During the severe drought of the mid-1970s, the residents of Bangalala were encouraged and assisted by the Government of Tanzania to migrate to Ruvu Mferejini and other low-lying areas where irrigation facilities were being developed. Many did so, but quite a few returned to Bangalala in the late 1970s when rainfall improved.

The findings from PRA sessions, the HH survey and expert interviews indicate that there is a relationship between rainfall variability and migration. It was explained that in case of rainfall failure, people move with their livestock. Rainfall is a key determinant factor to make someone move; therefore rainfall variability is what triggers migration, amongst other factors. Rainfall variability negatively affects both crops and livestock and thus contributes to food insecurity, which forces people to move. It was further explained that rainfall variability directly affects the natural resource base (crops, pasture and natural vegetation). However, population growth is also adding more pressure on the natural resource base.

To further elaborate this interrelationship it was explained that "Consecutive years of drought is what affects food security; if not sure of food tomorrow you can migrate or find alternative livelihood activities." For farmers, rainfall variability triggers and negatively influences water availability for crops and thus contributes to food insecurity. Similarly for livestock keepers, rainfall variability affects water and pasture availability for animals.

All three villages regarded drought as an extreme event with adverse impacts on the livelihoods of the community. Drought implications for livelihoods included crop failure, food shortage, lack of pastures and dried up water sources, loss of animals, more and recurrent conflicts between farmers and pastoralists, migration, poor health and education, and income going down. The ultimate outcome of drought for all three villages appeared to be a more dependent society, decreased levels of development, or no village development.

From the analysis of the research findings the circumstances under which the HHs on the research site use migration as an adaptation strategy to rainfall variability and food insecurity can be listed as follows:

1. When farmers rely in their agricultural production entirely on rainfall, the latter being erratic makes the farmers go for irrigated agriculture by leaving their land (even if not for the long run), in order to have more regular and reliable crop/food production.

2. When the population grows rapidly, this leads to a conflict over natural resources, especially water which is a limited resource in the first place, given the erratic rainfall, droughts, seasonal shifts, shorter seasons and dry spells.

3. When rain variability has a negative impact on food availability, pasture for livestock and income generation, all these factors together make people head to other places to seek livelihood alternatives.

4. When the floods occur, people move from the lowlands to the uplands, and vice versa when the droughts occur or when the rain is erratic.

5. The severer the problems related to rainfall variability, the more people are mobile and willing to leave for new livelihood possibilities.

6. Gender plays a role in the migration decision/process. It is mostly the young men who migrate. Once they settle, they sometimes ask their wives/families to follow them to the destination. However, when this has negative implications on the schooling of the children, the families might be left behind. Women who are head of HHs usually do not migrate, since they need to take care of the children.

7. People migrate when there are animals/livestock depending on them and need to be fed, especially given that the latter are a source of nutrition and income for them and their families. Therefore, they migrate (for short periods) in search of water and pasture.

8. People migrate when there are no alternative livelihood opportunities or activities that compensate for the losses that happen due to rainfall problems. In cases where there are activities in their home villages, they prefer to go for these until the rain situation improves.

9. People migrate when they know that the destinations provide them with better alternative livelihoods, where more water and pasture is available.

10. People migrate when they receive support from families, relatives and friends in the origin and at the destination. In the origin, migrants need to assure that their family members left behind, especially the elderly and children, are taken care of by friends or extended families. At the destination, the existence of friends and relatives helps them to find land, jobs and accommodation.

11. The existence of communication/telephone companies on the one hand helps local communities in finding information on where to go, and on the other hand helps people to stay in touch with their families after migrating.

12. Businessmen and traders who visit the research sites and distribute their products are involved in the migration process as mediators who support the migrants and even offer them job opportunities at the destinations.

Section 9: Summary and conclusions

This research aimed at improving the understanding of how rainfall variability affects food and livelihood security, and how these factors interact with HH decisions about mobility/migration among groups of people who are particularly vulnerable to the impacts of climate change. The research focused on perceived as well as measured changes in rainfall (e.g., extended dry and wet periods, droughts and floods, erratic rainfall) and shifting seasons. The study was conducted in the Same District situated in the semi-arid areas of the north-eastern zone of Tanzania.

