A Climate Risk Profile of Maize Value Chain Farming System in Malawi, Zambia and Zimbabwe

Vulnerability Assessment Report

Submitted
by

Munyaradzi Mutenje, CIMMYT
m.mutenje@cgiar.org

with support from

Christian Thierfelder (CIMMYT, Mulundu Mwila (ZARI), Mphatso Gama (MACHINGA ADD) and Sepo Marongwe (AGRITEX)

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Table of Contents

Executive summary

This study examines the vulnerability to climate variability and change of the conventional maize value chain in the mid and low altitude agro-ecological zones of Malawi, agro-ecological zone II of Zambia and agro-ecological zone III of Zimbabwe. The aim is to develop feasible priorities and strategies for climate variability and change adaptation based on farmer preference. A literature review for the countries Malawi, Zambia and Zimbabwe was conducted to assess the current and future impact of climate change and variability on the smallholder farming system. A mix of methods, which included participatory vulnerability assessment tools, focus group discussions and key informant interviews among 108 farmers from five communities, complemented the literature review. Data were collected on the current and likely future impacts and sensitivity of the systems and adaptation capacities.

The vulnerability assessment identified heat waves, erratic onset of the season, early cessation of the season, flash floods and cyclones, in season dry spells and droughts as the most common climate hazards in the last 28 years in both mid and low altitude agro-ecological regions of Malawi, agro-ecological zone II of Zambia, and agro-ecological zone III of Zimbabwe. The trend analysis further revealed that 9 years out of 28 were considered as droughts out of which more than 50% were severe.

The new millennium marks the beginning of unpredictable onset of the rain season in 3 of the surveyed communities. Farmers from the 5 communities concurred that interaction of these climate shocks with non-climate shocks such as HIV/ AIDS and macro-economic turbulence intensified the effects. Since 2000, regularly occurring droughts that now take place every two to three years in the drought prone districts such as southern parts of Malawi, Zambia and Zimbabwe have significantly compromised maize production in the three countries resulting in food deficits ranging from 13 to 60%. The worst drought in 35 years that occurred in the 2015/16 season in the three countries resulted in maize deficit of up to 40% in southern parts Malawi, Zambia and Zimbabwe, 25% in central Malawi and eastern Zambia. The production trends were also closely correlated with maize grain prices. In the lean period of 2016, maize grain price increased by 50% and 100% in Malawi and Zimbabwe respectively.

A range of climate smart agricultural practices such as conservation agriculture (CA), intercropping and other forms of crop diversification, mulching, drought tolerant maize varieties and compost manure emerged as the common most effective adaptation strategies in the target communities. In some few areas, agro-forestry was also mentioned.

The results show that, high population densities, high poverty levels, limited economic off-farm activities and high reliance on maize value chain as the main source of income characterize the most vulnerable communities. They also rely on the usual traditional negative coping mechanisms such as charcoal making, prostitution of girls, [i]casual labour and migration to address inter-annual climate shocks. These results demonstrate that households with high sensitivity to climate risks as surveyed in the three countries are likely to invest in risk-reduction strategies, utilizing whatever options are available to them. For development practitioners and policy makers, it will be critical in future years to assist smallholder farmers in identifying scalable and the most feasible options to address future climate risk impacts.

1. Introduction

Agriculture is one of the sectors significantly affected by climate variability and change in southern Africa (IPCC 2014; Niang et al., 2014). Season dynamics, increased frequency of droughts (especially early and mid-season dry spells), increased temperatures, and altered patterns of precipitation and intensity are some of the extreme weather events apparent in southern Africa (Cairns *et al*., 2013;Serdeczny, *et al*., 2017). Global climate models indicate that southern Africa will be one of the most affected regions, with expected agricultural yield decreases of up to 30% for staple grains by 2030 (Boko, 2007; Cline, 2007; Lobell, *et al.*, 2008). Climate variability and change represents a serious threat to food security and poverty reduction in this region due to the multiple influences and environmental stresses predicted to directly impact the smallholder farming system. For example, the 2015/16 El Niño induced drought has been estimated to have reduced cereal crop production and incomes in this region by more than 40% and 33%, respectively (World bank2017; FAO 2017). Malawi, Zambia and Zimbabwe are among southern Africa's most vulnerable countries to climate variability and change (FAO, 2017SADC RVAC, 2017). The possible reasons are abject poverty, weak institutional development and infrastructure as well as frequent extreme weather events. These socio-economic issues increase negative climate change effects and decrease the population's capacities to adapt (MVAC,2017; ZimVAC, 2017; SADCRVAC, 2017).

- Approximately 60% of the rural population live below the poverty line and more than 60% of the economically active population is employed in the agricultural sector in these countries (World Bank 2017 & FAO 2017). High levels of poverty and weak institutional development limit smallholder farmer's options for making agricultural activities more climate-resilient and for finding alternative livelihood strategies. Climate change is also expected to cause a drop in GDP of 4-14% by 2050 among these most vulnerable Southern African countries, further hampering economic development (FAO, 2017; World bank 2017).

Generalizing the impacts of climate change and extreme weather in southern Africa is difficult, as regions will be affected differently (Boko et al., 2007). Vulnerability to climate change and extreme weather events vary greatly among regions, sectors, communities and social groups in southern Africa. Differential vulnerability is related to current socio-economic and institutional development, production systems, climatic and geographic heterogeneity. In Zimbabwe, Eriksen *et al.*, 2007 revealed that some communities are more vulnerable to climate variability due to poor infrastructure, lack of markets, limited institutional support, and a poor and deteriorating biophysical environment, relative to the other communities which have well-developed infrastructure and markets (Ramírez & Jarvis 2008; Collins et al., 2013; Ramírez-Villegas & Thornton 2015).

The farming systems within specific countries are heterogeneous with maize-based rain-fed mixed cropping system by smallholder farmers being more dominant (Dixon, Gulliver & Gibbon, 2001). Therefore, vulnerability to climate change and variability can be highly farm and context-specific. Brooks et al., (2005). Kelly and Adger (2000) note that vulnerability is highly contextual and must always be linked to specific hazards and the exposure to the impacts of these hazards. Site specific and rigorous analyses are needed to identify potentially climate smart agricultural practices for successful adaptation strategies under various agro-ecological settings and climatic conditions. It is very important to understand and catalogue the measures that farmers are taking to manage climate change and variability in the heterogeneous southern African communities.

Vulnerability largely depends on the capacity of the affected households and communities to adapt (Collins et al., 2013; Niang et al., 2014). Empirical evidence show that smallholder farmers have developed and been exposed to a variety of adaptation strategies that help them buffer against climatic shocks and environmental stressors (Eriksen *et al.,* 2007; Collins et al., 2013; Ramírez-Villegas & Thornton 2015). However, there is limited knowledge regarding the spatial variation in vulnerability and most feasible adaptation approaches among different rural households and in communities. It is important to document such strategies, understand the determinants of farmers' choices and identify the most feasible adaptation strategies for specific context that out scaled for future climate change. Understanding the different dimensions of vulnerability is also important for the designing and implementation of adaptation strategies that will promote equitable and sustainable development.

The primary objective of this study is to assess vulnerability to climate variability and change of the conventional maize value chain in the mid and low altitude agro-ecological zones of Malawi, agro-ecological zone II of Zambia and agro-ecological III of Zimbabwe. This will assist to develop feasible priorities and strategies for adaptation based on farmer preference.

2. Conceptual Framework for Analyzing Vulnerability

A number of conceptual understandings of vulnerability to climate change and variability have been put forward (GIZ, 2013; Hinkel & Bisaro, 2015). In the context of climate change, vulnerability is a function of the character, magnitude and rate of climate variation to which human and natural systems are exposed, people's sensitivity and their adaptive capacity. Vulnerability is defined as "the degree to which a system is susceptible to or unable to cope with, adverse effects of climate change, including climate variability and extremes" (IPCC, 2014; Parry et al., 2004). Vulnerability to climatic shocks is a multi-dimensional concept, encompassing bio-geophysical, economic, institutional and socio-cultural factors. Vulnerability is usually considered to be a function of a system's ability to cope with stress and shock. The assessment of vulnerability then includes a measure of exposure to the risk factors and sensitivity to these factors, together comprising the potential impact of such risks, and the capacity to manage and respond to those risks.

Figure 1 shows that the risks posed by climate change and extreme weather events are dependent on the interaction of climate-related hazards and sensitivity of both human and natural systems as well as their ability to adapt (Field et al., 2014). Risks are considered important when there is a high probability of a hazard occurring, or high sensitivity of the systems exposed (or both), and for which the ability to adapt is severely constrained (GIZ/WRI 2011; GIZ, 2013). This conceptual framework also demonstrates that changes in the climate system and socio-economic processes, including adaptation can reduce or intensify climate change impacts/risks (Vogel & O'Brien, 2004; O'Brien et al., 2007).

Vulnerability to climate change therefore, is assessed as a function of three components: exposure, sensitivity and adaptive capacity, which are influenced by a range of biophysical and socio-economic factors (IPCC, 2014; Parry et al., 2004). Exposure refers to the nature and degree to which human and natural systems are subjected to significant climatic variations. Exposure is directly linked to climate parameters, that is, the character, magnitude, and rate of change and variation in the climate. Exposure factors include temperature, precipitation, evapotranspiration and wind, as well as extreme events such as heavy rain and meteorological drought (O'Brien et al., 2009). Changes in these parameters can exert major additional stress on systems (e.g. heavy rain events, increase in temperature).

Sensitivity determines the degree to which a system is adversely or beneficially affected by a given climate change variable (O'Brien et al., 2007). The effect may be direct such as a change in crop yield in response to temperature change or indirect, an increase in pest and disease infestation due to increase in temperature. Sensitivity is typically shaped by biological and/or physical attributes of the system including topography, soil types, vegetation type and cover. It also refers to human activities, which affect the physical composition of a system, such as tillage systems, water management, and resource depletion and population pressure. Empirical evidence suggests that social factors such as population density should only be regarded as sensitivities if they contribute directly to a specific climate (change) impact (Parry et al., 2004; Collins et al., 2013; Ramírez-Villegas & Thornton 2015). Exposure and sensitivity in combination determine the potential impact of climate change (GIZ/WRI, 2011; Fritzsche, et al., 2014). For instance, heavy rain events (exposure) in combination with gentle slopes and clay soils with high susceptibility to waterlogging (sensitivity) may result in waterlogging (potential impact).

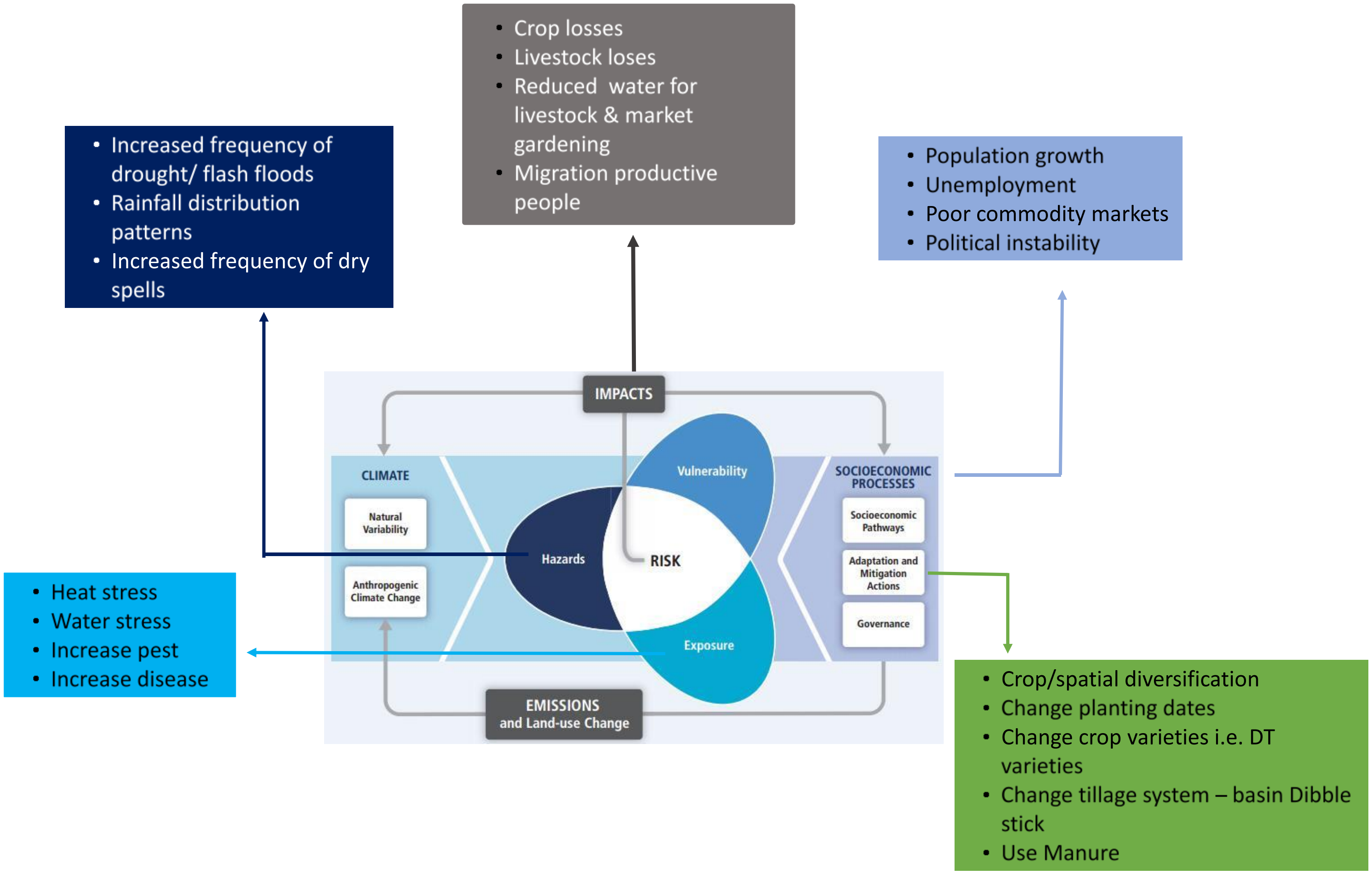

Figure 1: The IPCC AR5 vulnerability assessment framework where the risk of climate-related impacts results from the interaction of the climate-related hazards with vulnerability and exposure of human and natural systems (Field et al., 2014; Fritzsche et al., 2014).

Adaptive capacity refers to the ability of a system to adjust to climate change, variability and extremes – to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (GIZ/WRI 2011, p. 65; Fritzsche, et al., 2014). Adaptive capacity depends on resource access/ endowments that could help in responding to threats and exposures including physical assets, availability of and access to technological alternatives, income levels and diversity, social assets such as trust, transparency, accountability, security of entitlements, and the quality of informal and formal institutions (Eriksen, et al., 2007).

Sensitivity and adaptive capacity are context-specific and vary from country to country, from community to community, among social groups and individuals, and over time. The system's adaptive capacity determines its vulnerability to the potential climate risks/impacts. Hence, assessing vulnerability to climate change is important for defining the risks posed by climate variability and change and provides information for identifying measures to adapt to climate change impacts. It enables practitioners and decision-makers to identify the most vulnerable areas, sectors and social groups. It also helps to develop and implement adaptation options and policies targeted at specified contexts.

3. Methodology

3.1 Community Selection

Five communities from the three Southern African countries (Malawi, Zambia and Zimbabwe) formed the unit of analysis in this study. These included Lemu (Balaka district, Southern Malawi), Mwansambo, (Nkhotakota district, Central Malawi), Chanje, (Chipata district, Eastern Zambia), Bvukururu and Zishiri (Zaka district, southern Zimbabwe). The case study sites were selected from the 19 target communities in the project, in consultation with CIMMYT experts and national partners responsible for the on-farm trials in the respective countries.

The researchers working with extension officers and key informants from each community identified four types of households based on CSA technology uptake. These include farmers hosting on farm trials, adopters of CSA, dis- adopters of CSA and non-adopters. The researchers invited a random sample of each type of household (at least four from each category) to come to the meetings.

In each community, three Focus Group Discussions (FGDs) were conducted: a community-wide discussion and one FGD each with male and female respondents, to understand the gendered climate trends and impacts of extreme weather events, livelihood trends, adaption capacities and other non-climate and socio-economic risks dynamic influencing agricultural livelihood portfolios. The number of participants in each focus group varied between 18 and 22 people. A total of 108 farmers (56 women and 52 men) participated in the 15FGDs and KIIs (5 women only, 5 men only and 5 mixed).

Plate 1: Women (left) and men (right) groups participating in focus group discussion in southern Malawi

 

Plate 2: A community wide focus group discussion in central Malawi (left) and eastern Zambian (right)

Plate 3: A community wide focus group discussion in southern Zimbabwe Bvukururu community (left) and Zishiri (right)

3.2 Data collection and analysis

Vulnerability assessments (VAs) are often vital for the construction of adaptation strategies and policies. However, the diversity of definitions and methodologies for vulnerability assessment has led to attempts to classify the knowledge into different approaches (Wirehn, Danielson, &Neset, 2015; Hinkel,2011; O'Brien et al., 2007; Füssel & Klein, 2006, Parry et al., 2004). Three approaches of vulnerability assessments are most commonly used to identifying, quantifying and prioritizing important risks of a human or natural system to climate change and vulnerability (O'Brien et al., 2007). These include proxy- or indicator-based approaches, model- and GIS-based methodologies, participatory and multi-stressor approaches. The choice of approach in conducting a vulnerability assessment mainly depends on the objective and spatial scale of the assessment as well as the resources available, including data and budget (Hinkel, 2011). GIZ/WRI (2011); Patt, 2013 and Wirehn, Danielsson, & Neset (2015) recommend participatory approaches for climate vulnerability assessment focusing on households and communities at micro scale level.

In this study, we used mixed methods. Literature review of the predicted climate change and vulnerability, hot spots, impacts on maize production and prices constituted the first step. It also provided socio-economic factors that makes these communities more vulnerable to these climate calamities. The second step included use of a range of participatory vulnerability assessment tools, such as: a) hazard and vulnerability mapping; b) vulnerability matrices; and c) field profiles; d) seasonal calendars to understand how vulnerability is expressed at different times of the year and e) vulnerability matrices that link climate stressors hazards with sensitivity of the system; f)adaptation and livelihoods strategies; g) wealth ranking; h) climate impact; i) key informant interviews (KIIs) with community traditional leaders, community organization representative and government official working in the agriculture, agro-metrology and social welfare departments, livelihood portfolio evolution and household portfolio management; and j) village history.

At community level, FGDs and KIIs assessed farm-specific gender differentiated climate impacts and disaster risks including underlying causes, impacts on agricultural livelihood portfolios, and the activities and resources of women and men farmers. The objective of the FGDs was to assess the current and likely impacts of future climate change and identify experiences and adaptation capacities of women and men farmers in the face of climate hazards and extreme events. The FGDs used a mix of participatory techniques to collect risk and vulnerability data, which include: a) participatory story telling on farming activities, adaptation strategies, and women led initiatives; b) matrix ranking to self-assess local climate hazards, extreme weather events, sensitivity and impacts and c) community group presentations to analyze the key findings.

During the FGDs, men and women groups (with the assistance of researcher facilitators) developed risk assessment sheets describing the range of climate and extreme weather events and other non-climate calamities contributing socio-economic risks to agricultural livelihoods described in the sustainable livelihoods framework (Chambers and Conway, 1992). The design of participatory models of vulnerability assessment at community levels provided flexibility while comprehending farmers' and key informant perspective of vulnerability. Information from FGDs and key informant interviews complemented field observations, and secondary data on climate trends and hazards, sensitivity of the agriculture sector and household socio-economic and vulnerability assessment obtained from different stakeholder organizations, consisting of published and unpublished assessment reports.

Qualitative data analysis was undertaken, using NVivo 10, via thematic analysis, where data are grouped into themes regarding the climate hazards and extreme weather risks/ impacts, socio-economic risks to agricultural portfolios and adaptation strategies and technology trends. Coding was applied to all the transcripts at three levels: initial/open coding, focused coding and thematic coding as recommended by Strauss and Corbin, (1990). The transcribed interviews were coded line by line during the initial coding process and open coding continued until no further new codes emerged (QSR, 2012). At the second level, open codes were re-examined before developing themes in a third level of coding, following the adductive reasoning approach. Data obtained from matrix rankings were tabulated, mean values calculated. In examining the qualitative data, important timeline features were extracted and discussed in relation to the climate hazards and agricultural portfolios. The community-level risk and hazard specific data were triangulated with key informant interviews, secondary data from country level vulnerability assessments reports.

3.3. Research Team

The research team consisted of a Socio-Economist and an Agronomist who are well acquainted with the southern African communities as team leaders, 8 Facilitators and Data Capturers conversant with the local languages, and experienced national researchers. Three of the team members were female, ensuring gender sensitivity in the research. The team underwent an intensive two day training including half day of field practice applying the techniques in a pilot community.

4. Results and discussion

4.1 Projected Climate projections and vulnerability hotspots

The 2050 projections show that all districts in Malawi, Zimbabwe and the whole of Zambia except parts of the Northern Province will be hotspots of climate variability and extreme weather events (Figure 2) (Cairns et al., 2013; Davies, Midgley and Chesterman, 2010). Climate hazards such as severe droughts and flash floods are anticipated to be more frequent and intense in the coming decades for the southern Malawi and Zimbabwe (Davies, Midgley and Chesterman, 2010; McSweeney et al., 2010; 2012; Adhikari et al., 2015). The increased climate variability and extreme weather exposure combined with increased population, undiversified economies, poorly developed infrastructure and the lower adaptive capacity of these countries will make them highly vulnerable. The Malawi population is projected to increase to 25.9 million by 2050, further reducing the available arable land per capita (Davies, Midgley and Chesterman, 2010). Addressing the challenges of climate change and variability will therefore, require identification and prioritization of climate smart agricultural (CSA) technologies and practices for smallholder farming communities.

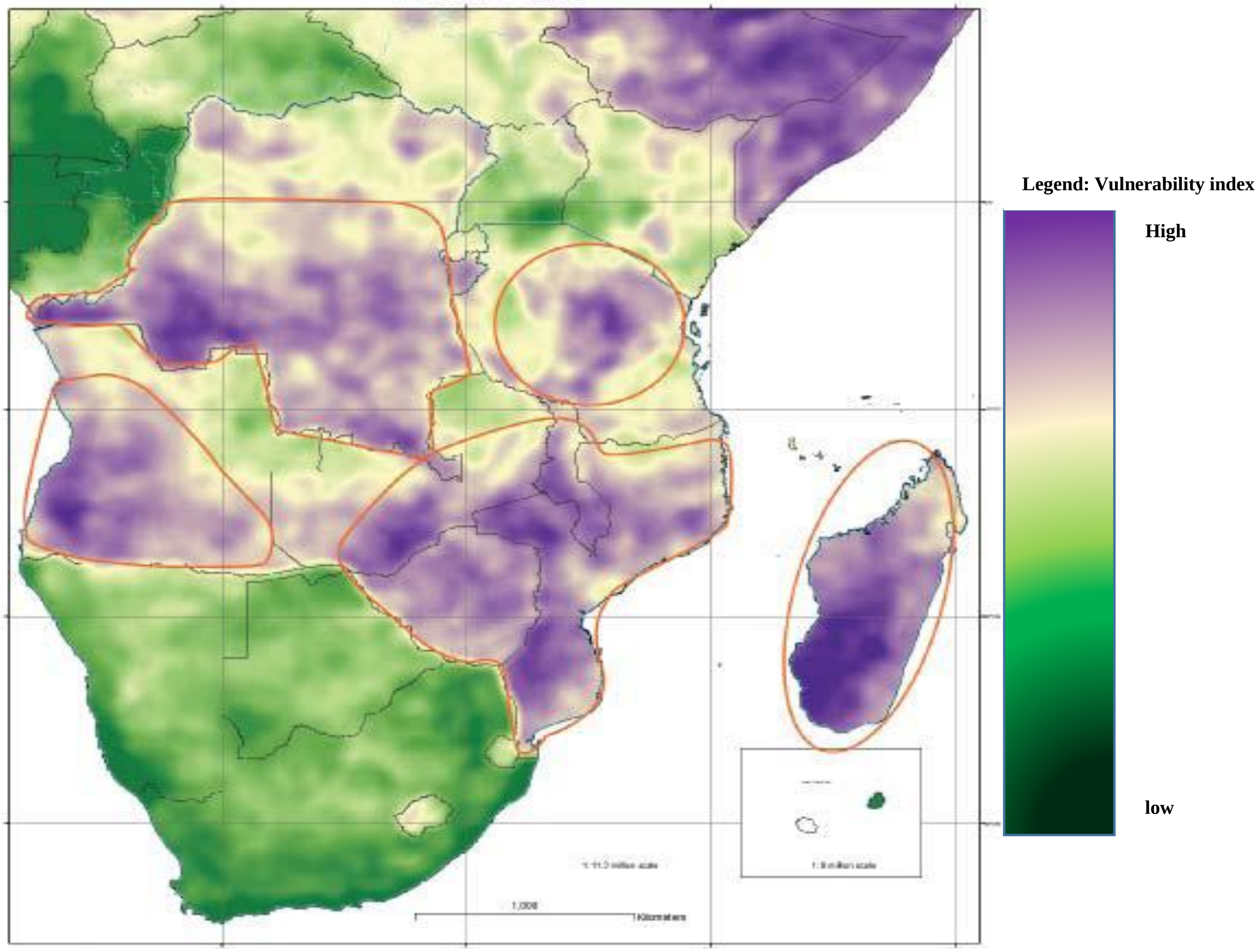

Figure 2: Projected Climate vulnerability (combination of climate exposure, sensitivity and adaptation capacity to climate stressors) hotspots for Southern Africa up to 2050 (circled) showing high climate variability. Purple colour indicate hotspots where people are most likely to be most in need of help adapting to climate stressors, while the green areas indicate areas of resilience. *source JRC technical report, 2018*