Analysis of the meteorological data appears to be in line with the perceptions of local communities. Firstly, the findings indicate that climate change is real, and is happening now as expressed by increasing rainfall variability. As confirmed by the IPCC, climate change is already affecting people, economies and the environment.

Local communities are at stake in this semi-arid zone of Tanzania. Current climate variability and extremes, such as droughts, floods and storms, severely affect the livelihoods of the poor, economic performance and key assets, particularly crops and livestock.
The findings further show that communities in the study area are vulnerable to climate change (particularly rainfall variability) due to heavy reliance on rain-fed agriculture, as well as low adaptive capacity due to a lack of economic resources and technology within their vicinity.

The study indicates that the research area is highly vulnerable to rainfall variability as expressed in terms of prolonged drought, erratic rainfall and seasonal shifts impinging on water availability to support various livelihood activities. The livelihoods of the majority are directly affected by rainfall variability since most of the people depend on agriculture as their main economic activity. Rainfall variability appears to present a number of challenges to farmers and livestock keepers by directly and negatively affecting crop production and livestock production through water scarcity, thereby indirectly affecting their income levels.

In response to these climatic challenges, local communities appear to be engaged in various agricultural and non-farming activities to cope with climatic conditions. Under prolonged drought conditions, the traditional irrigation system *(Ndiva)* is unable to support irrigated agriculture, due to water scarcity. Prolonged drought further affects livestock through lack of pasture and water. Consequently, people are forced to migrate to other areas, particularly with water availability and potential for farming and livestock keeping. Most of the migration patterns appear to be seasonal, but with increasing drought incidences. Migration thus appears to be one of the important adaptation strategies to rainfall variability under conditions of extreme moisture stress, to support existing livelihood activities in the areas, particularly regarding farming and livestock keeping.

The study findings from the three research villages (Bangalala, Ruvu Mferejini and Vudee) present perceived changes in rainfall patterns over the last few decades. This is regardless of the varying agro-ecological conditions of the sites, particularly with regard to elevation and average annual rainfall. The findings appear to concur with climatic analyses and information obtained from expert interviews. The findings further indicate that drought incidences have increased, coupled with prolonged dry periods and water scarcity.

Change in the onset of rain and the unpredictability of rain were reported relatively consistently by communities in all three villages. Perceptions indicate variations in the onset of rainfall during both rainy seasons (*Masika* – long rainy season; and *Vuli* – short rainy season), which triggers a number of events including crop failure and reduced pasture availability, which in turn affect food security and HH incomes, and influence migration decisions. The research findings thus reveal that rainfall variability as expressed in terms of drought and seasonal shifts is the most limiting factor to the livelihood security of inhabitants in the area. Drought ranked high as a major livelihood risk across the study villages. The impact assessment of rainfall variability shows that drought implies a lack of enough food due to poor crop productivity. Drought also implies a lack of water and scarcity of pasture for livestock. Consequently, drought leads to poor income and forces people to migrate to other places in search of food.

Hence, the study findings indicate that there is a relationship between rainfall variability and migration. Rainfall variability is a key determinant factor to make someone move. Therefore, rainfall variability – amongst other factors – triggers migration. Rainfall variability negatively affects both crops and livestock and thus contributes to food insecurity, which forces people to move. Moreover, rainfall variability directly affects the natural resource base (crops, pasture and natural vegetation). However, population growth is also adding more pressure on the natural resource base.

To further elaborate this interrelationship, it can be concluded that *"Consecutive years of drought is what affects food security; if not sure of food tomorrow you can migrate or find alternative livelihood activities"*, as commented by the Tanzania Meteorological Agency (TMA – personal communication, 2012). The key limiting factor and determinant of mobility patterns appears to be moisture stress. For farmers, rainfall variability triggers and negatively influences water availability for crops and thus contributes to food insecurity; similarly, for livestock keepers, rainfall variability affects water and pasture availability for animals. In totality, these negatively affect income levels and food security through reduced ability to access food.