Climate change is projected to increase the median temperature of Malawi by 1.1 to 3.0 °C by the year 2060 and further by 1.5 to 5.0 °C by the year 2090 (McSweeney et al., 2010; 2012; Adhikari et al 2015). While data on temperatures show significant changes, long-term precipitation trends are inconsistent. Median precipitation changes are predicted between −2%- 20% by the end of the

21st century (Adhikari, et al., 2015). Vizy et al. (2015) predict a shortening of the growing season in southern Malawi while McSweeney et al. (2012) found no statistically significant trends in precipitation. Though future predictions of annual rainfall show no substantial change, it is expected to fall in a shorter period, causing heavier rainfall events. The seasonal predictions project general precipitation increase by up to 4% in December to March, but decrease by 10% in September to November by 2060 particularly in the southern region. The percent changes in annual rainfall are very small, but they are larger at the beginning of the cropping seasons, for example, drying of up to 10% in September to November. There is increased wetting of up to 4% in December to February. By the 2090s the changes have similar spatial patterns but are larger, with changes in annual rainfall decreasing throughout Malawi of about 14% (Adhikari, et al., 2015; Vizy et al., 2015). Increase in extreme events such as dry spells, seasonal droughts, intense rainfall, riverine floods and flash floods is also predicted (Njaya et al., 2011 McSweeney et al., 2010; 2012; Adhikari et al 2015). Malawi's geographical position, located between two regions of opposing climatic response to El Niño makes annual rainfall prediction challenging (IPCC, 2014). Eastern equatorial Africa usually receives above-average rainfall during El Niño, while southeastern Africa tends to experience below average rainfall. The impact of climate variability and change on crop yields for Malawi is largely negative. Among the cereal crops, maize, sorghum and rice are reported as the most vulnerable crops, for which up to 27% yield reduction is projected to decline by 2090. Root crops, such as sweet potato, potato and cassava are projected to be less affected than the grain crops with changes to crop yields ranging from about 5% to 10%.

Future climate predictions for Zambia up to the year 2080 using Global Climate Models (GCMs), reveal that Agro-ecological Zone I will become increasingly prone to droughts and more vulnerable to rainfall variability (IPCC, 2014; Christensen et al., 2013). The model also forecasts increased rainfall variability of up 30% using the coefficient variation for this zone. Agro ecological Zone II accounting for more than 75% of the national agricultural production is also going to be subject to a trend of increasing rainfall variability. According to this model these two agro-ecological zones are going to experience up to 20% decrease in length of growing season by the year 2050 (DFID, 2006). Farmers in these agro-ecological zones are already observing a generally shortened growing season (Kurukulasuriya and Mendelsohn 2008). The National Adaptation Programme of Action (NAPA) of Zambia predicts increased late onset of the season and early termination of the season for southern, central and eastern province (Agro-ecological zones II and I) (GoZ, 2011). This spatial and temporal change in the rainfall distribution is estimated to reduce the areas suitable for staple crops, particularly maize production by more than 80% in these two agro-ecological zones (Kurukulasuriya and Mendelsohn 2008). Such alteration in rainfall distribution are predicted to result in severe maize yield decrease of 66% under rainfed conditions. Hence, climate variability and change adaptation strategies in these two regions are a necessity.

To the contrary, rainfall is projected to increase in Agro-ecological Zone III (high rainfall area). This agro-ecological zone is also predicted to be less vulnerable to climate variability and change (IPCC, 2014; Christensen et al., 2013), but the highly leached and acidic soils found in this zone constrain agriculture production. The projected climate variability and change trend combined with an increased population growth rate of 3% and a reduction of cultivatable and range land in the southern, central and eastern zones is predicted to result in the shift of the traditional conventional farming systems from the highly productive Agro-ecological zones I and II to the low productive Agro-ecological Zone III. These changes will lead to intensified land pressure and have serious socio-economic implications for the traditional farming systems in general and in the Agro-ecological Zone III in particular (Kurukulasuriya and Mendelsohn 2008).

In Zimbabwe, similar to Malawi and Zambia rainfall predictions are less certain. However, GCM models suggest that rainfall patterns are likely to change and extreme events are set to increase. The model predicts a 15% decline in total annual rainfall by the end of 21st century (Jury 2013). The maize suitable areas overall will decrease by more than 40% by 2080, while suitable areas for cotton and sorghum will increase by more than 30% by 2080. In the southern parts of the country, sorghum, maize and legumes will become increasingly vulnerable to climate variability and change while cotton will become less vulnerable (Brown, *etal.*,2012). Net Primary Production of rangelands (NPP) is anticipated to decrease from the current average maximum of over 8 tonnes per hectare per year to just over 5 tonnes per hectare per year by 2080. This suggest a decrease in rangeland carrying capacity for livestock. The south eastern and north-western parts of Zimbabwe will experience more reductions than in other parts of the country (Brown *et al.*, 2012). Climate models project that climate variability and extreme weather conditions will persist in the future for these 3 southern African countries. Therefore, there is need for development practitioners, researchers and policy makers to find sustainable solutions to hazards associated with climatic variability and extreme weather events.

4.2 Current and future Climate change and extreme weather events

Countries of the southern African region particularly Malawi, Zambia and Zimbabwe have experienced negative impacts associated with climate variability and change, especially in the recent past decades e.g. the frequency and severity of extreme events such as droughts and flash floods have increased significantly. The rainfall distribution has changed with a trend of late onset and early cessation of rainy season. In Malawi, excessive rainfalls and flooding in the north and central part of the country, and moderate to severe droughts and dry spells in the southern parts of the country stymied the agricultural production season in the past 16 years. For example, the rainfall coefficient of variation using 1982 to2011rainfall data show increased seasonality ranging from about 11% to 20% for the central and northern region, 16% to 30% for the southern region (Figure 3).

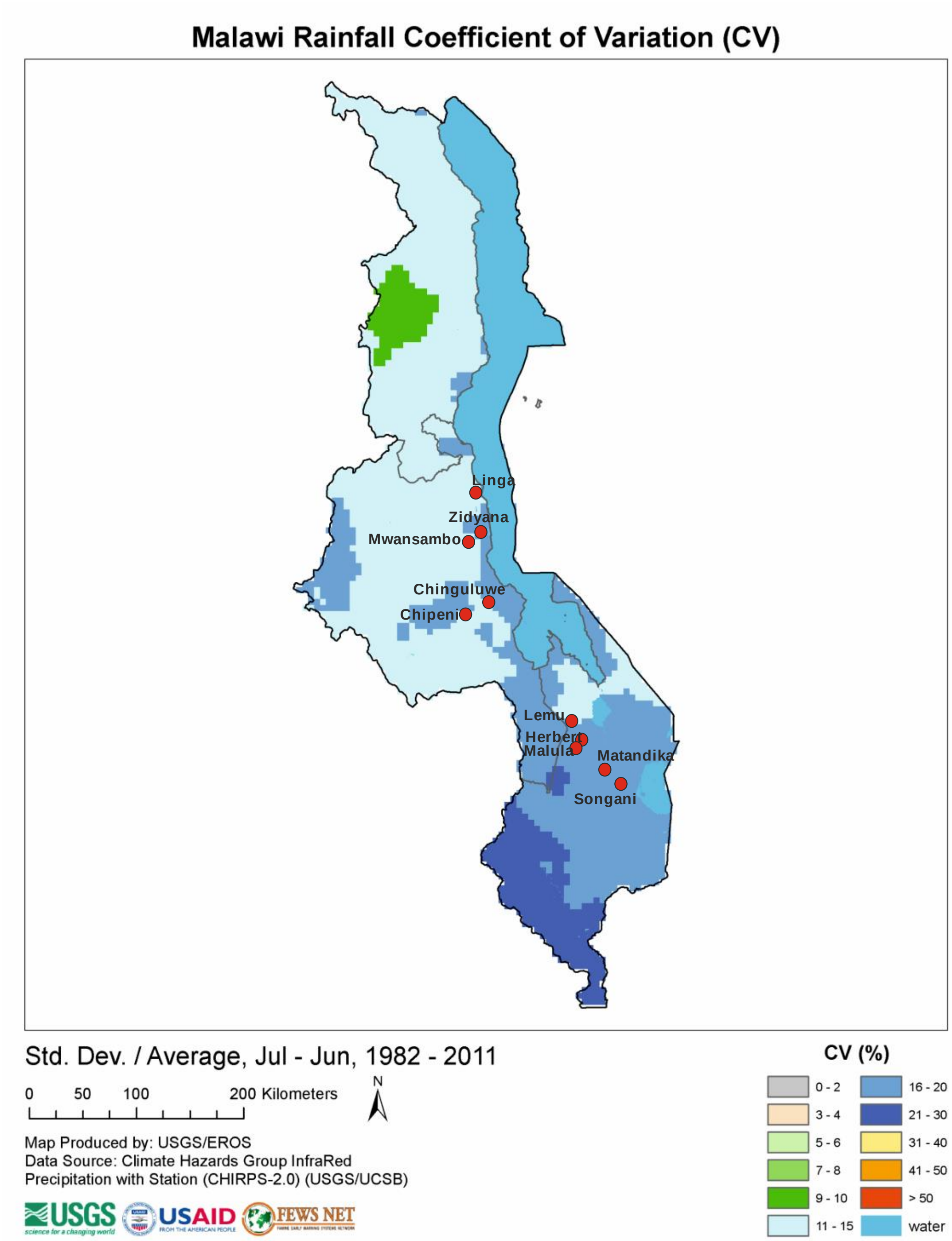

Figure 3: Malawi Rainfall coefficient variation 1982- 2011: *source: southern Africa Famine Early Warning Systems Network, March 2018*

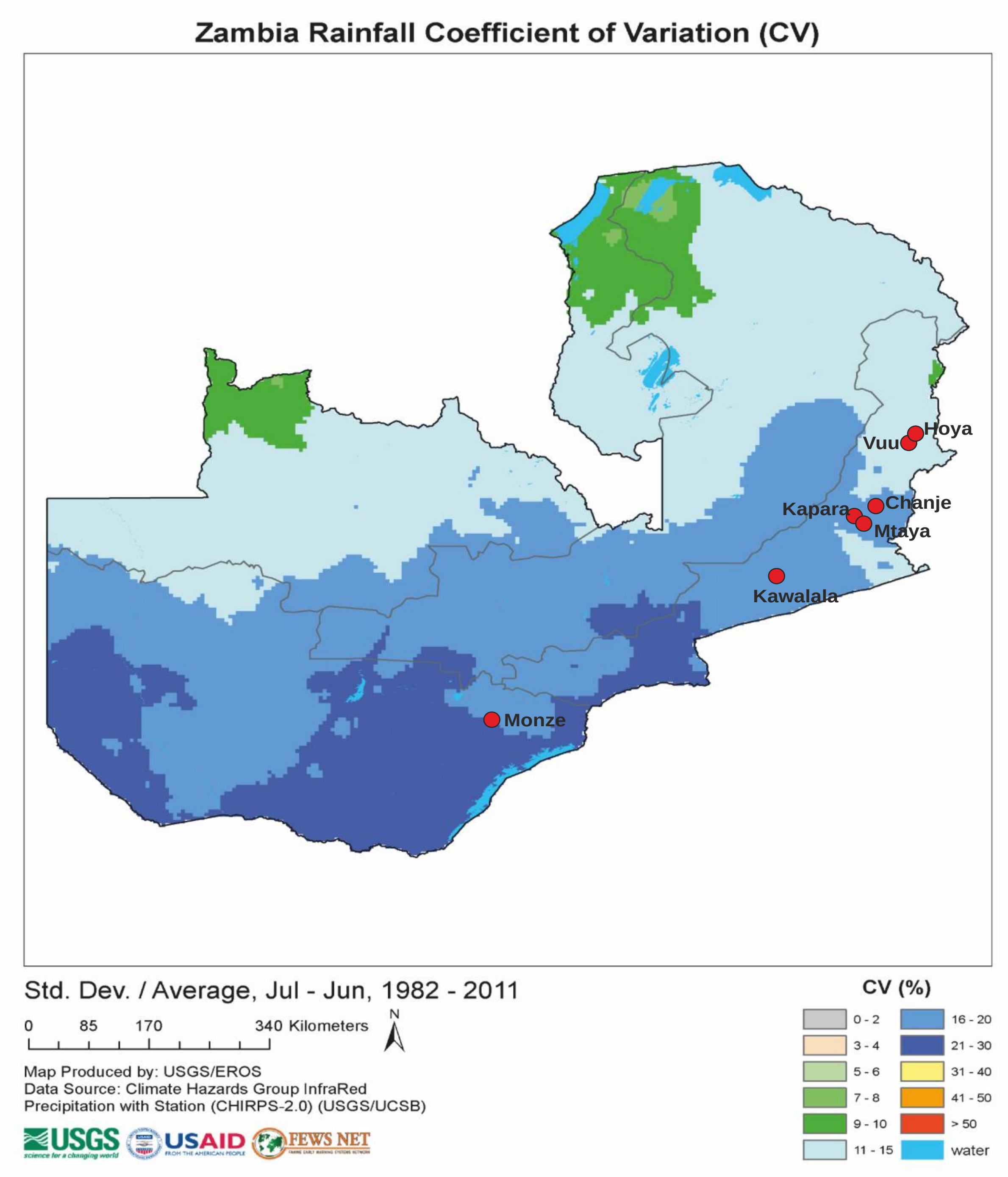

Figure 4: Zambia Rainfall coefficient variation 1982- 2011 *source: southern Africa Famine Early Warning Systems Network, March 2018*

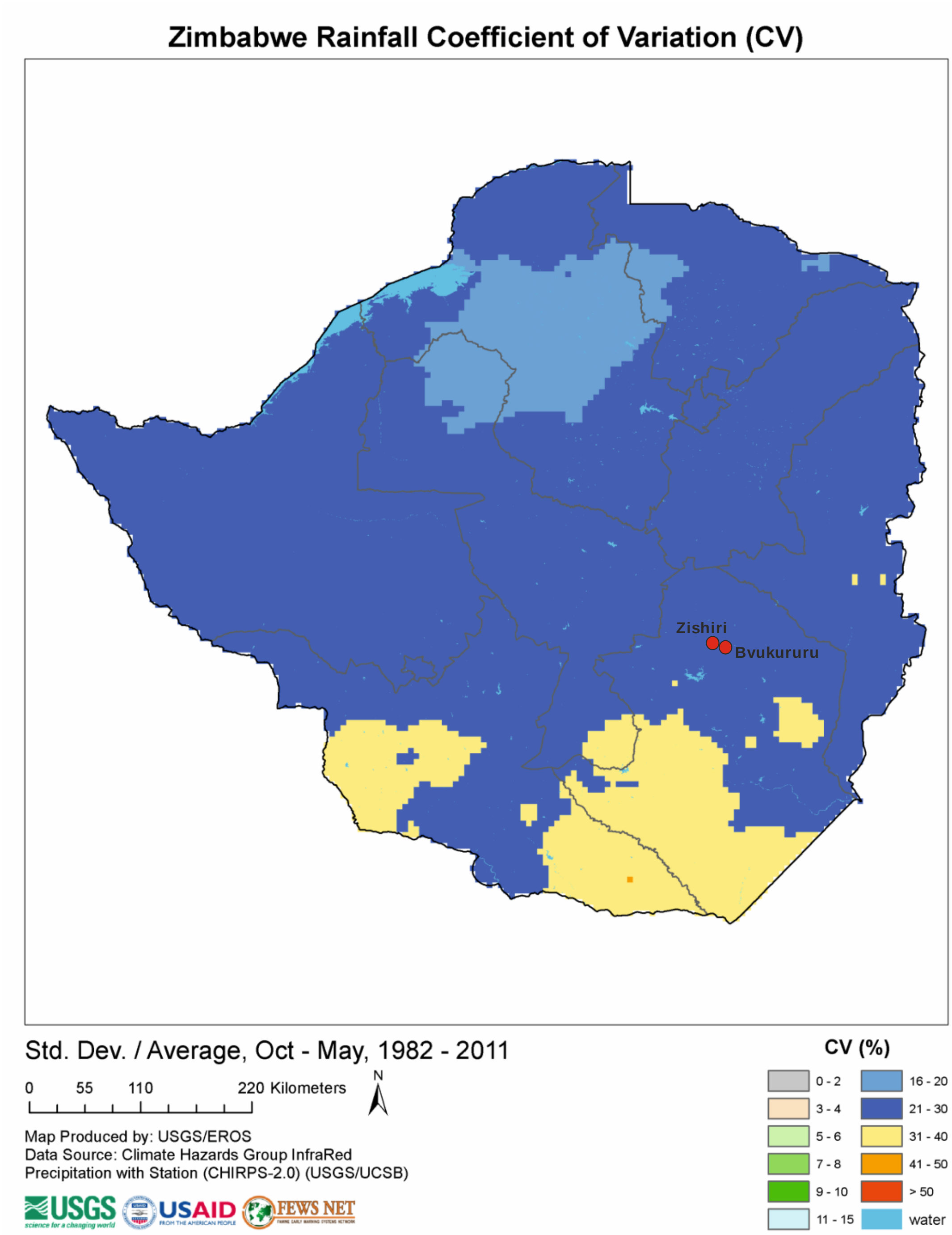

Figure 5: Zimbabwe Rainfall coefficient variation 1982- 2011 *source: southern Africa Famine Early Warning Systems Network, March 2018*

Similar trends have been observed in Zambia and Zimbabwe with greatest rainfall variability experienced in southern Zambia and Zimbabwe (Figure 4 and 5). Out of the 28 districts of Malawi 8 are prone to severe droughts, and 17 to moderate droughts (Figure 6). Southern and eastern province in Zambia are very prone to severe and moderate droughts respectively.Similarly in Zimbabwe 11 and 12 of the 52districts are at risk of severe and moderate droughts respectively (Figure 6).

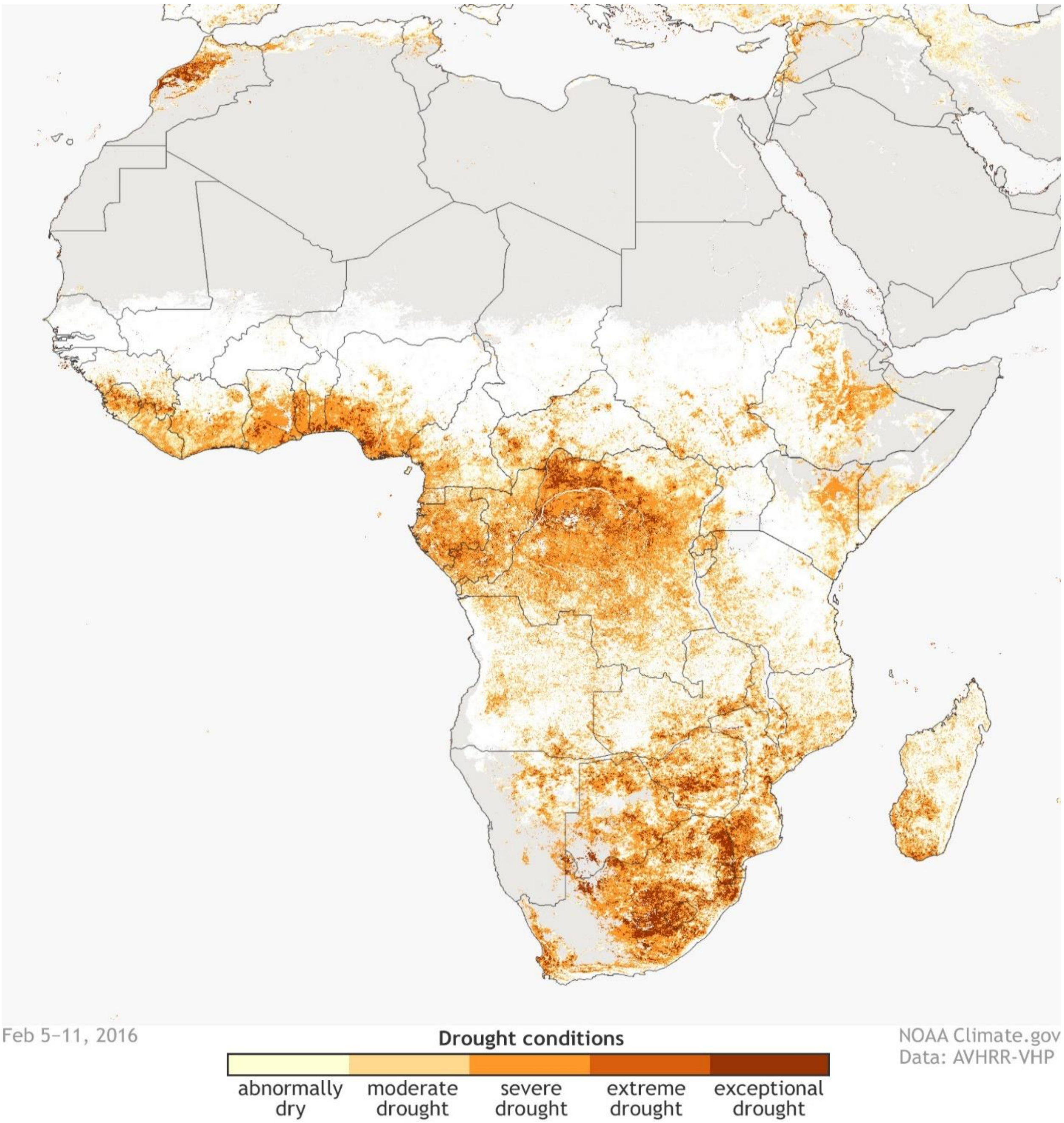

Figure 6: Malawi, Zambia and Zimbabwe drought prone areas: *source JRC technical report, 2018*

4.2 Maize production and price trends

The maize production trends for the three countries correlates well with the annual rainfall trend(Figure 7). The national average maize requirements per year are 3.6, 3.5 and 1.6 million metric tonnes for Malawi, Zambia, Zimbabwe, respectively (WFP, 2016). Both market-oriented and climate change-related factors have influenced maize production trends in the three countries. Market-oriented factors such as limited input subsidies access, increasing numbers of middlemen, increasing input prices, low output prices and lack of credit have impeded pro-poor agricultural enterprises in all the three countries. From 1990 to 2000, regularly occurring droughts have significantly compromised maize production in the three countries resulting in food deficits that now take place every two to three years in the drought prone districts (MVAV, 2017, ZAMVAC, 2017 and ZIMVAC 2017). The trend also shows that the extreme weather events intensified from 2000 to 2018in all the three countries resulting in recurrent food deficits. Southern Malawi and Zimbabwe has experienced food deficit for about 9 years. For example, from 2014 to 2016 maize production in the three countries has had deficits ranging from 13% to 60%. Zimbabwe was the worst affected in 2016 with annual deficit of 60% (WFP, 2016). The production trends were also closely correlated with maize grain prices. In the lean period of 2016 maize grain price per kilogram increased by 50% in Malawi while in Zimbabwe it increased by 100% (MVAV, 2017,ZIMVAC 2017).