Rainfall variability and food insecurity have the potential of becoming significant drivers of human mobility in cases of recurrent drought in consecutive years. This is due to the fact that, under such conditions, communities are likely to have exploited various coping mechanisms using available resources – sometimes having a negative impact in the long term (such as deforestation) – or exploited existing opportunities in nearby areas before resorting to migration.

In terms of climate change adaptation, migration could be better understood as the diversification of income sources entailing some form of mobility. As such, it is an essential element of livelihood strategies in reducing vulnerability, which is likely to become increasingly important as climate change affects the crop and livestock production which are the key livelihood activities of communities in this semi-arid environment.

The majority of HHs in the study are dependent on rain-fed agriculture as a major livelihood strategy; climate change adaptation can therefore be best addressed through a comprehensive climate risk management approach, with better management of risks related to current rainfall variability, particularly by strengthening water availability through improving water harvesting technologies to support irrigated agriculture in times of drought.

Section 10: Reflections for policymakers

Livelihoods in the Same District remain largely dependent on crop and livestock production, which is an inherently tenuous business in this semi-arid zone. Current livelihood strategies are highly dependent on rainfall, both in the villages and catchment areas that supply local irrigation systems. Rainfall in this area shows a high degree of variability and unpredictability, which seems to be increasing over time. HHs already use migration as both a short-term coping and long-term adaptation strategy, and there is evidence to suggest that this trend will continue to grow due to climate change, environmental degradation, population growth and other factors. Thus, there is need to support the key livelihood systems to reduce the vulnerability of these communities to the impact of rainfall variability. Migration in itself is not necessarily the worst strategy. Nevertheless, the context is very important. With regard to the observed migration patterns, policy interventions are inevitable for the well-being of the migrants, their families in the areas of origin, and for the communities that host the migrants in the areas of destination.

This section provides some policy reflections that might be relevant for the government of Tanzania, as well as the NGOs and civil society, in order to counteract the vulnerabilities of the communities, not only in the research sites, but also in the whole region and in other regions that might have similar conditions and where the people share similar problems. These policy actions might be carried out by the communities themselves, but would certainly need backing and support from the government as well as local NGOs.

The following are policy reflections drawn, based on the above analysis:

Water resources management

1. Since water stress appears to negatively affect the key livelihood activities of farming and livestock production, there is a need to strengthen the irrigation potential of the area by rehabilitating and improving the irrigation schemes and water harvesting technologies in both the highlands and lowlands.

2. There is a need for more efficient natural resource management that leads to more protection of existing water resources. This includes prohibiting logging and mining in the areas that provide such resources. It also includes planting trees and upgrading the current traditional irrigation methods.

3. Rural water supply schemes should be developed in the context of water resources management, taking into account the multiple uses of water including both domestic and productive. The development of these schemes should also consider other water uses and the available water resources in catchment areas.

4. People and livestock migrate not only to where there are favourable weather conditions (e.g., abundant rainfall) but also to where there is a permanent source of water to support their livelihood activities. This trend would imply increasing competition over water use in already water-stressed areas, thereby fuelling conflicts over water use among and between users. In such cases it is necessary to explore and roll out management options that promote water use efficiency and water use permits.

5. Lower-level structures for water resources management (e.g., basin water boards, catchment committees and water user associations) should be capacitated to enforce water use permits, manage water allocation and manage growing water conflict among users.

Diversification of livelihood options: agriculture/livestock/economic activities

6. There is a need to support livelihood activities that contribute to food security but with limited negative environmental impact so as to protect the natural resource base.

7. The introduction of new livestock varieties that produce more milk for HHs is an important strategy that would be sustainable in the long run. Given the limited natural resources, the population growth and the decreasing income caused by factors related to rainfall variability, increasing the productivity of the livestock could help people sustain their livelihoods and make the best out of the existing resources.