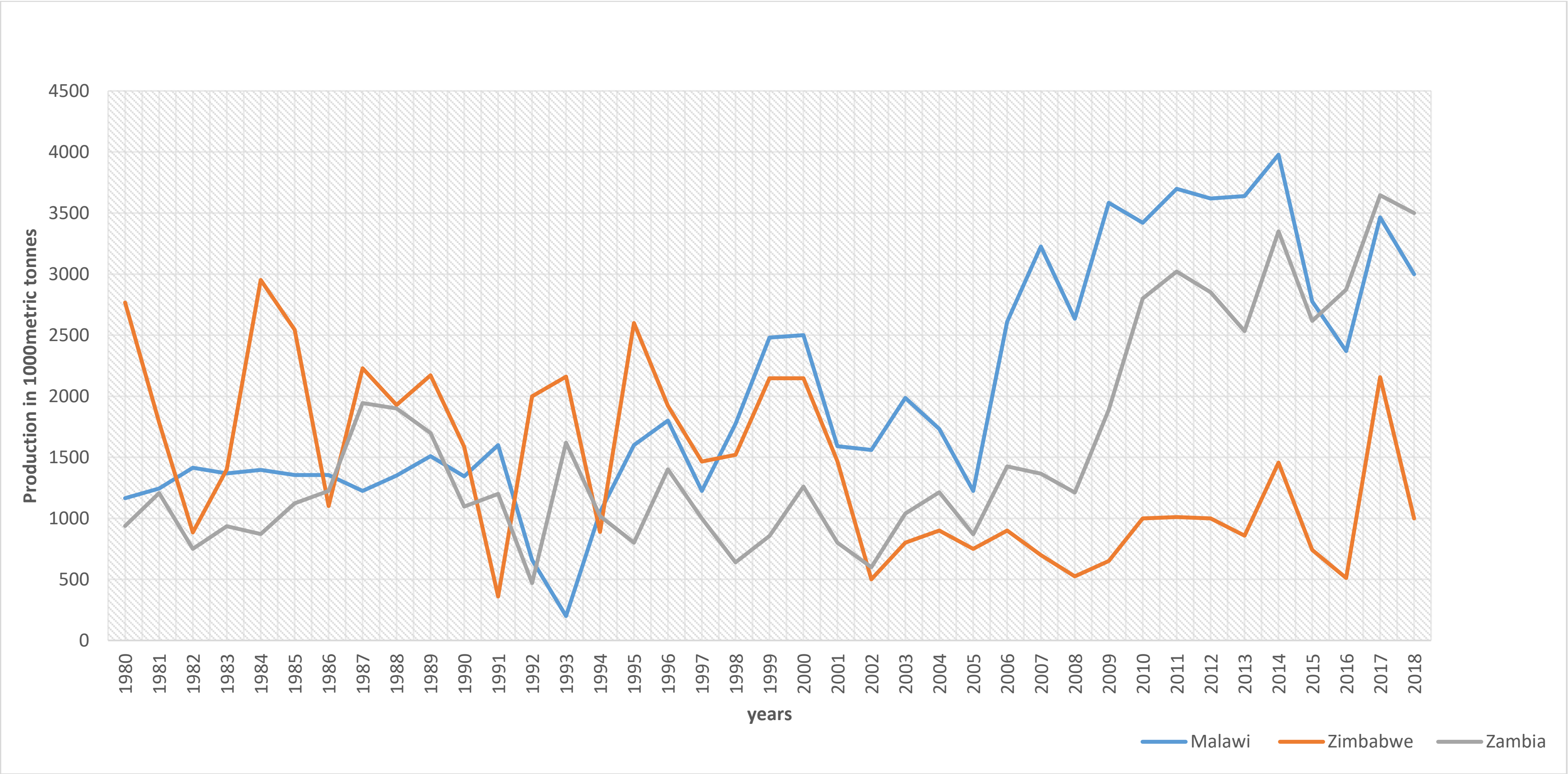

Figure 7: Maize production trends from 1980-2018 in Malawi, Zambia and Zimbabwe. *source: southern Africa Famine Early Warning Systems Network, March 2018*

4.3 Empirical review of CSA bio-economic performance

Climate change and variability significantly affect crop production in southern Africa maize. A number of CSA technologies, practices and approaches are used as a means to reduce the risk of climate change and sustain productivity. In this report we considered various forms of minimum tillage (dibble stick, ripline and direct seeder IrmãosFitarelli) in combination with drought tolerant/ improved crop varieties, legume intercropping and rotation common in the CSA context. In the three countries these CSAs are deemed to be low-regret options (Boto *et al.*, 2012, Mashingaidze, *et al*., 2012, Mupangwa *et al.*, 2012, 2017, Ngwira *et al.*, 2012, Thierfelder et al., 2012, 2013, 2014, 2016, 2017). In the manual systems of Malawi and Zambia, the full dibble-stick CA implementation i.e. dibble stick CA, maize-legume intercropping and residue retention holds the promise of providing greatest resilience to smallholders through increased crop yields and income as well as improved resource use (Table 1) (de Nijs*et al*., 2014, Mupangwa *et al*, 2017, Ngwira *et al.*, 2012, Thierfelder et al. 2016and 2017). On average, this full dibble stick CA implementation increased maize yields per hectare by 23 to 112% and net income by 50% to 120% relative to conventional practice, but effects vary significantly depending on management practices and agro-ecological factors. The benefits of this system were more apparent in season characterized by poor rainfall distribution and drier areas such as southern Malawi (de Nijs*et al*., 2014, Mupangwa *et al*, 2017, Ngwira *et al.*, 2012, Thierfelder et al. 2016 and 2017). Similarly, dibble stick CA maize-legume rotation and residue retention provides highest benefits to smallholders in the least land constrained areas of central Malawi and parts of Eastern Zambia (Mupangwa *et al*, 2017, Ngwira *et al* 2012, Thierfelder et al., 2016 and 2017). The empirical review show that maize and groundnuts yields were significantly higher overtime for full dibble stick CA relative to partial CA (dibble stick CA, maize continuous and residue retention), and conventional practice. On average maize yield per hectare increased by 30-120% for the full dibble stick CA relative to 18 to 84% for the partial CA. The dominance analysis demonstrated increasing benefits of full dibble stick CA that exceeded thresholds for farmer adoption (Ngwira et al., 2012, Mupangwa et al., 2017). Given the use of familiar technologies and food legumes the magnitude of yield and income improvements, these types of CSAs should be acceptable and attractive for smallholder farmers in similar communities.

***Table 1*: Mean Maize yield and Net income per hectare for different CSAs overtime for the low and high rainfall areas in Southern Africa (meta-analysis).**

Farming System	CSA	Low rainfall areas		High rainfall areas	
		Average maize yield/hectare for at least 3 seasons (Kg/ha)	Average maize net-benefit/ hectare US$/ ha	Average maize yield/hectare for at least 3 seasons	Average maize net-benefit/ hectare
Manual Farming system	Conventional maize legume rotation	2048 (2328)	235 (477)	2863 (1652)	342 (557)
	Dibble stick CA maize-legume intercrop	4528 (2019)	584 (382)	4620 (1768)	832 (673)
	Dibble stick CA maize-legume rotation	4264 (2452)	547 (403)	4416 (2441)	718 (648)

	Dibble stick CA maize continuous	3476 (1589)	346 (371)	3816 (912)	438 (467)
Mechanized Animal traction	Conventional maize-legume rotation	2468 (2654)	396 (361)	2967 (1002)	514 (296)
	Ripline CA maize-legume rotation	3641 (1723)	587 (468)	4276 (2981)	1224 (692)
	Ripline CA maize continuous	3358 (1002)	446 (369)	3548 (2401)	916 (718)
	Direct seeder maize legume rotation	3209 (1348)	465 (412)	3462 (3192)	891 (812)

Mean standard error in parentheses; **(**source: CIMMYT long term on-farm trial data and own calculations)

In the mechanized animal traction maize-legume based system of Zimbabwe and Zambia, the full ripline CA implementation i.e. ripline minimum tillage maize-legume rotation and residue retention hasshown to be the most climate resilient CSA practice. On average the maize grain yield increased significantly overtime by 16 - 100% for the full ripline CA relative to 15 to 60% of the direct seeder, and the conventional sole maize cropping (Mupangwa, 2017 Thierfelder 2014 and 2017). The improved maize yields signify the synergetic effects of combining the multiple CSA technologies (minimum tillage, improved maize seed, rotation).

4.4 Climate change and vulnerability impacts

4.4.1 Exposure to climate hazards

Farmers in the five southern African communities of the three countries identified heat waves, erratic onset of the season, early cessation of the season, flash floods / cyclones, in season dry spells and droughts as the most common climate hazards in the last 20 years (Table 1). Though heat waves were more recent phenomenon for Malawi and Zimbabwe communities, farmers in the Chanje community reported having experienced this as early as 2001 and have become a recurrent climatic hazard. Farmers in all the communities noted that these heat waves preceded long dry spells of an average of 2 decades (20 days) or accompanied a moderate to severe drought. The new millennium change marks the beginning of unpredictable onset of the rain season for the Chanje, Bvukururu and Zishiri communities yet Lemu farmers reported having observed this change as early as 1992 (Table 1).

For the four communities that have experienced flash floods/ cyclones they acknowledged that they were linked to El Niño-Southern Oscillation (ENSO) events. They occurred during a severe drought period or after a drought season linked to El Niño and La Niña events. For example, Bvukururu community farmers reiterated that the 1995 and 1999 cyclones preceded severe droughts. The community FGDs also showed that Lemu, Bvukururu and Zishiri were most vulnerable to in-season dry spell lately an average of 2.5 to 3 events per season. In all the communities, it was observed that these in season dry spells occurred during the critical physiological plant development period. The first in-season dry spell occurred 2 weeks after the onset of the rain season reducing the maize area, the last one occurred during flowering significantly reducing the maize yield. The climate variability and extreme weather trend analysis for 28 years (1990-2018) revealed that 4 of the communities were significantly impacted by droughts in the past (Table 1). The farmers in Lemu, Bvukururu and Zishiri perceived that more than 50% of the drought years were severe. In contrast, farmers from Mwansambo and Chanje perceived that more than 50% of the drought years were moderate. This is evidenced by a usually higher and more evenly distributed rainfall regime in both Central Malawi and Eastern Zambia. Only the Mwansambo community perceived that the average annual rainfall amount has not change but the rainfall distribution. They reiterated that they either receive more at the beginning of the season or at the end of the season.

Table 2: Summary of climate hazards/challenges& sensitivity by community and country from 1990- 2018 in 5 target communities of southern Africa

Climate hazards	Malawi		Zambia	Zimbabwe		comments
	Lemu	Mwansambo	Chanje	Bvukururu	Zishiri	
Heat wave	2 (2015; 2018)	1 (2018)	4 (2001; 2008; 2016; 2018)	2 (2016; 2018)	2 (2016; 2018)	• Increase incidence of Malaria and insects in Malawi & Zambia • Low productivity of pigs and sheep in Malawi & Zambia
Erratic onset of season	Started 1992	Started 2010	Started 2000	started 2000	Started 2000	• Highly unpredictable the seasons have been shifting in all the three countries
Early termination of rain	Started 1991,	Started 2002	Started 2002	8 (2003; 2009 - 2016)	8 (2003; 2009 - 2016)	• rainfall amount is perceived to have decrease in southern Malawi and Zimbabwe • the cropping season is perceived to be coming shorter and shorter
Flash floods/ Cyclones	0	3 (2002; 2009; 2012)	3 (2001; 2012; 2013)	3 (1995; 1999 ; 2000)	3 (1995; 1999 ; 2000)	
Dry-spell (no per season)	3	2	2	2.5	2.5	1990 -1999 1 long dry spell in mid-January • 2000 -2018 average of 2.5
Severe droughts	6 (1992, 1994, 1998,2002, 2008; 2016,)	0	4(1992;1998;2003; 2016)	5 (1992; 2002; 2004; 2008; 2016)	5 (1992; 2002; 2004; 2008; 2016)	
Moderate droughts	3 (2012; 2014; 2015)	5 (2000; 2002; 2005; 2015; 2016)	5 (2000; 2002;2005, 2014,2015)	4 (1994; 1998; 2013; 2015)	4 (1994; 1998; 2013; 2015)	
Sensitivity						
HIV/ AIDS						• Exacerbated the effects of droughts in the 1990s. • Structural adjustment program implemented in all the countries expounded the effects of droughts

						and led to break down of social safety-nets
Loss of employment by population	1994	1994	1990,	1992; 1998; 2002;2008	1992; 1998; 2002, 2008	• Mainly change of economic policy & government
Weakening of the currency	1994, 2002-2004, 2012	1994, 2002-2004, 2012	2006, 2009, 2016	1992; 1998; 2002;2008	1992; 1998; 2002, 2008	
Change of government	1994, 2005, 2012, 2014	1994, 2005, 2012, 2014	1991, 2002, 2008, 2011, 2014, 2015	2013	2013	
Crop pest & diseases	• African army worms & larger grain borer before 2017 • 2017 & 2018 Fall army worm	• African army worms & larger grain borer before 2017 • 2017 & 2018 Fall army worm	• African army worms & larger grain borer before 2017 • 2017 & 2018 Fall army worm	• African army worms & larger grain borer before 2017 • 2017 & 2018 Fall army worm	• African army worms & larger grain borer before 2017 • 2017 & 2018 Fall army worm	2017 no treatment
Declining soil fertility		Degraded clay-loamy – witch weed infestation		Poor sand-loamy – witch weed infestation	Poor sand loamy	• Delayed planting results in more than Maize 75% yield decrease
Slope	Undulating topography	Gently sloping	Gently slopping	Undulating topography & loosesandy loam soils	Undulating topography & loose sand loamy soils	

Note: the red area of the Table (HIV/AIDS sensitivity) was not analyzed in full detail. *Source PRA survey data*

4.3.2 Sensitivity to climate hazards

The farmers from the five communities concurred that their communities' vulnerabilities to these climate hazards is further intensified by the interaction of climatic shocks with social, economic, and biophysical factors (Table 1). For example, In Zimbabwe, Bvukururu community members observed that severe droughts occurred simultaneously with macro-economic turbulence creating multiple sources of food insecurity. They further highlighted that the worst drought of 1992 occurred concurrently with the economic structural adjustment program (EASP) and peak HIV/AIDS impact (Table 1). The conflation of these shocks led to the breakdown of the community safety nets and immigration of the productive family members to towns/cities and neighboring countries (e.g. South Africa). They also reiterated that the severe 2008 drought also coincided with the country's worst economic depression leading to deep poverty and wide spread migration of young girls to the nearby towns for prostitution. In Malawi, the Lemu community members linked severe droughts to policy and political changes. In particular, 1994, 2012 and 2014 droughts, the community perceived that the effects were worsened by change of government and weakening of the currency resulting in increased maize grain prices. This increased the community's dependency on the charcoal and prostitution further weakening the social network. Similar to other communities, the Chanje community of Eastern Zambia noted that severe climatic shocks such as the droughts of 2003 and 2016 were aggravated by weakening of their currency, change in economic policies linked with government changes. They reiterated that the increased frequency of metrological droughts has also reduced the watershed's water supplies to major local rivers impacting market gardening activities. This amplified effects of climate shocks as more people are relying on natural resources such as charcoal and brick making that further increases deforestation and soil degradation.

The sensitivity of these communities to delayed onset of rains and cyclones were mainly linked to biophysical factors. For instance, delayed onset of rains by more than 2 decades in Bvukururu and Zishiri communities led to increased *Striga asiatica* weed infestation in maize plots. The farmers in both communities observed that a delayed onset of rainfall combined with Striga weed infestation in February during flowering caused significant maize yield reduction of more than 75%. In Mwansambo, cyclones/flash floods were associated with increased Striga infestation in maize fields while intensified dry spells with fall armyworm. In contrast, Lemu community noted that intensified dry spell were accompanied by a significant reduction in fall armyworm infestation. The steep slope of some sites in the Bvukururu and Zishiri communities intensified the sensitivity to cyclones while the gentle slope of Mwansambo resulted in waterlogging. Overall, all the five communities concurred that sensitivity of their communities to climate hazards are determined by socio-economic profile of the households and market stability of the key agricultural commodities. Relating to the pre-market liberalization phase, the farmers lamented that the current market dynamics intensified their susceptibility to climate calamities. They expressed their dissatisfaction with current market arrangement for agricultural products that it was highly variable and controlled by political forces without farmers' interest. Using land size, food security status, and livestock as major differentiators of wealth status, the Lemu farmers alleged that more than 60% households in their community were poor (Figure8) making the society very vulnerable to climate shocks. Chanje and Zishiri communities estimated that more than 50% are medium resourced households based on food self-sufficiency and livestock (Figure 8). They perceived that fluctuating markets and prices for key cash crops intensified their susceptibility to climate shocks.

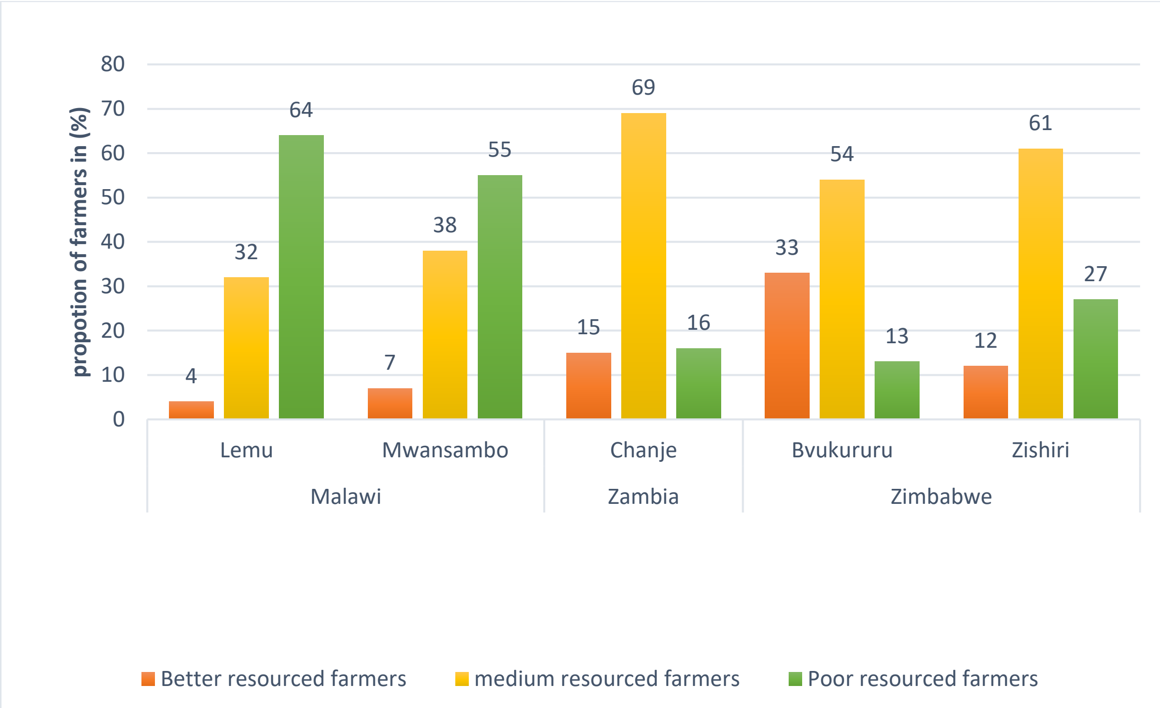

Figure 8: Community Wealth Index in target communities of southern Africa, Feb 2018 *(source: PRA survey data)*

4.4.3 Differential Climatic risk

Farmers were asked to provide an assessment of the likelihood and severity of current, future and potential impact through combining the information on the current exposure, predicted and sensitivity to climate hazards. Using risk matrix /qualitative ranking, these communities profiled their climate hazards risks (Table 3). The likelihood of the climate hazard was on a 5 point Likert scale ranging from 1= rare; 2= unlikely; 3 = possible; 4 = likely; to 5 = almost certain.

Farmers also ranked the consequence of the hazard using a 5 point Likert scale ranging from 1= insignificant, 2= minor, 3 = moderate, 4 = major to 5 = extreme. Using the risk assessment matrix outlined in Table3, risk assessment scores were calculated for each climate hazard risk source, with values ranging from 1 = very low; 2 = low; 3= medium; 4 =high to 5 = very high.

Table 3: Climate Risk/Impact Assessment matrix used in the survey

		Consequence of hazard				
Probability of hazard		**1 = Insignificant**	**2 = minor**	**3 = Moderate**	**4 = Major**	**5 = extreme**
	5 = almost certain	**Medium**	**high**	**very high**	**very high**	**very high**
	4 = likely	**Medium**	**medium**	**high**	**very high**	**very high**
	3 = possible	**Low**	**medium**	**medium**	**high**	**very high**
	2 = unlikely	**Low**	**low**	**medium**	**medium**	**high**
	1= rare	**Very low**	**Very low**	**low**	**medium**	**medium**

The results revealed that differential climate risk/impact is related to current climatic exposure, biophysical and socio-economic heterogeneity. Table 1results also indicate that the four communities (Lemu, Chanje, Bvukururu & Zishiri) have been exposure to a number of climate risk for over a longer period relative to Mwansambo. The geographical location of these communities increased their exposure to climate hazards (Tables 3-5).

All communities have experienced nearly the same average number of droughts and dry spells in a given season. However, the availability of more agricultural land, many rivers and livelihood diversification makes the Bvukururu community less vulnerable to climate risks compared to the other three communities (Tables 3-5). The long exposure to climate calamities, poor physical infrastructure development and high population densities and poverty levels intensified the climate risks/ impacts for the Lemu community. The farmers in the Zishiri community noted that soil fertility degradation and limited ground water supplies for winter irrigation increased their risk to climate hazards particularly drought and heat waves (Table 5). All climate hazards had the greatest impact on the Lemu community except for flash floods, which were very rare. The Mwansambo community members alleged that the impact of heat waves, and severe droughts were medium because of their rare occurrence. The community members also perceived that their geographical location, the relatively fertile clay loamy soils, big farm sizes an average of 2.5 hectares and makes them less vulnerable to climate shocks The Chanje community members perceived that severe drought were becoming more frequent accompanied by distress selling of productive assets and drying of major rivers in the area. The community supplement their crop harvest with horticultural production during winter. The annual rainfall deficit accompanied with increased rainfall intensity and heat wave being experience current and expected to increase in the future is perceive to make this community more vulnerable to climate shocks. They alleged that almost all severe droughts resulted in deep poverty among more than 50% of their households. They also perceived that the impact/risk is likely to increase. The community members highlighted that the climate trend pointed to a bleak future.

Table 4: Community perceptions about current and future risks of the prevailing climate hazards in Malawi

	Lemu						Mwansambo					
Climate hazard	**Existing Risks**			**Future Risk**			**Existing risk**			**Future risk**		
	Likelihood	**Consequence**	**Risk**	**Likelihood**	**Consequence**	**Risk**	**Likelihood**	**Consequence**	**Risk**	**Likelihood**	**Consequence**	**Risk**
Heat wave	possible	major	**high**	possible	major	Very High	Unlikely	moderate	**medium**	possible	moderate	medium
Erratic season onset	likely	moderate	**high**	possible	moderate	Very high	likely	moderately	**high**	likely	high	Very high
Early season termination	likely	moderate	**high**	possible	moderate	high	likely	moderate	**high**	likely	moderate	high
Flash floods/cyclones	rarely	minor	**Very low**	rarely	minor	Very low	likely	moderate	**high**	likely	high	Very high
Dry spells	almost certain	major	**very high**	almost certain	major	Very high	likely	moderate	**high**	almost certain	very high	high
Severe droughts	likely	major	**very high**	likely	major	Very high	rarely	major	**medium**	unlikely	major	high
Moderate droughts	likely	moderate	**high**	likely	major	Very high	likely	major	**very high**	possible	moderate	Very high

Source : PRA survey data, 2018

Table5:Community perceptions about current and future risks of the prevailing climate hazards in Zambia

Chanje						
Climate hazard	**Existing Risks**			**Future Risk**		
	Likelihood	**Consequence**	**Risk**	**Likelihood**	**Consequence**	**Risk**
Heat wave	possible	moderate	**medium**	likely	major	high
Erratic season on-set	likely	moderate	**high**	likely	moderate	Very high
Early season ter-mination	likely	moderate	**high**	likely	moderate	Very high
Flash floods/cy-clones	unlikely	moderate	**medium**	unlikely	moderate	medium
Dry spells	likely	major	**very high**	likely	major	Very high
Severe droughts	likely	extreme	**very high**	Likely	extreme	Very high
Moderate droughts	likely	moderate	**high**	likely	moderate	Very high

Source : PRA survey data, 2018

It was interesting to note that for Bvukururu and Zishiri communities though some extreme weather events such as flashfloods / cyclones were rare phenomena; they were associated with destruction of key productive assets such as public infrastructure, storage, livestock and crops. The more frequent ones such as erratic onset of rains and dry spells have moderate to major impacts on their community and households through reduced cropping area and crop yields. Devastating crop and livestock diseases and pests usually accompany these calamities. For example, a cold front that resulted in the death of many cattle and goats accompanied the onset of the 2017/2018 season. They also highlighted that most dry spells are accompanied by either African armyworm or fall armyworm. Thus, these communities are experiencing a very high climatic risk/ impact and expect it to intensify in the future.

Table 6: Community perceptions about current and future risks of the prevailing climate hazards in Zimbabwe

	Bvukururu						**Zishiri**					
Climate hazard	**Existing Risks**			**Future Risk**			**Existing risk**			**Future risk**		
	Likeli-hood	**Conse-quence**	**Risk**	**Likelihood**	**Consequence**	**Risk**	**Likeli-hood**	**Conse-quence**	**Risk**	**Likeli-hood**	**Conse-quence**	
Heat wave	possible	major	**high**	likely	major	high	possible	major	**high**	likely	major	high
erratic season onset	almost certain	major	**very high**	almost certain	major	Very high	almost certain	major	**very high**	almost cer-tain	major	Very high
Early season termination	likely	moderate	**high**	likely	moderate	Very high	likely	moderate	**Very high**	likely	moderate	Very high
Flash floods/cyclones	unlikely	extreme	**high**	likely	extreme	high	unlikely	extreme	**high**	likely	extreme	Very high
Dry spells	likely	major	**very high**	likely	major	Very high	likely	major	**very high**	likely	major	Very high
Severe droughts	likely	extreme	**very high**	likely	extreme	Very high	likely	extreme	**very high**	likely	extreme	Very high
Moderate droughts	likely	moderate	**high**	likely	moderate	high	likely	major	**very high**	likely	major	Very high

Source : PRA survey data, 2018

 

Plate 4: Maize-legume rotation and ***Faidherbia*** albida, central Malawi – maize cowpea (left) and maize- groundnuts and pigeon pea (right)

Plate 5: crop diversification as adaptation strategy in eastern Zambia (left) and doubled up-legume systems with groundnuts and pigeon pea (right)

Plate 6: Maize-finger millet-round-nuts rotation in Bvukuru community and (left) and maize- groundnuts and round-nuts in Zishiri community, southern Zimbabwe (right)

4.4.4 Adaptation Capacity and Differential Vulnerability Profiles

Farmers from the five communities reported undertaking different adaptation actions to deal with climate variability and extreme weather events (Figure 9-10). They categorized the adaptation actions into proactive (those activities undertaken prior to the occurrence) and reactive (activities to cope with the impacts after the occurrence). The farmers in all the communities highlighted that the effectiveness of the adaptation strategies depend on the intensity of the climate risk, awareness about the risk, associated non climatic shocks, diversity of income sources, availability and accessibility of technologies and rural support systems.