8. The diversification of agriculture is an essential strategy; more drought-tolerant crops, such as lablab, sorghum and cassava should – to a large extent – replace water-consuming crops. Moreover, relying on shorter-term crops and varieties that do not exhaust the soil can help sustain the livelihoods of the communities. In addition, a useful strategy is to use terracing in hillside agriculture, more inter-cropping, agro-forestry, tree crops, vegetables and legumes (for nitrogen fixation and thus intensify soil fertility and consequently improve crop productivity). This is a recommendation that came from the communities themselves.

9. The communities need the necessary support in creating small business/trading and other non-agricultural activities in order for them to diversify without the risks associated with rainfall variability.

Support for migration: financial services/education

10. Migrants should be encouraged to transfer remittances to their families in the areas of origin to create investment opportunities there. The remittances could be used in profitable projects for the families, which would encourage the men to return home and make the best use of the resources created during the migration period.

11. There is a further need to develop sustainable saving systems through already existing as well as new village savings and loan associations.

12. The communities in the areas of destination should be prepared for receiving migrants in a way that both of them would benefit. Activities that the migrants do in the new areas should not be in conflict with the activities of the original inhabitants, in order that both complement each other and create added value instead of competing over natural resources, a problem that exists already in the areas of origin.

13. It is essential to improve the educational infrastructure in the areas of destination in order to fulfil family unity and prevent men from leaving and abandoning their families in the villages of origin. It is also crucial to improve the educational infrastructure in the villages of origin in order to enhance the skills of migrants so that they can migrate with dignity and resulting from choice.

Health

14. Human health is threatened by rainfall variability. Indeed, this change has a negative impact on nutrition (reduction in numbers of meals and quality of food) and access to safe drinking water. Thus, the implementation of the different policy reflections stated above is crucial to ensure respect for the lives and health of the population concerned.

Annex I:
List of experts interviewed

Type of organization	Organization	Interviewed person
National/ Government Ministries/ Development Policies	Vice President's Office	Mr. Richard Muyungi
	Prime Minister's Office	Mr. Fanueal Kalugendo
	Tanzania Meteorological Agency	Dr. Emmanuel Mpeta
	Ministry of Agriculture	Ms. Amy Mchelle
	Ministry of Livestock and Fisheries Development	Ms. Lucia Chacha
International Organization/NGOs	WWF – TPO	Dr. George Jambiya
	IFAD Country Programme Officer	Ms. Mwatima Juma
	RED CROSS Director (Branch Development)	Mr. Julius Kejo
	OXFAM	Mr. Ralph Roothhaert
	TNRF	Mr. Alais Morindat Mr. Geofrey Mwanjela

Type of organization	Organization	Interviewed person
Academic Institutions	Sokoine University of Agriculture – Faculty of Agricultural Engineering	Professor Siza Tumbo
	Sokoine University of Agriculture – Team Leader Soil Water Management Research Programme	Professor Henry Mahoo
	University of Dar es Salaam Institute of Resource Assessment – Climate Change/ Hydrology	Professor James Ngana
	Ardhi University	Dr. Riziki Shemdoe
Regional	Kilimanjaro Regional Agricultural Advisor	Ms. Mkamba
	Pangani Basin Water Office	Mr. Abraham Yesaya Mr. Dumas A-Damas Mr. Gwau Kimia Mr. Vendelin Zbasso Mr. Hezron Philipo
District	Same District – DALDO	Mr. Majid Kabemela
Civil Society Organizations	PINGOS	Mr. Edward Porokwa
	TAPGHO – Coordinator	Mr. Daudi Haraka
	EPMS	Ms. Euster Kibona