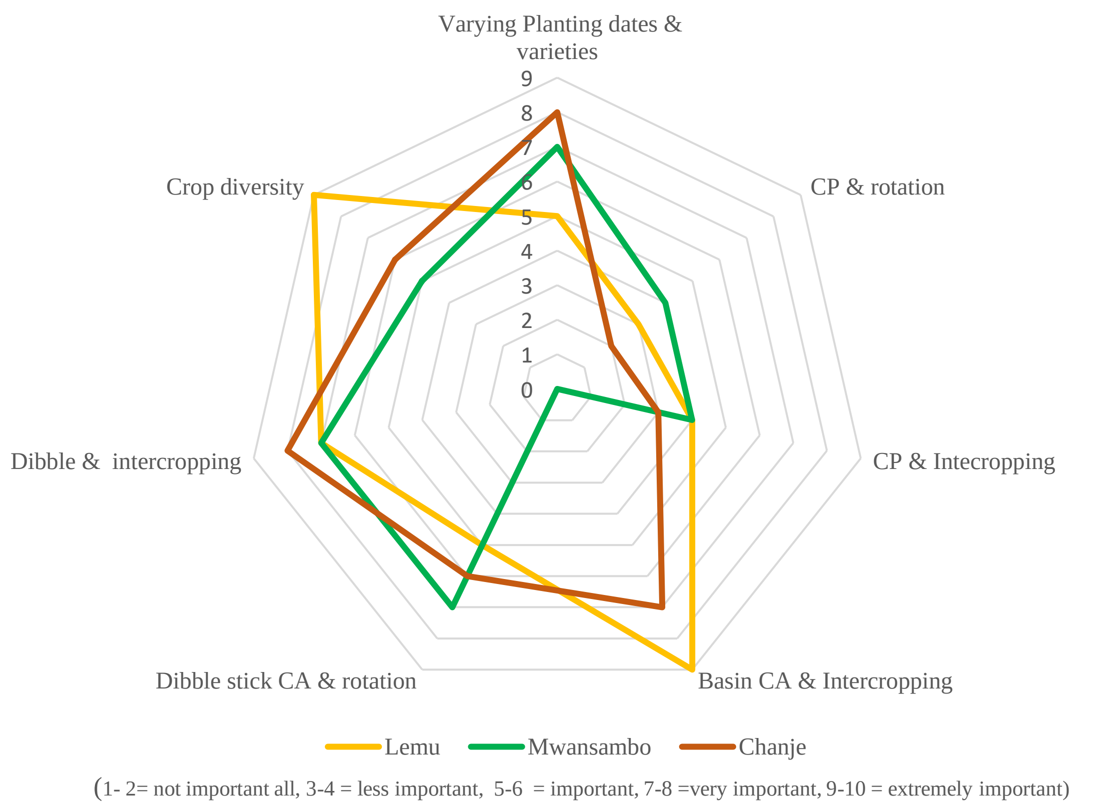

Figure 9: Drought adaptation strategies ranked by importance for Malawi and Zambia communities: CP = conventional tillage; CA = conservation agriculture. *Source : PRA survey data, 2018*

The PRA findings show that Lemu farmers used a combination of variety and crop diversification and soil water conservation strategies to manage climate risk (Figure 9). During the interactive discussion, community members reiterated that due to the increased exposure to climate variability and change they have reduced the maize area significantly from the previous 75% to 50% replacing it with cassava and sweet potatoes which are more resistant to drought. However, the farmers concurred that this strategy was not effective under severe droughts. It worked well under prolonged dry spells and early cessation of rains. A combination of soil water conservation practices such as basin CA, intercropping maize with legumes, rotations, adding compost manure and varying maize varieties (early, medium and late maturing varieties) were the most important strategies for erratic onset of season, in-season dry spell, and droughts (Table 7 & figure 9). The Lemu community members highlighted that adoption of basin CA integrated with compost manure and drought tolerant medium maturing varieties such as PAN53 and MH26 or MH30 proved to be very effective climate risk management strategy even under severe drought conditions (Table 6). The farmers reported that those who adopted this strategy during the 2016 severe drought produced enough food to last to the next season. During the interactive discussions farmers highlighted that irrigation could be a potential solution to both current and future climatic risks but most rivers within the community were seasonal. The reactive strategies commonly adopted by the community included selling of land, livestock and charcoal making (Table 6). The community also practiced stream bank cultivation as an adaptation strategy. The young girls engaged in prostitution under extreme climate risks, while young boy migrated to cities and neighboring countries (Table 6).

The community members were asked to rate their vulnerability to the different climate hazards risks on a 5 point Likert scale 1 = least vulnerable 2= less vulnerable 3 = more vulnerable 4 = most vulnerable and 5 extremely vulnerable. The farmers observed that they were extremely vulnerable to erratic onset and dry spells, most vulnerable to droughts. Drought recurrent, intensification of dry spells during critical periods, shortage of arable land, lack of access to preferred drought tolerant maize seed and accurate early warning information constrained the effectiveness of a combination of strategies in managing climate risk. For example, Lemu farmers illustrated that even if there were aware of drought tolerant maize varieties they were normally not available in the local market. The situation was also observed to be worse for farmers who rely on the government farm input subside program (FISP).

In the Mwansambo community, Central Malawi, farmers mainly adopted a combination of dibble stick CA, cereal legume rotation, crop diversification, improved maize varieties and varying planting dates as adaptation strategies (plate 4). The integration of different strategies was mainly driven by input and output markets. The farmers considered dibble stick CA, with maize legume rotation and improve maize varieties integration as the most effective adaptation strategy for erratic onset of rains, in-season dry spells, and moderate droughts. The community member concurred that improved access to basal and urea fertilizer enhanced the adaptation capacity of this strategy. The farmers also observed that the conventional ridge and furrow combined with rotation and improved maize varieties were effective for managing flash floods and dry spell when they are not prolonging (not more than 2 decades). Based on the matrix ranking, the community perceived that they were most vulnerable to erratic onset of rains, more vulnerable to floods/cyclones, dry spells and moderate drought. They considered their community less vulnerable to severe droughts and heat waves because of their geographical location (Table 6).

Table 7:Summary of climatic risks, and vulnerability profiles by community, Malawi

Lemu					Mwansambo			
Climate hazard	**Future Risk**	**Adaptation Strategies**		**Vulnerability Profile**	**Future risk**	**Adaptation strategies**		**Vulnerability**
		Proactive	**Reactive**			**Proactive**	**Reactive**	
Heat wave	**Very high**	• Mulching • intercropping	None	**More vulnerable**	**medium**	• Mulching	none	**Less vulnerable**
erratic season onset	**Very high**	• Varying planting dates & varieties • Various CA forms	• Replanting	**Extremely vulnerable**	**Very high**	• Dibble stick CA • Varying planting dates & varieties	Replanting	**Most vulnerable**
Early season termination	**high**	• Planting short season varieties • Crop diversification • Stream bank cultivation	• Selling small stock. & land • Casual labour • Migration	**Most vulnerable**	**high**	• Varying planting dates & varieties • Dibble stick CA Crop diversification • Stone bunds & terracing	• Selling small stock • Casual labour • Migration	**More vulnerable**
Flash floods/cyclones	**Very low**	None	None	**Least vulnerable**	**Very high**	• Stone bunds • Crop diversification • Spatial diversification	• Selling small stock • Casual labour • Migration	**More vulnerable**
Dry spells	**very high**	• Varying planting dates & varieties • Various CA forms • Crop diversification	• Selling small stock. & land • Casual labour	**Extremely vulnerable**	**high**	• Varying planting dates & varieties • Dibble stick CA • Crop diversification	• Selling small stock • Casual labour • Migration	**More vulnerable**
Severe droughts	**very high**	• Various CA forms • Planting short season varieties • Crop diversification	• Charcoal selling • Selling small stock & land • Prostitution • Migration	**Most vulnerable**	**high**	• Varying planting dates & varieties • Dibble stick CA • Crop diversification • Stone bunds & terracing	• Selling small stock • Casual labour • Migration	**Less vulnerable**

Lemu					Mwansambo			
Climate hazard	**Future Risk**	**Adaptation Strategies**		**Vulnerability Profile**	**Future risk**	**Adaptation strategies**		**Vulnerability**
		Proactive	**Reactive**			**Proactive**	**Reactive**	
Moderate droughts	**Very high**	• Varying planting dates & varieties • Various CA forms • Crop diversification	• Selling small stock. & land • Casual labour • Migration • charcoal	**Most vulnerable**	**Very high**	• Varying planting dates & varieties • Dibble stick CA • Crop diversification • Stone bunds & terracing	• Selling small stock • Casual labour • Migration	**More vulnerable**

Source : PRA survey data, 2018vvv

The Chanje community of Zambia used various forms of CA tillage techniques in combination (basin, dibble-stick and ripping CA) with agroforestry, drought tolerant varieties and crop diversification to manage climate risks (plate 5). Integration of conventional ridge and furrow tillage with drought tolerant maize, crop rotation, intercropping and agroforestry was also an important adaptation strategy practiced by more than 60% of the community members. The farmers reported that it was common practice to intercrop maize with more than three crops (cowpeas, pumpkins, sunflowers and sweet potatoes) under the conventional ridge and furrow tillage system. They observed that this strategy was very effective if farmers used recommended fertilizer or farm on relatively fertile soils and under moderate drought conditions. Use of both local and improved maize varieties in combination with manure was also highlighted as an important adaptation strategy to hedge against erratic onset of rains particularly for poor resources farmers.

Table 8: Summary of climatic risks, and vulnerability profiles by community, Chanje community, Zambia

Chanje				
Climate hazard	**Future Risk**	**Adaptation Strategies**		**Vulnerability Profile**
		Proactive adaptation strategies	**Reactive**	
Heat wave	**high**	• Various CA form & agroforestry • Diversification crop & market gardening	• Migration, Casual labour, Small business, Charcoal selling	**More Vulnerable**
Erratic season onset	**Very high**	• Varying planting dates and varieties • Various CA forms	• Small business, Casual labour, Charcoal	**Extremely vulnerable**
Early season termination	**veryhigh**	• planting short season varieties • Various CA forms	• Small business, Casual labour, Charcoal	**More vulnerable**
Flash floods/cyclones	**medium**	• Agro-forestry • Stone bunds	• Small business, Casual labour, Brick making & selling	**More Vulnerable**
Dry spells	**very high**	• Varying planting dates & varieties • Various CA forms & Agroforestry • Crop diversification	• Small business, Casual labour	**Most Vulnerable**
Severe droughts	**very high**	• Varying planting dates & varieties • Various CA forms & Agroforestry • Crop diversification	• Reducing meals, • Dropping children from school, • Migration, • Charcoal selling.	**Most vulnerable**
Moderate droughts	**Very high**	• Varying planting dates & varieties • Various CA forms • Crop diversification	• Small business, bicycle tax business, Vending, casual labour, • brick making and selling	**Extremely vulnerable**

Source : PRA survey data, 2018

The community perceived that they were extremely vulnerable to erratic onset of rains and moderate droughts because of the increased frequency and lack of technologies and institution to buffer against these climate risks (Table 7). The community members echoed that planting with the first rains was like gambling: "You either win or lose". They also stressed that unreliable weather forecast and limited crop insurance services in the smallholder sector increased their vulnerability to erratic onset of the season. Though they have developed a number of adaptation strategies to dry spell and severe drought, they thought they were not very effective to cushion them against total crop failure under extreme conditions. They emphasized that their community was most vulnerable to prolonged dry spells and moderate droughts.

Basin CA integrated with mulching and compost/manure, crop diversification and varying maize varieties emerged as the common most effective adaptation strategies to manage climate shocks in Bvukururu and Zishiri communities (Table 8, Figure 4, plate 6). The farmers confirmed that since the introduction of basins after the 1998 severe drought by an NGO, they have never experienced total crop failure even under extreme drought conditions. The resilience of this strategy to the common shocks experienced in their location has led to spontaneous adoption despite being labour intensive. During the interactive discussion, members underscored that it was common practice for each household in their community to allocate at least 0.4 hectare of maize under basins CA. The community highlighted that in the past (early 1990s), small grains such as sorghum and pearl millet were the most effective adaptation strategies widely grown in their location. HIV/AIDS and migration of the most productive household member to towns/cities and neighboring countries constrained continued use of this strategy.