Annex II:
PRA sessions in study villages

Satellite village Ruvu Mferejini	Base camp village Bangalala	PRA tools
6 people (mixed groups + local leaders)	6 people (mixed groups + local leaders)	Resource mapping, Wealth ranking & Transect walk
5 farmers 5 non-farmers	5 farmers 5 non-farmers	
5 women 5 most vulnerable people	5 women 5 most vulnerable people	Livelihood risk ranking
	6 elders (men and women) 7 young people (boys and girls)	Timeline & trend analysis FGD
6 farmers 6 non-farmers 6 most vulnerable	6 farmers 6 non-farmers 6 most vulnerable	Ranking on coping strategies on rainfall
7 men (farmers & non- farmers) 7 women (farmers & non- farmers)	7 men (farmers & non-farmers) 7 women (farmers & non-farmers)	Seasonal calendar & Venn diagram
10 people of mixed group (elders, farmers, non-farmers, pastoralists, people with migration experience)		Seasonal calendar Impact diagram Mobility map FGD
Vudee 6 men (with migration experience) 6 women (with migration experience)	*Vudee* 6 men (with migration experience) 6 women (with migration experience)	*Vudee* Mobility map, FGD & Venn diagram on migration support system or network
6 men (farmers & pastoralists) 6 women (farmers & pastoralists)	6 men (farmers & pastoralists) 6 women (farmers & pastoralists)	Impact diagram & FGD on Coping and adap- tation with rainfall variability & food security

Annex III:
Household survey sampling (sampling chart)

Village	HHs	Proportion (%)	of the total	Required HHs
Ruvu Mferejini	572	0.38	38	68
Bangalala	562	0.37	37	67
Vudee	373	0.25	25	45
Total	1,507	1.00	100	180

Village	Wealth category	Population	Proportion (%)	of the total	Sampled HHs
Ruvu Mferejini	Lowest	313	0.55	55	n_1=37
	Middle	257	0.45	45	n_2=31
	Highest	2	0.00	0	0
	Total	572	1.00	100	n_{rm}=68
Bangalala	Lowest	250	0.44	44	n_1=30
	Middle	280	0.50	50	n_2=33
	Highest	32	0.06	6	n_3=4
	Total	562	1.00	100	n_b=67
Vudee	Lowest	137	0.37	37	n_1=17
	Middle	200	0.54	54	n_2=24
	Highest	36	0.10	10	n_3=4
	Total	373	1.00	100	n_v=45

Annex IV: Descriptive statistics of monthly rainfall

1950s

Statistic	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Minimum	1.27	16.00	0.76	37.87	11.43	0.00	0.00	0.00	0.00	0.00	11.43	13.72
Maximum	140.43	186.18	129.80	205.74	186.49	33.53	13.30	41.40	36.42	70.87	138.43	102.36
1st Quartile	7.11	27.04	27.62	88.34	26.28	0.32	0.25	0.06	0.25	1.52	21.83	22.51
Median	20.52	53.21	75.72	118.14	75.57	1.01	1.65	2.16	4.93	12.83	28.19	48.66
3rd Quartile	104.84	130.66	82.38	154.36	109.34	8.38	2.54	10.75	10.49	34.80	52.76	66.55
Mean	50.33	77.89	63.76	122.34	77.52	6.35	3.44	10.52	8.17	22.33	49.19	47.97
Variance	3,518.14	4,285.11	1,875.49	2,962.59	3,396.08	114.57	23.98	269.59	124.68	647.54	2,283.70	834.43
Std. dev.	59.31	65.46	43.31	54.43	58.28	10.70	4.90	16.42	11.17	25.45	47.79	28.89

1960s

Statistic	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Minimum	0.00	1.30	4.60	29.70	3.40	0.00	0.00	0.00	0.00	6.80	0.30	6.70
Maximum	157.00	104.60	326.10	261.80	179.70	73.90	37.60	24.60	81.80	114.80	182.20	156.50
1st Quartile	19.78	25.93	54.13	36.25	7.50	1.43	0.28	0.58	1.63	32.33	25.20	24.43
Median	39.70	40.30	59.90	90.25	30.40	4.50	1.45	3.85	5.60	47.40	77.55	56.15
3rd Quartile	65.50	88.73	130.80	170.53	77.18	12.60	10.25	12.53	7.43	96.15	97.28	76.73
Mean	48.18	51.53	96.05	114.39	50.38	13.33	9.28	7.99	14.58	60.24	74.37	56.60
Variance	2,078.16	1,401.89	8,738.87	7,980.97	3,176.22	516.46	212.25	89.35	658.25	1,384.31	3,714.82	2,054.48
Std. dev.	45.59	37.44	93.48	89.34	56.36	22.73	14.57	9.45	25.66	37.21	60.95	45.33

1970s

Statistic	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Minimum	4.40	1.50	17.90	63.10	2.30	0.00	0.10	0.00	0.30	0.30	2.80	11.80
Maximum	152.90	159.00	295.50	198.10	217.30	28.50	13.90	25.70	89.90	136.80	212.20	151.20
1st Quartile	44.50	21.88	41.58	107.88	28.70	2.13	0.65	0.90	1.03	2.55	10.03	49.38
Median	74.65	52.80	52.90	116.70	42.80	8.85	2.30	2.65	4.35	8.75	20.70	70.10
3rd Quartile	120.78	60.83	135.03	137.35	69.50	20.73	3.80	5.85	34.93	16.00	66.20	136.08
Mean	80.04	50.71	104.80	122.72	69.89	11.98	3.37	5.36	22.19	23.51	52.90	83.62
Variance	2,646.05	2,018.26	11,317.28	1,793.96	5,297.89	127.82	16.83	59.67	1,117.11	1,734.55	4,531.94	2,930.92
Std. dev.	51.44	44.93	106.38	42.36	72.79	11.31	4.10	7.72	33.42	41.65	67.32	54.14

1980s

Statistic	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Minimum	0.00	0.00	19.40	16.70	5.50	0.00	0.00	0.00	0.00	2.70	21.20	6.60
Maximum	128.70	112.70	184.30	300.20	156.80	30.50	24.00	70.30	46.70	137.50	230.40	175.10
1st Quartile	6.78	1.28	27.93	86.43	31.98	0.60	0.00	1.20	1.63	12.70	27.98	31.53
Median	26.70	10.70	55.25	119.55	86.45	6.35	1.10	7.95	4.20	25.05	40.90	62.00
3rd Quartile	90.75	46.30	75.88	146.08	109.33	18.05	4.53	20.85	7.33	48.48	62.65	109.68
Mean	48.03	32.77	61.90	122.84	78.04	10.80	4.24	16.12	10.75	41.19	60.55	72.60
Variance	2,267.14	1,911.33	2,444.95	6,044.57	2,807.63	143.70	56.74	507.32	259.45	1,971.59	3,882.01	2,952.80
Std. dev.	47.61	43.72	49.45	77.75	52.99	11.99	7.53	22.52	16.11	44.40	62.31	54.34

1990s

Statistic	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Minimum	0.10	1.20	2.30	38.30	13.20	0.00	0.00	0.00	0.00	3.60	7.00	0.80
Maximum	272.10	190.00	221.90	183.60	132.60	55.70	16.20	24.60	38.30	133.20	279.20	184.00
1st Quartile	8.35	12.58	29.58	63.65	41.85	0.08	0.93	0.63	0.00	10.03	14.83	11.45
Median	32.05	34.10	39.50	87.30	75.25	0.45	3.50	1.35	0.50	23.65	47.85	40.45
3rd Quartile	49.15	56.70	82.98	147.88	91.13	0.73	5.93	10.58	2.78	53.53	71.35	68.80
Mean	53.50	46.54	68.02	101.97	69.53	8.47	4.60	7.06	5.09	38.18	76.23	51.94
Variance	6,511.83	3,109.86	4,258.15	2,515.75	1,493.69	343.19	24.68	93.31	140.13	1,595.65	7,984.12	3,142.16
Std. dev.	80.70	55.77	65.25	50.16	38.65	18.53	4.97	9.66	11.84	39.95	89.35	56.05