Crop diversification into high value drought tolerant crops such as groundnuts, bambara nuts, sweet potatoes and finger millet has also become an important adaptation strategy for erratic onset of rains, dry spells, moderate and severe droughts in these communities (Table 8, Figure 4, plate 6). During the interactive discussion farmers illustrated that they had significantly reduced the maize area to 40% of the cultivated land holdings, producing enough for the household consumption. The existence of lucrative market for groundnuts, bambara nuts and sweet potatoes in the neighboring countries (Botswana, Namibia and South Africa) influenced crop choices and land allocation decisions. The proliferation of perennial rivers in Bvukururu community, led to widespread establishment of community gardens and irrigation schemes by NGOs. Farmers from this community highlighted that they were utilizing a 0.5 hectares' irrigation area per household as an adaptation strategy for all the identified climate calamities. During normal seasons they grow high value horticultural crops for urban markets and groundnuts for the winter market. In severe drought years they produce maize to supplement the shortfalls. The community reiterated that the community gardens have helped them to recoup their physical assets lost due to previous climate related shocks. Adoption of drought tolerant maize varieties integrated with varying planting dates and rotation under conventional tillage has also been an effective strategy to manage dry spells and moderate droughts, except in extreme conditions in both communities.

Table 9: Summary of climatic risks, and vulnerability profiles for Bvukururu & Zishiri communities, Zimbabwe

Bvukururu					**Zishiri**			
Climate hazard	Future Risk	Adaptation Strategies		Vulnerability Profile	Future risk	Adaptation strategies		Vulnerability Profile
		Proactive	Reactive			Proactive	Reactive	
Heat wave	**high**	• Basin CA • Crop variety diversification	• Borrow money from local savings club • Winter irrigation	**Less vulnerable**	**high**	• Basin CA • Crop variety diversity	• Replanting	**More vulnerable**
Erratic season onset	**very high**	• Varying planting dates & Varieties • Crop diversity • Diversification (market gardening & fruit trees)	• Small business • Brick molding for sale	**Extremely vulnerable**	**very high**	• Vary planting dates & varieties • Crop diversity	• Replanting • Molding bricks & fire wood selling	**Extremely vulnerable**
Early season termination	**high**	• Plant short season varieties • Crop diversity • Irrigate high value crops (ground nuts)	• Winter irrigation • Small business • Brick molding for sale	**More vulnerable**	**very high**	• Plant short season varieties • Crop diversity • Irrigate high value crops (ground nuts)	• Small business • Brick molding for sale • Casual labour	**Most vulnerable**
Flash floods/cyclones	**high**	• Agro- forestry • Terracing	• Winter irrigation • Small business • Savings clubs	**Most vulnerable**	**Very high**	• Agro- forestry • Terracing	• Small business • Brick molding for sale • Casual labour	**Most vulnerable**
Dry spells	**very high**	• Basin CA • Varying planting dates & Varieties • Crop diversity • Diversification (market gardening & fruit trees)	• Winter irrigated maize. • Small business • Savings clubs	**More vulnerable**	**very high**	• Basin Ca • Varying planting dates & Varieties • Crop diversity • Diversification (market gardening & fruit trees)	• Small business • Brick molding for sale • Casual labour	**More vulnerable**
Severe droughts	**very high**	• Basin CA • Varying planting dates & Varieties • Crop diversity • Diversification (market gardening & fruit trees)	• Winter irrigated maize. • small business • savings clubs • sale livestock	**Most vulnerable**	**very high**	• Basin CA • Varying planting dates & Varieties • Crop diversity • Fruit production	• Small business • Brick molding for sale • -Casual labour	**Extremely vulnerable**

Bvukururu					Zishiri			
Climate hazard	Future Risk	Adaptation Strategies		Vulnerability Profile	Future risk	Adaptation strategies		Vulnerability Profile
		Proactive	Reactive			Proactive	Reactive	
Moderate droughts	**high**	• Basin CA • Varying planting dates & Varieties • Crop diversification • Diversification (market gardening & fruit trees)	• Winter irrigate maize. • small business • savings clubs • sale livestock	**Most vulnerable**	**Very high**	• Basin CA • Varying planting dates & Varieties • Crop diversification • Diversification (market gardening & fruit trees)	• Small business • Brick molding for sale • Casual labour	**More vulnerable**

Source : PRA survey data, 2018

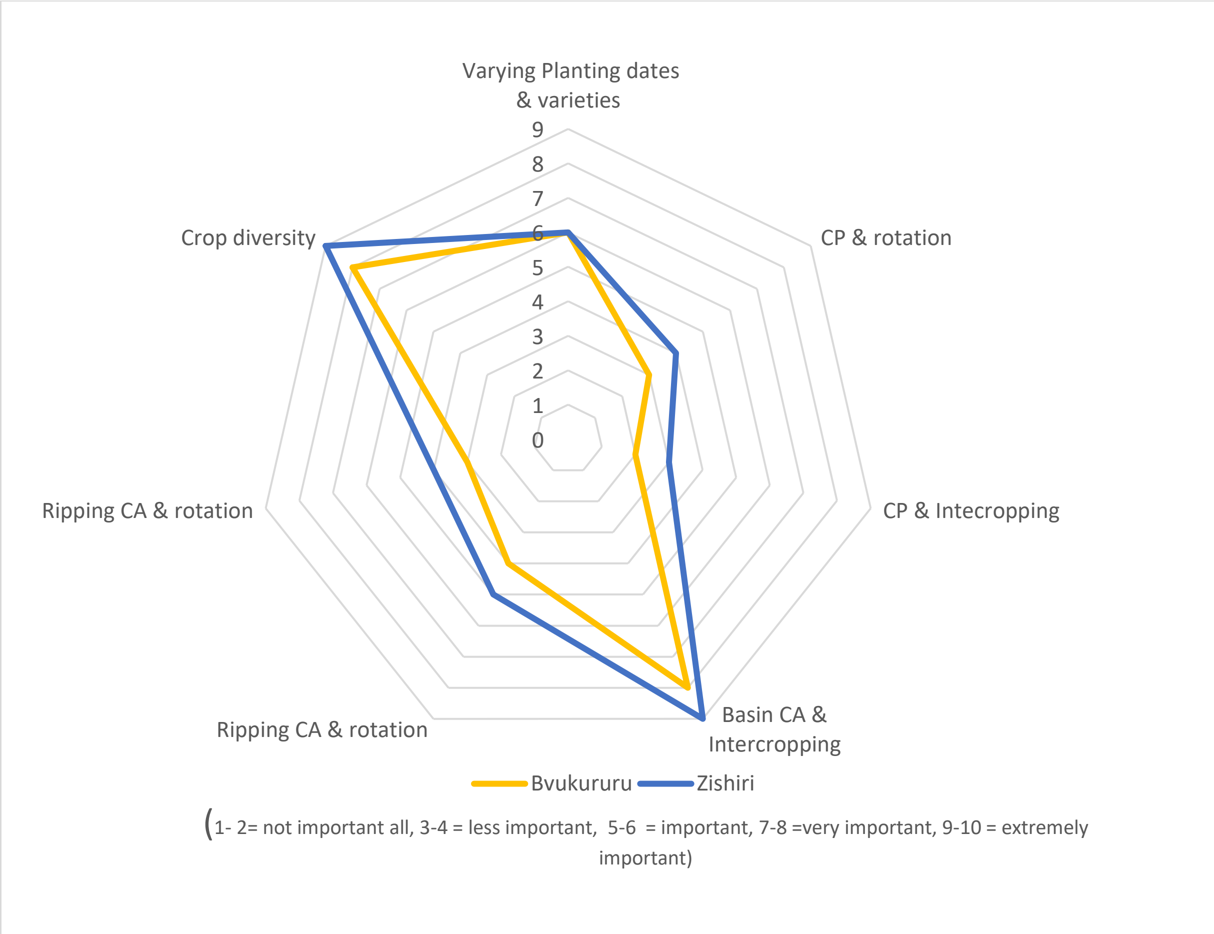

Figure 10: Drought adaptation strategies ranked by importance for Zimbabwean communities.
Source : PRA survey data, 2018

The Bvukururu community members observed that they were extremely vulnerable to erratic onset of the season (Table 8). Their adaptation strategies were mainly focused on Basin CA, intercropping and diversification (Figure 4). They professed that limited access to accurate weather forecast information, technologies and institutions to cushion them against this calamity made farming a daunt business. They perceived that they were most vulnerable to severe droughts but also floods/cyclones. The community member emphasized that severe drought reduced irrigation water and ground water discharge. They also illustrated that they had very few strategies to deal with floods and cyclones such as planting fruit trees around their fields and terracing.

Similarly, Zishiri farmers confirmed that they were extremely vulnerable to erratic onset of rains and severe droughts. The community stressed that they relied more on reactive adaptation strategies and natural resources such as harvesting of both timber and non-timber forestry products. Degraded soils, small land holding and few perennial rivers made this community extremely vulnerable to severe droughts. They also perceived that they were most vulnerable to early cessation of rains and floods/cyclones. Similar to Bvukururu they reiterated that access to accurate weather forecast information and access to very early maturing maize varieties would reduce their vulnerability.

5. Conclusion

The qualitative vulnerability assessment shows interesting findings on vulnerability at the community level: First, the most devastating climate shocks are partially or perfectly correlated to socio-economic and political forces and climate shocks will usually have devastating effects even far away from the field they occur.

Second, the communities most exposed and sensitive to climate variability and extreme weather events have developed a number of adaptation strategies. In this study, Lemu, Chanje, Bvukururu and Zishiri communities have been highly exposed and are sensitive to a number climate shocks over a long period to the extent that some of the adaptation strategies are an integral part of their farming system. It seems these communities most vulnerable are increasing diversifying their maize varieties and crop portfolios to more climate and market resilient portfolios. The results also reveal that these communities are reducing their dependence on maize as a staple and cash crop, diversifying to drought tolerant food crops such as cassava, sweet potatoes or high value crops such as finger millet, groundnut and bambara nuts with lucrative markets. This suggests that the households with high sensitivity to climate risks are likely to invest in risk-reducing strategies, utilizing whatever options are available to them. Therefore, it is important for development practitioners and policy maker to assist in identifying scalable and most feasible options to address future climate risk impacts.

Thirdly, the study results revealed that communities such as Lemu and Zishiri that were considered most vulnerable are characterized by high population densities, high poverty levels, limited economic off- farm activities and high reliance on crop production as the main source of income. They also rely on the usual traditional negative coping mechanism such as charcoal making, prostitution of girls, casual labour and migration to address inter-annual climate shocks. These measures are turning out to be ineffective to deal with climate risks but aggravating the communities' vulnerability. Technologies and policy measures aimed at reducing the sensitivity and increasing the effectiveness of adaptation actions will therefore greatly assist in reducing the vulnerability of these communities.

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Appendix

Table 1: Common livelihood strategies in the different on-farm communities of Malawi, Zambia and Zimbabwe

Livelihood activities	**Malawi**		**Zambia**	**Zimbabwe**	
	Lemu	**Mwansambo**	**Chanje**	**Bvukururu**	**Zishiri**
Cash crops	Maize, cotton, sweet potatoes	Maize, groundnuts, Tobacco,	Maize, Cowpea, tobacco, Market gardening, cotton	Groundnuts, sweet potatoes, bambaranuts**,** market gardening	Groundnuts, sweet potatoes, bambaranuts**,** market gardening
Livestock	Goats, cattle, pigs and poultry	Goats, pigs & poultry	Cattle, goats, pigs, poultry	Cattle, goats, pigs, poultry	Cattle, goats, pigs, poultry
Men Off-farm Income sources	Charcoal making, Bicycle taxi business, market gardening	Market gardening, casual labour	Charcoal making	Making bricks for sale, building, thatching, carpentry, Selling firewood	Making bricks for sale, building, thatching, carpentry, Selling firewood
Income sources - women	Small business - selling second hand clothing, canteens,	Canteens, casual labour**,**	Small business- vending, selling of second hand, market gardening	Cross border trading, vending, market gardening	Vending, market gardening
Income sources – men youths	Bicycle taxi business Taxi rank marshals	Bicycle taxi business, casual labour	Quarry and brick making and selling, market gardening,	Casual labour, brick and fire wood selling	Casual labour, brick and fire wood selling
Main source of income women youths	Housemaids, Trading,	Housemaids trading	Trading, market gardening, housemaids	Housemaids, vegetable vending along main roads	Housemaids, vegetable vending along main roads

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[i] Prostitution and out migrations are among the common strategies employed by households in southern Malawi who are failing to cope with climate change and variability shocks. Limited economic opportunities, breakdown of community safety nets because of the increased frequency of the climate calamities, limited public and donor assistance drive the most vulnerable households to such erosive coping mechanisms.