2000s

Statistic	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Minimum	0.00	0.00	12.50	24.70	1.10	0.00	0.00	0.00	0.00	0.00	15.80	5.80
Maximum	121.90	65.90	399.00	202.00	94.20	62.60	10.90	43.30	42.60	171.00	168.20	169.80
1st Quartile	14.83	17.00	45.13	48.30	14.33	3.20	0.00	0.93	0.13	2.48	40.23	24.23
Median	25.45	35.05	68.25	57.15	26.95	7.00	1.10	2.10	6.65	35.90	52.55	46.60
3rd Quartile	67.58	53.10	100.43	76.28	34.85	11.15	1.93	24.60	23.68	51.15	80.90	63.58
Mean	43.64	34.02	108.20	74.18	33.72	14.69	2.01	13.14	13.03	47.00	65.83	56.00
Variance	1,659.05	581.72	13,277.35	2,823.34	1,011.56	420.77	11.17	309.80	239.86	3,229.08	2,060.96	2,608.21
Std. dev.	40.73	24.12	115.23	53.14	31.80	20.51	3.34	17.60	15.49	56.82	45.40	51.07

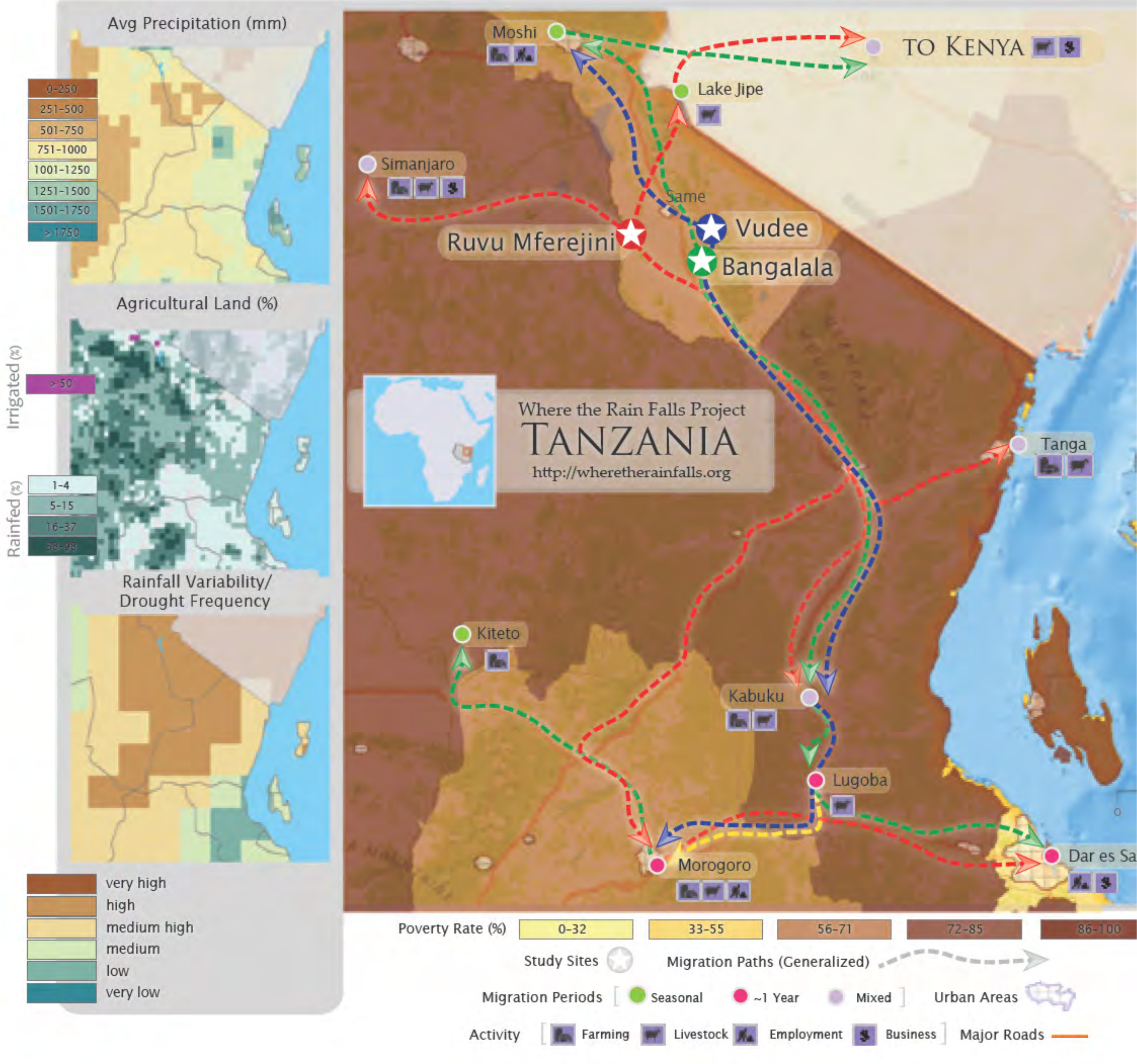
Descriptive statistics of rainfall distribution in Same (1950–2010)

Statistic		Minimum		Maximum			
Season/month		Value	Year	Value	Year	Mean	SD*
Vuli:	October	0.00	1950, 1955, 2001	171.00	2002	38.13	42.19
	November	0.30	1964	279.20	1997	62.67	61.53
	December	0.80	1998	184.00	1997	61.02	48.45
	January	0.00	1967, 1982, 2000	272.10	1978	54.63	54.54
Masika:	February	0.00	1986, 1989, 2005	190.00	1990	48.65	47.15
	March	0.76	1954	399.00	2008	84.86	82.11
	April	16.70	1985	300.20	1989	109.84	62.66
	May	1.10	2004	217.30	1979	62.85	53.30
Dry:	June	0.00	1954, 1956, 1962, 1965, 1970, 1972, 1980, 1981, 1990, 1991, 1994, 2002, 2005	73.90	1968	10.82	16.09
	July	0.00	1952, 1956, 1958, 1964, 1966, 1981, 1983, 1986, 1989, 1996, 2001, 2002, 2003, 2005,	37.60	1967	4.43	7.57
	August	0.00	1951, 1952, 1956, 1960, 1963, 1971, 1983, 1990, 1996, 2001, 2010	70.30	1989	9.87	14.65
	September	0.00	1951, 1955, 1958, 1960, 1986, 1990, 1992, 1993, 1997, 2003, 2009	89.90	1976	12.17	20.28

** SD = Standard Deviation.*

Annex V: National research team composition

Mr. Telemu Kassile
Ms. Jacqueline Senyagwa
Ms. Madaka Tumbo
Ms. Winifrida Matutu
Mr. Raymond Nzalli
Ms. Lucia Alphin
Ms. Lydia Mcharo
Mr. Mohamed Kambi
Ms. Mwanane Shabani
Ms. Rachael Maleza



Avg Precipitation (mm)
0-250
251-500
501-750
751-1000
1001-1250
1251-1500
1501-1750
> 1750
Agricultural Land (%)
Irrigated (%)
> 50
Rainfed (%)
1-4
5-15
16-37
38-98
Rainfall Variability/
Drought Frequency
very high
high
medium high
medium
low
very low
Moshi
TO KENYA
Lake Jipe
Simanjaro
Same
Vudee
Ruvu Mferejini
Bangalala
Where the Rain Falls Project
TANZANIA
http://wheretherainfalls.org
Tanga
Kiteto
Kabuku
Lugoba
Morogoro
Dar es Sa
Poverty Rate (%)
0-32
33-55
56-71
72-85
86-100
Study Sites
Migration Paths (Generalized)
Migration Periods
Seasonal
~1 Year
Mixed
Urban Areas
Activity
Farming
Livestock
Employment
Business
Major Roads

Annex VI

This map shows the location, landscape, average precipitation, agricultural land and drought frequency of the research sites. It also demonstrates the main destinations of the migrants of the research villages, based on consolidated information collected from FGDs and the HH survey.

Note: The maps (and associated rainfall variability graphs) produced for each case study report were developed using data sets from multiple sources. Each map provides the location of each research site along with contextual data on rainfall amounts and variability, poverty and agriculture. For a full list of sources please see chapter 9.2 of the Where the Rain Falls Global Policy Report (Warner et al., 2012).

Source: CIESIN (2012).

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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
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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*.